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ENVIRONMENTAL SCIENCES DIVISION

**BALD EAGLE HABITAT SUITABILITY
ON MELTON HILL RESERVOIR
AND THE CLINCH RIVER**

D. A. Buehler

Environmental Sciences Division
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**MANAGED BY
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ENVIRONMENTAL SCIENCES DIVISION

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AND THE CLINCH RIVER

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ABSTRACT

The area around Melton Hill Reservoir and sections of the Clinch River along the Oak Ridge Reservation (ORR) provide suitable habitat for bald eagles for both breeding and wintering activities. The highest quality habitat is available along Melton Hill in the Bearden Creek–Gallaher Bend area. Primary limitations on habitat suitability appear to be human activity in aquatic habitats and along shoreline areas, and human development (residential and industrial) along shoreline areas. ORR provides the majority of the suitable habitat because shoreline development is very limited. Four eagle management strategies discussed for ORR include planning development away from high-quality habitats, allowing forest stands near water to mature, conducting timber stand improvement (thinning) to foster growth and development in pines and hardwoods, and using introductions to foster the development of a breeding population.

The primary objective of this project was to make a qualitative assessment of bald eagle habitat suitability along Melton Hill Reservoir and the Clinch River and in adjacent areas on the ORR, including the proposed Advanced Neutron Source (ANS) site. This survey's aim was to provide ORR managers with an indication of whether suitable habitat exists and, if so, where it occurs on ORR. This information should provide the basis for incorporating eagle management into the overall ORR land management plan, if so desired.

1. INTRODUCTION

Bald eagles (*Haliaeetus leucocephalus*) are listed as an endangered species in the state of Tennessee and throughout the southeastern United States. Bald eagles historically bred in western Tennessee in Lake and Obion Counties on Reelfoot Lake [see Alsop (1979) for review]. Nesting continued at Reelfoot until 1964, before the effects of dichlorodiphenyl-trichloroethane (DDT) on reproductive success and other factors on survival eliminated nesting eagles from Tennessee [Hatcher (*in press*)]. Nesting also was reported in Stewart County on Kentucky Lake in the late 1940s to Ganier by DeLime (Ganier 1951). Ganier (1951) also suggested that eagles historically might have nested on Eagle Nest Island on the Tennessee River in Decatur County. There were no reports of nesting of bald eagles in eastern Tennessee until recently. The lack of nesting historically on Tennessee reservoirs may be attributed to the population decline that began at about the same time the Tennessee Valley Authority was developing suitable habitat in its reservoir system.

Breeding resumed in Tennessee with 1 occupied territory in 1983 and has increased to more than 20 occupied territories in 1993, primarily on Reelfoot Lake and on the Tennessee River and associated reservoirs in the northern part of the state (Hatcher, R., Tennessee Wildlife Resources Agency, unpublished data). In eastern Tennessee, only one active territory has become established, located on Tellico Reservoir.

The eagle recovery work has been fostered by extensive reintroduction efforts supported by state, federal, and private cooperators, including the Tennessee Wildlife Resources Agency, the Tennessee Department of Conservation, the Tennessee Valley Authority, the U.S. Fish and Wildlife Service, the U.S. Forest Service, the U.S. Army Corps of Engineers, and the National Foundation to Protect the American Eagle (NFPAGE). The reintroduction program is nearing completion, with hacking on South Holston Reservoir expected to be finished in 1994 and hacking on Douglas Reservoir expected to finish in 1996. The state of Tennessee will not financially support any additional projects, although they may approve privately sponsored projects, such as those funded by NFPAGE, to reintroduce eagles elsewhere in the state (Hatcher, R., Tennessee Wildlife Resources Agency, personal communication).

Although the breeding population in Tennessee is increasing, the low numbers of occupied territories leaves the population highly vulnerable to an array of potential threats. Primary threats to development of a viable breeding population include habitat destruction from development, pesticides, and shooting (Bohall Wood et al. 1990).

Given this precarious but improving situation and considering the legal requirements under the Endangered Species Act, federal agencies and their contractors, such as the U.S. Department of Energy and Martin Marietta Energy Systems, Inc., at the Oak Ridge

Reservation (ORR), must consider how their land management activities affect the bald eagle recovery. In some cases, it is necessary to consider whether federal actions will jeopardize the bald eagle recovery by developing otherwise suitable habitat. In other cases, it may be appropriate to take specific management actions in an attempt to enhance recovery efforts where suitable habitat is present. Both of these scenarios exist on the ORR.

The primary objective of this project was to make a qualitative assessment of bald eagle habitat suitability along Melton Hill Reservoir and the Clinch River and in adjacent areas on the ORR, including the proposed Advanced Neutron Source (ANS) site. This survey's aim was to provide ORR managers with an indication of whether suitable habitat exists and, if so, where it occurs on ORR. This information should provide the basis for incorporating eagle management into the overall ORR land management plan, if so desired.

1.1 CHARACTERISTICS OF BALD EAGLE HABITAT

An accurate description of habitat requirements is needed to evaluate habitat suitability. On the basis of research conducted in Tennessee and in other parts of the bald eagle's range, certain habitat requirements can be consistently identified in relation to nesting, roosting, and foraging activities.

1.1.1 Nesting Habitat

Nesting habitat can be defined on both the micro scale, related to the characteristics of the nest tree itself, and on the macro scale, related to the landscape-level patterns that provide conditions suitable for nesting and foraging. On the micro scale, nest trees throughout the majority of the bald eagle's range, including Tennessee, are generally the largest trees available in the area with accessible limbs capable of holding the nest structure (Herrick 1924; Gerrard et al. 1975; McEwan and Hirth 1979; Andrew and Mosher 1982; Anthony et al. 1982; Mathisen 1983; Swenson et al. 1986; Stalmaster 1987; Anthony and Isaacs 1989; Bohall Wood et al. 1989; Livingston et al. 1990). A large, super-canopy tree provides good flight access to the nest and good visibility of the surrounding area. The branches also must occur in a configuration capable of holding the first few sticks brought to the nest as the breeding pair begins nest construction.

Tree species used for nesting varies throughout the bald eagle's range because of regional differences in dominant trees [see Stalmaster (1987:184–185) for review]. Coniferous trees [pines (*Pinus* spp.), spruces (*Picea* spp.), and firs (*Abies* spp. and *Pseudotsuga* spp.)] are used in areas where conifers become dominant in the canopy. Deciduous trees, including oaks (*Quercus* spp.), hickories (*Carya* spp.), and cottonwoods

and aspens (*Populus* spp.), are used in regions where large conifers are absent (primarily in the eastern United States). In Tennessee, nests have been built in bald cypress (*Taxodium distichum*), oaks, yellow poplars (*Liriodendron tulipifera*), hickories, cottonwoods, and sycamore (*Platanus occidentalis*) (Hatcher, R., Tennessee Wildlife Resources Agency, unpublished data).

The size of the nest tree is highly variable, depending on the individual tree species available and how that compares with the surrounding canopy. Stalmaster (1987), in reviewing nest tree data from 14 areas throughout the bald eagle's range, reported nest trees varied from 20 to 60 m in height and from 50 to 190 cm in diameter. Deciduous trees used for nesting on the Chesapeake Bay, similar species to the limited number of nest trees found in Tennessee, averaged 82-cm dbh and 28-m tall (Andrew and Mosher 1982). Five nest trees at Land Between the Lakes (LBL), on the border between Kentucky and Tennessee, averaged 77.2-cm dbh and 33.3-m tall (Lackey 1991).

Eagles usually build nests in live trees, although adjacent snags often are used for perching (Herrick 1924; Gerrard et al. 1975; McEwan and Hirth 1979; Mathisen 1983; Swenson et al. 1986; Stalmaster 1987; Anthony and Isaacs 1989; Bohall Wood et al. 1989; Livingston et al. 1990).

At the macro scale, nests usually occur in mature, forested areas that have some habitat edge and are relatively close to a body of water with suitable foraging opportunities (Stalmaster 1987). The actual distance to water varies within and among populations. In some cases, distance to water is not as critical as the quality of the foraging area that is present. This may include the diversity of the prey base (Livingston et al. 1990) and the characteristics of the aquatic habitat, such as the presence of shallow water (MacDonald and Austin-Smith 1989).

In general, areas with considerable shoreline development or human activity (e.g., Florida, Chesapeake Bay, Minnesota, parts of the Greater Yellowstone ecosystem) tend to have eagles nesting farther from the shoreline, compared with nest sites in less developed areas, such as Alaska (Robards and Hodges 1977; Andrew and Mosher 1982; Fraser et al. 1985; Swenson et al. 1986; Stalmaster 1987; Bohall Wood et al. 1989). Most nest sites throughout the bald eagle's range occur within 3 km of water. In Tennessee, 16 nest sites averaged 350 m from water, although sites have been reported over 3 km from water (Hatcher, R., Tennessee Wildlife Resources Agency, unpublished data). Five nests studied at LBL averaged about 200 m from water (Lackey 1991).

The size of the forest tract holding the nest tree may be unimportant if the tract is isolated from human development and disturbance. The minimum distance from an eagle nest to human development in some nesting populations is <100 m. The average distance in most populations, however, is >500 m and reflects habitat selection away from these developments (Andrew and Mosher 1982; Fraser 1984; Fraser et al. 1985; Stalmaster 1987; Anthony and Isaacs 1989; Bohall Wood et al. 1989; Livingston et al. 1990). LBL eagle

nests were located, on average, 3.9 km from the nearest building; the locations reflect the lack of shoreline development of this national recreation area (Lackey 1991).

Forested tracts used for nesting tend to have either relatively open canopies, some form of habitat discontinuity or edge, or high levels of foliage height diversity, which provide access to nest trees (Gerrard et al. 1975; McEwan and Hirth 1979; Anthony and Isaacs 1989; Bohall Wood et al. 1989).

1.1.2 Roosting Habitat

Roost use and roost site characteristics have been studied extensively in the middle and western United States (Southern 1963; Swisher 1964; Edwards 1969; Jonen 1973; Lish 1973; Shea 1973; Servheen 1975; Griffin 1978; Stalmaster et al. 1979; Hansen et al. 1980; Steenhof et al. 1980; Anthony et al. 1982; Keister and Anthony 1983; Harmata 1984; Sabine and Klimstra 1985; Keister et al. 1987). Relatively little study has been done on roost use and site characteristics for eastern populations. Nye (1977) briefly described features of two winter roosts located in association with hydroelectric dams on rivers in New York; Chester et al. (1990) described the use and characteristics of two summer roosts at man-made reservoirs in North Carolina. Buehler et al. (1991a) described communal and solitary roost sites used in summer and winter on the Chesapeake Bay. On the basis of these studies and trends from western areas, several consistent patterns emerge in roost site selection.

Eagles throughout their range select large, super-canopy trees that are open and accessible for roosting (Hansen et al. 1980; Steenhof et al. 1980; Anthony et al. 1982; Keister and Anthony 1983; Chester et al. 1990; Buehler et al. 1991a). Roost trees used in eastern North America may be deciduous or coniferous (Southern 1963; Lish 1973; Griffin 1978; Steenhof et al. 1980; Chester et al. 1990; Buehler et al. 1991a), whereas most western roosts are dominated by conifers (Swisher 1964; Edwards 1969; Hansen et al. 1980; Anthony et al. 1982; Keister and Anthony 1983), except in some riparian zones (Shea 1973; Servheen 1975). Eagles in New York roosted in white pines (Nye 1977), whereas northern Chesapeake eagles roosted in deciduous trees (Buehler et al. 1991a). Eagles in North Carolina used a loblolly pine (*Pinus taeda*) seed-tree stand as one roost but dead hardwoods for another.

Roost trees range in size from 30 to 110 cm in diameter and 15 to 60 m in height (Stalmaster 1987). In general, roost trees are "mature" trees in a forest system, although age varies widely from 200–300-year-old, old-growth trees in the Pacific Northwest to 50–100-year-old trees in the eastern United States (Anthony et al. 1982; Keister and Anthony 1983; Buehler, D., unpublished data).

Macro-scale roost characteristics differ in several significant ways from nest-site characteristics. Although roost sites are generally associated with aquatic foraging areas,

which are similar to nest sites, they are not located nearly as closely to water, especially in western states. A roost site in Utah was located 29 km from the major foraging area (Swisher 1964), and many other western roosts are located >10 km from a foraging area (Edwards 1969; Hansen et al. 1980; Harmata 1984; Keister et al. 1987). Roosts in North Carolina and the Chesapeake Bay area, in contrast, were all within 1 km of an aquatic foraging area (Chester et al. 1990; Buehler et al. 1991a). Roosts were located within the same distance zones to water as nests in these eastern populations.

Similar to nest sites, eagles selected roost sites away from houses and roads throughout their range (Lish 1973; Hansen et al. 1980; Harmata 1984; Buehler et al. 1991a).

Eagles on the Chesapeake selected sites in relatively large forested blocks but adjacent to large open corridors (Buehler et al. 1991a), similar to the observation made by Stalmaster et al. (1979) that roosts in western Washington were adjacent to clearings. These corridors may be important for providing access to roost sites given the eagles' limited flight agility.

It is unclear what the ultimate cause is for roost-site selection in Tennessee or in the eastern United States. Stalmaster and Gessaman (1984) reported that Washington eagles saved energy by selecting conifer sites within 3.88 km of foraging areas, rather than roosting in closer deciduous stands. This observation suggests that minimizing nightly energy expenditure drove roost-site selection. Keister et al. (1985), however, reported that Klamath Basin eagles selected distant, coniferous roost sites that were more protected than the exposed foraging areas, but the overall energy savings at these sites did not offset the cost of flying there. This suggests that protection from rare, unpredictable, catastrophic (survival-reducing) winter weather may be more important than minimizing nightly energy expense on most nights. On the northern Chesapeake, as in Oregon, eagles did not save energy by flying back to the protected communal roosts at night, despite the fact that distances and flight costs were rather small (Buehler et al. 1991b).

The studies in Oregon and the Chesapeake suggest that roost-site selection is not driven by energy balance considerations alone. Most roost sites, however, are located in areas that are at least protected from prevailing winter winds, regardless of whether they occur in coniferous or deciduous trees (Hansen et al. 1980; Stalmaster and Gessaman 1984; Keister et al. 1985; Buehler et al. 1991b). Site characteristics that facilitate social interaction in communal roosts, such as information exchange (Ward and Zahavi 1973), also may affect roost-site selection.

Roost-site characteristics in Tennessee have not been well documented. Roost-site characteristics, however, are expected to be similar to the characteristics reported elsewhere in the eastern United States. Eagles probably select conifers if they are available in large sizes or else eagles select mature deciduous trees, such as oaks, poplars, and hickories. The macro-scale characteristics (proximity to water, avoidance of human

developments and human activity, protection from prevailing winter winds, and location in large forest blocks) are expected to be similar to those reported for the northern Chesapeake because of the similarities in forest composition and the availability of mature, forested tracts near suitable foraging habitat in Tennessee.

1.1.3 Foraging Habitat

Foraging habitat can be characterized based on the foraging opportunities that are located close to suitable nesting and roosting habitat. Because eagles are opportunistic foragers, their food habits can be highly varied (Todd et al. 1982; Stalmaster 1987; Mersmann 1989). Food habits tend to be site-specific, based on prey species available in a given area. In most regions, bald eagles seek aquatic systems and prefer fish whenever they are available (Wright 1953; Spencer 1976; Steenhof 1978; Stalmaster 1987; DeLong 1990). Bald eagles, however, have been reported eating a great variety of aquatic and terrestrial mammals, including muskrats (*Ondatra zibethicus*) and hares (*Lepus* spp.); reptiles and amphibians; crustaceans; and a variety of birds, including many species of waterfowl and gulls (*Larus* spp.); and even great blue herons (*Ardea herodias*) [see Stalmaster (1987:182–183) for review].

In Tennessee, eagles exhibit similar trends in being opportunistic foragers and probably preferring fish. Good foraging habitat for eagles can be defined by conditions that make fish available to the limited fishing ability of eagles. Eagles typically forage at or near the surface of any body of water. Shallow water increases the likelihood that live fish will be available to eagles because the limited depth of the water column brings the fish closer to the surface (Todd et al. 1982; Stalmaster 1987; MacDonald and Austin-Smith 1989; Mersmann 1989; Livingston et al. 1990). Live fish species most available are those that spend much time near the surface or that naturally occur in shallow water, such as gizzard shad (*Dorosoma cepedianum*), threadfin shad (*D. petenense*), and white bass (*Morone chrysops*). Benthic-dwelling species, like catfish (*Ictalurus* spp.), were seized dead on the Chesapeake, floating on the surface (Mersmann 1989), contrary to reports by Haywood and Ohmart (1986) of the capture of benthic-dwelling species live.

In addition to capturing live fish, eagles gain food from natural or human-caused events that kill fish. Dead fish can provide an important component in the eagle's diet. On the northern Chesapeake, dead fish comprised 25–67% of all fish seized by eagles, even though the relative abundance of dead fish was generally low (Mersmann 1989; DeLong 1990). In Tennessee, turbines at hydroelectric facilities kill and stun fish, making them potentially available to eagles. In addition, high water temperatures and oxygen depletion during hot periods in summer or oxygen depletion in iced-over areas during severe winters can lead to sporadic fish-kills that eagles can take advantage of (Mersmann 1989; DeLong 1990).

The quantity of foraging habitat within a given distance from nesting habitat also contributes to habitat suitability. Areas with greater water surface area, everything else being equal, will have greater habitat suitability. The amount of foraging habitat actually required, however, depends on the quality of that habitat.

An order-of-magnitude estimate of the amount of habitat required per breeding pair can be derived by examining eagle territory size during the breeding season. Territory size varies with habitat quality and breeding density (Newton 1979). Territories in poor-quality habitat will be larger than territories in high-quality habitat, and territories in saturated habitats will be smaller than territories in sparsely populated areas (Newton 1979; Stalmaster 1987). Territory size across the eagle's range may average 1–2 km² (Stalmaster 1987), although two territories delineated by visual observation at Cross Creeks National Wildlife Refuge in Tennessee each exceeded 10 km² (Floyd 1990). If these territories were circular, the diameter of the territory would be about 2 km. On the northern Chesapeake, one radio-tagged adult always stayed within 3 km of its nest site during the breeding season, although this area reflected the home range size rather than a defended territory (Buehler et al. 1991c).

The amount of aquatic surface area within a 2- to 3-km zone around the nest would be one measure of the quantity of foraging habitat. A better measure, however, would be the surface area of "shallow" water within that 2- to 3-km zone around the nest. Shallow water on the northern Chesapeake was defined as water <2-m deep (Mersmann 1989).

2. STUDY AREA AND METHODS

The study area included portions of Melton Hill Reservoir, navigable tributaries, the Clinch River, and adjacent inland areas; the total was approximately 60 km of river (Fig. 1). The study area extended from the Route 62 bridge over Melton Hill Reservoir downstream to the Melton Hill Dam, and continued downstream on the Clinch River to river mile 10 at Brashear Island, below the K-25 Site. In addition to the riverine habitat, the study also evaluated terrestrial habitat within 3 km of the river-reservoir shoreline, which defines an eagle management zone (Fig. 2). A distance of 3 km from the shoreline was selected as an outer limit beyond which eagles were unlikely to seek nesting habitat, on the basis of average distances from nests to foraging areas reported elsewhere. It is possible, although unlikely, that eagles will nest >3 km from water.

A shoreline boat survey was conducted along all shoreline areas during weekends in May, June, and July 1992 to document human activity levels. Surveys began at 1 hour after sunrise and alternated between starting at the Route 62 end of Melton Hill Reservoir and the Brashear Island end of the Clinch River. All shoreline areas were surveyed to the limits of navigation. One-half of the study area was surveyed on one weekend day (for example, from the Route 62 bridge to the Melton Hill Dam on a Saturday), and the rest of the shoreline, from Melton Hill Dam to Brashear Island, was surveyed on the other weekend day (Sunday). This sampling strategy negated any differences in human activity between Saturdays and Sundays.

The location of all human development in the study area was digitized from 1985 U.S. Department of Energy (DOE) 1:24,000-scale topographic maps (based on 1984 aerial photography) through the use of ARC/INFO computer software (Environmental Systems Research Institute, Inc., Redlands, California) (Fig. 3). A 500-m buffer zone was delineated around each human development to create a human-development coverage for the habitat suitability model. The buffer distance (500 m) was selected on the basis of a review of literature pertaining to eagle tolerance of human development (Andrew and Mosher 1982; Fraser et al. 1985; Anthony and Isaacs 1989; Bohall Wood et al. 1989; Livingston et al. 1990; Buehler et al. 1991d; McGarigal et al. 1991).

An additional development coverage was created from the U.S. Geological Survey (USGS) Land Use and Land Cover (LULC) data base (Anderson et al. 1976) by selecting human-developed polygons from that coverage and delineating 500-m buffers around each of those areas. The LULC data base was developed in 1978; and some additional development has occurred since then. When combined with the development coverage described above, however, the final coverage contained all but the most recent developments. Areas within the development coverage were assigned a suitability score of 0, whereas areas outside the development coverage were assigned a score of 1 (Fig. 4).

Fig. 1. Melton Hill Reservoir and adjacent areas of the Clinch River included in the habitat evaluation.

Fig. 2. Bald eagle management zone, defined as a 3-km buffer zone around Melton Hill Reservoir and the Clinch River.

Fig. 3. Developed areas around Melton Hill Reservoir and the Clinch River.

Fig. 4. Unsuitable habitat in the eagle management zone, based on a 500-m buffer zone around developed areas.

The vegetation on the study area was evaluated in a two-step process. The USGS LULC data base was used to delineate basic cover types and land-use classes, including human-developed, cropland, rangeland, forest, water, wetlands, and transitional (Anderson et al. 1976) (Fig. 5). Forest classes included deciduous, coniferous, and mixed. The minimum block of habitat delineated was 4 ha.

Field surveys were conducted in April–May 1993 to evaluate the suitability of individual cover-type polygons on the study area in relation to bald eagle habitat requirements, including tree diameters and heights, tree species composition, and stand canopy cover. On the basis of the on-site inspection, cover-type polygons were assigned a habitat suitability score of 0–10.0. A score of 0 implied the habitat was unsuitable for eagles, primarily because human development was present in the area and precluded eagle use. A score of 3.3 was assigned to marginal-quality habitats, reflecting the general lack of forest cover (pasture and field habitats). Eagles could nest in this habitat if a suitable tree was present along a fencerow or in a small woodlot, although eagle use would be unlikely. Habitats with fair suitability received a score of 6.7. These habitats were primarily forested, but stand age and structure were marginal, containing only a few trees capable of supporting nesting. Habitats receiving a rank of 10.0 reflected highly suitable conditions, including the presence of many mature trees suitable for nesting or roosting with little human disturbance in the immediate area. In field surveys, some polygons were reclassified to other covertypes (e.g., cropland to human-developed), on the basis of changes in the vegetation or land use that have occurred since 1978. In addition, some polygons were subdivided to reflect field-documented changes over a portion of the polygon.

The shoreline boundaries of Melton Hill Reservoir and the adjacent areas of the Clinch River were digitized from the DOE topographic map. The effect of distance from the water was incorporated into the habitat suitability evaluation by creating three 1-km buffer zones in ARC/INFO radiating outward from Melton Hill Reservoir and the Clinch River (Fig. 6). A distance of 3 km was selected as the outer limit of the analysis for reasons stated above. The author assumed the energetic cost to an eagle of locating a nest further away from water affected habitat suitability in a linear fashion; as a result, habitats within 1 km of the water received a distance score of 1.00, habitats 1–2 km from water a distance score of 0.67, and habitats 2–3 km from water a distance score of 0.33.

The foraging area characteristics were evaluated on the basis of the surface area of water available within 5-km sections along the main axis of Melton Hill Reservoir and the Clinch River. Although water depth also is an important determinant of foraging habitat quality (see Introduction, Sect. 1), it was not evaluated because of the lack of an existing digital data base. Digitizing this information was deemed too labor intensive. Each river section was scored on the basis of the ratio of the available surface area of water in that section to the surface area present in the section with the greatest amount of water.

Fig. 5. U.S. Geological Survey land cover types on the study area (based on Anderson et al. 1976).

Fig. 6. Distance buffer zones (1 km, 1-2 km, and 2-3 km) around Melton Hill Reservoir and the Clinch River. The buffer zones are used to evaluate the effect of distance on habitat suitability.

Foraging habitat scores ranged from 0.24, for the section with the least water, to 1.00, for the section with the greatest water (Fig. 7).

The bald eagle habitat suitability model was developed by overlaying successive coverages (maps) of vegetation, human development, distance zones, and foraging area with the use of ARC/INFO. The habitat suitability for each polygon in the study area was calculated on the basis of the following model:

$$\text{HABITAT SUITABILITY} = \text{VEG} \times \text{DEV} \times \text{DIS} \times \text{FOR}$$

where

VEG = vegetation suitability score

DEV = development score

DIS = distance score

FOR = foraging area score

As a result of defining this habitat suitability model, the final habitat suitability score for each polygon ranged from a low of 0, reflecting unsuitable conditions, to a high of 10.0, reflecting the highest suitability on the study area.

To evaluate the effect of development of the ANS site, the approximate boundaries of the ANS site were sketched onto the DOE topographic map after consultation with ANS engineering staff. The boundaries were digitized from the topographic map through the use of ARC/INFO. A 500-m buffer was placed around all ANS site boundaries to approximate the ultimate impact area from an eagle's perspective. The resultant coverage was used to clip out the potential eagle habitat that was contained in the original model. A comparison of the hectares of habitat that were clipped out of the original model represents an estimate of the impact of ANS site development on overall eagle habitat suitability of the Melton Hill Reservoir–Clinch River area.

Fig. 7. Bald eagle foraging habitat suitability (FOR), calculated as the ratio of water surface area (upper number) to total land area (lower number) per section.

3. RESULTS AND DISCUSSION

Habitat quality on Melton Hill Reservoir and adjacent areas of the Clinch River was largely limited by the presence of human development. Of the more than 28,000 ha of terrestrial habitat available for eagle use in the 3-km zone defined around the aquatic areas, more than 60% (17,765.3 ha) was deemed unsuitable because of human development. Almost all of the privately owned southern side of the reservoir–river was classed as unsuitable because of human development (Fig. 8). This pattern presents a stark contrast to the federally owned northern side of the aquatic areas. Even on the northern side, however, human development accounts for a considerable portion of the available area in the eagle management zone.

Only 5 polygons, covering a total of 270.8 ha, contained high-quality habitat (habitat score between 8.0 and 10.0) in the Melton Hill–Clinch River area (Table 1, Fig. 8). All of the high-quality habitat was located in the area around Bearden Creek and Gallaher Bend. All of the 1206.2-ha of good-quality habitat (habitat score of 6.1–8.0) was also located in the Bearden Creek–Gallaher Bend area (Fig. 8). These findings suggest that this area contains the best habitat on the study area. Large amounts of lower quality habitat exist throughout the rest of the study area, yielding a total of 10,427.0 ha of suitable habitat in the 30,144-ha eagle-management zone (Table 1).

Most of the suitable habitat was associated with Melton Hill Reservoir rather than the Clinch River primarily because Melton Hill provided more aquatic foraging area than the Clinch River (Fig. 7). If water depth had been included in the analysis, the results would not have changed, because the area around Gallaher Bend represents one of the largest shallow water areas on Melton Hill Reservoir.

Human activity was not directly incorporated into the habitat suitability model because of its ephemeral nature. Humans (boaters or people on shore) reduced habitat suitability while they were present (McGarigal et al. 1991), although their presence was generally limited to short periods (weekends). The human-activity surveys identified high human-activity areas (Fig. 9). Human activity from shore was limited primarily to areas below the Melton Hill Dam where people were fishing from the bank. Boating activity was much more dispersed and consisted primarily of fishing. Boating activity, including fishing, was more extensive on Melton Hill Reservoir with about one boat observed per 32 ha of surface water per survey in comparison with one boat per 84 ha of water per survey on the Clinch River. The narrow channel of the Clinch provides little buffer between eagles and boaters, however, which may negate the benefits of the lower levels of activity on the Clinch.

The area around the proposed ANS development contains the highest quality habitat in the study area (Fig. 10). The ANS site impact area, including a 500-m buffer around all

Fig. 8. Bald eagle habitat suitability on the study area.

**Table 1. Amounts (ha) of potential bald eagle habitat of differing qualities
on the Melton Hill Reservoir–Clinch River study area**

Number of polygons	Mean size (ha)	Habitat score	Total area (ha)
132	34.3	0.1–2.0	4524.1
95	32.1	2.1–4.0	3048.6
25	55.1	4.1–6.0	1377.3
23	52.4	6.1–8.0	1206.2
5	54.2	8.1–10.0	270.8
Total Eagle habitat			10427.0
Total Water			1951.7
Total Unsuitable terrestrial			17765.3
Total Within 3 km of water			30144.0

Fig. 9. Human activity (boats and people on shore) on Melton Hill Reservoir and the Clinch River.

Fig. 10. Bald eagle habitat suitability in the vicinity of the Advanced Neutron Source site.

site developments, will cover an estimated 627.5 ha. Site development will lead to the loss of 244.9 ha of potential eagle habitat, including 75.8 ha of good-quality habitat (habitat score of 6.1–8.0) and 169.1 ha of lower quality habitat (habitat score of 0.1–6.0) (Fig. 11). This habitat loss represents 2.3% of the total contained in the study area, and is insignificant on that basis. Because the site is located adjacent to the area with the best habitat, the impact of ANS development may increase in significance.

The area immediately north and east of the ANS site appears to have sufficient habitat to provide for at least one bald eagle breeding territory (>100–200 ha of suitable habitat) (Fig. 11). ANS site development would not detract significantly from the ability of this area to support a breeding pair. Site development would in all likelihood discourage a breeding pair from using both the area to the north of the site and the area to the south of the site. The area directly east of the ANS site and south of Bearden Creek also may contain sufficient habitat to support a breeding pair. Site development would tend to isolate this block of highly suitable habitat from other suitable areas on this part of Melton Hill Reservoir.

3.1 MODEL LIMITATIONS

It is important to note that results described above identify areas of *potential* bald eagle habitat. The underlying model has been developed from habitat relationships developed from information collected from throughout the bald eagle's range. Because nesting has never occurred in the study area, it is impossible to develop a model with site-specific habitat selection data. Wherever possible, regional data were incorporated into the analysis. For this reason (or possibly simply because of chance events), actual habitat selection by eagles in the study area may ultimately be different from the predicted habitat selection.

Fig. 11. Bald eagle habitat suitability after development of the Advanced Neutron Source site.

4. MANAGEMENT IMPLICATIONS

Melton Hill Reservoir and adjacent areas of the Clinch River contain modest amounts of potential bald eagle habitat. Unfortunately, given the pattern of land ownership (federal on the northern side and private on the southern side), the distribution of suitable habitat is limited to primarily the northern side of the reservoir-river. This situation will limit the suitability of the system to support significant numbers of breeding bald eagles.

Based on the results of this study, it appears that there is sufficient habitat along Melton Hill Reservoir to support breeding bald eagles. The highest quality and largest block of habitat is in the Bearden Creek-Gallaher Bend area. Given the expansion of the eagle breeding population in Tennessee and the introduction efforts in eastern Tennessee on the Douglas and South Holston reservoirs, establishment of a breeding population on Melton Hill Reservoir may occur without proactive management on ORR. Despite the block of suitable habitat on Melton Hill, development in surrounding areas may make Melton Hill less attractive to breeding eagles than other less-developed reservoirs in the region (Douglas, Cherokee, Norris, Watts Bar, and Tellico). If establishment of a breeding population on ORR becomes a management objective, ORR land managers could consider pursuing one or several of the following strategies:

1. Minimize development in areas with existing high-quality habitat;
2. Allow natural forest maturation to progress within 1 km of shoreline areas;
3. Use timber stand improvements (thinning) to promote desirable forest conditions within 1 km of shoreline areas;
4. Introduce juvenile eagles to the area (hack) to accelerate colonization of suitable habitat.

The above strategies can be implemented singly or in any combination to develop an overall management program for eagles on ORR. A more detailed explanation of each option follows.

1. **Minimize development in areas with existing high-quality habitat.**

This option requires relatively minimal management inputs, although it involves long-term commitment of land resources to eagle and other wildlife management. To implement this strategy, the habitat suitability model would be used to identify the

key blocks of existing habitat worthy of protection. The value of these areas to eagles and the need for their protection would be considered in the overall land management planning for ORR. This planning would be especially important when siting future projects that involve physical development and long-term commitment of land resources.

2. Allow natural forest maturation to progress within 1 km of shoreline areas.

This strategy also requires minimal management input and would occur without any change in current land management policy. To implement this strategy, future timber management activities need to be limited to low-quality stands if they occur within 1 km of a target shoreline area. Low-quality pine pole stands damaged by the southern pine beetle could be harvested under this strategy without affecting eagle habitat suitability. High-quality pine or hardwood stands that have good growth potential and are located within 1 km of the shoreline would be left to mature.

3. Use timber stand improvement (thinning) to promote desirable forest conditions within 1 km of shoreline areas.

This strategy would involve taking a more proactive forest management approach to create higher quality habitat conditions over time. Timber stand thinnings, especially in the pine stands, could be used to create a more open canopy and promote better growth and development of the remaining trees. A similar approach could be used in hardwood and mixed stands to promote individual trees with good growth potential. Thinning that favors species typically used for nesting (e.g., oaks) would promote development of stands of suitable trees for nesting, perching, and roosting.

4. Introduce juvenile eagles to the system (hack) to accelerate colonization of suitable habitat.

This strategy is the most management intensive and raises questions about its feasibility for ORR. Introduction methods are well established, and a successful introduction program has been implemented on several eastern Tennessee reservoirs. Given the amount of unoccupied habitat in eastern Tennessee on adjacent reservoirs, this approach may be required to substantially increase the probability of establishment of a breeding population at ORR. The Tennessee Wildlife Resources Agency (TWRA) has supported this strategy elsewhere in the state, although the TWRA has decided not to directly sponsor any additional introduction efforts. The TWRA is willing to cooperate in introduction efforts that are sponsored by other public or private groups that have a significant chance for success (Hatcher, R., Tennessee Wildlife Resources Agency, personal communication).

The primary question about the feasibility of an introduction program for ORR involves the potential impact of environmental contaminants rather than the habitat suitability. Because of the number of contaminated areas on ORR and the sensitivity of bald eagles to contaminants, eagles could become contaminated and possibly affect their offspring. The potential of such contamination, of course, exists whether or not eagles are introduced to ORR. A very limited number of eagles are observed on ORR each year during the winter. An introduction program would increase the presence of eagles in this area and thus increase the potential for exposure of eagles to contaminants. Because bald eagles are an endangered species, encouraging their use of a contaminated environment may be inadvisable.

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BALD EAGLE HABITAT SUITABILITY - MELTON HILL AND ADJACENT AREAS

HABITAT SCORE

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