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USDA Forest Service Section, Subsection, and Landtype Descriptions for Southeastern Ohio

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Abstract

The classification, mapping, and description of ecosystems are fundamental components of land management. The National Hierarchical Framework of Ecological Units (Cleland et al. 1997) provides the basis for the USDA Forest Service to accomplish these tasks. This framework allows the recognition of ecosystems or ecological units at eight spatial scales within a nested hierarchy. The highest levels of ecological units have been delineated nationally from domains through subsections. Our project, described here, is an extension of this national effort and concentrates on the local mapping and description of ecological landtypes, the seventh level of the hierarchy. It is envisioned that the results of this project will serve the Wayne National Forest in Ohio and its partners in many ways. This work provides an ecological basis by which future land management plans can be developed and executed. It helps give direction to silvicultural activities designed to maintain ecological sustainability, biological diversity, and local economies. It also informs research by distinguishing different ecosystems for experimental design and spatial extrapolation of findings.

Literature Cited

Cleland, D.T.; Avers, P.E.; McNab, W.H.; Jensen, M.E.; Bailey, R.G.; King, T.; Russell, W.E. 1997. **National Hierarchical Framework of Ecological Units.** In: Boyce, M.S.; Haney, A., eds. Ecosystem management: applications for sustainable forest and wildlife resources. New Haven, CT: Yale University Press: 181–200.

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Metric Equivalents

When you know:	Multiply by:	To find:
Inches	2.54	Centimeters
Feet (ft)	0.305	Meters
Miles (mi)	1.609	Kilometers
Acres	0.405	Hectares
Square miles (mi^2)	259	Hectares
Square miles (mi^2)	2.59	Square kilometers
Degrees Fahrenheit (°F)	0.56(°F - 32)	Degrees Celsius

Cover: Photos (from top): Dry Oak forest, Dry-Mesic Mixed Oak Hardwood forest, and Rolling Bottomlands Mixed Hardwood forest, representative of the landtypes depicted in the map at left of a research area on the Wayne National Forest in Athens County, Ohio. Photos: USDA Forest Service, Northern Research Station.

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PART 1: INTRODUCTION

1.1 ECOLOGICAL CLASSIFICATION AND MAPPING

The National Hierarchical Framework of Ecological Units, or ecological classification and mapping known as ECOMAP, forms the basis of Terrestrial Ecological Unit Inventory for the USDA Forest Service (hereafter, Forest Service) (Cleland et al. 1997, Winthers et al. 2005). It is a nested eight-tier hierarchical system that allows the classification, mapping, and description of ecosystems from global (millions of square miles) to site level (<100 acres). The primary purpose for delineating ecological units is to identify land areas at different levels of resolution that have similar capabilities and potentials for management and conservation. Depending on scale, ecological units are designed to exhibit similar patterns in natural communities, soils, hydrology, landform, climate, and important underlying processes such as nutrient and water cycling, succession, and natural and human disturbances. Tables 1 through 3 provide a summary of the National Hierarchical Framework of Ecological Units (Cleland et al. 1997).

The first five levels of ecological units (Table 1) have been mapped across the United States (www.fs.fed.us/land/pubs/ecoregions). Below the level of subsection, managers of individual national forests and grasslands are responsible for delineating and describing the remaining finer-scale levels. Within the 20 states in the Forest Service's Eastern Region, there are 14 national forests and 1 national tallgrass prairie in charge of local mapping efforts. Some National Forest System units work closely with states, such as the Superior and Chippewa National Forests and the Minnesota Department of Natural Resources (www.dnr.state.mn.us/ecs).

Local mapping efforts in Ohio have focused on the Wayne National Forest, beginning in the early 1990s (Hix and Pearcy 1997), but the forest has not been fully and consistently mapped. The need for an all-lands approach to ecological mapping in support of collaborative oak management was the impetus for this work. Local mapping efforts for southeastern Ohio have refined 5 subsection boundaries and mapped 15 landtypes, 3 for each subsection. Results of this work provide the context for conservation planning and future management activities, as well as important stratification for research.

Table 1.—National hierarchy of ecological units for planning (gray shade denotes units mapped at local levels) (adapted from Cleland et al. 1997)

Planning and analysis scale	Ecological unit	Purpose, objectives, general use
Ecoregion	domain, division, province	Broad applicability for modeling and sampling. Strategic planning and assessment. International planning.
Subregion	section, subsection	Strategic, multiforest, statewide, and multiagency analysis and assessment.
Landscape	landtype association	Forest or areawide planning, and watershed analysis.
Land unit	landtype, landtype phase	Project and management area planning and analysis.

Table 2.—Principal map unit design criteria of ecological units (gray shade denotes units mapped at local levels) (adapted from Cleland et al. 1997)

Ecological unit	Principal map unit design criteria
Domain	Broad climatic zones or groups (e.g., dry, humid, tropical)
Division	Regional climatic types, vegetational affinities, soil order
Province	Dominant potential natural vegetation Highlands or mountains with complex vertical climate-vegetation-soil zonation
Section	Geomorphic province, geologic age, stratigraphy, lithology Regional climatic data Phases of soil orders, suborders, or great groups Potential natural vegetation Potential natural communities (Forest Service Handbook 2090; USDA Forest Service 1991)
Subsection	Geomorphic process, surficial geology, lithology Phases of soil orders, suborders, or great groups Subregional climatic data
Landtype association	Geomorphic process, geologic formation, surficial geology, and elevation Phases of soil subgroups, families, or series Local climate Potential natural vegetation: series, subseries, vegetation systems
Landtype	Landform and topography (elevation, aspect, slope, gradient, and position) Phases of soil subgroups, families, or series Rock type, geomorphic process Potential natural vegetation: vegetation alliances, associations
Landtype phase	Phases of soil subfamilies or series Landform and slope position Potential natural vegetation: vegetation associations, phases

Table 3.—Map scale and polygon size of ecological units (gray shade denotes units mapped at local levels) (adapted from Cleland et al. 1997)

Ecological unit	Map scale range	General polygon size
Domain	1:30,000,000 or smaller	1,000,000s of square miles
Division	1:30,000,000 to 1:7,500,000	100,000s of square miles
Province	1:15,000,000 to 1:5,000,000	10,000s of square miles
Section	1:7,500,000 to 1:3,500,000	1,000s of square miles
Subsection	1:3,500,000 to 1:250,000	10s to low 1,000s of square miles
Landtype association	1:250,000 to 1:60,000	1,000s to 10,000s of acres
Landtype	1:60,000 to 1:24,000	100s to 1,000s of acres
Landtype phase	1:24,000 or larger	<100 acres

1.2 MAPPING APPLICATIONS

Terrestrial Ecological Unit Inventory is an integrated approach to classifying, mapping, and describing ecosystems based on biotic and abiotic factors that drive ecosystem formation. Ecological factors, including topography, climate, soils, geology, and vegetation, are described simultaneously to characterize an ecological type, and ecological units are mapped based on these characterizations. The purpose of this inventory is to classify ecosystem types and map land areas with similar capabilities and potentials for management. The combination of classifying and mapping provides spatial context for understanding ecological and hydrologic processes, disturbance regimes, vegetation and habitat patterns, succession, and productivity. It can also provide a structure for monitoring, experimental design, and extrapolation of models and findings.

Planning and analysis scales associated with levels in the National Hierarchical Framework of Ecological Units are shown in Table 1. Ecological units at the scale of landscape (landtype association) and land unit (landtype) are most useful for planning because of their relevance to land management plans and execution of projects (Winthers et al. 2005). Landtype associations have not been mapped in southeastern Ohio, but five subsections are described and serve to provide this landscape context.

1.3 USE OF SUBSECTIONS

Ecological subsections described for southeastern Ohio have much potential for use in landscape-level planning. As mentioned, an early application was to define the boundaries for collaborative oak management. A 17-county area in southeastern Ohio is also the assessment area for the Wayne National Forest Land and Resource Management Plan revision effort begun in 2018. Subsections are also being used in the LANDIS forest landscape change model for southeastern Ohio by the Forest Service's Northern Research Station. Nowacki et al. (2001) provide concepts for the application of ecological units and management. They envision ecological subsections as mid-sized terrestrial ecosystems that can be thought of as an ecological "address system" similar to ZIP Codes™. Their concepts for management applications are adapted with modifications specific to southeastern Ohio as follows:

1. Assist in the development of land management plans, National Environmental Policy Act Planning Projects, and landscape-scale assessment projects based on land capability and suitability.
2. Assess the effects of human activities (silvicultural treatments, road systems, recreation) on the environment (productivity, water quality, habitat fragmentation) at a broad scale.
3. Assess representation of natural areas (research natural areas, special interest areas, conservation easements, preserves) across the landscape.
4. Assist in the ecological design and description for landscape analyses, watershed assessments, riparian zone management, and other projects.
5. Assign reasonable spatial limits for collecting data, parameterizing models, and extrapolating findings for landscape-level research and monitoring.
6. Describe baseline environmental and vegetation characteristics to assess natural, land-use, and broad-scale climate changes.
7. Complement or aid in wildlife modeling by delimiting landscapes with similar vegetation patterns and productivity.
8. Explain landscape concepts and ecological characteristics to partner organizations, high school and college students, other citizens, and tourists.
9. Understand and model the spatial distribution of natural disturbances (wind, ice, floods, fire, insects, disease).
10. Assess biological diversity and landscape connectivity and delineate viewsheds.

1.4 USE OF LANDTYPES

The 15 landtypes mapped for southeastern Ohio also have great potential for management application. Landtypes are already being used on the Wayne National Forest as a tool to assist in delineation of forested stands. Landtypes have also been applied in a landscape-scale modeling effort to assess zones for oak management investment (Iverson et al. 2018). Additional concepts for management application of landtypes are as follows:

1. Use in rapid biological assessments in support of National Environmental Policy Act Planning Projects based on land capability and productivity.
2. Assist in the writing of silvicultural prescriptions and in the delineation of forest stands.
3. Use as a surrogate for site index and productivity and to assess the effects of vegetation treatments.

4. Aid in riparian zone management and archaeological site protection.

5. Assist in experimental design for analyzing and collecting data and extrapolating findings for research and monitoring.

6. Assist in predicting potential natural vegetation community assemblages under current and projected changing conditions.

7. Apply as a fine filter for assessing biological diversity or designing biological inventories.

1.5 STUDY AREA

The study area is Section 221E, the Southern Unglaciated Allegheny Plateau Section of the Eastern Broadleaf Forest Province, which is a highly dissected, unglaciated region immediately south of the Maximum Wisconsin Glaciation. This section consists of seven subsections (221Ea through 221Eg) across four states: Kentucky, Ohio, Pennsylvania, and West Virginia (Fig. 1). Two subsections, 221Ea and 221Eb, do not appreciably cover Ohio and will not be described at the subsection level in this document (though the entire section is described). Additionally, at the time of writing, we learned that Subsection 221Ea will be divided into two as part of a national effort to update the current subsection map (Cleland et al. 2007). A subset of the study area is defined by 17 counties in southeastern Ohio that were part of a Joint Chiefs' Restoration Partnership Project for Collaborative Oak Management (2015–2017), a project sponsored by the Forest Service and the USDA Natural Resources Conservation Service (https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/newsroom/features/?cid=stelprdb1244394). The 17 counties were selected as being most representative of Section 221E in Ohio as well as corresponding to the social designation by the Appalachian Regional Commission for most of the Appalachian counties in Ohio (https://www.arc.gov/). Appendix 1 lists common and scientific names of tree species recorded by the Forest Service, Forest Inventory and Analysis (FIA) in the 17-county project area.

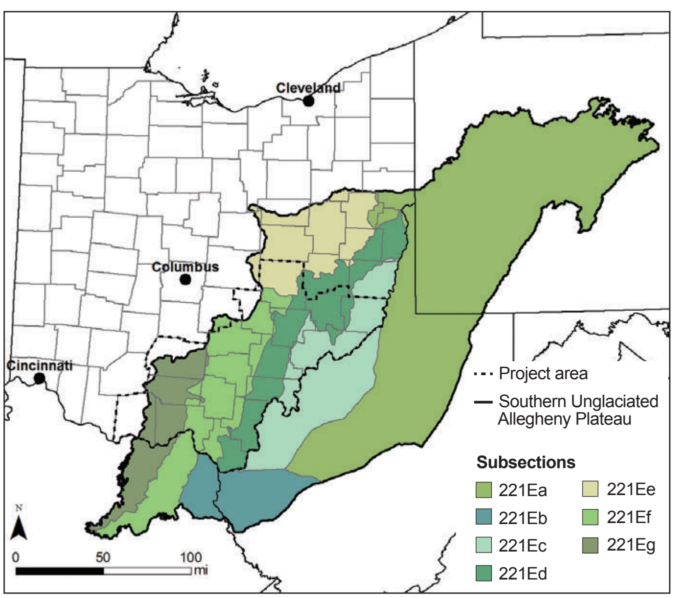


Figure 1.—Ecological Section 221E – Southern Unglaciated Allegheny Plateau, its subsections, the State of Ohio, and the 17-county region of detailed study in southeastern Ohio.

The highly weathered soils of Section 221E are primarily derived from sandstones and shales of Pennsylvanian age. It is a forest- and species-rich region, classified as oak-dominated forest type, with 90 species of trees recorded by FIA (Prasad et al. 2007).

The climate of the region is influenced by its highly dissected topography, where climatic variation is greater at the microscale than the macroscale. Mean annual temperature for the region is 51.6 °F (range: 44.2–55.7 °F) and mean annual precipitation is 42.7 inches (range: 36.6–54.8 inches), according to climate data from the Parameter-elevation Relationships on Independent Slopes Model (PRISM) for the 30-year period 1981 through 2010 (Daly et al. 2008).

PART 2: METHODS

2.1 DEFINING LANDTYPES

An all-lands approach was followed to evaluate the 17-county area (Fig. 2; see also map in pocket at back of document). A geographic information system (GIS) (ArcMap 10.5; Esri®, Redlands, CA) was used to classify and map landtypes and landtype phases across the area. Processing details are laid out in Appendix 2 and in Iverson et al. (2018).

Each landtype has a two-part name. The first part is taken from the subsection within which the landtype is mapped and represents the geology, landform, and soil properties. The second part represents the dominant forest ecosystem: Dry Oak, Dry-Mesic Mixed Oak, or Rolling Bottomlands Mixed Hardwoods. Oak-dominated forests are the primary forest type across southeastern Ohio, so current forest inventory estimates of percent oak were assessed to help develop the ecosystem names. Based on FIA data, Dry Oak forests have roughly 67 to 73 percent oak in the overstory whereas Dry-Mesic Mixed

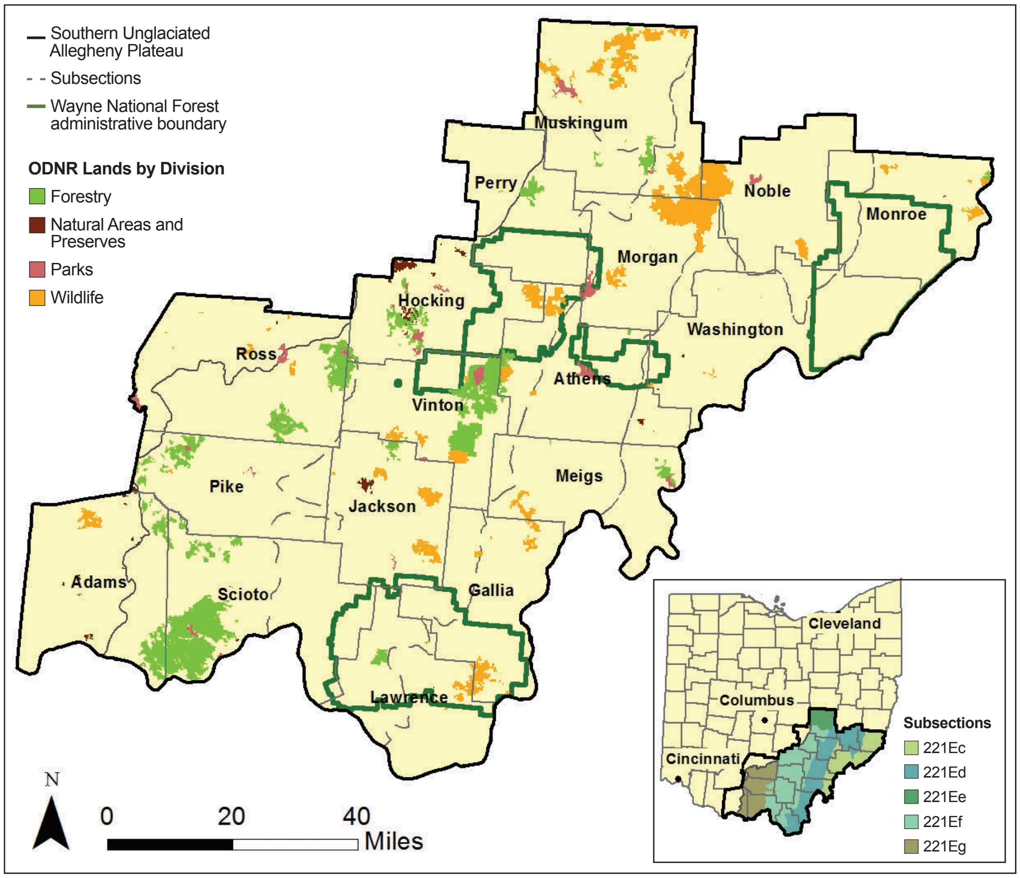


Figure 2.—Project area for ecological landtype mapping within 17 counties of southeastern Ohio. Land managed by each of four divisions of the Ohio Department of Natural Resources (ODNR) and Wayne National Forest lands are shown.

Oak forests have an oak component of 34 to 40 percent. The Rolling Bottomlands Mixed Hardwood forests have an oak component of about 43 percent. Even though some lower slopes above the floodplain have been included in Rolling Bottomlands Mixed Hardwood forests, the name of this ecosystem principally reflects the riparian forest systems of mixed hardwood assemblages.

2.2 DATA USED TO CHARACTERIZE THE SECTION, SUBSECTIONS, AND LANDTYPES

Many datasets were used and analyzed, inside a GIS, to map and quantify environmental characteristics for the overall section and each of 5 subsections and 15 landtypes. National data for climate, topography, soils, land use, land cover, and wetlands were used to characterize the section and subsections. In addition, generalized landscape, forest, cultural, and disturbance history information was drawn from the literature. The following datasets provided information for the section, subsections, and, in a few instances, landtypes.

Climate: Monthly precipitation and mean monthly temperature values, interpolated by using PRISM (Daly et al. 2008), were downloaded for the period 1981 through 2010 as a 30-year mean (PRISM Climate Group 2015). These values have a spatial resolution of 30 arc-seconds (about 2,625 feet) and were used to represent the current climate observations across Section 221E. Statistics were calculated for annual and growing season precipitation, temperature, and an aridity index (Koch et al. 2013), derived from potential evapotranspiration calculated using Thornthwaite's equation (Thornthwaite and Mather 1955).

Land Cover: The National Land Cover Database 2011 (Homer et al. 2015) was used to calculate the percentage of the landscape (subsection and landtype) represented by each of 15 classes of land cover and land use.

Topography: Elevation was obtained from the Shuttle Radar Topography Mission (SRTM) (Farr et al. 2007) 3 arc-second (pixel size of about 303.5 feet) dataset and used to elucidate elevation patterns, percent slope, and topographic roughness (Riley et al. 1999) for the entire section.

Soil: Information about soil properties was obtained from the 32.8-foot gridded county Soil Survey Geographic (gSSURGO) database (Soil Survey Staff 2017). Statistics were calculated at the subsection and landtype levels for permeability, pH, percent clay and sand, and available water storage, taken at a maximum depth of 60 inches. Depth to water table was also summarized, but only at the landtype level.

Wetlands: National Wetlands Inventory data were obtained for Kentucky, Ohio, Pennsylvania, and West Virginia (U.S. Fish and Wildlife Service 2017). Acreages by wetland type are reported, as are summaries by the three primary systems (lacustrine, palustrine, and riverine) to indicate the percentage of area within each subsection.

Forest Inventory: Trees prevalent in each subsection were extracted from the FIA database (USDA Forest Service 2018).

2.3 DATA USED TO CHARACTERIZE THE OHIO PORTION OF THE FIVE SUBSECTIONS AND LANDTYPES

The 5 subsections of Section 221E within the 17-county project area constitute 23.3 percent of the entire section. Additional data were available and summarized at the subsection and landtype level for this portion of Ohio, and several variables were required for the landtype modeling. We present the methodology for deriving landtypes in Appendix 2, and provide some detailed landtype modeling outcomes pertinent to managers in Appendix 3. Fourteen environmental and biological variables were identified to describe Ohio subsections: elevation, topographic roughness, available water supply, available water storage, soil permeability, pH, percent clay and sand, vegetation, bird observations, wetlands, land use, deer density, and landscape diversity. Statistics were calculated for environmental data within portions of the subsection or landtypes that fell within the 17-county project area. Unless described in the following discussion (noted also for subsection or landtype usage), the dataset and variables were from the same source as used at the section or subsection levels (see part 2.2).

Topography (Landtype): Elevation was obtained from the Ohio Environmental Protection Agency digital elevation data (32.8-foot pixel size) and used to calculate statistics for elevation, transformed aspect (Beers et al. 1966), percent slope, topographic roughness (Riley et al. 1999), and integrated moisture index, which combines topography and soil characteristics (Iverson et al. 1997).

Natural Vegetation of Ohio (Subsection): A digitized version (U.S. Geological Survey 2003) of Gordon's Natural Vegetation of Ohio at the Time of the Earliest Surveys (Gordon 1969) was used to estimate the percentage of area for Gordon's vegetation types in the subsections within Ohio. Additionally, bearing tree records summarized to townships by Sears (1925) representing three dominant and four minor species assemblages aided interpretation of Gordon's vegetation classes.

Witness Tree Data from Original Land Surveys (Subsection and Landtype): A portion of the study area was covered in two surveys conducted in the late 18th century, before Euro-American settlement: the Ohio Company Purchase and the Congress Lands East of the Scioto River. These rectilinear surveys were conducted under the same congressional ordinance. Townships (6 miles × 6 miles) were delineated, and divided into 36 sections (1 mile × 1 mile) and sometimes smaller divisions. Lot corners were marked with a wooden stake, and nearby trees (usually two) were blazed to assist with later location of the parcel boundaries. These "witness trees" were recorded by species and diameter, and serve as an inadvertent vegetation survey before widespread land clearing. Furthermore, because witness trees are referenced to specific locations, it is possible to establish relationships between species locations and topographic settings in the presettlement forest. Figure 3 shows the combined surveyed area with respect to subsection boundaries of Section 221E. Witness tree data were transcribed from archival sources (Ohio Company: Marietta College, Marietta, OH; Congress Lands: photocopies from the Ohio Historical Society, Columbus, OH) (Dyer 2001, Dyer and Hutchinson 2019).

Breeding Bird Atlas (Subsection): Birds are critical indicators of diverse forest habitats, and southeastern Ohio is a region recognized as containing important bird habitats (Rodewald 2013). Data for bird distributions were derived from the Ohio Breeding Bird Atlas 2 (OBBA2; Rodewald et al. 2016), which provides a comprehensive picture of birds living throughout Ohio during the period 2006–2011. The data consist of birds occurring in every 4 km × 4 km (2.5 mile × 2.5 mile) block in the State. Of these blocks, there were 764 "priority blocks,"

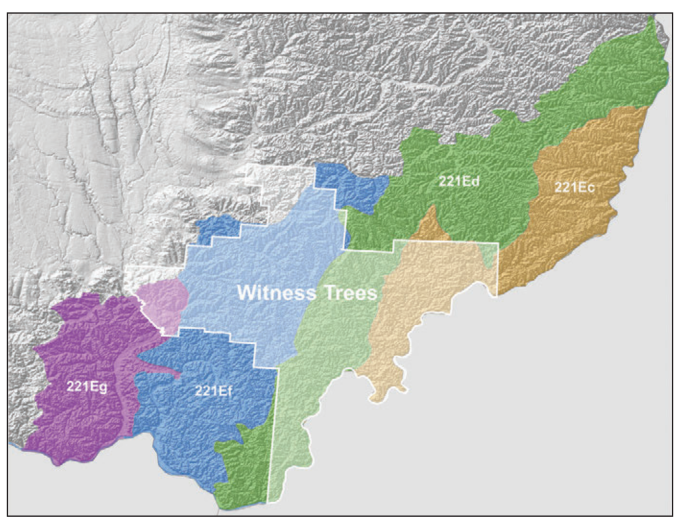


Figure 3.—Area from which witness tree data were obtained from two Ohio land surveys conducted in the late 18th century, relative to ecological subsection boundaries of Section 221E.

where additional effort and focus were dedicated to ensure data were comparable to the first atlas conducted from 1982 through 1987 (OBBA1; Peterjohn and Rice 1991). The data presented here focus on the presence or absence of all bird species that were recorded in the 217 priority blocks within the Ohio portion of Section 221E. We report the proportion of the blocks where the species was present as an incident value similar to Matthews et al. (2011) for each of the five subsections. In addition, we report the change in incidence for each subsection from the first atlas. Overall, there were 108 species recorded during OBBA2, 35 of which occurred in more than 90 percent of the priority blocks within the section. Many of these species are important forest indicator species and capture the diverse forest habitat needs of birds across Section 221E.

Deer (Subsection): The distribution and abundance of white-tailed deer (*Odocoileus virginiana*) on the landscape can greatly influence forest vegetation (Royo et al. 2017). In order to assess the general occurrence and prevalence of white-tailed deer across the five subsections, we focused on harvest data collected by the Ohio Department of Natural Resources (ODNR), Division of Wildlife (ODNR 2017). To address interannual variation, we report the 3-year average from 2013 through 2015. Following Karns et al. (2016), we report the number of females harvested. The number of antlerless permits varies little across years, making for suitable comparative values across subsections. We also report the number of males harvested during these 3 years, as buck harvests from one year to the next are used as an indicator of population sizes (ODNR 2017) in setting harvest levels. We believe that reporting both numbers gives a broader perspective on deer population status across the subsections. We interpret the average total yearly harvest of deer to indicate a general influence of this species on the landscape, but evidence shows that deer browse pressure can vary across the landscape (Royo et al. 2017) and management to reduce deer density can positively influence forest regeneration (Stout et al. 2013). Thus, the pattern of deer harvest in Ohio can help us understand the browsing pressure across the region.

Mined Lands (Subsection): Digital records for surface and underground mining were obtained from the ODNR Division of Mineral Resources Management. Records were summarized for two groups, land where mining was completed prior to the Surface Mining Control and Reclamation Act of 1977 and land where mining was completed after 1977, to indicate the probability that an area has been reclaimed or unreclaimed. Forested land on reclaimed mines tends to be less productive compared to unreclaimed mine land because of the higher soil compaction on the reclaimed mine land (Rodrigue et al. 2002, Zipper et al. 2011).

Dry-Mesic Mixed Oak Hardwood forest in southeastern Ohio. Photo by USDA Forest Service, Northern Research Station.

Landscape Diversity, Connectedness, and Resilience (Subsection): The Nature Conservancy has been implementing a process called Conserving Nature's Stage (CNS) to map much of the terrestrial landscape of the United States for its capacity to sustain biological diversity under a series of threats in coming decades, including a changing climate. The intent of this effort is to score the landscapes for their resilience, or capacity to sustain native plants, animals, and natural processes into the future (Anderson and Jenkins 2006, Anderson et al. 2014). It uses multiple GIS layers, at 30-m (98.4-foot) resolution, and processes to first understand the diversity of the landscape based on geology, soils, and especially topography. The more landscape diversity, the more microclimates will be available to host a diverse set of organisms. Second, the system assesses the connectedness, or flow paths, of the habitats; those locations with connected riparian corridors, for example, can harbor species migrating northward in the face of a changing climate (or other disturbance requiring movement). Patterns of agriculture and development largely impact how and where species can move. Third, the landscape (microclimate) diversity and connectedness scores are added to generate an overall resilience score. Sites with high microclimate diversity and connectedness, representing all geophysical settings, thus represent high biodiversity now and potentially into the future. Then, NatureServe (www.natureserve.org) and other biodiversity databases are used to confirm diversity in the locations deemed resilient in the preceding process. The scores, based on abiotic diversity, have correlated well to current biodiversity for plants and animals, so biodiversity at locations without adequate on-ground biodiversity sampling can be estimated via these analyses (Anderson et al. 2014, Beier et al. 2015). The intention is that these tools can be helpful in future prioritization of purposeful management and acquisition of sites. Data were downloaded for the northeastern United States from the Conservation Gateway site of The Nature Conservancy (The Nature Conservancy 2017).

PART 3: ECOLOGICAL UNIT DESCRIPTIONS

3.1 SECTION 221E – THE SOUTHERN UNGLACIATED ALLEGHENY PLATEAU: SETTING THE ECOLOGICAL CONTEXT

Section 221E lies between the maximum ice floes of Wisconsinan and Illinoian glaciations to the northwest and the Appalachian Mountains to the southeast. This highly dissected plateau marks a transition from flat till plains to the northwest and the deformed rocks of the Appalachians (Camp 2006). Because it is unglaciated, much of its ecological character is directly attributed to the underlying geology and erosional forces. The geologic layers that underpin this section are the result of mountain-building processes that span a half billion years (Camp 2006, Van Driver 1990). Three distinct mountain-building orogenies directly affected this section, each event contributing sediments that solidified over time to form present-day bedrock layers. The first event took place some 475 million years ago when the Baltic (European) and Laurentia (North American) plates collided, forming the Taconic Highlands. During this period (Ordovician) (Table 4), shallow seas dominated much of Laurentia; the marine environment gave rise to shales and limestones. As the Taconic Highland eroded, sediments were cast over a huge area from Delaware to Wisconsin (Camp 2006).

Long after the Taconic Highlands eroded away, another Baltic-Laurentia plate collision took place about 375 million years ago, creating the Acadian Mountains. Westward-forming streams actively eroded this mountain range, depositing sediments in a vast network of overlapping deltas. This deposition formed the basis of shales and sandstones that mark the Devonian and Mississippian Periods. The last event occurred some 318 million years ago during the Pennsylvanian Period, when northwestern Africa slammed into North America and uplifted the Appalachians (Camp 2006). Again, the sediments were shed westward towards Ohio, forming actively changing deltas due to fluctuating sediment supplies and uplift. Over time, a mishmash of depositional environments formed, including river channels, floodplains, coastal swamps, uplands, brackish estuaries, and shallow seas—surfaces that eventually became the Pennsylvanian- and Permian-aged rocks of southeastern Ohio (Camp 2006).

Starting at the late Ordovician time, around 450 million years ago, rock layers in southeastern Ohio had begun to sink (as part of the western edge of the Appalachian Basin) and tilt eastward from the stable, westward-lying Cincinnati Arch (Camp 2006). Erosion was greatest along the crest of the arch, so the oldest rock (Ordovician) occurs on top of it, with parallel bands of increasingly younger rock radiating outward along its flanks. Thus, the rock layers that span the Allegheny Plateau are aligned from oldest (Ordovician) to youngest (Permian) from west to east, their long axes lying in a north-south orientation (Camp 2006) (Fig. 4).

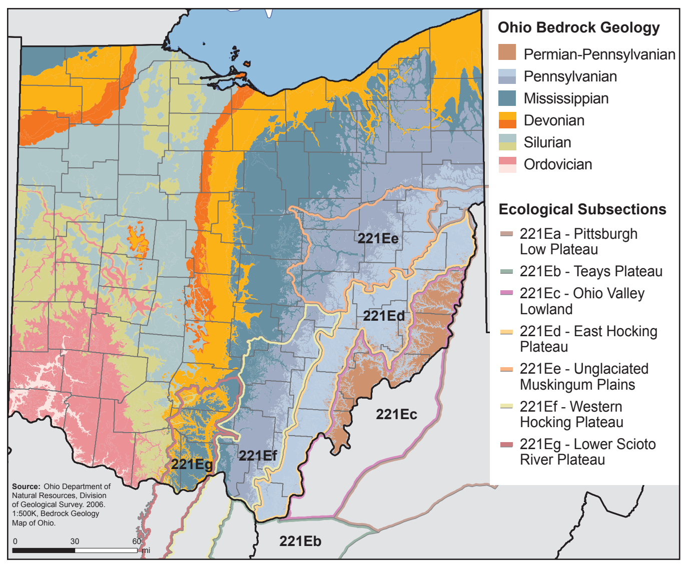


Figure 4.—Ecological subsections overlaid on Ohio bedrock geology.

Table 4.—Percentage of materials from each geologic period by ecological subsection within the Ohio portion of Section 221E

Geologic period	Age (million years ago; Mya)	Subsection						
		221Ea	221Eb	221Ec	221Ed	221Ee	221Ef	221Eg
		percent						
Upper Pennsylvanian	307.0–298.9 Mya	53.0	68.5	40.7	96.7	20.6	7.6	0.0
Lower Pennsylvanian	323.2–307.0 Mya	46.6	31.5	59.3	3.3	62.9	59.6	0.0
Mississippian	358.9–323.2 Mya	0.4	0.0	0.0	0.0	16.5	32.8	66.0
Devonian	419.2–358.9 Mya	0.0	0.0	0.0	0.0	0.0	0.0	28.4
Silurian	443.8–419.2 Mya	0.0	0.0	0.0	0.0	0.0	0.0	5.5
Upper Ordovician	458.4–443.8 Mya	0.0	0.0	0.0	0.0	0.0	0.0	0.1

Even though this portion of the Allegheny Plateau was not overridden by glacial ice, it was influenced by it in other ways, as shown in the Ohio glacial history map (Fig. 5). During the height of past glaciations, periglacial processes (geomorphic changes resulting from seasonal freeze-thaw cycles) dominated the frozen tundra that lined the glacier front. These processes, such as ice wedging and frost creep, resulted in the extensive mixing of surficial deposits. Meltwater rivers and streams gushed southward from vast ice sheets, depositing outwash sands and gravels along their course. These deposits are called valley trains, and the best examples in southeastern Ohio occur along the Scioto and Tuscarawas Rivers (Camp 2006). Where lakes were impounded along certain segments of rivers, fine-textured, glacio-lacustrine sediments (silts and clays) were deposited. Last, fine windblown sediments called loess were deposited on surfaces immediately adjacent to glacier-fed rivers.

The Wisconsinan Ice Sheet reached its maximum extent roughly 20,000 to 25,000 years ago, retracting at an irregular pace thereafter. Plants migrated northward independent of one another based on differences in (1) refugia location, (2) starting times, and (3) rates of dispersal (Pielou 1991). As such, many plant communities that formed were temporary and novel (no modern analog). Plants constantly reassembled along their northward advance as climates continually fluctuated (Fig. 6). According to Shane and Anderson (1993), sometime after 16,000 years before the present (BP), tundra on the Allegheny Plateau was replaced by spruce (*Picea*) woodlands and forests, which dominated until 13,000 years BP. Tamarack (*Larix*), fir (*Abies*), and pine (*Pinus*) occurred at low frequencies at that time. Spruce declined from 13,000 years to 11,000 years BP, being replaced by deciduous trees, principally oak (*Quercus*), ash (*Fraxinus*), and hophornbeam/musclewood (*Ostrya/Carpinus*). The release from megafaunal herbivory

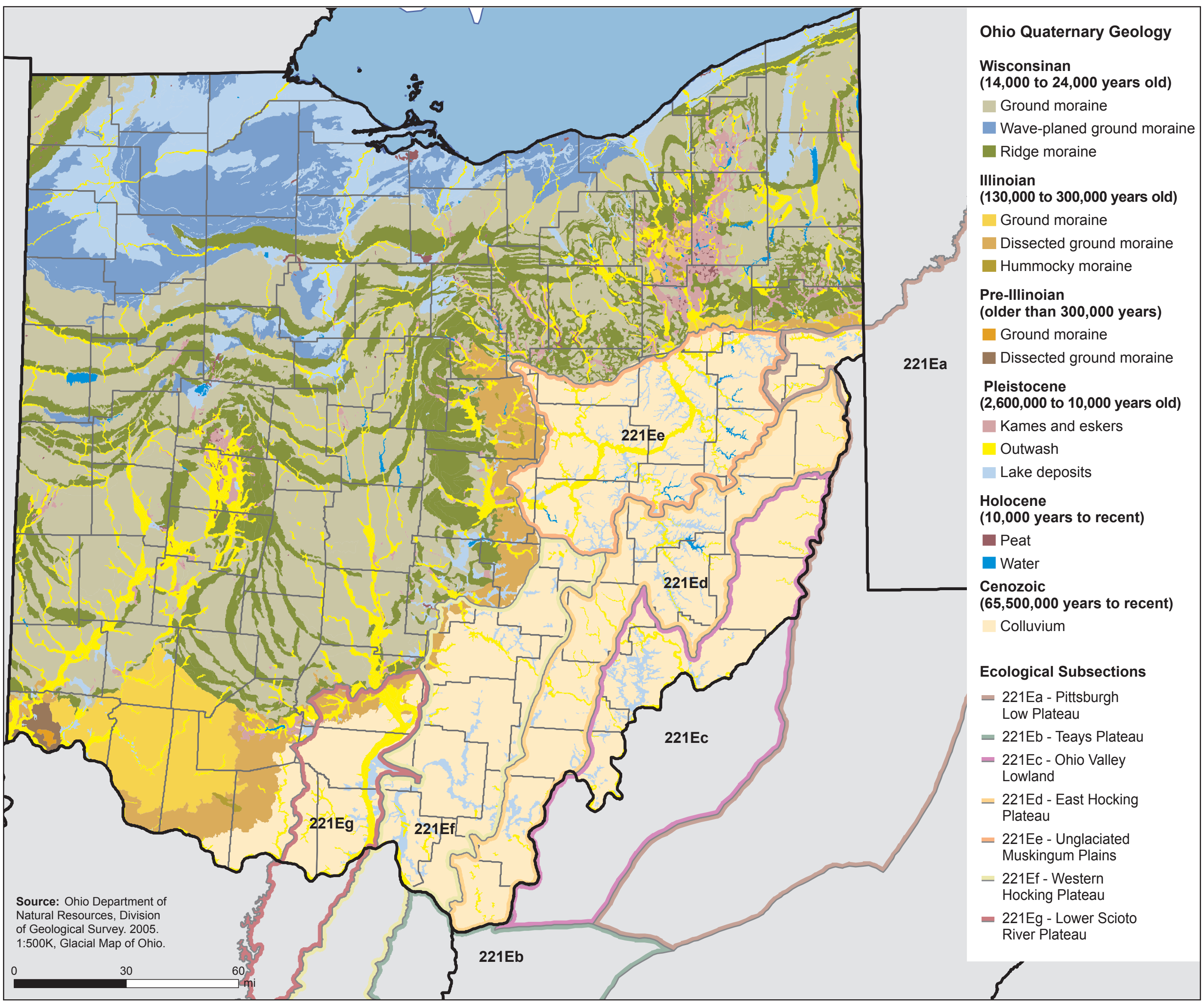


Figure 5.—Glacial map of Ohio (Ohio Department of Natural Resources, used with permission), which shows the influence of the glaciers, even in the Allegheny Plateau.

and concurrent increase of fire have been implicated in this pronounced increase in deciduous vegetation (Gill 2013, Gill et al. 2012). A sharp expansion of pine occurred at 11,000 years BP, corresponding to the short-lived Younger Dryas cooling event (Shuman et al. 2002), and ended when oak increased markedly at 9,500 years BP (Fig. 7). Since then, oak has dominated the arboreal vegetation with lesser amounts of hickory, according to a local pollen record at Stages Pond in south-central Ohio (Shane et al. 2001).

The antiquity of oak dominance over the Southern Unglaciated Allegheny Plateau is rather remarkable considering the climatic fluxes incurred over the past 10,000 years (Fig. 6) (Abrams 2002, Lorimer and White 2003). Oak is generally a warm-adapted genus (Nowacki and Abrams 2015), so its rise to prominence across the eastern United States during the Early Holocene Warming and continued dominance throughout the Holocene Thermal Maximum (warmer, drier conditions) make sense. However,

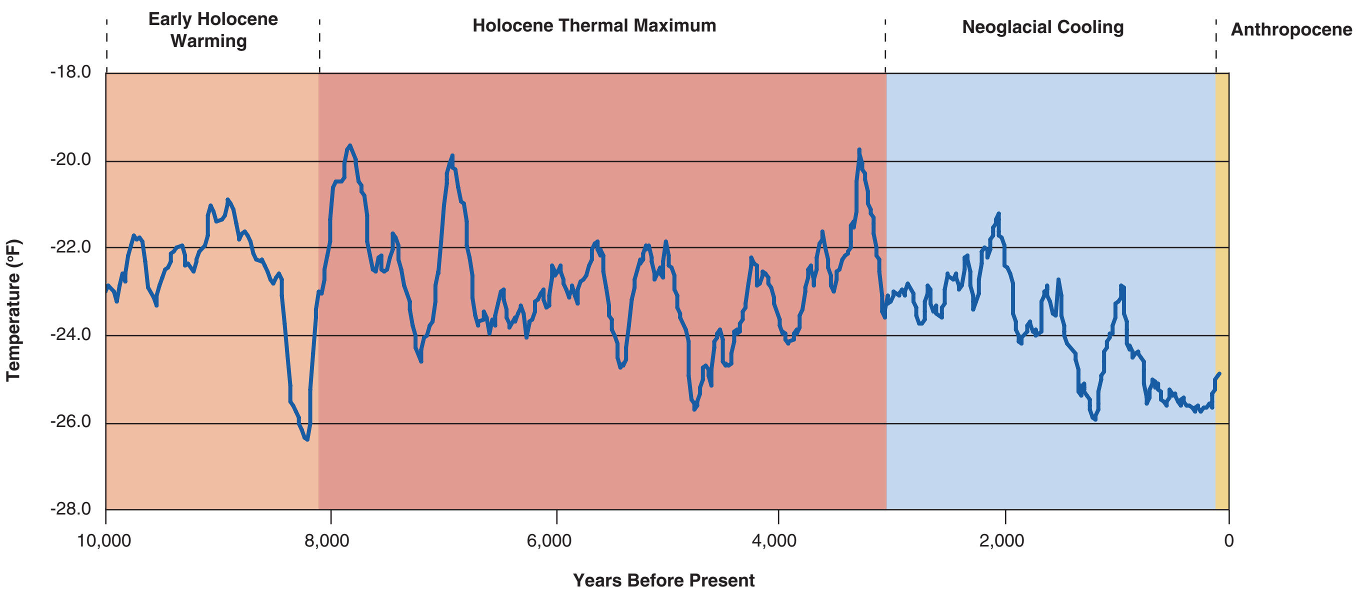


Figure 6.—Climatic record based on central Greenland temperature (GISP2 Ice Core; Alley 2004) spanning 10,000 years before present.

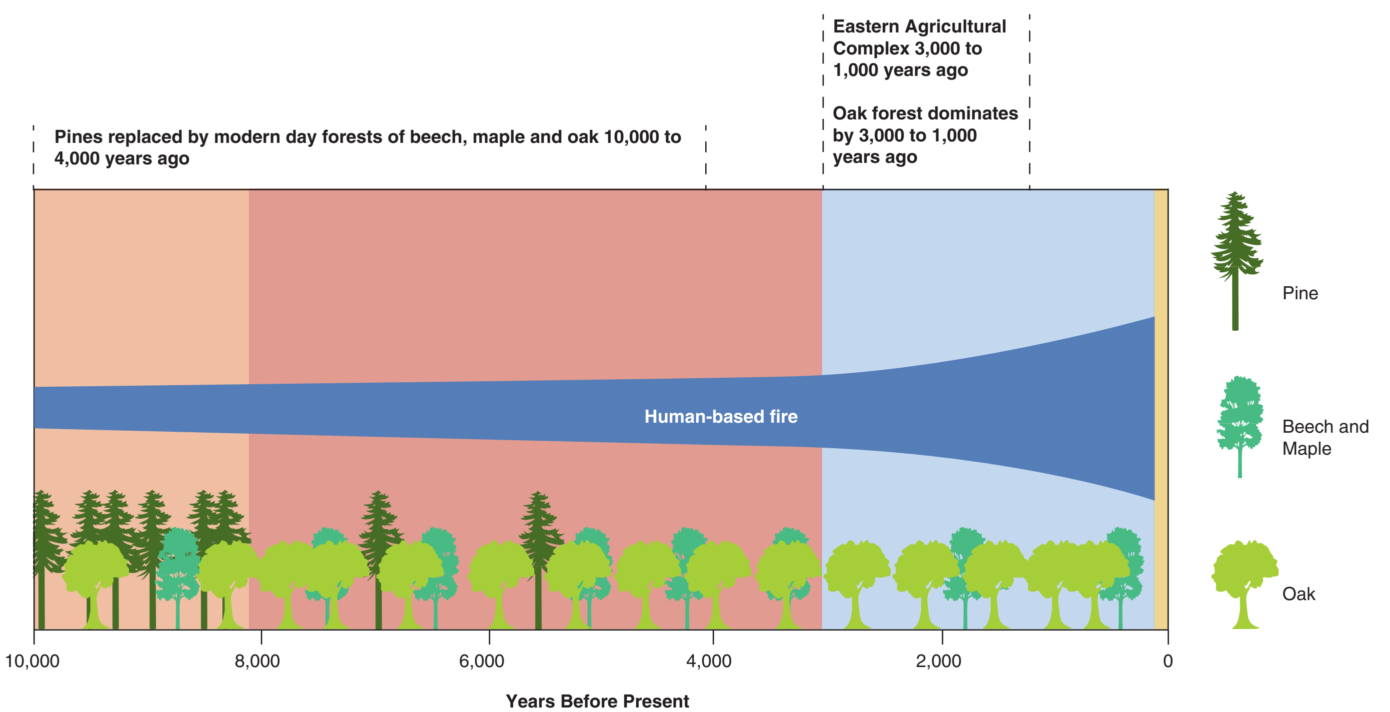


Figure 7.—Major forest types in southeastern Ohio (based on Shane et al. 2001) and vegetation drivers for southeastern Ohio (Abrams and Nowacki 2015, Patton and Curran 2016). See Figure 6 for color designations.

its persistence during Neoglacial Cooling (3,300 years BP onward) is anomalous and begs for an additional explanatory factor (Abrams and Nowacki 2015). That factor is most likely fire, as oak and associated plant species are highly adapted to fire (Abrams 1992, 1996; Brose and Van Lear 2004; Hart and Buchanan 2012; Lorimer and White 2003; Varner et al. 2016) (Fig. 8). Most pre-European fires occurred during the dormant "non-lightning" season (at least in the southern Appalachians, where the most data are available), have limited relations to drought, and vary in frequency over cultural time periods. For these reasons, ignitions were most likely human-caused, generally increasing over time with human population growth (Abrams and Nowacki 2008; Brose et al. 2013; Guyette et al. 2003, 2006; Nowacki and Abrams 2008; Stambaugh et al. 2018) (Figs. 7 and 8). Upon Euro-American settlement (ca. 1800), oaks continued to be the most dominant tree species across the Southern Unglaciated Allegheny Plateau (Dyer 2001, Gordon 1969, Sears 1925). Major, multiyear droughts in the 16th and 17th centuries may have reinforced oak's dominance in the region, as recorded in the Public Land Survey record (Dyer and Hutchinson 2019).

Fire regimes intensified with Euro-American settlement of the Allegheny Plateau, causing an east-to-west "wave of fire" to roll over the landscape (Brose et al. 2013, Stambaugh et al. 2018). Most of today's forests in this region regenerated either during this period of intense cutting and burning dating to the late 1800s and early 1900s, or thereafter, as farms and mines were abandoned (Brose et al. 2013, Gordon 1969, Hutchinson et al. 2008, McEwan et al. 2007). Oaks and light-seeded tree species (e.g., maples, yellow-poplar, black cherry, bigtooth aspen, ash) flourished under this disturbance regime, with oaks maintaining their dominance on cutover woodlots through vigorous stump sprouting and light-seeded species recolonizing abandoned fields and pastures (Dyer and Hutchinson 2019). However, with 20th-century fire suppression, a changing climate, and natural forest succession processes, understories now principally consist of fire-sensitive, shade-tolerant trees due, in part, to mesophication (Hutchinson et al. 2008, Nowacki and Abrams 2008, Palus et al. 2018). The degree of mesophication is contingent on site conditions. Mesophyte invasion is most aggressive and enduring on mesic, lower slope positions, and is more subdued on xeric, south-facing upper slopes and ridges (Iverson et al. 2017, 2018).

As discussed, because of glacial, climatic, and human influences, the Ohio portion of the region was almost entirely wooded before Euro-American settlement (ca. 1800); oaks and hickories were dominant (Gordon 1969). White oak was particularly abundant, accounting for more than 30 percent of survey witness trees (Dyer 2001). After Euro-American settlement, most forests were either cleared for agriculture or cut over for industrial uses (e.g., charcoal iron production, railroads) or mining (Table 5). Surface and underground mining for coal has affected more than 568,000 acres in Ohio (Lorenz and Lal 2007). Much of that land remains unreclaimed; there were an estimated 135,650 individual locations of unreclaimed abandoned mines as of 2011 (Mishra et al. 2012). Other mined land was excessively compacted during reclamation, preventing adequate tree establishment. The rate of forest loss was especially rapid from 1850 to 1880, when most of the counties in the study area went from being more than 60 percent forested to less than 35 percent forested (Leue 1886, Trautman 1977). With agricultural abandonment and the decline of industrial exploitation of forests in the first several decades of the 1900s, forest cover has returned to ca. 1850 levels in most counties. Unlike some other areas in the central Appalachians, such as Pennsylvania (Stout et al. 2013), deer browsing pressure in southeastern Ohio is relatively low and does not appear to have a major impact on tree regeneration outcomes (Apsley and McCarthy 2004).

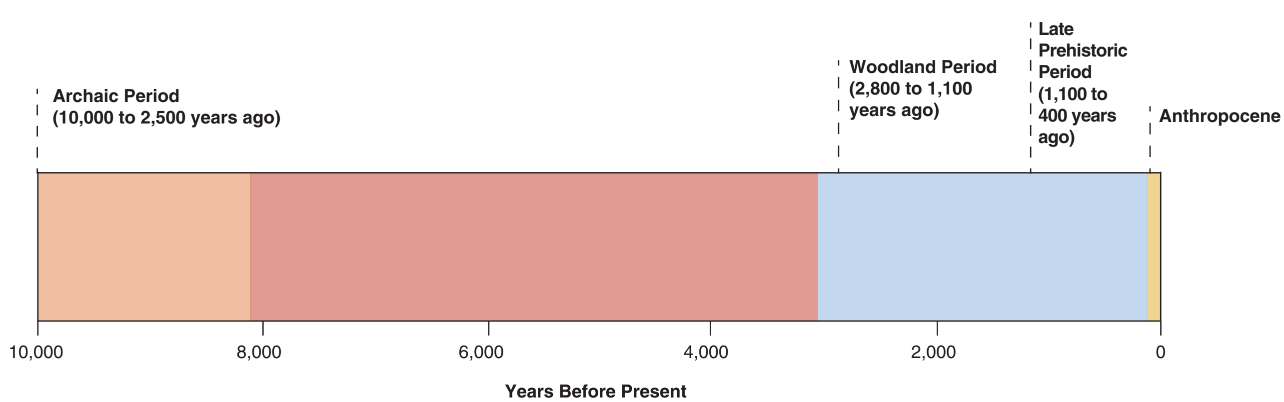


Figure 8.—Timeline of Ohio archaeological periods (Lepper 2005). See Figure 6 for color designations.

Table 5.—Historical and major disturbance events in Ohio since the 16th century

1550–1640: Indigenous peoples depopulated due to pandemic.
1788: Euro-American settlement begins; Ohio 95 percent wooded.
1803: Ohio becomes a state.
1820s: Coal mining begins in Ohio.
1830–1900: Charcoal produced within Hanging Rock Iron Region.
1886: Ohio's coal production peaks.
1900s: Oil and natural gas begin to replace coal in Ohio.
1916: Ohio State Forest System established.
1923: Active fire suppression begins (Fire Control District established in southern Ohio).
1930s: Chestnut blight enters Ohio (see Figure 2 in Anagnostakis [1987]).
1933–1942: Millions of trees planted in Ohio by the Civilian Conservation Corps.
1938: Annual acreage burned by wildfires greatly reduced.
Present day: Nonnative invasive species make up 25 percent of Ohio's plants (3,000 species documented); wildfires no longer a consequential disturbance.

3.1.1 Fire History of Appalachian Ohio

To what extent did Native American burning influence the development of the oak-dominated landscape that was present in Appalachian Ohio ca. 1800? Written observations by early traders and explorers in southern Ohio describe open habitats and landscape burning by the Shawnee and other historic tribes in some areas. Joseph Barker, noting conditions near Marietta, OH in 1790, observed: “The Indians, by burning the Woods every Year, kept down the undergrowth and made good pasture for the deer and good hunting for himself” (Barker 1958). However, quantifying the extent and frequency of pre-Euro-American settlement fire is difficult as few direct sources of scientific evidence (e.g., fire-scarred trees that predate 1800) have been found and examined.

Archaeological evidence unearthed from Archaic sites in Ohio suggest that fire was being used by aboriginal cultures as early as 8,000 years BP (Fig. 8) to propagate nut trees and reduce wildfire danger, among other purposes (Lepper 2005). Nut crops, especially acorns, became an important subsistence crop by 6,000 years ago. Climate change and fire influenced subsistence strategies and effected cultural change. Toward the end of the Archaic Period, the Hopewell peoples, who lived 2,000 years ago along the lower Scioto River, Paint Creek, Muskingum River, Licking River, Kanawha River, and Ohio River, emerged as one of North America’s most advanced aboriginal traditions. A suite of domesticated annual species common throughout Hopewell archaeological sites is now referred to as the “Eastern Agricultural Complex.” This transformation of local native plant species into domesticated food crops represents one of only four such achievements worldwide (Smith 1989). The County Home site (Patton and Curran 2016) in the Hocking Valley of southeastern Ohio provides information further documenting the emergence of plant domestication in the study area (Fig. 7).

Seeman and Dancy (2000), using palynological analysis from occupied Hopewell sites along the lower Scioto River and Kanawha River, conclude that these places have been in a state of constant disturbance for the last 2,200 years. The introduction of maize (*Zea mays*) agriculture marked the beginning of the Late Prehistoric Period 1,100 years ago and increased the scale of agriculture and use of fire as a tool. The addition of maize as a supplement to the aboriginal diet also increased the human population throughout the period until its peak in 1550. An assessment of 18 sites from the Prehistoric Period provides archaeological evidence of wild plant and animal remains that indicate more than 90 percent of plants were fire-dependent (D. Minney; The Nature Conservancy, retired; pers. comm.; Nov. 9, 2018). For oak-dominated ecosystems, an overall fire return interval of 5 to 15 years promotes nearly every aspect of subsistence resources: hard mast, soft mast, and game animal (D. Minney; pers. comm.; Nov. 9, 2018). The fire-maintained plant communities that supported aboriginal subsistence promoted game abundance, which further supported human subsistence (Abrams and Nowacki 2008). Palynological evidence from Patton Bog (Athens County) showed increased charcoal deposition rates throughout the Late Prehistoric Period, indicative of increasing fire frequency and extent burned (Abrams et al. 2014). The peoples of the Late Prehistoric Period were the last intact aboriginal culture before European contact (Table 5). They exerted an important effect on vegetation patterns in the study area until depopulation occurred from ca. 1550 to 1640.

There are more data showing that fire occurred regularly in southern Ohio after Euro-American settlement, particularly from the late 1800s to ca. 1930, as forests were regenerating in many areas after having been cleared for agriculture or cut over for industrial purposes (e.g., railroads, charcoal for iron production) (Hutchinson et al. 2008, McEwan et al. 2007). In the First Annual Report of the Ohio Forestry Bureau for the year 1885 (Leue 1886), the Reverend J.G. Hall, describing conditions in Nile Township (Scioto County), wrote: “Forest fires are the greatest enemies our forests have. They seem to come with fully as much regularity as drouth, and perhaps nearly as regularly as the seasons themselves. Forest fires also leave or make good pasturage, and it is suspected that cattle owners ‘fire the woods’ to secure the better pasture.” European settlers may have just adopted and continued Native American ways of burning. Hall also stated that in 1885, "forest-fires covered more than half the township this spring."

These and other written accounts suggest that the occurrence of fire in southern Ohio forests was common, at least in some areas, both before and after Euro-American settlement. However, to gain a better understanding of historical fire frequency, severity, and seasonality, quantitative fire history data are required. In our region, this information is best provided by dendrochronology studies of fire-scarred trees. Across the Appalachian Region, there have been a number of such studies in the last 15 years, which are reviewed in Lafon et al. (2017). Fires in this collection of studies were historically frequent prior to the fire suppression era, which started in the 1930s; mean fire return intervals (MFIs) were usually between 3 and 10 years. This was also the case for sites with deeper chronologies that included fire scars formed in the pre-Euro-American settlement era (ca. 1600s and 1700s). These Appalachian fire history studies, though not from our 17-county area, also show that the great majority of fires occurred in the dormant season (between annual rings, roughly October to April). These fires were largely human-caused as lightning is uncommon during the dormant season. Further, because many of the fire-scarred trees in these studies survived multiple fires, even in the xeric pine-dominated stands in the southern Appalachians, the authors conclude that fires were mostly low to moderate severity (Lafon et al. 2017).

A recent study in central Pennsylvania provides further evidence of long-term (350+ year) fire regimes in the Appalachians (Stambaugh et al. 2018). The authors dated and analyzed fire scars formed in living and dead pines at 12 sites. Similar to the findings of Lafon et al. (2017), low to moderate intensity dormant season fires occurred frequently until the fire suppression era. Although fires occurred regularly at most sites before Euro-American settlement, with MFIs ranging from 6 to 18 years, the authors also described an increased frequency of fire, a "wave of fire" at all sites that coincided with this settlement. During this era, MFIs were reduced to 3 to 7 years, until fire suppression policies went into effect in the early 20th century.

In southern Ohio, several studies have used fire scars formed in oaks in second-growth forests to quantify fire histories dating back to the late 1800s (Hutchinson et al. 2008, McEwan et al. 2007, Sutherland 1997). These studies, which cover 13 sites, show that low severity dormant season fires occurred frequently from ca. 1875 to 1930, with MFIs typically 5 to 10 years. In addition, Hutchinson et al. (2008) showed that the establishment and persistence of maples (red

Rolling Bottomlands Mixed Hardwood forest in southeastern Ohio. Photo by USDA Forest Service, Northern Research Station.

and sugar) began when fires ceased. Finally, using fire scar data, Guyette et al. (2012) modeled mean MFIs for 1650 to 1850 for the continental United States; for the Ohio portions of the subsections, the mean period between fires ranged from about 7 years to 14 years.

Throughout the Appalachians, old-growth forests are rare, so most of the fire history study sites that have fire scars dating back to the 1600s and 1700s are sites where yellow pines (e.g., pitch pine, shortleaf pine, Table Mountain pine [*Pinus pungens*]) are currently or were formerly a sizable component of the forest. These yellow pines are much better fire-scar recorders than hardwoods because fire scars are preserved with resin and stumps are durable (less prone to rot) and known for their longevity. By cross-dating techniques, pine stumps, snags, and logs that have been dead for many years can be used in fire history studies. Although witness trees indicate that yellow pines were not historically abundant (<2 percent of trees) in southern Ohio (Dyer 2001), there were areas where oak-pine stands were somewhat common (e.g., Jones 1945). Ongoing fire history research at a site in Shawnee State Forest (Scioto County) is using live and dead yellow pines to document a longer-term fire record for this area (Hutchinson et al., in press). At this 1-km^2 (250-acre) site, 34 fires were recorded from 1796 to 1941, and the MFI was 4.4 years. In the preindustrial period (before 1850), the MFI was 8.4 years and only 9 percent of trees were scarred in each fire. In the industrial period (1850–1930), fires became more frequent (MFI = 2.7 years) and a greater percentage of trees were scarred per fire (23 percent), suggesting greater fire intensity. After nearly 140 years of moderate to high frequency fire (ca. 1796–1930), only one fire, in 1941, was recorded in the fire suppression (post-1930) period.

In 1923, fire control began in southern Ohio. Fire towers were erected in the 1920s and 1930s, and detailed statistics were kept to record the number of fires and area burned in the Fire Control District (Leete 1938). Soon after fire control policies were implemented in southern Ohio's Forest Fire

District in 1923, the acreage burned annually was greatly reduced (Leete 1938). Although wildfires, nearly all caused by people, have continued to occur throughout the suppression era, effective control has resulted in a landscape where fire has been essentially absent from most forest stands for more than 80 years.

3.1.2 Current Climatic and Edaphic Conditions

The unglaciated plateau in Section 221E abuts the west side of the Appalachians, roughly corresponding to the Kanawha section of the Appalachian Plateaus province (Fenneman 1928). Elevations are highest in the northeast (2,500 feet above sea level [asl]) and grade to lowest elevations in the southwest (500 feet asl) (Fig. 9). The surface is highly dissected due to long-term erosional processes. Relief is greatest in the plateau's southeastern quadrant (principally West Virginia), and generally decreases to the north and west (Figs. 10 and 11). The plateau has a hot continental climate characterized by hot summers and cool winters (Bailey 2014). The average annual temperature ranges from 44 °F in the northeast to 56 °F in the southeast (Fig. 12). Growing season temperatures (May to September) range from 60 °F to 71 °F along the same gradient. Annual precipitation, ranging from 37 to 55 inches, corresponds to elevation and increases at higher elevations (Fig. 13). Growing season precipitation also follows the elevational gradient, increasing with elevation from 18 inches to 26 inches. The annual moisture index (Koch et al. 2013), or the ratio of annual precipitation to potential evapotranspiration scaled from -1 to 1, shows a similar pattern of higher values at higher elevations (Fig. 14); this trend is more pronounced during the growing season, which is the more important timeframe from a biological standpoint.

Soils largely reflect the weathering of the underlying bedrock, varying from coarser (sandier) soils residing on sandstones and finer (clay-enriched) soils on shales (Figs. 15 and 16); silt is rather uniform throughout the section (Fig. 17). Soil permeability also follows soil texture, with higher permeability on sandier soils and low permeability on clayey soils. Similarly, soil pH varies with substrate. Higher pHs are associated with calcareous rocks, and lower pHs occur in soils derived from sandstones (Fig. 18).

A

B

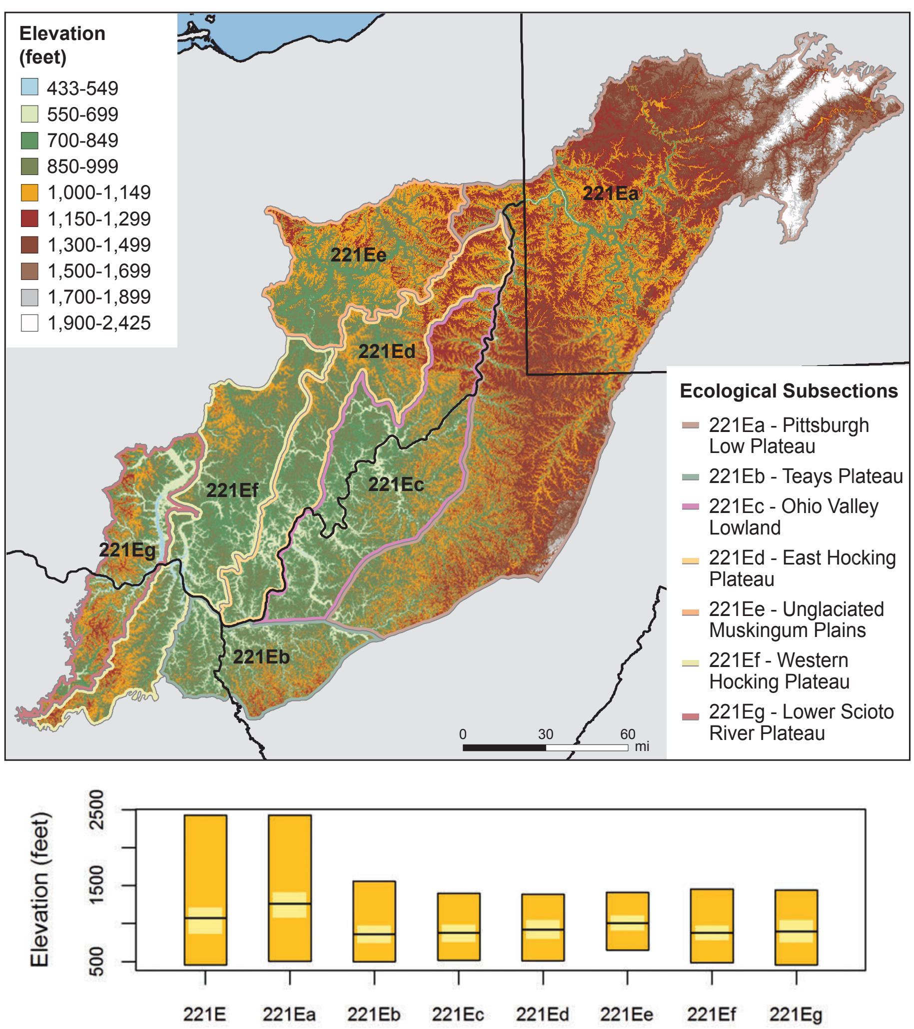
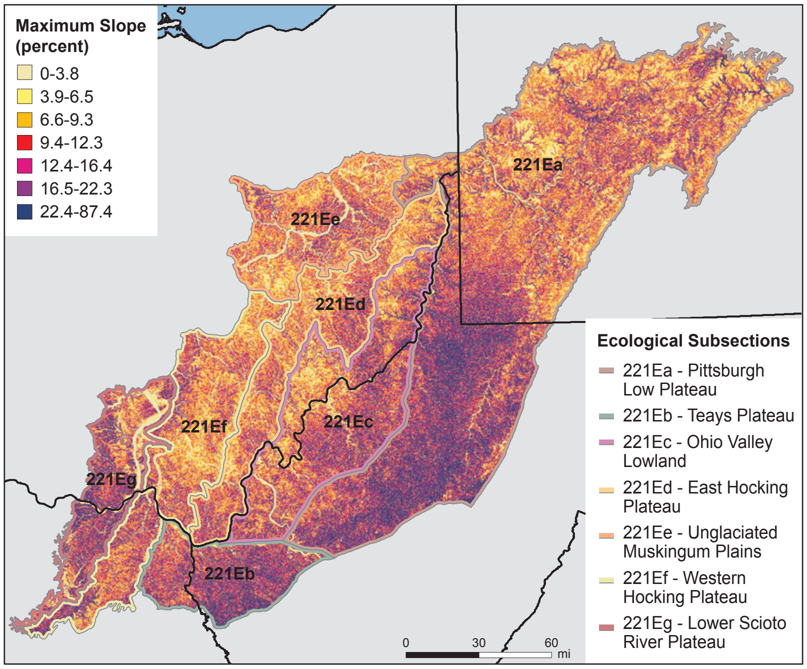


Figure 9.—(A) Elevation of Section 221E and ecological subsections (Source: Farr et al. 2007). (B) Chart showing mean elevations as bold lines; 50 percent of data fall within the lighter color, and full minimum and maximum values occur within the darker color of bars.

A



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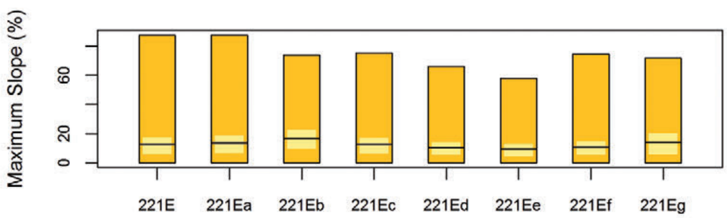
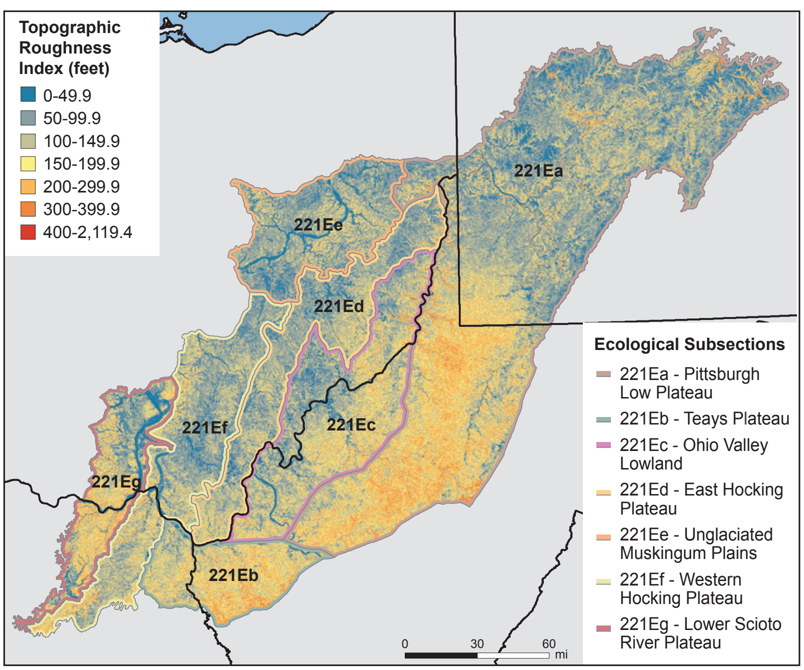


Figure 10.—(A) Maximum percent slope of Section 221E and ecological subsections, according to Shuttle Radar Topography Mission (3 arc-second) data. (B) Chart showing mean percent slopes as bold lines; 50 percent of data fall within the lighter color, and full minimum and maximum values occur within the darker color of bars.

A



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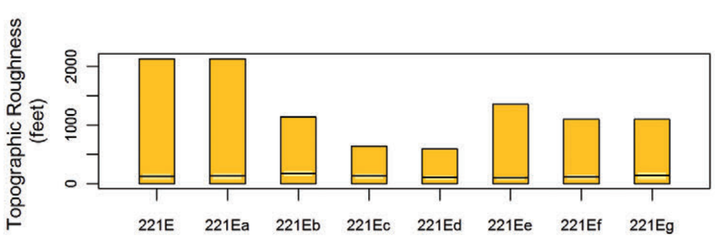
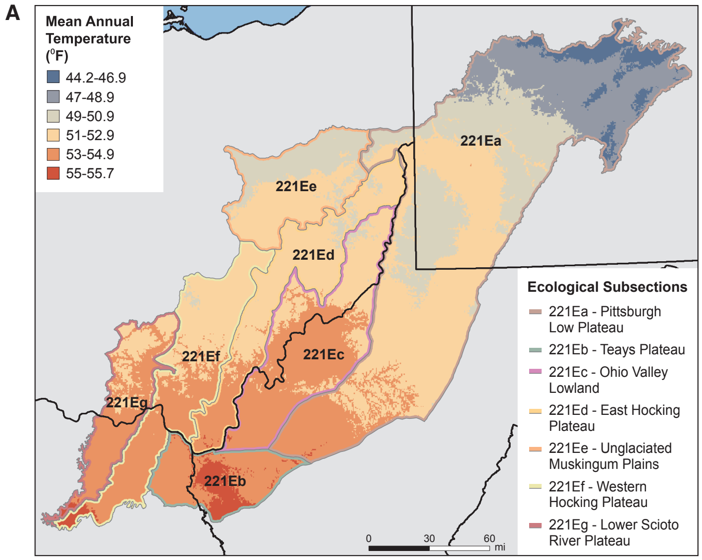


Figure 11.—(A) Topographic roughness index (Riley et al. 1999) for Section 221E and ecological subsections, according to Shuttle Radar Topography Mission (3 arc-second) data. (B) Chart showing mean topographic roughness indices as bold lines; 50 percent of data fall within the lighter color, and full minimum and maximum values occur within the darker color of bars.



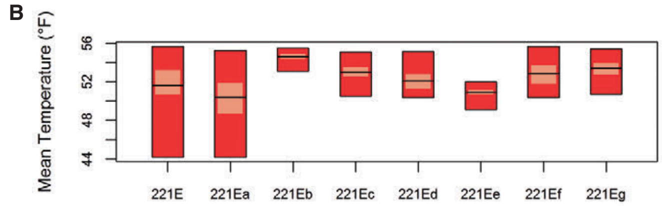
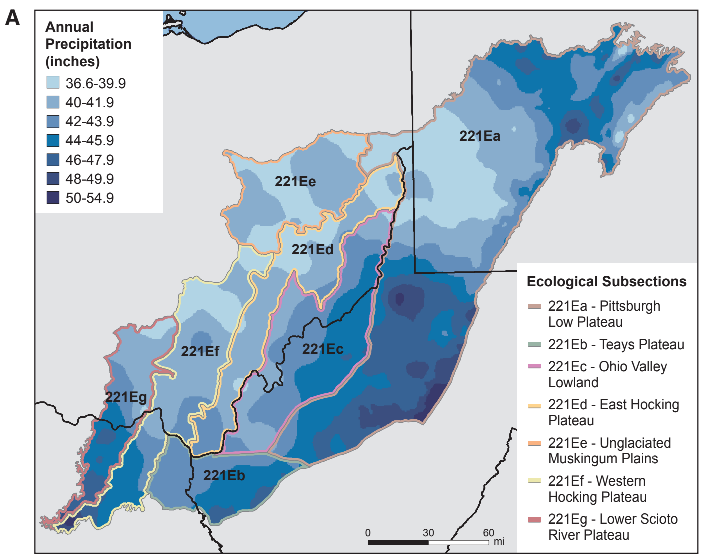


Figure 12.—(A) Mean annual temperature for Section 221E and ecological subsections. (B) Chart showing mean annual temperatures as bold lines; 50 percent of data fall within the lighter color, and full minimum and maximum values occur within the darker color of bars.



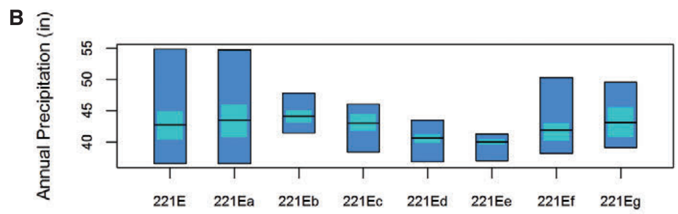
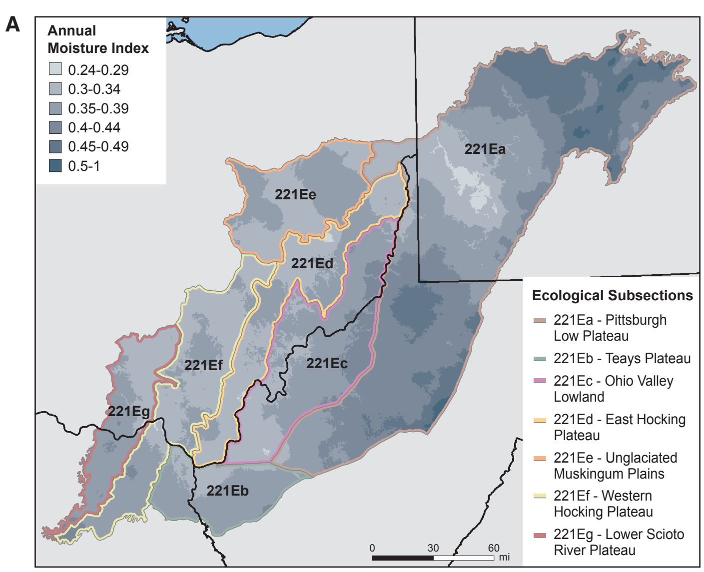


Figure 13.—(A) Annual precipitation for Section 221E and ecological subsections. (B) Chart showing annual precipitation as bold lines; 50 percent of data fall within the lighter color, and full minimum and maximum values occur within the darker color of bars.



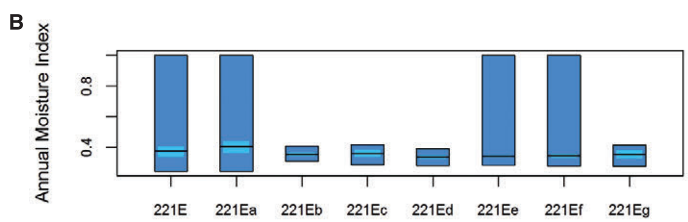
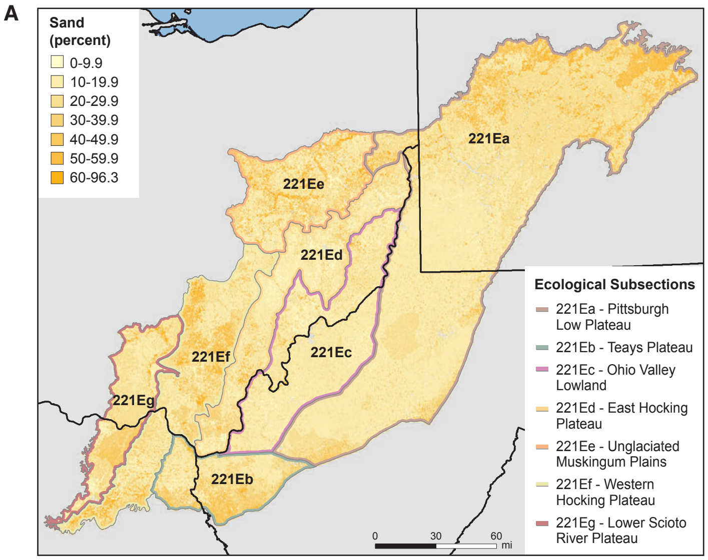


Figure 14.—(A) Annual moisture index (conditional ratio of precipitation to potential evapotranspiration; Koch et al. 2013) for Section 221E. (B) Chart showing mean annual moisture indices as bold lines; 50 percent of data fall within the lighter color, and full minimum and maximum values occur within the darker color of bars.



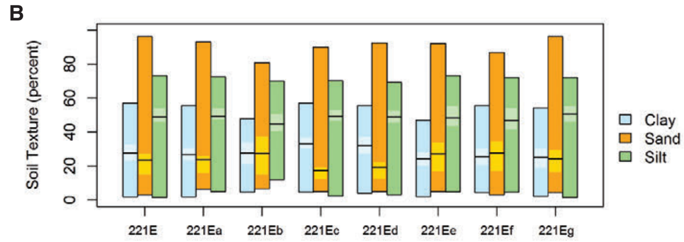


Figure 15.—(A) Percent sand for Section 221E and ecological subsections. (B) Percent clay, sand, and silt by section and subsection. Means are shown as bold lines, 50 percent of data fall within the lighter color, and full minimum and maximum values occur within the darker color of bars.

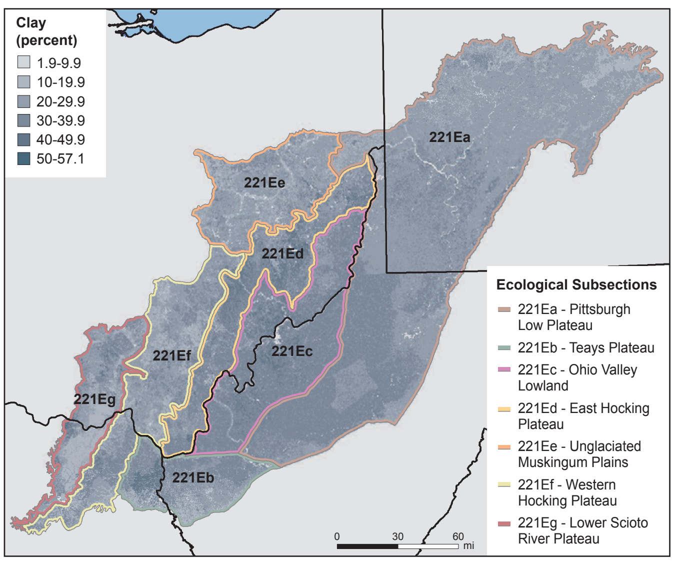


Figure 16.—Percent clay for Section 221E and ecological subsections.

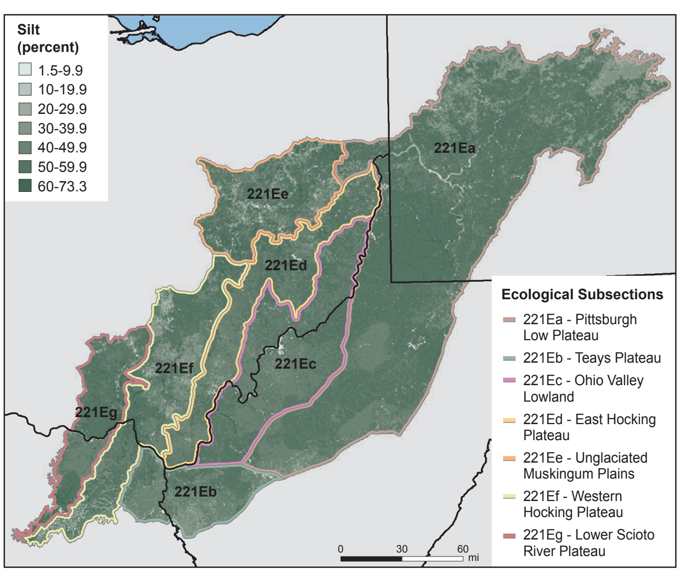


Figure 17.—Percent silt for Section 221E and ecological subsections.

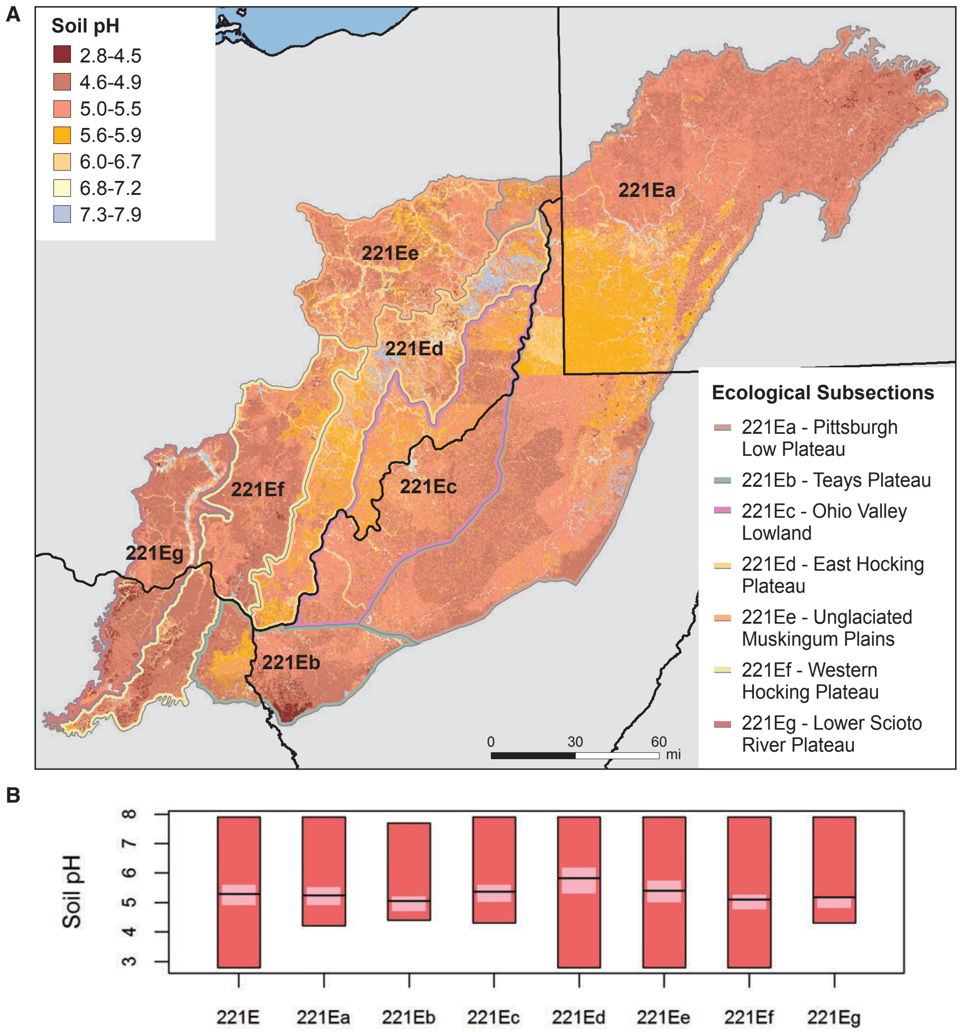


Figure 18.—(A) Soil pH for Section 221E and ecological subsections. (B) Chart showing mean soil pH as bold lines; 50 percent of data fall within the lighter color, and full minimum and maximum values occur within the darker color of bars.

3.1.3 Present-Day Vegetation

The vegetation today generally reflects land use, with more level and productive surfaces in agriculture and more rugged and less productive lands as forests (Fig. 19, Table 6). Forest overstories are still largely oak dominated, as they were before Euro-American settlement. Oak dominance is primarily the result of major Euro-American land disturbances (cutting and fire), along with multiple interacting factors such as earlier punctuated and episodic climatic events, and drier conditions during oak establishment and early growth compared to the recent past (McEwan et al. 2011).

Dry Oak forest in southeastern Ohio. Photo by USDA Forest Service, Northern Research Station.

However, because landscape-level burning is no longer much of a factor, and moisture levels have been generally increasing in recent decades (Hayhoe et al. 2018), forests are rapidly undergoing mesophication; shade-tolerant, fire-sensitive trees are increasing greatly (Hutchinson et al. 2008, Iverson et al. 2017, Nowacki and Abrams 2008, Palus et al. 2018). This transition is only accelerated by tree harvest, which effectively releases the mesophytic understory (Abrams and Nowacki 1992). Nonetheless, biological diversity is high among trees for Section 221E as 90 species are currently recorded by FIA (Table 7).

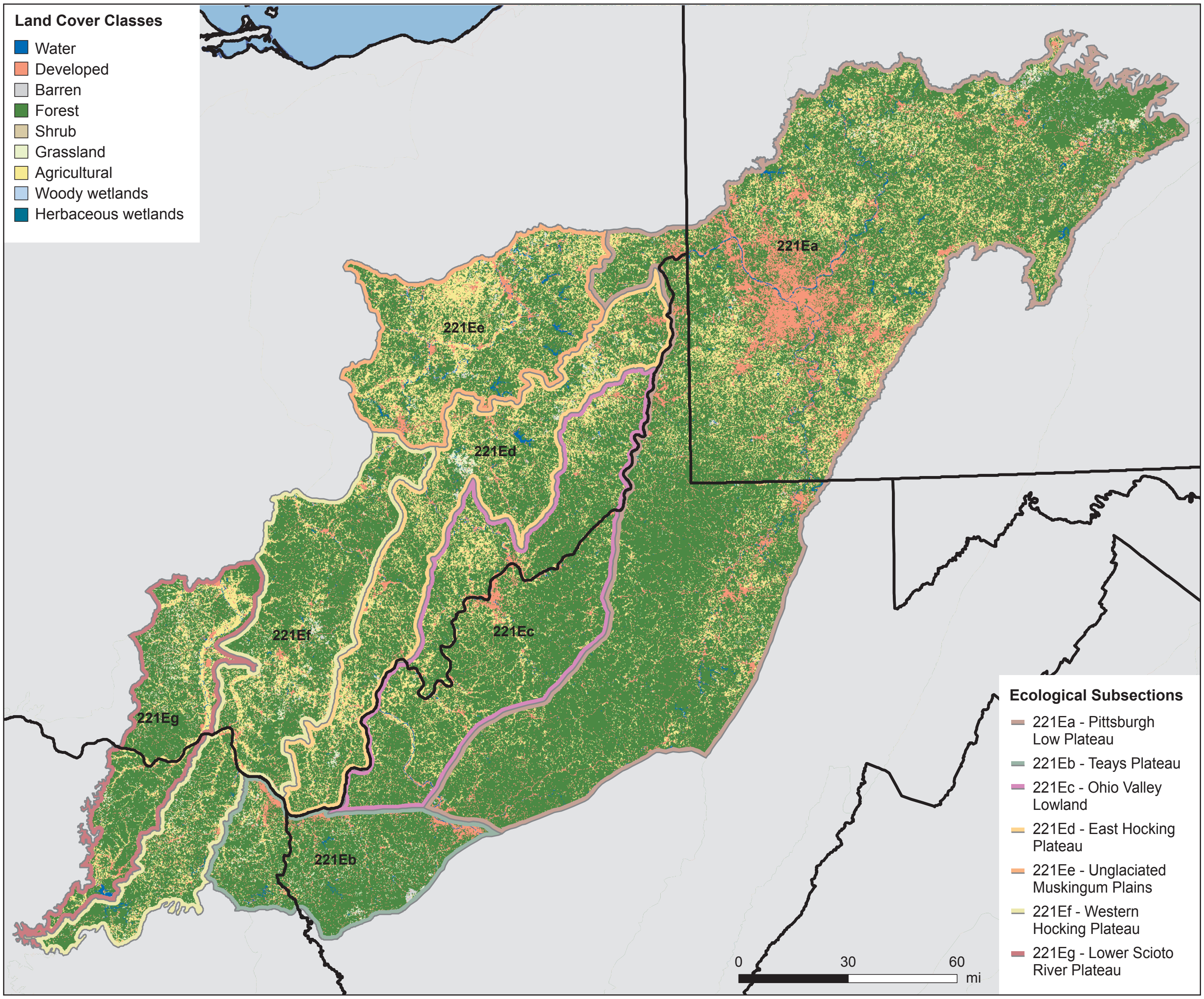


Figure 19.—Current (2011) land cover classes for Section 221E and ecological subsections.

Table 6.—Percentage of land cover in each ecological subsection of Section 221E

Land cover	Subsection 221Ea	221Eb	221Ec	221Ed	221Ee	221Ef	221Eg
	percent						
Water	0.9	1.2	1.6	1.0	1.6	0.7	1.3
Developed	12.7	12.1	8.8	8.6	9.0	7.2	6.3
Barren	0.5	0.7	0.1	0.6	0.4	0.3	0.1
Forest	68.6	75.5	71.7	63.4	55.2	71.6	68.4
Shrub	0.3	0.2	0.2	0.5	0.1	1.0	2.5
Grassland	1.3	5.2	1.1	3.2	1.6	3.8	4.2
Agricultural	15.5	5.2	16.5	22.7	31.5	15.3	17.2
Woody wetlands	0.1	0.0	0.0	0.1	0.4	0.0	0.0
Herbaceous wetlands	0.0	0.0	0.0	0.0	0.1	0.0	0.0

Table 7.—Tree species and summed importance percentages* for each ecological subsection in Section 221E

Scientific name	Subsection							Common name
	221Ea	221Eb	221Ec	221Ed	221Ee	221Ef	221Eg	
Acer negundo	1.079	1.132	0.881	1.305	0.617	0.254	0.072	boxelder
Acer nigrum	0.206	0.000	0.096	0.361	0.219	0.166	0.000	black maple
Acer pensylvanicum	0.060	0.000	0.000	0.005	0.013	0.000	0.000	striped maple
Acer rubrum	16.174	9.373	8.961	7.270	17.488	12.332	10.208	red maple
Acer saccharinum	0.080	0.361	0.211	0.432	1.731	0.540	0.402	silver maple
Acer saccharum	7.709	4.870	10.248	10.099	3.766	6.001	12.938	sugar maple
Acer spicatum	0.004	0.000	0.000	0.000	0.000	0.000	0.000	mountain maple
Aesculus glabra	0.025	0.032	0.341	0.357	0.000	0.063	0.140	Ohio buckeye
Aesculus octandra	0.333	1.476	2.056	1.282	0.069	0.628	0.000	yellow buckeye
Amelanchier spp.	0.269	0.146	0.037	0.254	0.053	0.112	0.308	serviceberry
Asimina triloba	0.089	0.097	0.507	0.379	0.004	0.197	0.901	pawpaw
Betula alleghaniensis	0.306	0.000	0.000	0.009	0.008	0.002	0.004	yellow birch
Betula lenta	2.202	0.448	0.140	0.000	0.023	0.480	0.420	sweet birch
Betula nigra	0.004	0.046	<0.001	0.313	0.223	0.591	0.086	river birch
Betula papyrifera	0.010	0.000	0.000	0.000	0.000	0.000	0.000	paper birch
Betula populifolia	0.011	0.000	0.000	0.000	0.000	0.000	0.000	gray birch
Carpinus caroliniana	0.527	0.407	0.254	0.225	0.237	0.534	0.257	American hornbeam; musclewood
Carya cordiformis	0.582	0.306	0.880	1.242	1.363	0.710	0.769	bitternut hickory
Carya glabra	1.629	4.934	2.425	1.300	0.457	2.414	3.549	pignut hickory
Carya laciniosa	0.001	0.147	0.030	0.179	0.046	0.129	0.117	shellbark hickory
Carya ovata	1.342	1.559	2.135	2.511	1.626	1.917	2.132	shagbark hickory
Carya tomentosa	1.433	3.752	2.854	1.381	0.605	2.224	2.266	mockernut hickory
Castanea dentata	0.010	0.042	0.001	0.000	0.000	0.001	0.000	American chestnut
Catalpa speciosa	0.000	0.000	<0.001	0.011	0.000	0.000	0.000	northern catalpa
Celtis laevigata	0.000	0.027	0.000	0.000	0.000	0.000	0.000	sugarberry
Celtis occidentalis	0.202	0.163	0.114	0.287	0.046	0.109	0.572	hackberry
Cercis canadensis	0.156	1.583	0.450	0.593	0.060	0.447	0.640	eastern redbud
Cornus florida	0.315	1.642	0.525	0.871	1.776	2.026	0.478	flowering dogwood
Diospyros virginiana	0.059	0.349	0.234	0.097	2.402	0.143	0.047	common persimmon
Fagus grandifolia	2.796	5.718	2.629	1.942	0.000	2.585	1.777	American beech
Fraxinus americana	4.983	3.101	4.782	5.735	3.340	2.078	1.977	white ash
Fraxinus nigra	0.020	0.000	0.000	0.000	0.019	0.006	0.000	black ash
Fraxinus pennsylvanica	0.092	0.202	0.328	1.135	1.968	0.469	1.228	green ash
Fraxinus quadrangulata	0.015	0.048	0.017	0.289	0.286	0.000	0.000	blue ash
Gleditsia triacanthos	0.000	0.000	0.000	0.000	0.000	0.060	0.081	honeylocust
Ilex opaca	0.003	0.007	0.000	0.000	0.000	0.000	0.000	American holly
Juglans cinerea	0.027	0.031	0.007	0.081	0.040	0.055	0.000	butternut
Juglans nigra	1.474	0.855	1.992	2.983	1.463	1.100	1.392	black walnut
Juniperus virginiana	0.056	0.150	0.132	0.092	0.000	0.149	1.298	eastern red cedar
Liquidambar styraciflua	0.007	0.002	0.000	0.000	0.148	0.203	0.425	sweetgum
Liriodendron tulipifera	5.519	9.065	6.694	6.176	7.407	12.132	8.515	yellow-poplar
Maclura pomifera	0.184	0.000	0.226	0.873	0.130	0.023	0.000	Osage-orange
Magnolia acuminata	0.499	0.736	0.054	0.044	0.271	0.051	0.015	cucumbertree
Morus rubra	0.021	0.000	0.007	0.056	0.000	0.061	0.051	red mulberry
Nyssa sylvatica	1.054	2.808	1.271	0.514	2.437	2.590	2.208	blackgum
Ostrya virginiana	0.432	0.212	0.379	0.361	1.104	0.284	0.056	eastern hophornbeam; ironwood
Oxydendrum arboreum	0.411	1.974	0.714	0.085	0.000	2.281	1.916	sourwood
Picea glauca	0.035	0.000	0.000	0.000	0.000	0.000	0.000	white spruce
Picea rubens	0.000	0.000	0.000	0.000	0.000	0.010	0.000	red spruce

(Table 7 continued on next page.)

(Table 7 continued)

Scientific name	Subsection							Common name
	221Ea	221Eb	221Ec	221Ed	221Ee	221Ef	221Eg	
Pinus banksiana	0.017	0.000	0.000	0.000	0.000	0.000	0.000	jack pine
Pinus echinata	0.006	0.577	0.021	0.000	0.000	0.240	0.411	shortleaf pine
Pinus resinosa	0.247	0.000	0.003	0.324	0.195	0.336	0.115	red pine
Pinus rigida	0.145	0.584	0.212	0.406	0.099	0.664	0.191	pitch pine
Pinus strobus	1.367	0.021	1.659	2.153	1.825	1.065	0.894	eastern white pine
Pinus taeda	<0.001	0.001	0.828	0.010	0.000	0.127	0.000	loblolly pine
Pinus virginiana	0.326	4.490	5.432	1.105	0.000	3.430	1.474	Virginia pine
Platanus occidentalis	0.846	1.250	1.070	0.995	2.182	0.925	0.809	sycamore
Populus balsamifera	0.011	0.000	0.000	0.000	0.000	0.000	0.000	balsam poplar
Populus deltoides	0.029	0.000	0.005	0.398	1.013	0.018	0.132	eastern cottonwood
Populus grandidentata	1.766	0.127	0.643	1.112	3.397	1.796	0.250	bigtooth aspen
Populus tremuloides	0.769	0.000	0.001	0.120	0.008	0.008	0.000	quaking aspen
Prunus americana	0.011	0.000	0.000	0.498	0.000	0.000	0.000	wild plum
Prunus pensylvanica	0.197	0.000	0.000	0.020	0.045	0.000	0.000	pin cherry
Prunus serotina	14.442	1.190	4.009	8.438	12.885	2.646	2.423	black cherry
Prunus virginiana	0.132	0.006	0.008	0.020	0.036	0.023	0.013	chokecherry
Quercus alba	4.682	12.474	10.082	4.728	3.317	7.970	8.363	white oak
Quercus bicolor	0.026	0.000	0.010	0.000	0.096	0.000	0.000	swamp white oak
Quercus coccinea	0.831	2.481	1.255	0.245	0.271	2.495	3.232	scarlet oak
Quercus falcata var. *falcata*	0.000	0.060	0.015	0.000	0.002	0.011	0.017	southern red oak
Quercus imbricaria	0.338	0.010	0.017	0.186	0.454	0.148	0.528	shingle oak
Quercus lyrata	<0.001	0.000	0.000	0.000	0.000	0.000	0.000	overcup oak
Quercus macrocarpa	0.000	0.000	0.000	0.005	0.000	0.000	0.000	bur oak
Quercus marilandica	0.000	0.006	0.000	0.038	0.005	0.000	0.000	blackjack oak
Quercus michauxii	0.003	0.000	0.001	0.000	0.000	0.000	0.000	swamp chestnut oak
Quercus muehlenbergii	0.014	0.062	0.038	0.132	0.000	0.087	0.422	chinkapin oak
Quercus palustris	0.024	0.000	0.002	0.128	0.186	0.007	0.053	pin oak
Quercus prinus	2.141	6.140	3.080	0.759	0.807	5.064	9.910	chestnut oak
Quercus rubra	4.171	2.475	3.448	1.560	2.654	2.513	2.129	northern red oak
Quercus shumardii	0.000	0.000	0.000	0.000	0.000	<0.001	0.013	Shumard oak
Quercus stellata	0.010	0.440	0.494	0.080	0.000	0.090	0.212	post oak
Quercus velutina	2.279	4.247	3.439	1.852	2.305	3.687	2.957	black oak
Robinia pseudoacacia	3.286	1.305	2.963	7.279	3.385	2.009	2.189	black locust
Salix nigra	0.037	<0.001	0.075	0.010	0.621	0.183	0.000	black willow
Sassafras albidum	2.178	2.225	2.452	3.986	3.331	3.464	2.895	sassafras
Tilia americana	0.712	0.287	0.406	0.448	0.528	0.214	0.763	American basswood
Tsuga canadensis	1.873	0.101	0.089	0.000	0.042	1.010	0.150	eastern hemlock
Ulmus alata	0.022	0.000	0.000	0.052	0.000	0.000	0.000	winged elm
Ulmus americana	2.750	0.693	3.250	8.382	6.222	1.847	1.136	American elm
Ulmus rubra	1.871	0.945	2.384	3.359	2.633	1.768	1.077	slippery elm
Ulmus thomasii	0.000	0.000	0.000	0.044	0.009	0.000	0.000	rock elm
Total number of species	81	62	68	69	62	70	60	

*The values represent relativized (within subsection) sum of the importance value (IV, based equally on number of stems and basal area) for the species across all pixels in the subsections; this sum of IV reflects both the abundance where it occurs and the areal coverage that it occupies according to the Forest Service's Forest Inventory and Analysis plot data. Colors represent abundance: common species (green, importance percentage >2), occasional species (yellow, importance percentage 0.2–2.0), and rare species (red, importance percentage >0 and <0.2). Species absent from the subsection are represented by gray.

3.2 SUBSECTION DESCRIPTIONS

Subsections 221Ec, 221Ed, 221Ee, 221Ef, and 221Eg are briefly described in this portion of the report, based on data presented elsewhere. In some cases, data exist for the entire subsection (see maps and data presented for Section 221E in part 3.1); in other cases, data exist for only the 17-county portion of Section 221E occurring in Ohio (see the maps and data that follow these descriptions). In Appendix 4, we present some overall trends among the subsections within Ohio (and outside Ohio within the section as well when the data are available).

3.2.1 Subsection 221Ec – Ohio Valley Lowland

Subsection 221Ec spans the Ohio River, covering 2.6 million acres in portions of extreme southeastern Ohio and northwestern West Virginia. With 31 percent contained within Ohio, it lands squarely on Permian-Pennsylvanian stratigraphy (Fig. 4), namely the Dunkard Group, dating to around 300 million years ago and composed of sedimentary rocks of shale, sandstone, siltstone, and mudstone (Slucher et al. 2006). True to its name, this subsection encompasses lower elevations surrounding the Ohio River, averaging 876 feet, and contains the highest percentage (3.3 percent) of riverine wetlands of all the subsections (Table 8). The topography is fairly steep and rugged, consisting of a highly dissected terrain that drains to the Ohio River from north- and south-flowing streams in West Virginia and Ohio, respectively. The catchment collects fine-textured fluvial sediments, so soils tend to be heavier than in surrounding subsections, with high clay content (averaging 33 percent) and low sand content (17 percent). The rich, mesic tendencies of this subsection are reflected in the current dominance of mesophytic trees, namely sugar maple, white oak, red maple, and yellow-poplar (Table 7; Table 35 in Appendix 4). The current equity among tree species is in stark contrast to the pre-Euro-American settlement era. During that time, white oak was the sole dominant, making up 53 percent of witness trees, its greatest abundance across subsections (Table 9).

Within Ohio, 92 bird species currently reside in this subsection (Table 10). The yellow-billed cuckoo has a relatively high incidence here in comparison to other subsections. Several forest species, such as American redstart, hooded warbler, and black-and-white warbler, have experienced increases over the last 25 years, whereas species such as chimney swift and several common wood warblers (e.g., cerulean warbler, prairie warbler) sustained reductions. This subsection has the lowest deer population among Ohio subsections based on overall deer harvest (Table 11). Surface mining has affected 1.2 percent of the area of this subsection, with an estimated 0.9 percent of its area in reclaimed status and 0.2 percent in unreclaimed status (Table 12).

Table 8.—Topographic, climatic, edaphic, and wetland area data for each ecological subsection in Section 221E, with standard deviations in parentheses

	Subsection						
Characteristic (unit)	221Ea	221Eb	221Ec	221Ed	221Ee	221Ef	221Eg
Area (acres)	9,479,696	1,240,024	2,608,486	1,968,063	1,722,000	2,346,833	1,331,568
Elevation (feet)	1,257.8 (284.4)	861.6 (163.5)	875.9 (170.5)	921.7 (170)	1,001.8 (132.1)	875.5 (141.5)	894.6 (188.5)
Slope (%)	13.5 (9.3)	16.5 (9.5)	12.2 (8.0)	10.2 (6.5)	9.3 (6.3)	10.7 (7.2)	13.6 (9.7)
Topographic roughness index (feet)	131.9 (75.7)	170.2 (71.7)	127.4 (64.9)	103.8 (52.6)	93.3 (52)	113.3 (60.7)	134.2 (80.3)
Annual precipitation (inches)	43.5 (3.2)	44.1 (1.2)	43.0 (1.5)	40.6 (1.1)	40.0 (0.6)	41.9 (2.3)	43.1 (2.5)
Growing season precipitation (inches)	20.8 (1.3)	20.6 (0.7)	20.1 (0.6)	19.2 (0.5)	19.6 (0.5)	19.4 (0.9)	19.8 (1.2)
Annual temperature (°F)	50.4 (2.2)	54.6 (0.4)	53 (0.9)	52.1 (1.1)	50.9 (0.5)	52.9 (1.1)	53.4 (0.8)
Growing season temperature (°F)	66.3 (1.9)	70.0 (0.3)	68.8 (0.8)	68.0 (1.0)	67.2 (0.3)	68.8 (0.9)	69.3 (0.7)
Annual moisture index	0.40 (0.06)	0.35 (0.02)	0.36 (0.03)	0.33 (0.02)	0.34 (0.04)	0.34 (0.03)	0.35 (0.03)
Growing season moisture index	-0.01 (0.09)	-0.09 (0.03)	-0.09 (0.03)	-0.12 (0.02)	-0.09 (0.06)	-0.12 (0.04)	-0.12 (0.05)
Available water storage (inches/inch)	6.4 (2.3)	6.2 (2.3)	6.5 (2.6)	7.1 (2.8)	8.0 (3.3)	7.2 (2.7)	7.5 (3.1)
Clay (%)	26.9 (6.4)	27.8 (8.5)	33.2 (6.9)	32.0 (8.1)	24.4 (7.8)	25.5 (7.5)	25.1 (8.7)
Sand (%)	23.6 (12.9)	27.3 (15.4)	17.3 (9.8)	19.2 (11.6)	27.1 (17.9)	27.7 (16.3)	24.3 (12.4)
pH	5.2 (0.5)	5.0 (0.5)	5.3 (0.5)	5.8 (0.8)	5.4 (0.6)	5.1 (0.6)	5.2 (0.7)
NWI—lacustrine (%)*	0.25	0.34	0.09	0.41	1.84	0.50	0.79
NWI—palustrine (%)*	0.53	0.25	0.64	1.88	2.64	1.40	1.07
NWI—riverine (%)*	1.69	2.61	3.25	0.93	0.48	0.86	1.54

*NWI = National Wetlands Inventory (U.S. Fish and Wildlife Service 2017).

Table 9.—Abundance of witness tree taxa by ecological subsection of Section 221E

	Subsection			
	221Ec – Ohio Valley Lowland	221Ed – East Hocking Plateau	221Ef – Western Hocking Plateau	221Eg – Lower Scioto River Plateau[‡]
Total number of witness trees	1,459	3,012	3,462	311
Taxon*	---------- *Percentage of total, by taxon* ----------			
White oak	52.8	35.7	35.1	22.5
Hickory	7.7	14.2	14.1	18.0
"Black oak"[†]	13.6	10.6	13.4	11.3
Beech	4.1	10.8	9.5	5.8
Sugar maple	2.7	4.6	3.3	9.0
Red maple	1.4	4.6	3.5	1.0
Chestnut oak	4.3	3.0	3.3	4.2
Tulip-poplar	1.9	3.1	3.1	4.2
Blackgum	1.1	1.7	4.3	2.9
Ash	1.4	3.1	1.1	4.2
Elm	1.3	1.4	1.2	4.2
Silver maple	1.2	1.4	1.6	--
Pine	3.2	1.3	0.9	0.3
Chestnut	--	0.2	2.5	2.9
Buckeye	1.6	1.7	0.3	1.3
Sycamore	0.4	0.7	0.5	1.3
Butternut	0.1	0.6	0.5	0.6
Black walnut	0.3	0.6	0.3	1.0
Basswood	0.1	0.5	0.3	0.3
Locust	0.1	0.0	0.1	3.2
Oak-other	0.1	0.1	0.3	0.6
Black cherry	0.1	0.1	0.2	--
Sassafras	--	0.1	0.2	--
Mulberry	0.2	0.0	0.1	--
Aspen	0.1	--	0.1	--
Boxelder	0.3	--	0.0	--
Birch	--	0.0	0.1	--
Sourwood	--	--	0.1	--
Hackberry	--	--	--	0.6
Cottonwood	--	--	--	0.3
Willow	--	--	--	0.3

*Taxa listed in order of decreasing abundance within Section 221E; "--" indicates that sample size was too small (expected value <5).

[†]*Quercus velutina* and probably also *Q. rubra, Q. coccinea,* and other species of the red oak group.

[‡]Witness tree data are omitted from landtype descriptions for Subsection 221Eg due to small sample size.

Table 10.—Bird occurrences (0–1 scale) reported as incidence* or the proportion of Ohio Breeding Bird Atlas (OBBA2; Rodewald et al. 2016) blocks† where the species was recorded in Section 221E‡, and change in incidence since OBBA1 (Peterjohn and Rice 1991) for each ecological subsection

Occurrence	Common name	Scientific name	Code	Section 221E	Subsection 221Ea (n = 8)	Change in Subsection 221Ea	Subsection 221Ec (n = 34)	Change in Subsection 221Ec	Subsection 221Ed (n = 56)	Change in Subsection 221Ed	Subsection 221Ee (n = 53)	Change in Subsection 221Ee	Subsection 221Ef (n = 44)	Change in Subsection 221Ef	Subsection 221Eg (n = 22)	Change in Subsection 221Eg
Ubiquitous	Eastern bluebird	*Sialia sialis*	EABL	1	1	0	1	0	1	0.02	1	0	1	0	1	0.05
Ubiquitous	White-breasted nuthatch	*Sitta carolinensis*	WBNU	1	1	0	1	0.06	1	0.02	1	0	1	0.02	1	0
Ubiquitous	Tufted titmouse	*Baeolophus bicolor*	ETTI	1	1	0	1	0	1	0	1	0	1	0	1	0
Ubiquitous	American crow	*Corvus brachyrhynchos*	AMCR	1	1	0	1	0	1	0	1	0	1	0	1	0
Ubiquitous	Red-eyed vireo	*Vireo olivaceus*	REVI	1	1	0	1	0	1	0	1	0	1	0	1	0
Ubiquitous	White-eyed vireo	*Vireo griseus*	WEVI	1	1	0	1	0	1	0	1	0.02	1	0.02	1	0
Ubiquitous	Eastern phoebe	*Sayornis phoebe*	EAPH	1	1	0	1	0	1	0	1	0	1	0	1	0
Ubiquitous	Red-bellied woodpecker	*Melanerpes carolinus*	RBWO	1	1	0	1	0	1	0.02	1	0.02	1	0	1	0
Ubiquitous	Scarlet tanager	*Piranga olivacea*	SCTA	1	1	0	1	0	1	0	1	0	1	0	1	0
Ubiquitous	Wood thrush	*Hylocichla mustelina*	WOTH	1	1	0	1	0	1	0	1	0	1	0	1	0
Ubiquitous	Acadian flycatcher	*Empidonax virescens*	ACFL	1	1	0	1	0	1	0	1	0	1	0	1	0
Ubiquitous	Eastern wood-pewee	*Contopus virens*	EAWP	1	1	0	1	0	1	0	1	0	1	0	1	0
Ubiquitous	Turkey vulture	*Cathartes aura*	TUVU	0.999	1	0	0.97	0	1	0.02	1	0	1	0.02	1	0.05
Ubiquitous	Downy woodpecker	*Picoides pubescens*	DOWO	0.997	1	0	1	0	0.98	-0.02	1	0	1	0	1	0
Ubiquitous	Eastern towhee	*Pipilo erythrophthalmus*	EATO	0.995	1	0	1	0	1	0	0.98	-0.02	1	0	1	0
Ubiquitous	Northern flicker	*Colaptes auratus*	NOFL	0.995	1	0	1	0	1	0	0.98	-0.02	1	0.02	1	0.05
Ubiquitous	Brown-headed cowbird	*Molothrus ater*	BHCO	0.989	1	0.12	0.97	0	1	0	0.98	-0.02	1	0	1	0
Ubiquitous	Yellow-throated vireo	*Vireo flavifrons*	YTVI	0.988	0.88	0	1	0.03	1	0.02	1	0.02	1	0	1	0.05
Ubiquitous	Field sparrow	*Spizella pusilla*	FISP	0.986	1	0	0.97	-0.03	1	0	1	0	1	0	0.95	-0.05
Ubiquitous	Brown thrasher	*Toxostoma rufum*	BRTH	0.986	1	0	1	0.03	0.98	-0.02	0.96	-0.02	1	0	1	0.05
Ubiquitous	Yellow warbler	*Setophaga petechia*	YEWA	0.981	1	0	1	0	0.98	0	1	0	0.93	-0.07	0.91	-0.09
Ubiquitous	Carolina wren	*Thryothorus ludovicianus*	CARW	0.981	0.88	-0.12	1	0.09	1	0.12	0.94	0.34	1	0.05	1	0
Ubiquitous	Common grackle	*Quiscalus quiscula*	COGR	0.967	1	0	0.91	-0.09	0.96	-0.04	1	0	0.98	-0.02	1	0.05
Ubiquitous	Barn swallow	*Hirundo rustica*	BARS	0.967	1	0	0.94	-0.03	1	0	1	0	0.93	-0.07	0.95	0.05
Ubiquitous	Hooded warbler	*Setophaga citrina*	HOWA	0.951	1	0.12	0.97	0.21	0.93	0.27	0.92	0.42	0.98	0.09	0.95	0.05
Ubiquitous	Baltimore oriole	*Icterus galbula*	BAOR	0.949	1	0	1	0	0.95	-0.02	0.94	-0.06	0.86	-0.14	1	0.05
Ubiquitous	Pileated woodpecker	*Dryocopuc pileatus*	PIWO	0.947	0.88	-0.12	0.97	0	0.91	0	0.94	0.06	0.95	-0.02	1	0
Ubiquitous	Red-tailed hawk	*Buteo jamaicensis*	RTHA	0.947	1	0	1	0.12	1	0	1	0	0.93	-0.02	0.86	0.09
Ubiquitous	Blue-gray gnatcatcher	*Polioptila caerulea*	BGGN	0.945	0.88	-0.12	0.88	-0.12	0.89	-0.09	0.92	-0.08	0.98	-0.02	1	0
Ubiquitous	Cedar waxwing	*Bombycilla cedrorum*	CEDW	0.942	1	0	0.85	-0.09	0.95	-0.02	0.98	-0.02	0.91	0.02	0.95	-0.05
Ubiquitous	Northern mockingbird	*Mimus polyglottos*	NOMO	0.942	1	0.75	0.97	0.35	0.96	0.07	0.91	0.38	0.91	0.16	0.95	0.18
Ubiquitous	Chimney swift	*Chaetura pelagica*	CHSW	0.932	1	0	0.88	-0.12	0.82	-0.18	1	0	0.91	-0.09	1	0.05
Ubiquitous	Yellow-breasted chat	*Icteria virens*	YBCH	0.928	0.88	-0.12	1	0	1	0	0.81	-0.19	0.93	-0.07	1	0
Ubiquitous	Ruby-throated hummingbird	*Archilochus colubris*	RTHU	0.926	1	0	0.94	-0.06	0.84	-0.11	0.96	-0.04	0.93	-0.05	0.91	-0.09
Ubiquitous	Blue-winged warbler	*Vermivora cyanoptera*	BWWA	0.905	0.88	-0.12	0.82	-0.18	0.93	-0.07	0.89	-0.08	0.93	-0.07	0.91	-0.05
Common	Eastern kingbird	*Tyrannus tyrannus*	EAKI	0.893	1	0	0.82	-0.15	0.89	-0.05	0.96	0.02	0.95	-0.02	0.82	-0.09
Common	Hairy woodpecker	*Dryobates villosus*	HAWO	0.892	1	0	0.85	-0.09	0.82	-0.05	0.96	-0.02	0.89	-0.07	0.86	-0.05
Common	Ovenbird	*Seiurus aurocapillus*	OVEN	0.890	0.75	-0.25	0.91	0	0.89	0.09	0.83	0.08	0.98	0	1	0.05
Common	Eastern meadowlark	*Sturnella magna*	EAME	0.881	1	0	0.88	-0.12	0.91	-0.02	0.98	0.02	0.82	-0.14	0.73	-0.23
Common	Yellow-billed cuckoo	*Coccyzus americanus*	YBCU	0.876	0.62	-0.25	0.97	0.09	1	0.09	0.91	-0.02	1	0	0.95	-0.05

(Table 10 continued on next page.)

(Table 10 continued)

Occurrence	Common name	Scientific name	Code	Section 221E	Subsection 221Ea (n = 8)	Change in Subsection 221Ea	Subsection 221Ec (n = 34)	Change in Subsection 221Ec	Subsection 221Ed (n = 56)	Change in Subsection 221Ed	Subsection 221Ee (n = 53)	Change in Subsection 221Ee	Subsection 221Ef (n = 44)	Change in Subsection 221Ef	Subsection 221Eg (n = 22)	Change in Subsection 221Eg
Common	Orchard oriole	*Icterus spurius*	OROR	0.865	0.75	-0.25	0.85	0	0.89	0.02	0.83	0.02	0.82	0.02	1	0.14
Common	Great crested flycatcher	*Myiarchus crinitus*	GCFL	0.861	1	0	0.71	-0.24	0.84	-0.16	0.91	-0.06	0.89	-0.09	0.77	-0.14
Common	House wren	*Troglodytes aedon*	HOWR	0.821	1	0	0.85	-0.03	0.75	0.02	1	0	0.77	-0.11	0.59	-0.18
Common	Killdeer	*Charadrius vociferus*	KILL	0.820	0.88	-0.12	0.79	-0.18	0.84	-0.14	0.96	-0.04	0.80	-0.16	0.73	-0.18
Common	House finch	*Haemorhous mexicanus*	HOFI	0.811	0.88	0	0.74	-0.09	0.68	0.09	0.87	0.06	0.82	0.18	0.77	0.27
Common	Kentucky warbler	*Geothlypis formosa*	KEWA	0.798	0.50	-0.50	0.88	-0.12	0.86	-0.12	0.81	-0.19	1	0	0.95	-0.05
Common	Northern rough-winged swallow	*Stelgidopteryx serripennis*	NRWS	0.776	0.88	-0.12	0.65	-0.12	0.84	-0.02	0.81	-0.17	0.73	-0.11	0.77	0.05
Common	Rock pigeon	*Columba livia*	ROPI	0.744	1	0.12	0.68	-0.03	0.62	-0.23	0.81	-0.06	0.75	-0.09	0.59	-0.23
Common	Yellow-throated warbler	*Setophaga dominica*	YTWA	0.734	0.38	-0.25	0.85	-0.03	0.75	0.05	0.42	-0.11	0.93	0.02	1	0.05
Common	Belted kingfisher	*Megaceryle alcyon*	BEKI	0.699	0.88	-0.12	0.68	-0.24	0.62	-0.16	0.85	-0.11	0.55	-0.09	0.41	-0.23
Common	Willow flycatcher	*Empidonax traillii*	WIFL	0.695	1	0.12	0.50	-0.18	0.66	0	0.96	0.08	0.45	-0.07	0.36	-0.32
Common	Warbling vireo	*Vireo gilvus*	WAVI	0.693	1	0	0.71	-0.18	0.66	-0.25	0.77	-0.17	0.50	-0.34	0.64	-0.09
Common	American redstart	*Setophaga ruticilla*	AMRE	0.679	0.62	-0.12	0.91	0.24	0.64	0.16	0.74	0.23	0.57	0.11	0.68	0
Common	American kestrel	*Falco sparverius*	AMKE	0.676	0.88	0	0.59	-0.26	0.61	-0.29	0.64	-0.21	0.61	-0.16	0.68	-0.05
Common	Louisiana waterthrush	*Parkesia motacilla*	LOWA	0.670	0.62	-0.25	0.85	-0.12	0.59	-0.16	0.55	-0.15	0.75	-0.07	0.86	-0.09
Common	Rose-breasted grosbeak	*Pheucticus ludovicianus*	RBGR	0.652	1	0	0.50	0.47	0.59	0.46	0.96	0.28	0.25	0.20	0.50	0.27
Common	Cerulean warbler	*Setophaga cerulea*	CERW	0.650	0.75	-0.25	0.71	-0.21	0.57	-0.29	0.57	-0.36	0.59	-0.30	0.73	-0.18
Common	Prairie warbler	*Setophaga discolor*	PRAW	0.617	0.25	-0.50	0.62	-0.29	0.82	-0.11	0.57	-0.25	0.89	-0.05	0.77	-0.05
Common	Red-shouldered hawk	*Buteo lineatus*	RSHA	0.614	0.50	0.38	0.68	0.53	0.68	0.41	0.45	0.34	0.82	0.43	0.41	0.23
Common	Eastern screech-owl	*Megascops asio*	EASO	0.600	0.75	-0.25	0.53	-0.44	0.55	-0.39	0.42	-0.58	0.64	-0.32	0.86	-0.14
Common	Black-and-white warbler	*Mniotilta varia*	BAWW	0.586	0.50	-0.12	0.53	0.18	0.41	0.07	0.40	0.19	0.64	-0.05	0.77	0.09
Common	Barred owl	*Strix varia*	BDOW	0.562	0.62	-0.12	0.53	-0.18	0.61	-0.05	0.47	-0.36	0.57	-0.23	0.64	-0.23
Common	Purple martin	*Progne subis*	PUMA	0.500	0.25	-0.12	0.50	0	0.57	0.05	0.43	-0.28	0.59	-0.02	0.82	0.09
Common	Northern parula	*Setophaga americana*	NOPA	0.497	0.50	0.12	0.26	0.21	0.12	0.11	0.25	0.21	0.48	0.34	0.82	0.55
Common	Summer tanager	*Piranga rubra*	SUTA	0.468	0.25	0.25	0.50	-0.32	0.46	-0.29	0.23	-0.28	0.59	-0.30	0.68	-0.27
Common	Grasshopper sparrow	*Ammodramus savannarum*	GRSP	0.464	0.88	0.12	0.24	-0.44	0.46	-0.14	0.60	-0.25	0.34	-0.27	0.14	-0.36
Common	Cooper's hawk	*Accipiter cooperii*	COHA	0.460	0.62	0.12	0.24	-0.18	0.41	0	0.66	0.28	0.43	-0.02	0.50	0.23
Common	Broad-winged hawk	*Buteo platypterus*	BWHA	0.452	0.50	-0.38	0.44	0.09	0.46	0.02	0.42	-0.15	0.36	-0.14	0.64	0.05
Occasional	Savannah sparrow	*Passerculus sandwichensis*	SAVS	0.438	0.88	0	0.24	0.03	0.32	-0.11	0.62	-0.06	0.18	0.02	0.14	0.09
Occasional	Great horned owl	*Bubo virginianus*	GHOW	0.380	0.88	0	0.41	-0.03	0.23	-0.18	0.36	-0.28	0.34	-0.20	0.14	-0.41
Occasional	Eastern whip-poor-will	*Antrostomus vociferus*	EWPW	0.372	0.12	-0.38	0.32	-0.21	0.30	-0.3	0.04	-0.36	0.59	-0.20	0.64	-0.18
Occasional	Worm-eating warbler	*Helmitheros vermivorus*	WEWA	0.327	0.38	0.12	0.41	0.03	0.16	-0.12	0.08	-0.06	0.59	-0.09	0.73	-0.09
Occasional	Black-billed cuckoo	*Coccyzus erythropthalmus*	BBCU	0.318	0.38	-0.25	0.21	0	0.45	0.02	0.40	-0.02	0.39	0.05	0.23	-0.18
Occasional	Bobolink	*Dolichonyx oryzivorus*	BOBO	0.304	0.88	-0.12	0.06	0.03	0.21	0.07	0.55	0	0.02	-0.09	0	-0.05
Occasional	Pine warbler	*Setophaga pinus*	PIWA	0.281	0.12	0	0.35	0.03	0.25	-0.05	0.13	0.06	0.43	-0.05	0.36	0
Occasional	Red-headed woodpecker	*Melanerpes erythrocephalus*	RHWO	0.271	0.12	-0.88	0.09	-0.91	0.21	-0.77	0.42	-0.57	0.16	-0.84	0.45	-0.55
Occasional	Henslow's sparrow	*Centronyx henslowii*	HESP	0.244	0.50	-0.12	0.03	-0.15	0.23	0	0.23	-0.34	0.27	-0.16	0.32	-0.14
Occasional	Blue grosbeak	*Passerina caerulea*	BLGR	0.243	0.25	0.25	0.15	0.12	0.16	0	0.04	0	0.27	0.18	0.68	0.50
Occasional	Swamp sparrow	*Melospiza georgiana*	SWSP	0.242	0.62	0.38	0.03	0.03	0.23	0.14	0.57	0.28	0.02	0.02	0	0
Occasional	American woodcock	*Scolopax minor*	AMWO	0.228	0.25	-0.50	0.06	-0.06	0.20	-0.16	0.23	-0.11	0.23	-0.14	0.36	-0.14

(Table 10 continued on next page.)

(Table 10 continued)

Occurrence	Common name	Scientific name	Code	Section 221E	Subsection 221Ea (n = 8)	Change in Subsection 221Ea	Subsection 221Ec (n = 34)	Change in Subsection 221Ec	Subsection 221Ed (n = 56)	Change in Subsection 221Ed	Subsection 221Ee (n = 53)	Change in Subsection 221Ee	Subsection 221Ef (n = 44)	Change in Subsection 221Ef	Subsection 221Eg (n = 22)	Change in Subsection 221Eg
Occasional	Horned lark	*Eremophila alpestris*	HOLA	0.218	0.50	-0.25	0.03	-0.24	0.14	-0.25	0.36	-0.13	0.07	-0.14	0.14	-0.09
Occasional	Black vulture	*Coragyps atratus*	BLVU	0.192	0.12	0.12	0.09	0.06	0.04	0.04	0.28	0.28	0.23	0.11	0.27	0.27
Occasional	Black-throated green warbler	*Setophaga virens*	BTNW	0.185	0.62	0.25	0.06	0.06	0	-0.02	0.21	0.13	0.18	0.09	0.05	0
Occasional	Cliff swallow	*Petrochelidon pyrrhonota*	CLSW	0.172	0	-0.25	0.15	0.15	0.11	0.09	0.45	0.25	0.16	0.16	0.27	0.27
Occasional	Spotted sandpiper	*Actitis macularia*	SPSA	0.158	0.50	-0.12	0.03	-0.26	0.05	-0.11	0.09	-0.28	0.07	-0.05	0.05	0
Occasional	Bank swallow	*Riparia riparia*	BANS	0.156	0.25	0	0.09	0	0.07	0.05	0.15	0.04	0.07	-0.07	0.23	-0.14
Occasional	Vesper sparrow	*Pooecetes gramineus*	VESP	0.135	0.38	-0.50	0.03	-0.12	0.09	-0.21	0.19	-0.47	0.05	-0.09	0	-0.18
Occasional	Sharp-shinned hawk	*Accipiter striatus*	SSHA	0.123	0.12	-0.12	0.18	0	0.09	-0.05	0.21	0.06	0.07	-0.02	0.09	-0.09
Rare	Purple finch	*Haemorhous purpureus*	PUFI	0.099	0.38	-0.12	0	0	0.02	0.02	0.09	0.06	0	0	0	0
Rare	Chestnut-sided warbler	*Setophaga pensylvanica*	CSWA	0.085	0.50	0.12	0	0	0	0	0.25	0.21	0.02	-0.02	0	0
Rare	Blue-headed vireo	*Vireo solitarius*	BHVI	0.067	0.25	0.12	0.03	0.03	0.02	0.02	0.08	0.04	0.09	0.07	0.05	-0.05
Rare	Common nighthawk	*Chordeiles minor*	CONI	0.066	0.12	0	0.06	-0.03	0.04	-0.20	0.08	-0.32	0.05	-0.14	0.05	-0.14
Rare	Brown creeper	*Certhia americana*	BRCR	0.062	0.25	0.25	0	0	0.02	0.02	0.08	0.06	0.02	0.02	0	0
Rare	Hermit thrush	*Catharus guttatus*	HETH	0.059	0.25	0.25	0	-0.03	0	-0.02	0.04	0.02	0.05	0.02	0	0
Rare	Alder flycatcher	*Empidonax alnorum*	ALFL	0.039	0.12	0.12	0	0	0.02	0.02	0.06	0.02	0	0	0	0
Rare	Magnolia warbler	*Setophaga magnolia*	MAWA	0.039	0.12	0.12	0	0	0	0	0.02	-0.02	0.09	0.07	0	0
Rare	Northern harrier	*Circus hudsonius*	NOHA	0.035	0.12	0.12	0	0	0	-0.04	0.04	0.04	0	0	0	0
Rare	Veery	*Catharus fuscescens*	VEER	0.033	0.12	0.12	0	0	0	-0.02	0.04	0.02	0.02	0.02	0	0
Rare	Least flycatcher	*Empidonax minimus*	LEFL	0.032	0	-0.12	0.06	0.06	0.02	-0.02	0.09	0	0	0	0	0
Rare	Prothonotary warbler	*Protonotaria citrea*	PROW	0.028	0	0	0.03	0	0.02	0	0.06	-0.04	0.05	-0.05	0.05	-0.05
Rare	Dickcissel	*Spiza americana*	DICK	0.021	0	0	0	0	0	-0.02	0.08	0.08	0.02	0	0	-0.05
Rare	Marsh wren	*Cistothorus palustris*	MAWR	0.017	0.12	0.12	0	0	0	-0.02	0.02	0	0	0	0	0
Rare	Sedge wren	*Cistothorus platensis*	SEWR	0.014	0	0	0	0	0.02	0.02	0.04	0.04	0.07	0.07	0	0
Rare	Blackburnian warbler	*Setophaga fusca*	BLBW	0.008	0	0	0	0	0	0	0.04	0.02	0.05	0.02	0	0
Rare	Yellow-bellied sapsucker	*Sphyrapicus varius*	YBSA	0.006	0	0	0	0	0	0	0.02	0.02	0.02	0.02	0	0
Rare	Red-breasted nuthatch	*Sitta canadensis*	RBNU	0.005	0	0	0	0	0	0	0.02	0	0	0	0	0
Rare	Winter wren	*Troglodytes hiemalis*	WIWR	0.004	0	0	0	0	0	0	0.04	0.04	0.02	0.02	0	0
Rare	Dark-eyed junco	*Junco hyemalis*	DEJU	0.002	0	0	0	0	0	0	0.02	0.02	0	0	0	0

*We report a general classification based on overall occurrence from ubiquitous (>90 percent incidence) to rare (<10 percent of block).
†Number of blocks per subsection is in parentheses after subsection name.
‡Color coding: Red = species listed in OBBA2 as species of concern and listed as focal species in the forest management guide for birds (Rodewald 2014); orange = species listed only in Rodewald (2014); green = species listed only in OBBA2.

Table 11.—Average annual harvest of white-tailed deer (2013–2015) for the Ohio portion of Section 221E and subsections (Source: ODNR 2017)

	Total	Subsection*					
	Section 221E	221Ea	221Ec	221Ed	221Ee	221Ef	221Eg
	---------- *Number of animals* ----------						
Bucks†	8,487	1,397	1,156	1,266	1,646	1,422	1,600
Does	9,608	1,651	1,357	1,299	1,835	1,615	1,851
Total	19,971	3,392	2,782	2,789	3,843	3,351	3,814

*Values are area weighted for each subsection based on county-level data.
†Excluding button bucks, which are included in the total.

Table 12.—Percentage and area of ecological subsections within the Ohio portion of Section 221E disturbed by surface mining

		Subsection				
		221Ec – Ohio Valley Lowland	221Ed – East Hocking Plateau	221Ee – Unglaciated Muskingum Plains	221Ef – Western Hocking Plateau	221Eg – Lower Scioto River Plateau
Area within Ohio	Acres	817,886	1,354,643	264,321	1,582,955	810,625
Surface mines – reclaimed	Percentage	0.91	5.49	8.11	4.23	0
	Area (acres)	7,471	74,399	21,426	66,977	0
Surface mines – unreclaimed	Percentage	0.24	3.45	2.89	2.64	0
	Area (acres)	1,980	46,751	7,644	41,848	0

Regarding landscape diversity, connectedness, and resilience, the Ohio portion of Subsection 221Ec has overall conditions that are better than average for all three measures, as compared to the rest of an "ecoregion," which is somewhat aligned with Section 221E (Anderson et al. 2014) (Fig. 20, Table 13). Specifically, 54 percent of the land is better than average in landscape diversity, including 23 percent far above average, due to its highly dissected topography. The largest share of the subsection is classified as slightly above average (41 percent) in connectedness. Overall resilience, which combines the other two factors, is classified as slightly above average or higher across 41 percent of this landscape.

3.2.2 Subsection 221Ed – East Hocking Plateau

Subsection 221Ed contains about 2 million acres, of which 69 percent occur in Ohio. The Ohio portion conforms to the Upper Pennsylvanian stratigraphy that strikes northeast to southwest across southeastern Ohio (Fig. 4). Roughly 302 million to 307 million years in age, the bedrock is composed of shale, sandstone, siltstone, and mudstone (Slucher et al. 2006). Because this subsection has not been glaciated, upland soils are largely derived from the underlying bedrock. Soils tend to be heavy and fertile, averaging 32 percent clay and having the highest average pH (5.8) of all subsections. Wetlands are rather infrequent and mainly palustrine (Fig. 21). Although elevation grades from 1,300 feet in the northeast to 550 feet in the southwest (Fig. 9), percent slope and topographic roughness are rather consistent throughout (Figs. 10 and 11). Annual and growing season temperatures decrease with elevation, being lowest in the northeast and highest in the southeast (Fig. 12). Based on Gordon (1969), mixed oak, mixed mesophytic, and beech were the principal forest types in pre-Euro-American settlement times (Table 14). These forest types were composed primarily of white oak, hickory, beech, and "black oak" (*Quercus velutina* and probably also *Q. rubra, Q. coccinea*, and other species of the red oak group) trees, which, together, were 71 percent of witness trees (Table 9). Sixty-nine species are currently recorded by FIA. The most numerous species include sugar maple, black cherry, American elm, black locust, red maple, yellow-poplar, and white ash (Table 7; Table 36 in Appendix 4).

Ninety-five bird species were recorded in the latest Ohio Breeding Bird Atlas (Table 10). Many of the species common throughout Section 221E are dominant here, including scarlet tanager, wood thrush, and Acadian flycatcher. The total number of species between the first (1982–1987) and second (2006–2011) surveys remained the same. Six species (including northerly distributed species such as black-throated green warbler and northern harrier) that were not observed during the second survey were replaced by six new species (alder flycatcher, blue-headed vireo, brown creeper, purple finch, black vulture, and sedge wren). Cerulean warbler, eastern screech-owl, and eastern whip-poor-will

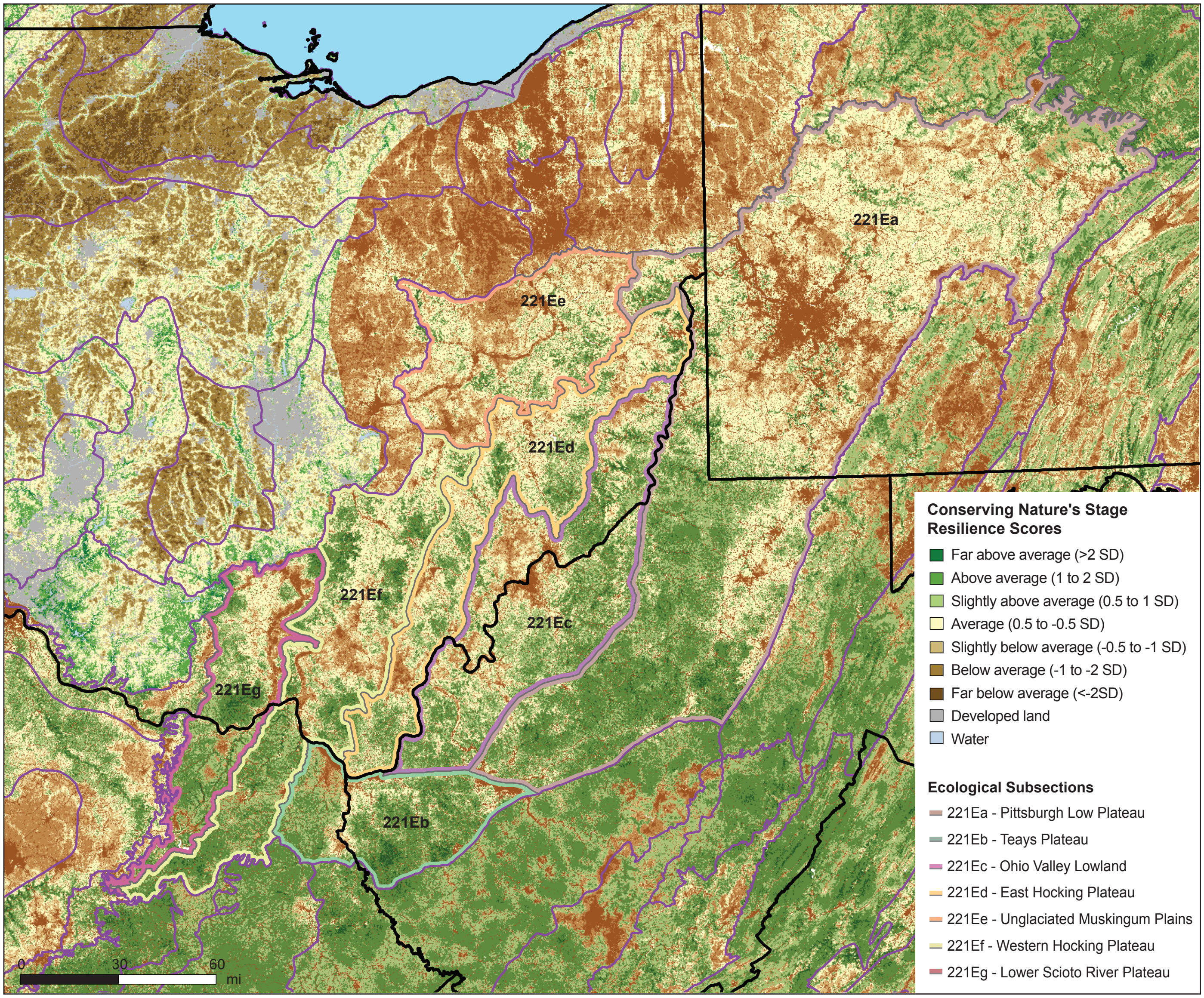


Figure 20.—Resilience estimates based on The Nature Conservancy's Conserving Nature's Stage (CNS) data. Each 30 m (98.4 feet) of landscape is assigned to one of eight classes of resilience which are defined in relation to the average for that geographical or regional setting; SD = standard deviation. Locations in green are deemed more resilient to a changing climate and other disturbances according to the CNS scheme; those in brown, less resilient. See text and Appendix 4 for further explanation of methods and interpretation of this map.

exhibited dramatic reductions in incidence over the last 25 years. The region is notable for the higher proportion of bucks harvested each year (ODNR 2017) and reflects a deer population that has the capacity to grow rapidly based on the association between buck harvest and population growth (Table 11). This subsection has been extensively mined, with an estimated 5.5 percent of its area in reclaimed and 3.5 percent in unreclaimed surface mines (Table 12).

In the Ohio portion of Subsection 221Ed, overall conditions are slightly more favorable than average for landscape diversity, connectedness, and resilience compared to the rest of the ecoregion (Fig. 20, Table 13). In terms of diversity, 69 percent of the landscape is rated as slightly above average or higher, including 28 percent far above average. The largest share of the subsection is classified as slightly above average (48 percent) in connectedness. Developed land, representing nearly 10 percent of the area, is essentially nonconnected. Overall resilience scores reveal that 44 percent of this landscape is classified as slightly above average or higher.

Table 13.—Percentage of land classified by overall resilience (Res), connectedness (Con), and landscape diversity (Div), by ecological subsections within the Ohio portion of Section 221E (Source: The Nature Conservancy 2017)

Conserving Nature's Stage Resilience Score*	Subsection				
	221Ec	221Ed	221Ee	221Ef	221Eg
	Percentage of Ohio portion of subsection				
Res_FB	0.6	0.6	2.1	0.9	4.2
Res_B	9.2	4.7	19.9	7.4	8.4
Res_SB	13.6	7.8	26.2	9.9	7.0
Res_Ave	25.8	32.5	31.2	30.0	24.3
Res_SA	20.5	25.5	4.0	19.9	22.1
Res_A	18.7	18.2	2.3	21.0	22.0
Res_FA	1.5	0.7	0.2	1.9	2.7
Res_Dev	10.3	9.9	14.2	9.0	9.3
Con_FB	10.2	9.9	14.1	9.0	9.3
Con_B	1.1	1.2	4.1	1.5	5.6
Con_SB	11.8	7.6	26.9	9.6	9.5
Con_Ave	14.6	11.3	23.5	10.9	8.2
Con_SA	41.1	48.2	29.3	41.2	30.6
Con_A	17.3	17.1	2.0	18.7	19.5
Con_FA	3.8	4.7	0.1	9.1	16.9
Con_Dev	0.0	0.0	0.0	0.1	0.4
Div_FB	10.2	9.9	14.1	9.0	9.3
Div_B	0.4	0.4	1.6	0.6	3.5
Div_SB	10.4	4.0	16.5	8.0	7.4
Div_Ave	11.8	7.2	22.3	11.5	8.4
Div_SA	21.9	27.6	35.0	25.3	22.5
Div_A	8.8	13.8	4.3	8.8	14.8
Div_FA	23.0	27.6	4.1	23.6	23.7
Div_Dev	13.4	9.6	1.9	13.2	10.5

*Abbreviations for ratings: FB = far below average; B = below average; SB = slightly below average; Ave = average; SA = slightly above average; A = above average; FA = far above average; Dev = developed.

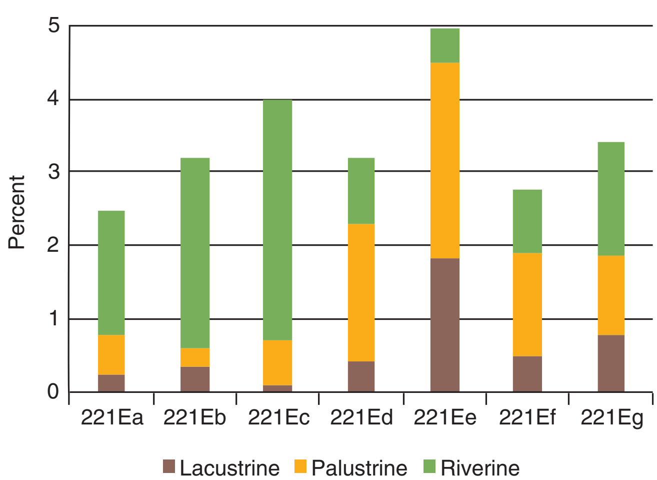


Figure 21.—Percentage of each subsection within Section 221E by National Wetlands Inventory definitions for lacustrine (lakes), palustrine (wetlands), and riverine (rivers and streams) types (U.S. Fish and Wildlife Service 2017).

3.2.3 Subsection 221Ee – Unglaciated Muskingum Plains

Subsection 221Ee occurs immediately south and east of the maximum glacial extent on Lower Pennsylvanian stratigraphy composed of sandstone, siltstone, shale, and conglomerate of deltaic and marine origin (Slucher et al. 2006). Of the 1.7 million acres in this subsection, only 15 percent are contained within Ohio. Although upland soils reflect underlying bedrock, riparian zones and lowlands have been infiltrated by glacial materials, either sandy outwash or clayey lake sediments (Fig. 5). The prevalence of glaciofluvial deposits and underlying sandstone explains the higher amounts of sand in the soils (27 percent) (Table 8). This subsection, in the northwestern portion of this section, tends to be cooler and receives less precipitation than the others (Figs. 12 and 13). Elevation decreases from the northwest to the southeast; however, the terrain is somewhat subdued in terms of percent slope (averaging 9 percent) and topographic

Table 14.—Original survey estimates of forest-type acreages, and percentage of land cover, within the Ohio portion of five ecological subsections of Section 221E (based on Gordon 1969)

Subsection		Vegetation type: Beech forests	Mixed oak forests	Oak-sugar maple forests	Elm-ash swamp forests	Mixed mesophytic forests	Freshwater marshes and fens	Bottomland hardwood forests
221Ec – Ohio Valley Lowland	Area (acres)	120,339	581,607	42,613	--	60,812	--	6,284
	Percentage	14.7	71.1	5.2	--	7.4	--	0.8
221Ed – East Hocking Plateau	Area (acres)	270,393	689,098	16,665	--	360,836	--	12,650
	Percentage	20.0	50.9	1.2	--	26.6	--	0.9
221Ee – Unglaciated Muskingum Plains	Area (acres)	10,638	203,067	--	4,189	46,446	--	--
	Percentage	4.0	76.8	--	1.6	17.6	--	--
221Ef – Western Hocking Plateau	Area (acres)	119,247	1,171,886	2	5,989	218,946	--	66,436
	Percentage	7.5	74.0	0.0	0.4	13.8	--	4.2
221Eg – Lower Scioto River Plateau	Area (acres)	44,953	232,459	39,825	4,022	394,073	185	91,089
	Percentage	5.5	28.7	4.9	0.5	48.6	0.0	11.2

roughness index (93 feet) (Table 8). The past dominance of oak (Table 14) has today largely switched to dominance by other species, led by red maple, black cherry, yellow-poplar, and American elm (Table 7; Table 37 in Appendix 4). This change is thought to reflect fire suppression, increased moisture, and mesophication. Wetlands, mainly palustrine and lacustrine, are more prevalent in this subsection than in the other subsections.

The 53 priority blocks of bird inventory for this subsection included records for all 108 species recorded across the Ohio portion of Section 221E (Table 10). This very species-rich subsection had high incidence values for many of the common species, including red-eyed vireo, wood thrush, and scarlet tanager. Seven new species were observed in priority blocks between the two bird surveys. While four of these species included examples of northerly distributed species (winter wren, northern harrier, yellow-bellied sapsucker, and dark-eyed junco), the most dramatic increase in incidence between atlases was observed for black vulture (+0.28 in incidence). Of the species recorded in both atlases, a total of 24, 33, and 44 species displayed no change, increases, and reductions in incidence values between atlases, respectively. Among those displaying increases in incidence were several conservation-relevant species, such as black-and-white warbler and hooded warbler. Several noteworthy species of high conservation importance exhibited marked reductions in incidence over the atlas periods, including cerulean warbler, Kentucky warbler, and prairie warbler. This subsection has the highest white-tailed deer harvest of the region (Table 11). The high numbers and consistent herd population reflect both the large extent of public land and its juxtaposition with agricultural landscapes (ODNR 2017). Surface mined lands are estimated to cover 11.0 percent of the area, more than any other subsection, with 8.1 percent in reclaimed status and 2.9 percent in unreclaimed status (Table 12).

Landscape diversity, connectedness, and resilience are relatively lower here compared to the other subsections because the landscape is less dissected and more highly developed (Fig. 20, Table 13). For landscape diversity, 44 percent of the landscape is rated as slightly above average or higher, but only 4 percent is far above average while 14 percent is in the far below average class. With connectedness, the subsection is rated fairly low; 14 percent is classified as far below average and only 0.1 percent is far above average. The latter percentage was much lower than the other subsections. Overall resilience to a changing climate is classified as poor, with 79 percent rated average or below. Another 14 percent is classified as developed.

3.2.4 Subsection 221Ef – Western Hocking Plateau

Subsection 221Ef spans Lower Pennsylvanian and Mississippian stratigraphies of sandstone, siltstone, shale, conglomerate, and some limestone of principally marine origin (Slucher et al. 2006). Most (67 percent) of the 2.3 million acres in this subsection are contained within Ohio. Elevation is rather uniform, ranging mostly from 700 to 1,000 feet (Fig. 9), and percent slope and topographic roughness are subdued compared to other subsections. Average temperature and precipitation increase from north to south across this elongated subsection (Figs. 12 and 13). Areas of rather high sand concentrations and soil permeability exist in this subsection (Fig. 15), presumably due to the underlying sandstone. Wetlands are infrequent and largely palustrine (Fig. 21). Forests were dominated by oaks in pre-Euro-American settlement times (Table 14), with white oak, hickory, and "black oak" as the principal constituents (Table 9). Today, tree diversity is very high, with 70 species. The most populous species are red maple, yellow-poplar, white oak, sugar maple, chestnut oak, black oak, sassafras, and Virginia pine (Table 7; Table 38 in Appendix 4). Pre-Euro-American settlement forest composition was very similar to that of Subsection 221Ed, the East Hocking Plateau; white oak, hickory, "black oak," and beech accounted for 72 percent of witness trees.

A total of 101 bird species were recorded in the Ohio portion of this subsection (Table 10), including an additional 7 new species recorded in the latter survey. The newly observed species included examples of northerly distributed species, such as winter wren, yellow-bellied sapsucker, veery, and brown creeper. Many of the species common throughout Section 221E also exhibited high incidence values for this subsection, such as red-eyed vireo, scarlet tanager, and wood thrush. Species such as northern parula, rose-breasted grosbeak, and blue grosbeak displayed dramatic increases in incidence over the last 25 years, while the red-headed woodpecker, warbling vireo, and eastern screech-owl exhibited reductions in incidence. Conservation-relevant species, such as prairie warbler and yellow-breasted chat, typical of shrublands and young forest habitats had relatively low reductions in incidence values. The heavily forested landscape dominated by Ohio state forest lands supports a robust deer population, with a consistent yearly average harvest of over 3,000 deer (Table 11). Surface mines cover 6.9 percent of the area, with an estimated 4.2 percent in reclaimed status and 2.6 percent in unreclaimed status (Table 12).

Overall landscape diversity, connectedness, and resilience are slightly more favorable relative to the rest of the ecoregion (Fig. 20, Table 13). For landscape diversity, 58 percent of the landscape is slightly above average or higher, including 24 percent far above average. The largest share of the subsection is classified as slightly above average (41 percent) in connectedness. Overall resilience scores indicate that 43 percent of the land is classified as slightly above average or higher.

3.2.5 Subsection 221Eg – Lower Scioto River Plateau

Subsection 221Eg lies at the western extent of Section 221. Of the subsection's 1.3 million acres, 61 percent are in Ohio, and its perimeter is defined by Illinoian-aged glacial deposits to the north and west (Fig. 5) and the Scioto River on the east. The subsection extends southward into Kentucky as defined by Devonian- and Mississippian-aged bedrock (Table 4). Bedrock is mainly shale, siltstone, and sandstone of marine origin (Slucher et al. 2006). The Scioto River valley represents a long continuous finger of glacial outwash sands deposited during the Illinoian and Wisconsinan glaciations (Fig. 5). The flat Scioto River floodplain contrasts starkly with its upland surroundings, where a high degree of topographic variability exists as reflected in elevation, percent slope, and topographic roughness (Figs. 9–11). Average annual temperature and precipitation increase from north to south (Figs. 12 and 13). Unlike the other subsections, here mixed mesophytic forests dominated the pre-Euro-American settlement landscape (48 percent) (Table 14), with lower abundance of white oak and greater abundance of sugar maple compared to other subsections (Table 9). However, white oak, hickory, "black oak," and beech still accounted for 58 percent of witness trees. Sixty species are currently recorded by FIA in this subsection. The most populous species are sugar maple, red maple, chestnut oak, yellow-poplar, white oak, pignut hickory, and scarlet oak (Table 7; Table 39 in Appendix 4).

Eighty-eight bird species were recorded among the 22 priority blocks of this subsection within Ohio (Table 10). Between the two surveys, about 25 years apart, two species were newly observed, and three species were not found. The newly observed species were cliff swallow and black vulture, whereas bobolink, vesper sparrow, and dickcissel were not observed in the later survey. Marked increases in incidence values were observed for northern parula, blue grosbeak, and rose-breasted grosbeak. This subsection had the second highest average deer harvest from 2013 to 2015 of all the subsections (Table 11). Mining is virtually nonexistent in this subsection, with no recorded reclaimed or unreclaimed surface mines (Table 12).

In the Ohio portion of the subsection, overall conditions are slightly more favorable for landscape diversity, connectedness, and resilience as compared to the rest of the ecoregion (Fig. 20, Table 13). For diversity, 61 percent of the landscape is rated as slightly above average or higher, including 24 percent rated as far above average. Regarding connectedness, most of the landscape is slightly to far above average (67 percent), including 17 percent of the area classified as far above average—much more than any other subsection. Overall resilience scores show 47 percent of the area is classified as slightly above average or higher.

3.3 LANDTYPE DESCRIPTIONS

Fifteen landtypes are described next, three for each of the five described subsections in Ohio. Environmental variables used to define the landtypes are also presented. Witness tree data were available for only nine of the landtypes.

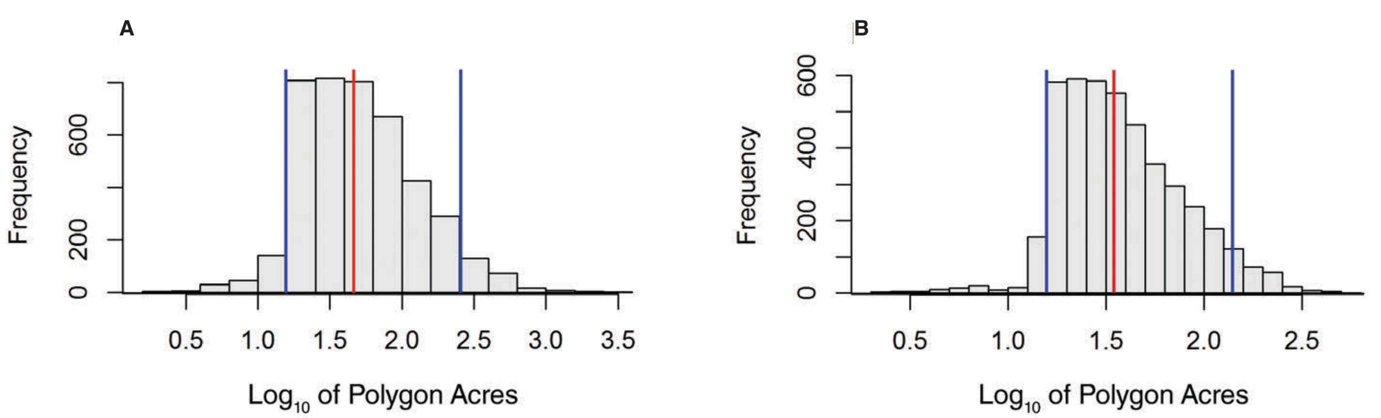
3.3.1 Ohio Valley Lowland (Subsection 221Ec) Dry Oak Forest

The Dry Oak forest (DO) landtype occurs on rugged upland positions across 362,338 acres (44 percent) of the portion of the Ohio Valley Lowland subsection that runs along the Ohio River in the extreme southeast corner of Ohio. Aspect is primarily southwesterly; average elevation is 909 feet, and average slope is 24 percent (Table 15). The median value for size of the landtype polygons is 47 acres; 90 percent of the polygons fall within a range of 16 to 257 acres (Fig. 22). Available water storage capacity is relatively low (6.5 inches per inch), with a low integrated moisture index score of 20, which indicates dryness. This landtype has one of the two greatest depths to water table (61 inches) of all the landtypes in southeastern Ohio. Current vegetation cover (Table 16) is mostly deciduous forest (69 percent) with a small percentage of coniferous forest (2 percent). Land use comprises a small amount of cultivated crops (4 percent), pasture or hay (16 percent), and developed land (7 percent). Historically, oaks and hickories were strongly dominant, making up 88 percent of witness trees (Table 17). Pines, presumably shortleaf or pitch pine (or both), were fairly common in this landtype

Table 15.—Topographic and soil characteristics (mean, standard deviation) of ecological landtypes* within the Ohio portion of Ecological Subsection 221Ec – Ohio Valley Lowland

Characteristic (units)	Landtype			Average for Ohio portion of Subsection 221Ec
	DO forest	DMMOH forest	RBMH forest	
Area (acres)	362,338	245,112	210,435	817,886
Percentage of subsection area	44.3	30.0	25.7	N/A
Elevation (feet)	909 (162)	892 (159)	776 (155)	870 (169)
Slope (%)	23.5 (12.7)	25.3 (13.3)	14.6 (12.5)	21.8 (13.5)
Topographic roughness index (feet)	19.8 (10.9)	21.2 (11.5)	13.4 (15.4)	18.5 (12.5)
Aspect, Beers'	0.50 (0.53)	1.63 (0.34)	0.99 (0.72)	0.97 (0.52)
Northeast aspect (share of area; %)	22.8	88.9	45.1	52.3
Southwest aspect (share of area; %)	77.1	10.3	52.9	46.8
Integrated moisture index	20.4 (9.7)	39.4 (8.6)	30.9 (10.6)	28.8 (9.6)
Available water storage capacity (inches/inch)	6.53 (2.32)	6.65 (2.45)	8.26 (3.76)	7.01 (2.73)
Depth to water table (inches)	60.6 (24.8)	61.1 (24.5)	58.6 (24.7)	60.2 (24.7)

*Landtypes abbreviated as DO: Dry Oak; DMMOH: Dry-Mesic Mixed Oak Hardwood; RBMH: Rolling Bottomlands Mixed Hardwood.



Landtype	Median	Minimum	5th percentile	95th percentile	Maximum
	acres				
DO	46.5	2.1	15.7	257.2	3,059.5
DMMOH	34.6	2.1	15.7	139.5	604.2

Figure 22.—Frequency of patch sizes (acres) of landtypes within Ecological Subsection 221Ec on a $\log_{10}$ scale: (A) Dry Oak forest (DO) and (B) Dry-Mesic Mixed Oak Hardwood forest (DMMOH). The median (red) and 5th and 95th percentile (blue) values, tabulated below the graphs, are indicated by vertical lines.

and represented 7 percent of witness trees. Witness tree data assessed for site affinities between landtypes and taxa showed that "black oak," chestnut oak, and pine had a positive association with this landtype (Table 18). White oak did not show a strong correlation with this landtype but instead had a relatively uniform distribution across ridge, valley, and slope positions in the pre-Euro-American settlement forest. These data contrast with current FIA data, which indicate that white oak is most abundant on ridge positions.

Dry Oak forest in southeastern Ohio. Photo by USDA Forest Service, Northern Research Station.

Table 16.—Land cover by ecological landtype* within the Ohio portion of Ecological Subsection 221Ec – Ohio Valley Lowland (Source: Homer et al. 2015)

Land cover	Percent DO forest	Percent DMMOH forest	Percent RBMH forest	Percentage of Ohio portion of Subsection 221Ec
Water	0.04	0.19	2.70	0.77
Developed, open space	5.79	5.19	9.03	6.44
Developed, low intensity	0.98	0.95	2.53	1.37
Developed, medium intensity	0.20	0.25	0.93	0.40
Developed, high intensity	0.05	0.07	0.27	0.11
Barren land	0.09	0.08	0.16	0.10
Deciduous forest	69.39	71.80	59.96	67.69
Coniferous forest	2.38	1.77	1.02	1.85
Mixed forest	0.05	0.03	0.08	0.05
Shrub/Scrub	0.29	0.28	0.14	0.25
Grassland/Herbaceous	0.96	0.89	1.09	0.97
Pasture/Hay	15.51	14.29	15.21	15.07
Cultivated crops	4.26	4.20	6.80	4.90
Woody wetlands	0.01	0.01	0.05	0.02
Emergent herbaceous wetlands	0.00	0.00	0.03	0.01
Area of landtype (acres)	362,338	245,112	210,435	817,886

*Landtypes abbreviated as DO: Dry Oak; DMMOH: Dry-Mesic Mixed Oak Hardwood; RBMH: Rolling Bottomlands Mixed Hardwood.

Table 17.—Pre-Euro-American settlement vegetation based on witness-tree percentages in each ecological landtype within the Ohio portion of Ecological Subsection 221Ec – Ohio Valley Lowland

Taxon*	Number of witness trees	Dry Oak forest	Dry-Mesic Mixed Oak Hardwood forest	Rolling Bottomlands Mixed Hardwood forest
		---------------------------	*(Percentage of all trees in this landtype)*	------------------------
White oak	771	56.3	55.0	47.2
"Black oak"†	198	17.1	13.9	9.3
Hickory	112	8.2	9.1	5.9
Chestnut oak	63	6.2	5.8	1.0
Beech	60	0.9	2.4	9.1
Pine	46	6.7	0.7	1.2
Sugar maple	40	0.2	2.9	5.5
Tulip-poplar	27	1.8	1.9	1.8
Buckeye	23	0.4	1.2	3.3
Red maple	20	0.2	1.7	2.4
Ash	20	0.2	1.4	2.6
Elm	19	0.2	0.7	3.0
Silver maple	17	0.7	0.2	2.4
Blackgum	16	0.7	1.2	1.4

*Taxa listed in order of descending abundance (>1 percent) within the ecological subsection.

†*Quercus velutina* and probably also *Q. rubra, Q. coccinea*, and other species of the red oak group.

Table 18.—Witness-tree taxa that demonstrate a positive association with a particular landtype (G-test, P ≤ 0.01), by ecological section and subsection

Taxon*	Section 221E – Southern Unglaciated Allegheny Plateau	Subsection: 221Ec – Ohio Valley Lowland	Subsection: 221Ed – East Hocking Plateau	Subsection: 221Ef – Western Hocking Plateau
White oak	Dry Oak	N.S.[†]	Dry Oak	N.S.
Hickory	Dry-Mesic Mixed Oak Hardwoods	N.S.	N.S.	Dry-Mesic Mixed Oak Hardwoods
"Black oak"[‡]	Dry Oak	Dry Oak	Dry Oak	Dry Oak
Beech	Rolling Bottomlands Mixed Hardwoods	Rolling Bottomlands Mixed Hardwoods	Rolling Bottomlands Mixed Hardwoods	Rolling Bottomlands Mixed Hardwoods
Sugar maple	Rolling Bottomlands Mixed Hardwoods	Rolling Bottomlands Mixed Hardwoods	Rolling Bottomlands Mixed Hardwoods	Rolling Bottomlands Mixed Hardwoods
Red maple	Rolling Bottomlands Mixed Hardwoods	Rolling Bottomlands Mixed Hardwoods	Rolling Bottomlands Mixed Hardwoods	Rolling Bottomlands Mixed Hardwoods
Chestnut oak	Dry Oak	Dry Oak	Dry Oak	Dry Oak
Tulip-poplar	N.S.	N.S.	N.S.	N.S.
Blackgum	Dry-Mesic Mixed Oak Hardwoods	--	N.S.	N.S.
Ash	Rolling Bottomlands Mixed Hardwoods	Rolling Bottomlands Mixed Hardwoods	N.S.	Rolling Bottomlands Mixed Hardwoods
Elm	Rolling Bottomlands Mixed Hardwoods	Rolling Bottomlands Mixed Hardwoods	Rolling Bottomlands Mixed Hardwoods	Rolling Bottomlands Mixed Hardwoods
Silver maple	Rolling Bottomlands Mixed Hardwoods	--	N.S.	N.S.
Pine	Dry Oak	Dry Oak	Dry Oak	N.S.
Chestnut	Dry-Mesic Mixed Oak Hardwoods	--	--	Dry-Mesic Mixed Oak Hardwoods
Buckeye	Rolling Bottomlands Mixed Hardwoods	Rolling Bottomlands Mixed Hardwoods	Rolling Bottomlands Mixed Hardwoods	--

*Only trees composing 1 percent or more of witness trees within Section 221E are included; "--" indicates that sample size was too small (expected value <5).

[†]Not statistically significant.

[‡]*Quercus velutina* and probably also *Q. rubra, Q. coccinea,* and other species of the red oak group.

3.3.2 Ohio Valley Lowland (Subsection 221Ec) Dry-Mesic Mixed Oak Hardwood Forest

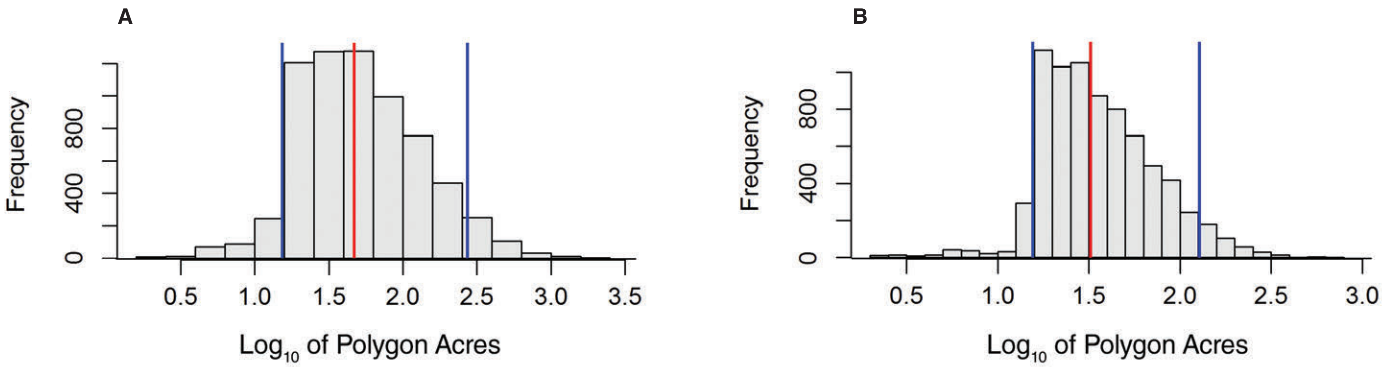
The Dry-Mesic Mixed Oak Hardwood forest (DMMOH) landtype occurs on rugged upland positions across 245,112 acres (30 percent) of the landscape in the Ohio Valley Lowland subsection in Ohio. Aspect is primarily northeasterly; average elevation is 892 feet and average slope is 25 percent (Table 15). The median value for size of the landtype polygons is 35 acres; 90 percent of the polygons fall within a range of 16 to 139 acres (Fig. 22). The integrated moisture index score for this landtype is high (39), indicating a mesic setting, even though this landtype is one of two with the greatest depth to water table (61 inches) of all the landtypes in southeastern Ohio. Current vegetation cover is mostly deciduous forest (72 percent) with a small percentage of coniferous forest (2 percent). Land use includes a small amount of cultivated crops (4 percent), pasture or hay (14 percent), and developed land (6 percent) (Table 16). Similar to the DO landtype, oaks and hickories dominated the pre-Euro-American settlement forest and were 84 percent of witness trees (Table 17).

3.3.3 Ohio Valley Lowland (Subsection 221c) Rolling Bottomlands Mixed Hardwood Forest

The Rolling Bottomlands Mixed Hardwood forest (RBMH) landtype occurs across 210,435 acres (26 percent) in the lowlands of the Ohio River Valley landscape in Ohio. It has a percent slope of 15, higher than the other four rolling bottomlands landtypes, with an average elevation of 776 feet. Though highly dissected, the valleys are generally very narrow (Table 15). This landtype also has the lowest available water storage capacity (8 inches per inch) when compared to the other bottomlands landtypes, and depth to water table is also high at 59 inches. Current vegetation cover data show mostly deciduous forest (60 percent) with a very small percentage of coniferous forest (1 percent). Land use includes a small amount of cultivated crops (7 percent), pasture or hay (15 percent), and developed land (13 percent) (Table 16). Witness tree records list white oak as nearly half of the recorded witness trees for this mesic landtype. Oaks and hickories were abundant but at 63 percent of witness trees, were somewhat less dominant than in the Ohio Valley Lowland DO forests and DMMOH forests. Beech, sugar maple, red maple, ash, elm, and buckeye are associated with this landtype, but together, these mesophytes were only 26 percent of the witness trees (Tables 17 and 18).

3.3.4 East Hocking Plateau (Subsection 221Ed) Dry Oak Forest

Dry Oak forests are the dominant landtype across the East Hocking Plateau subsection and occur on 571,638 acres (42 percent) within the Ohio portion. The topography is very dissected and more southwesterly in aspect than northeasterly. The median value for size of the landtype polygons is 47 acres; 90 percent of the polygons fall within a range of 15 to 274 acres (Fig. 23). This landtype is dry as expected, with an integrated moisture index score of 21. Depth to water table is 7 inches greater than in the DO landtype in the neighboring Western Hocking Plateau subsection (Table 19). Current vegetation cover data show mostly deciduous forest (69 percent) with a small percentage of coniferous forest (2 percent). Land use includes pasture or hay (16 percent), cultivated crops (3 percent), and developed land (6 percent) (Table 20). Witness tree data indicate that oaks and hickories were abundant in the pre-Euro-American settlement forest (75 percent of trees), with white oak (39 percent), hickory (14 percent), and "black oak" (17 percent) as the most commonly recorded species (Table 21). White oak did show site affinity with this landtype in the pre-Euro-American settlement forest, as did "black oak," chestnut oak, and pine (Table 18).



Landtype	Median	Minimum	5th percentile	95th percentile	Maximum
	------------	------------	------------ acres ------------	------------	------------
DO	47.0	2.1	15.4	274.0	2,322.9
DMMOH	32.4	2.1	15.6	127.8	634.0

Figure 23.—Frequency of patch sizes (acres) of landtypes within Ecological Subsection 221Ed on a $\log_{10}$ scale: (A) Dry Oak forest (DO) and (B) Dry-Mesic Mixed Oak Hardwood forest (DMMOH). The median (red) and 5th and 95th percentile (blue) values, tabulated below the graphs, are indicated by vertical lines.

Table 19.—Topographic and soil characteristics (mean, standard deviation) of ecological landtypes* within the Ohio portion of Ecological Subsection 221Ed – East Hocking Plateau

Characteristic (units)	Landtype: DO forest	Landtype: DMMOH forest	Landtype: RBMH forest	Average for Ohio portion of Subsection 221Ed
Area (acres)	571,638	400,887	382,119	1,354,643
Percentage of subsection area	42.2	29.6	28.2	N/A
Elevation (feet)	878 (132)	868 (135)	766 (132)	843 (133)
Slope (%)	22.4 (10.7)	24.0 (11)	12.4 (10.5)	20.0 (10.7)
Topographic roughness index (feet)	18.9 (9.2)	20.0 (9.5)	11.0 (10.7)	17.0 (9.7)
Aspect, Beers'	0.51 (0.52)	1.62 (0.33)	0.97 (0.71)	0.97 (0.52)
Northeast aspect (share of area; %)	23.0	88.4	44.3	51.9
Southwest aspect (share of area; %)	76.9	11.0	53.7	47.2
Integrated moisture index	20.5 (9.5)	39.3 (8.2)	30.8 (9.8)	29.0 (9.2)
Available water storage capacity (inches/inch)	6.54 (2.17)	6.75 (2.29)	8.78 (3.57)	7.23 (2.6)
Depth to water table (inches)	55.3 (25.5)	55.7 (25.2)	50.1 (25.2)	54.0 (25.3)

*Landtypes abbreviated as DO: Dry Oak; DMMOH: Dry-Mesic Mixed Oak Hardwood; RBMH: Rolling Bottomlands Mixed Hardwood.

Table 20.—Land cover by ecological landtype* within the Ohio portion of Ecological Subsection 221Ed – East Hocking Plateau (Source: Homer et al. 2015)

Land cover	Percent DO forest	Percent DMMOH forest	Percent RBMH forest	Percentage of Ohio portion of Subsection 221Ed
Water	0.16	0.23	2.07	0.72
Developed, open space	5.03	4.51	8.73	5.92
Developed, low intensity	0.89	0.96	3.28	1.59
Developed, medium intensity	0.20	0.26	0.89	0.41
Developed, high Intensity	0.04	0.06	0.20	0.09
Barren land	0.36	0.30	0.29	0.32
Deciduous forest	68.79	70.08	51.61	64.32
Coniferous forest	1.70	1.47	1.00	1.43
Mixed forest	0.07	0.07	0.05	0.06
Shrub/Scrub	0.65	0.74	0.36	0.60
Grassland/Herbaceous	3.15	3.02	3.22	3.13
Pasture/Hay	16.19	15.54	22.08	17.66
Cultivated crops	2.74	2.70	6.08	3.67
Woody wetlands	0.03	0.04	0.13	0.06
Emergent herbaceous wetlands	0.00	0.01	0.02	0.01
Area of landtype (acres)	571,638	400,887	382,119	1,354,643

*Landtypes abbreviated as DO: Dry Oak; DMMOH: Dry-Mesic Mixed Oak Hardwood; RBMH: Rolling Bottomlands Mixed Hardwood.

Table 21.—Pre-Euro-American settlement vegetation based on witness-tree percentages in each ecological landtype within the Ohio portion of Ecological Subsection 221Ed – East Hocking Plateau

Taxon*	Number of witness trees	Dry Oak forest	Dry-Mesic Mixed Oak Hardwood forest	Rolling Bottomlands Mixed Hardwood forest
		(Percentage of all trees in this landtype)		
White oak	1,076	39.4	36.5	30.5
Hickory	427	14.2	16.0	12.6
Beech	326	8.0	10.2	14.8
"Black oak"[†]	320	16.9	7.4	5.8
Sugar maple	139	2.3	5.1	7.1
Red maple	138	3.0	4.8	6.3
Tulip-poplar	93	2.3	4.4	2.9
Ash	92	2.4	3.8	3.1
Chestnut oak	90	4.5	3.4	0.8
Blackgum	50	0.9	2.4	1.9
Buckeye	50	0.3	1.6	3.3
Elm	42	0.7	0.6	3.0
Silver maple	41	1.3	1.2	1.7
Pine	40	2.4	0.2	0.9

*Taxa listed in order of abundance (>1 percent) within the ecological subsection.

[†]*Quercus velutina* and probably also *Q. rubra, Q. coccinea*, and other species of the red oak group.

3.3.5 East Hocking Plateau (Subsection 221Ed) Dry-Mesic Mixed Oak Hardwood Forest

The Dry-Mesic Mixed Oak Hardwood forest landtype occupies 400,887 acres or approximately 30 percent of the East Hocking Plateau subsection within Ohio. The topography is highly dissected and is northeasterly in aspect (Table 19). The median value for size of the landtype polygons is 32 acres; 90 percent of the polygons fall within a range of 16 to 128 acres (Fig. 23). This landtype has a high integrated moisture index score of 39 and has the wettest northeast-facing slopes. However, depth to water table is 8 inches greater than in the DMMOH landtype in the neighboring Western Hocking Plateau subsection. Current vegetation cover is mostly deciduous forest (70 percent) with a small amount of coniferous forest (1 percent). Land use includes some cultivated crops (3 percent), pasture or hay (16 percent), and developed land (6 percent) (Table 20). In the pre-Euro-American settlement forest, oaks and hickories were dominant, making up 63 percent of the witness trees. White oak (37 percent), hickory (16 percent), and beech (10 percent) were the most commonly recorded species on this landtype (Table 21).

3.3.6 East Hocking Plateau (Subsection 221Ed) Rolling Bottomlands Mixed Hardwood Forest

The Rolling Bottomlands Mixed Hardwood forest landtype occurs on the lowest landscape position within the East Hocking Plateau. This landtype spans 382,119 acres, nearly the same extent (28 percent) as the more upland DMMOH landtype within Ohio. The topography of this landtype is similar to the RBMH landtype in the neighboring Western Hocking Plateau subsection, but the river valleys here are generally very narrow relative to farther west. Current vegetation cover is less forested with only 52 percent in deciduous forest. Land use includes slightly more cultivated crops (6 percent) and pasture or hay (22 percent) with more developed land (13 percent) than the upland types (Table 20). Oaks and hickories were 50 percent of the witness trees in the pre-Euro-American settlement forest, while beech, maples, and other mesophytes were 42 percent. White oak (31 percent), beech (15 percent), and hickory (13 percent) were the most commonly recorded species on this landtype (Table 21). The following tree taxa showed site affinity for this landtype in the pre-Euro-American settlement forest: beech, sugar maple, red maple, elm, buckeye (Table 18).

3.3.7 Unglaciated Muskingum Plains (Subsection 221Ee) Dry Oak Forest

The Dry Oak forest landtype occurs across 91,774 acres or just over one-third (35 percent) of the Unglaciated Muskingum Plains subsection. Aspect is more southwesterly than northeasterly with a relatively low integrated moisture index score of 22. This landtype has the highest average elevation (912 feet) of all the landtypes in southeastern Ohio but is also gentle in topography due to glacial influences (Table 22, Fig. 5). The median value for size of the landtype polygons is 41 acres; 90 percent of the polygons fall within a range of 16 to 185 acres (Fig. 22). Current vegetation cover is only slightly more than half forested, with 52 percent deciduous forest and less than 1 percent coniferous forest. Land use includes cultivated crops (9 percent), pasture or hay (27 percent), and developed land (10 percent) (Table 23). This landtype occurs in a subsection where reclaimed surface mined land covers 8 percent of the Ohio portion (Table 12) and makes up at least some part of the 27 percent of land that is used for pasture or hay.

3.3.8 Unglaciated Muskingum Plains (Subsection 221Ee) Dry-Mesic Mixed Oak Hardwood Forest

The Dry-Mesic Mixed Oak Hardwood forest landtype occupies 78,956 acres or slightly less than one-third (30 percent) of the Unglaciated Muskingum Plains subsection. Aspect is more northeasterly than southwesterly. Although topography is gentle due to glacial influences, this landtype is one of the highest, with an average elevation of 903 feet (Table 22). The median value for size of the landtype polygons is 36 acres; 90 percent of the polygons fall within a range of 14 to 169 acres (Fig. 24). Current vegetation cover

Table 22.—Topographic and soil characteristics (mean, standard deviation) of ecological landtypes* within the Ohio portion of Ecological Subsection 221Ee – Unglaciated Muskingum Plains

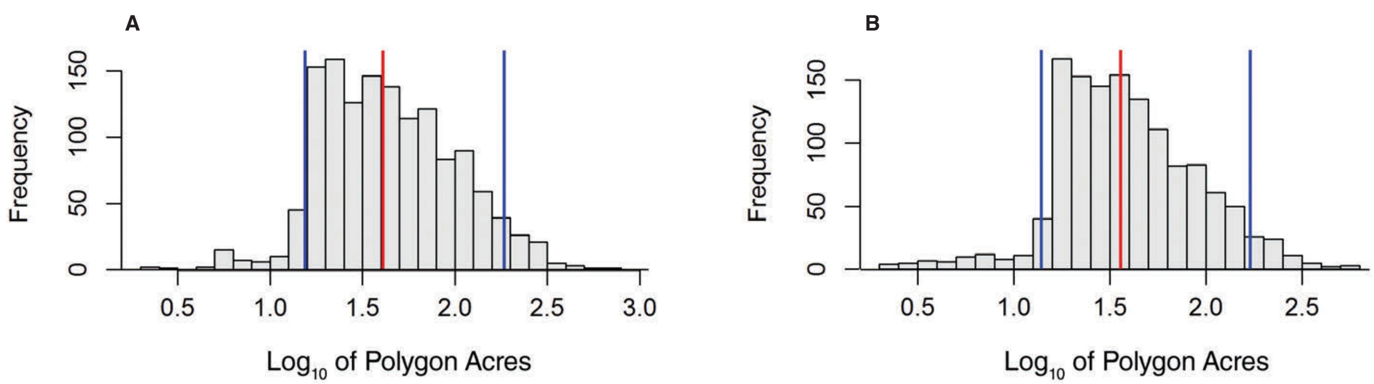
	Landtype			
Characteristic (units)	DO forest	DMMOH forest	RBMH forest	Average for Ohio portion of Subsection 221Ee
Area (acres)	91,774	78,956	93,591	264,321
Percentage of subsection area	34.7	29.9	35.4	N/A
Elevation (feet)	912 (80)	903 (84)	804 (77)	871 (80)
Slope (%)	17.0 (9.7)	17.1 (10.4)	7.6 (7.5)	13.7 (9.1)
Topographic roughness index (feet)	14.2 (8.3)	14.2 (8.9)	6.6 (6.5)	11.5 (7.8)
Aspect, Beers'	0.43 (0.44)	1.61 (0.34)	1.01 (0.71)	0.99 (0.5)
Northeast aspect (share of area; %)	17.2	85.3	43.1	48.5
Southwest aspect (share of area; %)	82.7	11.2	49.7	47.9
Integrated moisture index	21.7 (7.7)	37.6 (7.1)	31.2 (7.8)	29.8 (7.6)
Available water storage capacity (inches/inch)	7.94 (2.74)	8.15 (2.85)	10.27 (3.84)	8.83 (3.17)
Depth to water table (inches)	37.3 (25)	36.7 (24.7)	35.7 (26.8)	36.6 (25.5)

*Landtypes abbreviated as DO: Dry Oak; DMMOH: Dry-Mesic Mixed Oak Hardwood; RBMH: Rolling Bottomlands Mixed Hardwood.

Table 23.—Land cover by ecological landtype* within the Ohio portion of Ecological Subsection 221Ee – Unglaciated Muskingum Plains (Source: Homer et al. 2015)

Land cover	Percent DO forest	Percent DMMOH forest	Percent RBMH forest	Percentage of Ohio portion of Subsection 221Ee
Water	0.08	0.24	4.50	1.69
Developed, open space	6.98	6.89	8.65	7.55
Developed, low intensity	2.10	2.04	3.69	2.65
Developed, medium intensity	0.58	0.67	1.68	1.00
Developed, high intensity	0.20	0.25	0.78	0.42
Barren land	0.38	0.33	0.27	0.33
Deciduous forest	51.65	55.22	41.30	49.05
Coniferous forest	0.86	0.75	0.47	0.69
Mixed forest	0.00	0.00	0.02	0.01
Shrub/Scrub	0.14	0.21	0.14	0.16
Grassland/Herbaceous	1.48	1.40	1.41	1.43
Pasture/Hay	26.70	23.24	21.50	23.82
Cultivated crops	8.81	8.70	14.92	10.94
Woody wetlands	0.03	0.05	0.55	0.22
Emergent herbaceous wetlands	0.00	0.01	0.10	0.04
Area of landtype (acres)	91,774	78,956	93,591	264,321

*Landtypes abbreviated as DO: Dry Oak; DMMOH: Dry-Mesic Mixed Oak Hardwood; RBMH: Rolling Bottomlands Mixed Hardwood.



Landtype	Median	Minimum	5th percentile	95th percentile	Maximum
	acres				
DO	40.7	2.3	15.5	185.2	653.7
DMMOH	36.0	2.1	13.9	169.2	621.7

Figure 24.—Frequency of patch sizes (acres) of landtypes within Ecological Subsection 221Ee on a $\log_{10}$ scale: (A) Dry Oak forest (DO) and (B) Dry-Mesic Mixed Oak Hardwood forest (DMMOH). The median (red) and 5th and 95th percentile (blue) values, tabulated below the graphs, are indicated by vertical lines.

is mostly deciduous forest (55 percent) with less than 1 percent coniferous forest. Land use includes cultivated crops (9 percent), pasture or hay (23 percent), and developed land (10 percent) (Table 23). This landtype occurs in a subsection where reclaimed surface mined land covers 8 percent of the Ohio portion (Table 12) and makes up at least some part of the 23 percent of land that is used for pasture or hay.

3.3.9 Unglaciated Muskingum Plains (Subsection 221Ee) Rolling Bottomlands Mixed Hardwood Forest

The Rolling Bottomlands Mixed Hardwood forest landtype covers 93,591 acres, slightly more than the DO landtype within the project area portion of the Unglaciated Muskingum Plains subsection. Water storage capacity is the highest among all the landtypes at 10 inches per inch, but the integrated moisture index score is slightly drier at 31 in part because it includes some southwest-facing toe slopes. Average elevation is 804 feet, and the Licking and Muskingum Rivers form the major valleys (Table 22). Current vegetation cover is slightly less forested than the other two landtypes, with 41 percent deciduous forest. Land use includes slightly more cultivated crops (15 percent), pasture or hay (22 percent), and developed land (15 percent) (Table 23). This landtype also occurs in a subsection where reclaimed surface mined land covers 8 percent of the Ohio portion (Table 12) and makes up at least some part of the 21 percent of land that is used for pasture or hay.

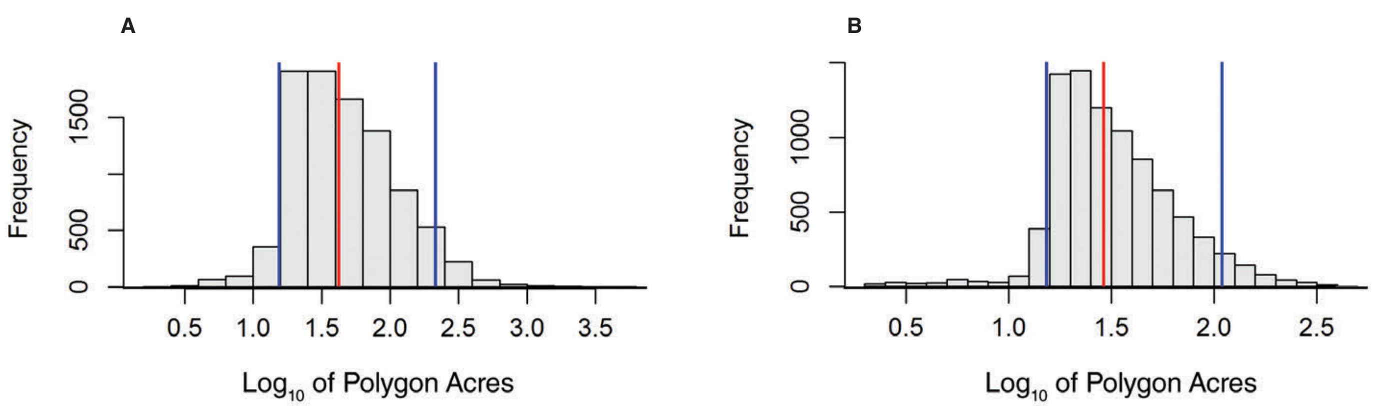
3.3.10 Western Hocking Plateau (Subsection 221Ef) Dry Oak Forest

The Dry Oak forest landtype covers 657,842 acres and most (42 percent) of the Ohio portion of the Western Hocking Plateau subsection. Aspect is mostly southwesterly, and average elevation is 864 feet (Table 24). The median value for size of the landtype polygons is 42 acres; 90 percent of the polygons fall within a range of 16 to 214 acres (Fig. 25). Current vegetation cover is mostly forested, with 73 percent deciduous forest and 4 percent coniferous forest. Land use includes a small amount of cultivated crops (2 percent) and pasture or hay (10 percent), with less than 5 percent

Table 24.—Topographic and soil characteristics (mean, standard deviation) of ecological landtypes* within the Ohio portion of Ecological Subsection 221Ef – Western Hocking Plateau

Characteristic (units)	Landtype: DO forest	Landtype: DMMOH forest	Landtype: RBMH forest	Average for Ohio portion of Subsection 221Ef
Area (acres)	657,842	433,634	491,480	1,582,955
Percentage of subsection area	41.5	27.4	31.1	N/A
Elevation (feet)	864 (104)	854 (107)	759 (106)	828 (106)
Slope (%)	22.3 (12.1)	23.8 (12.6)	12.7 (12)	19.7 (12.2)
Topographic roughness index (feet)	18.9 (10.3)	19.8 (10.8)	11.3 (11.4)	16.8 (10.8)
Aspect, Beers'	0.53 (0.54)	1.62 (0.34)	1.0 (0.71)	0.97 (0.54)
Northeast aspect (share of area; %)	24.4	87.6	44.5	52.2
Southwest aspect (share of area; %)	75.6	11.4	52.7	46.6
Integrated moisture index	20.9 (9.8)	38.8 (8.3)	30.8 (9.8)	28.9 (9.4)
Available water storage capacity (inches/inch)	6.55 (2.14)	6.76 (2.28)	8.85 (3.46)	7.32 (2.59)
Depth to water table (inches)	48.6 (25.4)	48.2 (25.4)	44.7 (26.5)	47.3 (25.8)

*Landtypes abbreviated as DO: Dry Oak; DMMOH: Dry-Mesic Mixed Oak Hardwood; RBMH: Rolling Bottomlands Mixed Hardwood.



Landtype	Median	Minimum	5th percentile	95th percentile	Maximum
	acres				
DO	42.2	2.1	15.6	214.4	4,921.2
DMMOH	29.0	2.1	15.3	109.5	422.5

Figure 25.—Frequency of patch sizes (acres) of landtypes within Ecological Subsection 221Ef on a $\log_{10}$ scale: (A) Dry Oak forest (DO) and (B) Dry-Mesic Mixed Oak Hardwood forest (DMMOH). The median (red) and 5th and 95th percentile (blue) values, tabulated below the graphs, are indicated by vertical lines.

developed land (Table 25). Historically, oaks and hickories were dominant, representing 74 percent of witness trees in this dry landtype. White oak, hickory, "black oak," and beech were the most commonly recorded tree species (Table 26). Chestnut oak and "black oak" were the only two taxa that showed a strong relationship to site for this landtype in the pre-Euro-American settlement forest (Table 18).

3.3.11 Western Hocking Plateau (Subsection 221Ef) Dry-Mesic Mixed Oak Hardwood Forest

The Dry-Mesic Mixed Oak Hardwood forest landtype occupies 433,634 acres or 27 percent of the Ohio portion of the Western Hocking Plateau subsection. Aspect is primarily northeasterly, and average elevation is 854 feet (Table 24). The median value for size of the landtype polygons is 29 acres; 90 percent of the polygons fall within a range of 15 to 110 acres (Fig. 25). Current vegetation is mostly deciduous forest (72 percent) with a small component of coniferous forest (3 percent). Land use includes a small amount of cultivated crops (3 percent) and pasture or hay (11 percent), with over 5 percent developed land (Table 25). Witness tree records list white oak, hickory, "black oak," and beech as the most commonly recorded tree species; oaks and hickories represented 66 percent of witness trees (Table 26). Hickory and American chestnut were significantly associated with this landtype, though chestnut was only 3 percent of the witness trees (Tables 18, 26).

3.3.12 Western Hocking Plateau (Subsection 221Ef) Rolling Bottomlands Mixed Hardwood Forest

The Rolling Bottomlands Mixed Hardwood forest landtype covers 491,480 acres, or 31 percent of the Ohio portion of the Western Hocking Plateau subsection. Average elevation is 759 feet (Table 24). This landtype contains the broad ancient Teays River Valley as well as several smaller river valleys (Hocking River, Salt Creek, Raccoon Creek). Current vegetation cover is just more than half forested with 57 percent deciduous forest and 2 percent coniferous forest. Land use includes cultivated crops (6 percent) and pasture or hay (16 percent) with approximately 13 percent developed land (Table 25). Witness tree data indicate that white oak, beech, and hickory were the most commonly recorded species on this landtype. Together, oaks and hickories made up 54 percent of witness trees. This landtype also showed a site affinity relationship for beech, sugar maple, red maple, ash, and elm; these species combined were 28 percent of witness trees (Tables 18, 26).

3.3.13 Lower Scioto River Plateau (Subsection 221Eg) Dry Oak Forest

The Dry Oak forest landtype occurs across 302,802 acres of the Ohio portion of the Lower Scioto River Plateau subsection along the western edge of the unglaciated Allegheny Plateau in Ohio. Aspect is mostly southwesterly, and the average elevation (911 feet) is the second highest

Table 25.—Land cover by ecological landtype* within the Ohio portion of Ecological Subsection 221Ef – Western Hocking Plateau (Source: Homer et al. 2015)

Land cover	Percent DO forest	Percent DMMOH forest	Percent RBMH forest	Percentage of Ohio portion of Subsection 221Ef
Water	0.07	0.17	1.38	0.50
Developed, open space	3.86	4.23	8.38	5.37
Developed, low intensity	0.65	0.89	2.96	1.43
Developed, medium intensity	0.18	0.30	1.01	0.47
Developed, high intensity	0.05	0.08	0.27	0.12
Barren land	0.41	0.35	0.34	0.37
Deciduous forest	73.38	72.11	57.07	67.97
Coniferous forest	3.92	3.24	2.14	3.18
Mixed forest	0.06	0.06	0.03	0.05
Shrub/Scrub	1.33	1.48	0.68	1.17
Grassland/Herbaceous	3.21	3.12	2.80	3.06
Pasture/Hay	10.48	11.28	16.33	12.52
Cultivated crops	2.39	2.68	6.48	3.74
Woody wetlands	0.01	0.02	0.11	0.04
Emergent herbaceous wetlands	0.00	0.00	0.03	0.01
Area of landtype (acres)	657,842	433,634	491,480	1,582,955

*Landtypes abbreviated as DO: Dry Oak; DMMOH: Dry-Mesic Mixed Oak Hardwood; RBMH: Rolling Bottomlands Mixed Hardwood.

of all the landtypes in southeastern Ohio (Table 27). The median value for size of the landscape polygons is 49 acres; 90 percent of the polygons fall within a range of 13 to 471 acres (Fig. 26). The landtype is dry and has a depth to water table of 49 inches. Current vegetation cover is mostly forested with 76 percent deciduous forest and 1 percent coniferous forest. Land use includes a component of cultivated crops (4 percent), pasture or hay (7 percent), and only 4 percent developed land (Table 28).

3.3.14 Lower Scioto River Plateau (Subsection 221Eg) Dry-Mesic Mixed Oak Hardwood Forest

The Dry-Mesic Mixed Oak Hardwood forest landtype covers 248,610 acres of the Ohio portion of the Lower Scioto River Plateau subsection along the western edge of the unglaciated Allegheny Plateau in Ohio. Aspect is primarily northeasterly, and average elevation is 881 feet (Table 27). The median value for size of landtype polygons is 37 acres; 90 percent of the polygons fall within a range of 13 to 266 acres (Fig. 26). This landtype has wetter northeastern slopes and an average water storage capacity of 8 inches per inch. Current vegetation cover is deciduous forest (66 percent) with a small component of coniferous forest (1 percent). Land use includes cultivated crops (8 percent), pasture or hay (8 percent), and developed land (5 percent) (Table 28).

Table 26.—Pre-Euro-American settlement vegetation based on witness-tree percentages in each ecological landtype within the Ohio portion of Ecological Subsection 221Ef – Western Hocking Plateau

Taxon*	Number of witness trees	Dry Oak forest	Dry-Mesic Mixed Oak Hardwood forest	Rolling Bottomlands Mixed Hardwood forest
		---------------------------	(Percentage of all trees in this landtype)	----------------------
White oak	1,215	35.8	35.3	33.8
Hickory	489	13.7	17.9	11.2
"Black oak"†	465	19.6	10.2	7.5
Beech	329	8.5	8.4	12.1
Blackgum	150	3.4	5.5	4.5
Red maple	121	2.2	2.6	6.3
Sugar maple	114	1.6	3.9	5.1
Chestnut oak	114	4.8	2.8	1.6
Tulip-poplar	107	3.4	3.7	2.1
Chestnut	86	2.8	3.3	1.3
Silver maple	56	1.5	1.1	2.3
Elm	42	0.3	0.7	3.0
Ash	38	0.5	1.3	1.8

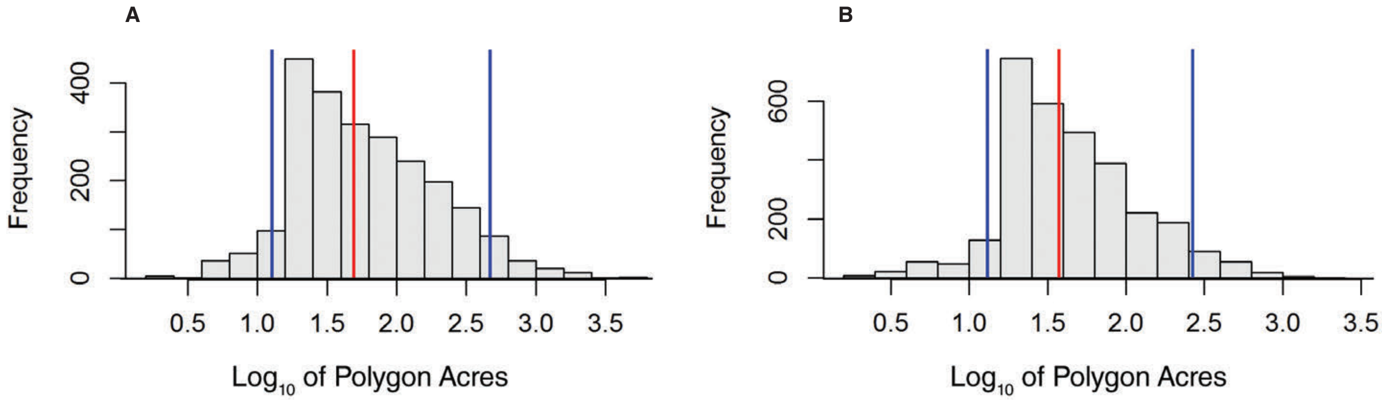
*Taxa listed in order of abundance (>1 percent) within the ecological subsection.

†*Quercus velutina* and probably also *Q. rubra, Q. coccinea*, and other species of the red oak group.

Table 27.—Topographic and soil characteristics (mean, standard deviation) of ecological landtypes* within the Ohio portion of Ecological Subsection 221Eg – Lower Scioto River Plateau

	Landtype			
Characteristic (units)	DO forest	DMMOH forest	RBMH forest	Average for Ohio portion of Subsection 221Eg
Area (acres)	302,802	248,610	259,214	810,625
Percentage of subsection area	37.4	30.7	32.0	N/A
Elevation (feet)	911 (165)	881 (173)	727 (150)	843 (163)
Slope (%)	23.9 (13.4)	22.3 (14.7)	10.0 (11.6)	19.0 (13.2)
Topographic roughness index (feet)	20.1 (11.5)	18.6 (12.6)	8.8 (12.4)	16.1 (12.1)
Aspect, Beers'	0.47 (0.49)	1.63 (0.33)	1.03 (0.71)	1.0 (0.51)
Northeast aspect (share of area; %)	20.1	83.9	44.2	49.4
Southwest aspect (share of area; %)	79.7	10.2	48.5	46.1
Integrated moisture index	20.5 (9.3)	39.1 (8.7)	31.1 (8.8)	29.6 (8.9)
Available water storage capacity (inches/inch)	7.46 (2.10)	7.92 (2.40)	9.66 (3.49)	8.31 (2.63)
Depth to water table (inches)	48.6 (23.8)	46.9 (23.7)	51.9 (25.3)	49.1 (24.2)

*Landtypes abbreviated as DO: Dry Oak; DMMOH: Dry-Mesic Mixed Oak Hardwood; RBMH: Rolling Bottomlands Mixed Hardwood.



Landtype	Median	Minimum	5th percentile	95th percentile	Maximum
	-----	-----	acres	-----	-----
DO	49.4	2.1	12.8	470.9	5,711.4
DMMOH	37.4	2.1	13.1	266.3	1,907.9

Figure 26.—Frequency of patch sizes (acres) of landtypes within Ecological Subsection 221Eg on a $\log_{10}$ scale: (A) Dry Oak forest (DO) and (B) Dry-Mesic Mixed Oak Hardwood forest (DMMOH). The median (red) and 5th and 95th percentile (blue) values, tabulated below the graphs, are indicated by vertical lines.

Table 28.—Land cover by ecological landtype* within the Ohio portion of Ecological Subsection 221Eg – Lower Scioto River Plateau (Source: Homer et al. 2015)

Land cover	Percent DO forest	Percent DMMOH forest	Percent RBMH forest	Percentage of Ohio portion of Subsection 221Eg
Water	0.07	0.25	2.18	0.80
Developed, open space	2.59	2.67	5.94	3.69
Developed, low intensity	1.01	1.37	3.75	2.00
Developed, medium intensity	0.34	0.64	1.49	0.80
Developed, high intensity	0.09	0.21	0.39	0.22
Barren land	0.17	0.16	0.12	0.15
Deciduous forest	75.57	66.17	43.88	62.55
Coniferous forest	1.15	1.09	1.26	1.16
Mixed forest	0.09	0.12	0.05	0.08
Shrub/Scrub	2.84	6.03	1.54	3.40
Grassland/Herbaceous	5.08	5.18	3.46	4.59
Pasture/Hay	6.95	8.18	17.75	10.78
Cultivated crops	4.05	7.92	18.10	9.73
Woody wetlands	0.01	0.01	0.08	0.03
Emergent herbaceous wetlands	0.00	0.00	0.03	0.01
Area of landtype (acres)	302,802	248,610	259,214	810,625

*Landtypes abbreviated as DO: Dry Oak; DMMOH: Dry-Mesic Mixed Oak Hardwood; RBMH: Rolling Bottomlands Mixed Hardwood.

3.3.15 Lower Scioto River Plateau (Subsection 221Eg) Rolling Bottomlands Mixed Hardwood Forest

The Rolling Bottomlands Mixed Hardwood forest landtype occupies 259,214 acres of the Ohio portion of the Lower Scioto River Plateau subsection along the western edge of the unglaciated Allegheny Plateau in Ohio. This landtype is the second flattest of all the landtypes in southeastern Ohio because of the wide Scioto River floodplain. It also has the second highest water storage capacity with 10 inches per inch. Current vegetation is deciduous forest (44 percent) with a small component of coniferous forest (1 percent). Land use includes cultivated crops (18 percent), pasture or hay (18 percent), and developed land (12 percent) (Table 28).

PART 4: FIELD VERIFICATION OF LANDTYPES

4.1 PRELIMINARY FIELD VERIFICATION

A preliminary field verification was performed during the development of landtype mapping (Iverson et al. 2018). For preliminary verification, forest inventory data were used both to assess current vegetation condition for oak-dominated forests and to validate landtypes. Understory and overstory inventory data came from a regional dataset of SILVAH inventory plots collected by public agencies across southeastern Ohio. The ODNR Divisions of Forestry and Wildlife have both adopted SILVAH and created datasets from their state forests (1,673 plots) and State Wildlife Management Units (1,133 plots), respectively. Additionally, the Wayne National Forest provided data from 104 plots for a combined total of 2,910 georeferenced plots. Overstory and understory data collection protocols for SILVAH plots are described in Brose et al. (2008), and analytical protocols are described in Iverson et al. (2018). All plot data were placed into a GIS to assess spatial relationships between oak composition and the proposed landtypes. These overstory and understory metrics were used to assign and map both overstory and understory conditions of oak dominance for selected areas where SILVAH inventories have been completed. As reported in Iverson et al. (2018), the ability of the model to predict an oak-dominated overstory on the Dry Oak landtype was rated as "good." The Dry Oak landtype also showed a much higher proportion of plots classified as stocked for oak, as compared to the other two landtypes.

4.2 FUTURE FIELD VERIFICATION

There is a need for additional verification of the landtype mapping using other existing datasets supplemented by field-checking. First, other independent datasets are available for the study region from various university studies; these should be searched out and used if appropriate. Further field verification includes the collection of vegetation, soil, and site data from a subset of landtypes following the steps outlined next.

1. Site information
    - 1.1 Randomly select between 1 and 5 percent of the polygons for each landtype (Figs. 22–26).
    - 1.2 Select one centrally located plot and monument the center from which all data can be collected to facilitate the integration of vegetation, soils, and site data to describe and verify the landtype.
    - 1.3 Site information should include plot number and global positioning system coordinates, general location information (such as landmarks), and notes on plot surroundings.
2. Vegetation
    - 2.1 Photograph panoramic view of plot vegetation.
    - 2.2 Collect overstory composition data.
    - 2.3 Collect understory composition data.
    - 2.4 Collect ground surface cover data.
3. Site productivity
    - 3.1 Calculate site index if acceptable trees are present.
    - 3.2 Dig soil pit to characterize soils.
4. Compare sampling results to landtype descriptions.
5. Document results and refine descriptions as needed.

4.3 PEER REVIEW

The effort to classify, map, and describe 15 landtypes in southeastern Ohio has been accomplished through a collaborative all-lands approach. In addition to peer review within the USDA Forest Service, the following partners have participated in review of mapping concepts and products: USDA Natural Resources Conservation Service; Ohio Department of Natural Resources Division of Forestry, Division of Wildlife, and Division of Natural Areas and Preserves; Ohio State University; Ohio University; The Nature Conservancy; and the National Wild Turkey Federation.

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APPENDIX 1: NAMES OF TREE SPECIES

Table 29.—Common and scientific names of tree species recorded by the Forest Service, Forest Inventory and Analysis (FIA) for the 17-county project area within Section 221E

FIA code*	Common name	Scientific name
951	American basswood	*Tilia americana*
531	American beech	*Fagus grandifolia*
972	American elm	*Ulmus americana*
591	American holly	*Ilex opaca*
391	American hornbeam; musclewood	*Carpinus caroliniana*
743	bigtooth aspen	*Populus grandidentata*
402	bitternut hickory	*Carya cordiformis*
762	black cherry	*Prunus serotina*
901	black locust	*Robinia pseudoacacia*
314	black maple	*Acer nigrum*
837	black oak	*Quercus velutina*
602	black walnut	*Juglans nigra*
922	black willow	*Salix nigra*
693	blackgum	*Nyssa sylvatica*
824	blackjack oak	*Quercus marilandica*
546	blue ash	*Fraxinus quadrangulata*
842	bluejack oak	*Quercus incana*
313	boxelder	*Acer negundo*
823	bur oak	*Quercus macrocarpa*
601	butternut	*Juglans cinerea*
832	chestnut oak	*Quercus prinus*
826	chinkapin oak	*Quercus muehlenbergii*
763	chokecherry	*Prunus virginiana*
521	common persimmon	*Diospyros virginiana*
651	cucumbertree	*Magnolia acuminata*
742	eastern cottonwood	*Populus deltoides*
261	eastern hemlock	*Tsuga canadensis*
701	eastern hophornbeam; ironwood	*Ostrya virginiana*
68	eastern red cedar	*Juniperus virginiana*
471	eastern redbud	*Cercis canadensis*
129	eastern white pine	*Pinus strobus*
491	flowering dogwood	*Cornus florida*
544	green ash	*Fraxinus pennsylvanica*
462	hackberry	*Celtis occidentalis*
552	honeylocust	*Gleditsia triacanthos*
131	loblolly pine	*Pinus taeda*
555	loblolly-bay	*Gordonia lasianthus*
409	mockernut hickory	*Carya tomentosa*
452	northern catalpa	*Catalpa speciosa*
833	northern red oak	*Quercus rubra*
331	Ohio buckeye	*Aesculus glabra*
641	Osage-orange	*Maclura pomifera*
367	pawpaw	*Asimina triloba*
403	pignut hickory	*Carya glabra*
761	pin cherry	*Prunus pensylvanica*
830	pin oak	*Quercus palustris*
126	pitch pine	*Pinus rigida*
835	post oak	*Quercus stellata*
746	quaking aspen	*Populus tremuloides*
316	red maple	*Acer rubrum*
682	red mulberry	*Morus rubra*
125	red pine	*Pinus resinosa*
373	river birch	*Betula nigra*
977	rock elm	*Ulmus thomasii*
931	sassafras	*Sassafras albidum*
806	scarlet oak	*Quercus coccinea*
356	serviceberry	*Amelanchier* spp.
407	shagbark hickory	*Carya ovata*
405	shellbark hickory	*Carya laciniosa*
817	shingle oak	*Quercus imbricaria*
317	silver maple	*Acer saccharinum*
975	slippery elm	*Ulmus rubra*
711	sourwood	*Oxydendrum arboreum*
315	striped maple	*Acer pensylvanicum*
318	sugar maple	*Acer saccharum*
804	swamp white oak	*Quercus bicolor*
372	sweet birch	*Betula lenta*
611	sweetgum	*Liquidambar styraciflua*
731	sycamore	*Platanus occidentalis*
132	Virginia pine	*Pinus virginiana*
541	white ash	*Fraxinus americana*
802	white oak	*Quercus alba*
766	wild plum	*Prunus americana*
971	winged elm	*Ulmus alata*
371	yellow birch	*Betula alleghaniensis*
332	yellow buckeye	*Aesculus octandra*
621	yellow-poplar	*Liriodendron tulipifera*

*Species code used by FIA.

APPENDIX 2: METHODS TO CREATE LANDTYPE AND LANDTYPE PHASE MAPS

Generating landtypes and landtype phases was accomplished across the 5 subsections of Section 221E within the 17-county project area in Ohio. The primary data needed to model landtypes were generated from a digital elevation model (DEM) at 10-m (32.8-foot) resolution, obtained from the Ohio Environmental Protection Agency, Division of Emergency and Remedial Response. Derivatives of the DEM used for modeling landtypes were all generated within Esri® (Redlands, CA) ArcGIS, and each of the derivatives, or intermediate products necessary for the final products, is presented in a flowchart (Fig. 27).

Aspect was transformed to a scale from 0 to 2 according to Beers et al. (1966), where "2" indicates cool, northeast-facing (NE) slopes and 0 indicates warm, southwest-facing (SW) slopes. Slope angle was used to designate flat areas (<15 percent slope, such as valley bottoms and ridge tops).

Topographic position index, or TPI (Jenness et al. 2011), was used to identify slope positions. It is simply the difference between the elevation value of a focal cell and the average elevation of the neighborhood radius around that cell. Positive values mean the cell is of higher elevation than its neighborhood; negative values mean it is lower. Highest positive values occur on ridges, and lowest negative values occur in valley bottoms. Therefore, TPI can be used to classify slope position by changing the thresholds within the TPI (Land Facet Corridor Designer; Jenness et al. 2011). In this effort, we used a radius of 50 m (164 feet) and adjusted TPI cutoffs within the software to distinguish upper slopes from lower slopes in this tightly dissected region. A TPI with a radius of 600 m (1,969 feet) was used for determining the broad, flat valley bottoms. Another derivative from TPI at 164 feet was the slope position tool within the Land Facet Corridor Designer to pull out narrow valleys and ridge tops.

By combining the Beers' aspect map (NE versus SW slopes) with the TPI-defined upper versus lower slopes, we generated

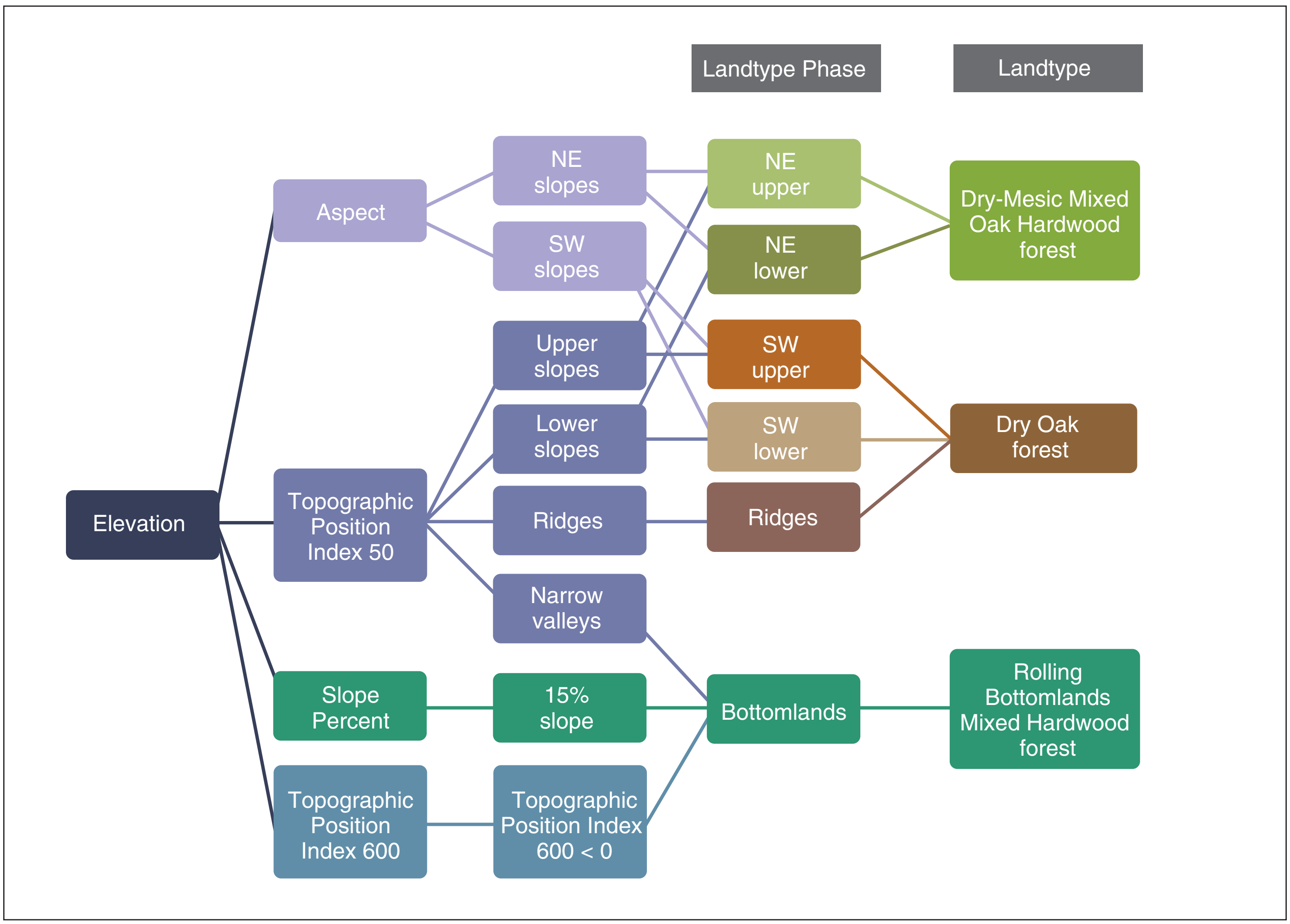

Figure 27.—Flowchart showing flow of ArcGIS processing to produce the landtype phases and landtypes.

four new classes important for ecological mapping: SW upper, SW lower, NE upper, and NE lower slopes. The combination of ridges and valleys from the 164-foot radius slope position with the four slope classes yielded a six-class landtype phases map with one exception. The broad, flat valleys needed to be "burned in," or overlaid with priority, as a last step to accommodate these prominent features. We chose to eliminate them from consideration for intentional oak regeneration management. This final combination produced a six-class map of landtype phases, ranging from the dry ridges to dry SW slopes to moist NW slopes and rolling bottomlands. (Note that bottomlands are called rolling in that the broad bottomlands class did contain some lower slopes from all aspects, but hereafter, they will be referred to just as "bottomlands forest.")

Finally, the six landtype phases were reduced to three landtype classes by using field data (e.g., Iverson et al. 2017), solar radiation, and soil moisture characteristics from integrated moisture index modeling (Iverson et al. 1997) to collapse the ridge, SW upper, and SW lower slopes into the Dry Oak forest landtype, and the NE upper and NE lower phases into the Dry-Mesic Mixed Oak Hardwood forest landtype. The rolling bottomlands class remained as the Rolling Bottomlands Mixed Hardwood forest landtype.

The agencies owning most of the public land in the study area also provided detailed geographic information system layers of their ownership and stand boundaries. Ohio Department of Natural Resources' Divisions of Forestry and Wildlife and the Wayne National Forest use stand boundaries for management, even though the boundaries are dynamic. In this study, ownership boundaries were used to summarize landtypes as well as to report plot-level data.

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APPENDIX 3: DISTRIBUTION OF LANDTYPES WITHIN SOUTHEASTERN OHIO AND RELATIONSHIPS TO ANCILLARY DATA

The map of landtype phases, the initial 6-class product, reveals a complex, dissected landscape with many ridgelines and drainages in the 5 subsections of Section 221E within the 17-county project area in Ohio (Fig. 28). The map is simply derived from derivatives of the digital elevation model (cell size of 10 m, or 32.8 feet) so that the outcomes can be logically deduced from a compass and observations in the field. This map has a resolution of only 10 m × 10 m; many small patches are prevalent, and the map is too fine-grained for operational-scale management. A thinning and smoothing algorithm was used to smooth the data to a version that removes many small patches, which is more practical for field use and land management application. Nonetheless, the full-resolution map was used for all statistical summaries so as to not distort the role of some of the smaller side slopes or ridge patches.

Similarly, the three-class landtype map, as collapsed from the landtype phase map, shows again the complex nature of the landscape but at a scale that correlates better with forest types and stand mapping. The Dry Oak forest (DO) landtype is prominently featured on ridges and southwest-facing slopes (Fig. 29, map in pocket at back of document). Within the stands delineated in the Bailey's project area on the Wayne National Forest, the DO landtype ranges from 16 to 70 percent, and 10 of the 17 stands have at least 50 percent mapped as DO landtype. These stands have higher potential site productivity and greater propensity overall for regenerating oak (see Appendix 1 for tree species names).

Over the 17-county area, about 87 percent of the land is privately owned, with the remaining divided between State (8 percent) and Federal (5 percent) ownerships (Table 30). The model places about 41 percent of the landscape, or about 1.98 million acres out of 4.83 million acres, into the DO landtype. For stands being managed by the Wayne National Forest, 48 percent were classified as DO, or about 116,512 acres out of the 243,946 acres; and for stands under management by Ohio Department of Natural Resources' (ODNR's) Division

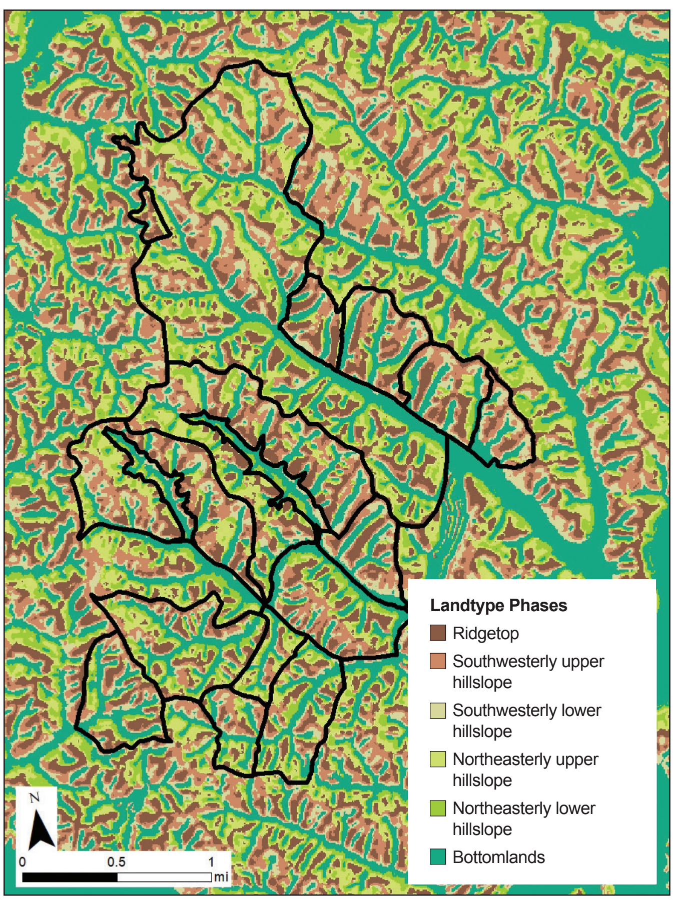

Figure 28.—Subsection 221Ed – East Hocking Plateau landtype phases in the Bailey's Project Area (outlined in black) on the Wayne National Forest in Athens County, Ohio.

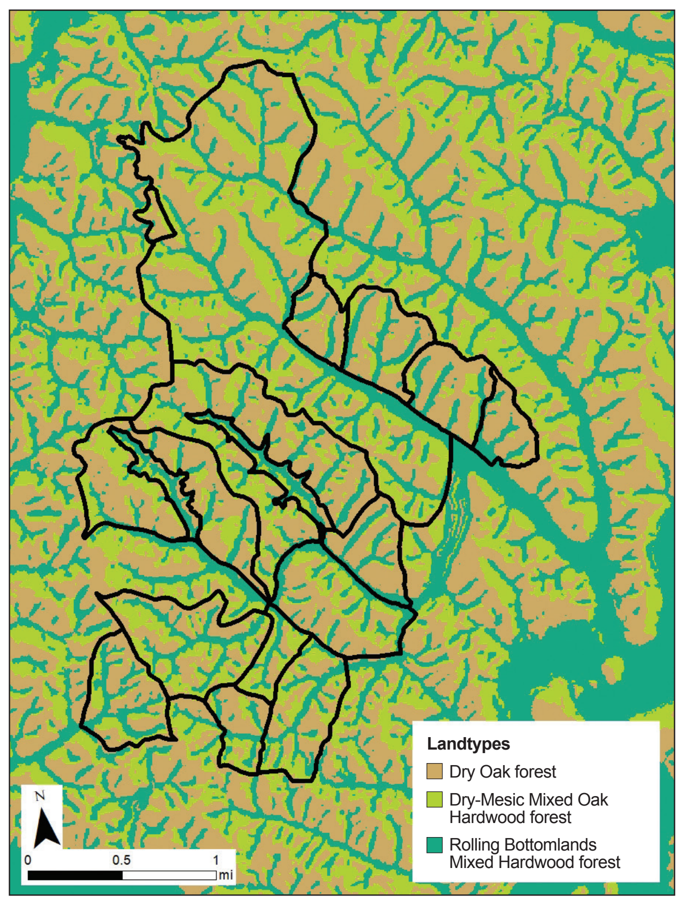

Figure 29.—Subsection 221Ed – East Hocking Plateau landtypes in the Bailey's Project Area (outlined in black) on the Wayne National Forest in Athens County, Ohio.

of Forestry, 49 percent are in the DO landtype. The other State ownerships—Wildlife, Natural Areas and Preserves, and Parks—each have a more evenly distributed area across the three landtypes. Each ownership has less than 44 percent in the DO landtype, whereas private land has only 40 percent in this class (Table 30). On land managed by agencies with objectives extending beyond forest management (ODNR Divisions of Wildlife, Natural Areas and Preserves, and Parks), and over the 17-county project area, there are many broad river valleys that reduce the overall proportion of DO (to about 41 percent) as compared to the national forest land (about 48 percent).

In the study area, the five ecological subsections (see Figure 1 in part 1.5 and Figure 2 in part 2.1 of the main text) were also overlain to assess the proportion of landtypes within each. The more dissected subsections of the Ohio Valley Lowland, East Hocking Plateau, and Western Hocking Plateau have the largest proportions of DO landtype (41.5–44.3 percent). The relatively flatter Unglaciated Muskingum Plains and Lower Scioto River Plateau have the largest share of bottomlands forest (32.0–35.4 percent) (Table 30).

The relationship of the landtypes and landtype phases to the integrated moisture index (IMI; Iverson et al. 1997) is apparent, especially for sloping lands (Table 31). The index was much higher on northeast-facing slopes (Dry-Mesic Mixed Oak Hardwood forest; DMMOH) than ridges and especially southwest-facing slopes (DO). The RBMH class (identical for both landtype and landtype phase) has a somewhat lower IMI (drier) than the northeast-facing slopes. This is expected because, by definition, the bottomlands are a broad class (using the topographic position index with a radius of 1,969 feet) intended to include some lower slopes of all aspects and allow for riparian forests to remain mostly intact. The IMI is related to many ecological phenomena driven by moisture, including oak-hickory regeneration (Iverson et al. 2017), but it is not very effective in two situations: when the landscape has broad valleys of flat land, and when there are very long slopes. The current ecological mapping effort addresses these shortcomings and models across broad expanses of southern Ohio.

Table 30.—Area and percentage of land in each of three landtypes* for the 17-county project area within Section 221E, by ownership class and ecological subsection

Name	Area (acres)	Percentage of area	Percent DO forest	Percent DMMOH forest	Percent RBMH forest
17-County project area	4,830,424	100	41.1	29.1	29.7
Privately owned land	4,215,771	87.3	40.3	29.2	30.4
State land					
Forestry	185,952	3.8	49.1	28.0	22.9
Natural Areas and Preserves	11,779	0.2	43.9	31.0	25.1
Parks	25,636	0.5	37.4	23.1	39.5
Wildlife	160,854	3.3	42.5	29.0	28.5
Total or average	384,222	8.0	43.2	27.8	29.0
Wayne National Forest					
Athens District	72,481	1.5	46.2	28.5	25.4
Ironton District	106,776	2.2	48.3	27.1	24.6
Marietta District	64,690	1.3	48.8	30.9	20.4
Total or average	243,946	5.1	47.8	28.8	23.4
Federal and State-owned land	628,168	13.0	46.3	28.3	25.4
Ecological subsections					
Ohio Valley Lowland (221Ec)	817,886	16.9	44.3	30.0	25.7
East Hocking Plateau (221Ed)	1,354,643	28.0	42.2	29.6	28.2
Unglaciated Muskingum Plains (221Ee)	264,321	5.5	34.7	29.9	35.4
Western Hocking Plateau (221Ef)	1,582,955	32.8	41.5	27.4	31.1
Lower Scioto River Plateau (221Eg)	810,625	16.8	37.4	30.7	32.0

*Landtypes abbreviated as DO: Dry Oak; DMMOH: Dry-Mesic Mixed Oak Hardwood; RBMH: Rolling Bottomlands Mixed Hardwood.

Table 31.—Integrated moisture index (IMI) values* for each landtype and landtype phase† for the 17-county project area within Section 221E

Landtype	IMI mean	IMI median
DO forest	20.4	19
DMMOH forest	38.0	38
RBMH forest	30.3	30
Landtype phase‡		
Ridge	26.8	28
SW upper	18.4	19
SW lower	18.1	17
NE upper	35.8	36
NE lower	39.4	40
Bottomland	30.3	30

*Higher IMI values equate to higher long-term soil moisture.
†Landtypes abbreviated as: DO = Dry Oak; DMMOH = Dry-Mesic Mixed Oak Hardwood; RBMH = Rolling Bottomlands Mixed Hardwood.
‡SW = southwest-facing slope; NE = northeast-facing slope.

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APPENDIX 4: SPATIAL TRENDS AMONG SUBSECTIONS

Here we briefly present selected data and analyses among ecological subsections of Section 221E to enable comparison and a closer look at selected conditions present within each subsection.

GEOLOGY AND SOILS

Soil texture, based on percent sand and clay, shows a trend of increasing coarseness moving from east to west within this area of Ohio (Table 32). This is linked to a greater permeability (higher Ksat values) of the soils in the western subsections. With regard to pH, the weathered, unglaciated soils tend to be acidic. The western portions of the area have very low pHs. The northern part of Subsection 221Ed has the highest pH due to the greater levels of underlying limestone. In addition, some locations with high pHs (≥7.3) are highly basic mine soils. Many of these trends can be related to the age of the soils, with the western subsections having much older and more weathered soils (Table 4 in part 3.1).

CURRENT LAND COVER

All subsections within the Ohio portion of Section 221E are highly forested with deciduous forest. All but Subsection 221Ee have over 62 percent deciduous forest (Table 33). Subsection 221Ee is an anomaly in our study because its Ohio piece is only a small part (15 percent) of the overall subsection, and it extends northward into the highly agricultural regions of the State (10.9 percent cropland, 23.8 percent pasture or hay). Subsection 221Eg has the next greatest share of cropland, with 9.7 percent cultivated land. The most forest is found in Subsection 221Ef, where land cover is 68 percent deciduous forest, plus 3.2 percent coniferous forest and a very small component of mixed forest.

WETLANDS

The National Wetlands Inventory data allowed a tally of wetland acreages by subsection both across the entire section (Fig. 21 in part 3.2.2) and for those areas within Ohio (Table 34). Overall, the highest percentage of wetlands exists in Subsection 221Ee, with 5.8 percent of the area classified as wetlands, including 2.5 percent as lakes, and 2.3 percent as pond-related wetlands within Ohio. The flatter topography of this subsection supports more extensive wetland areas. Subsections 221Ef and 221Eg to the west also had relatively higher percentages of wetlands (2.2–2.4 percent) as compared to the eastern subsections 221Ec and 221Ed.

CURRENT TREES

We here present data on the Ohio portion of the Forest Service, Forest Inventory and Analysis (FIA) data within each of five subsections, to supplement the information in Table 7 in part 3.1.3. In the following tables, data are presented in decreasing rank order of importance (FIAsum) based on the number of stems, basal area, and areal coverage of each species among plots. This provides a general estimate of the abundance of each species within the subsection. Also provided in each table is the average importance value (FIAi), showing the importance of the species in the plots where it exists (not across the entire subsection). This gives an estimate of the prominence of the species wherever it does occur. For example, a plantation species may have a high FIAi but lower FIAsum because it is common in a few plots but uncommon across the entire subsection.

Table 32.—Soil characteristics (mean, standard deviation) within the Ohio portion of five ecological subsections of Section 221E

	Subsection				
	221Ec – Ohio Valley Lowland	221Ed – East Hocking Plateau	221Ee – Unglaciated Muskingum Plains	221Ef – Western Hocking Plateau	221Eg – Lower Scioto River Plateau
Sand (%)	18.8 (11.4)	18.9 (11.6)	22.0 (16.5)	27.3 (15.3)	22.4 (11.4)
Clay (%)	32.0 (7.67)	32.8 (7.96)	25.8 (6.97)	25.4 (6.9)	26.1 (7.72)
pH	5.37 (0.53)	5.70 (0.68)	5.61 (0.68)	5.13 (0.53)	5.25 (0.81)
Ksat (μm/sec)	8.63 (12.85)	7.96 (10.67)	10.81 (17.17)	12.93 (12.92)	14.39 (20.89)

Table 33.—Land cover percentages, as of 2011, within the Ohio portion of five ecological subsections of Section 221E

	Subsection				
Land cover	221Ec – Ohio Valley Lowland	221Ed – East Hocking Plateau	221Ee – Unglaciated Muskingum Plains	221Ef – Western Hocking Plateau	221Eg – Lower Scioto River Plateau
	---------- *percent* ----------				
Water	0.75	0.71	1.69	0.50	0.79
Developed, open space	6.43	5.92	7.55	5.37	3.69
Developed, low intensity	1.36	1.59	2.65	1.43	2.00
Developed, medium intensity	0.40	0.41	1.00	0.47	0.80
Developed, high intensity	0.11	0.09	0.42	0.12	0.22
Barren land	0.10	0.32	0.33	0.37	0.15
Deciduous forest	67.74	64.33	49.05	67.97	62.56
Evergreen forest	1.85	1.43	0.69	3.18	1.16
Mixed forest	0.05	0.06	0.01	0.05	0.08
Shrub/Scrub	0.25	0.60	0.16	1.17	3.40
Grassland/Herbaceous	0.97	3.13	1.43	3.06	4.59
Pasture/Hay	15.07	17.66	23.82	12.52	10.78
Cultivated crops	4.88	3.67	10.94	3.74	9.73
Woody wetlands	0.02	0.06	0.22	0.04	0.03
Emergent herbaceous wetlands	0.01	0.01	0.04	0.01	0.01
Area of landtype (acres)	817,886	1,354,643	264,321	1,582,955	810,625

Table 34.—Wetland acreages, and percentage of land, within the Ohio portion of five ecological subsections of Section 221E

				Subsection									
				221Ec – Ohio Valley Lowland		221Ed – East Hocking Plateau		221Ee – Unglaciated Muskingum Plains		221Ef – Western Hocking Plateau		221Eg – Lower Scioto River Plateau	
System	Subsystem	Class	Wetland type	Acres	Percentage	Acres	Percentage	Acres	Percentage	Acres	Percentage	Acres	Percentage
Lacustrine	Limnetic	Unconsolidated bottom	Lake	610.5	0.1	4,977.0	0.4	1,980.9	0.7	2,967.0	0.2	947.4	0.1
	Littoral	Aquatic bed	Lake	--	--	--	--	--	--	14.5	0.0	--	--
		Unconsolidated bottom	Lake	--	--	242.7	0.0	4,669.5	1.8	37.8	0.0	20.5	0.0
		Unconsolidated shore	Lake	3.9	0.0	6.8	0.0	--	--	--	--	18.1	0.0
Palustrine		Aquatic bed	Freshwater pond	0.7	0.0	61.7	0.0	14.3	0.0	154.9	0.0	25.9	0.0
		Aquatic bed/emergent	Freshwater pond	--	--	--	--	--	--	15.1	0.0	5.2	0.0
		Aquatic bed/unconsolidated bottom	Freshwater pond	0.4	0.0	--	--	--	--	11.0	0.0	2.8	0.0
		Emergent	Freshwater emergent wetland	682.3	0.1	2,416.6	0.2	1,309.2	0.5	5,064.6	0.3	2,197.9	0.3
		Emergent/forested	Freshwater emergent wetland	--	--	2.4	0.0	--	--	--	--	--	--
		Emergent/unconsolidated bottom	Freshwater emergent wetland	13.9	0.0	155.7	0.0	--	--	100.7	0.0	7.0	0.0
		Forested	Freshwater forested/shrub wetland	870.4	0.1	1,608.2	0.1	2,328.7	0.9	5,541.6	0.4	3,514.9	0.4
		Forested/emergent	Freshwater forested/shrub wetland	53.1	0.0	127.7	0.0	51.5	0.0	386.3	0.0	34.7	0.0
		Forested/scrub-shrub	Freshwater forested/shrub wetland	271.3	0.0	1051.6	0.1	242.4	0.1	5,254.7	0.3	1,090.5	0.1
		Forested/unconsolidated bottom	Freshwater forested/shrub wetland	--	--	--	--	--	--	8.5	0.0	7.8	0.0
		Scrub-shrub	Freshwater forested/shrub wetland	172.2	0.0	396.4	0.0	378.1	0.1	2,556.2	0.2	367.7	0.0
		Scrub-shrub/emergent	Freshwater forested/shrub wetland	211.0	0.0	1,103.8	0.1	481.5	0.2	2,431.8	0.2	401.7	0.0
		Scrub-shrub/unconsolidated bottom	Freshwater forested/shrub wetland	--	--	5.6	0.0	--	--	8.3	0.0	--	--
		Unconsolidated bottom	Freshwater pond	2,279.8	0.3	8,021.3	0.6	1,426.4	0.5	7,659.7	0.5	2,191.3	0.3
		Unconsolidated bottom/forested	Freshwater pond	--	--	4.3	0.0	--	--	--	--	--	--
		Unconsolidated shore	Freshwater pond	--	--	20.1	0.0	--	--	11.7	0.0	--	--
			Freshwater emergent wetland	--	--	--	--	--	--	--	--	85.2	0.0
			Freshwater forested/shrub wetland	--	--	--	--	--	--	--	--	33.6	0.0
			Freshwater pond	--	--	--	--	--	--	--	--	9.7	0.0
Riverine	Intermittent	Streambed	Riverine	2.0	0.0	3.4	0.0	--	--	4.4	0.0	20.1	0.0
	Lower Perennial	Unconsolidated bottom	Riverine	7,397.4	0.9	4,503.7	0.3	2,481.8	0.9	5,232.3	0.3	6,176.3	0.8
		Unconsolidated shore	Riverine	51.4	0.0	0.7	0.0	13.2	0.0	14.6	0.0	209.8	0.0
	Upper Perennial	Unconsolidated bottom	Riverine	23.5	0.0	164.9	0.0	1.5	0.0	208.7	0.0	104.2	0.0
		Unconsolidated shore	Riverine	--	--	--	--	--	--	0.7	0.0	--	--
				Acres	Percentage	Acres	Percentage	Acres	Percentage	Acres	Percentage	Acres	Percentage
			Total area of wetlands	12,643.8	1.5	24,874.7	1.8	15,378.8	5.8	37,685.1	2.4	17,472.2	2.2

Subsection 221Ec

The species with the highest importance values in the Ohio portion are also the most important species for the subsection as a whole (Table 7, Table 35) but have somewhat different rankings. Of the 68 species recorded in the entire subsection, FIA records 59 species in the Ohio portion. Sugar maple, red maple, white oak, and yellow-poplar have the highest FIAsum values, followed by Virginia pine, northern red oak, black cherry, and white ash.

Subsection 221Ed

The species with the highest importance values in the Ohio portion are almost identical to the most important species for the subsection as a whole (Table 7, Table 36) but have somewhat different rankings. FIA records 64 species, most of the 69 species found in the entire subsection (the Ohio portion is 69 percent of the subsection's area). Sugar maple, yellow-poplar, American elm, white ash, red maple, white oak, and black locust have the highest FIAsum values.

Table 35.—Tree species (n = 59) recorded by the Forest Service, Forest Inventory and Analysis (FIA), sorted by decreasing importance* within the Ohio portion of Subsection 221Ec – Ohio Valley Lowland

FIA code†	Common name	FIAi‡	FIAsum	N
318	sugar maple	13.24	699.31	1
316	red maple	10.54	598.10	2
802	white oak	11.45	562.90	3
621	yellow-poplar	10.05	440.49	4
132	Virginia pine	12.89	245.13	5
833	northern red oak	5.37	232.62	6
762	black cherry	6.05	231.96	7
541	white ash	5.79	221.95	8
901	black locust	6.40	211.16	9
972	American elm	5.08	194.25	10
407	shagbark hickory	4.89	191.39	11
129	eastern white pine	16.87	175.75	12
931	sassafras	4.53	174.94	13
837	black oak	4.42	147.98	14
975	slippery elm	3.75	143.32	15
602	black walnut	4.19	140.29	16
403	pignut hickory	4.04	133.45	17
531	American beech	4.55	129.05	18
409	mockernut hickory	3.45	93.43	19
332	yellow buckeye	5.55	92.28	20
402	bitternut hickory	3.91	88.18	21
743	bigtooth aspen	5.23	61.80	22
693	blackgum	2.15	59.14	23
731	sycamore	3.86	58.27	24
491	flowering dogwood	2.82	48.87	25
331	Ohio buckeye	5.32	47.72	26
832	chestnut oak	2.39	42.46	27
313	boxelder	3.28	39.46	28
806	scarlet oak	2.90	35.67	29
367	pawpaw	2.19	35.06	30
641	Osage-orange	9.72	27.50	31
711	sourwood	2.50	24.83	32
701	eastern hophornbeam; ironwood	1.42	23.60	33
951	American basswood	1.99	19.04	34
391	American hornbeam; musclewood	1.25	17.97	35
521	common persimmon	3.56	12.07	36
314	black maple	2.49	11.03	37
544	green ash	2.17	9.71	38
471	eastern redbud	0.90	9.70	39
317	silver maple	3.35	7.18	40
126	pitch pine	2.00	5.95	41
131	loblolly pine	2.84	5.74	42
826	chinkapin oak	1.68	5.38	43
462	hackberry	1.98	4.47	44
405	shellbark hickory	6.69	3.55	45
356	serviceberry	0.76	2.66	46
372	sweet birch	5.67	2.03	47
651	cucumbertree	0.90	1.82	48
261	eastern hemlock	0.78	1.39	49
552	honeylocust	3.36	0.78	50
763	chokecherry	0.79	0.73	51
68	eastern red cedar	0.48	0.46	52
601	butternut	0.88	0.32	53
125	red pine	1.76	0.30	54
830	pin oak	2.78	0.30	55
825	swamp chestnut oak	1.04	0.25	56
682	red mulberry	0.27	0.23	57
746	quaking aspen	4.46	0.02	58
452	northern catalpa	0.83	0.02	59

*Importance is expressed as FIAsum, which is based on the number of stems, basal area, and areal coverage of each species among plots.

†Species code used by FIA.

‡Average importance value, showing the importance of the species in the plots where it exists (not across the entire subsection).

Table 36.—Tree species (n = 64) recorded by the Forest Service, Forest Inventory and Analysis (FIA), sorted by decreasing importance* within the Ohio portion of Subsection 221Ed – East Hocking Plateau

FIA code†	Common name	FIAi‡	FIAsum	N
318	sugar maple	13.58	757.34	1
621	yellow-poplar	10.05	472.17	2
972	American elm	8.66	438.91	3
541	white ash	7.97	429.56	4
316	red maple	8.56	381.59	5
802	white oak	8.98	358.72	6
901	black locust	8.53	309.19	7
931	sassafras	6.34	273.83	8
602	black walnut	5.37	217.28	9
762	black cherry	5.18	212.06	10
975	slippery elm	4.02	173.70	11
407	shagbark hickory	4.71	172.13	12
837	black oak	3.74	130.69	13
531	American beech	4.81	129.24	14
129	eastern white pine	10.86	115.97	15
833	northern red oak	3.59	114.57	16
332	yellow buckeye	4.21	112.91	17
409	mockernut hickory	4.04	105.15	18
313	boxelder	4.73	104.72	19
403	pignut hickory	4.13	101.47	20
132	Virginia pine	7.54	95.79	21
402	bitternut hickory	2.93	75.83	22
731	sycamore	3.65	75.18	23
743	bigtooth aspen	6.58	70.78	24
832	chestnut oak	3.20	60.49	25
641	Osage-orange	9.51	52.38	26
491	flowering dogwood	2.06	47.71	27
544	green ash	2.53	45.47	28
471	eastern redbud	2.16	44.49	29
766	wild plum	18.95	44.23	30
693	blackgum	2.12	34.31	31
317	silver maple	10.38	34.05	32
367	pawpaw	3.54	31.05	33
314	black maple	6.93	30.67	34
331	Ohio buckeye	3.78	30.08	35
373	river birch	9.80	27.78	36
951	American basswood	3.27	26.30	37
701	eastern hophornbeam; ironwood	2.11	23.84	38
462	hackberry	2.46	20.17	39
552	honeylocust	2.84	18.81	40
806	scarlet oak	2.56	18.52	41
126	pitch pine	18.67	17.42	42
742	eastern cottonwood	4.18	16.96	43
356	serviceberry	3.01	15.12	44
391	American hornbeam; musclewood	1.08	13.95	45
405	shellbark hickory	4.66	13.92	46
125	red pine	4.83	12.57	47
826	chinkapin oak	3.38	11.70	48
521	common persimmon	1.01	8.56	49
68	eastern red cedar	2.04	8.14	50
711	sourwood	1.53	7.54	51
835	post oak	2.09	7.07	52
746	quaking aspen	3.66	5.45	53
682	red mulberry	4.30	5.01	54
601	butternut	1.83	4.23	55
651	cucumbertree	1.75	3.93	56
830	pin oak	2.73	3.08	57
824	blackjack oak	2.35	2.74	58
452	northern catalpa	0.83	0.96	59
131	loblolly pine	2.22	0.93	60
371	yellow birch	0.69	0.81	61
823	bur oak	0.41	0.48	62
922	black willow	2.22	0.04	63
817	shingle oak	0.60	0.01	64

*Importance is expressed as FIAsum, which is based on the number of stems, basal area, and areal coverage of each species among plots.
†Species code used by FIA.
‡Average importance value, showing the importance of the species in the plots where it exists (not across the entire subsection).

Subsection 221Ee

In this subsection, which has only a small portion (15 percent) represented by our Ohio project area, the species with the highest importance values are somewhat different from the subsection as a whole (Table 7, Table 37). FIA records only 36 species in the Ohio portion of this subsection compared to 62 species in the subsection. Black cherry, red maple, American elm, sycamore, yellow-poplar, and black locust have the highest FIAsum values.

Subsection 221Ef

Within the Ohio portion of Subsection 221Ef, the most important species are almost identical to the subsection as a whole and differ only slightly in ranking (Table 7, Table 38). The Ohio portion encompasses 67 percent of the area of the subsection, and within this portion FIA records 67 of the 70 total species. Red maple, yellow-poplar, white oak, sugar maple, sassafras, and chestnut oak have the highest FIAsum values.

Subsection 221Eg

Within the Ohio portion of Subsection 221Eg, the most important species are fairly similar to the subsection as a whole, though fewer southern species are present (Table 7, Table 39). The Ohio portion occupies 61 percent of the subsection area, and within this portion FIA records 53 of the 60 total species. Sugar maple, chestnut oak, yellow-poplar, red maple, white oak, black cherry, pignut hickory, and sassafras have the highest FIAsum values.

Table 37.—Tree species (n = 36) recorded by the Forest Service, Forest Inventory and Analysis (FIA), sorted by decreasing importance* within the Ohio portion of Subsection 221Ee – Unglaciated Muskingum Plains

FIA code†	Common name	FIAi‡	FIAsum	N
762	black cherry	13.18	446.04	1
316	red maple	13.50	404.41	2
972	American elm	10.80	372.10	3
731	sycamore	15.72	297.85	4
621	yellow-poplar	12.24	265.50	5
901	black locust	12.73	260.24	6
743	bigtooth aspen	6.71	147.23	7
541	white ash	7.50	107.13	8
931	sassafras	3.86	86.64	9
531	American beech	4.95	85.58	10
837	black oak	4.04	77.41	11
402	bitternut hickory	5.35	74.70	12
602	black walnut	3.55	71.73	13
833	northern red oak	4.11	67.83	14
975	slippery elm	3.65	61.31	15
407	shagbark hickory	3.61	54.90	16
701	eastern hophornbeam; ironwood	4.00	54.29	17
693	blackgum	2.62	48.72	18
802	white oak	3.25	44.41	19
544	green ash	4.13	42.96	20
318	sugar maple	4.53	41.78	21
951	American basswood	9.59	36.59	22
313	boxelder	2.49	29.45	23
409	mockernut hickory	3.29	28.58	24
491	flowering dogwood	1.78	27.51	25
129	eastern white pine	10.69	23.39	26
314	black maple	6.71	20.49	27
317	silver maple	4.08	16.56	28
552	honeylocust	2.77	16.56	29
332	yellow buckeye	11.51	10.76	30
391	American hornbeam; musclewood	1.88	10.42	31
471	eastern redbud	2.68	8.77	32
403	pignut hickory	1.62	5.95	33
922	black willow	2.22	4.69	34
763	chokecherry	0.75	2.59	35
806	scarlet oak	1.83	2.17	36

*Importance is expressed as FIAsum, which is based on the number of stems, basal area, and areal coverage of each species among plots.
†Species code used by FIA.
‡Average importance value, showing the importance of the species in the plots where it exists (not across the entire subsection).

Table 38.—Tree species (n = 67) recorded by the Forest Service, Forest Inventory and Analysis (FIA), sorted by decreasing importance* within the Ohio portion of Subsection 221Ef – Western Hocking Plateau

FIA code†	Common name	FIAi‡	FIAsum	N
316	red maple	13.14	801.76	1
621	yellow-poplar	13.22	781.78	2
802	white oak	7.85	437.78	3
318	sugar maple	7.99	415.69	4
931	sassafras	5.67	277.48	5
832	chestnut oak	7.61	270.16	6
837	black oak	5.01	241.12	7
762	black cherry	5.10	233.28	8
531	American beech	4.83	192.31	9
132	Virginia pine	7.00	185.65	10
491	flowering dogwood	4.17	171.33	11
743	bigtooth aspen	4.96	170.09	12
833	northern red oak	3.91	168.85	13
541	white ash	3.65	165.67	14
972	American elm	4.04	158.41	15
901	black locust	4.00	153.27	16
975	slippery elm	3.54	153.01	17
407	shagbark hickory	3.43	136.78	18
403	pignut hickory	3.08	122.70	19
693	blackgum	2.83	116.87	20
711	sourwood	3.13	116.23	21
806	scarlet oak	3.63	108.83	22
129	eastern white pine	7.87	94.28	23
409	mockernut hickory	3.11	92.34	24
731	sycamore	3.48	80.35	25
602	black walnut	2.46	62.14	26
402	bitternut hickory	2.65	58.72	27
332	yellow buckeye	3.95	55.53	28
373	river birch	13.88	51.66	29
126	pitch pine	4.13	37.95	30
317	silver maple	8.54	35.92	31
125	red pine	21.00	32.05	32
261	eastern hemlock	6.39	31.39	33
391	American hornbeam; musclewood	1.08	28.63	34
471	eastern redbud	1.52	27.49	35
701	eastern hophornbeam; ironwood	1.97	22.16	36
544	green ash	1.97	18.66	37
922	black willow	4.18	17.48	38
314	black maple	13.44	15.85	39
367	pawpaw	1.92	15.16	40
611	sweetgum	5.83	14.86	41
817	shingle oak	1.72	14.11	42
521	common persimmon	1.70	12.54	43
372	sweet birch	2.65	11.03	44
951	American basswood	1.37	10.07	45
131	loblolly pine	9.22	9.66	46
313	boxelder	2.38	8.55	47
356	serviceberry	1.92	5.88	48
462	hackberry	1.64	5.67	49
552	honeylocust	9.98	5.65	50
682	red mulberry	3.46	5.56	51
331	Ohio buckeye	0.95	5.33	52
601	butternut	0.78	2.47	53
68	eastern red cedar	0.82	1.91	54
742	eastern cottonwood	0.71	1.68	55
826	chinkapin oak	1.63	1.17	56
405	shellbark hickory	0.83	0.94	57
97	red spruce	0.88	0.90	58
641	Osage-orange	3.52	0.75	59
746	quaking aspen	1.00	0.74	60
830	pin oak	0.59	0.62	61
835	post oak	2.55	0.56	62
543	black ash	0.53	0.56	63
110	shortleaf pine	0.53	0.51	64
763	chokecherry	0.53	0.40	65
651	cucumbertree	0.84	0.14	66
546	blue ash	6.45	0.05	67

*Importance is expressed as FIAsum, which is based on the number of stems, basal area, and areal coverage of each species among plots.

†Species code used by FIA.

‡Average importance value, showing the importance of the species in the plots where it exists (not across the entire subsection).

Table 39.—Tree species (n = 53) recorded by the Forest Service, Forest Inventory and Analysis (FIA), sorted by decreasing importance* within the Ohio portion of Subsection 221Eg – Lower Scioto River Plateau

FIA code†	Common name	FIAi‡	FIAsum	N
318	sugar maple	19.54	906.65	1
832	chestnut oak	14.65	507.47	2
621	yellow-poplar	11.74	469.98	3
316	red maple	9.04	419.25	4
802	white oak	7.81	352.44	5
762	black cherry	6.03	198.62	6
403	pignut hickory	5.31	186.54	7
931	sassafras	5.33	186.52	8
837	black oak	4.50	153.97	9
901	black locust	4.97	153.25	10
407	shagbark hickory	5.35	137.12	11
541	white ash	4.40	126.73	12
693	blackgum	3.58	111.46	13
833	northern red oak	3.27	100.21	14
806	scarlet oak	3.68	97.35	15
531	American beech	3.55	85.05	16
409	mockernut hickory	3.12	83.19	17
972	American elm	3.30	74.53	18
68	eastern red cedar	13.68	70.61	19
129	eastern white pine	9.14	65.03	20
975	slippery elm	2.94	64.73	21
367	pawpaw	4.28	62.75	22
951	American basswood	4.15	52.66	23
711	sourwood	5.10	51.12	24
402	bitternut hickory	2.62	44.60	25
731	sycamore	2.64	43.14	26
817	shingle oak	8.51	40.58	27
462	hackberry	3.18	38.59	28
132	Virginia pine	3.00	36.21	29
602	black walnut	2.34	35.26	30
317	silver maple	9.62	34.82	31
471	eastern redbud	2.25	28.95	32
491	flowering dogwood	1.28	24.20	33
743	bigtooth aspen	3.39	21.60	34
544	green ash	2.51	14.94	35
356	serviceberry	2.54	13.53	36
546	blue ash	4.69	13.11	37
826	chinkapin oak	2.20	12.60	38
742	eastern cottonwood	6.88	11.42	39
125	red pine	11.01	9.94	40
110	shortleaf pine	2.59	8.36	41
126	pitch pine	1.39	6.30	42
331	Ohio buckeye	1.52	6.02	43
835	post oak	2.90	4.45	44
552	honeylocust	1.49	4.32	45
521	common persimmon	1.24	4.10	46
313	boxelder	4.30	3.47	47
701	eastern hophornbeam; ironwood	1.74	3.31	48
611	sweetgum	1.38	1.96	49
391	American hornbeam; musclewood	0.62	1.48	50
830	pin oak	0.80	1.33	51
763	chokecherry	0.68	1.13	52
651	cucumbertree	0.84	0.88	53

*Importance is expressed as FIAsum, which is based on the number of stems, basal area, and areal coverage of each species among plots.
†Species code used by FIA.
‡Average importance value, showing the importance of the species in the plots where it exists (not across the entire subsection).

LANDSCAPE DIVERSITY, CONNECTEDNESS, AND RESILIENCE

The potential for conserving Nature's stage (CNS) is expressed by ratings of resilience such that each 30 m (98.4 feet) of landscape is assigned to one of eight classes of resilience based on expected responses to changes in climate or other conditions, and compared to an "ecoregion," which is somewhat aligned with Section 221E (Anderson et al. 2014) (Fig. 20 and Table 13 in part 3.2.1). Ratings range from far above average (FA; 2 standard deviations above the average for that geographical or regional setting), through average (Ave), to far below average (FB; 2 standard deviations below average), and a developed class for land, along with a water class (Fig. 20). Locations in green in Figure 20 are deemed more resilient to a changing climate and other disturbances according to the CNS scheme; those in brown, less resilient. Also presented in Table 13 are measures of connectedness and landscape diversity, the two elements that are combined to form the resilience measure. We next discuss CNS trends within the subsections represented by the 17-county region of Ohio.

Subsection 221Ec

In the Ohio portion of Subsection 221Ec, overall conditions are better than average for connectedness and landscape diversity, as compared to the rest of the ecoregion (Fig. 20, Table 13). For landscape diversity, 53.7 percent of the landscape is better than average, including 23.0 percent in the FA class, due to the dissected topography described in part 3.2.1. With connectedness, the Ohio portion of the subsection is largely slightly above average (SA) (41.1 percent), but in contrast to landscape diversity, very little area (3.8 percent) is rated as FA. Overall resilience, which combines the other two factors, shows a tendency to dampen extreme classes (FA and FB), and push values to the center (slightly below average [SB], Ave, SA). However, 40.7 percent of the Ohio portion of the subsection is still classified as SA or higher for overall resilience.

Subsection 221Ed

In the Ohio portion of Subsection 221Ed, overall conditions are slightly more favorable than average for all three measures, as compared to the rest of the ecoregion (Fig. 20, Table 13). For landscape diversity, 69 percent of the landscape is rated as SA or higher, including 27.6 percent FA, due to the dissected topography described in part 3.1. With connectedness, the Ohio portion of the subsection is largely rated as SA (48.2 percent), but in contrast to landscape diversity, very little area (4.7 percent) is rated as FA. Developed land, nearly 10 percent of the Ohio portion, is essentially nonconnected. Overall resilience scores reveal that 44.4 percent of this landscape is classified as SA or higher.

Subsection 221Ee

In the Ohio portion of Subsection 221Ee, overall conditions are relatively less favorable for all three measures, as compared to the results from the other subsections, because the landscape is less dissected and more highly developed (Fig. 20, Table 13). For landscape diversity, 43.5 percent of the landscape is rated as SA or higher, but only 4.1 percent is in the FA class, while 14.1 percent is in the FB class. With connectedness, the Ohio portion of the subsection is rated fairly low: primarily SA, Ave, or SB (79.7 percent), with 14.1 percent FB and only 0.1 percent FA—the lowest FA percentage among all subsections. The resilience score shows overall relatively poor resilience to a changing climate with 79.4 percent rated Ave or below. Another 14.2 percent is rated as developed, and only 6.5 percent is rated as SA or higher.

Subsection 221Ef

In the Ohio portion of Subsection 221Ef, overall conditions are slightly more favorable for all three measures, as compared to the rest of the ecoregion (Fig. 20, Table 13). For landscape diversity, 57.7 percent of the landscape is SA or higher, including 23.6 percent FA, due to the dissected topography described in part 3.1. With connectedness, the Ohio portion of the subsection is mostly SA (41.2 percent), but in contrast to landscape diversity, only 9.1 percent is rated as FA. Overall resilience scores show that 42.8 percent of the land is classified as SA or higher.

Subsection 221Eg

In the Ohio portion of Subsection 221Eg, overall conditions are slightly more favorable for all three measures, as compared to the rest of the ecoregion (Fig. 20, Table 13). For landscape diversity, 61.0 percent of the landscape is SA or higher, including 23.7 percent FA, due to the dissected topography described in part 3.2.5. With connectedness, the Ohio portion of the subsection is mostly SA to FA (67.0 percent), and still has 16.9 percent of the area rated as FA—much more than any other subsection. Overall resilience scores show that 46.8 percent of the landscape is classified as SA or higher.

Among subsections, a wide disparity in resilience is evident, ranging from only 6.5 percent classified as SA or higher in Subsection 221Ee (the home of areas surrounding Columbus and extensive agricultural lands) to 46.8 percent in Subsection 221Eg (the home of Shawnee State Forest and Edge of Appalachia, a property of The Nature Conservancy and Cincinnati Museum Center). An examination of Figure 20, however, shows that overall, this 17-county portion of Ohio is much more resilient than any other part of Ohio.

MINED LANDS

Both surface and underground mining operations have occurred and continue to occur throughout the landscape; however, regulations (e.g., Surface Mining Control and Reclamation Act of 1977) have changed how mined lands are restored after operations close. No surface coal mining operations were reported within Subsection 221Eg, though industrial minerals are mined within this subsection. Reclaimed surface coal mines account for less than 1 percent to about 8 percent of the land area in each subsection; unreclaimed mines account for less than 3.5 percent of each subsection (Table 40). Forested land on reclaimed mines tends to be less productive compared to unreclaimed mine land because of the higher soil compaction on the reclaimed mine land (Rodrigue et al. 2002, Zipper et al. 2011). Subsections 221Ec and 221Ef also have sizable amounts of reclaimed land disturbed by underground mining (Table 40).

BIRD COMMUNITIES

The region is noted for its diverse and abundant bird community and is a priority region in the State for bird conservation. Across Section 221E there were 108 species recorded during the second Ohio Breeding Bird Atlas (OBBA2; Rodewald et al. 2016) (Table 10 in part 3.2.1). Thirty-five of these species occurred in more than 90 percent of the 214 priority blocks, and an additional 34 species occurred in at least 45 percent of the blocks. Several high priority conservation species, such as wood thrush and scarlet tanager, are relatively common in the region. However, other high priority species, such as Kentucky warbler and cerulean warbler, have undergone substantial declines in recent decades. In addition, species occurrence can vary considerably across the region and in several cases, species of conservation focus, such as the eastern whip-poor-will, worm-eating warbler, and black-billed cuckoo, are infrequent but locally abundant within the region. Finally, there is a group of rare species (<10 percent of block occurrence) which comprises several species that utilize unique forest habitats, such as hermit thrush, magnolia warbler, and others. Many of these species are important forest indicator species and represent the diverse forest habitat needs of birds across Section 221E.

Subsection 221Ec

There were 92 species recorded in the Ohio portion of Subsection 221Ec during OBBA2 (Table 10). These species include the most abundant species in the region. Several forest species, such as American redstart, hooded warbler, and black-and-white warbler, demonstrated marked increases in this subsection over the last 25 years. Species such as chimney swift, which is an example of insectivorous birds in the area that are undergoing continental declines, sustained reductions. Other species, such as the yellow-billed cuckoo, obtained their highest incidence in this subsection with nearly every block occupied. In other cases, several common wood warblers of conservation note are observed in this subsection, but reflect declines (e.g., cerulean warbler, prairie warbler). Additionally, least flycatcher, blue-headed vireo, and black-throated warbler represent three new species for the subsection.

Table 40.—Percentage and area of ecological subsections within the Ohio portion of Section 221E disturbed by mining

		Subsection				
		221Ec – Ohio Valley Lowland	221Ed – East Hocking Plateau	221Ee – Unglaciated Muskingum Plains	221Ef – Western Hocking Plateau	221Eg – Lower Scioto River Plateau
Area within Ohio	Acres	817,886	1,354,643	264,321	1,582,955	810,625
Surface mines – reclaimed	Percentage	0.91	5.49	8.11	4.23	0
	Area (acres)	7,471	74,399	21,426	66,977	0
Surface mines – unreclaimed	Percentage	0.24	3.45	2.89	2.64	0
	Area (acres)	1,980	46,751	7,644	41,848	0
Underground coal mining – reclaimed	Percentage	2.04	0.16	0.03	1.43	0
	Area (acres)	16,685	2,108	82	22,665	0

Subsection 221Ed

In the Ohio portion of Subsection 221Ed, 95 species were recorded in the OBBA2 (Table 10). Six species were detected in the original atlas (OBBA1; Peterjohn and Rice 1991) that were not observed in the priority blocks during the second atlas. Included in this group were many northerly distributed species such as black-throated green warbler and northern harrier. Six other species were detected in the second atlas and not in the first. Members of this group also included four northerly distributed species—alder flycatcher, blue-headed vireo, brown creeper, and purple finch—as well as black vulture and sedge wren. Many of the species common in the entire Section 221E are dominant in this subsection, such as scarlet tanager, wood thrush, and Acadian flycatcher. Among the species of special conservation note, many displayed little change (either positive or negative) or no change in incidence between atlases. However, cerulean warbler, eastern screech-owl, and eastern whip-poor-will exhibited dramatic reductions in incidence over the last 25 years.

Subsection 221Ee

The 53 priority blocks in the Ohio portion of Subsection 221Ee included records for all 108 species recorded across Section 221E in Ohio (Table 10). This species-rich subsection displayed high incidence values for many of the species common across the section; for example, red-eyed vireo, wood thrush, and scarlet tanager were recorded among all priority blocks. Seven new species were observed in priority blocks during OBBA2 that were not observed during OBBA1. Four of these species were northerly distributed species (winter wren, northern harrier, yellow-bellied sapsucker, and dark-eyed junco), but the most dramatic increase in incidence between atlases was observed for black vulture (i.e., +0.28 in incidence). All species recorded during OBBA1 were also observed during OBBA2. Of these species, a total of 24, 33, and 44 species displayed no change, increases, and reductions in incidence values between atlases, respectively. Among those displaying increases in incidence were several conservation-relevant species, such as black-and-white warbler and hooded warbler. Several noteworthy species of high conservation importance exhibited marked reductions in incidence between the atlases, including cerulean warbler, Kentucky warbler, and prairie warbler.

Subsection 221Ef

A total of 101 species were recorded in OBBA2 for the Ohio portion of Subsection 221Ef (Table 10). Records included the addition of seven new species that were not observed in OBBA1. The remaining species were observed during both atlases. The newly observed species included examples of northerly distributed species, such as winter wren, yellow-bellied sapsucker, veery, and brown creeper. Many of the species common across Section 221E also exhibited high incidence values for this subsection, such as red-eyed vireo, scarlet tanager, and wood thrush. Species such as northern parula, rose-breasted grosbeak, and blue grosbeak displayed dramatic increases in incidence over the last 25 years, whereas the red-headed woodpecker, warbling vireo, and eastern screech-owl exhibited reductions in incidence. Conservation-relevant species such as prairie warbler and yellow-breasted chat, which are typical of shrublands and young forest habitats, exhibited relatively low reductions in incidence values among the priority blocks of this subsection between atlases.

Subsection 221Eg

The Ohio portion of Subsection 221Eg was characterized by 88 species that were recorded during OBBA2 among the 22 priority blocks of the subsection (Table 10). Two species, cliff swallow and black vulture, were newly observed in priority blocks during OBBA2. Three grassland species, bobolink, vesper sparrow, and dickcissel, were unique to OBBA1. Marked increases in incidence values were observed for northern parula, blue grosbeak, and rose-breasted grosbeak.

DEER POPULATIONS

White-tailed deer (*Odocoileus virginiana*) are an important part of the Ohio portion of Section 221E, from both a recreational and an ecological perspective. The average total yearly harvest of almost 20,000 deer across this area demonstrates the large influence that this iconic species has on the landscape (Table 11 in part 3.2.1). Active herd management with consistent population objectives has sustained a healthy deer population in the State that affords ample recreational opportunities. Just over 40 percent of the harvest is bucks, and 48 percent consists of does. These numbers reflect an overall population that is maintained below carrying capacity where an overabundance of deer has hindered forest regeneration. In fact, across the area, vegetation monitoring plots consistently show lower deer browse pressure than in many surrounding states. The continued adaptive management of deer in Ohio is critical for citizens and forests alike.

Subsection 221Ec

The Ohio portion of Subsection 221Ec, the easternmost subsection, has had the lowest overall deer harvest (Table 11). The demographics of the harvest reflect those of the broader section. In many counties in the subsection a large portion of deer are harvested by landowners. Despite the presence of the Marietta unit of the Wayne National Forest in this subsection, there was a lower proportion of deer harvested on public land than in other subsections (ODNR 2017). All of these results point to a stabilized deer population.

Subsection 221Ed

White-tailed deer in the Ohio portion of Subsection 221Ed intersect State public land areas, where a large portion of the annual harvest occurs (Table 11). This area is notable for the higher proportion of bucks harvested each year (ODNR 2017). Given the association between buck harvest and potential population growth, the deer population in this subsection has the capacity to grow rapidly.

Subsection 221Ee

The Ohio portion of Subsection 221Ee has the highest white-tailed deer harvest of all the subsections (Table 11). Coshocton and Muskegon Counties have the highest annual harvest (ODNR 2017). The high numbers and consistent herd population reflect both large proportions of public land and the juxtaposition of these lands with agricultural landscapes (ODNR 2017). These components, along with extensive forests, provide ample space and resources for a sustained larger deer herd.

Subsection 221Ef

The Ohio portion of Subsection 221Ef is dominated by State forest lands. In Hocking and Vinton Counties, more than 20 percent of the deer harvest occurs on those public lands (ODNR 2017). The heavily forested landscape supports a robust population, manifested in the consistent yearly average harvest of over 3,300 deer (Table 11).

Subsection 221Eg

The Ohio portion of Subsection 221Eg contains parts of two counties important for deer (Scioto and Adams) and includes the Shawnee State Forest (ODNR 2017). This subsection had the second highest average deer harvest from 2013 to 2015 (Table 11). The relative number of bucks and does reflects the sectionwide pattern of 42 percent and 48 percent, respectively. This landscape is dominated by forest with a considerable component of agricultural land, providing ample high-quality habitat for deer.

PRE-EURO-AMERICAN SETTLEMENT VEGETATION

According to Gordon's (1969) vegetation classes, mixed oak forest occurred in more than 50 percent of Subsections 221Ec, 221Ed, 221Ee, and 221Ef; beech and mixed mesophytic forests also occupied a sizable portion of the landscape (Table 14 in part 3.2.2). Public Land Survey System records summarized by Sears (1925) support Gordon's estimates of the distribution of mixed oak and beech forest. Chestnut, chestnut oak, scrub pine (*Pinus virginiana*; Virginia pine), and pitch pine were also prevalent within this area (Sears 1925).

Pre-Euro-American Settlement Witness Trees

Most witness trees were at least 10 inches in diameter. As was often the case with contemporary forest surveys, surveyors did not consistently differentiate between species in some genera when noting witness trees in the original land surveys. For example, they simply recorded "hickory," "ash," and "pine," the last of which presumably also included hemlock. This limitation is especially notable with species in the red oak group (subgenus *Erythrobalanus*), which surveyors usually referred to as "black oak." Table 9 in part 3.2.1 lists witness tree abundance for each taxon for Section 221E and its subsections. Aside from the issue of "taxonomical lumping," Dyer (2001) found no evidence of bias in surveyors' selection of particular species.

The most compelling observation from Table 9 is the dominance of oak, especially white oak, in the pre-Euro-American settlement forest. Across Section 221E (refer to Figure 3 in part 2.3.3 for extent of witness trees), white oak made up 38.0 percent of all witness trees, and all oaks combined accounted for 53.9 percent of witness trees. The four most abundant taxa—white oak, hickory, "black oak," and beech—composed 72.3 percent of witness trees. This pattern is in accord with Whitney's (1982) findings in the presettlement forest of the Unglaciated Appalachian Plateau in northeastern Ohio.

Dyer (2001) and Dyer and Hutchinson (2019) compared abundance of taxa in the presettlement forest with contemporary FIA data drawn from the same southeastern Ohio area, and documented a clear transition from oak-hickory to maple-poplar dominance. This transition has been observed throughout the eastern deciduous forest (Abrams

2003), and has been attributed to changes in land use, climate, and fire frequency (McEwan et al. 2011, Nowacki and Abrams 2008). Reforestation following widespread clearing favors small-seeded wind-dispersed species such as sugar maple, red maple, tulip-poplar, elm, ash, and aspen, and tends not to support large-seeded animal-dispersed species such as oak, hickory, and beech. Drought would favor tolerant species such as oak and hickory, and impede mesophytes like maple and tulip-poplar. The centuries before settlement were characterized by deep, multiyear droughts, whereas the 20th century experienced fewer droughts and more frequent precipitation events. An increase in fire frequency would also favor oak over maple. There is some evidence of fire noted in the line descriptions of the Ohio Company survey, but fire-scar data from living trees are currently limited to the postsettlement period in southeastern Ohio. These data reveal that fires occurred frequently at several sites from ca. 1870 to 1930 (Hutchinson et al. 2008, McEwan et al. 2007) and that the establishment of maples coincided with the cessation of fire (Hutchinson et al. 2008).

An examination of witness tree abundance by subsection (Table 9) reveals a pattern similar to that for the entire ecological section, but with some notable differences. (Subsection 221Eg had only 311 witness trees, and they occurred in a predominantly riparian setting [Fig. 3]. Consequently, witness trees will not be discussed for this subsection.) White oak, "black oak" (including red oak), and hickory were dominant taxa across Subsections 221Ef, 221Ed, and 221Ec (composing 62.6, 60.5, and 74.1 percent of witness trees, respectively). American beech was also a prominent species. The most striking difference among the subsections is the higher percentage of white oak in Subsection 221Ec, where it was 52.8 percent of all witness trees.

In addition to having a greater percentage of white oak, Subsection 221Ec had less hickory, beech, red maple, and tulip-poplar than the other two subsections, and more pine (Table 41). Subsection 221Ed had a higher percentage of ash and buckeye, whereas Subsection 221Ef had blackgum and chestnut in greater abundance.

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Table 41.—Witness trees* listed by decreasing abundance in percentage classes for three ecological subsections of Section 221E

	Subsection		
Percentage of witness trees	221Ec – Ohio Valley Lowland	221Ed – East Hocking Plateau	221Ef – Western Hocking Plateau
≥30	White oak	White oak	White oak
10–29.9	"Black oak"	Hickory Beech "Black oak"	Hickory "Black oak"
5–9.9	Hickory		Beech
2–4.9	Chestnut oak Beech Pine Sugar maple	Sugar maple Red maple Tulip-poplar Ash Chestnut oak	Blackgum Red maple Sugar maple Chestnut oak Tulip-poplar Chestnut
1–1.9	Tulip-poplar Buckeye Red maple Ash Elm Silver maple Blackgum	Buckeye Blackgum Elm Silver maple Pine	Silver maple Elm Ash
<1		Chestnut	Pine Buckeye

*Only trees composing ≥1 percent of witness trees within Section 221E are included.

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The classification, mapping, and description of ecosystems are fundamental components of land management. The National Hierarchical Framework of Ecological Units (Cleland et al. 1997) provides the basis for the USDA Forest Service to accomplish these tasks. This framework allows the recognition of ecosystems or ecological units at eight spatial scales within a nested hierarchy. The highest levels of ecological units have been delineated nationally from domains through subsections. Our project, described here, is an extension of this national effort and concentrates on the local mapping and description of ecological landtypes, the seventh level of the hierarchy. It is envisioned that the results of this project will serve the Wayne National Forest in Ohio and its partners in many ways. This work provides an ecological basis by which future land management plans can be developed and executed. It helps give direction to silvicultural activities designed to maintain ecological sustainability, biological diversity, and local economies. It also informs research by distinguishing different ecosystems for experimental design and spatial extrapolation of findings.

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