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Forest Management Plan for the DOE Oak Ridge Reservation: An Interdisciplinary Approach for Managing a Heritage Resource

P. D. Parr
G. S. Byrd
J. W. Johnston, Jr.
N. R. Giffen

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OAK RIDGE NATIONAL LABORATORY
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Cover photo is an aerial view of the Oak Ridge Reservation by Jason Richards.

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Natural Resources Management Program

FOREST MANAGEMENT PLAN FOR THE DEPARTMENT OF ENERGY OAK RIDGE RESERVATION: AN INTERDISCIPLINARY APPROACH FOR MANAGING A HERITAGE RESOURCE

Patricia D. Parr
Natural Resources Ecologist

Greg S. Byrd
Oak Ridge Reservation Forester

J. William Johnston, Jr.
Ecologist

Neil R. Giffen
ORNL Natural Resources Manager

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ACRONYMS AND ABBREVIATIONS

ANA	Aquatic Natural Area
CMA	Cooperative Management Area
CRD	Contractor Requirements Document
dbh	diameter at breast height
DOE	Department of Energy
EAB	emerald ash borer
EMS	Environmental Management System
EO	executive order
EPA	US Environmental Protection Agency
ETTP	East Tennessee Technology Park
HA	Habitat Area
IPM	integrated pest management
ISO	International Organization for Standardization
MOU	Memorandum of Understanding
MSL	mean sea level
NA	Natural Area
NAAQS	National Ambient Air Quality Standard
NFPA	National Fire Protection Association
NOAA	National Oceanic and Atmospheric Administration
NSF	National Science Foundation
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
PFP	Pre-Fire Plan
PH	Potential Habitat
PIF	Partners In Flight
RA	Reference Area
RMC	Reservation Management Coordinator
SMZ	Streamside Management Zone
SPB	southern pine beetle
SSP	Site Sustainability Plan
TNC	The Nature Conservancy
TVA	Tennessee Valley Authority
TWRA	Tennessee Wildlife Resources Agency
USFS	US Forest Service
USFWS	US Fish and Wildlife Service
WMU	Wildland Management Unit
Y-12	Y-12 National Security Complex

1. INTRODUCTION

The Oak Ridge Reservation (ORR) is unique and valuable within the region as the largest contiguous protected land ownership in the southern Valley and Ridge Physiographic Province. Management of ORR forests and associated ecosystems has evolved considerably over the 70 years of its existence. Building on past achievements in erosion control and timber marketing as early goals to current ones of managing a diverse, healthy forest ecosystem in support of Department of Energy (DOE) research, sequestration of carbon, and other DOE missions has widened the vision for management of the forest and created the new opportunities addressed in this document.

When the federal government acquired the land in the 1940s that is now the ORR, approximately half of the area was forested (Johnston 2012). Figure 1 shows the forested and cleared areas of the ORR around 1941. Land use was typical of east Tennessee with areas cleared for farmsteads. Historic agricultural practices resulted in severe erosion on most slopes. Except on very steep slopes, most of the forest was cut for timber, although not necessarily cleared. Many partially cut forest areas were used as rough pasture (Dale et al. 1990).

In 1942, public access to the ORR was restricted. Natural succession and planting of trees resulted in reestablishment of forests in previously cleared areas of the Reservation (Mann et al. 1996). Currently, approximately 70% of the ORR is in forest cover (Fig. 2, based on 2006 flyover data from the Oak Ridge Environmental Information Systems Geographic Information System).

ORR natural resources (forests, plants, wildlife, wetlands, and ecologically sensitive areas) are managed for DOE by the Oak Ridge National Laboratory (ORNL) Natural Resources Management program. Additionally, there is close interaction with the Tennessee Wildlife Resources Agency (TWRA) (responsible for wildlife management through an agreement with DOE) and other state and federal agencies.

This Forest Management Plan is the fifth update to the original plan prepared in 1965 (Curlin 1965). Periodic revisions are necessary to update management practices, introduce new management techniques, and document conformance to changes in DOE management policy. The primary objective of this plan is to provide the framework for management of the forests and associated ecosystems of the ORR.

The overall goal of forest management for the ORR is to manage the forest resources of the Reservation in support of current and potential future missions, while maintaining forest health and diversity. Present DOE Oak Ridge missions include operation of research, development, and production for national security efforts; research and development in support of national energy initiatives; and environmental restoration to address the legacy of past research, development, and production activities. The ORR forests and associated ecosystems are important for the site missions because they provide

- a safety and security buffer around major installations,
- an outdoor laboratory in support of research investigating effects of various energy technologies on environmental processes,
- land and natural resources for future DOE missions, and
- a model for management through carbon sequestration and enhanced biological diversity approaches.

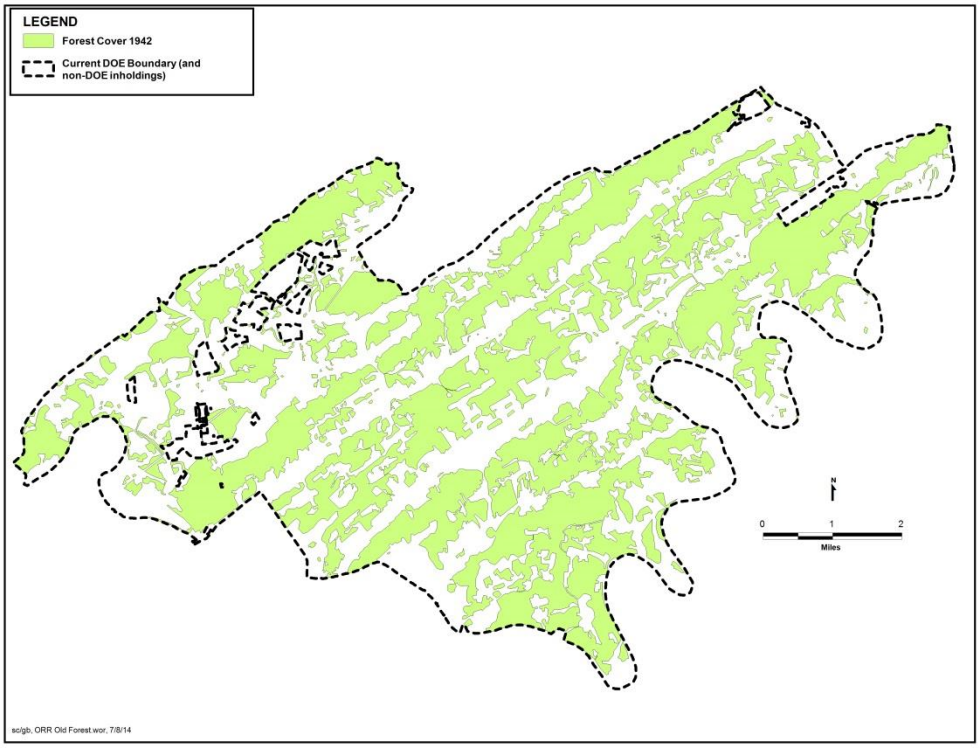

Fig. 1. Historic forested and cleared areas on the ORR.

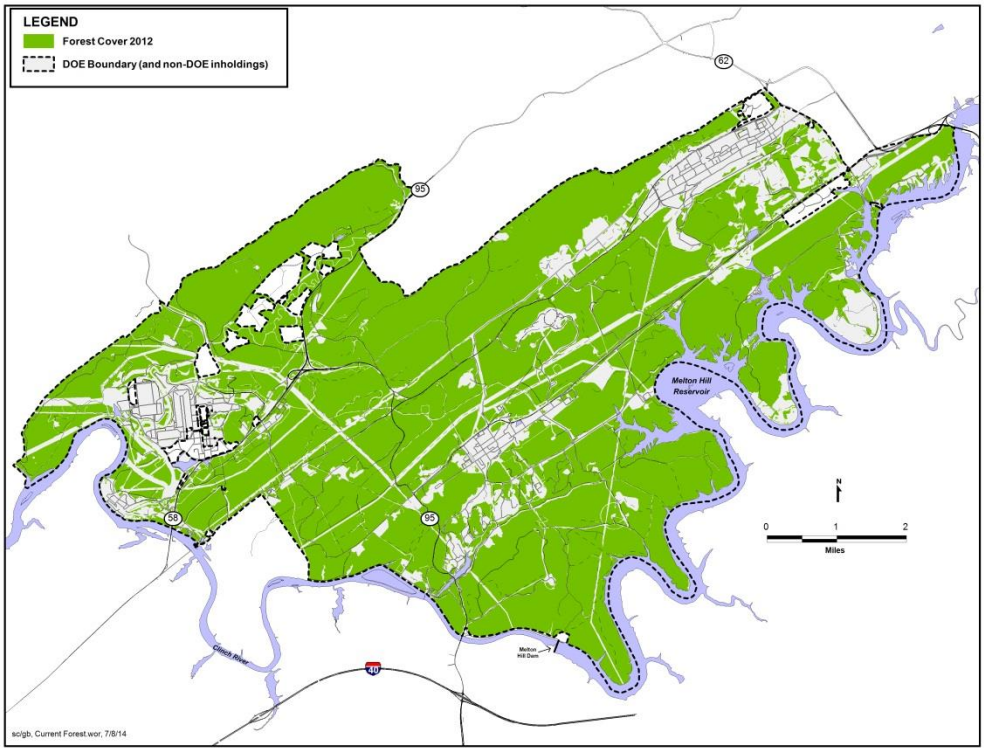

Fig. 2. Current forest cover on the ORR.

Biologically and ecologically significant natural areas and habitats have been identified as present on the ORR. These areas (forests, grasslands, bogs, barrens, bluffs, outcrops, and other areas) represent high-quality examples of natural communities and/or habitats for populations of rare species and species of concern. Forest management actions include promoting the conditions necessary to conserve, protect, and maintain existing natural areas and habitats.

In addition, a diverse, healthy ecosystem enhances forest adaptation and mitigation when faced with changes and disturbances such as may be expected as a result of predicted changes in climate. Activities and goals are provided within the context of environmental stewardship inherent in the mission of all federal land-managing agencies.

This plan for the ORR provides an overview of regulatory drivers and current management approaches and the longer-term vision of the desired future state in support of the DOE mission. History and past forest management activities are discussed in Appendix A.

Forest management necessarily works on several different time scales. For purposes of budgeting and project planning, the 10-year planning horizon and 5-year condition assessment cycles required by DOE O 430.1B, *Life Cycle Asset Management*, are adequate. However, the forest life cycle is measured in decades and centuries, so vision and planning to address this longer cycle are also required.

Management of the forest and associated ecosystems can be evaluated and adapted continually. This plan can be modified and refined appropriately to reflect changes.

1.1 BENEFITS OF A HEALTHY, DIVERSE FOREST ECOSYSTEM

For the ORR a healthy forest with its associated ecosystems provides a multitude of ecological benefits. Healthy, functioning ecosystems have an important role in mitigating pollution, maintaining diversity, and improving overall global health (Deal, Cochran, and LaRocco 2012). The Sustainable Sites Initiative (Sustainable Sites Initiative 2009) states, "Ecosystem services are goods and services of direct or indirect benefit to humans that are produced by ecosystem processes involving the interaction of living elements, such as vegetation and soil organisms, and non-living elements, such as bedrock, water, and air." These services include providing viable habitats for plants and animals (including those that are uncommon), supporting species diversity (and therefore genetic biological diversity), capturing atmospheric carbon dioxide and sequestering carbon, improving air quality, capturing and storing water, regulating stream flows and water quality, reducing flooding and storm damage, controlling erosion, replenishing groundwater and surface flow, stabilizing stream banks, cycling nutrients, providing annual crop pollination services by species often found in forest ecosystems (birds, bats, bees, and other pollinators), producing wood products, providing a giant outdoor laboratory for education and scientific research, supporting recreation, and offering scenic beauty.

In addition to providing various services, a healthy, intact forest has a better ability to respond to or recover from disturbances associated with changes in climate, such as increased wildfire potential, insects and disease outbreaks, invasive exotic species spread, and alterations in precipitation and temperature.

The loss of land and/or replacing of forest with cleared or developed areas is the most obvious threat to the forest, but activities within and adjacent to forested areas can also have hurtful impacts. Activities such as road widening, road building, and utility right-of-way areas can open the forest canopy, resulting in increased fragmentation of the forests and impacting wildlife, especially migratory birds. Past practices for land clearing, unmanaged logging, road building, monitoring well drilling, revegetation of areas with nonnative seed mixes, and other manipulations have compacted soils, caused severe erosion, channelized streams, and assisted in the spread of nonnative invasive plants, animals, and diseases. Large plantations

of pine increased the potential for impact from the southern pine beetle and now dense, unthinned stands have the potential for disease and wildfire outbreaks. Decisions related to activities within the forest must be considered from multiple angles so that impacts can be minimized and benefits maximized.

2. REGULATORY DRIVERS FOR MANAGEMENT AND PROTECTION OF THE FOREST RESOURCE

DOE, as manager of public lands, operates under the constraints of numerous environmental statutes, laws, orders, and guidance. Four DOE orders—DOE O 430.1B, *Life Cycle Asset Management*; DOE O 450.1, *Environmental Protection*; DOE O 436.1, *Departmental Sustainability*; and DOE O 420.1B, *Facility Safety*—govern the management of forest resources on the ORR.

2.1 DOE O 430.1B, *REAL PROPERTY AND ASSET MANAGEMENT*

Timber is a real property asset by definition and, therefore, is managed under the umbrella DOE O 430.1B, *Life Cycle Asset Management*, and is administered by the DOE Real Estate Office in regard to overall programmatic direction and responsibilities (Bradburn and Rosenbalm 1984; Bradburn and Byrd 2001). According to Attachment 3 of DOE O 430.1B, *Real Property Assets*, real property assets are "any interest in land, together with the improvements, facilities, structures, and fixtures located thereon, including prefabricated movable structures and appurtenances thereto, under control of DOE. All real property owned by or leased to the Government or acquired by the Government under the terms of the contract. It includes both government-furnished property and contractor-acquired property as defined in Federal Acquisition Regulation 45.101. DOE-owned, and -used and -controlled land, land improvements, structures, utilities, installed equipment, and components are included. Real property and real estate means land and rights in land, ground improvements, utility distribution systems, and building and other structures. Real Property Assets are defined by the Federal Property Management Regulations & 101-47.103-12, Real Property."

DOE O 430.1B 4a(1), dated April 25, 2011 states, "Departmental land and facilities are valuable national resources. Land use planning and stewardship responsibilities will be implemented consistent with the principles of ecosystem management and sustainable development."

DOE O 430.1B, Sects. 4a(2), 4b(3), and 4d(2) require, respectively, that real property assets (forest resources) be managed

- with a 10-year planning horizon;
- to integrate land uses at each site and examine multiple land-use options; and
- to conduct condition assessments on all real property assets at least once during any 5-year period using inspection methods in accordance with industry standards.

2.2 DOE O 436.1, *DEPARTMENTAL SUSTAINABILITY*

This order defines requirements and responsibilities for managing sustainability within DOE to ensure that the department carries out its missions in a sustainable manner that addresses national energy security and global environmental challenges and advances sustainable, efficient, and reliable energy for the future; institutes wholesale cultural change to factor sustainability and greenhouse gas reductions into all DOE corporate management decisions; and ensures that DOE achieves the sustainability goals established in its Strategic Sustainability Performance Plan (DOE 2011b). It cancels DOE O 450.1A and DOE O 430.2B.

The provisions of the Contractor Requirements Document (CRD) apply to DOE contractors. Regardless of the performer of the work, the contractor is responsible for complying with the requirements of the CRD and flowing down the CRD requirements to subcontractors to the extent necessary to ensure

contractor compliance with these requirements. Three key provisions applicable to the ORR are that the contractor must establish and implement

1. activities that support DOE's required submittal of reports and data and implementation of sustainability goals specified by DOE in the contract. The contractor must also meet the requirements of the Emergency Planning and Community Right-to-Know Act.
2. Site Sustainability Plans (SSPs). Contractors must develop or support development and commitments to identify their respective contributions toward meeting DOE's sustainability goals. Contractors must integrate their SSPs with their operational plans.
3. Environmental Management Systems (EMSs). Contractors must develop and implement an EMS that is certified to or conforms with International Organization for Standardization (ISO) 14001:2004 in accordance with references 7.o and 7.p, respectively. Site sustainability goals must be integrated into the EMSs.

When deemed appropriate by the Contracting Officer, a contractor having an EMS that is certified to the ISO 14001:2004 standard in accordance with the accredited registrar provisions of the standard may allow the CRD to not be included in its contracts. In such cases, sustainability goals will flow down to contractors through established contractor-performance-management processes or other contract mechanisms.

2.3 DOE ORDER 420.1C, CHANGE 1, *FACILITY SAFETY*

DOE O 420.1, *Facility Safety*, contains the basic requirements for the fire protection program as a whole. Applicable National Fire Protection Association (NFPA) Codes and Standards are mandatory as stipulated by DOE O 420.1. The order also requires nuclear facility safety analysis reports to identify those systems, structures, components, and programs that are important to the safety basis assumptions and consequences.

The order establishes facility and programmatic safety requirements for nuclear and explosives safety design criteria, fire protection, criticality safety, natural phenomena hazards mitigation, and the System Engineer Program. Change 1 incorporates the use of DOE-STD-1189-2008, *Integration of Safety into the Design Process*, mandatory for Hazard Category 1, 2, and 3 nuclear facilities. It cancels DOE O 420.1B.

2.4 LAWS, REGULATIONS, GUIDANCE, AND RULES GOVERNING FOREST MANAGEMENT AT THE ORR

Forest management for the ORR is governed by numerous additional federal and state laws, rules, and regulations, executive orders (EOs), DOE orders, policies, plans, guidance, and agreements. The following selected governing documents influence ORR forest management:

- National Environmental Policy Act of 1969 (42 USC 4321)
- Endangered Species Act of 1973 (16 USC 1531)
- National Historic Preservation Act of 1966 (16 USC 470)
- Clean Water Act of 1977 (33 USC 1251)
- Rivers and Harbors Act of 1899 (33 USC 401)
- Clean Air Act of 1970 (42 USC 7401)
- Federal Insecticide, Fungicide, and Rodenticide Act of 1972 (7 USC 136)

- Federal Noxious Weed Act (7 USC 2814)
- North American Wetlands Conservation Act (16 USC 4401-4414)
- Sikes Act of 1960 (16 USC 670)
- EO 12148, "Federal Emergency Management"
- EO 11989, "Use of Off-Road Vehicles on Public Lands"
- EO 11990, "Protection of Wetlands"
- EO 13112, "Invasive Species"
- EO 13148, "Greening the Government Through Leadership in Environmental Management"
- EO 13186, "Responsibilities of Federal Agencies to Protect Migratory Birds"
- "Memorandum of Understanding Between the U.S. Fish and Wildlife Service, Department of the Interior, and the Department of Energy Regarding Implementation of Executive Order 13186, 'Responsibilities of Federal Agencies To Protect Migratory Birds'" (*Federal Register*, Vol. 78, No. 219 [Nov. 13, 2013])
- DOE P 450.4A, Integrated Safety Management Policy
- Rules of Tennessee Department of Agriculture Division of Forestry Chapter 0080-7-3, "Forestry Best Management Practices"
- Tennessee Water Quality Control Act of 1977

The DOE Land Use Plan outlines potential future uses of the ORR. Future uses of the ORR will, in most cases, expand and build on current land uses, not replace them. Future uses may include field research areas and facilities (environmental research, security, and monitoring systems); environmental management and long-term stewardship areas (remediated, restored, and protected contaminated areas); infrastructure improvements (communications, utilities); land responsibility actions (emergency response, wildland fire prevention and response, conservation easements); integrated management of natural resources; and additional public and educational opportunities (greenways, stakeholder involvement) (DOE 2012).

Decisions about proposed activities or land use changes are made on a case-by-case basis to ensure compatibility with the following priorities:

- Priority 1: Preserve and protect land needed to meet the requirements of existing and future DOE mission-related facilities and programs that require large, biologically and physically diverse protected land areas so that DOE can continue to meet its local, regional, and national mission obligations.
- Priority 2: Maintain land and facilities to promote sustainable economic development for the region through enhanced DOE missions, as well as through technology transfer and deindustrialization.
- Priority 3: Protect the environment, meet the requirements of scientific and technical education, and support educational research opportunities on the ORR (DOE 2012).

3. ORR PHYSICAL CHARACTERISTICS

Consisting of 33,480 acres within the Valley and Ridge Physiographic Province of East Tennessee, the ORR is located in Anderson and Roane Counties, with most of the ORR within the corporate limits of the city of Oak Ridge (Fig. 3). The physical boundaries of the ORR are urban areas of the city on the north and northeast; the Clinch River (Melton Hill Lake and Watts Bar Lake) on the east, south, and southwest; and rural areas to the west. Residential and business areas have been, and continue to be, developed since the ORR was established in 1942 and now border much of the Reservation on the north and northwest sides. These urban interfaces create some challenging issues that influence the ORR forest resource and approaches to management.

3.1 TOPOGRAPHY, GEOLOGY, AND SOILS

The local topography is characterized by a series of narrow, elongated ridges and interconnected valleys that follow a northeast-to-southwest trend (Fig. 4). Major valleys include East Fork Valley, Bear Creek Valley, Bethel Valley, and Melton Valley. Major ridges within the ORR include Black Oak Ridge, McKinney Ridge, East Fork Ridge, Pine Ridge, Chestnut Ridge, Haw Ridge, and Copper Ridge.

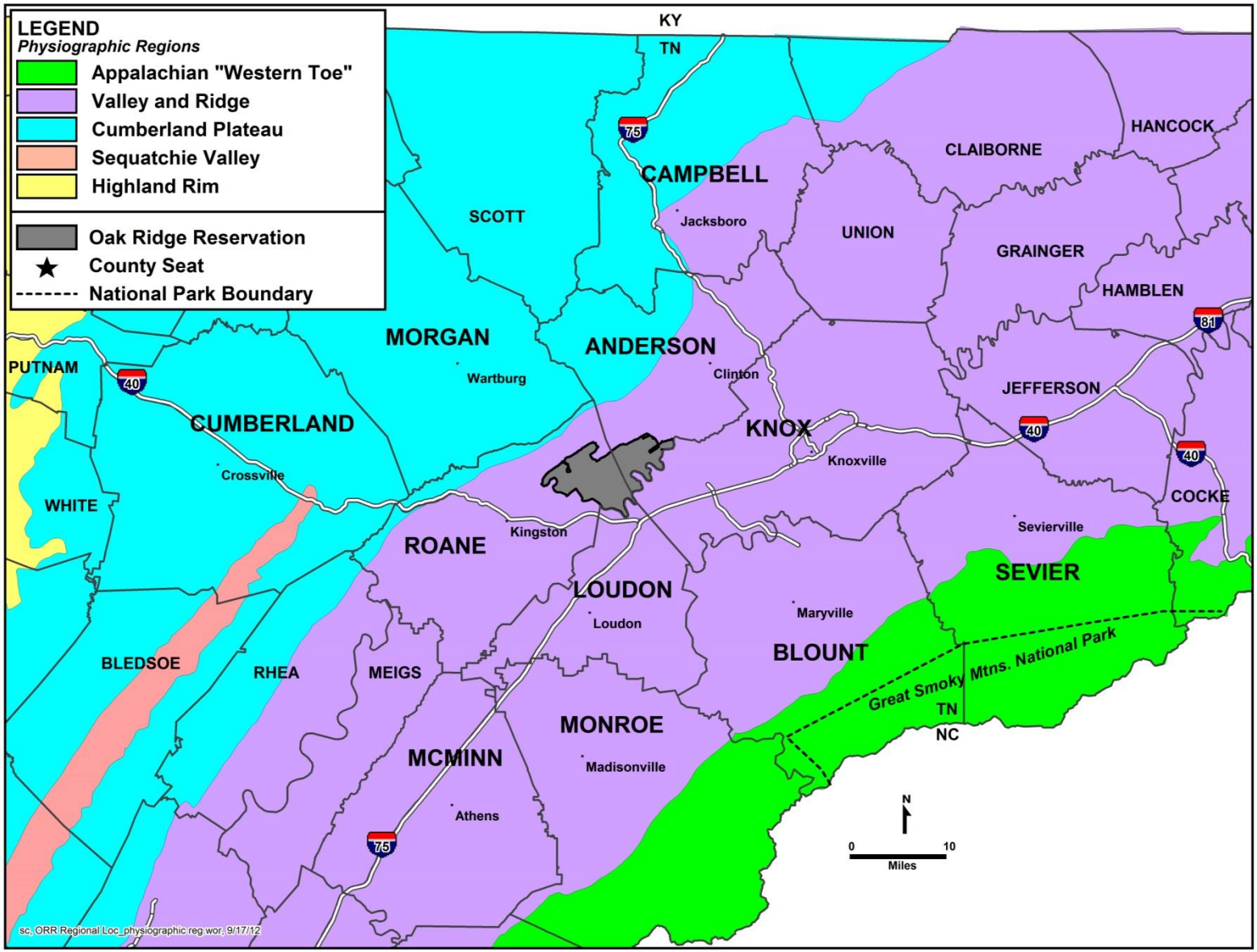

Fig. 3. Regional location.

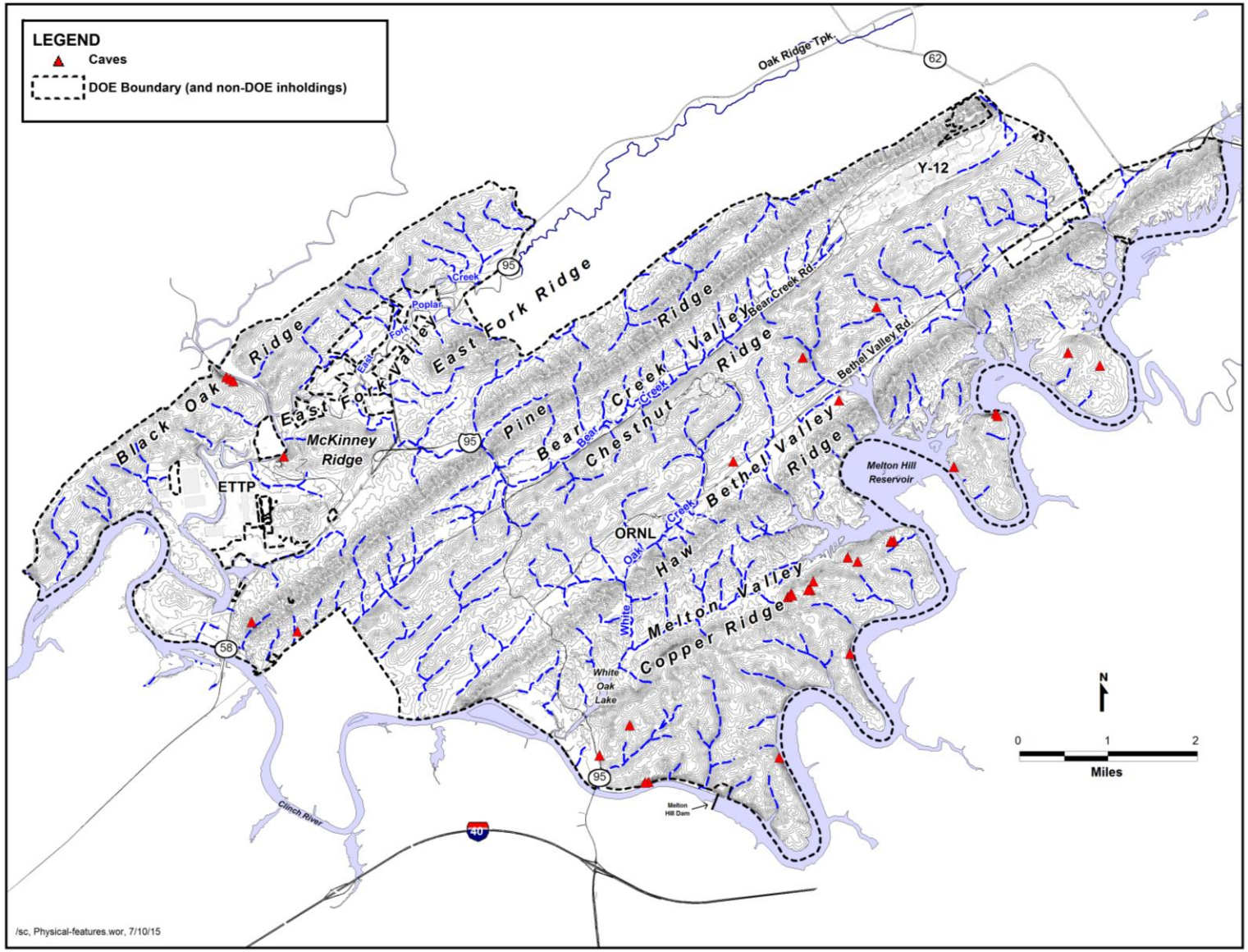

Fig. 4. Physical features of the ORR.

Elevations range from a low of 750 ft mean sea level (MSL) along the Clinch River to a high of 1,356 ft MSL atop Melton Hill on Copper Ridge. Topographic relief between valley floors and ridge crests is generally about 300–350 ft. Valleys within the ORR are underlain by bedrock formations predominated by calcareous siltstones and limestone. Ridges within the ORR are underlain by bedrock formations predominated by either weathering-resistant sandstones and siliceous shales and siltstones or siliceous dolostones that weather to form thick, residual, silty clay soils rich in chert that are resistant to erosion.

The topographical features of the ORR reflect geological structures and processes beneath the surface and weathering and erosion processes. Groundwater flow through bedrock and, to some degree, surface water flow are controlled by widespread fractures in bedrock formations on the ORR. The carbonate bedrock also displays dissolution features and landforms collectively referred to as karst. Karst features represent a spectrum ranging from minor solution enlargement of fractures to conduit flow paths to enterable caves. All of these are in evidence on the ORR and associated with the carbonate strike belts along ridge lines and valley bottoms (Parr and Hughes 2006). Surface evidence of karst development includes sinking streams (swallets) and overflow swallets, karst springs and overflow springs, enterable caves, and numerous sinkholes of varying size. In general terms, karst is most developed in association with the Cambro–Ordovician Knox Group carbonate bedrock that underlies Copper Ridge, Chestnut Ridge, McKinney Ridge, and Black Oak Ridge. The highest density of sinkholes and caves occurs in the Knox Group. Large springs in the Knox Group typically occur along the base of the ridges underlain by the group.

Evidence of extensive soil erosion that occurred on the ORR before government acquisition and that was caused by past agricultural practices is visible in areas characterized by fragile soils. Large gullies and washes are still present today along the sides of ridges.

3.2 SURFACE WATER

Surface water hydrology within the ORR is characterized by a network of Clinch River tributaries arranged in a trellis drainage pattern (Fig. 4). TVA regulates water levels in the Clinch River by retaining or releasing water at Melton Hill Dam or Watts Bar Dam for hydroelectric generation and flood control. The main three DOE facilities (ORNL, Y-12 National Security Complex [Y-12], and East Tennessee Technology Park [ETTP]) on the ORR affect different subbasins of the Clinch River drainage system. Poplar Creek, with a total drainage area of approximately 136 $mile^2$ (the majority of which is outside the ORR), flows through the Heritage Center. White Oak Creek, which has a total drainage area of approximately 6.0 $mile^2$, drains the area encompassing ORNL. Both Bear Creek and East Fork Poplar Creek, which have total drainage areas of 7.4 and 30 $mile^2$, respectively, drain Y-12. East Fork Poplar Creek also drains the western two-thirds of the land area of the city of Oak Ridge. All other streams within the ORR drain predominantly forested areas, with little or no impact from the major facilities.

3.3 CLIMATE

The ORR is located in the temperate region of the United States with four distinct seasons. Temperature data for Oak Ridge from the years 1951–77 are summarized in the Anderson County soil survey (Moneymaker 1981). Temperature data for the years 1976–2005 are summarized in the *Oak Ridge Reservation Physical Characteristics and Natural Resources* report (Parr and Hughes 2006). Average summer temperatures are highest during July, with the daily high temperature averaging 87°F and the daily low temperature averaging 66°F. Average winter temperatures are lowest during January, with the daily high temperature averaging 47°F and the daily low temperature averaging 29°F. Annual precipitation during the period 1951–2005 in the city of Oak Ridge averaged 54 in., including an average of 11 in. of snow. Rainfall is typically greatest in winter (December–March) and least during late summer and fall (August–October).

4. BIOTIC RESOURCES

Viewed from above, the ORR is an island of contiguous, mostly hardwood forest embedded within the fragmented, urban sprawl landscape of the Knoxville metropolitan area (Mann et al. 1996). Before government acquisition, the agrarian landscape was made up of forest (approximately 50%), isolated woodlots, fields, and homesteads. By 1994 the ORR was approximately 70% forested; 10% developed land; and the remaining 20% early successional areas consisting of old fields, cutover forest, roadsides, and utility corridors. The majority of the ORR forests can be grouped into three major types: hardwoods (oak–hickory), mixed forest (pine–hardwood), or conifer (pine), as shown in Fig. 5. Minor areas of other forest cover types are found throughout the ORR, including northern hardwoods, cedar–hardwood, a few small stands of hemlock or white pine, and bottomland hardwood forests. Other communities include cedar barrens, river bluffs, and palustrine and lacustrine wetlands.

Biologically and ecologically significant natural areas and habitats have been identified as present on the ORR. These areas (forests, grasslands, bogs, barrens, bluffs, outcrops, and other areas) represent high-quality examples of natural communities and/or habitats for populations of rare species and species of concern.

The Nature Conservancy (TNC) used occurrences of rare species and communities and other biologically important features, such as caves, springs, and previously designated natural areas, to identify and rank "sites of conservation importance" (TNC 1995) (Fig. 6). The study also considered high-quality examples of more common communities to be of high conservation value. According to TNC, the ORR is one of the largest remaining areas in the southern Valley and Ridge Physiographic Province with relatively intact natural communities, especially those of valley bottoms and lower slopes. Subsequently, Baranski (2009) developed a set of guidelines for evaluating the natural value of specific areas with preliminary assessments of relative biodiversity importance.

More than 1,100 vascular plant species have been identified at the ORR, including 14 species designated Threatened or Endangered by the Tennessee Department of Environment and Conservation (Baranski and Pounds 2014, draft). Certain species formerly on the state list have been delisted, in part because of the protection they have received on the ORR.

Planning can include promotion of the conditions necessary to conserve, protect, and maintain existing natural areas and habitats. Appropriate management can be conducted on a site-specific basis. In many cases, this management may involve nothing more than protection from unnatural disturbance and modification; in other cases, though, it may involve active manipulation of site conditions. Forest management on the ORR can incorporate and integrate natural areas and natural area values as legitimate uses of Reservation forests and can consider these uses to be of equal or greater importance than many other traditional forest uses.

4.1 OLD-GROWTH FOREST

An uncommon forest occurrence within the ORR is old-growth forest, defined by the US Forest Service Old-Growth Task Group (White and Lloyd 1998) to be "ecosystems distinguished by old trees and related structural attributes. Old-growth encompasses the latter stages of stand development that typically differ from earlier stages in a variety of characteristics which may include tree size, accumulations of large dead woody material, number of canopy layers, species composition, and ecosystem function." One old-growth stand has been documented at the ORR, and others may exist.

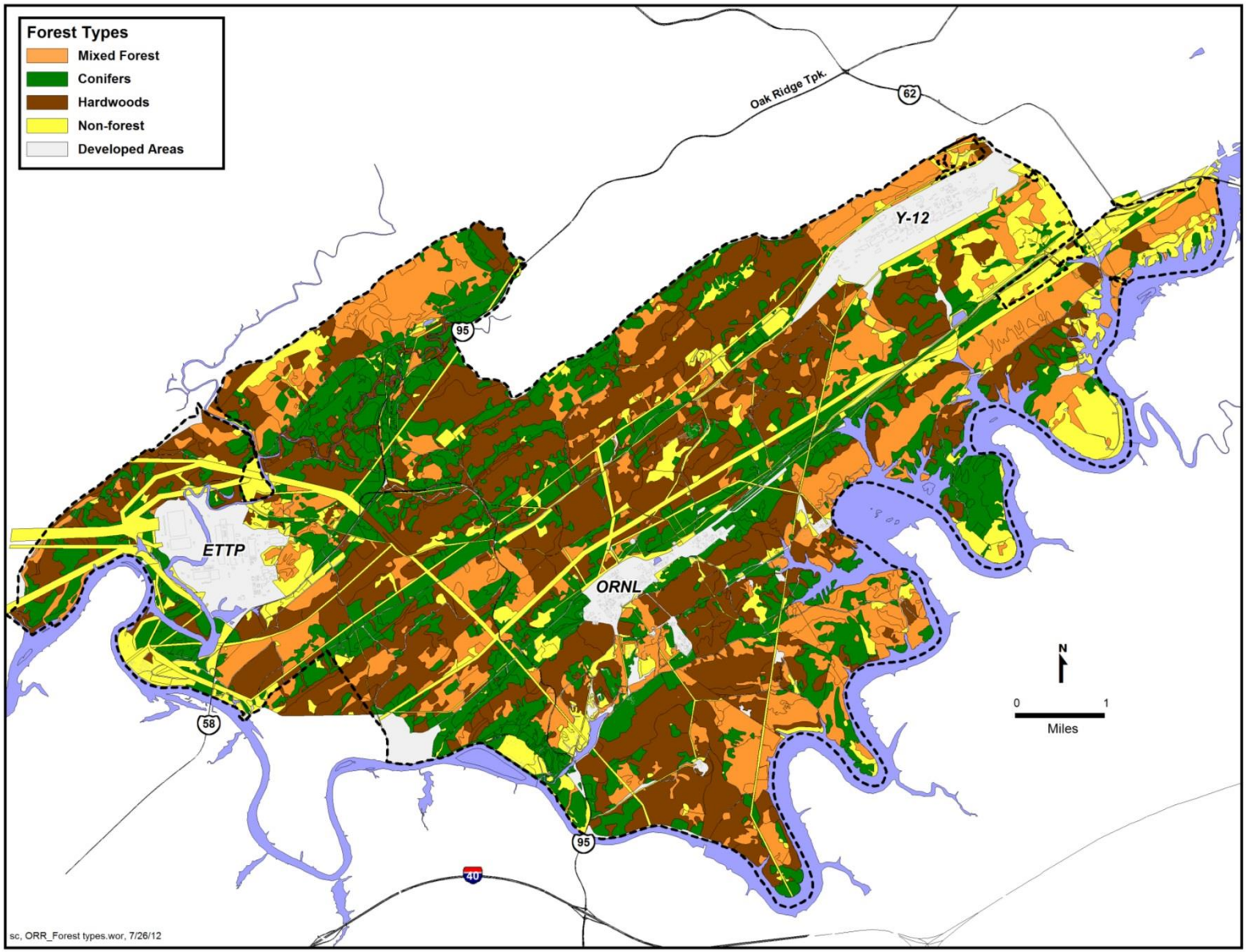

Fig. 5. ORR forest types.

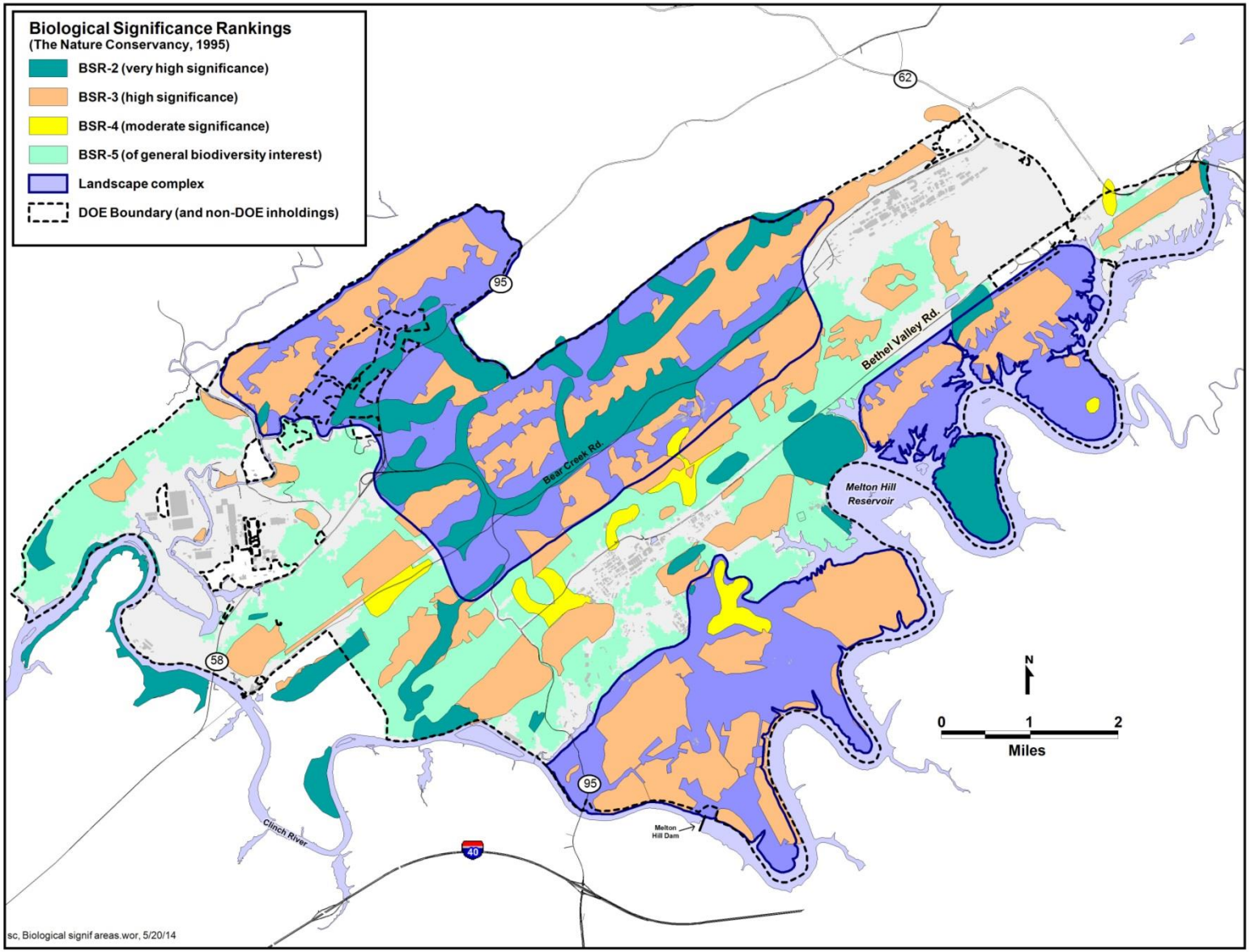

Fig. 6. The Nature Conservancy ORR biological significance rankings.

4.2 INTERIOR FOREST HABITAT

The ORR is recognized as the largest contiguous protected land ownership in the southern Valley and Ridge Physiographic Province, making it a significant regional resource. The forests of the ORR are important due to not only the relatively large total acreage, but also the number of relatively large contiguous tracts of forest (Giffen, Evans, and Parr 2012). As the Knoxville Metropolitan Area continues to expand, the ORR forest represents an increasingly scarce forested area of relatively large, contiguous tracts. Forests outside the boundaries of the ORR have been fragmented by clearing for land uses such as agriculture, industry, commercial and residential development, roads, and utility corridors. Interior forest habitat is an important component of biologically diverse systems, offering habitat critical to the survival of numerous neotropical bird species (Fig. 7). Additional discussion of interior forest and how it is identified on the ORR is provided in the current forest section (Sect. 6).

4.3 FOREST SEQUESTRATION OF CARBON

Opportunities to both explore climate change mitigation research and demonstrate it in action are present within the ORR forests. Natural uptake of atmospheric carbon by vegetation through photosynthesis and storage or sequestration of the carbon in the biomass and soils may help mitigate the impacts of increased atmospheric carbon dioxide. The capacity to sequester carbon is enhanced with healthy forest systems and actions that include afforestation, avoiding conversion of forest lands to other uses, restoring degraded lands, reducing the potential for wildfire, providing continuous canopy cover, establishing multi-aged and mixed species stands, and minimizing losses to insects and diseases.

A crude estimate of the carbon stock of the Oak Ridge forest was provided by Dr. Paul Hanson (2011) and is explained in more detail in the ORR Land Use Plan (DOE 2012). Ignoring differences due to stand species composition, the Reservation's 22,789 acres of forest land contain 890,920 MgC in live biomass; 75,364 MgC in forest floor carbon (downed wood, litter, and humus); and an additional 573,310 MgC stored in soils for a grand total of 1,539,595 MgC stored in the forests of the ORR.

In the absence of major disturbances such as the southern pine bark beetle outbreak of 1998–99, these ORR forests are currently adding carbon at a rate of between 16,777 and 23,865 MgC/year. Therefore, the Reservation is holding approximately 80–90 years' worth of carbon accumulation in its combined aboveground and belowground carbon stocks. Planting new trees, protecting established forests, and improving forest health through thinning and prescribed burning are some of the ways to increase forest carbon for the future.

4.4 WILDLIFE

The diversity of wildlife species ranges from common species found in urban and suburban areas of eastern Tennessee to species with more restrictive habitat requirements, such as interior forest bird species. The ORR hosts about 73 species of fish; 68 species of reptiles and amphibians; up to 228 species of migratory, transient, and resident birds; and 49 species of mammals, as well as innumerable invertebrate species. Among these, 32 federal- or state-protected vertebrate species have been confirmed during recent and historic surveys (ORNL internal list, "Animal species of special concern reported from the Oak Ridge Reservation," updated April 2014; maintained by Neil R. Giffen, Natural Resources Manager, ORNL Facilities and Operations Directorate, Natural Resources Program). In addition, 36 bird species recorded on the ORR are recognized to be of Regional Concern by Partners in Flight (Roy et al. 2014). Wildlife management is described in the ORR Wildlife Management Plan (Giffen, Evans, and Parr 2012).

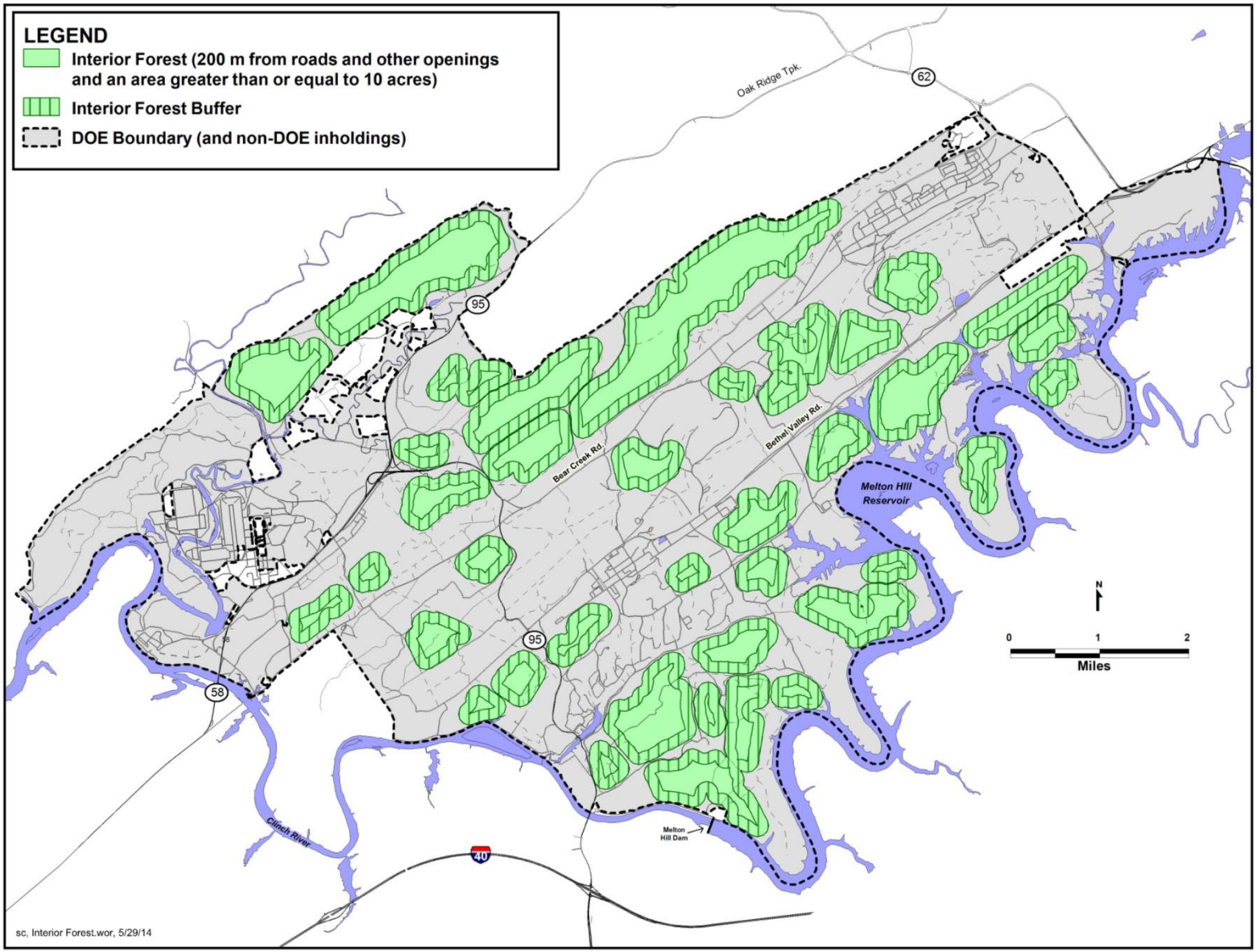

Fig. 7. ORR interior forest.

Management of wildlife on an area as large as the ORR is necessary to ensure public safety (e.g., reduce deer/vehicle collisions, reduce Canada goose/human interactions) and maximize wildlife health and diversity. Maintaining important habitats is essential to the preservation of species in need of management. Characterizing habitats and understanding wildlife requirements are necessary for making decisions that could affect species or habitats and for evaluating potential impacts of proposed activities. Information on the species and habitat types present, wildlife diversity, and protected habitat locations is also essential in land-use planning and decision making. Additionally, information collected through the wildlife program can be used in regional forest and wildlife management throughout the state.

Outstanding features of the ORR for wildlife include its large areas of unfragmented, mature eastern deciduous hardwood forest and overall habitat diversity, particularly in comparison with surrounding land uses. Such areas are increasingly uncommon in the region and nation. Overall, the ORR provides a diversity of wildlife habitats both imbedded within this forest matrix and as a result of other activities that have occurred since the area was acquired by the federal government in the 1940s. Thus, in addition to a variety of forested habitats and pine plantations, the ORR contains seminatural, managed grasslands and forest edges, which together provide considerable habitat diversity capable of supporting a variety of wildlife species. Habitat features include, among others, the following:

- large areas of mature hardwood forest;
- significant blocks of interior forest;
- sizeable areas of grassland;
- old fields at different stages of succession;
- unique or important vegetation communities;
- seminatural corridors;
- planted hardwoods and pines;
- bottomlands, wetlands, riparian areas, creeks, and ponds, including an increasing number of beaver ponds;
- caves; and
- developed and semideveloped areas and roads.

The ORR is a premier site in the southeastern United States of relatively undisturbed, unfragmented, primarily natural habitat (TNC 1995). The major objective of wildlife management planning is to maintain and preserve this regionally and nationally important refuge for wildlife diversity. There are, in addition, opportunities to improve general wildlife diversity on the ORR as follows:

- management of large fields for native grasses;
- promotion of forestry management techniques that benefit wildlife;
- maintenance of large, unbroken tracts of mature forest;
- development of natural riparian zones and aquatic habitats; and
- enhancement of featured habitats.

The above-mentioned goals would further define the objectives and methods for implementing the recommended practices. These habitat management measures contribute to species-richness management. Managing for species richness ensures that all wildlife species currently found on the ORR are maintained

as residents in viable numbers. Each species, even those about which little or nothing is known (e.g., most invertebrates), is important. Preservation, development, and maintenance of a broad spectrum of habitats are long-term goals (Giffen, Evans, and Parr 2012).

A Memorandum of Understanding between the Fish and Wildlife Service and DOE demonstrates DOE's commitment to integrate migratory bird conservation principles, measures, and practices into agency activities (*Federal Register*, Vol. 78, No. 219 [Nov. 13, 2013]).

5. ORR LAND USES AND DESIGNATIONS

The ORR land is intensively used for multiple purposes to meet the mission goals and objectives of DOE. Four major facilities (ETTP, Y-12, ORNL, and Oak Ridge Institute for Science and Education) represent developed areas within the primarily undeveloped ORR. Transportation and utility corridors also traverse the ORR. Figure 8 shows the primary urban and industrial interface on the ORR.

Total management area for the ORR is 33,480 acres, of which approximately 24,000 are forested and managed for DOE by the ORNL Natural Resources Program. Fewer than 10,000 acres are not forested and include building sites, utility corridors, rights-of-way, streams, ponds, rivers, lakes, access roads, highways, and waste remediation areas.

Numerous ORR land-use designations and agreements result in overlapping, and potentially contradictory, land-use objectives. DOE is committed to a philosophy of managing forest and other natural resources for multiple use objectives. All of the land uses described below are embedded within the ORR forests. A more in-depth description of land uses at the ORR may be found in *Oak Ridge Reservation Planning: Integrating Multiple Land Use Needs, FY2012 Update* (DOE 2012).

5.1 TRANSPORTATION AND UTILITY CORRIDORS

Transportation corridors include paved highways, paved secondary highways, secondary roads, unimproved trails, and railroads. Roadsides are maintained as grassland by periodic mowing. Utility corridors include electric transmission lines, natural gas pipeline corridors, and radio-transmission tower sites. Utility corridors are maintained as grasslands by either periodic mowing or herbicide application.

5.2 ECOSYSTEM RESEARCH AREAS

The ORR provides land for numerous ecosystem research activities, including the National Science Foundation (NSF) National Ecological Observatory Network, Walker Branch Watershed Research Area, Natural Resources Conservation Service Ecological Site Description characterization areas, Freels Bend Reference Area, Integrated Field Research Challenge site (Bear Creek Valley), Pine Ridge Forested Catchments, National Oceanic and Atmospheric Administration (NOAA) Atmospheric Turbulence and Deposition Research Sites, Solway Bend Long-Term Field Studies, and 0800 Carbon Partitioning in Soils (DOE 2012) (Fig. 9).

5.3 OAK RIDGE NATIONAL ENVIRONMENTAL RESEARCH PARK

DOE designated approximately 20,000 acres of the ORR as a National Environmental Research Park (one within a national network of seven) to use as an outdoor laboratory for evaluating the environmental consequences of energy use and development as well as strategies for mitigating these effects (Fig. 10). The Research Park is also an International Biosphere Reserve unit of the Southern Appalachian Biosphere Reserve. These designations are indicative of the recognized value of the ORR as an outdoor laboratory for investigating natural ecological processes.

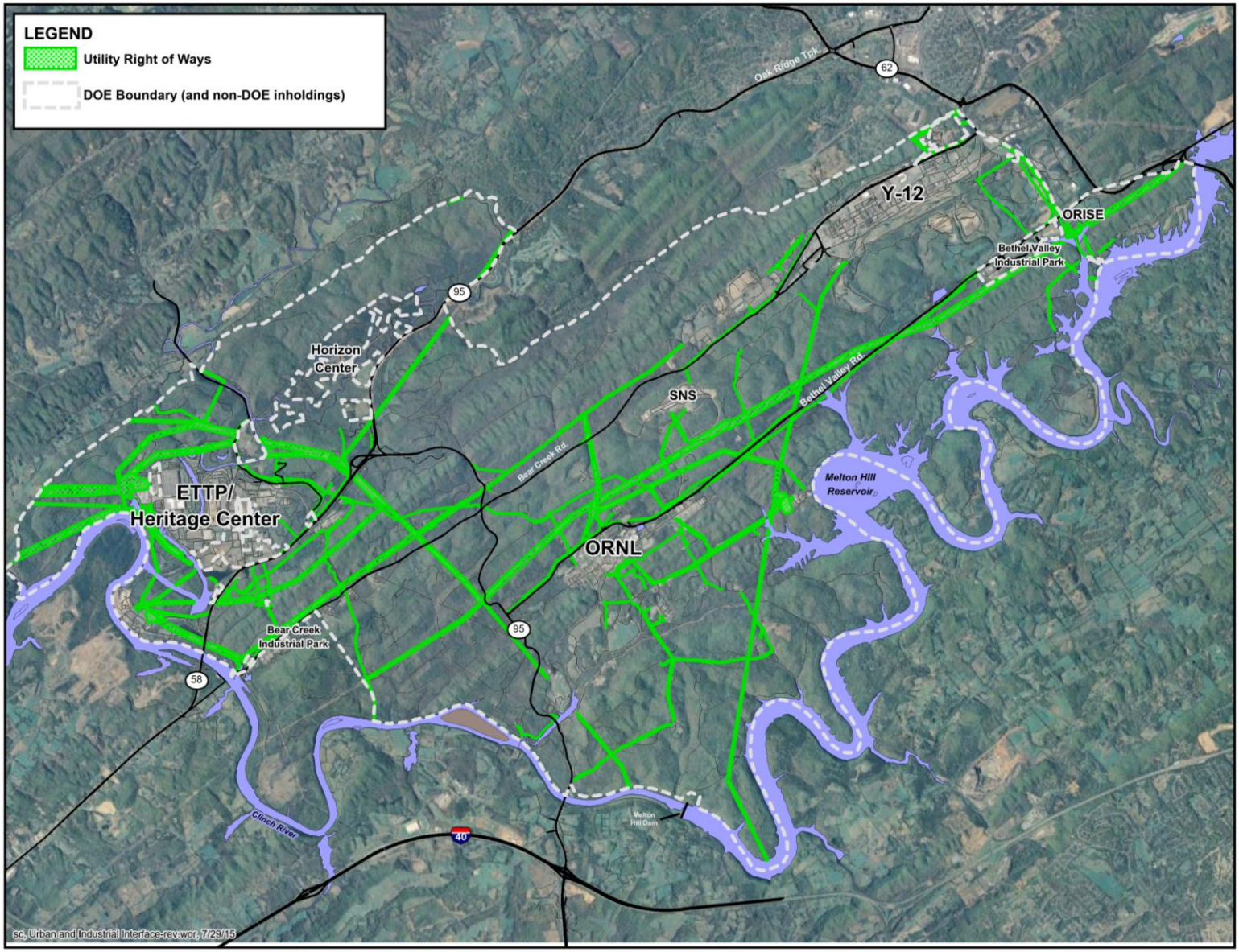

Fig. 8. Primary urban and industrial interfaces.

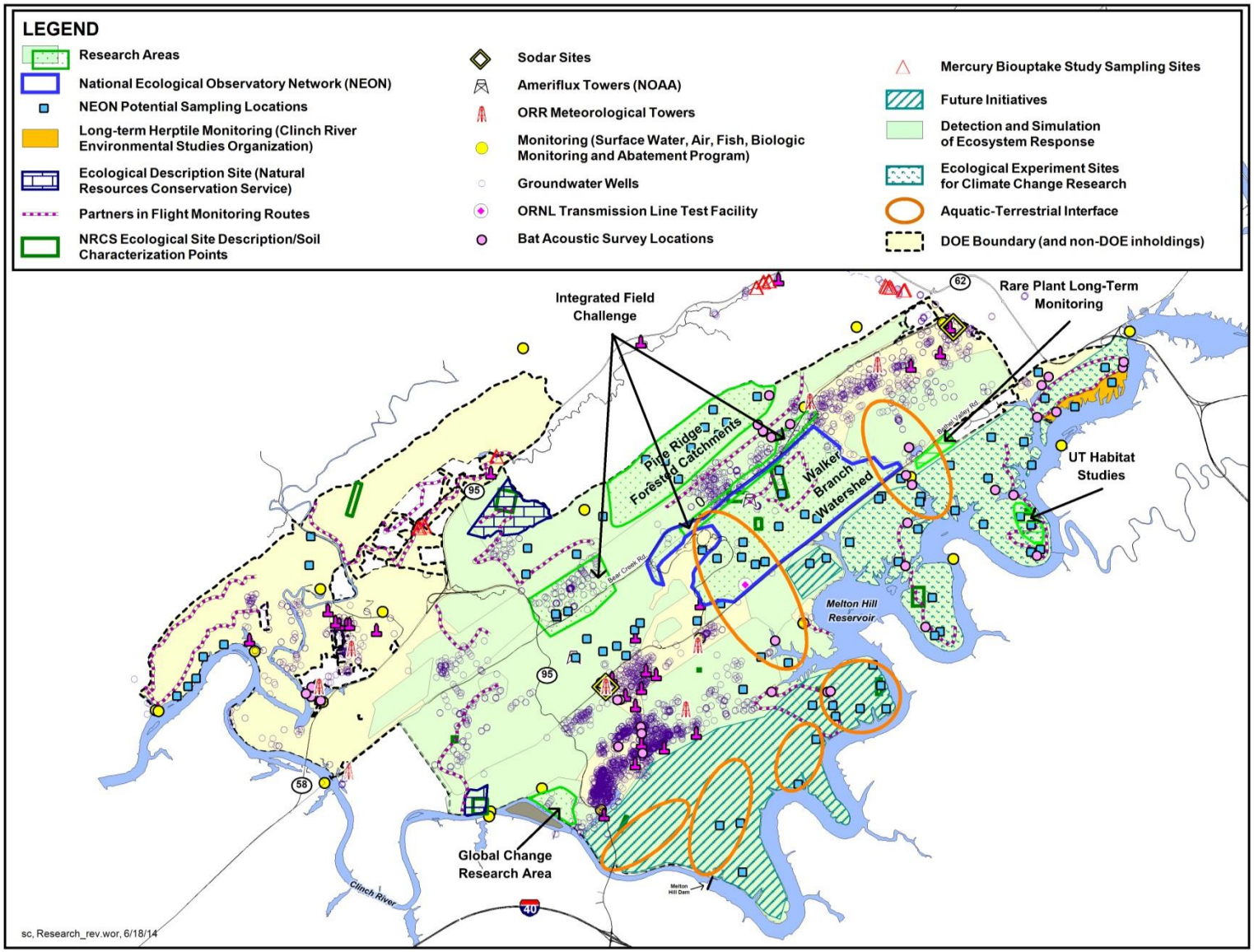

Fig. 9. ORR research and monitoring areas.

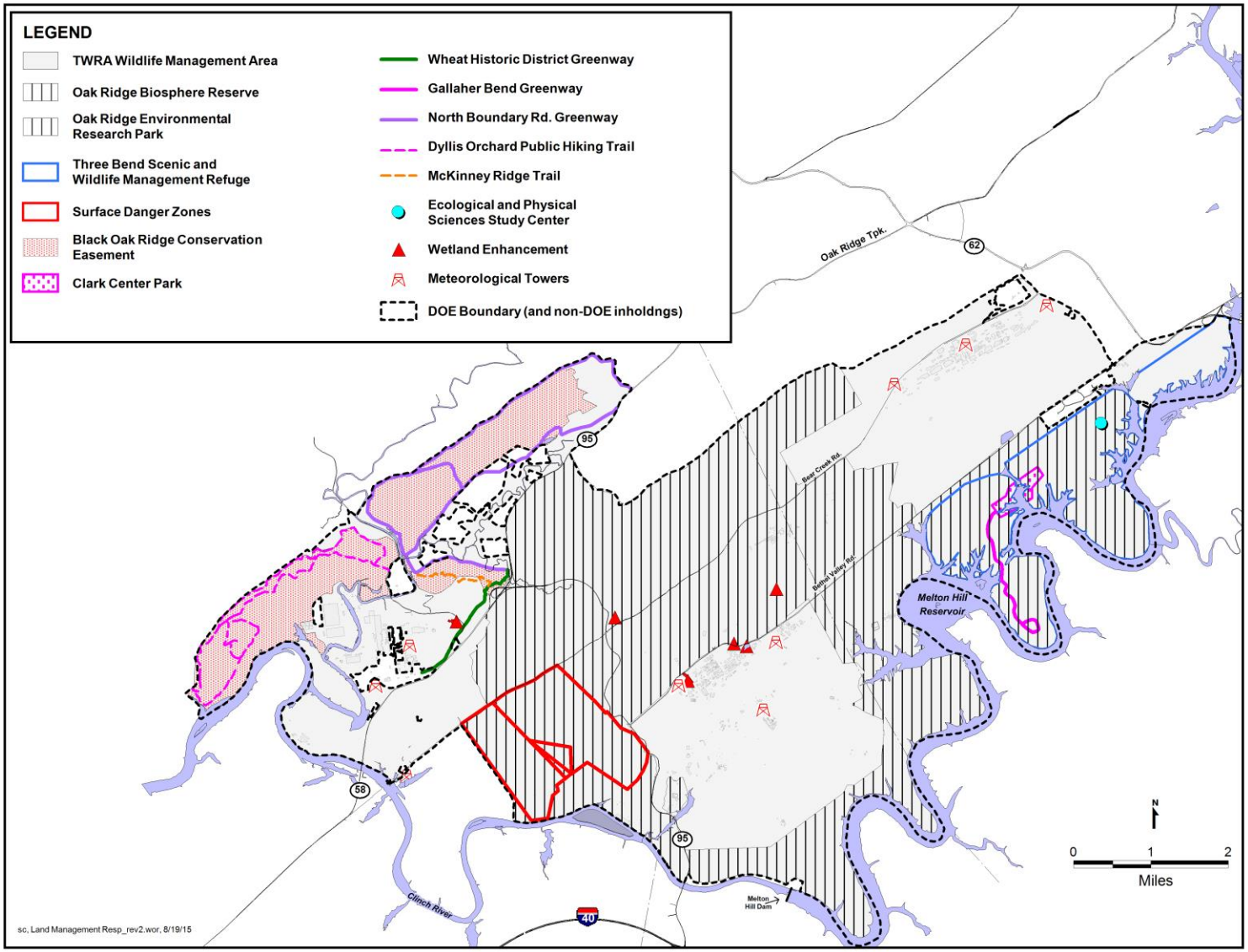

Fig. 10. ORR land management responsibilities.

5.4 OAK RIDGE WILDLIFE MANAGEMENT AREA

The ORR was designated as the Oak Ridge Wildlife Management Area through an agreement between DOE and TWRA that gives wildlife management responsibility to TWRA (Fig. 10). Management includes wildlife population control through hunting, trapping, and removal; wildlife damage control; restoration of wildlife species; preservation, management, and enhancement of wildlife habitats; coordination of wildlife studies; and law enforcement. A Wildlife Management Plan is used to integrate TWRA and DOE wildlife management goals for the ORR (Giffen, Evans, and Parr 2012). DOE continues to have management responsibility for forested lands within the wildlife management area.

5.5 ECOLOGICALLY SENSITIVE AREAS

The Natural Resources Management program maintains a list of special habitats within the ORR collectively termed Sensitive Areas (Baranski and Pounds 2014, draft). Sensitive Areas (Fig. 11) are those containing state- or federally listed species or ecologically significant habitat and/or having particular management requirements, as specified below.

- Natural Areas (NAs)—Terrestrial or Aquatic Natural Areas (ANAs) are systems classified primarily on the basis of the presence of listed species.
- Reference Areas (RAs)—Terrestrial or Aquatic Reference Areas are areas that contain uncommon habitat or ecologically sensitive features, such as wetlands, barrens, caves, or springs, that may also serve as reference or control areas for biological monitoring.
- Cooperative Management Areas (CMAs)—CMAs are areas being used for nonecological purposes (e.g., mowed areas) that contain sensitive habitat for which close cooperation among programs is required to achieve multiple management objectives.
- Habitat Areas (HAs)—HAs are areas designated as such because of the presence of plants listed by the state as Threatened due to commercial exploitation.
- Potential Habitat (PH)—PH areas have habitat characteristics suitable for habitation by state- or federally listed species but in which those species have not been recorded.

In an assessment of NAs and RAs on the ORR, Baranski (Baranski 2009, Baranski and Pounds 2014, draft) noted that several of the currently recognized NAs and RAs stood out as units that could be combined into larger functional natural-area units. As a result of this recommendation, some existing areas were merged to create three new NAs, three existing NAs were reconfigured as a result of facility development within the site, one NA was reconfigured based on ownership changes, and a new NA was established. NAs with boundary changes are listed with more detailed information below:

- Walker Branch Watershed Natural Area,
- West Haw Ridge Natural Area,
- Bear Creek Spring Natural Area,
- Pine Ridge Mature Forest Natural Area,
- White Cedar Area,
- Melton Valley Lily Area,
- East Fork (Poplar Creek) Floodplain, and
- Chestnut Ridge Springs Area.

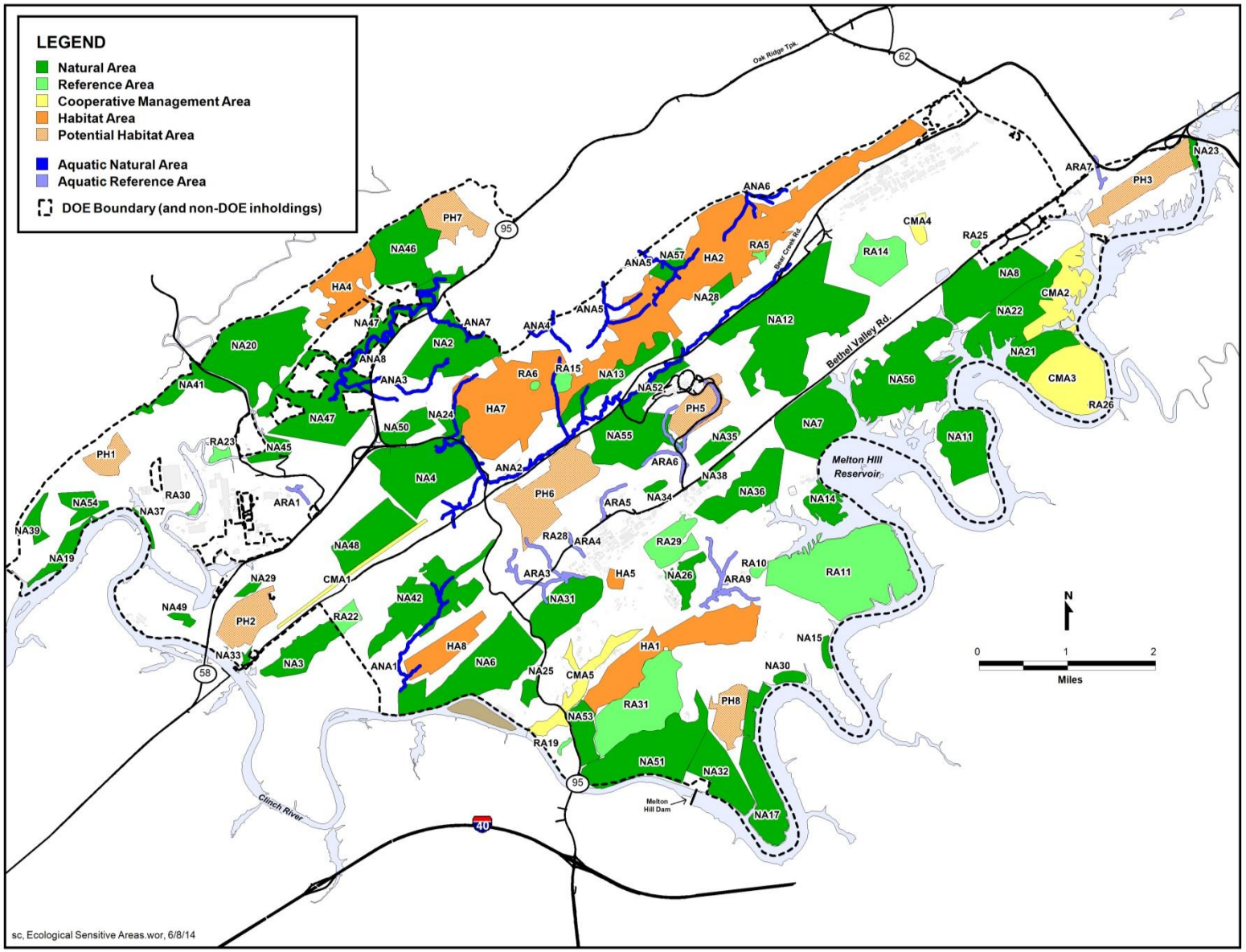

Fig. 11. Ecologically Sensitive Areas on the ORR.

5.5.1 Walker Branch Watershed Natural Area (NA12)

The Walker Branch Watershed Research Area, although protected for long-term research, was not originally protected as a natural area. The new Walker Branch Watershed Natural Area combines NA12: Walker Branch Fothergilla Site; NA43: Lower Walker Branch Ledges; NA44: Chestnut Ridge Whorled Horse-balm Area; and some other recognized areas, including a mapped HA (HA6: Walker Branch Forests) and a mapped PH Area (PH4: East Chestnut Ridge Forest). The research area includes an excellent quality, largely unfragmented northern red–oak tuliptree–chestnut oak–white oak forest type. It also supports nesting interior-forest neotropical migrant birds. The area now encompasses approximately 840 acres.

5.5.2 West Haw Ridge Natural Area (NA6)

Three adjacent NAs and RAs (NA6: Raccoon Creek Golden Seal Area; RA8: Golden Seal Barrens; and RA9: Haw Ridge Upland Hardwoods) were merged into an expanded NA6 of approximately 445 acres and renamed NA6:West Haw Ridge Natural Area.

5.5.3 Bear Creek Spring Natural Area (NA52)

Two areas (NA52: Bear Creek Spring Area and RA7: Bear Creek Mesic Forest) were merged into an expanded NA52 because they were adjacent and similar. The approximately 125 acres also includes part of an ANA.

5.5.4 Pine Ridge Mature Forest Natural Area (NA57)

This new NA has been recognized as important in ecosystem research. It has recently been determined to contain significant features, consisting of a mixed-age, primarily beech-sugar maple forest with many large trees and some possible old-growth areas. It also includes the uncommon beech-mountain laurel community. The area is noncalcareous. It is nearly high-quality interior forest. An ANA, the site of stream chemistry research, is included. This new NA consists of approximately 53 acres.

5.5.5 White Cedar Area (NA14)

This existing NA was reconfigured as a result of construction of the Clinch River Cabin in 2010 that directly impacted a high-quality forested section of 2.3 acres. The cabin and small area around it have been removed from the NA. Adjacent to the original NA boundaries, areas of ecological importance were identified and were added to NA14. The additional area includes quality wetlands, a mature beech forest, a significant amount of forested lakeshore, two *Cypripedium* element occurrences, and some remnant bottomland forest. NA14 is approximately 88 acres.

5.5.6 Melton Valley Lily Area (NA26)

This was a very small NA. Construction of the Melton Valley maintenance facility resulted in disturbances and elimination of an element occurrence for *Cypripedium*. Study of the adjacent area led to the discovery of important natural resources such as surveyed wetlands, a substantial stream system, some steep terrain, and an older forest, including large bottomland oaks. This resulted in the addition of new acreage and the development of a significantly new entity comprising about 77 acres.

5.5.7 East Fork (Poplar Creek) Floodplain (NA47)

This NA became highly fragmented and reduced in size over recent years due to transfers of ownership of some of the areas along Poplar Creek. To provide continuity and help buffer and protect the remaining

bottomland community, some small fragments that were retained by DOE were brought into the NA. In addition, a large steep slope section was incorporated to help protect the watershed. The newly configured NA is about 609 acres.

5.5.8 Chestnut Ridge Springs Area (NA55)

The original NA55 was impacted a few years ago by the construction of the access road to the Spallation Neutron Source facility. Evaluation of the region surrounding the Spallation Neutron Source resulted in the retention of most of the original NA and the addition of a large area of hardwood interior forest that included HA3 (Chestnut Ridge Forest). NA55 now consists of about 291 acres.

The intent of these designations is to elevate awareness that these are unusual habitats deserving special consideration during ORR planning and/or operational activities that could potentially result in land-use changes.

5.6 CONSERVATION AREAS

In 1999 DOE designated 2,920 acres of Clinch River shoreline and adjacent ridgeline for conservation/preservation purposes, including wildlife management (Fig. 10). The area has been designated the Three Bend Scenic and Wildlife Management Refuge Area. The proclamation, signed by Secretary of Energy Richardson and George Akans, Jr., of the Tennessee Wildlife Commission, calls for the land to be cooperatively managed for presentation purposes under a use permit (DOE 1999). The forested land in the Three Bend Area continues to be managed by DOE.

In 2003 DOE transferred to the Community Reuse Organization of East Tennessee approximately 490 acres of land in what is called the Horizon Center (formerly designated ED-1) for industrial development purposes (Fig. 8). An approximately equal acreage consisting of floodplain and wetland was retained as a protected area. Much of this is now included in NA47.

In 2005 DOE created the Black Oak Ridge Conservation Easement on 2,966 acres along Black Oak Ridge and McKinney Ridge in the northwestern part of the ORR, including Watts Bar Lake shoreline, as partial restitution for damages to Watts Bar Reservoir due to releases of hazardous substances to the Clinch and Tennessee Rivers as part of the Natural Resource Damage Assessment process under the Comprehensive Environmental Restoration, Compensation, and Liability Act (Superfund) (Fig. 10). Under the easement agreement, DOE continues to have responsibility for forest management within the Black Oak Ridge Conservation Easement.

5.7 CULTURAL AND HISTORIC RESOURCES

The locations of documented cultural resources on the ORR are shown in Fig. 12. Cultural resources include (1) surface and buried archeological artifacts and sites dating to the Prehistoric, Historic, and Ethnohistoric periods; (2) standing structures that are more than 50 years of age or are important because they represent a major historic theme or era, including six properties listed in the National Register of Historic Places; (3) cultural and natural places, selected natural resources, and objects with importance for Native Americans; and (4) American folklife traditions and arts (Parr and Hughes 2006; DOE 2001). Numerous cemeteries within the ORR boundaries require special consideration when conducting various field activities (Bradburn 1997). Cultural and historic resources management at the ORR is described in the Cultural Resource Management Plan (DOE 2001).

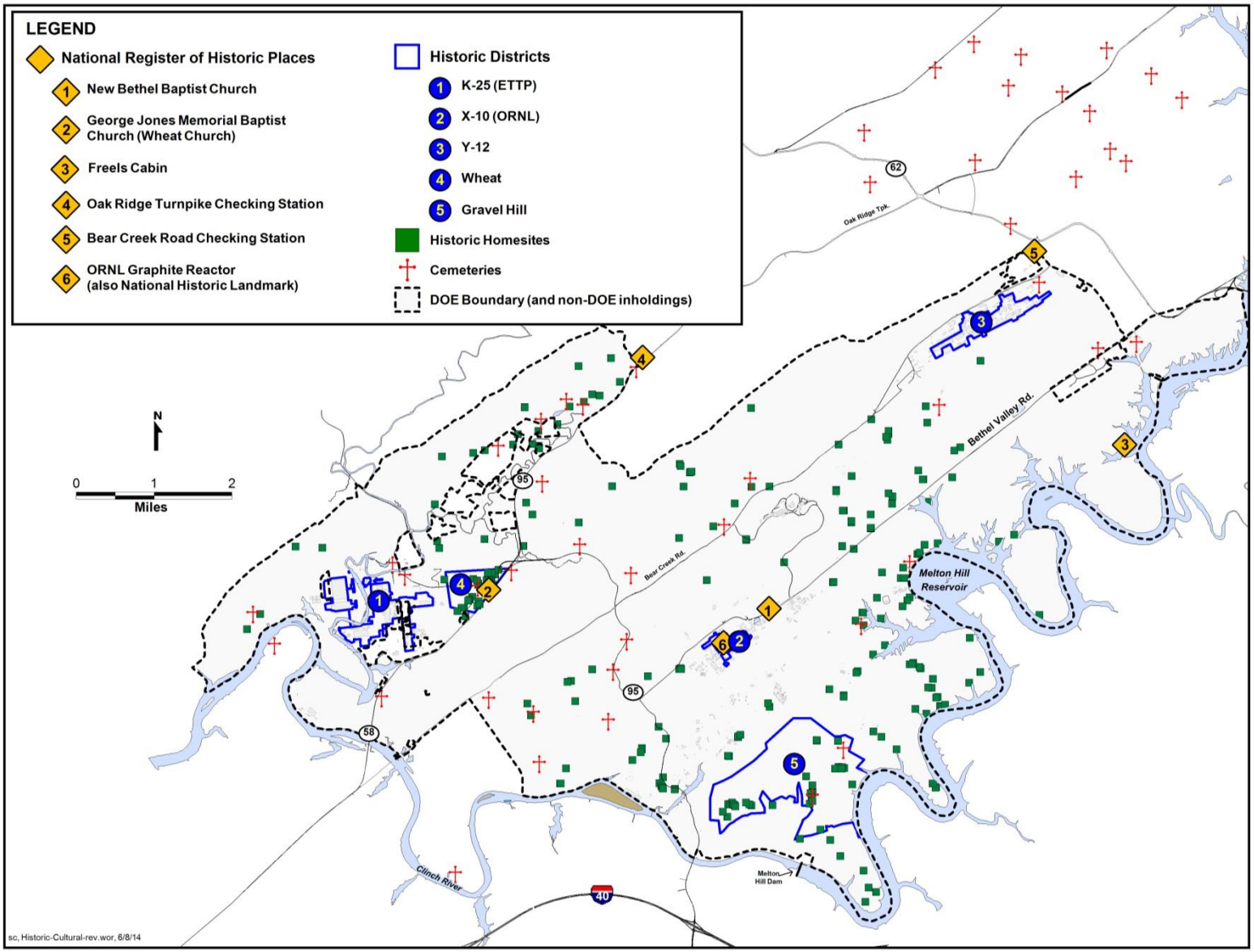

Fig. 12. ORR cultural and historic features.

5.8 PUBLIC RECREATION AREAS

DOE has opened several areas within the ORR for public recreational use. These areas include greenway biking and hiking trails and Clark Center Park (Fig. 10).

Greenways include the Gallaher Bend Greenway in the Three Bend Scenic and Wildlife Management Refuge, North Boundary Road Greenway, Wheat Historic District Greenway, Dyllis Orchard Public Hiking Trail, and McKinney Ridge Trail within the Black Oak Ridge Conservation Easement.

Clark Center Park, located in the Three Bend Scenic and Wildlife Management Refuge, is a multiple use recreation area with a launching ramp, fishing piers, softball fields, volleyball courts, picnic shelters, and a swimming area.

DOE continues to have management responsibility for the forest within these public recreation areas.

6. CURRENT FOREST MANAGEMENT ON THE ORR

The primary objectives in management of the ORR forests are to maintain healthy forests and support present and potential future DOE missions.

Forest management tasks include

- conducting inventory assessments, updating data, and sharing data;
- monitoring and maintaining forest health;
- regenerating, restoring, and enhancing forests and associated communities;
- facilitating opportunities for ecosystem research;
- interfacing on infrastructure maintenance;
- preplanning for wildland fire preparedness;
- salvaging and harvesting timber;
- communicating regarding urban forestry; and
- planning and integrating with other users.

Accomplishment of each management action requires use of management tools, some actively applied and others provided by natural, passive processes. Passive processes, when appropriate, require fewer financial and human resources inputs. Review and evaluation of the effectiveness of management actions leads to adjustments, or adaptive management.

Economic efficiency is gained by allowing natural processes, to the extent practical and within the constraints of other competing objectives, to govern the composition and ecological function of ORR forested systems. To that end, the passive processes of natural recruitment and natural selection are the basis of most current forest management strategies.

Allowing natural processes to determine forest function also helps ensure the preservation and maintenance of diverse natural habitats. Natural selection pressures within the diverse geologic and topographic landscape of the ORR result in diverse natural communities functioning within the ecological constraints of competition.

Active processes are also required to meet the management objectives for ORR forest. Disturbance is a major determinant of ecosystem function in the Valley and Ridge region. Fire is thought to have been one of the main sources of disturbance in the past. Clear-cutting, selective harvesting, mowing, and/or controlled burning may provide a similar disturbance function when it is deemed necessary for maintenance of habitat diversity.

Given the above objectives and considerations, the long-term vision of the undeveloped portions of the ORR landscape into the future includes maintenance of contiguous blocks of hardwood forest with interspersed, actively maintained grasslands and actively managed forest. Diversity of habitat can be maintained by occasional use of active disturbance processes, such as clear-cutting, selective cutting, mowing, and controlled burning, to achieve specific management objectives, including maintenance of grasslands and pine stands of diverse forest age structure. Competing natural resources and land use management objectives can be balanced according to this long-term vision. The optimal mix of land uses

can vary over time as different DOE missions and research priorities evolve. Specific management objectives include the following:

- maintain the approximate mix of vegetation types that currently inhabit ORR (undeveloped land as primarily native hardwood and hardwood–pine, with pine and open grassland);
- promote maximization of interior forest;
- provide a diversity of forest ages, including old-growth areas;
- support wildlife diversity (compatible with diversity of forest ages and habitat types);
- protect riparian areas and wetlands and, when practical, maximize diversity of riparian and wetland habitats through active management processes; and
- minimize the incidence and potential severity of wildfire and disease and thereby minimize impacts to DOE missions and mitigation expenses.

The Forest Management Plan provides the framework by which the ORR forest resource can be managed to optimize forest values, including integration with the other valuable natural resources of the ORR. In this regard, scarce or uncommon resources, such as threatened or endangered species, interior forest habitat, natural areas, and old-growth forest, can be maintained and preserved.

6.1 FOREST INVENTORY AND MAPPING

6.1.1 Forest Inventory Assessment

Forest inventory assessments provide data critical for evaluation of the health of the forest. The current inventory, initiated in 2010, can be used to determine wildland fuel load; estimate timber volumes; provide pest management observations; evaluate the need for forest health maintenance activities such as thinning, culling, or prescribed burns; identify forest research opportunities; and identify and delineate forest tracts with unique characteristics and/or that require special management regimes. Data collected at grid points within each wildland management unit include land use, canopy cover, ground cover, exotic invasive species, trees larger than 2 in. diameter at breast height (dbh), species, merchantable height, and quality of timber. With these data, calculations can be made that include basal area, tree density, species dominance, wood volume, timber value, and carbon content.

Timber is a real property asset by definition and therefore is managed under the umbrella DOE O 430.1B, *Life Cycle Asset Management*. The order requires that condition assessments on all real property assets occur at least once during any 5-year period using inspection methods in accordance with industry standards.

A 5-year inventory planning cycle, with one-fifth of the ORR inventoried annually, would meet the DOE requirement as well as provide needed information for management of the ORR forests. Figure 13 shows the original forest compartments and an ideal 5-year inventory cycle.

6.1.2 Data Management

Forest conditions, composition, and needs change. Updated data are collected for use in identifying potential areas for research or siting of DOE facilities and for identifying areas needing maintenance or management (e.g., invasive species, pest infestations, fuel reduction). Natural resources data are maintained in the ORNL Shared Data Initiative using MapInfo software and shared with other

Reservation users (DOE contractors and subcontractors) as requested. Detailed forestry specific data are maintained by the ORR Forester.

Another important tool used in mapping and planning inventory field data collection is aerial photography (typically updated every 5 years). The last complete ORR aerial photo survey was done in September 2013. Aerial photos are required to efficiently update timber-type maps and accurately depict land-use changes. They are also valuable tools for planning of controlled burns, wildland fire control, timber sales access, new land uses, etc. Aerial photography, taken as a time series, has been used to document ORR uses and activities over time.

6.2 FOREST HEALTH MONITORING

Forest health is a complex issue that involves interaction among numerous factors, including climate (extremes of temperature and precipitation), insect infestations, plant diseases, air quality, and nutrient availability.

6.2.1 Invasive Insects and Plants Management

An integrated pest management (IPM) program has been implemented. IPM is a series of pest management evaluations, decisions, and controls designed to provide cost-efficient, timely management of pest issues.

In an IPM program, potential threats to particular resources are identified, action thresholds are set, a monitoring program to provide early detection is initiated, preventive measures are taken, and control methods are applied when indicated by the monitoring program.

IPMs have been developed for

- southern pine beetle (SPB) (*Dendroctonus frontalis* Zimmermann),
- hemlock woolly adelgid (*Adelges tsugae* Annand),
- emerald ash borer (EAB) (*Agrilus planipennis* Fairmaire), and
- exotic invasive plants.

Other forest pests/diseases in the region that are being monitored include

- gypsy moth (*Lymantria dispar* L.) and
- thousand canker disease—insect vector: walnut twig beetle, *Pityophthorous juglandis*; fungal vector: *Geosmithia morbida.*

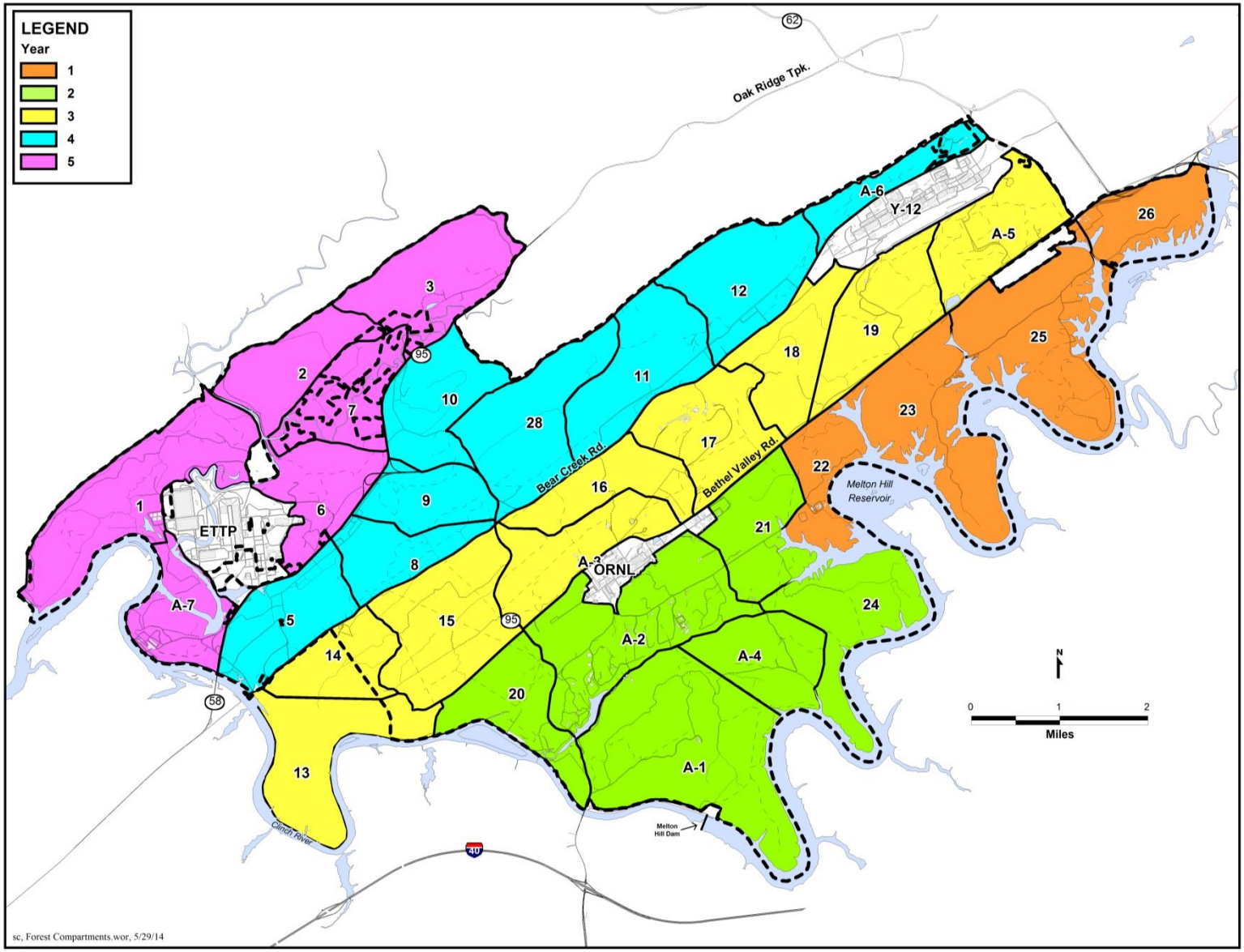

Fig. 13. Forest compartment map with 5-year inventory cycle.

6.2.2 Southern Pine Beetle

There have been four significant SPB epidemics at the ORR since federal acquisition in 1942. Major epidemics occurred in 1964, 1974–76, 1993–94, and 1999–2001. SPBs are naturally occurring insects native to the southeastern United States that tend to produce cyclic epidemic outbreaks every 10–12 years. Before federal acquisition of the ORR, there were primarily scattered shortleaf, Virginia, and eastern white pine stands within the matrix of fields and hardwood forests, so significant SPB outbreaks did not occur. The establishment of pine plantations (predominantly shortleaf and loblolly pines) at the ORR beginning in the 1940s provided the susceptible host material necessary to sustain cyclic SPB epidemics. There were approximately 9,515 acres of predominately pine forest on the ORR before the 1993 SPB outbreak. Approximately 2,248 acres of pine forest were either salvaged or lost during the 1993–1994 outbreak, leaving a total of 7,267 acres of uninfested pine forest before the 1999 outbreak. Most of the remaining pine plantation acreage was eliminated in the 1999–2001 outbreak. All locally occurring pine species (loblolly pine, short leaf pine, Virginia pine, longleaf pine, and white pine) on the ORR were infested. At present, large, contiguous stands of mature pine are greatly reduced, with most now present resulting from natural regeneration of previous plantation plantings.

IPM actions include

- planting diverse pine and hardwood species and
- monitoring through field observations and aerial photography.

Considerations if areas become infested and action is necessary include

- removing trees that pose imminent danger to DOE facilities and infrastructure and
- salvaging stands of significant size and easy accessibility.

6.2.3 Hemlock Woolly Adelgid

The hemlock woolly adelgid is a nonnative insect pest introduced from Asia that is killing eastern hemlocks in the eastern United States. The first documented occurrence of hemlock woolly adelgid at the ORR was in January 2008. While hemlock is not a dominant member of the forest communities at the ORR, eastern hemlock is an important component of mesic forest, and locations have been documented in the forest management program database (Fig. 14). Treatment is done on some hemlocks but is not possible for all due to cost and accessibility. Treatments include use of imidacloprid (Merit) and dinotefuran (Safari). Hemlocks treated as of 2012 are shown in Fig. 14.

IPM actions include

- documenting locations of infested trees and
- prioritizing trees to treat based on proximity to facilities, infrastructure, and public areas; significant size; or other unique aspects.

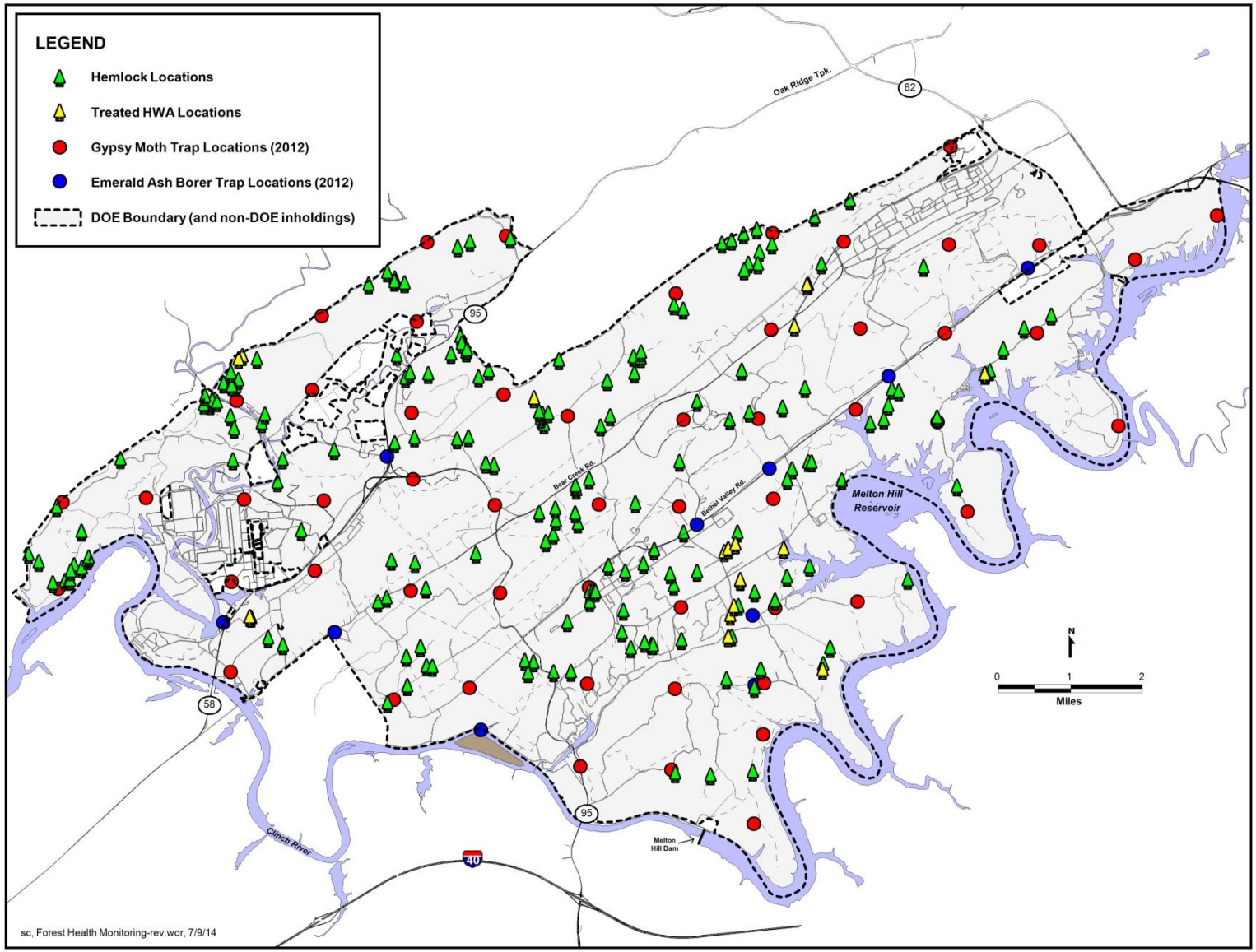

Fig. 14. ORR forest health monitoring.

6.2.4 Gypsy Moth

The gypsy moth is a nonnative insect pest introduced from Europe whose larvae defoliate oak trees, thereby weakening them to other climatic and biological stresses. After repeated attacks, gypsy moth infestations can cause extensive mortality. Gypsy moth infestations have not been detected at the ORR, although there have been scattered occurrences in eastern Tennessee, including the nearby city of Oak Ridge. The ORR Forester cooperates with the US Forest Service (USFS), Division of Pest Control in monitoring for this pest on the ORR. Gypsy moth traps are placed throughout the ORR each summer by the ORR Forester to monitor gypsy moth range expansion into the ORR. The ORR has been part of the USFS gypsy moth survey program since 1983. Trap locations in 2012 are shown in Fig. 14. Traps are monitored monthly, and results are reported to the USFS. Annual gypsy moth reports are then received from the USFS covering all trapping results for the southeastern United States, which includes eight states.

Early detection of gypsy moths may allow eradication of the insect and possibly prevent a damaging infestation.

An IPM has not yet been developed for the gypsy moth. Gypsy moth monitoring is ongoing. If infestation is detected, appropriate control measures can be determined in consultation with the USFS and Tennessee Division of Forestry.

6.2.5 Emerald Ash Borer

EAB is a nonnative pest of North American ash trees. The insect was first detected in North America in 2002, when it was discovered in southeastern Michigan and adjacent areas in Canada. It is thought to have been introduced in the 1990s on solid wood packing material originating from Asia. As of July 2014, a total of 23 states and 2 Canadian provinces had infestations of EAB.

Locally, EAB was first observed in July 2010 at a truck stop at the Watt Road exit of I-40 on the Knox-Loudon County line, a point only 2 miles from the nearest ORR forest. In May 2012, EAB was detected in two locations on the ORR, at the Highway 95/58 interchange and at the Mt. Vernon/Bethel Valley Road intersection. The finds represented the first detections of EAB in Roane and Anderson Counties, respectively. In June 2012, EAB was detected at two additional sites in Bethel Valley, and in this general area, several ash trees were noted to exhibit symptoms of the infestation (thinning crowns, branch dieback, and/or 1/8 in. D-shaped exit holes in the bark). Figure 14 shows the location of EAB monitoring traps on the ORR in 2012. As of August 2012, EAB had been confirmed in 16 East Tennessee counties and in the Great Smoky Mountains National Park. Given the extent of the infestation and analysis of infested tree ring chronology, it is assumed the pest has been present in area forests since at least 2004.

To better anticipate specific EAB impacts to the ORR and various site roads and grounds operations and to respond under the principles of IPM, it is necessary to determine how the EAB host trees are matrixed within the local infrastructure. A cursory visual inspection by the ORNL Forester and ORNL Natural Resources interns was made on foot and from vehicles during June/July 2012. The primary focus was a quick inventory of the ORNL campus and environs, Clark Center Park, and primary DOE-owned roads. Later efforts can expand the inventory to include Y-12, ETTP, Oak Ridge Associated Universities, and other DOE Oak Ridge Operations sites and facilities. Those ash species (*Fraxinus* sp.) 6 in. dbh and up and 25 ft or more in height were documented in the urban interface. Of principle concern were those trees capable of striking facilities, utilities, parking areas, workers, pedestrians, recreational areas, outdoor-use areas, areas in which people may congregate, or other operations and maintained areas.

Chemical treatments to control instances of EAB infestations in the ORR forest may be limited by sheer logistics to high-value individual trees. However, given the ORR's fortunate proximity to state plant pathology research centers, biocontrol by introductions of exotic EAB parasitoid wasps is being explored. Treatment of individual trees identified on the ORNL campus during the survey can be managed on a case-by-case basis following management input and may include no action, felling, or annual treatment with systemic insecticides via soil or trunk sprays or possibly trunk injection systems.

Another important role of the ORR EAB response can be to promote an outreach among the workforce that can assist in ash and EAB identification and educate employees about the role that moving firewood has played in the spread of the insect.

IPM actions include

- surveying ash trees to determine the extent of infestation,
- prioritizing treatment areas,
- evaluating biocontrol, and
- educating people on ways to reduce spread.

6.2.6 Exotic Invasive Plants

Invasive plants pose a number of ecological threats to natural systems as well as to facilities and infrastructure. In natural systems, they alter ecosystem operation and the services provided, decrease native biodiversity, and increase risks to rare species; additionally, they are costly to control once established. They impact facilities and infrastructure by overtaking and damaging structures, open areas, power lines, boundary and security fences, and research areas, and they degrade aesthetics.

The need to actively manage pest plant problems is not a new issue in terms of grounds, forestry, and facility maintenance responsibilities. For other resources (natural areas, wetlands, and cultural resources), care that was once passive in nature (identify and protect the area from disturbance) now requires active management to maintain the integrity of the habitat or ecosystem.

The ORR has an Invasive Plant Management Plan, first prepared and approved by DOE in 2004 (Parr et al. 2004) and updated in 2011 (Quarles et al. 2011). Figure 15 illustrates areas across the ORR that have been treated for invasive plants.

IPM actions include

- identifying invasive pest plants,
- making efforts to detect them early so they can be treated before they spread,
- integrating invasives treatment and removal with other tasks,
- protecting specific types of areas,
- targeting treatment of certain areas,
- emphasizing safety and health considerations, and
- staying updated on effective treatment options for the various plant species.

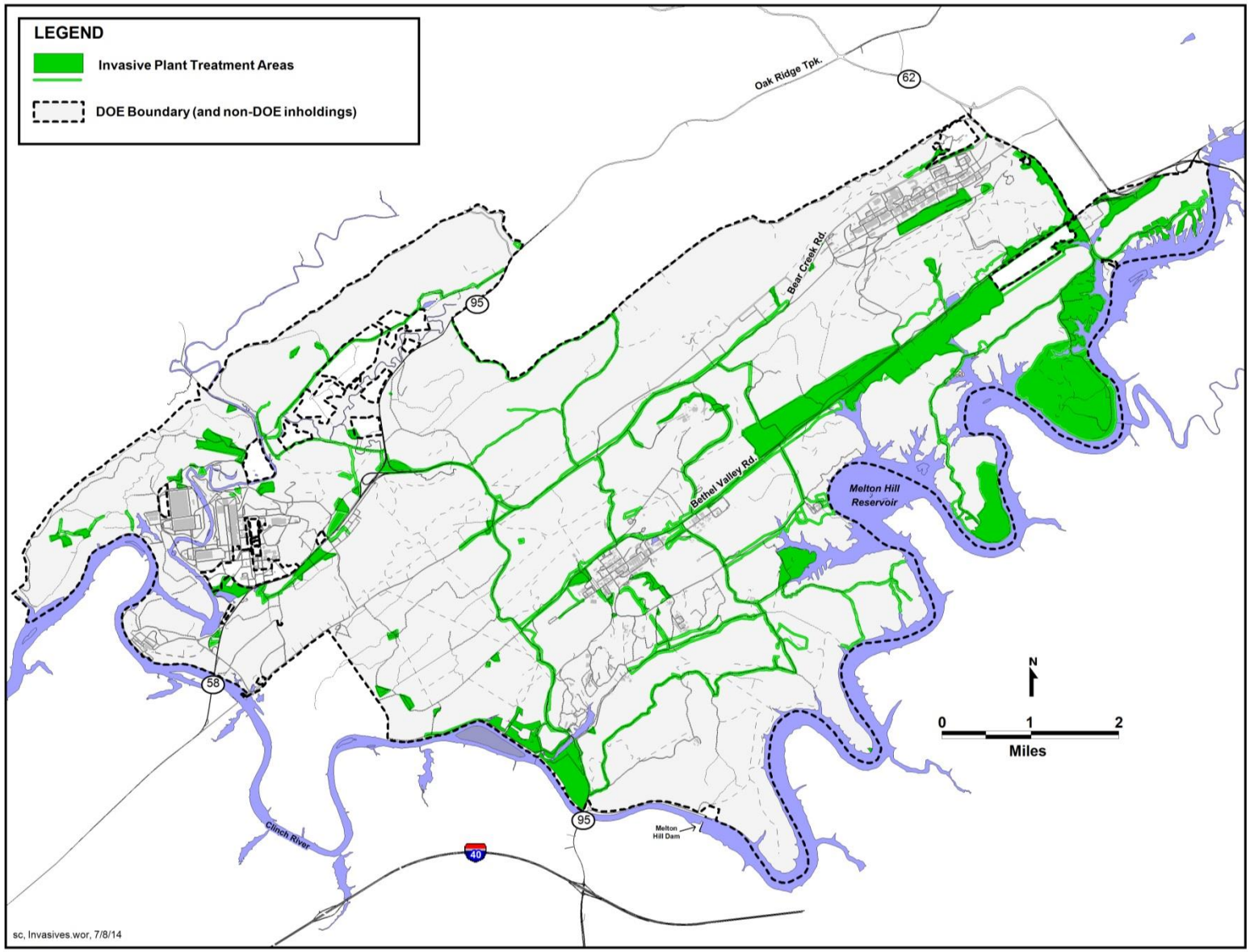

Fig. 15. ORR invasive plant treatment areas.

6.2.7 Air Quality

Air quality information is taken from *Oak Ridge Reservation Physical Characteristics and Natural Resources* (Parr and Hughes 2006). The US Environmental Protection Agency (EPA) has designated Anderson County as a basic nonattainment area for the 8 h O_3 National Ambient Air Quality Standard (NAAQS), as part of the larger Knoxville 8 h basic nonattainment area for 8 h O_3, and for $PM_{2.5}$. For all other criteria pollutants for which EPA has made attainment designations, existing air quality in the greater Knoxville and Oak Ridge area is in attainment as defined by NAAQS. In terms of forest health initiatives, there is little that can be done on a local basis to address regional air quality issues.

6.3 FOREST REGENERATION, RESTORATION, AND ENHANCEMENT

Seen from the air, the ORR is clearly a large and nearly continuous island of forest within a regional landscape that is fragmented by urban development and agriculture. ORR forests provide important blocks of interior forest and include various uncommon forest habitats and associated communities (e.g., grassland, edges, barrens, river bluffs, wetlands, successional). Maintaining, restoring, and expanding specific habitat types provide benefits to local as well as regional areas.

6.3.1 Habitat and Community Restoration

For the most part, forest regeneration and establishment are through natural processes. Now, however, even natural processes require some management to keep out invasive plants and insects as native vegetation becomes reestablished. Areas that have been impacted, such as wetlands or native grass/meadow areas, may be actively restored or enhanced. Figure 16 shows areas of habitat enhancement or restoration on the ORR.

Restoration of native grass/meadow communities, particularly conversion of fescue areas, has improved wildlife habitat, enhanced aesthetics, reduced long-term maintenance costs, and provided compliance with EO 13112, "Invasive Species." The *Native Grass Community Management Plan for the Oak Ridge Reservation* (Ryon, Parr, and Cohen 2007) outlines the approaches and goals of establishing/restoring native grass/meadow communities on the ORR. Prescribed burning has been an important tool in maintaining native grass communities.

The approximately 580 acres of wetlands on the ORR provide water quality benefits, stormwater control, habitat for wildlife and rare species, and landscape and biological diversity. Management activities have recently created additional wetlands on the ORR. These wetlands resulted from activities such as development of water detention basins during building construction, creation of artificial wetlands as mitigation for impacts to wetlands, and reestablishment of wetlands by curtailing vegetation mowing.

Former pine plantations impacted by the pine beetle have been allowed to reestablish as hardwood areas, thinned to allow pine regeneration, or cleared and replanted with a mix of pine/hardwoods or native grasses.

Chestnuts, once an important tree species in the southeast, occurred across the ORR (e.g., Chestnut Ridge, Copper Ridge) until they were decimated by the chestnut blight. Remnants remain visible as stumps and stump sprouts. Hybrid seeds, with a high percentage of native chestnut crossed with disease-resistant genes, were obtained from the American Chestnut Foundation in 2010. These were germinated on-site, grown in greenhouses, and planted in a suitable habitat in the 0800 area during 2013. Survival surveys can be made near the end of the 2015 growing season.

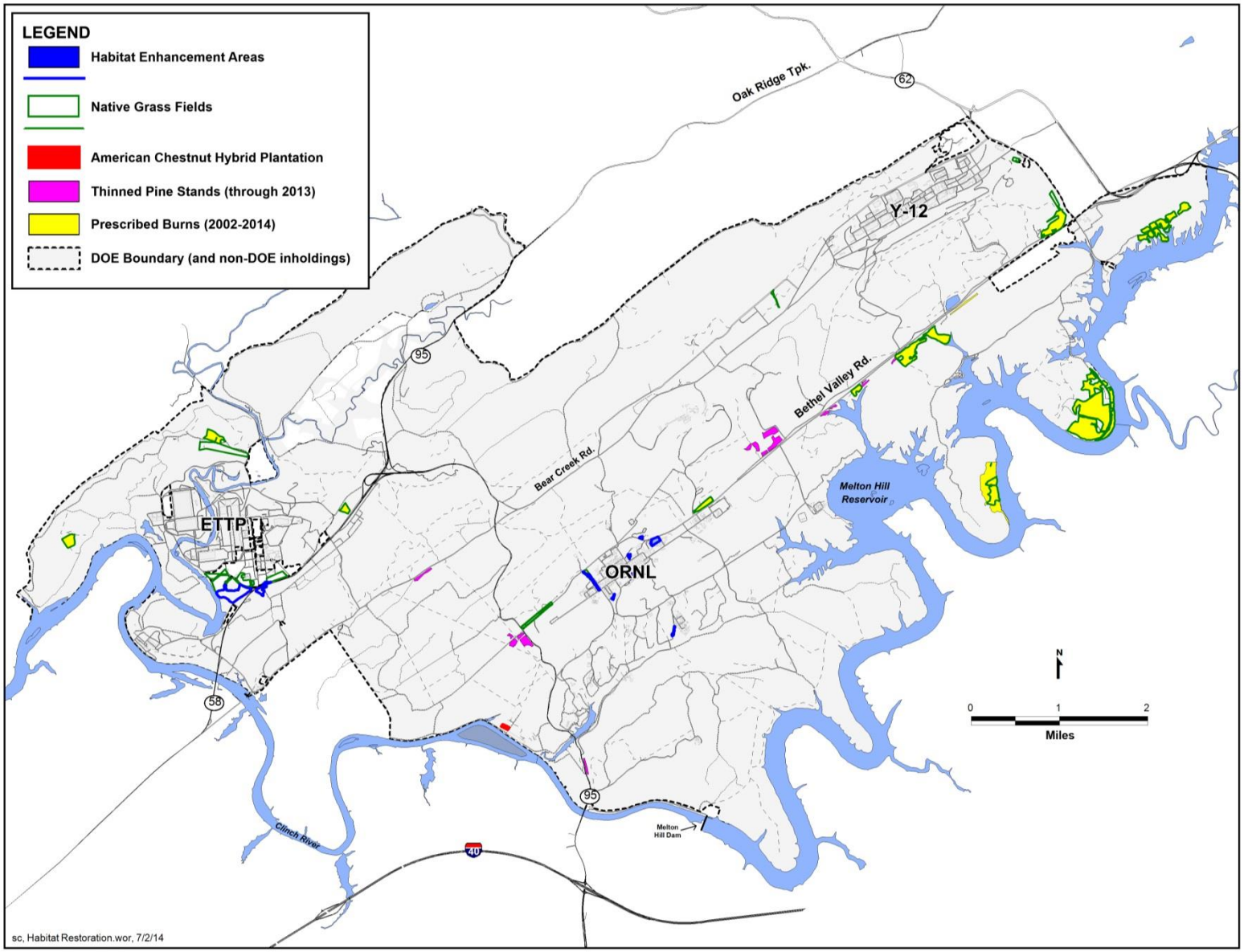

Fig. 16. Habitat enhancement and restoration sites.

6.3.2 Interior Forest

The ORR contains extensive interior forest acreage not present in adjacent suburban areas. The ORR, approximately 70% forested, plays a significant role in the region because it represents the largest contiguous protected land ownership in the southern Valley and Ridge Physiographic Province. These large blocks of forest, shown in Figure 7, provide habitats that have been documented to support wildlife species, especially birds, that are uncommon in or absent from surrounding areas (Giffen, Wade, and Mueller 2012).

The size of interior forest is the most critical factor in providing protection. The larger the interior of the forest (defined as being at least 656 ft from the forest edge), the better it can sustain natural processes without intrusion or disturbance. Baranski (2009) developed ranking scales for the evaluation of tract size for natural area values. Additionally, the relationship of interior forest areas to adjacent large, undeveloped forest tracts provides extra benefits.

The criteria used in defining "interior" forest for the ORR combine guidelines from Temple and Cary (1988) and from the Chesapeake Bay Critical Area (Jones, McCann, and McConville 2001) for identifying habitat capable of supporting forest-interior-dwelling birds (Giffen, Wade, and Mueller 2012). Studies by Temple and Cary (1988) indicate that edge effects extend into a forest as much as 656 ft, and researchers have used this distance as a criterion for identifying "interior" forest areas, which would be less affected by forest fragmentation. The Chesapeake Bay Critical Area guidelines further refine the criteria by establishing a minimum size for the interior forest as a forest at least 50 acres in size with 10 or more acres in "forest interior" habitat (i.e., greater than 300 ft from the nearest forest edge). Figure 7 shows ORR interior forest areas and the 656 ft buffer. It is recognized that the criteria do not constitute a one-size-fits-all approach. Some forest-interior-dwelling birds may be found in smaller forests or may be absent from larger ones.

EO 13186 ("Responsibilities of Federal Agencies to Protect Migratory Birds") requires federal agencies to avoid or minimize the negative impacts of their actions on migratory birds. Agencies must actively protect birds and their surroundings by, for example, restoring and enhancing habitat, preventing or abating pollution affecting birds, and incorporating migratory bird conservation into agency planning processes. The EO requires each agency to develop a Memorandum of Understanding (MOU) with the US Fish and Wildlife Service (USFWS) to promote the conservation of migratory bird populations. The DOE MOU commits the department to cooperate with the USFWS to "substantially contribute to the conservation and management of migratory birds and their habitats." The preservation of large contiguous tracts of interior forest is an integral part of meeting this commitment on the ORR.

6.3.3 Migratory Bird Protection on the ORR

A total of 228 bird species have been recorded on the ORR. Of these 228 species, 113 have been recorded during yearly breeding bird surveys conducted on the ORR since 1995 as part of the international Partners In Flight (PIF) Program. Through this program, bird numbers are monitored to track increases and declines in species populations. The PIF program divides the United States into a number of regions to monitor populations on a finer scale. The ORR is within the Appalachian Mountains region. Thirty-six species of birds found on the ORR are considered to be of concern to PIF because of their declining populations in the Appalachian Mountains region. Many of these species are long-distance neotropical migrants also impacted by loss of habitat in their tropical wintering areas (Roy et al. 2014).

A number of measures are being taken on the ORR to protect migratory birds. These include the protection of large contiguous areas of interior forest specifically to protect neotropical migratory birds. Measures taken to maintain contiguous forest areas include allowing canopy closure over natural area dirt

and gravel roads and careful planning of projects to minimize clearing and fragmentation of forest vegetation. The larger contiguous tracts of interior forest on the ORR support as many as 18 species of interior forest birds.

Establishment and maintenance of native grasslands throughout the ORR improve migratory bird habitat and long-term protection of species. The incorporation of prescribed burns into the management strategy has been integral in maintaining this important habitat. More than 20 grassland, field, and edge bird species have benefitted from these habitat improvements.

The establishment and protection of natural riparian zones have resulted in increased habitat structure and diversity in a number of areas on the ORR. This, in turn, has resulted in significant increases in bird numbers and species diversity, with benefits to several important species not found in other habitats on the ORR.

6.3.4 Identifying and Maintaining Significant Habitat Types

TNC (1995) listed many natural communities occurring on the ORR (identified as either significant community or high-quality types). The study mapped Preliminary Conservation Sites and mentioned an additional 44 sites containing intact hardwood areas larger than 100 acres. Rare natural communities on the ORR the study listed included boggy forest wetland, floodplain pool, hemlock–white oak–white pine limestone cliff forest, limestone barren (annual grass dominated), limestone barren (perennial grass dominated), limestone cliff, limestone sinkhole, northern white-cedar woodland, oak-hickory-ash-limestone woodland, Valley and Ridge calcareous mixed mesophytic forest, Valley and Ridge wet meadow shrub-herb complex, rocky limestone woodland, and streamside seepage swamp. Numerous additional occurrences of natural communities are cited in the report, but these are examples of areas to be protected and enhanced, as possible.

A set of guidelines was developed (Baranski 2009) to assist in the evaluation of the natural value of specific land areas on the ORR. This approach was expanded to include aquatic areas (Baranski 2011). The study was designed to develop criteria for assessing the ecological importance/significance of special habitats, communities, and species on the ORR in a relevant and consistent manner and with the ability to be integrated into the Tennessee Natural Heritage Program system and the potential for application with new areas.

Categories of factors were used in the evaluation that included the size of the area, including relationship to large undeveloped tracts; number of status taxa present; number of Endangered and Threatened taxa present on a site; rarity of the Endangered or Threatened taxa on the ORR; general community and landscape diversity on a site; overall integrity and quality of the area, its communities, and species populations, including age of forest; current disturbances, threat of future disturbances, and threat manageability; and other significant features or factors, including special uses and management considerations. These categories are explained in more detail in the two documents (Baranski 2009; Baranski 2011). Categories were ranked by a calculated composite score. A highly ranked site would be representative of the natural diversity of the region; it would contain outstanding natural features, communities, or geology and/or very rare taxa or other elements; it would be relatively large in size with mature or old-growth vegetation or community composition; it would lack current disturbance factors or be essentially recovered from historical disturbances and in excellent condition with good buffers; it would have low potential for continuing or future impacts from development, logging, or other human activity that would degrade or destroy its natural area values; it would be a place in which ecological and evolutionary processes can occur relatively unaffected by human disturbance; and it could reasonably be defended and maintained as an NA in the presently undeveloped condition. Figure 17 shows the relative

ranking of ORR NAs based on data from the 2009 and 2011 (Baranski) studies. Recent information has changed some of the NA boundaries, so some modification of the rankings is expected.

This approach is a beginning to the development of an evaluation system for determining the value of NAs on the Reservation. As more information is gathered about ORR biodiversity, data are refined, and interpretations of status and significance of elements and assessment categories continue to change. Periodic revisions of the input data can provide updated evaluations of all areas in relationship to each other.

6.3.5 Adapting to Climate Changes

Changes in climate in the southeast are bringing changes in the forest composition, structure, and management issues. Disturbance from weather events (high winds, heavy rains, drought, heat), pests and diseases (invasive insects, wildlife, and plants), and wildfire intersects with manmade impacts from infrastructure that fragments the landscape, from clearing of areas for other uses, or from air quality issues. Compounded, these disturbances create challenges for protecting the forests. Southeastern forests, including the forest of the ORR, are already changing, and the capacity to adapt to and mitigate climate-change impacts is being tested. The United States Department of Agriculture Forest Service, Southern Research Station has published a global change research strategy for National Forests (USDA 2012a). Although the ORR is only a small percent of forested federal land in the southeast, it is one of the largest protected areas within the Valley and Ridge Physiographic Province. Management of the ORR forest has the potential for consequences at local, regional, and national levels.

Reduction of carbon losses and increasing carbon sequestration are complementary to other forest management objectives such as soil stability, water and air quality, and wildlife habitat. The global change research strategy (USDA 2012a) gives examples such as planting trees to restore forest cover, which also improves wildlife habitat and sequesters carbon. Reducing soil erosion through vegetation or soil conservation measures can also sequester carbon, while improving water quality by reducing runoff.

6.4 INFRASTRUCTURE INTERFACE

The secondary road network is important to the success of DOE's primary missions as well as for managing natural resources. Secondary roads provide access for

- patrolling by site security personnel;
- wildfire detection and suppression;
- invasive plant treatment;
- game and nuisance wildlife management;
- habitat restoration;
- forest health monitoring;
- salvaging, thinning, culling, and burning;
- timber harvests;
- access for public recreation, including greenway trails and managed hunts;
- ecosystem research;
- utility infrastructure access; and
- environmental remediation and monitoring.

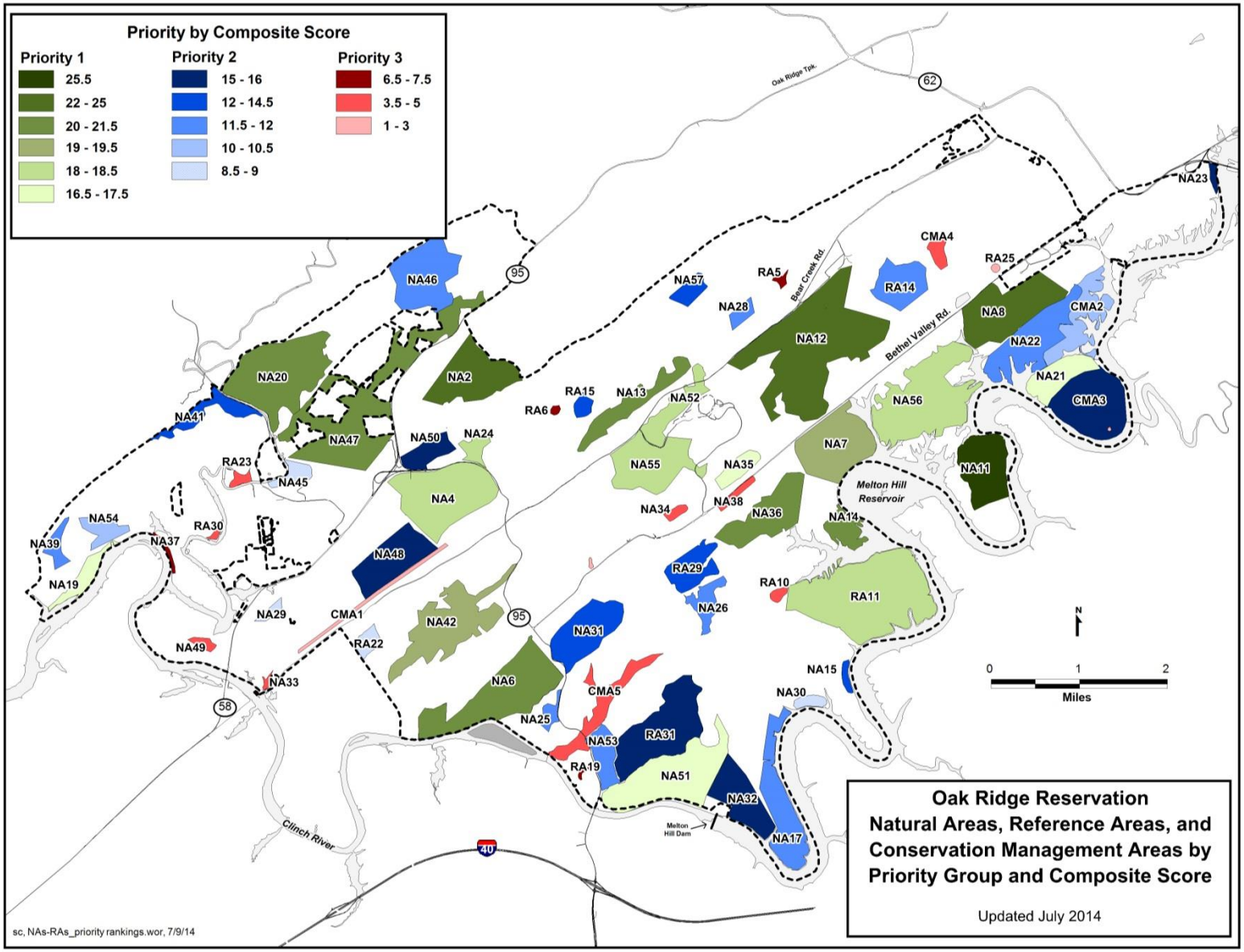

Fig. 17. ORR Natural and Reference Area priority rankings.

The ORR road system serves as the primary fire-break system and is often used in establishing boundaries of fire management units. Boundary maintenance protects the ORR perimeter, providing the first defense against trespassing. The boundary is also maintained as a fire break, thus protecting the ORR from outside wildfire and protecting areas outside the boundary from wildfire originating within the ORR. Secondary ORR roads maintained as wildfire access roads are shown in Figure 18.

Secondary roads, access gates, and the ORR boundary are maintained by a contractor to DOE. The Natural Resources Management Program provides input concerning secondary road system and boundary maintenance, including identification of

- secondary road maintenance and construction management practices,
- additional access or fire-break requirements in support of the wildland fire program,
- opportunities to modify mileage of secondary roads,
- opportunities to improve maintenance standards to enhance safe access while reducing erosion and other environmental impacts, and
- opportunities to improve the visual resource by recommending more aesthetic roadside maintenance practices.

6.5 RESEARCH

The ORR offers unparalleled resources for ecosystem-level and large-scale research within a 20,000 acre outdoor laboratory. Along with large blocks of forest and diverse vegetational communities, the Oak Ridge National Environmental Research Park offers the ability to use or establish highly equipped sites in a secure area. Existing roads and the utility infrastructure provide critical field research components. National recognition of the ORR as a resource has led to proposed uses that are components of both continental- and regional-scale projects (DOE 2012).

Current and potential future research extends across the entire ORR. Research users, in addition to DOE and DOE contractors, include TWRA; NSF; Clinch River Environmental Studies Organization; NOAA, Atmospheric Turbulence and Diffusion Division; US Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services; Natural Resources Conservation Service; and individuals from academic institutions and others.

Environmental field research on the ORR addresses major national issues and contributes to national and international collaborative initiatives on global climate change (e.g., temperature, carbon dioxide, precipitation), tropospheric air quality, remediation of contaminated land, sustainable development, biodiversity, energy operations, and site characterization for modeling.

Figure 9 shows current and potential future research areas on the ORR.

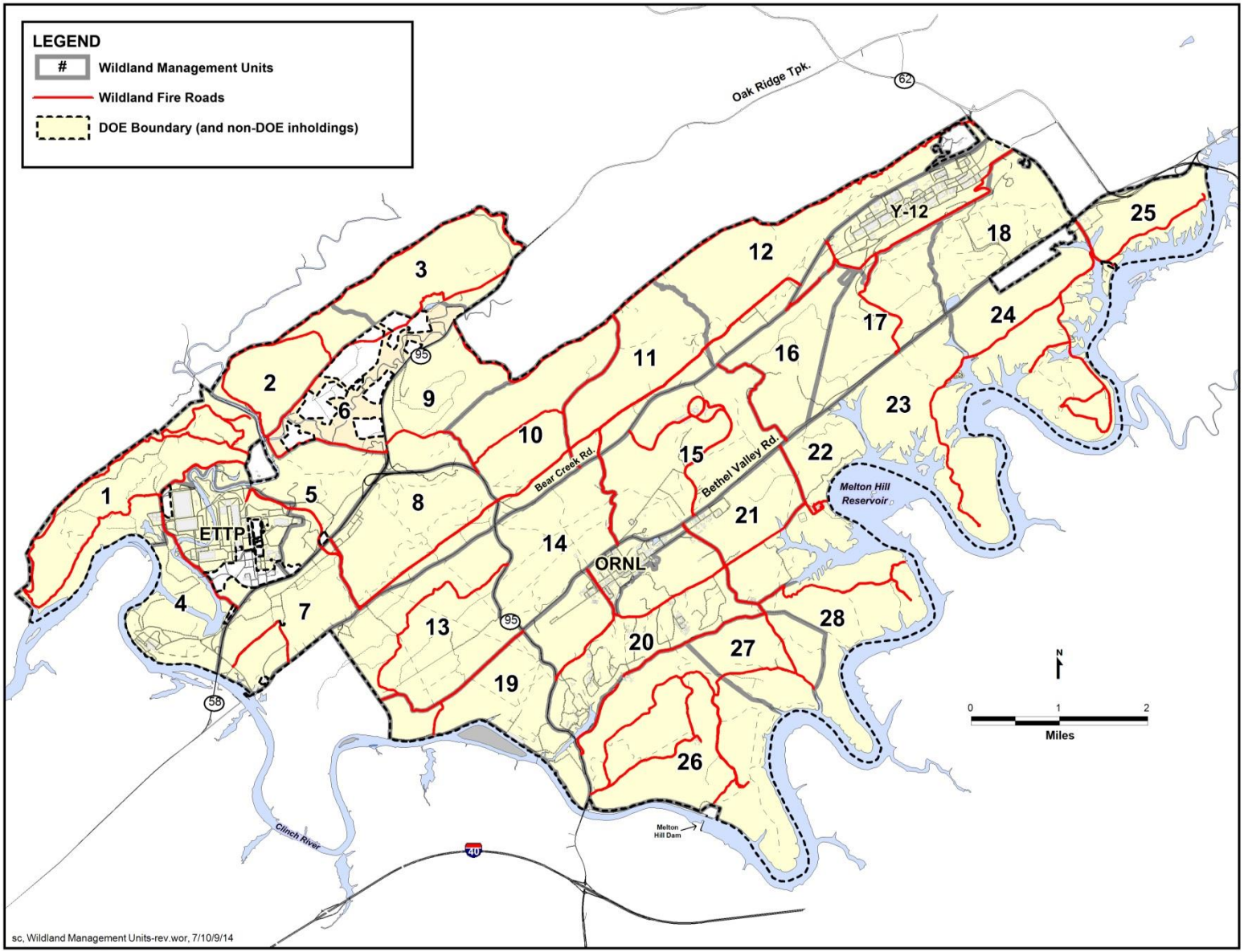

Fig. 18. Wildland Management Units.

6.6 TIMBER SALVAGING AND HARVESTING

Timber harvesting at the ORR is currently used as a tool to accomplish identified missions or natural resource goals, including ecosystem research manipulations, site development, right-of-way clearing, timber salvaging, timber-stand maintenance (thinning), regeneration, pest control or treatment, fire prevention and control measures, and disturbance imitation for habitat creation and maintenance.

All timber harvesting activities adhere to the State of Tennessee Forestry Best Management Practices (Chapter 0080-7-3, Rules of Tennessee Department of Agriculture Department of Forestry, August 2001, Revised).

The ORR Forester reviews all candidate sites to be cleared for the presence of merchantable timber and then initiates the appropriate procedure to market the timber to a contractor.

Timber is marketed through a DOE Real Estate Timber Agreement with timber harvesting contractors. This approach provides a standing agreement for use to efficiently accomplish small or emergency clearing or salvage operations. When timber removal becomes necessary, the ORR Forester notifies the contractor, specifying location and other harvest information. In this manner, the ORR Forester has a logging contractor available to respond to timber removal requirements in an efficient and timely manner. The ORR Forester determines the merchantability of any timber that requires removal, then marks the merchantable trees that are to be cut and removed.

When timber appraisal is required, the evaluation procedure involves establishing harvest boundaries and designating and assessing the species, diameter, merchantable height, and quality of all merchantable trees within the harvest area. The ORR Forester then develops a timber description and appraisal based on area market conditions. A map of the harvest area is prepared along with any special conditions or requirements pertaining to that specific job. This information, along with a cover letter, is then forwarded to the designated DOE Real Estate Timber Sales Representative for mailing to prospective timber buyers under the sealed-bid sales procedure. The bid opening date, time, and place of sealed-bid opening are specified by the Representative. The timber removal period is specified by the ORR Forester.

The logging subcontractor reimburses DOE for the timber removed based on pre-negotiated stumpage rates. Proceeds from ORR timber sales are currently deposited into the US Treasury and are not retained by DOE, so revenue does not offset costs for implementing the operation.

6.6.1 Disposal of Non-Merchantable Timber

Non-merchantable timber is defined as wood that may be too small in diameter, length, or volume to compose an operable timber sale. Additionally, wood quality, species composition, or inaccessible location may also render timber non-merchantable. Disposal of such timber often creates challenges for site operations. During an evaluation of merchantable timber, the ORR Forest Manager may recommend one of the following avenues for processing this wood waste:

- leave debris in place at the generating site or at its margins;
- mulch the debris in situ;
- burn the woody debris in situ;
- transport the waste wood to Hawk's Nest Woody Debris Burn Facility, a specially prepared site dedicated to safely storing and drying wood before combusting it during controlled burns; or

- Sequester it in landfills. While appropriate for treated wood or wood with radiological concerns, this is the least desirable method because landfill volumes are limited and this practice consumes space better served as a repository for materials having fewer disposal options.

6.7 WILDLAND FIRE PREPLANNING

Wildland fire management support is an important responsibility of the ORR Forest Manager per DOE orders and recent new DOE policy and directives.

6.7.1 ORR Wildland Fire Memorandum

The ORR Wildland Fire Memorandum (Boyd 2006) defines shared responsibilities of UT-Battelle, LLC (ORR Forester and ORNL Fire Department); the DOE Roads and Grounds Contractor; DOE Oak Ridge Operations Reservation Management Coordinator; Y-12; ETTP; the city of Oak Ridge; and the State of Tennessee Division of Forestry.

The ORR Forester is assigned the following responsibilities:

- Assist in the development and/or review of burn plans generated by external and/or internal organizations.
- Conduct routine operational controlled burns.
- Provide ground fire control, water supply support, protection of structures from wildland fire, and personnel resources for operational controlled burns.
- Incorporate wildland fire mitigation and response activities and procedures into the ORR land-use planning process.
- Prepare and update pre-fire planning maps. Ensure that hard-copy maps of the ORR are available for wildland fire response and mitigation.
- Participate in emergency management exercises as necessary or appropriate. Develop after-action reports identifying areas of weakness or needs for improvement to the Reservation Management Coordinator (RMC) and Emergency Management personnel as required/requested.
- Assist in the development of stakeholder involvement plans in support of the wildland fire program.
- Through the Natural Resources organization, review all wildland fire-potential data and provide notification and postings at all portals, if warranted, indicating wildland fire risk.
- Support the RMC and DOE Fire Protection Engineer in the development of risk assessment data. Assist in the development of a Wildland Fire Risk Report, including a wildland fire hazard severity analysis based on the NFPA standard *Protection of Life and Property from Wildfire* (NFPA 1144). Assist in the gathering and incorporation of a wildfire hazard analysis, which can be entered into a tracking system.
- Identify equipment necessary to perform forest management activities and assignments.
- Assist the RMC in the development of budget presentations for the Natural Resources budget, including wildland fire activities, to the Contractor Interface Team to secure sitewide funding in support of the ORR.

Within the ORR Wildland Fire Management Implementation Plan, the DOE Roads and Grounds Contractor currently is responsible for establishing and maintaining the wildland fire roads, many of which delineate Wildland Management Units (WMUs) (Fig. 18), and maintaining barricades that control

access to ORR secondary roads. The sites—ORNL, Y-12, and ETTP—are responsible for providing personnel trained in wildland fire activities and equipment. The city of Oak Ridge has entered into a Mutual Aid Agreement with DOE to provide assistance for wildland fire activities. The State of Tennessee Department of Agriculture, Division of Forestry has entered into an MOU to provide wildland-fire-trained and -equipped personnel and heavy equipment, including fire plows, when requested to assist with wildland fires.

6.7.2 Wildland Management Unit Pre-fire Plans

Because the ORR is a large (33,480 acres), mainly forested property with access restrictions, it is a challenge for most site emergency personnel to know all remote areas and back roads very well and to quickly recognize and size up concerns associated with those areas**.**

The ORR wildland management unit pre-fire plans (PFP) serve on-site first responders and are designed both to aid those not familiar with an area and to assist the recall of those who are. As DOE's wildfire strategy now relies on outside agencies for assistance with large or difficult wildfires, the plans also serve as guidance for those responders who may have little or no experience on the ORR. The plans offer awareness of the ORR's unique hazards and can help avoid inadvertent impacts to structural, cultural, environmental, and research assets.

The PFPs are a series of brief documents covering each of 28 ORR segments referred as WMUs (Fig. 18). Each plan summarizes access issues, assets, and hazard concerns within its area. Hard copies of the plans are intended to remain in responder vehicles for immediate reference during remote events. Terse and compact in format, the plans are easily updated, stored, and shared electronically. Pre-fire plan copies are also maintained at ORO site fire departments and emergency operations centers and by shift superintendents and certain managers. The plans are meant to influence quick decisions but are not meant to dictate tactics.

The format of the PFPs includes a single-page synopsis that provides a WMU's unit identification number and name, general location within the ORR, and its boundaries and size. The most important information or hazards are highlighted near the top of the form, followed by topical guidance on tactics, access, vegetation and fuels, water sources, topographic considerations, and hazards. Plan maps depict access, fuel types, water sources, and urban interface areas. Utilities, hazards, research areas, and sensitive resources are also depicted.

Gradually, the information within each plan may become outdated. PFPs are reviewed on a 3-year cycle and updated as significant changes occur. The ORR Forester is the point of contact for plan distribution.

6.8 TIMBER-STAND IMPROVEMENT

Timber-stand improvement typically involves reducing competition for desirable trees by removing less desirable ones. Traditionally, timber-stand improvement was performed with a focus on developing marketable timber. However, similar forest manipulations may provide benefits in other forest communities.

The process may involve removal of undesirable species or of poorly formed or stunted individuals of desirable species. The result is a forest stand in which most of the growth is directed to a smaller number of more desirable individuals. Stand improvement also tends to promote resistance to disease and insect attack and reduced susceptibility to wildfire. Stand-improvement activities may include thinning, culling, and controlled burning.

6.8.1 Thinning and Culling

Thinning may be necessary to reduce wildfire risk and disease and insect susceptibility in the remaining and regenerating ORR pine stands. Thinning is under way in areas that had been salvaged and cleared as a result of the pine beetle. Many of these areas have regenerated as very dense areas of pine. The need for thinning is determined using input from inventory and mapping, aerial photography, and forest surveillance.

Culling undesirable vegetation is an activity necessary for improving stand growth and removing invasive exotic tree species such as royal paulownia (*Paulownia tomentosa*), tree of heaven (*Ailanthus altissima*), and mimosa (*Albizia julibrissin*) and invasive exotic shrubs such as privet (*Ligustrum japonicum*), bush honeysuckle (*Lonicera* sp.), and autumn olive (*Elaeagnus umbellata*). Culling of exotic trees and shrubs is a continuous process, as budgets allow. Management of invasive exotic vegetation is described in the *Invasive Plant Management Plan for the Oak Ridge Reservation* (Quarles et al. 2011).

6.8.2 Burning

Controlled fire is one of the most valuable and inexpensive tools available in the management of southern yellow pines. A controlled burn may reduce the wildland fire hazard by removing litter buildup. Controlled burns also eliminate much of the competing understory vegetation and release nutrients to the soil. Controlled burning of pine slash after SPB salvage helps prepare sites for reforestation and reduces the risk and hazards associated with wildland fires. Controlled burns were successfully used in 1995 in association with site preparation of SPB-killed areas. Controlled burns are also important in native warm season grass habitat management (Giffen, Evans, and Parr 2012) for promoting native grass regeneration over undesirable species by limiting growth and recolonization of woody nonnative species. They are also used for maintenance of special habitats such as cedar barrens and are beneficial for maintenance and regeneration of forest dominated by oak and hickory species.

A Prescribed Burning Plan is prepared for review and approval prior to initiation of any burning. The plan details objectives, location, types of fuels, training, accessibility, responsibilities and fire control response, burn conduct, and public notifications; it requires signature concurrence by the various programs and agencies involved (i.e., DOE, Tennessee Division of Forestry, TWRA, ORNL Natural Resources, other DOE contractors, and community agencies).

6.9 URBAN FORESTRY AND COMMUNITY INTERACTIONS

An urban forest is a forest or collection of trees that grow within a city, town, or suburb. Forest patches, remnants of larger ecosystems, and other vegetation around places where humans work and live provide important services such as trapping pollutants, cleaning stormwater, slowing wind, moderating climate, providing food and shelter for wildlife, sequestering carbon, and filtering air and sunlight. The USFS recently led a study that documented Tennessee's urban forests as being valued at about $80 billion and providing $650 million in benefits such as carbon storage, pollution removal, and energy reduction (Nowak et al. 2011). Urban forests are found within the more developed site areas of the ORR and along the property boundaries. The ecosystem services provided by even small patches of forest are important to recognize and protect.

Recommendations for protecting the urban forest include

- landscaping with native plants (DOE has an approved list of locally native plants for landscaping on the ORR),
- protecting existing trees and planting more trees,

- monitoring and treating for invasive plant pests,
- controlling invasive plant species, and
- protecting creeks and streams with vegetated buffers.

Sustainable landscaping practices that are being implemented at the ORNL campus of the ORR have helped demonstrate concepts regarding protection of water quality, habitat restoration, nuisance wildlife management, and use of native plants in landscaping. These practices mimic ecological processes found in the larger ORR landscape.

6.10 POTENTIAL ENVIRONMENTAL IMPACTS OF FOREST MANAGEMENT ACTIVITIES

Natural resources management actions, including those targeted for forest health, are reviewed for impacts before implementation. Adherence to forestry best management practices, as well as interaction with other land managers to stay abreast of the most current practices, ensures that any potential impacts are minimal, temporary, and reversible.

7. THE FUTURE ORR FOREST

The ORR is unique and valuable within the region as the largest contiguous protected land ownership in the southern Valley and Ridge Physiographic Province. It is also recognized as an irreplaceable resource for DOE energy-mission research.

A long-term vision of the undeveloped ORR landscape highlights the need to preserve existing special resources, expand them where possible, and maintain diverse areas that can be manipulated to better understand processes or support other DOE mission needs (Fig. 19).

Preservation of special resources includes

- protection of existing contiguous blocks of hardwood/mixed pine-hardwood forests, particularly the larger blocks and those with interior forest;
- preservation of sensitive ecological ecosystems and associated communities, particularly those identified as biologically significant such as the Research Park NAs and RAs; and
- continued nondisturbance of long-term ecosystem research areas such as Walker Branch Watershed.

Expansion of significant resources includes

- increasing block sizes of forests by evaluating the factors causing fragmentation and working to eliminate them;
- evaluating special habitat conditions and determining whether boundaries can be manipulated to allow natural regeneration or spread of certain plant or wildlife species;
- establishing natural community habitats into additional areas, such as continued establishment of native grasses/meadows or riparian buffers or other plant communities in remediated areas and transitioning to native vegetation in utility right-of-way areas; and
- enhancing, preserving, and protecting pollinator habitat.

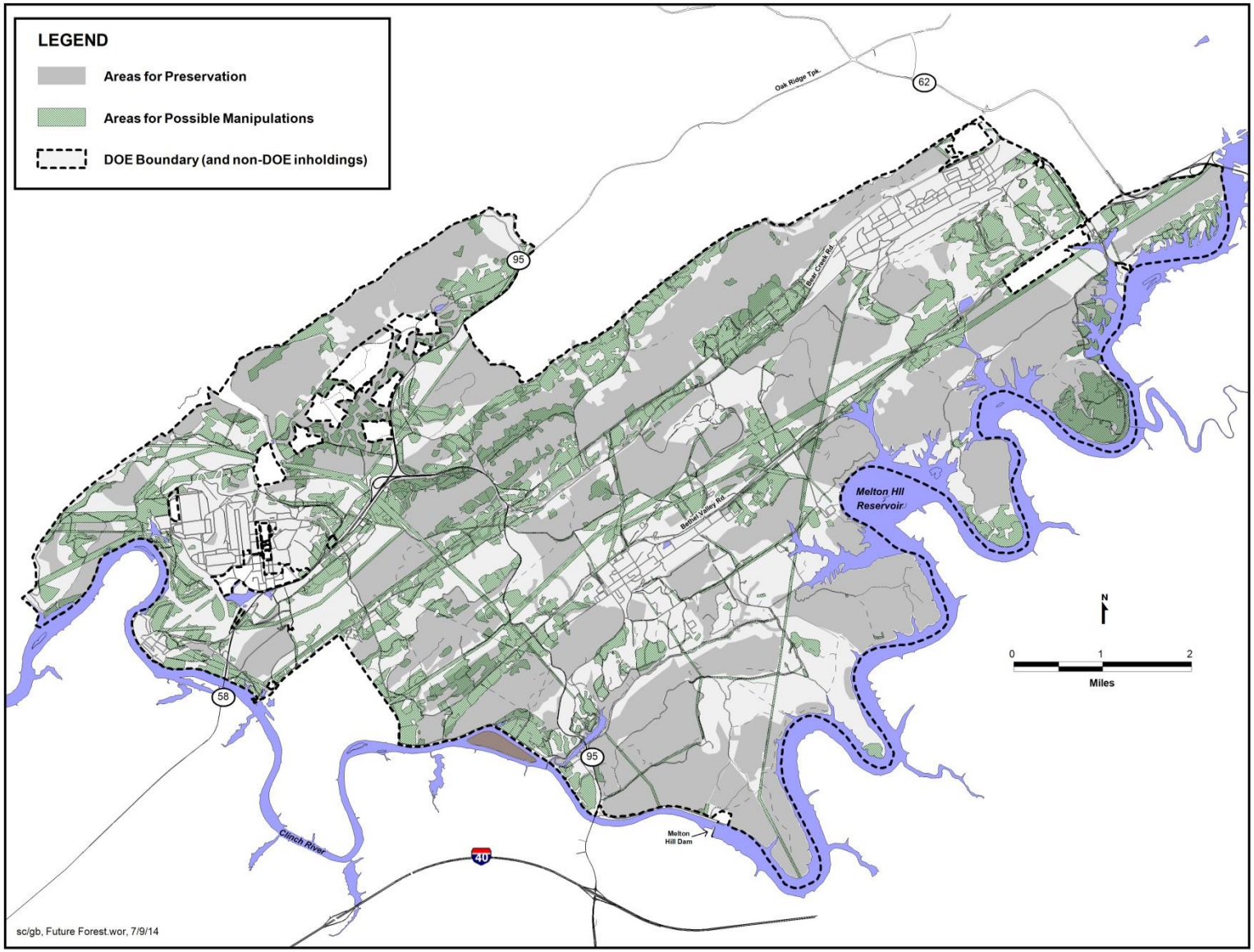

Fig. 19. Future ORR forest.

Manipulations within areas may include

- thinning and culling to reduce smaller multiple stems, allow room for growth, encourage natural regeneration, and eliminate undesirable species;
- clearing to eliminate undesirable species and reestablish specific communities or successional stages or meet specific wildlife habitat requirements;
- planned burning to eliminate undesirable competing vegetation and reduce fuel loading;
- mowing, bush-hogging, and burning to maintain certain communities such as native grasses/meadows;
- site disturbance for research studies or demonstration areas (such as providing models for wildlife management and oak regeneration studies); and
- restoration/enhancement of highly disturbed or maintained areas such as remediated sites, impaired wetlands (for possible mitigation recognition), and fescue maintained sites.

Maintaining the ORR as primarily hardwood/hardwood-pine with the remainder a balance of successional forest and grassland types and managed timber plots for research, demonstration, and regeneration studies can provide the framework to ensure

- age diversity (succession to old),
- wildlife diversity (varying habitats),
- riparian buffer expansion,
- wildland fire reduction,
- interior forest expansion,
- sensitive ecological areas protection,
- forest management or research manipulation areas,
- research forest protection, and
- flexibility to meet future needs.

Preservation of existing interior forest and buffer areas as well as of areas recognized for their biological significance (i.e., NAs, RAs) can allow protection of biodiversity in a primarily passive manner (with the need for invasive plant control and other occasional management actions to maintain certain conditions).

Boundaries of these areas can be refined as new information is obtained and evaluated. An evaluation, including on-the-ground review, of the boundaries of the Reservation's NAs and RAs can be initiated that incorporates the ranking criteria developed in 2009 (Baranski 2009). Long-term research areas that are used as reference, such as Walker Branch Watershed, can remain undisturbed.

There can be overlap of some manipulations or actions within areas that are primarily areas of preservation. Active disturbance processes, such as clear-cutting, selective cutting, thinning and culling, mowing, and controlled burns, can be used to achieve specific management objectives such as maintenance of grasslands, pine stands, or specific communities (e.g., cedar barrens); maintenance of diverse forest age structure (ranging from early succession to mature forests); targeted wildlife habitat enhancement; enhancement or restoration of special habitats (e.g., riparian areas, uncommon

communities, cave sites, remediated areas); and manipulations for research. The optimal mix of land uses can vary over time as different DOE missions and research priorities evolve.

Areas forested in 1942 when the federal government acquired the land are shown in Fig. 1 and include many areas that are now recognized as biologically significant in the region.

Areas on the ORR that were cleared before 1942 are also shown in Fig. 1. These are the areas of the ORR that currently have the greatest history and variety of land use and disturbance. Potential areas for manipulations (Fig. 19) have generally been identified based on information of past land use. Activities or uses of the previously cleared land have provided continued disturbance in many cases and include

- remediation and waste management areas,
- utility right-of-way areas (active and abandoned),
- spoils areas,
- soil borrow areas,
- research areas,
- grounds,
- roadsides,
- grass fields (former hayfields) and pastures, and
- forest plantations.

Other than right-of-way and waste management areas, almost all of these more recent disturbances are within old fields (i.e., areas not forested in 1941).

These previously disturbed areas have been identified as ones to consider as a starting point for tasks that require disturbance of an area. There is overlap of areas to preserve and areas for possible manipulation (Fig. 19). Specific proposed uses and the potential sites for this use or action require evaluation in greater detail and on a case-by-case basis.

8. FOREST BEST MANAGEMENT PRACTICES

Best management practices and guidelines have been developed for use on the ORR, including recommendations customized to fit DOE mission needs and support stewardship of the ORR.

8.1 ECOSYSTEM/WATERSHED PROTECTION

8.1.1 Riparian Zone Protection

Protection of water quality is especially important during maintenance or management activities. A Streamside Management Zone (SMZ) is defined as an area in which extra care is required while carrying out forest practices to protect water quality. SMZs and riparian buffers provide important benefits in lessening the impacts of pollutants before they reach a creek, shading streams from intense sunlight, capturing sediment, providing stabilization for stream banks, and reducing erosion (Baranski 2011). The 2011 report *Aquatic Natural Areas Analysis and Evaluation* (Baranski 2011) reviewed the state and other SMZ guidelines and made the following recommendation for use on the ORR: "As a general practice, the establishment of riparian buffer zones only 100 ft (30 m) wide on each side of the stream is recommended. Buffer zones of this dimension should be sufficient to protect the water quality of the streams themselves and also allow for some channel movement. If a case can be made for wider buffer zones, such as might be necessary to protect biological integrity or specific organisms, then they should be so designated … Extra precautions (e.g., pollution discharge standards) might be taken to ensure water quality of certain specially designated water bodies. If there are purposes other than the maintenance of water quality, then other buffer and SMZ treatments or size layouts may be desirable."

8.2 REVEGETATION AND LANDSCAPING

The use of locally native vegetation is important in maintaining the quality and integrity of the ecosystems present on the ORR. Use of non-native plants can disrupt the ecosystem and result in the need to treat or restore sites. Seed mixes, especially, often contain species that are invasive (requiring removal efforts later) or not native. Often several different kinds of plants have the same common name. When planning and purchasing seeds or plant materials, it is necessary to use the scientific names.

In 2010 the DOE Oak Ridge Reservation Management Team accepted the ORNL list for plants approved for use in landscaping to be applied for the ORR. The list includes plants that occur naturally on the ORR and some that occur adjacent to the ORR. It does not include plants listed as invasive in Tennessee by the Tennessee Exotic Pest Plant Council. The list is categorized by type (tree, shrub, vine, etc.). Plants used both in landscaping and in restoration activities should in most cases come from this list. Exceptions should be discussed with DOE. The current approved list is in Appendix B. Additions and changes to the list are made periodically, and updates are posted at http://web.ornl.gov/adm/fo/nr/lm/Documents.htm.

8.3 ROAD AND CULVERT MAINTENANCE

8.3.1 Road Development and Maintenance Guidelines

The forest road system is an extensive and viable infrastructure within the ORR. Proper maintenance is vital to the health of the surrounding environment as well as for users (including security, researchers, emergency responders, remediation workers, and resource managers). Improperly constructed and/or maintained roads result in impacts to interior forests, water quality, wetlands, creeks and streams, protected habitats, cultural resources, research areas, soils, wildlife, and forest resources.

Best management practices for ORR forest roads are different from those for typical public road maintenance. The secondary roads throughout the ORR experience minimal impact from road use and maintenance. Roads and drainage systems deteriorate because of traffic, weather, and age. Some roads become saturated during extended wet periods. Matching road maintenance to road maintenance needs can reduce upkeep costs.

Best management practices for ORR secondary roads must include the following:

- minimize erosion and sediment production during the life of the road,
- protect the road investment,
- match the use of the road to what it is designed to handle,
- ensure that road surfaces and drainage systems allow natural drainage functioning,
- install culverts to align natural stream channel and allow fish passage,
- include periodic assessments of road condition to determine operational controls and maintenance needs,
- restrict maintenance activities when roads are saturated, and
- use low-impact maintenance techniques to minimize disturbance of both stable sites and sensitive areas.

Guidelines for construction and maintenance have been developed using established Best Management Practices (TDF 2003; NCFS 2006; USDA 2012b) and customized for ORR non-paved road needs. Most non-paved roads on the ORR are "All Season Roads," that is, roadbeds improved with a gravel surface that are suitable for year-round use. Detailed guidelines are in Appendix C.

8.3.2 Culvert Installation Guidelines

Management and placement of culverts can ease road impact on water, streambed, and riparian zones in the culvert area. Following proper culvert guidelines is key in reducing maintenance costs on roadbeds and protecting water quality of streams.

Culvert guidelines

- Align the culvert with the natural stream channel.
- Maintain a 90° angle as close as possible to the natural streambed.
- Cover culvert with sufficient fill to avoid or minimize damage by traffic.
- Construct at or near natural elevation of the streambed to avoid or minimize potential flooding upstream of the crossing and erosion below the outlet.
- Install culverts long enough to extend beyond the toe of the fill slopes to minimize erosion.
- Consider the use of bottomless arch culverts where appropriate to allow for natural channel migration and desired aquatic organism passage.
- Use suitable measures and materials to avoid or minimize water from seeping around the culvert.
- Use suitable materials to avoid or minimize culvert plugging from road and ditch line.
- Regularly inspect culverts and clean as necessary. Replace fill around culverts as needed.

- Use *Guide to Best Management Practices for Forest Roads*, State of Tennessee, 2003.

Best management practices resources include the following:

- TDF (Tennessee Division of Forestry). 2003. *Best Management Practices in Tennessee*. Tennessee Division of Forestry Publication.
- TDEC (Tennessee Department of Environment and Conservation). 2012. *Tennessee Erosion and Sediment Control Handbook. A Stormwater Planning and Design Manual for Construction Activities*.
- NCFS (North Carolina Forest Service). 2006. *Best Management Practices and Soil Factors.* North Carolina Forest Service Publication.
- USDA (US Department of Agriculture). 2012. *National Best Management Practices for Water Quality Management on National Forest Service System Lands.*

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APPENDIX A.
OAK RIDGE RESERVATION FOREST MANAGEMENT HISTORY

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OAK RIDGE RESERVATION FOREST MANAGEMENT HISTORY

Forest management activities at the Oak Ridge Reservation (ORR) were initiated in the mid-1940s with a goal of reforesting to control soil erosion on the agricultural lands that were vacated when the ORR was created in 1942. Reforestation activities continued through 1954. In 1964 the Atomic Energy Commission directed Oak Ridge National Laboratory (ORNL) to hire a professional forester and necessary staff to create a self-sufficient forestry operation funded from revenue derived from timber sales. Because revenues from timber harvesting in the ensuing years were channeled to the federal government in Washington, DC, there was no opportunity for the forestry program to demonstrate sufficiency.

Inventory and Mapping at the ORR

Originally the ORR was organized into 28 management compartments, 7 alternate compartments (alternate compartments being so designated due to specific management restrictions from adjacent plant facilities), and 4 plant complexes totaling 34,060 acres (Fig. A.1). These forest compartments ranged in size from 139 to 1,198 acres.

Timber volume growth estimates obtained from Tennessee Valley Authority (TVA) Continuous Forestry Inventory plots in 1961 and 1965 were used to determine estimates of allowable cutting on the ORR and develop silvicultural guidelines incorporated into the original Forest Management Plan (Curlin 1965). An inventory using temporary plots similar to the Continuous Forest Inventory system was conducted in 1970 (Strock 1970). To obtain a more comprehensive comparison of data and growth estimates for the 1975 to 1980 revision, 207 of the original 226 TVA Continuous Forest Inventory plots were relocated and reinventoried in 1975 (TVA 1975); 16 were lost over the years to construction projects such as the Melton Hill Lake impoundment and power line right-of-way installations, and 3 plots were not located.

A forest inventory and mapping system was initiated in 1974 to evaluate and describe the ORR forest in detail (ORNL 1984). Thirty-five forest compartments were designated in which timber type and volume were evaluated (Fig. A.1).

All sawtimber inventories on the Department of Energy ORR were computed from Girard class volume tables, the International 1/4-in. rule (Girard and Mesavage 1966). Thus, the inventory system, which provides the basis for deriving sawtimber volumes, was standardized for each forest stratum throughout all management compartments. The field sampling procedure involved timber-type mapping and cruising of each compartment using point sampling (probability proportional to size) techniques (Avery 1967). Field tallies were separated on a merchantability basis into three categories: (1) nonmerchantable planted stands (fixed plot tally), (2) merchantable planted stands (variable plot tally), and (3) merchantable natural stands (natural tally). Merchantable stands were also double tallied for both pulpwood and sawtimber (sawtimber tally). Stand volumes were computed for each species in each stratum with appropriate algorithms using tree diameter taken at breast height (4.5 ft) and at merchantable height. Regression constants, fitted to Girard volume tables, were used to adjust the final volumes by individual species for their respective form classes. Stand and stocking tables were then developed deriving tree volumes, number of trees by diameter classes, and merchantable height classes for all strata.

In 1981 and 1982, emphasis was placed on completing the initial phases of the compartmental timber-type mapping and probability proportional to size inventory, but few updates have been completed since 1982.

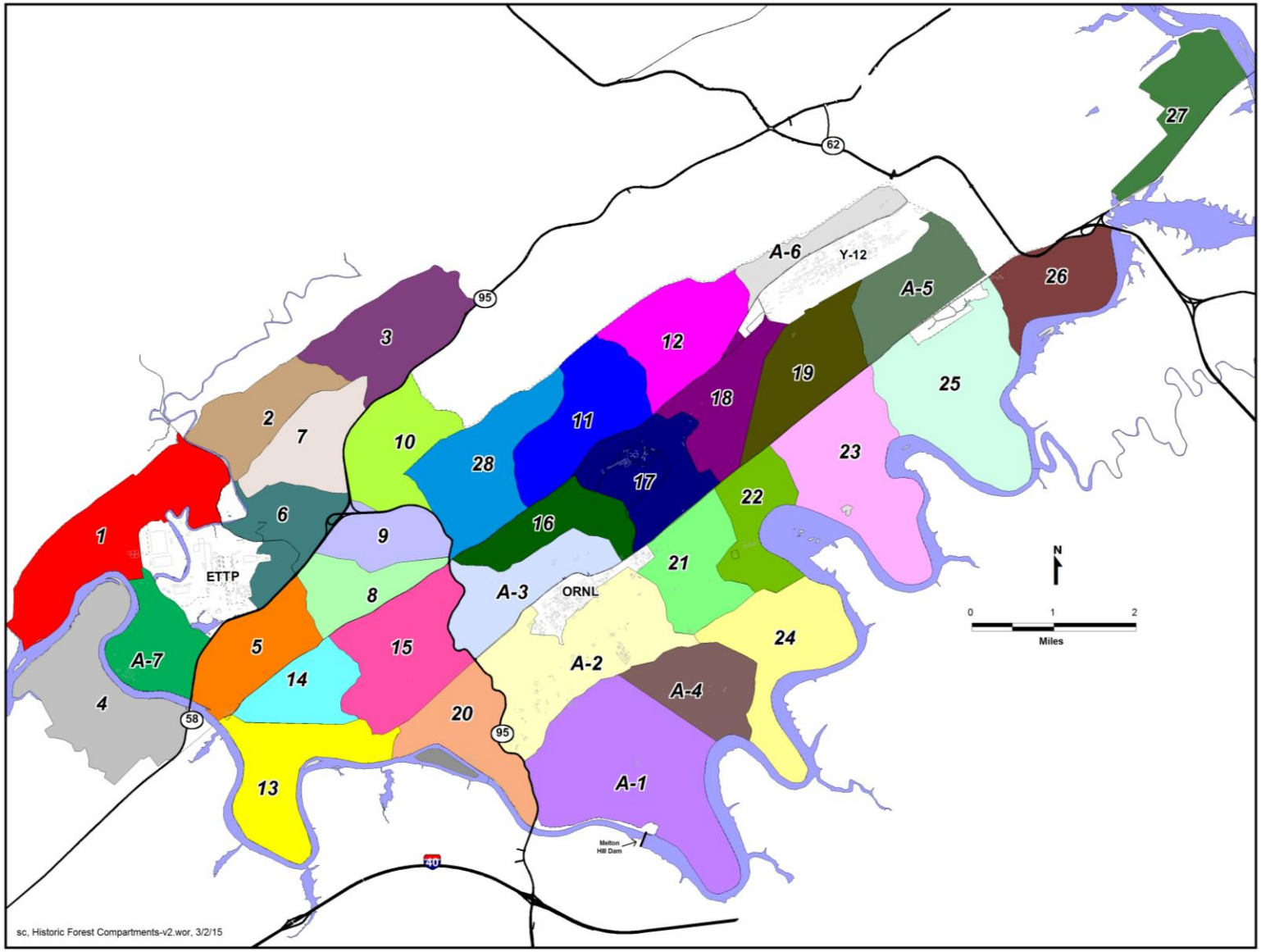

Fig. A.1. Forest management compartments.

A summary of estimated sawtimber volumes from 1961 to 2001 is provided in Table A.1. The estimated sawtimber volume at the ORR in 1961 was 62.9 million bd-ft based on the TVA inventory. By 1965, when the original Forest Management Plan was written, the estimated volume was 81.0 million bd-ft (Curlin 1965). In 1970 Strock estimated the forested area to be 26,725 acres, with a volume of 93.6 million bd-ft (Strock 1970). A reinventory of the original Continuous Forest Inventory plots in 1975 placed the forested area at 25,555 acres, with a volume of 127.995 million bd-ft (Bradburn and Rosenbalm 1984).

Table A.1. Forest inventory, 1961–2001[a]

	Sawtimber volume[b]	Forested acres	Source
1961	62.4		TVA 1975
1965	80.4		Curlin 1965
1970	92.9	26,725.0	Strock 1970
1975	127.0	25,555.0	Bradburn and Rosenbalm 1984
1981	122.1	25,319.0	Bradburn and Rosenbalm 1984
2001	181.48[c]	24,050.0	Bradburn and Byrd 2001

[a] Data taken from Bradburn and Byrd 2001, Table 2.
[b] Million board feet.
[c] Calculated; not an inventoried value.

Sawtimber volume in 1981 was calculated by modeling tree growth in 735 strata from their last measurement date through 1981 assuming a 6% annual growth rate (Applegate 1982; Watson 1979; TVA 1975). Volume deductions were made in those stands sustaining a harvest cut between their last measurement date and 1981. The updated total volume estimate accounting for growth in 1991 was approximately 123.1 million bd-ft. Volume per acre by compartment ranged from 6,435 bd-ft per acre in Compartment A1 to 3,497 bd-ft per acre in Compartment 14. Average volume per acre was 4,862 bd-ft.

Timber volumes updated for 2001 were calculated using a method similar to that used in 1982 with the same assumptions of growth, mortality, and land loss taken into account. The updated total volume accounting for growth was approximately 181.48 million bd-ft based on a forested area of 24,050 acres with an average volume per acre of approximately 7,546 bd-ft (Table A.1).

Estimated tree number and volume by species in 1981 are provided in Table A.2. Loblolly pine was most abundant, followed by yellow poplar, the red oak group, and white oak. Loblolly pine also had the greatest volume, followed by the red oak group, yellow poplar, and white oak (Bradburn and Byrd 2001).

Stand Establishment History

Stand establishment statistics are summarized in Table A.3. Areas in which stand establishment activities have been conducted are shown in Fig. A.2. The original stand establishment program at the ORR was contracted through Management Services Incorporated in the mid-1940s to reforest the numerous old field sites located primarily in the valleys and lower slopes. Species planted by Management Services Incorporated from 1947 to 1954 in order of predominance were shortleaf pine, loblolly pine, white pine, Virginia pine, yellow poplar, white ash (*Fraxinus americana*),sycamore (*Platanus occidentalis*), black locust (*Robinia pseudoacacia*), red maple (*Acer rubra*), and eastern red cedar.

Table A.2. Estimated tree number and sawtimber volume by species or species group in 1991

Species	Number of trees ($\times 10^3$)	Board feet ($\times 10^6$)
Loblolly pine	435	32.3
Yellow poplar	131	18.7
Red oak group	151	17.6
White oak	99	14.3
Misc. high value[a]	68	9.7
Chestnut oak	86	9.3
Hickory group	50	6.1
Misc. low value[b]	71	5.7

[a] Includes black walnut, black cherry, red cedar, and miscellaneous other oaks.
[b] Includes elm species, sycamore, and ash.

Table A.3. Tree planting summary, 1947–2001

Year	Shortleaf pine	Loblolly pine	White pine	Virginia pine	All others	Total
1947–54	3,450,000	2,500,000	744,000	85,000	236,000	7,105,000
1955–70	*	*	*	*	*	
1971–80	0	1,364,000	7,000	0	273,151	1,644,151
1981–90	0	299,144	9,000	0	74,715	382,859
1991–2000	6,609	14,059	13,607	0	7,565	41,840
					TOTAL	**9,173,850**

* Records not found.

The principal goal was rapid reforestation of abandoned agricultural lands. Shortleaf pine was heavily favored and extensively planted over a diversity of sites. This species has since proven to be the least desirable of the pine species on most of the sites primarily due to its susceptibility to southern pine beetle (SPB) (*Dendroctonus frontalis* Zimmermann) attacks. A total of 7,105,000 seedlings of all species were planted through 1954, with spacing of initial plantings ranging from 2 × 6 ft to 6 × 6 ft. Pine species accounted for 97% of the plantings during the 1947 to 1954 period.

No tree planting records are available for the period 1955 to 1970.

Tree planting during the interval 1971 to 1981 included 1,790,060 trees, of which 83% were loblolly pines.

Reforestation efforts from 1982 to 2001 consisted of replanting SPB salvaged areas, two wetland areas, two sludge land farm demonstration sites, sludge land farm application sites, and various landscaping and aesthetic projects with ornamental trees and shrubs. Species totals during this period were pine seedlings: 342,419; and hardwood seedlings and shrubs: 82,280.

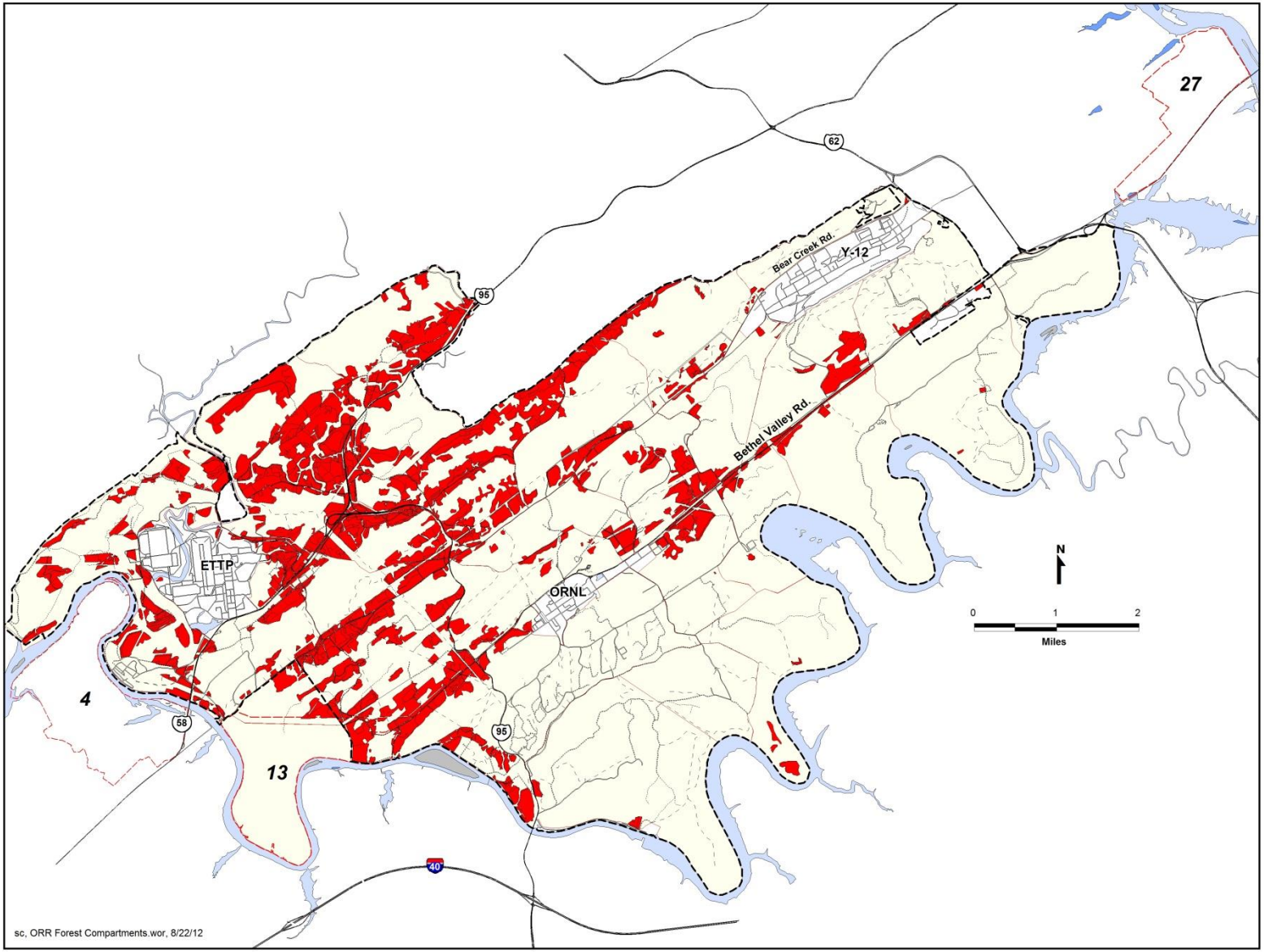

Fig. A.2. Stand establishment locations.

Total acres planted during this time period were pines: 352 acres; and hardwoods: 95 acres. The shrub acreage is included in the hardwood acres. In addition, various wildflower and prairie grass species were interplanted with loblolly pine and white pine along Blair Road in 1996.

During the 1970s, experimental hardwood stands were planted at various locations within the ORR (Fig. A.2). Two approximately 5 acre stands, one each of sweet gum and sycamore, were planted at the O800 area at the request of the Biomass Production Program. These trees have been used extensively in well-publicized research projects since then.

A summary of all tree planting on the ORR from 1947 to 2000 for which records are available indicates a total of 9,173,850 seedlings planted on approximately 8,319 acres. Pine species accounted for 93.6% of the total plantings. The actual grand totals are probably larger than these numbers, though, because records for plantings from 1955 through 1969 could not be located.

Timber Harvest History

Timber harvest data are summarized in Table A.4. The locations of timber harvests are shown in Fig. A.3.

Table A.4. ORR timber harvest summary, 1964–2001[a]

Period	Volume[b]	Value
1942–47	no data available	no data available
1947–52	0.0	$0
1952–56	2.7	$55,835
1956–64	0.0	$0
1964–70	4.3	$175,928
1971–75	6.8	$234,216
1976–82	5.3	$347,682
1983–87	2.9	$329,981
1988–92	0.2	$32,495
1993–97	0.9	$275,696
1998–2001	3.1	$544,496

[a] Data taken from Bradburn and Byrd 2001, Table 2.
[b] Million board feet.

During the initial construction phases of the Manhattan Project in the mid-1940s, there was sufficient logging activity at the ORR to support three saw mills. No records from those early logging efforts are known to exist. From approximately 1946 to 1951, there was apparently no logging activity. From 1952 to 1956, records indicate 2.7 million bd-ft of sawtimber and 134 cords of pulpwood were sold for $55,834 (Bradburn and Byrd 2001). No timber was cut from 1956 to 1964, at which time the first in-house forest management program was initiated. Sawtimber sales over the first 5-year management cycle (1964 to 1970) totaled 4.3 million bd-ft or 860,000 bd-ft per year. Thinning in the 5,000 acres of merchantable pine plantations progressed as scheduled, with 2,058 acres yielding 10,544 cords of pulpwood. Revenues from timber sales during this period totaled $175,928.

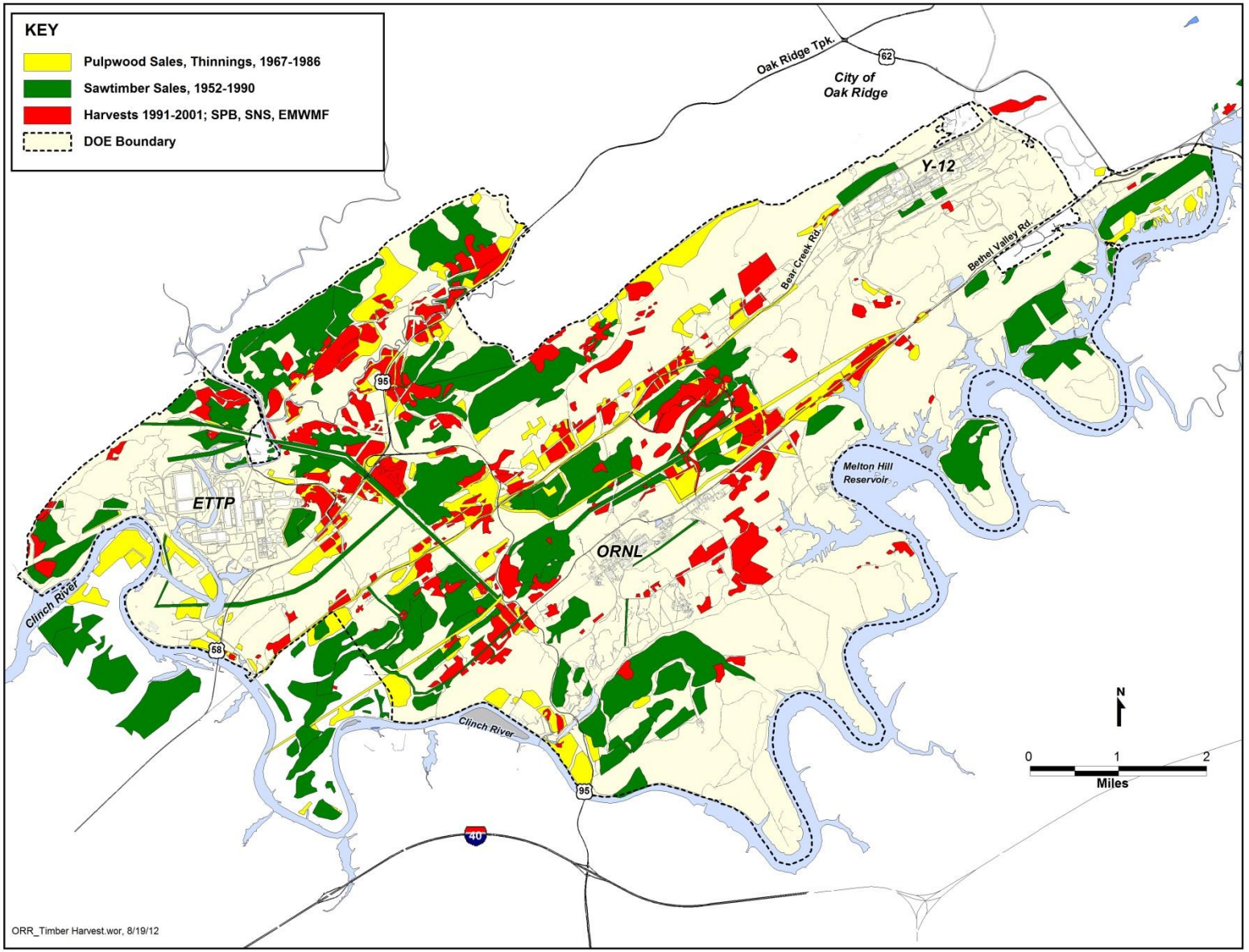

Fig. A.3. Timber harvest locations.

In 1969 the Atomic Energy Commission, along with TVA; the city of Norris, Tennessee; and Emory River Land Company entered into a 10-year timber sale contract with Longleaf Industries, Inc., of Lumpkin, Georgia, to entice an integrated wood utilization industry into the Oak Ridge area. Due to erratic mill operation and an unpredictable lumber market, only 7.7 million bd-ft of pine and hardwood sawtimber were harvested from 1970 through 1975, 1.3 million bd-ft short of the anticipated volume. The net value of this sawtimber was $183,496. The remaining $50,720 was received as revenue for the 14,145 cords of pulpwood sold during the same time period. The average annual income for the period was $61,000, with a total 5-year-period income of $234,216. Sawtimber sales under the 10-year timber contract with Longleaf Industries, Inc., from 1976 through 1980 totaled 4.2 million bd-ft. This contract was transferred in 1976 from Longleaf Industries, Inc., to American Forest Products, a subsidiary of Bendix Corporation. The final timber volume cut under the 10-year contract was 11.0 million bd-ft. Neither American Forest Products nor DOE wished to renew the long-term contract for an additional 10-year period; therefore, it was terminated in December 1978.

Sawtimber sales for the 1976 through 1982 period consisted of spot bid sales of hardwood, pine, and red cedar sawtimber. Total revenue for 1981 was $13,597, generated through the sale of 974 cords of pulpwood and 138,141 bd-ft of sawtimber. Sales increased in 1982 partly due to clearing for the site of the Clinch River Breeder Reactor, where 365,000 bd-ft of sawtimber and 11,051 cords of pulpwood were harvested. Total revenue for 1982 was $39,885 and for the 1976 to 1982 management period was $347,682.

Following the end of the long-term contract with American Forest Products in 1978, there was no requirement to fulfill the obligations of a long-term timber supply contract. Forest management transitional activities were limited to clearing for construction and development and as a tool for promoting good forest management practice (e.g., wildland fire control). Additional revenues have been generated since 1982 from timber salvaged from new projects initiated on the ORR and by salvaging timber following outbreaks of SPB in 1993, 1994, and 1999 through 2001.

No forest management–planned timber harvests were conducted from 1983 to the present. All timber sales were the direct result of specific customer requests or salvage operations due to insect infestations or storm damage. Customer requests for timber salvage included new utility rights-of-way, new roads and highways, power line right-of-way maintenance, safety zones, and new facilities. New facilities included buildings, waste sites, borrow pits, and fences. Therefore, totals of 56,221 cords of pulpwood and 7.112 million bd-ft of sawtimber were salvaged from the ORR during this time period with a combined value of $1,182,668.

Approximately 13,802 total forest acres have been harvested throughout the ORR since 1952.

ORR Wildland Fire Management History

The ORR has an excellent history of wildland fire control (Table A.5). The total area burned by wildland fires since March 1977 has been less than 42 acres. An escaped prescribed fire in May 2000, now referred to as the Cerro Grande fire, resulted in the destruction of more than 400 homes and structures in and near Los Alamos National Laboratory. The fire impacted DOE operations there for years and added impetus to an examination of national fire prevention practices. DOE immediately issued a moratorium on open burning at all of its sites. In May and June of 2000, the ORR Forester served in a DOE Fire Safety Working Group that reviewed burning practices and was a necessary step in lifting the moratorium. Based on this review, the ORR Forester completed a wildland fire analysis and evaluation. DOE issued the *Wildland Fire Management Plan at the Oak Ridge Reservation* (DOE 2005), which assigned responsibilities for wildland fire management, and the Oak Ridge Reservation Wildland Fire Implementation Plan (Appendix A of DOE 2008), which provided specific details on achieving complete implementation of the program. The most recent guidance for forest management is defined in a DOE Oak Ridge Wildland Fire Memorandum dated April 5, 2007.

Table A.5. DOE Oak Ridge Reservation wildland fire history, 1966–2006

Date	Location	Source	Acres	Responding units
4/2/1966	C-18, 0907 Area, power line fuse transformer failed, overheated, and dropped into fuels	Power line	100	ORNL FD, ETTP FD, Y-12 FD, COR, ORNL FM, Anderson Co. Rescue Squad, ORNL guards, AEC personnel and employees called in from the three ORR plants (100–150 people)
4/7/1966	Y-12 Burning Pits (and moved south of Bear Creek Rd.)	Escaped control burn	450	Y-12 FD, ORNL FM, ORNL P & E
2/21/77 to 2/23/77	C-8, Pine Ridge west of 500 kv P/L. Burned for 3 d prior to control; TVA clearing contractor	Escaped control burn	48.8	ORNL FM, COR
7/1981	Three small spots on Bethel Valley Rd., arson	Arson	0.1	ORNL FD, ORNL FM
1/28/1982	C-8, grass fire Bear Creek Rd. west of Hwy. 95	Smoker	0.1	ORNL FM
3/10/1982	Oak Ridge Tpk. 0.5 mile west of Westover Dr., cigarette	Smoker	1.5	COR
3/10/1987	C-27, barn fire, teenagers smoking?	Trespass/arson or smoker	0.2	COR, ORNL FM
8/23/1988	A-6, Pine Ridge, fire from brush-pile burning	Escaped control burn	6	ORNL FM, Y-12 FD
7/27/1993	A-4, lightning strike on Copper Ridge	Lightning	0.1	ORNL FM
4/3/1995	C-15, DOE Firing Range, bullet ricochet	Firearms	12	ORNL FD, ETTP FD, Y-12 FD, COR, ORNL FM
4/11/1995	C-21, citizen-reported fire along remote lakeshore; source not located (pine pollen cloud or shoreline campfire?)	Campfire?	0	ORNL FM
4/21/1995	C-18, lightning strike, power pole flame arrestor	Lightning	0	ORNL FM
7/10/1995	C-1, Black Oak Ridge, power line hit ground/grass fire	Power line	14	ETTP FD, COR, ORNL FM
9/12/1995	C-6, Blair Rd./Wheat Rd., gas line right-of-way, escaped windrow burning	Escaped control burn	0.75	ORNL FM, ETTP FD
8/1995	C-6, Blair Rd. at Hwy. 58 intersection, cigarette	Smoker	1	ETTP FD
4/1996	C-28, Gum Hook trail, lightning strike (observed)	Lightning	0.1	ORNL FM
3/7/2000	C-15, Bethel Valley Rd. at Hwy. 95, cigarette	Smoker	0.1	ORNL FD, ORNL FM

Table A.5. (continued)

Date	Location	Source	Acres	Responding units
5/4/2000	C-17, logging contractor skidder fire	Vehicle	0	ORNL FD, ORNL FM
5/23/2000	ORNL BG#5, straw fire	Chemical reaction	0	ORNL FD
10/24/2000	Hwy. 95 northwest of Bear Creek Rd. intersection	Smoker	0.1	ORNL FD, ORNL FM, COR
2/8/2001	C-12, EMWMF Construction Site, Y-12 National Security Complex	Escaped control burn	3	Y-12 FD, ORNL FM, TDF, OR FD
11/14/2001	C-26, Haw Ridge east of Pumphouse Rd., fisherman's cigar	Smoker	1.5	COR, ORNL FM
6/12/2002	C-17, Chestnut Ridge Rd. at SNS power line right-of-way, escaped TVA pit burn	Escaped control burn	0.2	ORNL FM, ORNL FD
1/9/2003	A-2, Lagoon Rd. at WAG 4, ember from brush burn	Escaped control burn	0.1	ORNL FM
3/7/2005	C-18, Hwy. 58, 0.3 mi. east of Blair Rd., fireball blown from automobile engine ignited grass	Vehicle	0.25	COR, ETTP FD, ORNL FM
10/31/2005	A-3, Hwy. 95, 800 ft north of Bethel Valley Rd., cigarette	Smoker	0.01	ETTP FD, ORNL FD, ORNL FM
3/29/2006	A-3, Hwy. 95, 4000 ft north of Bethel Valley Rd., cigarette	Smoker	<0.01	ORNL FD
	Total acres		**639.91**	
			23.7	Acres/event, all time
			0.45	Acres/event, previous 10 years
			0.68	Incidents per year

Abbreviations
AEC = Atomic Energy Commission
COR = city of Oak Ridge Fire Department
EMWMF = Environmental Management Waste Management Facility
ETTP FD = East Tennessee Technology Park Fire Department
ORNL FD = Oak Ridge National Laboratory Fire Department
ORNL FM = Oak Ridge National Laboratory Forest Management
ORNL P & E = Oak Ridge National Laboratory Plant and Equipment Division
SNS = Spallation Neutron Source
TDF = Tennessee Division of Forestry
TVA = Tennessee Valley Authority
WAG = waste area grouping
Y-12 FD = Y-12 National Security Complex Fire Department

Notes
The above table summarizes the ORR wildfire history for the past 40 years, describing 27 reported events occurring throughout the Reservation. Only 25 of these fires would be classed as wildfires in the forest, while two were confined to equipment and materials (straw) but had the potential to spread into surrounding grass or forested areas. The prompt response by the specific fire control units confined most of these fires to minimal areas and damage. Therefore, the incident ratio for these fires over 40 years was 0.675 fires per year. The annual fire incident risk is directly related to weather and rainfall distribution. In 1995, the worst year for wildland fire by number of events (6), the rainfall was patchy with an extended dry spring and dry weather in late summer and early fall. The worst week was in April 1966 when two fires burned more than 500 acres in the Walker Branch/Bear Creek area.

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APPENDIX B.
OAK RIDGE RESERVATION APPROVED LANDSCAPING PLANT LIST

APPENDIX B.
OAK RIDGE RESERVATION APPROVED LANDSCAPING PLANT LIST

Scientific Name	Common Name	Synonym
CANOPY		
Acer rubrum	Red Maple	
Acer saccharum	Sugar Maple	
Aesculus flava	Yellow Buckeye	
Betula nigra	River Birch	
Carya glabra	Pignut Hickory	
Carya ovata	Shagbark Hickory	
Carya tomentosa	Mockernut Hickory	
Celtis occidentalis	Hackberry	
Cladrastis lutea	American Yellowwood	
Diospyros virginiana	Persimmon	
Fagus grandifolia	American Beech	
Fraxinus pennsylvanica	Green Ash	
Ilex opaca	American Holly	
Juniperus virginiana	Eastern Red Cedar	
Liquidambar styraciflua	Sweetgum	
Liriodendron tulipifera	Tulip Poplar	
Morus rubra	Red Mulberry	
Nyssa sylvatica	Blackgum	
Pinus echinata	Shortleaf Pine	
Pinus strobus	White Pine	
Pinus taeda	Loblolly Pine	
Pinus virginiana	Virginia Pine	
Platanus occidentalis	Sycamore	
Prunus serotina	Wild Black Cherry	
Quercus alba	White Oak	
Quercus bicolor	Swamp White Oak	
Quercus coccinea	Scarlet Oak	
Quercus falcata	Southern Red Oak	
Quercus montana	Chestnut Oak	
Quercus palustris	Pin Oak	
Quercus phellos	Willow Oak	
Quercus prinus	Chestnut Oak	
Quercus rubra	Red Oak	
Quercus shumardii	Shumard Oak	
Quercus stellate	Post Oak	
Quercus velutina	Black Oak	
Salix nigra	Black Willow	
Sassafras albidum	Sassafras	
Thuja occidentalis	Northern White Cedar	

Scientific Name	Common Name	Synonym
Tilia americana	Basswood	
Tsuga canadensis	Eastern Hemlock	
Ulmus alata	Winged Elm	
Ulmus americana	American Elm	
SUB-CANOPY/ACCENT		
Aesculus pavia	Red Buckeye	
Alnus serrulata	Stream Alder	
Amelanchier arborea	Common Serviceberry	
Amelanchier laevis	Allegheny Serviceberry	
Aralia spinosa	Devil's Walking Stick	
Asimina triloba	Pawpaw	
Carpinus caroliniana	Ironwood	
Cercis canadensis	Eastern Redbud	
Chionanthus virginicus	Fringetree	
Cladrastis lutea	American Yellowwood	
Cornus florida	White Dogwood	
Crataegus phaenopyrum	Washington Hawthorn	
Crataegus calpodenron	Late Hawthorn	
Crataegus crus-galii	Cockspur Hawthorn	
Halesia tetraptera	Silverbell	
Hamamelis virginiana	Witchhazel	
Ilex opaca	American Holly	
Magnolia tripetala	Umbrella Magnolia	
Ostrya virginiana	Hophornbeam	
Oxydendrum arboreum	Sourwood	
Prunus americana	Wild Plum	
Ptelea trifoliata	Hoptree	
Rhamnus caroliniana	Carolina Buckthorn	
Rhus copallina	Shining/Winged Sumac	
Rhus glabra	Smooth Sumac	
Viburnum prunifolium	Blackhaw	
Viburnum rufidulum	Rusty Blackhaw	
SHRUB		
Amorpha fruticosa	Indigobush	
Aronia arbutifolia	Red Chokeberry	*Photinia melanocarpa*
Arundinaria gigantea	River Cane	
Callicarpa americana	American Beautyberry	
Calycanthus floridus	Sweetshrub	
Ceanothus americanus	New Jersey Tea	
Cephalanthus occidentalis	Buttonbush	
Clethra alnifolia	Summersweet	
Cornus amomum	Silky Dogwood	
Corylus americana	American Hazelnut	

Scientific Name	Common Name	Synonym
Euonymus americanus	Hearts-a-bustin'	
Fothergilla major	Fothergilla	
Hydrangea arborescens	Wild Hydrangea	
Hydrangea quercifolia	Oakleaf Hydrangea	
Hypericum frondosum	Golden St. John's Wort	
Hypericum hypericoides	St. Andrew's Cross	
Hypericum prolificum	Shrubby St. John's Wort	
Ilex verticillata	Winterberry	
Itea virginica	Virginia Sweetspire	
Kalmia latifolia	Mountain Laurel	
Lindera benzoin	Spicebush	
Photinia melanocarpa	Black Chokeberry	
Photinia pyrifolia	Red Chokeberry	*Aronia arbutifolia*
Physocarpus opulifolius	Common Ninebark	
Rhododendron maximum	Rosebay Rhododendron	
Rhododendron minus	Small-leaved Rhododendron	
Rhododendron periclymenoides	Pinxter-bush	
Rhus aromatica	Fragrant Sumac	
Rhus aromatica 'Gro-low'	Gro-low Fragrant Sumac	
Rhus copallina	Shining/Winged Sumac	
Robinia hispida	Prickly Locust	
Rosa carolina	Carolina Rose	
Rosa palustris	Swamp Rose	
Sambucus canadensis	Elderberry	
Symphoricarpos orbiculatus	Coralberry	
Vaccinium arborem	Farkleberry	
Viburnum acerifolium	Maple leaf Viburnum	
Viburnum dentatum	Arrowwood Viburnum	
HERBACEOUS		
Amsonia tabernaemontana	Eastern Bluestar	
Antennaria plantaginifolia	Pussy Toes	
Aquilegia canadensis	Wild Columbine	
Arisema triphyllum	Jack-in-the-pulpit	
Aruncus diocus	Goat's Beard	
Asarum canadense	Wild Ginger	
Asclepias incarnata	Swamp Milkweed	
Asclepias syriaca	Common Milkweed	
Asclepias tuberosa	Butterfly Weed	
Aster cordifolius	Blue Wood Aster	*Symphyotrichum cordifolium*
Aster divaricatus	White Wood Aster	*Eurybia divaricata*
Aster laevis	Smooth Aster	*Symphyotrichum laeve*
Aster novae-angliae	New England Aster	*Symphyotrichum novae-angliae*
Aster oblongifolis	Aromatic Aster	*Symphyotrichum oblongifolium*

Scientific Name	Common Name	Synonym
Aster patens	Late Purple Aster	*Symphyotrichum patens*
Aster undulatus	Waxy Leaf Aster	*Symphyotrichum undulatum*
Astilbe biternata	False Goat's Beard	
Baptisia australis	Blue Wild Indigo	
Conoclinium coelestinum	Wild Ageratum	*Eupatorium coelestinum*
Coreopsis auriculata	Mouse-eared Coreopsis	
Coreopsis lanceolata	Lance-leaved Coreopsis	
Echinacea purpurea	Purple Coneflower	
Eupatorium coelestinum	Wild Ageratum	*Conoclinium coelestinum*
Eupatorium fistulosum	Joe-pye Weed	
Eupatorium purpureum	Woodland Joe-Pye Weed	
Eurybia divaricata	White Wood Aster	*Aster divaricatus*
Gaultheria procumbens	Wintergreen	
Geranium maculatum	Wild Geranium	
Helianthus angustifolius	Swamp Sunflower	
Helianthus occidentalis	Western Sunflower	
Heuchera americana	Alumroot	
Hymenocallis caroliniana	Spiderlily	*Hymenocallis occidentalis*
Hymenocallis occidentalis	Spiderlily	*Hymenocallis caroliniana*
Impatiens capensis	Jewel Weed	
Iris cristata	Dwarf Crested Iris	
Liatris aspera	Rough Blazing Star	
Liatris cylindracea	Ontario Blazing Star	
Liatris spicata	Dense Blazing Star	
Liatris squarrosa	Scaly Blazing Star	
Lobelia cardinalis	Cardinal Flower	
Lobelia syphilitica	Big Blue Lobelia	
Mertensia virginica	Virginia Bluebells	
Monarda didyma	Beebalm	
Monarda fistulosa	Wild Bergamot	
Opuntia humifusa	Prickly Pear	
Pachysandra procumbens	Allegheny Spurge	
Penstemon canescens	Hairy-Beardtongue	
Penstemon digitalis	White Beardtongue	
Penstemon laevigatus	Smooth Beardtongue	
Phlox divaricata	Woodland Phlox	
Phlox glaberrima	Smooth Phlox	
Phlox paniculata	Summer Phlox	
Phlox stolonifera	Crawling Phlox	
Physostegia virginiana	False Dragonhead/Obedient Plant	
Polygonatum biflorum	Solomon’s Seal	
Pycnanthemum torrei	Torry’s Mountain Mint	
Ratibida pinnata	Prairie Coneflower	

Scientific Name	Common Name	Synonym
Rudbeckia fulgida	Orange Coneflower	
Rudbeckia hirta	Black-eyed Susan	
Rudbeckia triloba	Brown-eyed Susan	
Sedum ternatum	Wild Stonecrop	
Silene virginica	Fire Pink	
Silphium terebinthenaceum	Prairie Dock	
Sisyrinchium angustifolium	Blue-eyed Grass	
Smilacina racemosa	False Solomon's Seal	
Solidago caesia	Blue-Stemmed Goldenrod	
Solidago canadensis	Canada Goldenrod	
Solidago flexicaulis	Zig-Zag Goldenrod	
Solidago nemoralis	Southern Gray Goldenrod	
Solidago odora	Fragrant Goldenrod	
Solidago ptarmicoides	Prairie Goldenrod	
Solidago rugosa	Stiff Goldenrod	
Solidago speciosa	Showy Goldenrod	
Solidago sphacelata	Short-Pappus Goldenrod	
Solidago ulmifolia	Elm-Leaved Goldenrod	
Spigelia marilandica	Indian Pink	
Symphiotrichum oblongifolium	Aromatic Aster	*Aster oblongifolis*
Symphyotrichum cordifolium	Blue Wood Aster	*Aster cordifolius*
Symphyotrichum novae-angliae	New England Aster	*Aster novae-angliae*
Symphyotrichum laeve	Smooth Aster	*Aster laevis*
Symphyotrichum patens	Late Purple Aster	*Aster patens*
Symphyotrichum undulatum	Waxy Leaf Aster	*Aster undulatus*
Tradescantia virginica	Spiderwort	
Vernonia gigantea	Ironweed	
Veronicastrum virginicum	Culver's Root	
GRASS/SEDGE		
Andropogon gerardii	Big Bluestem	
Andropogon glomeratus	Woolly/Bushy Broomsedge	
Andropogon ternaries	Splitbeard Bluestem	
Andropogon ternarius	Split Beard Bluestem	
Andropogon virginicus	Broomsedge	
Arundinaria gigantea	River Cane	
Bouteloua cutipendula	Side-oats Grama	
Carex cherokeensis	Cherokee Sedge	
Carex lurida	Lurid Sedge	
Carex pennsylvanica	Pennsylvania Sedge	
Carex vulpinoidea	Fox Sedge	
Chasmanthium latifolium	River Oats	
Eleocaharis quadrangulata	Square-sided spikerush	
Elymus virginicus	Virginia Wild Rye	

Scientific Name	Common Name	Synonym
Eragrostis spectabilis	Purple Lovegrass	
Hystrix patula	Bottlebrush Grass	
Juncus effusus	Soft Rush	
Panicum virgatum	Switchgrass	
Saccharum giganteum	Sugarcane Plumegrass	
Schoenoplectus pungens	Three-square rush	*Scirpus americanus*
Schoenoplectus tabernaemontani	Soft-stem Bulrush	*Scirpus validus*
Schyzachyrium scoparium	Little Bluestem	
Scirpus americanus	Three-square rush	*Schoenoplectus pungens*
Scirpus cyperinus	Woolgrass	
Scirpus validus	Soft-stem Bulrush	*Schoenoplectus tabernaemontani*
Sorghastrum nutans	Indian Grass	
FERN		
Adiantum pedatum	Maidenhair Fern	
Asplenium platyneuron	Ebony Spleenwort	
Athyrium filix-femina	Lady Fern	
Deparia acrostichoides	Silvery Glade Fern	
Dryopteris intermedia	Fancy Wood Fern	
Dryopteris marginalis	Marginal Wood Fern	
Osmunda cinnamomea	Cinnamon Fern	
Osmunda regalis	Royal Fern	
Polystichum acrostichoides	Christmas Fern	
Pteridium aquilinum	Bracken Fern	
AQUATIC		
Alisma subcordata	Water Plantain	
Eleocaharis spp.	Spikerush	
Equisetum arvense	Field Horsetail	
Equisetum hymale	Scouring Rush	
Hibiscus laevis	Halberd-leaved Mallow	
Hibiscus moscheutos	Swamp Rose Mallow	
Juncus effusus	Soft Rush	
Nelumbo lutea	American lotus	
Nuphar lutea	Spadderdock	
Nymphaea odorata	American White Water Lily	
Pontederia cordata	Pickerelweed	
Sagittaria latifolia	Arrowhead	
Saururus cernuus	Lizard’s Tail	
Scirpus cyperinus	Woolgrass	
Typha latifolia	Broad-leaf Cattail	
Vallisneria americana	Water Celery	
VINE		
Bigonia capreolata	Crossvine	
Campsis radicans	Trumpet Creeper	

Scientific Name	Common Name	Synonym
Clematis viorna	Leatherflower	
Clematis virginiana	Virgins Bower	
Lonicera sempervirens	Coral Honeysuckle	
Parthenocissus quinquefolia	Virginia Creeper	
Passiflora incarnata	Passionflower	
Rosa setigera	Climbing Prairie Rose	
Wisteria frutescens	American Wisteria	
Limited Use Plants—Require approval (not on ORR, but may meet special needs)		
CANOPY		
Acer freemanii	Freeman Maple	
Magnolia virginiana	Sweetbay Magnolia	
SHRUB		
Fothergilla gardenii	Dwarf Fothergilla	
Ilex glabra	Inkberry	
Yucca filamentosa	Yucca	
HERBACEOUS		
Echinacea tennesseensis	Tennessee Coneflower	
GRASS/SEDGE		
Muhlenbergia capillaris	Pink Muhly Grass	
Sporobolus heterolepis	Prairie Dropseed	

APPENDIX C.
ROAD DEVELOPMENT AND MAINTENANCE BEST MANAGEMENT PRACTICES GUIDELINES FOR THE OAK RIDGE RESERVATION

APPENDIX C
ROAD DEVELOPMENT AND MAINTENANCE BEST MANAGEMENT PRACTICES GUIDELINES FOR THE OAK RIDGE RESERVATION

The forest road system is an extensive and viable infrastructure within the Oak Ridge Reservation (ORR). Proper maintenance is vital to the health of the surrounding environment as well as for users (including security, researchers, emergency responders, remediation workers, and resource managers). Improperly constructed and/or maintained roads result in impacts to interior forests, water quality, wetlands, creeks and streams, protected habitats, cultural resources, research areas, soils, wildlife, and forest resources (Figs. C.1 to C.5). Proper road design can be a major factor in minimizing such impacts (Figs. C.6 to C.7).

Best management practices for ORR forest roads are different from those for typical public road maintenance. The secondary roads throughout the ORR require minimal impact from road use and maintenance. Roads and drainage systems deteriorate because of traffic, weather, and age, and some roads become saturated during extended wet periods. Matching road maintenance to actual needs can reduce upkeep costs.

Best management practices for ORR secondary roads must

- minimize erosion and sediment production during the life of the road,
- protect the road investment,
- match the use of the road to what it is designed to handle,
- ensure road surfaces and drainage systems allow natural drainage functioning,
- install culverts to align natural stream channels and allow fish passage,
- include periodic assessments of road condition to determine operational controls and maintenance needs,
- restrict maintenance activities when roads are saturated, and
- use low-impact maintenance techniques to minimize disturbance of both stable sites and sensitive areas.

Guidelines for construction and maintenance have been developed using established Best Management Practices (TDF 2003; NCFS 2006; USDA 2012) and customizing them for ORR non-paved road needs. Most non-paved roads on the ORR are "All Season Roads," that is, roadbeds improved with a gravel surface that are suitable for year-round use. Certain ORR non-paved roads may have to meet specific DOE requirements and do not fall under this best management practice (such as the Environmental Management Haul Road).

Wasted time, materials, and money are the results of improperly constructed and/or maintained roads. Examples include

- excessive side-casting (pushing road gravel onto shoulders, ditches, turnouts, and beyond)—causes blockage to ditch lines, streambeds, culverts, and turnouts and requires cleanup and additional surface gravel;
- extended turnouts (creating turnouts longer then needed)—causes runoff to carry road surface material out into undisturbed forest floor;

- improper crown on road (removal of elevated center in road to allow drainage)—results in water collection on roads, erosion of roadbed, potholes, ruts or gullies, and wash-boarding;
- inadequate drainage (blocking proper water flow)—results in erosion, and drainage ends up on forest floor and in streambeds;
- improper ditch line/water shedding—results in ditches becoming deeper and creates driving hazards;
- surface compaction changes (creating impermeability such as using a roller to compact the road surface on slopes, especially when crown has been removed)—causes potholes, increases energy to runoff, and standing water;
- increased road width and removal of additional vegetation—results in a potential to increase impact to ecosystem, fragment the forested areas, and create impacts in areas that have not been assessed through required environmental surveys;
- mechanical damage to roadside vegetation (bark damage, downed trees, vegetation impacts)—causes unnecessary damage and death to vegetation, compacts soil, and creates future hazardous trees that may need to be removed;
- removing surface above culvert (grading road above culverts)—results in culvert exposure and damage from and to vehicles; and
- backfilling culverts, by erosion or side-casting of road surface material—causes erosion on outsides of culverts, pinches culvert shut resulting in reduced drainage capacity and habitat damage.

Improper maintenance can actually cause hazards resulting in damage to vehicles and slow emergency vehicle response time.

Special situations (sensitive habitats) may need to be evaluated on a case-by-case basis.

Non-Paved Road Layout and Construction

Use topographic maps and soil surveys to develop a plan before road construction begins.

Incorporate existing roads where possible to minimize overall environmental impact.

Minimize stream crossings wherever possible. When crossings are necessary, use culverts of sufficient size so as not to impede the natural flow of the stream. Use fill that will not allow stream flow or erosion to bypass the culvert.

Follow natural contours and use upper slopes but avoid placing roads on the tops of ridgelines.

Keep grades at greater than 2% but below 12% where possible. Avoid less than 2% grade as this tends to hinder proper roadbed drainage during wet periods.

Properly control runoff by variations in road slope, crowning the center of roads, broad base dips, and out sloping.

Ditch lines should strive to have final turnouts located 25 ft ahead of Streamside Management Zones (SMZs), and efforts should be taken to prevent contact with SMZs. If ditch lines are in contact with a stream or SMZ, the ditch lines should have materials in place to control the runoff of sedimentation from the ditch into the stream or SMZ area. These materials may include riprap, native vegetation, check dams, or silt fence.

Inspection and Maintenance Guidelines

Periodically inspect roads to evaluate conditions and to assist in maintenance needs and improvement priorities.

Inspect drains and drainage structures, especially after major weather events, and perform necessary maintenance.

Efforts should be made to return shoulder material to the roadbed for reuse as much as possible. Side-cast material should also be returned to the roadbed for reuse when cleaning out ditch lines whenever possible, because this material can collect at turnouts and at streamside edges.

Grading of roadbeds should be done so as to maintain crowns, outslope, and broad base dips. Shoulder buildup should also be maintained to keep outflow of water in the ditch line. Shoulder buildup should be returned to the road for reuse, re-contouring, and repacking wherever possible, but not discarded into ditches or forest areas.

Appropriate gravel should be reapplied to roads where necessary to maintain an adequate road surface.

Grading on ditch lines and turnouts should be done only to the extent that will keep them functioning properly.

Grade road surfaces only as necessary to meet smoothness requirements and to provide adequate surface drainage.

Do not undercut the toe of the cut slope when grading roads.

Do not permit side-casting of maintenance-generated debris into undisturbed forest or streamside management areas. This material should be reused where possible on the existing roadbed.

Avoid over-widening of roads due to repeated grading over time, especially where side-cast material would encroach on water bodies or undisturbed forest areas.

Maintain permanent stream crossings and approaches to reduce the likelihood that water would be diverted onto the road if the structure becomes obstructed.

Maintain the road surface drainage system to collect and remove water from the road surface in a manner that reduces concentrated flow in ditches, culverts, and the road surface.

Fig. C.1. Side-cast builds up from improper road maintenance. This can damage trees, and water cannot drain from the road surface.

Fig. C.2. An undercut road toe causes water to drain down the road surface instead of draining into ditch lines and turnouts.

Fig. C. 3. An improperly maintained turnout can create damage to the undisturbed forest surrounding it and also can allow for excess erosion of the road surface material.

Fig. C.4. Improper turnouts allow road material to clog streams.

Fig. C.5. An open forest canopy and poor maintenance can allow vegetation to reclaim roadbeds, incurring extra cost to rebuild existing roads. Restricting road width to 20 ft can reduce this effect.

(a) **(b)**

Fig. C.6. Proper ditch line turnouts allow for water runoff while preventing road material from entering the undisturbed forest areas.

Fig. C.7. Proper crowning and reuse of road material is evident here. There is no sign of runoff or side-cast. Notice the closed forest canopy and the lack of encroachment by roadside vegetation.

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