



Natural Areas Analysis and Evaluation

OAK RIDGE RESERVATION

November 2009

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Oak Ridge National Laboratory

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**NATURAL AREAS ANALYSIS AND EVALUATION:
OAK RIDGE RESERVATION**

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ACRONYMS AND ABBREVIATIONS

ANA	Aquatic Natural Area
ARA	Aquatic Reference Area
BSR	Biodiversity Significance Rank
CMA	Cooperative Management Area
DOE	U.S. Department of Energy
EO	element occurrence
GIS	Geographic Information System
HA	Habitat Area
NA	Natural Area
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
PHA	Potential Habitat Area
RA	Reference Area
TDEC	Tennessee Department of Environment and Conservation
TNC	The Nature Conservancy
TVA	Tennessee Valley Authority

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A number of individuals provided invaluable insights and assistance during the course of this study. The author had no familiarity with the Oak Ridge Reservation before the study was initiated and was dependent upon others who have had long experiences working there. These persons provided the necessary orientation, important background information, technical expertise, and personal knowledge and opinions about natural resources and natural areas on the Reservation. Many of these individuals also provided critical review of the first draft of the study. The contributions of the natural resources team and the Natural Resources Manager are particularly acknowledged.

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EXECUTIVE SUMMARY

The Oak Ridge Reservation, encompassing 33,639 acres in the Valley and Ridge Physiographic Province of east Tennessee, has long been known for its unfragmented forests and high biodiversity. Many areas on the Reservation have been recognized as important natural areas, but no comprehensive treatment has been performed to evaluate the relative significance and importance of these areas compared to one other. The present study was conducted to develop a set of guidelines for evaluating the natural value of specific areas, evaluate all the terrestrial areas that are currently delineated, and rank all areas according to their relative biodiversity importance.

All available data, reports, and site-specific information relevant to Reservation lands, including Tennessee Division of Natural Areas database information, were evaluated, and fieldwork was conducted. Methodologies and criteria for assessment and evaluation of areas were developed, categories of criteria were devised, and a ranking system for evaluation of natural areas was produced. Seventy areas were evaluated during the study. The system is flexible, dynamic, and easily revised to reflect updated and new information and interpretations.

Eight categories of evaluation factors were established and used to characterize each site: (1) size of area, (2) number or status taxa present, (3) number of Endangered and Threatened taxa present, (4) rarity of the Endangered and Threatened taxa on the Reservation, (5) community and landscape diversity, (6) site integrity and quality, (7) disturbance and threat levels, and (8) other significant features and factors. Each category generally consisted of a 5-point ranking scale from 0 to 4, except for one category that has a 6-point scale, allowing for a possible composite score of 32 or 33, with higher-ranked, more-important sites attaining higher scores. Highly ranked sites are representative of regional natural diversity; contain outstanding natural features, communities, or geology and/or very rare taxa or other elements; are relatively large in size with mature or old-growth community composition; lack current disturbance factors or potential threats and disturbances; are in excellent condition with good buffers; are places where ecological and evolutionary processes can occur relatively unaffected by humans; and can be reasonably defended and maintained as natural areas in an undeveloped condition. Highly ranked sites are the most significant and should receive the greatest protections.

Composite scores of the ranked areas ranged from 1 to 25.5, with a mean score of 12.2. The ranked areas were divided into three Priority Groups. Group I, the most highly ranked group, included 21 sites and covered 5611 acres or 16.7% of Reservation lands; Group II included 30 sites and covered 3686 acres; and Group III included 19 sites covering 400 acres of Reservation lands. All sites together comprise 9697 acres or 28.8% of Reservation lands. Six sites emerged as clearly the most significant natural areas on the Reservation.

The study developed a number of recommendations that should be implemented to enhance and refine the natural areas data for the Reservation. There is a clear need for better and standardized ecological community classification and identification. Several areas are proposed for merger into larger units, and some new areas are proposed for inclusion and recognition in a natural areas system. Various gaps and discrepancies in the existing data are described and should be corrected. Other recommendations are made, including the development of a corollary system that can accommodate aquatic natural areas.

The study relied primarily on the synthesis of information from many sources and from limited reconnaissance and direct observation during fieldwork to produce a methodology for assessing natural area importance and assigning priorities for protection. Many instances of incomplete, missing, or conflicting information made it difficult to complete a thorough analysis. Further review and discussion among natural resources personnel will likely reveal possibilities for refinement and some additional factors that should be included in the evaluation. Despite the limitations, this study,

as conducted, illustrates the importance of the Oak Ridge Reservation for protecting the nation's increasingly threatened and declining biodiversity.

1. PROJECT PURPOSE

The purposes of the present study were to (1) develop a set of guidelines that can be used by Oak Ridge Reservation (ORR) resource managers to evaluate the natural value of specific land areas on this National Environmental Research Park, (2) reconsider the areas as they are currently delineated, and (3) rank them according to their relative biodiversity importance. This information will allow protection efforts to be focused on those areas that are most important and permit the evaluation of extrinsic human factors that might modify, degrade, or destroy the natural value of recognized areas. Secondly, a ranked system of natural areas would allow maximum flexibility for development of lands for other uses in a way that would not compromise the biodiversity on the Reservation. A forest management planning effort is also currently under way, and this natural areas analysis is considered a component of that effort. Updated evaluations of ecologically significant areas are necessary for integration into the forest plan.

The study was specifically designed to develop the following information:

- 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 for integration into the Tennessee Natural Heritage Program system and application to potential new areas;
- advice on approaches to incorporating ecologically significant areas into ORR forest management planning;
- recommendation of a sequential process for verifying and evaluating all ORR ecologically significant areas for the criteria that have been established; and
- initiation of the evaluation of ORR areas in the established sequence with the ultimate goal of prioritizing and ranking all sites for their ecological importance and significance.

2. METHODS

Study Area. The ORR currently encompasses 33,639 acres of federal land, administered by the U.S. Department of Energy (DOE), in Roane and Anderson Counties, in the Valley and Ridge Physiographic Province of east Tennessee. The land was acquired in the 1940s, and approximately 25,000 acres have remained undeveloped in a relatively natural state (Mitchell et al. 1996). Approximately 20,000 acres of the Reservation have been designated a DOE National Environmental Research Park, an International Biosphere Reserve, and part of the Southern Appalachian Man and the Biosphere Cooperative. At the time of acquisition, the landscape was primarily agrarian in nature and generally considered to be about 50% forested. In 1984 and 1987, remote-sensing analyses revealed an expansion of forest cover to about 70% of the Reservation (Mann et al. 1996). In 1994 forest cover remained at 70%, with the rest of the land in successional communities (20%) and other uses (Washington-Allen et al. 1995). The physical characteristics and natural resources of the Reservation are thoroughly described by Parr and Hughes (2006). Their report discusses topography, geology, hydrology, landscape features, plant and animal diversity, vegetation and forest resources, and special designated areas including Research Park Natural Areas and Reference Areas. Oak Ridge National Laboratory (ORNL) is a major national DOE research facility located on the Reservation, and ORR natural resources management is performed by ORNL for DOE. There is a long record of biological and ecological research on the Reservation. The significance of Reservation lands for the maintenance of biodiversity in the Valley and Ridge Province and nationally has also long been

recognized (Mann et al. 1996) and is largely due to the extensive, relatively unfragmented forest (> 75%) that still exists there (TDEC 2001). More than 1100 vascular plant species, 345 vertebrate animals, and several rare ecological communities have been documented on the Reservation. These will be discussed in later sections of this report.

Procedures. A work plan was established in consultation with the ORNL Natural Resources Manager. The Manager provided all available documentation concerning natural areas and significant ecological resources on the Reservation, including relevant reports, database information, and maps. Geographic Information System (GIS) mapping resources were also made available. The element occurrences (EOs) data for the ORR were secured from the Tennessee Division of Natural Areas in May 2008. The taxa evaluations performed in this study followed the natural heritage database and listing information maintained by the Division of Natural Areas (September 2008 at <http://www.state.tn.us/environment/na/nhp.shtml>); county and quadrangle lists were dated June 2007; the animal list was dated May 2004; and the plant list was dated August 2008. Site visits, in the company of resource management personnel and other consultants, were made to selected areas on the Reservation on four occasions: May 7–9, 2008; June 1–4, 2008; August 13–16, 2008; and September 11–13, 2008.

Existing data and information were synthesized and evaluated. The site visits provided important insight into the biodiversity on the ORR and also yielded some specific new findings. Discussion among field-study participants helped coalesce ideas and conclusions about natural areas, land use, and biodiversity on the ORR. The data were assembled into a table of attribute information (Table 1) and a summary of natural area descriptions (see the appendix). Methodologies and criteria for assessment and evaluation of natural areas were developed. Categories of criteria were devised, and a ranking system for evaluation of natural areas was produced.

On the ORR various land areas and sensitive and special management areas are currently recognized and classified in several categories (Pounds et al. 2008). These Research Park special areas are known as Natural Areas (NA), Aquatic Natural Areas, Reference Areas (RA), Aquatic Reference Areas, Special Management Zones, Conservation Easement Areas, Cooperative Management Areas (CMA), Habitat Areas, and Potential Habitat Areas (Fig. 1). Natural Areas are defined as those terrestrial areas containing listed species. Reference Areas are defined as primarily terrestrial areas that contain special habitats or features and that also may serve as reference or control areas for research, monitoring, remediation, or characterization activities. Cooperative Management Areas are managed cooperatively with other programs and agencies for special purposes, such as wildlife management. Habitat Areas contain known occurrences of commercially exploited state-listed species. Only the terrestrial areas including the NAs, RAs, and CMAs are discussed and evaluated in this report. Unless specifically identified as recognized areas, these are usually all referred to as “sites” or “natural areas” in this study.

Because the existing recognized Natural Areas are all defined on the basis of the presence of species with highly ranked rarity status, other areas are not easily accommodated. Areas containing good examples of old forest, interior forest, representative communities, aesthetic qualities, and other values cannot be recognized. The present study should help ORR resource managers consider other factors in the definition of natural areas.

A draft report was prepared in September 2008. In January 2009 an extensive review of the draft document was conducted. The review team participants included all those personnel (both employees and subcontractors) who are involved in the various aspects of natural resource management on the ORR. The input received from this review was considered, and the report was revised to produce this final document reflecting the new information and concerns.

Table 1. Attributes associated with Natural Areas, Reference Areas, and Conservation Management Areas on the Oak Ridge Reservation^a

Area number	Area (acres)	Relationship to large tracts ^b	Number of status taxa present ^c	Number of Endangered or Threatened taxa present ^d	Number of rare communities ^e	Forest intact in 1935? ^f	Disturbance impacts ^g
<i>Natural Areas</i>							
2	283	4	3	1	1	Yes	Intermediate
4	421	4	3	1	3	Intermediate	Intermediate
6	237	4	3	1		Yes, mostly	Low
7	324	4	3	1	3	Yes	Low
8	347	4	2	2	2	Yes	Intermediate
11	239	4	3	2	2	Intermediate	Low
12	60	4	1	1		Intermediate	Low
13	159	2	2	2	2	No, mostly	Low
14	26	3	4	2	1	Intermediate	Low
15	17	4	1	1	1	Yes, mostly	Low
17	293	3	1			Intermediate	Low
19	89	1	2	1	1	? Yes	Low
20	476	4	4		1	Intermediate	Low
21	142	4	1		1	Yes, mostly	Low
22	289	4	1	1		Yes, mostly	Intermediate
23	15	2	1	1		Yes	Low
24	50	2	4	1	2	No, mostly	Intermediate
25	18	3	1	1	2	No, mostly	Intermediate
26	3	0	1	1		No	High
28	33	0	1	1	1	No	Low
29	20	1	1	1	1	? Yes	Intermediate
30	23	3	1			Yes	Low
31	238	4	1	1		Yes	Intermediate
32	108	4	2		1	Intermediate	Intermediate
33	7	0	2	1		No	High
34	17	0	1	1		No	Intermediate
35	63	0	2	2	1	Intermediate	Intermediate
36	240	4	2	2		Intermediate	Low

Table 1 (continued)

Area number	Area (acres)	Relationship to large tracts ^b	Number of status taxa present ^c	Number of Endangered or Threatened taxa present ^d	Number of rare communities ^e	Forest intact in 1935? ^f	Disturbance impacts ^g
37	12	0	2			? No	Intermediate
38	25	1	1			No	High
39	46	1	1		2	? Yes	Intermediate
41	107	4	1			? Intermediate	Intermediate
42	376	4	3	1	1	Intermediate	Low
43	29	0	1	1		No, mostly	Intermediate
44	110	3	1			Yes	Intermediate
45	52	0	2			? No	High
46	300	4	1			? No	Intermediate
47	422	3	5	1	1	No, mostly	Intermediate
48	233	4	1	1	1	Yes	Intermediate
49	17	0				? Yes	Intermediate
50	89	1	2	2	1	No, mostly	Intermediate
51	519	4	4		1	Intermediate	Intermediate
52	147	4	4	1		Intermediate	Intermediate
53	102	3	2		1	Intermediate	High
54	74	0	2			? No	Intermediate
55	25	2	3			Intermediate	High
56	512	4	2	1	1	Yes, mostly	Low
<i>Reference Areas</i>							
5	9	2				No	Low
6	6	4	1			Intermediate	Intermediate
7	13	1				No	Intermediate
8	62	2			1	Intermediate	Intermediate
9	144	4	1			Intermediate	Intermediate
10	15	1				Intermediate	Intermediate
11	479	4	1	1		No	Low
14	162	4	1			Yes	Intermediate
15	27	3	1			Yes	Low
19	6	0			1	No	High
22	43	3				? Yes	Low
23	18	0				? No	Intermediate

Table 1 (continued)

Area	Area (acres)	Relationship to large tracts ^b	Number of status taxa present ^c	Number of Endangered or Threatened taxa present ^d	Number of rare communities ^e	Forest intact in 1935? ^f	Disturbance impacts ^g
25	5	1				No	High
26	1	0				No	High
28	3	0	1			No	High
29	128	4	1		1	Yes	Intermediate
30	6	0				No	Intermediate
31	375	4	1			No, mostly	Low
<i>Conservation Management Areas</i>							
1	51	0				No	High
2	198	0				No	Low
3	326	0	2			No	Low
4	33	0				? No	High
5	153	1	1			No	High

^a Information gathered from available reports, maps, and data. Elements are those listed for Tennessee by the Tennessee Division of Natural Areas, Natural Heritage Program.

Acreages are rounded to the nearest whole acre.

^b Evaluation of relationship of site to subjectively defined large undeveloped tracts, usually forested, from 0 (not proximate) to 4 (embedded within or includes interior forest) (see text).

^c Status taxa defined as all those listed by Tennessee Division of Natural Areas (2008) for the state of Tennessee (see text).

^d Taxa listed as Endangered or Threatened in Tennessee by the Tennessee Division of Natural Areas (2008).

^e Community types listed as rare in Tennessee by The Nature Conservancy for the Common Ground Process (1995) and NatureServe (2008).

^f Based on evaluation of 1935 aerial photography assembled for the Oak Ridge Reservation by J. W. Johnston. Intermediate areas were a mosaic of open and forested areas. Sites indicated with a “?” were not represented in the photography, and a subjective judgment was made.

^g Subjective judgment was made of effects of actual or potential anthropogenic disturbances, impacts, or development on the site (see text).

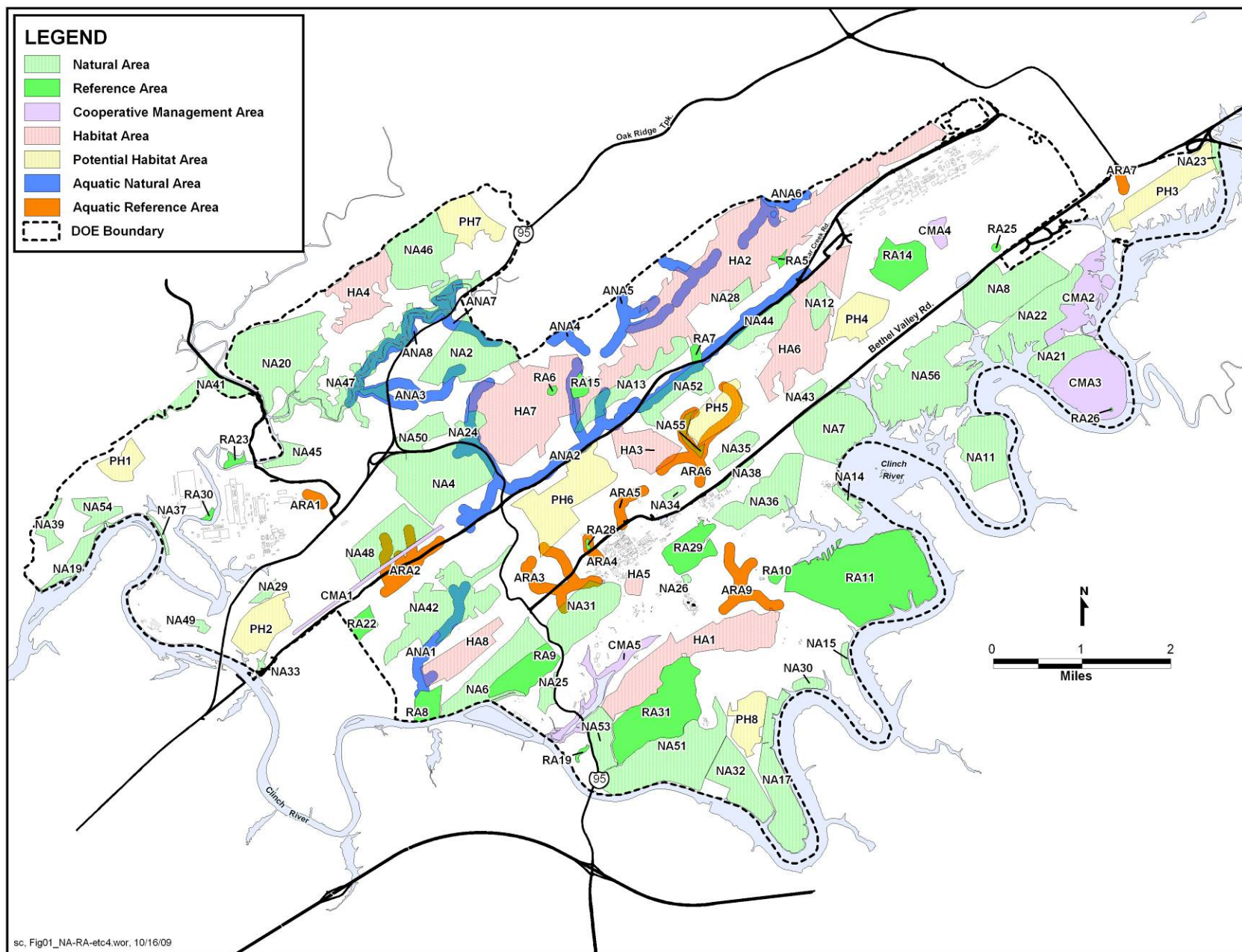


Fig. 1. Special and sensitive areas recognized in the Research Park, including Natural Areas (NA), Aquatic Natural Areas (ANA), Reference Areas (RA), Aquatic Reference Areas (ARA), Cooperative Management Areas (CMA), Habitat Areas (HA), and Potential Habitat Areas (PHA). Special Management Zones and Conservation Easement Areas not shown.

3. PREVIOUS STUDIES AND ACTIONS

The first ORR land-use plan recognized that the Reservation had provided a de facto preservation of several natural areas, and it identified special areas that should be preserved in a natural and relatively undisturbed state (Oak Ridge Land-Use Committee 1980). Several categories of lands (protective natural zones, representative biogeographic areas, cultural features, potential archeological sites) in a Unique Natural and Cultural Areas classification were established and mapped. The objectives of the land-use plan were the “continued protection of unique and natural areas” and continued research to identify additional areas. The land-use plan also discussed the prior establishment of NAs and RAs on the Reservation and defined these areas. The plan noted that designated areas were excluded from forest-management activities or environmental research that required significant disturbance; these areas were designated for restricted access. Periodic reinventory for status updating was to be established. The plan noted a required commitment to preserve unique and representative features, consistent with the National Environmental Policy Act of 1969 and Public Law 93-205, 1973, which obligate federal institutions to preserve significant national heritage aspects.

A 1985 agreement between DOE and the Tennessee Department of Environment and Conservation (TDEC, known as the Tennessee Department of Conservation at the time of the agreement) placed seven small areas on the Tennessee State Natural Areas Registry in recognition of rare plant populations and critical plant communities, and DOE agreed to manage a program that would protect and preserve these areas (letter dated October 3, 2001, from P. T. Marquess, DOE Assistant Manager for Administration, Oak Ridge Operations, to Charles Howard, TDC Commissioner). A 1987 ORNL report recognized 80 significant aquatic and terrestrial areas on the ORR (Parr and Pounds 1987).

In 1995 The Nature Conservancy (TNC) published an evaluation of the biodiversity on the ORR as part of a larger Common Ground Process led by DOE’s environmental management program (TNC 1995). This was a final report of special areas, including NAs and RAs, on the Oak Ridge National Environmental Research Park. The Nature Conservancy sought to collect existing data, standardize the data, provide new inventory information, and map sites with conservation values. GIS maps were prepared that showed proposed boundaries of Preliminary Conservation Sites and other areas and features. Brief descriptions of the Biodiversity Significance Ranks (BSRs) that were assigned to sites are as follows:

- BSR-1: Outstanding significance. Only occurrences of any element; best or excellent high-ranked occurrences of high-ranked elements; concentrations of high-ranked occurrences. Viable and defensible sites.
- BSR-2: Very high significance. One of most outstanding examples of any community element; areas containing intermediate-ranked elements and occurrences; concentrations of intermediate-ranked elements.
- BSR-3: High significance. Lower ranked occurrences of lower ranked elements; excellent examples of any community; concentrations of low-ranked occurrences and elements.
- BSR-4: Moderate significance. Less significant combinations of occurrences and elements than described above.
- BSR-5: Of general biodiversity interest. Open space. Any forested land on the ORR. Category was not applied on the ORR.

The TNC report noted that “a methodical and comprehensive inventory of plant and animal life covering the entire Reservation has never been made” (TNC 1995). A major objective was to provide a detailed analysis that would improve the ability to designate sites worthy of conservation protection.

The TNC study identified 27 sites ranked as BSR-2, 54 sites ranked as BSR-3, and five sites ranked as BSR-4. No sites were assigned a BSR-1 ranking. The study identified 270 occurrences of significant communities and species on the Reservation.

In 2001 the Tennessee Natural Areas Program of TDEC submitted a proposal to the Department of Energy Manager at Oak Ridge “to protect ecologically significant lands at the Oak Ridge Reservation under the Natural Areas Preservation Act of 1971” (TDEC 2001 and letter dated June 18, 2001, from Brian Bowen to G. Leah Dever). (Previously the 1985 agreement between the ORR and the Natural Areas Program had recognized seven small Registered State Natural Areas on Reservation lands because they contained rare plant species, but this was a nonbinding agreement and the ORR Real Estate Office terminated the agreement in June 2000.) Five landscape-scale Natural Areas were proposed for designation and protection under the Natural Areas Preservation Act. These five areas represented ecological core areas, contained 34 sites (including the 7 original Registered Natural Areas) and covered approximately 20,000 acres. The five landscape-scale areas did not include many other smaller disjunct areas. The proposal was acknowledged by the Manager and was accepted as information useful in an ongoing comprehensive land-use management planning process, but no action was taken to designate additional areas as protected NAs.

In June 1999 the Secretary of Energy designated the Three Bend Scenic and Wildlife Management Refuge, totaling 2920 acres. The Black Oak Ridge Conservation Easement, consisting of 3000 acres, was designated by DOE and the state of Tennessee in April 2005. The latter area is managed by the Tennessee Wildlife Resources Agency in cooperation with TDEC and includes the largest block of unfragmented forest on the ORR.

In 2006 a draft report on Oak Ridge National Environmental Research Park NAs and RAs collected existing information about ORR biodiversity and presented summary descriptions of all special areas; the draft report was revised in 2008 (Pounds et al. 2008). This report also included location information, lists of status species found on sites, the relationship of sites to the TNC Preliminary Conservation Sites, and other information. GIS maps showing site boundaries were included with the report. For the most part the boundaries of recognized NAs and other special areas do not coincide with the boundaries of the Preliminary Conservation Sites recognized by TNC (1995), but there is considerable similarity in some cases.

The natural areas report was developed to bring together in one document all the existing data and ideas about such areas. Over the years personnel and consultants working from the Natural Resources Manager’s office had been evaluating ORR lands for natural area value, creating boundary maps, and working to institute measures that would protect special areas in the long term. The emphasis has been on the presence of status species. The 2008 natural areas report did not attempt to rank areas for their significance or need for protection. There are 47 Natural Areas, eight Aquatic Natural Areas, 17 Reference Areas, five Aquatic Reference Areas, five Conservation Management Areas, eight Habitat Areas, eight Potential Habitat Areas, and eight Special Management Zones listed in the 2008 report. Since the issuance of the 2008 report, there have been slight modifications of the interpretation and number of sites that are recognized, such that the present study covers 47 Natural Areas (NA3 deleted, NA29 included), 18 Reference Areas (the unofficial RA32 not included; RA7 and RA19 included) and five Conservation Management Areas.

4. EVALUATION CRITERIA

Various approaches exist for determining the value of natural areas. Baranski (1994) employed three separate ranking categories: site significance, site integrity, and threat status. Site significance considered the presence of important biological, ecological, or geological elements and their relative rarity. Site integrity described the quality of the elements and features on a site, including size of land

area; size, age, vigor, and viability of species populations; and level of disturbance. Disturbance factors included the existence of roads; logging history; and presence of exotic species, utility lines, and structural development. Threat status assessed those factors that could affect the aesthetics, integrity, or viability of the elements. A five-tiered ranking scale was used for each category: from national to low/local significance, from prime to poor integrity, and from extreme to negligible threat status. A composite rank was derived by summing across all three categories.

The 1995 evaluation by TNC considered four criteria when assigning BSR rankings: quality (size of populations and areas, maturity, density), condition (deviation from the optimal condition due to disturbances, exotic species, etc.), viability (prospects for continued existence of the important elements), and defensibility (the degree to which threats from degrading or destructive human factors can be managed). Each criterion was assigned one of four rankings from excellent to poor. Relative rarity of species and communities was considered in combination with the four criteria when determining site significance. Sites were placed into five site BSRs as used by TNC and the Network of Natural Heritage Programs, from BSR-1 (outstanding significance) to BSR-5 (of general biodiversity interest). (These ranks were discussed in Sect. 3.)

For purposes of the present report, eight categories of factors, categories A through H, were established for evaluation: (A) size of area, including relationship to large undeveloped tracts; (B) number of status taxa present; (C) number of Endangered and Threatened taxa present on a site; (D) the rarity of the Endangered and Threatened taxa on the Reservation; (E) the general community and landscape diversity on a site; (F) the overall integrity and quality of the area, its communities, and species populations, including age of forest; (G) current disturbances, threat of future disturbances, and threat manageability; and (H) other significant features or factors, including special uses and management considerations. These categories are explained in detail in the following sections. Each category consists of a 5-point ranking scale from 0 to 4. A composite score is calculated by summing the values for each of the eight categories. Composite values can range from 0 to 32. (Category B allows for an additional point, thus giving a maximum possible score of 33.) 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 be reasonably defended and maintained as a natural area in the presently undeveloped condition. Obviously, any given natural area would more likely represent a combination of those values and not be ideal in all respects.

This approach is presented as a beginning to the development of an easily managed evaluation system for determining the value of natural areas on the ORR. The relative weights attached to these categories and the ranking criteria can be debated and adjusted to satisfy concerns that may arise. Categories can be combined or additional categories can be developed. As more information is gathered about the biodiversity on the ORR, data are refined, and interpretations of status and significance of elements and assessment categories continue to change, periodic revisions of the input data should occur to provide updated evaluations of all areas in relationship to each other. The format and nature of the category ranking system also permit easy adaptation to a spreadsheet database that can be easily updated and revised from time to time.

4.1 SIZE OF NATURAL AREAS (A)

The size of a natural area is essentially the most fundamental criterion that one might use to evaluate its value. It is well known that larger areas can sustain more viable populations, permit

natural processes to function, are less susceptible to outside influences, and are more resilient to disturbances. Areas defined as natural areas should also include sufficient buffer zones to protect the core areas being preserved for their biodiversity value. Much of the current discussion relating to adequate size of bioreserves is centered on the requirement of core interior areas that many species and species assemblages need for self-maintenance.

The criteria applied in the determination of interior forest are not absolute. It is generally recognized that edge effects are important in determining the presence and distribution of species, but the significance of width of the edge depends on the particular species. For example, for many forest interior-dwelling bird species, an edge habitat as wide as 200 m may be necessary to eliminate negative biotic effects of competitors and nest predators and define an interior forest. For certain plant species, on the other hand, microclimatic edge effects might be reduced or eliminated at a distance only 25 m or less from the boundary. Topography can be a mitigating factor, and the type of boundary is also an important consideration (e.g., a boundary at the edge of a field or a clearcut is very different from a boundary with a second-growth forest). An “interior” area suitable for any particular species is that area free of negative microclimatic or biotic edge effects.

Significant edge effects may be present for only a few meters for vegetation and some small animals but up to thousands of meters for some birds and large mammals. A good recent review of habitat fragmentation issues and edge effects can be found in Lindenmayer and Fischer (2006). For purposes of the present study, the standards reported in Ministry of Forests (1995) were used. Microclimatic edge influences are considered to be effectively eliminated over a distance of 100 to 200 m from the forest edge. An edge of 200 m is the recommended minimum width for providing forest interior. An idealized circular patch should be a minimum of 600 m in diameter to buffer an interior core and provide a recommended minimum core size of 200 m. Obviously all patches are not circular in dimensional outline; therefore, in practice, considerable judgment and latitude must be exercised in applying the minimum criteria. The elimination of certain biotic edge effects may require the application of even larger buffer widths.

Previous studies (SAIC 2002, Parr and Hughes 2006) on ORR determined the presence of interior forest by applying a 200 m buffer zone from all boundaries with roads, transmission lines, and other features. GIS maps have been produced illustrating the location of these interior areas (Parr and Hughes 2006). The buffer zone as determined in these studies is rigidly applied and does not allow for evaluation of site-specific circumstances. Fieldwork for the present study revealed that not all the boundaries used for the GIS mapping may be effective boundaries producing significant edge effects. For example, many unpaved forest roads on the ORR are so narrow that the forest canopy over these roads is intact, and the vegetation structure and composition is not significantly altered except for the footprint of the road. It would appear that many animal species should not be experiencing negative edge effects from these roads. In some cases the roads may be providing disturbance corridors for the introduction and establishment of nonnative invasive plant species, but the effects on animal species may be minimal or nonexistent. It is recommended that the boundaries for delineating interior forests be reevaluated; the rigid application of a 200 m buffer without consideration of the nature of the boundary is an overly conservative method that is probably not resulting in a realistic view of the extent of interior forests on the ORR.

Parr and Hughes (2006) considered that a minimum of 50 contiguous acres of forest habitat was necessary to sustain many deep forest-dwelling plant and animal species. In the present study the recommended minimum sizes for recognition of an interior forest are 200-m-wide buffer zones surrounding a core width of 200 m; this requires a 28 ha (70 acre) patch and produces a 3.2 ha (7.8 acre) core. For purposes of evaluating the size of tracts with respect to the presence of interior forest, a set of ranking criteria was developed to reflect their value (Table 2); the acreages are given in Table 1, and the site rankings are given in a final table presented in Sect. 6. A site ranked as 1.5 has a minimum core size of 7.8 acres, the recommended minimum, but the buffer zone is at the narrow end of the required minimum. A site ranked as 2.5 has the same recommended minimum core size, but

also has the recommended minimum buffer-zone width. Of course, because this method assumes idealistic patches that are circular in dimension, it should be made clear that it gives only a relative indication of the potential for the amount of true interior forest. A more elaborate site-specific evaluation that includes topography, nature of the boundary, and shape of the natural area would give the best estimate of true interior forest.

Table 2. Ranking scale for the evaluation of tract size for natural area value^a

Rank	Acreage	Buffer zone width	Core size
0	< 5.0	100 m	None
0.5	5.1–17.0	100 m	< 3.2 ha (7.8 acres)
1.0	17.1–31.0	100 m	< 3.2 ha (7.8 acres)
1.5	31.1–48.0	100 m	3.2 – 7.1 ha (7.8 – 17.5 acres)
2.0	48.1–70.0	150 m	3.2 – 7.1 ha (7.8 – 17.5 acres)
2.5	70.1–95.0	200 m	3.2 – 7.1 ha (7.8 – 17.5 acres)
3.0	95.1–194.0	200 m	7.1 – 28.3 ha (17.5 – 70.0 acres)
3.5	194.1–300.0	200 m	28.3 – 55.8 ha (70.0 – 138 acres)
4.0	> 300.0	200 m	> 55.8 ha (138 acres)

^a Recommended minimum core size for functional interior forest is 200 m wide = 3.2 ha (7.8 acres). Rank is determined by site acreage. Ranks from 0–2.0 are not interior forest. Ranks from 2.5–4.0 are considered to be interior forest.

The model presented above gives only a general indication of the presence of interior forest or the ability of the site to sustain natural processes without intrusion or disturbance. Another measure was used to help further refine the determination. For purposes of evaluating Research Park natural areas for values relating to their spatial relationship to interior forests and the long-term sustainability of natural ecological and biological processes, a determination of the relationships of sites to subjectively defined large, undeveloped tracts was made using the Oak Ridge Area topographic map (TVA 1987) and a Color Balanced Mosaic of Multiple Orthoimages prepared by the Geographic Information Science and Technology Group at ORNL (1993). These tracts were usually forested. For purposes of this report, open woodlands (such as red cedar barrens) were considered as forested. (The determination was not based on the interior forest boundaries shown on recent GIS maps of the ORR.) Sites were ranked from 0 to 4 on a 5-point scale, as shown in Table 3.

Table 3. Ranking criteria for relationship of sites to large, undeveloped tracts

Rank	Criteria
0	Site is nonforested, or small and isolated, or not proximate to large forest tracts or it contains highly fragmented forest.
1	Site is adjacent to the buffer zone of a large, undeveloped area.
2	Site is within the buffer zone of an interior forest.
3	Site is on the margin of an interior forest.
4	Site is either embedded within or includes bona fide interior forest.

The site rankings for this evaluation are presented in Table 1. This is a preliminary evaluation, based mostly on limited map sources and published information. Additional analysis with more complete and definitive information would produce a better assessment of this relationship. The rank value for relationship to large tracts was used as a modifier of the acreage rank value (e.g., a small natural area embedded within a large interior forest tract is ranked higher than a small isolated tract

set well apart from a forested area). The second and third columns in Table 1 were considered together in producing a final size-of-area rank presented in Sect. 6. If the relationship rank was 2, the size-of-area rank was retained. Area rank was increased by 0.5 when the relationship value was 3 and by 1 when the relationship value was 4, up to the maximum of 4. Area rank was decreased by 0.5 when the relationship value was 1 and by 1 when the relationship value was 0, down to no less than the minimum value of 0.

4.2 RARE SPECIES ON THE ORR (B, C, AND D)

For purposes of this report, it was decided to adopt the status criteria categories followed by Natural Heritage Programs and the U.S. Fish and Wildlife Service to evaluate the significance of species and communities that occur on the ORR. In Tennessee the Division of Natural Areas is the unit charged with developing listing criteria, evaluating species and natural community occurrences, and protecting biological diversity. Detailed descriptions of status criteria and definitions are available online and in publications by these agencies, and they are not repeated here. The rare species currently listed by the Tennessee Division of Natural Areas (2008) for the ORR are presented in Table 4. The following descriptions of federal and state ranks and status codes for taxa are those used in this report. (It is noted here that there are significant differences between the two lists—from the Division of Natural Areas database of EOs and the on-site records maintained by ORR personnel—of the animals that are reported or known to occur on the ORR. These differences should be resolved.)

Table 4. Rare plants and animals documented or reported on the Oak Ridge Reservation^a

Endangered (E) and Threatened (T) taxa [Status in Tennessee, Federal Status, Global Rank, State Rank]		
<u>Vascular plants</u>		
<i>Agalinis auriculata</i> (Earleaved False-foxglove)	[E, -, G3, S2]	Site no longer part of ORR
<i>Cimicifuga rubifolia</i> (Appalachian Bugbane)	[T, -, G3, S3]	
<i>Delphinium exaltatum</i> (Tall Larkspur)	[E, -, G3, S2]	May be extirpated on ORR
<i>Diervilla lonicera</i> (Northern Bush-honeysuckle)	[T, -, G5, S2]	
<i>Fothergilla major</i> (Mountain Witch-alder)	[T, -, G3, S2]	
<i>Juglans cinerea</i> (Butternut)	[T, -, G4, S3]	
<i>Liatris cylindracea</i> (Slender Blazing-star)	[T, -, G5, S2]	Site no longer part of ORR
<i>Lilium canadense</i> (Canada Lily)	[T, -, G5, S3]	
<i>Lilium michiganense</i> (Michigan Lily)	[T, -, G5, S3]	Extirpated, under impoundment
<i>Liparis loeselii</i> (Fen Orchis)	[T, -, G5, S1]	
<i>Platanthera flava</i> var. <i>herbiola</i> (Tubercled Rein-orchid)	[T, -, G4T4Q, S2]	Site no longer part of ORR
<i>Solidago ptarmicoides</i> (Prairie Goldenrod)	[E, -, G5, S1S2]	
<i>Spiranthes lucida</i> (Spiranthes Ladies'-tresses)	[T, -, G5, S1S2]	

Table 4 (continued)

<u>Animals</u>	
<i>Myotis grisescens</i> (Gray Bat)	[E, LE, G3, S2]
<i>Pituophis melanoleucus melanoleucus</i> (Northern Pine Snake) ^b	[T, -, G4T4, S3]
<i>Erimonax monachus</i> (Spotfin Chub) ^c	[T, LT, G2, S2]
<i>Dromus dromas</i> (Dromedary Pearlmussel)	[E, LE-XN, G1, S1]
<i>Fusconaia cuneolus</i> (Fine-rayed Pigtoe)	[E, LE, G1, S1]
<i>Fusconaia edgariana</i> (Shiny Pigtoe)	[E, LE-XN, G1, S1]
<i>Lampsilis abrupta</i> (Pink Mucket)	[E, LE, G2, S2]
<i>Plethobasus cooperianus</i> (Orange-foot Pimpleback)	[E, LE-XN, G1, S1]
<i>Quadrula cylindrica strigillata</i> (Rough Rabbitsfoot Pearlmussel)	[E, LE, G3T2, S2]
Other taxa, listed as Special Concern (S) for plants or Deemed in Need of Management (D) for animals and S1, S2, or S3 in Tennessee	
<u>Vascular plants</u>	
<i>Aureolaria patula</i> (Spreading Fox-glove)	[G3, S3]
<i>Bulboschoenus fluviatilis</i> (River Bulrush)	[G5, S1]
<i>Carex gravida</i> (Heavy Sedge)	[G5, S1]
<i>Carex oxylepis</i> var. <i>pubescens</i> (Hairy Sharp-scaled Sedge)	[G5?T3, S1]
<i>Cypripedium acaule</i> (Pink Lady's-slipper)	[CE, G5, S4]
<i>Draba ramosissima</i> (Branching Whitlow-grass)	[G4, S2]
<i>Elodea nuttallii</i> (Nuttall's Waterweed)	[G5, S2]
<i>Helianthus occidentalis</i> (Naked-stem Sunflower)	[G5, S2]
<i>Hydrastis canadensis</i> (Goldenseal)	[CE, G4, S3]
<i>Juncus brachycephalus</i> (Small-headed Rush)	[G5, S2]
<i>Lonicera dioica</i> (Mountain Honeysuckle)	[G5, S2]
<i>Panax quinquefolius</i> (American Ginseng)	[CE, G3G4, S3S4]
<i>Pseudognaphalium helleri</i> (Heller's Catfoot)	[G4G5, S2]
<i>Ruellia purshiana</i> (Pursh's Wild-petunia)	[G3, S1S2]
<i>Thuja occidentalis</i> (Northern White Cedar)	[G5, S3]
<i>Viola tripartita</i> var. <i>tripartita</i> (Three-parted Violet)	[G5T3?, S2S3]
<u>Animals</u>	
<i>Sorex dispar</i> (Long-tailed Shrew) ^b	[G4, S2]
<i>Accipiter striatus</i> (Sharp-shinned Hawk)	[G5, S3B]
<i>Aimophila aestivalis</i> (Bachman's Sparrow)	[G3, S2]
<i>Dendroica cerulea</i> (Cerulean Warbler)	[G4, S3B]
<i>Haliaeetus leucocephalus</i> (Bald Eagle)	[G5, S3]
<i>Limnothlypis swainsonii</i> (Swainson's Warbler)	[G4, S3]
<i>Tyto alba</i> (Common Barn-owl)	[G5, S3]

Noted because of CE designation

Table 4 (continued)

<i>Ophisaurus attenuatus longicaudus</i> (Eastern Slender Glass Lizard)	[G5T5, S3]
<i>Aneides aeneus</i> (Green Salamander)	[G3G4, S3S4]
<i>Cryptobranchus alleganiensis</i> (Hellbender)	[G3G4, S3]
<i>Hemidactylium scutatum</i> (Four-toed Salamander)	[G5, S3]
<i>Carpionodes velifer</i> (Highfin Carpsucker)	[G4G5, S2S3]
<i>Cycleptus elongatus</i> (Blue Sucker)	[G3G4, S2]
<i>Hemitremia flammea</i> (Flame Chub)	[G3, S3]
<i>Phoxinus tennesseensis</i> (Tennessee Dace)	[G3, S3]
<i>Cumberlandia monodonta</i> (Spectaclecase)	[G3, S2S3]
<i>Io fluviialis</i> (Spiny Riversnail)	[G2, S2]
<i>Pleurobema rubrum</i> (Pyramid Pigtoe)	[G2, S1S2]

^a Status and Global and State Ranks as given in the most recent Tennessee Division of Natural Areas online documents (as of September 2008). Status definitions are available in Natural Heritage Program documents.

^b Included in Tennessee Division of Natural Areas database, but not present in Reservation records.

^c Included in Reservation records, but not in Tennessee Division of Natural Areas database.

Federal Status

- Listed Endangered (LE) – In danger of extinction throughout all or a significant portion of its range
- Listed Threatened (LT) – Likely to become an Endangered species in the foreseeable future
- Nonessential experimental population (XN) – Introduced or reintroduced in an area from which it has been extirpated

State Status

- Endangered (E) – Any species or subspecies whose prospects of survival or recruitment within the state are in jeopardy or are likely to become so within the foreseeable future
- Threatened (T) – Any species or subspecies that is likely to become an Endangered species within the foreseeable future
- Threatened-Proposed Special Concern (T-PS) – Species currently listed as Threatened, but proposed to be downlisted to Special Concern
- Special Concern (S) – Any species or subspecies of plant that is uncommon in Tennessee or has unique or highly specific habitat requirements or scientific value and requires careful monitoring
- Deemed in Need of Management (D) – Any species or subspecies of nongame wildlife deemed to require investigation to determine management measures necessary for continued successful survival
- Commercially Exploited (CE) – Plants of conservation concern because large numbers are being taken from the wild to meet market demand

Global Rank

- G1 – Extremely rare and critically imperiled in the world with five or fewer occurrences, or very few remaining individuals, or because of some special condition in which the species is particularly vulnerable to extinction
- G2 – Very rare and imperiled within the world, six to twenty occurrences, or few remaining individuals, or because of some factor(s) making it vulnerable to extinction

- G3 – Rare and uncommon in its range or found locally in a restricted range, generally from 21 to 100 occurrences
- G4 – Widespread, abundant, and apparently secure globally, but with cause for long-term concern
- G5 – Demonstrably widespread and secure globally
- -T# – Subspecific taxon rank
- -Q – Questionable taxonomy
- G? – Unranked at this time or rank uncertain

State Rank

- S1 – Critically imperiled. Extremely rare and critically imperiled in the state with five or fewer occurrences, or very few remaining individuals, or because of some special condition where the species is particularly vulnerable to extinction within the state
- S2 – Imperiled. Very rare and imperiled within the state, six to twenty occurrences, or few remaining individuals, or because of some factor(s) making it very vulnerable to extinction
- S3 – Vulnerable. Rare and uncommon in the state, from 21–100 occurrences
- S4 – Apparently secure. Widespread, abundant, and apparently secure within the state, but with cause for long-term concern
- S5 – Demonstrably widespread and secure in the state
- S? – Unranked at this time or rank uncertain

4.3 EVALUATION OF SITES FOR PRESENCE OF STATUS TAXA (B)

A ranking system was devised to evaluate sites for the presence of status taxa (i.e., those that have been listed by the Tennessee Division of Natural Areas as E, T, S, or D. The Special Concern plant taxa (S) and those animal taxa listed as D are included only if they have been assigned a state rank of S1, S2, or S3 or listed as CE. Twenty-nine plants and 27 animals are included in this category of status taxa. A subjective adjustment was made for size of populations and number of EOs by increasing the evaluation rank one increment (+1) when populations were particularly large, healthy, or numerous. The category ranking criteria are given in Table 5.

Table 5. Ranking scale for evaluation of sites for the presence of status taxa

Rank	Number of status taxa present	Population adjustment rank
0	None	0
1	1	2
2	2	3
3	3	4
4	4 or more	5

4.4 EVALUATION OF SITES FOR PRESENCE OF ENDANGERED AND THREATENED SPECIES (C)

The presence of taxa that are listed as Endangered or Threatened in Tennessee is defined as a separate factor, even though these taxa have already been considered in category B (presence of status taxa). This category was created and defined to emphasize the special habitats that harbor Endangered and Threatened species. The duplicative weighting is justified because of the higher status of these taxa, which are in greater jeopardy than taxa listed as S or D. Table 6 describes the ranking criteria for this factor. Presently there are no Natural Areas on ORR that harbor more than two Endangered or Threatened taxa. The category can easily be redefined to reflect additional discoveries of such taxa or

to change the weighting. Currently only eight plants and three animals are listed as Endangered or Threatened in Tennessee and are known or thought to occur on specific Natural Areas that are within the current ORR boundaries. Some of the records in the Division of Natural Areas EOs database are not currently reported in the natural area documentation for the Reservation, and the mussels are not reported for the terrestrial Natural Areas that are evaluated in this study.

Table 6. Ranking scale for evaluation of sites for the presence of Endangered (E) and Threatened (T) species

Rank	Criteria
0	No E and T taxa present
1	One E or T taxon present
2	Two E and T taxa present
3	Three E and T taxa present
4	Four or more E and T taxa present

4.5 EVALUATION OF SITES FOR RARITY OF ENDANGERED AND THREATENED SPECIES ON THE ORR (D)

Of the taxa listed as Endangered or Threatened in Tennessee that have been reported as occurring on the ORR, only a small number exist as only one or a few EOs. The others have been documented as occurring on several sites or with several EOs on a given site. The rarity of listed taxa on the Reservation is an important consideration when evaluating sites for their natural area value. Sites containing taxa that occur in only a few areas of the ORR should be weighted more heavily than sites containing taxa that are more widely distributed on the Reservation. Table 7 presents information that describes the relative rarity of species on the ORR. The data were derived from Pounds et al. (2008); GIS maps available in the ORNL Natural Resources Manager's office; and internal documents and personal communications from resource personnel. There were some inconsistencies in the data, and the number of EOs needs to be confirmed. *Liparis loeselii* and *Spiranthes lucida* are examples of extremely rare taxa on the ORR, and the sites harboring them should be accorded a higher value because of their presence. Taxa such as *Cimicifuga rubifolia*, *Lilium canadense*, and *Platanthera flava* var. *herbiola* are relatively common on the ORR, and the sites on which they occur should be considered less unusual and important and carry a lower rating value.

Table 7. Occurrences on the Oak Ridge Reservation of taxa listed as Endangered or Threatened by the Tennessee Division of Natural Areas (2008)^a

<u>Plants</u>
<i>Cimicifuga rubifolia</i> – NA11:1, NA14:1, NA15:1, NA19:1, NA23:1
<i>Delphinium exaltatum</i> – NA7:1, NA8:2, NA35:1, NA36:1, NA43:2
<i>Diervilla lonicera</i> – NA11:1, NA14:1
<i>Fothergilla major</i> – NA12:2
<i>Lilium canadense</i> – NA2:2, NA6:1, NA8:1, NA13:1, NA22:3, NA25:1, NA26:1, NA29:1, NA31:2, NA34:1, NA35:1, NA36:2, NA42:1, NA50:1, NA56:2
<i>Liparis loeselii</i> – NA24:1
<i>Platanthera flava</i> var. <i>herbiola</i> – NA4:1, NA13:4, NA28:1, NA48:1, NA50:2, NA52:1
<i>Spiranthes lucida</i> – NA33:1
<u>Animals</u>
<i>Erimonax monachus</i> – NA47:1
<i>Myotis grisescens</i> – RA11:1
<i>Pituophis melanoleucus melanoleucus</i> – CMA3:1

^a Taxa are presented for Natural Areas (NAs), Reference Areas (RAs), and Conservation Management Areas (CMAs) followed by number of occurrences in each area.

With the recent down-listing of two species, *Aureolaria patula* from T-PS to S and *Cypripedium acaule* from E-CE to S-CE, several of the currently identified special areas no longer contain status taxa at the Endangered and Threatened level. These areas are NA17, NA20, NA30, NA37, NA45, NA46, NA47, RA6, RA9, RA15, and RA29. Because the past practice was to designate areas as NAs primarily because they contained listed species, the original justification for retaining the NA designation for the above-mentioned areas may no longer exist. These sites were retained for this analysis, however, because they are currently officially recognized NAs.

A ranking scale was devised to reflect the relative importance of sites for protecting Endangered and Threatened species. The scale considers that sites containing species that are relatively common on the ORR should receive a lower rating than sites containing the only (or one of the few) EOs for a given taxon on the Reservation. Table 8 presents the ranking scale for evaluating the rarity of species.

Table 8. Ranking criteria for assessing sites according to the number of Endangered or Threatened taxa present with regard to their rarity on the Oak Ridge Reservation

Rank	Number of Endangered or Threatened taxa present	Population adjustment
0	None	Not applicable
0	1	On 11 or more sites
1	1	On 7 to 10 sites
1.5	1	On 4 to 6 sites
2	1	On 1 to 3 sites
2.5	2	Both on 7 or more sites
3	2	One on 7 or more sites; one on 6 or fewer sites
3.5	2	Both on 6 or fewer sites
4	3 or more	All on 7 or more sites

4.6 COMMUNITY AND LANDSCAPE DIVERSITY (E)

The ORR is a large area containing high species and community diversity, much of which is related to the diverse geology in the Valley and Ridge Province in the region. Many areas are known to have high species diversity, even though they may not contain particularly rare species. Richness, in this sense, is a factor that merits consideration. Other communities are not especially diverse in terms of the numbers and kinds of species present, but the particular assemblage is rare or unique. Some communities have been identified, and a number of rare communities have been noted on the Reservation by TNC (1995) and others, but it does not appear that a comprehensive survey of ORR lands for the purpose of describing and classifying community diversity has ever been undertaken. Forest management information is available on 35 forest compartments (latest inventory in 1981), including some compositional and age data, but detailed ecological analyses are lacking. Most of the Reservation has not been studied with regard to overall vegetation composition, community type, and quality. This is an area requiring investigation to gain the understanding necessary for full evaluation of sites and areas for their natural area significance. Though only minimal community data are available, the limited information is nonetheless used here to contribute to an evaluation of natural areas on the ORR. The summary natural area descriptions in the appendix contain some descriptive information that has been gathered from available reports, especially the TNC (1995) report and the draft NAs and RAs report by Pounds et al. (2008). The fieldwork conducted for the present study also provided insights into the nature of community diversity on the ORR.

TNC (1995) listed many natural communities occurring on the ORR; communities were presented either as *significant* community types or as other *high-quality* types. The 1995 report specifically mentioned that additional investigation was needed on the ORR to identify and classify

communities and determine their quality, boundaries, and connectivity. That study mapped Preliminary Conservation Sites and mentioned an additional 44 sites containing intact hardwood areas larger than 100 acres.

Several areas on the ORR contain rare communities that have been noted by TNC and cause them to be considered as significant natural communities. These communities and the areas in which they are found (if they could be determined) are presented in Table 9; most of these are also referenced in natural area descriptions in Pounds et al. (2008). Most of the listed communities have S1, S2, or S3 rankings. Some communities with high state rankings mentioned in the TNC report are not connected with particular areas on the ORR. Many of the communities listed in the TNC report were not cited with a ranking, or the rankings have not yet been determined, and they are not mentioned here.

Though TNC (1995) lists the communities in Table 9 as occurring on ORR lands, it is not possible at this time to readily associate all community occurrences with the recognized natural areas. Many of them are cited in Pounds et al. (2008), but others are not.

In the sense presented here, this category also includes landscape diversity and a consideration of overall species diversity on a site. Landscape diversity is defined as all those other features, particularly geological and topographical, that often contribute to the development of specific communities. Thus, features such as caves, springs, sinkholes, outcrops, cliffs, and similar features are also considered for their uniqueness and significance. Overall species diversity covers those cases in which sites may be especially rich and diverse.

The nomenclature used to describe natural communities in most of the documentation available for the ORR is somewhat outdated. However, Pounds et al. (2008) mention known and potential significant communities apparently following the National Vegetation Classification System (USGS 2009, available at <http://biology.usgs.gov/npsveg/nvcs.html>), but only minimal, often speculative, association is made with specific areas on the Reservation. A major effort should be undertaken to inventory all natural areas on the ORR for the presence of significant natural communities, their boundaries, and their integrity. These should be classified using standardized Natural Heritage methodologies for ecological communities as currently reported in NatureServe Explorer (available at <http://www.natureserve.org>).

Table 9. Rare natural communities on the Oak Ridge Reservation and the areas in which they are located, if known^a

*Boggy Forested Wetland (BFW) [G3?S3?] — NA4, NA42
*Floodplain Pool (FP) [G2?S2?] —
Hemlock-White Oak-White Pine Limestone Cliff Forest (HWOWPLCF) [G3?,S?] — NA20
*Limestone Barren (annual grass dominated) (LBA) [G2] — NA7, NA8, NA35, RA8
*Limestone Barren (perennial grass dominated) (LBP) [G2] — NA7
*Limestone Cliff (LC) [G3?S3?] — NA11
*Limestone Sinkhole (LS) [G1] — NA21, NA50
*Northern White-Cedar Woodland (NWCW) [G1, S1] — NA14
*Oak-Hickory-Ash Limestone Woodland (OHALW) [G3?,S3?] — NA7, NA8, NA39, NA51, NA53, NA56
*Ridge and Valley Calcareous Mixed Mesophytic Forest (RVCMMF) [G3?,S3?] — NA11, NA15, NA19, NA32, NA39
Ridge and Valley Swamp Forest (RAVSF) [G2G3,S2] — NA2, NA4, NA13, NA24, NA25, NA47
Ridge and Valley Wet Meadow Shrub-Herb Complex (RAVWMSHC) [G2?G3?,S?] — NA29, NA48
Rocky Limestone Woodland (RLW) [G3,S3] — RA29
*Streamside Seepage Swamp (SSS) [G2?,S2?] — NA4, NA13, NA28
*Sweetflag Pond (SP) [G?,S?] — NA24, NA25, RA19

^a Significant natural communities specifically emphasized by The Nature Conservancy (TNC) (1995) are denoted with *. All others are mentioned as high-quality community types by TNC. Status taken from TNC (1995) or NatureServe Explorer (2008). Numerous additional occurrences of natural communities are cited in the TNC report. Only those that appear to be ranked S3 or higher are included here.

The status of the Sweetflag Pond community is currently being reviewed to determine whether it should be retained as a rare community type. The sweetflag that is present on the ORR appears to be an introduced sterile triploid rather than the native sweetflag that is a fertile diploid. The latter taxon has generally not been recognized in floras and has a poorly known distribution. In the present report, the community is still recognized as a rare type, pending resolution of its uniqueness. It is present in three areas.

Sites may be ranked for the presence of rare communities and community diversity in general. The determination is made from interpretations of the data and descriptions presented in Table 1, the summary natural area descriptions (see the appendix), and also from the fieldwork. The ranking scale is as shown in Table 10. Application of these criteria involves some subjective assessment, but if the criteria guidelines are consistently followed, the relative ranking across a number of sites should be legitimate.

In essence community significance is considered at three levels: local, regional, and state/national, which reflect whether they are common, uncommon, or rare. Other factors are also considered, such as whether sites are especially biodiverse or contain a variety of landscape elements. At present the values accorded each site for this criterion are extremely subjectively drawn. A concerted effort must be undertaken to evaluate sites for overall diversity. A goal should be to identify and delimit vegetative communities, whether rare or not.

Table 10. Ranking criteria for community and landscape diversity

Rank	Criteria
0	Site includes one common community type representative of local or regional natural diversity; site physiognomy is uniform; overall species diversity is usually low.
1	Site includes two or more common communities representative of local or regional natural diversity; site physiognomy is less uniform; species diversity is higher.
2	Site includes three or more common communities representative of regional natural diversity; <u>or</u> site includes one or more uncommon communities for the region; <u>or</u> site includes some combination of common and uncommon communities for the region; <u>and/or</u> site contains several physiognomic features, and overall species diversity is high.
3	Site includes at least one rare regional community type of state or national significance and may also include other communities; site physiognomy is quite varied; species diversity is higher.
4	Two or more rare communities of state or national significance are present and other common communities may also be present; <u>and/or</u> site exhibits very high overall species diversity and a large variety of habitats and landscape features.

4.7 QUALITY AND INTEGRITY (F)

This category essentially describes the age and maturity of an area; how well a site conforms to accepted concepts of community types; the degree to which the essential nature of the site is impaired or impacted; the evidence of current intrusive activities and the presence of invasive exotic species; and recovery from past disturbances such as homesteads, historical logging activity, old roads, and similar things. For the present report, three sources of information were used to determine the rank value given to a site for quality and integrity. The first source was a subjective opinion derived from the limited observational information available in various reports; this information is synthesized in the appendix. The second source was an opinion derived from site visits during the course of the fieldwork for this study; however, not all sites were visited or visited thoroughly, so this information is also limited in scope. The third source was based on evaluation of aerial photographs taken in 1935. (J. W. Johnston, a consultant, assembled a mosaic of these old aerial photos for most of the Reservation.) The photography was thoroughly examined to determine whether sites contained apparently intact old forests in 1935. By comparison with the Color Balanced Mosaic of Multiple

Orthoimages prepared by the Geographic Information Science and Technology Group at ORNL (1993), it seemed possible to conclude that if forests were still present on a site at the later date, they were at least old second-growth forests, if not older. Table 1 presents the conclusions regarding the presence of intact forest in 1935 (yes, no, intermediate, ?). Sites labeled “intermediate” appeared to be a mix of open and forested lands in 1935. Sites labeled with a “?” were not represented in the photography, so a subjective judgment was made based on the general appearance of the landscape in the region where the site was located.

A subjective assessment of site quality and integrity was attempted for each of the areas under study for this report. A value was assigned to each site by collectively evaluating the three sources of information described above. The assigned values were reevaluated in light of the opinions and information offered by ORR personnel during their review of the draft of the present study. The ranking scale is presented in Table 11. In general, higher rank values are associated with more mature forests. This scale and assessment criteria should be revised as more information becomes available about ORR community diversity.

Table 11. Ranking criteria for site quality and integrity

Rank	Criteria
0	Biotic communities and landscape are in generally poor condition; recent disturbance activity is strongly evident.
1	Biotic communities and landscape are in generally fair condition; disturbance activity is less evident.
2	Most biotic communities and landscape are in generally good condition; some communities may be of higher or lower integrity; site is recovering from past disturbances.
3	Most biotic communities and landscape are in generally very good condition; some communities may be of higher or lower integrity.
4	Most biotic communities and landscape are in generally excellent and prime condition; site has high integrity; there is little or no evidence of disturbances or site has essentially recovered from past disturbances.

This category is also one that requires additional research and refinement to adequately describe the natural areas. Only limited information is available at this time. The data are not consistent or representative of all areas; mostly what is available are qualitative observational data in various reports, not quantitative data. At least one source for this kind of information does exist for the entire Reservation (i.e., the forest management stand composition data mentioned previously). These data could provide some insight into the ages of stands, as well as their composition. The best way to gather the information about site quality and integrity, however, is to conduct a thorough examination of each site using a consistent methodology and with consideration of the kinds of communities present. A standard quantitative ecological methodology should first be applied to determine the community age and composition. Such studies should be undertaken.

4.8 DISTURBANCE, DEFENSIBILITY, MANAGEABILITY (G)

This is a subjective judgment of the effects of current and potential anthropogenic disturbances, development, and other activities on a site (i.e., how well a site is isolated or insulated from these factors). It is assumed that no planned direct impacts from DOE actions are known to exist. Certain kinds of these activities adjacent to an area may affect the natural value of a site from an aesthetic or even a functional aspect.

Given that there will always be competing uses for specific lands and that continuing structural, land, and utility development is expected at a DOE facility, it seems reasonable to expect that it will sometimes be necessary to compromise or sacrifice certain natural areas and values in specific cases.

If disturbance and development activities cannot be reasonably managed through mitigation, minimization, or prevention, it will likely be impossible to prevent impacts that could harm or even destroy the natural values of a site. Sites that are too difficult to protect from human activity and future development are not defensible if their natural value is low. Sites that rank more highly for their natural value and that appear to be located in landscape situations that are defensible because other alternatives appear to be available closer to developed areas are the sites that should receive the most protection and the most vigorous defensive effort. The latter sites should be valued more highly in a ranking system. This issue of managing threats will always involve seeking a balance between the natural values and the need for development.

For purposes of this report, a subjective evaluation of this category of factors was derived from several sources: inspection of the 1987 Tennessee Valley Authority (TVA) topographic map of the Oak Ridge area (TVA 1987), inspection of the Orthoimage Mosaic map referenced above, direct observation during the fieldwork, and opinions provided by personnel having active and direct experience with Reservation lands. This evaluation is reported under the column labeled “disturbance impacts” in Table 1. In a final table presented in Sect. 6, this determination of the proximity to disturbances, the potential for future disturbances, and threat manageability is presented as a rank value. The ranking scale is presented in Table 12. Though the scale ranges from 0 to 4, only three levels are used in the current application. This category requires additional development to better define the criteria and refine the ranking scale.

Table 12. Ranking criteria^a for disturbance, defensibility, and manageability

Rank	Criteria
0	Site is currently subject to high levels of disturbance.
2	Site is currently or potentially subject to moderate levels of disturbance and impact.
4	Site is currently subject to no or very low levels of disturbance; threat level is low.

^a The current evaluation does not attempt to discriminate five levels.

4.9 OTHER SIGNIFICANT FEATURES AND FACTORS (H)

There are other significant features and factors that should be considered in the determination of natural area importance. This more or less catchall category is devised to allow attention to things that are not easily covered in the other categories. They might include such things as the presence of a number of unusual (but unlisted) species, the presence of unusually significant or extensive geological or landscape features, areas exhibiting exceptional aesthetic or scenic value, special uses such as important research or monitoring sites, special management areas such as nongame habitat, important wetland habitats, important demonstration areas, and other similar items. The presence of culturally and historically significant sites was not considered in the natural areas assessment (though mentioned in the natural areas descriptions in the appendix). The available information was used to make this evaluation. As for several of the other categories, this category can be refined with more specific definitions of the rank values. The ranking criteria are presented in Table 13.

Table 13. Ranking criteria for other significant features and factors

Rank	Criteria
0	No value
1	Low value
2	Moderate value
3	High value
4	Highest value

5. SUMMARY DESCRIPTIONS OF NATURAL AREAS

Brief summary descriptions of ORR natural areas were constructed and are presented in the appendix. The information was drawn from Pounds et al. (2008), TNC (1995), TDEC (2001), Tennessee Division of Natural Areas database information, analysis and cross-referencing with GIS maps available in the Natural Resources Manager's office, evaluation of other available data, and fieldwork. Status taxa information was updated to reflect the September 2008 listings by the Tennessee Natural Areas Division. Significant descriptive information was not available for all sites. More elaborate descriptions, including location information, are available for many of these areas in TDEC (2001) and Pounds et al. (2008).

The name and number of the NAs, RAs and CMAs are given. When two names are given, the first name is the name currently used in Pounds et al. (2008), and the second is the one used in TDEC (2001). These are followed by some parenthetical information in a format that includes acreage (a), number of status species (ss), names of taxa that are Endangered or Threatened in Tennessee and the number of occurrences on the site, abbreviations of rare natural communities (see Table 9), and a notation regarding proposed protection by TDEC in 2001 under the Natural Areas Preservation Act ("PPO" for the areas originally registered in the 1985 agreement and "PP" for new areas proposed in 2001).

The relationships to the Preliminary Conservation Sites ranked by TNC (1995) and the BSRs are also given, if they could be determined. The TNC maps of Preliminary Conservation Sites and their BSR were compared to the Resources Manager's GIS maps to make this determination. Virtually all currently recognized NAs and RAs have Preliminary Conservation Site counterparts, but many of the boundaries are dissimilar. There are some areas that were ranked by TNC that are not included in currently recognized NAs or RAs.

There are some additional EOs of listed taxa on ORR lands that are not in currently recognized NAs or RAs. However, it appears that most of those elements with at least S3 state ranks are in recognized areas.

Because there are differences in the site boundaries recognized in the various reports, it may be that some of the data presented in the summaries do not fit the currently recognized NA and RA boundaries. These differences and potential discrepancies in data, if they exist, could not be resolved in this study. In general, the currently recognized natural areas are more inclusive, covering larger areas than the sites assigned BSRs by TNC (1995).

6. ASSESSMENT AND RANKING OF AREAS

The information presented in previous sections was used to rank all areas for their relative natural area importance and value. The emphasis was still on rare species, as in the past, but other dimensions

are now considered important in the understanding of what constitutes a natural area. Exemplary natural areas can also be those that contain high-quality examples of representative biodiversity and landscape diversity in the broad sense, not exclusively those areas that contain rare species.

The summary information for each area presented in the appendix and the attribute information presented in Table 1 were collectively used to complete the rank-scale data presented in Table 14. The size-of-area rank is derived from the second and third columns of Table 1 as discussed in Sect. 4.1. The rank values for the other categories were directly determined as discussed in Sects. 4.3 to 4.9. Table 14 includes a total value or composite score in the range from 0 to 33. Highly ranked sites are the most significant and should receive the greatest protections. Lesser ranked sites, though each important in its own way, might not be defended as vigorously in comparison to highly ranked sites if it should become necessary to leverage greater protection for more highly ranked areas.

The ranked areas were divided into three Priority Groups that reflect priority for protection: I - High Priority most important sites, II - Medium Priority average importance sites, III - Low Priority least important sites. The sites were ranked against the criteria, not against themselves. The maximum possible score was 33, a score that is virtually impossible to attain. The mean score of 70 sites was 12.2. Because of the improbability of a single site scoring highly in all categories, it was decided that sites receiving a score greater than 16 (approximately half of the theoretically attainable value of 33) should be considered High Priority and most important (Priority Group I). Sites receiving scores between 8.5 and 16 were placed into Priority Group II. Sites receiving scores of 8 or less were placed in Priority Group III, the lowest category. This division also used some natural breaks in the rankings. Twenty-one sites are in Group I, 30 sites in Group II, and 19 sites in Group III. These Priority Groups are mapped and identified in Fig. 2, which also reflects the composite scores through differential color intensity.

Priority Group I includes sites covering 5611 acres of the Reservation. This is only approximately 16.7% of total Reservation lands. Areas representing 12 of the 15 rare communities currently recorded or reported for the ORR are found on these sites. The exceptions are Ridge and Valley Wet Meadow Shrub-Herb Complex and Rocky Limestone Woodland (both occurring in Priority Group II sites) and Floodplain Pool (not recorded for any of the areas studied for this report). Priority I sites also contain populations of all the status taxa recorded for the ORR, except *Spiranthes lucida* (NA33, Priority Group III, composite score 5). Some further special consideration might be accorded the sites in Priority Groups II and III that contain the only occurrences of rare communities or status taxa.

Out of the 70 ranked sites, six sites in Priority Group I are clearly separated from the remainder with the highest composite scores and emerge as the most important sites on the Reservation. These are the following: NA11: (1) Bull Bluff (composite score 25.5), (2) NA2: East Fork Ridge Mesic Forest (score 22), (3) NA8: McCoy Branch Embayment "Barren" (score 22), (4) NA14: White Cedar Area (score 22), (5) NA13: Pine Ridge Wetlands (score 21), and (6) NA36: Bearden Creek Water Gap and Wetland (score 21) (Table 14).

Priority Group II covers 3686 acres of Reservation lands, and there are 400 acres in Priority Group III. Altogether 9697 acres on the ORR are currently recognized as the special areas evaluated for the present study. This acreage represents 28.8% of the Reservation lands, which total 33,639 acres.

There is substantial agreement of the findings here with the BSRs identified by TNC (1995) and with the sites proposed by TDEC (2001) for priority areas for natural area designation. Most of the sites identified as important by those agencies are recognized in Priority Group I in this study, but there are exceptions. Some sites identified as more important in this study were not recognized in the previous studies, and a few sites recognized in the previous studies were ranked in lower Priority Groups in the present study.

Table 14. Ranking of Natural Areas, Reference Areas, and Conservation Management Areas for eight categories of factors: A (size of area), B (number of status taxa present), C (Endangered and Threatened taxa present), D (rarity of Endangered and Threatened taxa on the Oak Ridge Reservation), E (community and landscape diversity), F (integrity and quality), G (disturbance, defensibility, manageability), H (other significant features and factors)^a

Area	A	B	C	D	E	F	G	H	Composite score	Priority Group
<i>Natural Areas</i>										
2	4	3	1	1	3	4	2	4	22	I
4	4	3	1	1.5	4	2	2	1	18.5	I
6	4	3	1	0	2	3	4	2	19	I
7	4	3	1	1.5	4	2	4	0	19.5	I
8	4	3	2	3	4	3 ^b	2	1	22	I
11	4	3	2	3.5	4	2	4	3	25.5	I
12	3	1	1	2	1	3	4	2	17	I
13	3	2	2	3	4	2	4	1	21	I
14	1.5	4	2	3.5	3	3	4	1	22	I
15	1.5	1	1	1.5	3	2	4	0	14	II
17	4	1	0	0	1	2	4	0	12	II
19	2	2	1	1.5	3	2	4	1	16.5	I
20	4	4	0	0	3	2 ^c	4	2	19	I
21	4	1	0	0	3	3	4	2	17	I
22	4	1	1	0	2	2	2	0	12	II
23	0.5	1	1	1.5	1	4	4	2	15	II
24	2	4	1	2	4	1	2	2	18	I
25	1.5	1	1	0	4	1	2	1	11.5	II
26	0	1	1	0	1	1	0	0	4	III
28	0.5	1	1	1.5	3	1	4	0	12	II
29	0.5	1	1	0	3	1	2	0	8.5	II
30	1.5	1	0	0	0	2	4	0	8.5	II
31	4	1	1	0	2	3	2	1	14.5	II
32	4	2	0	0	3	3	2	1	15	II
33	0	2	1	2	0	0	0	0	5	III
34	0	1	1	0	0	0	2	0	4	III
35	1	2	2	3	3	2	2	2	17	I
36	4	2	2	3	2	3	4	1	21	I

Table 14 (continued)

Area	A	B	C	D	E	F	G	H	Composite score	Priority Group
37	0	2	0	0	1	1	2	1	7	III
38	0.5	1	0	0	1	1	0	1	4.5	III
39	1	1	0	0	4	3	2	1	12	II
41	3	1	0	0	2	3	2	2	13	II
42	4	3	1	0	3	2	4	2	19	I
43	0	1	1	1.5	2	1	2	0	8.5	II
44	3.5	1	0	0	1	3	2	0	10.5	II
45	1	2	0	0	2	2	0	2	9	II
46	4	1	0	0	2	2 ^c	2	1	12	II
47	4	4	1	2	3	1	2	2	19	I
48	4	1	1	1.5	3	2	2	1	15.5	II
49	0	0	0	0	0	1	2	2	5	III
50	2	2	2	3	3	2	2	0	16	II
51	4	4	0	0	3	2	2	2	17	I
52	4	4	1	1.5	2	3	2	1	18.5	I
53	3.5	2	0	0	3	1	0	3	12.5	II
54	1.5	2	0	0	2	2 ^c	2	1	10.5	II
55	1	3	0	0	2	2	0	1	9	II
56	4	2	1	0	3	3	4	1	18	I
<i>Reference Areas</i>										
5	0.5	0	0	0	0	1	4	1	6.5	III
6	1.5	1	0	0	0	2	2	1	7.5	III
7	0	0	0	0	0	1	2	1	4	III
8	2	0	0	0	3	2	2	3	12	II
9	4	1	0	0	1	2	2	0	10	II
10	0	0	0	0	0	1	2	1	4	III
11	4	1	1	2	2	2	4	2	18	I
14	4	1	0	0	1	4	2	0	12	II
15	1.5	1	0	0	2	4	4	1	13.5	II
19	0.5	0	0	0	3	1	0	2	6.5	III
22	2	0	0	0	0	2	4	1	9	II
23	0	0	0	0	0	2	2	1	5	III

Table 14 (continued)

Area	A	B	C	D	E	F	G	H	Composite score	Priority Group
25	0	0	0	0	1	0	0	1	2	III
26	0	0	0	0	1	0	0	1	2	III
28	0	1	0	0	0	0	0	1	2	III
29	4	1	0	0	3	4	2	0	14	II
30	0	0	0	0	0	2	2	1	5	III
31	4	1	0	0	1	2	4	4	16	II
<i>Conservation Management Areas</i>										
1	1	0	0	0	0	0	0	0	1	III
2	2.5	0	0	0	1	2	4	1	10.5	II
3	3	2	0	2	1	2	4	2	16	II
4	0.5	0	0	0	2	0	0	1	3.5	III
5	2.5	1	0	0	1	0	0	0	4.5	III

^a Maximum factor value is 4, except category B can be 5. Maximum total composite score is 33. See text for description of each category.

^b Some heavy clearing occurred at some earlier time on southeast slopes.

^c Some older timber logged in 1960s and 1970s.

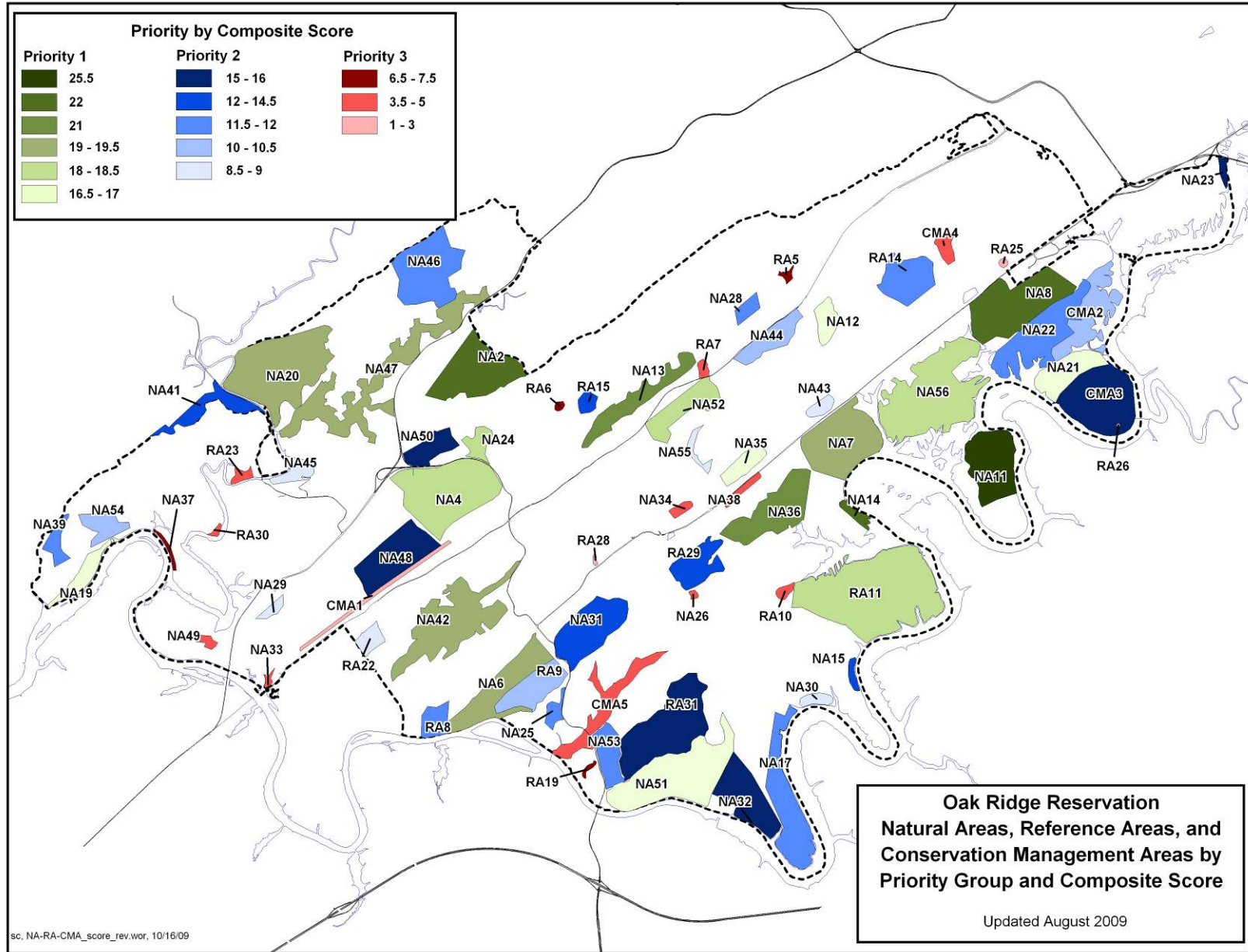


Fig. 2. Oak Ridge Reservation Natural Areas, Reference Areas and Conservation Management Areas illustrated by Priority Group. Deeper color intensity within each Group indicates higher composite score.

7. RECOMMENDATIONS

The present study attempted to synthesize all the existing information about terrestrial natural areas (in the broad sense) on the ORR and supplement it with field observations. Through the course of the study, various gaps and discrepancies in the data became apparent. Various conclusions and insights were also developed. A number of recommendations emerged and are described below.

1. Throughout the course of this study, it was very apparent that there was certain key information missing from the natural area characterizations that were drawn from the existing sources; specifically, no consistent ecological community classification system had been applied, and the community descriptions for each area were inadequate or lacking. Information regarding the integrity and quality of the natural communities on most areas was also lacking. There appears to be a clear need for additional and substantive community-related data about lands on the ORR. A concerted effort should be undertaken to evaluate sites for overall diversity; identify and delimit vegetative communities, whether rare or not; and assess their integrity and quality in a standardized and consistent manner. Standard quantitative ecological methodologies should be applied to determine community age and composition, and an accepted vegetation classification system should be employed to classify community types.
2. The boundaries of NAs and RAs should be reexamined and more carefully drawn or even redefined. Lands that are not part of natural area cores or necessary buffer zones should not be included within boundaries. As far as possible, the boundaries should follow natural topographic and physiographic features such as ridgelines and streams, incorporating entire watersheds if reasonable and feasible. Established roads and utility-line corridors should also be used when possible. These practices will make it easier to communicate boundaries to all concerned and interested parties. In the process of boundary redefinition, it may be that some existing areas can be combined, and some new areas might be parceled out and recognized as separate areas.
3. The Reservation's on-site GIS documentation and the Division of Natural Areas database information indicate that there are many EOs of rare species on the Reservation that are not included in NAs or RAs. It may be that some of these could be incorporated into existing natural areas by boundary extension or that some new natural areas could be established to include them. An evaluation of these EOs is recommended.
4. Some records in the Division of Natural Areas database are not included in the Reservation's on-site documentation; these should be evaluated to determine if they are valid. There are significant differences in animal occurrences that should be resolved. There are discrepancies between the two lists of the animals reported or known to occur on the ORR (Division of Natural Areas database of EOs and the on-site records maintained by ORR personnel).
5. Several of the currently recognized NAs and RAs stand out as units that could be combined into larger functional natural area units. It is recommended that three new reorganized units be created through merger of existing areas. These areas are described below and shown in Fig. 3.
 - a. The Walker Branch Watershed Research Area is not currently recognized as a natural area even though it is a world-renowned research area. It includes 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 Habitat Area (HA6) and a mapped Potential Habitat Area (PH4). 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. Cerulean warblers (*Dendroica cerulea*) were last observed nesting in the area in the early 1970s, and migrants have been observed more recently. The area was proposed as a protected area (PPO) by TDEC (2001). The proposed area included what is now recognized as NA12. It is recommended that the parts of the research area that include NA12, NA43, NA44, HA6, and PH4 be circumscribed as a single merged NA. This action would create a large unit called Walker Branch Watershed Natural Area covering more than 800 acres.

- b. NA6: Raccoon Creek Golden Seal Area, RA8: Golden Seal Barrens, and RA9: Haw Ridge Upland Hardwoods are adjacent areas in the southwestern section of the Reservation and should be merged into an expanded NA6 of 443 acres called West Haw Ridge Natural Area. They include some similar features, and there appears to be no good biological reason for separating these three adjoining areas in the same geographical setting.
 - c. It is recommended that NA52: Bear Creek Spring Area and RA7: Bear Creek Mesic Forest be merged into an expanded NA52 called Bear Creek Spring Natural Area that would include 160 acres and part of an Aquatic Natural Area. The two areas are not sufficiently distinct to merit separate statuses.
6. A new area, the Pine Ridge Mature Forest Natural Area (53 acres), merits recognition as an NA (Fig. 3). This is an area that has recently been determined to contain significant features. It consists of a mixed-age, primarily beech-sugar maple forest, but 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 all interior forest in good condition. An Aquatic Natural Area, the site of ongoing stream chemistry research, is included. The area falls within TNC's BSR3-2 and BSR3-9 Preliminary Conservation Sites.
7. Several of the areas currently recognized as RAs might better be thought of as NAs. Even though they may not contain status species, they do have other values that are important and should be maintained under a natural area concept. It may be more practical and reasonable to simply recognize all the areas studied in this report as NAs and let the significance rankings (i.e., composite scores) reflect their relative values. Thus, there would be no distinction between NAs, RAs, and CMAs.
8. The delimitation of interior forests should be reexamined. The currently mapped interior forest tracts are very conservatively drawn, apparently using every existing transmission line and utility corridor, field edge, or roadway as a boundary demarcating a forest edge. As mentioned previously in this report, some of the forest roads that were seen during the fieldwork do not appear to present significant forest borders that would function as edges, and they should probably be ignored in boundary determination.

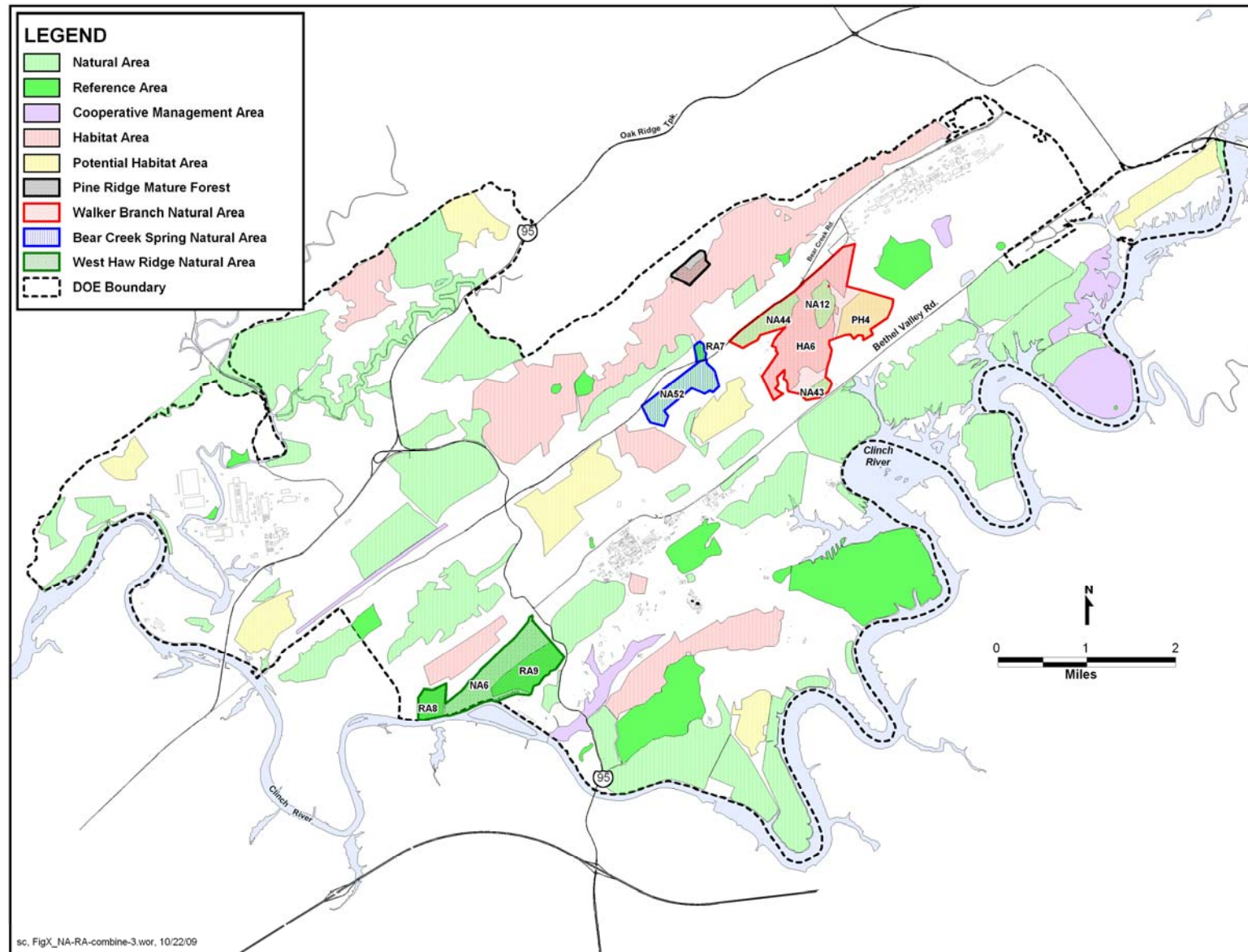


Fig. 3. Areas recommended for recognition as new or reorganized natural areas: Walker Branch Watershed Natural Area, West Haw Ridge Natural Area, Bear Creek Spring Natural Area, and Pine Ridge Mature Forest Natural Area. See text for discussion.

9. The presence of some species (e.g., *Juglans cinerea*) on the ORR needs to be confirmed. The locations of other elements (e.g., *Myotis grisescens*) need to be confirmed, incorporated into the database, and communicated to the Tennessee Division of Natural Areas. The number of EOs in each area and an estimation of the size and viability of rare species populations in each area should be information that is routinely gathered and incorporated in the database characterization of each area. At present there appears to be inconsistency in recording detailed population information about the EOs on each site.
10. The areas that are currently recognized as Aquatic Natural Areas and Aquatic Reference Areas should be evaluated for their natural area value. It should be possible to modify the existing criteria (which have been developed for the evaluation of terrestrial areas) in a way that would accommodate aquatic parameters and allow these areas to be incorporated into a single overall treatment of natural areas.
11. A field data form should be developed for the standardization and recording of data about specific sites on the Reservation—both currently recognized areas and any new areas that might be circumscribed for study in the future. The form should include all the categories of information that are developed in the present study and could be routinely carried into the field by personnel when examining and evaluating sites on the Reservation. Much of the information could be presented in a checklist format. Further, it is recommended that the information in these data forms also be transferred to a spreadsheet database that could be routinely updated to calculate revised rankings and Priority Groups of natural areas.
12. The Forest Management Plan that is being separately developed should recognize the existence of the biologically and ecologically important Research Park natural areas and habitats that have been officially recognized on the ORR. The plan should stipulate that these areas are off limits to timber marketing as an objective and give special attention to protecting the natural area values represented on these sites when active management is planned for adjacent lands. These officially recognized areas should be subject to direct management and manipulation only when necessary to maintain the natural values. The Natural Resources Manager would use the appropriate scientific expertise and guidelines in determining these actions. Forest management planning on the ORR should recognize the most important natural areas (Priority Group I sites, 16.7% of the Reservation) as a distinct land type that assumes a permanent protected status as a matter of policy and makes this land use of equal or greater importance than other traditional forest uses.

This report has primarily relied on the synthesis of information from many sources and from limited reconnaissance and direct observation during fieldwork. There were numerous cases of incomplete and missing information and some cases of conflicting information. All information has been subject to the interpretation of the investigator. The data presented in the draft version of this report were reviewed for accuracy by all parties having direct knowledge and experience with the biodiversity on the ORR. Following this review and subsequent discussions, the definition of categories, criteria used for category ranks, number of categories to be retained, relative weighting of rank factors, and conclusions reached for each site and area were evaluated and refined to produce the final methodology for assessing natural area importance and assigning priorities for protection. It may be that further review and discussion will reveal some additional factors that should also be included in the evaluation. The methods and guidelines presented here are flexible and allow for continuing evolution to reflect the latest findings, interpretations, and valuations.

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APPENDIX.
SUMMARY NATURAL AREA DESCRIPTIONS

APPENDIX. SUMMARY OF NATURAL AREA DESCRIPTIONS

This appendix provides a summary of additional information related to the natural areas considered in this report. The information for each area is presented as follows:

Identifying number. Current official name underlined/synonymous name (acreage rounded to nearest whole acre [a], number of status species present [ss], taxa that are Endangered and Threatened in Tennessee – number of occurrences on the site, abbreviations of rare natural communities). Description and other significance. Relationship to The Nature Conservancy Preliminary Conservation Sites, with BSR. Tennessee Department of Environment and Conservation designation in 1985 agreement and for new areas proposed in 2001 (PPO or PP). See Sect. 5 of accompanying document for full explanation.

NA2. East Fork Ridge Mesic Forest (283a, 3ss, *Lilium canadense* – 2, *RAVSF*). Includes 25 acres of old-growth beech-maple-basswood. Rich flora. Largest area of noncalcareous rock outcrops and talus. Forested wetlands, one unusually undisturbed. Rare Tennessee dace in stream. Supports nesting interior forest neotropical migrant birds. Parts of BSR2-12, BSR2-14, and BSR3-14. PP.

NA4. Rein-orchid Swamp/Bear Creek Forested Wetland (421a, 3ss, *Platanthera flava* v. *herbiola* – 1, *SSS*, *BFW*, and *RAVSF*). Most is forested wetlands. Old channels, seeps, some uplands. Significant beaver activity. Uncommon *Orontium aquaticum* present. Part of BSR2-10. PPO.

NA6. Raccoon Creek Golden Seal Area/Haw Ridge Uplands and Raccoon Creek Embayment (237a, 3ss, *Lilium canadense* – 1). Forested with limestone outcrops. Diversity of forest communities and diverse species composition. Good embayment wetland, emergent, and scrub/shrub. Some high-quality open old forests. Some river bluffs. Some other rare or uncommon Oak Ridge Reservation (ORR) plant species. Parts of BSR2-8 and BSR3-44. PP.

NA7. Walker Creek Embayment “Barren” (324a, 3ss, *Delphinium exaltatum* – 1, *OHALW*, *LBA* and *LBP*). Variety of mesic and xeric forests and mowed area barrens. Some limestone outcropping. *Delphinium* concentrated in one area and scattered throughout. BSR2-20 and southeast edge is BSR3-21. PPO.

NA8. McCoy Branch Embayment “Barren” (347a, 2ss, *Delphinium exaltatum* – 2, *Lilium canadense* – 1, *OHALW* and *LBA*). Variety of forests and mowed areas, including oak-hickory-ash limestone woodland and tuliptree-red cedar-white oak-hickory. Some limestone outcropping. Large population of *Delphinium* and scattered elsewhere. Long-term research for *Delphinium*. Northern one-third is BSR2-23, remainder BSR3-7. PPO.

NA11. Bull Bluff (239a, 3ss, *Cimicifuga rubifolia* – 1, *Diervilla lonicera* – 1, *LC* and *RVCMMF*). Steep limestone bluff, wooded, cliffs. Rocky ridge with sinks and cave entrances. Research site for *Cimicifuga*, lichens, bryophytes, gastropods. Old red cedars, hybrid fern, cave. Supports nesting interior forest neotropical migrant birds. Part of Three Bend Scenic and Wildlife Management Refuge. BSR2-22. PP.

NA12. Walker Branch Fothergilla Site (60a, 1ss, *Fothergilla major* – 1). Steep slope. Heath, oak-hickory-tuliptree, dry oak-hickory forest, especially open old chestnut oak. Long-term research area. Only colony of *Fothergilla* on the ORR. Within BSR3-8. PP.

NA13. Pine Ridge Wetlands (159a, 2ss, *Lilium canadense* – 1, *Platanthera flava* v. *herbiola* – 4, *SSS* and *RAVSF*). Forested, emergent and scrub/shrub wetlands along tributaries. Part in open power line right-of-way. Other rare species or species uncommon on the ORR. Heavy Nepal grass infestation. Part of BSR2-10. PP.

NA14. White Cedar Area (26a, 4ss, *Cimicifuga rubifolia* – 1, *Diervilla lonicera* – 1, *NWCW*). Shaly cliffs with northern white cedar woodland. Rare ORR plant. Cave. BSR2-21, half of BSR2-14.

NA15. North Hickory Creek Bend Bluffs/Hickory Creek Bend Bluffs (17a, 1ss, *Cimicifuga rubifolia* – 1, *RVCMMF*). Mixed hardwood/pine. Steep slope. BSR3-46. PP.

NA17. Tower Shielding Bluffs (293a, 1ss). Steep slope. Dominant oak-hickory with some mesics (*Acer saccharum*). PP.

NA19. Black Oak Ridge River Bluffs (89a, 2ss, *Cimicifuga rubifolia* – 1, *RVCMMF*). Forested slopes with some limestone outcrops. Supports nesting interior forest neotropical migrant birds. Lower section is BSR2-3, a small part is BSR3-20.

NA20. Poplar Creek Cliffs (476a, 4ss, *HWOWPLCF*). Water gap, steep slopes. Small limestone cliffs near stream. Several more unusual plant species for ORR. Supports nesting interior forest neotropical migrant birds. Part of Black Oak Ridge Conservation Easement. Part of BSR2-11, most in BSR3-11. PPO.

NA21. Rainy Knob Bluff (141a, 1ss, *LS*). Scenic, wooded, rocky limestone sinkhole with cave entrance in area of bluffs near embayment. Other rare plants and several rare animals. Part of Three Bend Scenic and Wildlife Management Refuge. Small part is part of BSR3-13. PP.

NA22. Bull Bluff Road Area (289a, 1ss, *Lilium canadense* – 3). Two concentrations of *Lilium* in drainage areas. Part of Three Bend Scenic and Wildlife Management Refuge. Most is part of BSR3-7.

NA23. Solway Bend Bluffs (15a, 1ss, *Cimicifuga rubifolia* – 1). Steep, rocky slopes. Two or three other rare plants and plants unique for the ORR. Part of Three Bend Scenic and Wildlife Management Refuge. BSR2-26. PP.

NA24. Hembree Marsh (50a, 4ss, *Liparis loeselii* – 1, *SP* and *RAVSF*). One of two major emergent wetlands not connected to reservoir. Complex of emergent, scrub/shrub, forested wetlands. Unusual hydrology for the ORR. High diversity; other rare or unusual species, including *Hemidactylum scutatum*. *Acorus calamus* dominates open area. Part of BSR2-10. PPO.

NA25. Clinch Floodplain Swamp/Highway 95 Lily Area (18a, 1ss, *Lilium canadense* – 1, *RAVSF* and *SP*). Headwater riparian area and downstream wetlands. Few other rare plants. Essentially BSR2-25. PP.

NA26. Melton Valley Lily Area (3a, 1ss, *Lilium canadense* – 1). Ephemeral depressional pond in forested headwater stream bottom. Disturbed.

NA28. Eastern Bear Creek Rein-orchid Wetland (33a, 1ss, *Platanthera flava* v. *herbiola* – 1, *SSS*). Forested wetlands in upper watershed. Exotic Nepal grass is a dominant herb. Similar to NA4.

NA29. Northwest Pine Ridge Natural Area (formerly Northwest Pine Ridge Fringeless Orchid Site) (20a, 1ss, *Lilium canadense* – 1, *RVWMSHC*). Boundaries must be redefined to include *Lilium*. One-half is BSR2-24.

NA30. Health Physics Research Reactor Lake Bluffs (23a, 1ss). Steep, rocky limestone bluffs along reservoir shoreline. BSR3-48.

NA31. Environmental Sciences Division Lily Site (238a, 1ss, *Lilium canadense* – 2). Moist limestone woods on northwest-facing slope. High tree diversity. Supports nesting interior forest neotropical migrant birds. BSR3-40.

NA32. Melton Dam Bluffs (108a, 2ss, *RVCMMF*). Diverse forest community types: tuliptree-mixed hardwood with pine, Ridge and Valley calcareous mixed mesophytic forest, chestnut oak-tuliptree-northern red oak-hickory, chestnut oak-tuliptree-northern red oak-hickory-white oak, hickory-red cedar-Virginia pine. Mostly open second growth, with some older nice areas. Recent disturbances from fire management roads. Limestone rock outcrops. *Carex grvida* present. Other rare species. Part is BSR3-54. PP.

NA33. The ETTP Filtration Plant Wetland (7a, 2ss, *Spiranthes lucida* – 1). Wetland adjacent to a filtration lagoon.

NA34. Chestnut Ridge Lily Area (17a, 1ss, *Lilium canadense* – 1). Small ravine with immature hardwood forest. Small wet areas. Most is BSR3-31.

NA35. Chestnut Ridge Barren and Wetland (63a, 2ss, *Delphinium exaltatum* – 1, *Lilium canadense* – 1, *LBA*). Limestone cedar barren, wet meadow, riparian wetlands, stream. Partly under

power line. Some other rare plant species, including *Isoetes caroliniana*, that may warrant listing. BSR2-18. PP.

NA36. Bearden Creek Water Gap and Wetland (240a, 2ss, *Delphinium exaltatum* – 1, *Lilium canadense* – 2). Narrow forested gap in Haw Ridge. Steep slopes, rocky limestone woods, forested wetlands, embayment emergent and scrub/shrub wetlands. Tuliptree-oak-hickory community. Other rare plant and animal species. Includes young forest areas, but also diverse flora and nice older forests on steep slopes. Nice clear stream and wet stream bottoms. BSR3-28. PP.

NA37. Duct Island Road Bluffs (12a, 2ss). Shoreline of a peninsula along reservoir. Low limestone outcrops. Dry to moist hardwood or cedar forest and barrens. Only known site on the ORR for *Cornus drummondii* and the listed *Draba ramosissima*. BSR2-4.

NA38. Bethel Valley Small-head Rush Wetland (25a, 1ss). Spring-fed emergent and scrub/shrub wetlands and stream; small shaly barrens. Dominant white pine plantation that could be restored to barrens. Essentially BSR3-29. PP.

NA39. West Black Oak Ridge Mesic Forest (46a, 1ss, *OHALW* and *RVCMMF*). Mesic forest and xeric open second-growth woodlands in headwater area. Significant forest types and rare mammals. Supports nesting interior forest neotropical migrant birds. Part of Black Oak Ridge Conservation Easement. BSR2-2.

NA41. Leatherwood Bluffs (107a, 1ss). Mature hardwood and hemlock with diverse understory species assemblage unique to the ORR and four plant species unique to the ORR. Steep northwest slope. Mostly young second-growth. Limestone outcrops, three caves. PP.

NA42. New Zion Boggy Area (376a, 3ss, *Lilium canadense* – 1, *BFW*). Forested wetland and adjacent oak-hickory uplands. Groundwater seeps and sinking creek in headwater area with *Sphagnum*/fern wetland and pools. Mostly young second growth. Old roads. Possibly only ORR site with *Aronia arbutifolia*. Supports nesting interior forest neotropical migrant birds. Parts are BSR3-38, BSR3-39, and BSR3-41. PP.

NA43. Lower Walker Branch Ledges (29a, 1ss, *Delphinium exaltatum* – 2). Limestone outcrops on slope in forest and right-of-way. Barrens. BSR2-19, part is BSR2-7, lower part not recognized. PP.

NA44. Chestnut Ridge Whorled Horse-balm Area (110a, 1ss). Mature, mesic hardwoods. Moist ravine, steep slopes. Within BSR3-8, and northern half is BSR3-17.

NA45. McKinney Ridge Hemlocks (52a, 2ss). Most extensive area of hemlocks and rhododendron on the ORR. Dry to mesic forests, from young to nice older growth. Past disturbances, and proximate to current disturbances. Two small caves. BSR3-24. PPO.

NA46. East Fork Limestone Quarry/Black Oak Ridge Limestone Quarry/Black Oak Ridge Forest (300a, 1ss). Mature mixed hardwood/pine, oak-hickory-tuliptree, pine. Limestone quarry. Only location of unlisted *Rhynchospira colorata* in Tennessee. Mostly BSR3-4, lower part is BSR2-13. PP.

NA47. East Fork (Poplar Creek) Floodplain (422a, 5ss, *Erimonax monachus*-1, *RAVSF*). Bottomland hardwoods with canebrake understory. Some rare communities in uplands, including cedar barrens and beech-maple forest. Rare animals and plants. Supports nesting interior forest neotropical migrant birds. A sycamore may be largest tree on Reservation. Northern two-thirds is part of BSR2-12. PP.

NA48. Sleepy Salamander Forest (233a, 1ss, *Platanthera flava* v. *herbiola* – 1, *RVWMSHC*). Forested and emergent wetlands. Wet meadow/shrub/herb complex in power line right-of-way. Oak forest on south slopes. Rare salamanders. Most is BSR3-35.

NA49. K-25 (ETTP) Beaver Pond Complex (17a). Loblolly pine plantation. Prime birding area, especially cavity-nesting birds and water birds. Most is BSR3-49.

NA50. Bear Creek Tributary 4 Area/Bear Creek Tributary and Floodplain (89a, 2ss, *Lilium canadense* – 1, *Platanthera flava* v. *herbiola* – 2, *LS*). Variety of forests and wetlands, including oak-hickory, red maple-sweetgum woodland, bottomland hardwoods, emergent and scrub/shrub wetlands,

and canebrakes. Mature forest and forested limestone sinkhole. Active sludge area on edge. One-half is BSR3-30. PPO.

NA51. Dry River Bluffs and Caves (519a, 4ss, *OHALW*). Large variety of communities, including oak-hickory-ash limestone woodland, oak-hickory, mixed pine/hardwood, natural mature white pine, cedar forest, forested wetlands. Mostly open second growth. Landscape elements include sinkholes, caves, ravines, calcareous steep cliffs, outcrops, springs, seeps, ponds, etc. Much of BSR3-51 and BSR3-53. PP.

NA52. Bear Creek Spring Area (147a, 4ss, *Platanthera flava* v. *herbiola* – 1). Top and northwest-facing slope. Mesic hardwoods, mixed hardwood/pine, mature white pine, meadows, forested wetlands, springs (one large), spring-fed pond, outcrops. Another uncommon plant present. Rare Tennessee dace in creek. Part of BSR2-10 and BSR3-16. PP.

NA53. Flashlight Heaven Area (102a, 2ss, *OHALW*). One of most impressive caves on the ORR. Cave organisms. Indian burial site. Water-quality concerns. Mature oak-hickory forest and oak-hickory-ash limestone woodlands. Steep slopes and rock outcrops. PP.

NA54. Black Oak Ridge White Pines (74a, 2ss). Mature forests: pines, oak-hickory, mesic hardwoods, xeric hardwoods, forested floodplain wetlands. Springs, moist ravine. Supports nesting interior forest neotropical migrant birds. Part of Black Oak Ridge Conservation Easement.

NA55. Chestnut Ridge Springs Area (25a, 3ss). Various immature forests on south slopes. Spring-seep-stream associated wetlands. Calcareous cliffs, outcrops. Another species, *Bartonia paniculata*, is uncommon in east Tennessee. Part is BSR3-18.

NA56. Middle Haw Ridge Mesic Forests (512a, 2ss, *Lilium canadense* – 2, *OHALW*). Mature forests. Oak-hickory-ash limestone woodlands, oak-hickory, bottomland hardwoods, mesic and xeric hardwoods. Steep slopes, outcrops. Supports nesting interior forest neotropical migrant birds. Northern half is BSR3-12. PP.

RA5. Quillwort Temporary Pond (9a). Forested wetland. Amphibian breeding site. *Isoetes caroliniana* may be a rare species that will warrant listing.

RA6. Pink Lady Slipper Community (6a, 1ss). Unusually large population of lady-slipper in a Virginia pine forest.

RA7. Bear Creek Mesic Forest (13a). Area of mature white pines with American holly. Uncommon *Aesculus parviflora* along Bear Creek. Large spring discharging into Bear Creek.

RA8. Raccoon Creek Barren (62a, *LBA*). Cedar-post oak barren-glade on shallow limestone. Many interesting plants. A rare community, frequently used as a demonstration area. Restoration possibilities. Most of BSR2-8. PP.

RA9. Haw Ridge Upland Hardwoods (144a, 1ss). Representative upland hardwoods. Included in BSR3-44.

RA10. Moss and Lichen Community (15a). Good demonstration of succession following soil erosion damage.

RA11. Copper Ridge Area (479a, 1ss, *Myotis grisescens* – 1). Relatively undisturbed; oak-hickory, pine, cedar, various successional communities. Rocky ridge section with limestone sinks and caves. Supports nesting interior forest neotropical migrant birds. Mostly BSR3-37.

RA14. Fanny Knob White Oak Area (162a, 1ss). White oak community. Essentially BSR3-6.

RA15. Beech-Mountain Laurel Community (27a, 1ss). Unusual community, from mesic to xeric and riparian to steep slope. Beech and mountain laurel throughout. Part of BSR3-19.

RA19. Sweetflag Marsh (6a, SP). Rare community occurrence. Open emergent and shrub wetland with rare hydrology for ORR.

RA22. Grassy Creek Security Site (43a). Limestone outcrops. Some uncommon plants for the ORR. Part of BSR2-5.

RA23. Upper Poplar Creek Rookery (17a). Heron nesting area, but presence varies by year. BSR3-27.

RA25. Large Pond (5a). Artificial pond with high plant and animal diversity. In an active sludge area.

RA26. Small Pond (1a). Artificial pond with high plant and animal diversity.

RA28. Spring Pond (3a, 1ss). Spring-fed pond with dominant *Elodea nuttallii*.

RA29. ORNL Rocky Limestone Forest (128a, 1ss, *RLW*). Dry rocky woods. Oaks and cedars. Most is BSR3-36, one-third is BSR2-17.

RA30. Lower Poplar Creek Rookery (6a). Forested wetland. Heron nesting area, but presence varies by year. BSR3-33.

RA31. Copper Ridge Cave Area (375a, 1ss). Oak-hickory-tuliptree forest. Nice, older second growth. Old home places. Largest known cave on the ORR. Uncommon animals; cave species. Geomagnetic research. Within BSR3-45. PP.

CMA1. Grassy Creek Power Line Area (51a). Lower edge is BSR3-35.

CMA2. Upper Freels Bend Hayfield Area (198a). Nesting ospreys. Invasive plants and forage grasses. Part is BSR4-2.

CMA3. Lower Freels Bend Hayfield Area (326a, 2ss). High-diversity prime birding area, especially grassland species. Nesting grassland and open-habitat birds. *Pituophis melanoleucus melanoleucus* is indicated as present in Natural Heritage Program database but is not thought to be present by ORR personnel; it was not considered in the evaluation. Good area for nongame wildlife management. PP.

CMA4. Ash Storage Area (33a). Two open areas. Unusual plant communities for the ORR. Interesting plant species.

CMA5. White Oak Creek (153a, 1ss). Extensive wetlands. High radioactivity present.

