CHAPTER 4 - AFFECTED ENVIRONMENT

The existing conditions of various environmental resources that could be affected by implementation of the proposed NRP are described in this chapter. Because of the nature of this project, TVA has determined that adoption of the No Action or any Action Alternative would not result in waste stream generation or alteration involving solid or special wastes. Likewise, TVA has determined there would be no impacts to noise or traffic.

4.1. Recreation

4.1.1. Facility-Based Recreation

For the purpose of this EIS, the discussion of facility-based recreation focuses primarily on those recreation areas and facilities owned by TVA. The majority of TVA recreation facilities occur on TVA dam reservations and on other TVA reservoir lands allocated to Zone 6 - Developed Recreation. Developed recreation facilities are also located on TVA's.Bellefonte and Browns Ferry Nuclear, Raccoon Mountain Pumped-Storage, and John Sevier, Cumberland, and Kingston Fossil Plant reservations. TVA also owns 81 stream access sites located on streams and rivers throughout the Tennessee River watershed. Recreation facilities on dam and power plant reservations are typically operated by TVA. Other TVA recreation facilities are either operated by TVA or by another party under contract with TVA. TVA recreation facilities make up a notable proportion of all of the recreation facilities located in the TVA region (Table 4-1).

Table 4-1. Recreation Facilities Located Within the TVA Region

Facility Type	Number in TVA region	Number of TVA Facilities	Percent of Facilities in Region Managed by TVA
Picnic tables	4,000	400	10
Pavilions	400	16	4
Trail miles	3,100	100	8
Fish berms/piers	250	25	10
Swimming beach	150	12	8
Swimming/splash pools	150	0	0
Playgrounds	400	6	2
Play courts	400	6	2
Golf courses	500	0	0
Amusement parks	65	0	0
Visitor centers	40	9	23
Overlooks	75	22	29
Museums	400	0	0
Campsites with water and electric hookups	18,000	270	2
Campsites without water and electric hookups	5,000	400	8
Boat ramps	1,200	49	4
Boat ramp parking	24,000	1,200	5
Wet boat slips	35,000	0	0
Dry boat slips	5,000	0	0

Facility Type	Number in TVA region	Number of TVA Facilities	Percent of Facilities in Region Managed by TVA
Stream access sites	200	81	41

Source: Extracted from State Comprehensive Outdoor Recreation Plans inventory data for TVA region states

Recreation demand is driven by population levels, recreation participation rates, changing preferences for different types of recreation, and innovations in recreation equipment. Analysis of the current U.S. Census data provides estimates over the next 20 years of population increases of about 17 percent for the TVA region (Table 4-15). Assuming that current participation rates remain relatively constant, recreation demand is anticipated to grow in direct proportion to the population. Consequently, public use of TVA lands, shoreline, and waterways to fill the recreation demand will likely increase.

TVA currently has around 21,200 acres committed to helping fill demand for developed recreation through their designation as Zone 6 - Developed Recreation in RLMPs. About 2,100 acres (10 percent) of this Zone 6 land is not committed through a land use agreement to developed recreation and a small portion of the committed land is not yet developed. If TVA chooses to assist in filling the projected increase in recreation demand over the next 20 years and provide the same proportion of facilities as listed in Table 4-1, it would require an additional commitment of around 3,500 to 3,600 acres and increased development of facilities and infrastructure by between 18 and 19 percent. TVA currently provides around 5 to 10 percent of the public recreation facilities in the region, and TVA could choose to operate in that range over the next 20 years.

As described in Section 2.3, TVA operates several campgrounds and day use recreation areas. TVA currently has land use agreements for the operation of 164 campground and 135 marinas on its Zone 6 lands by private and other public operators. These are a major component of the approximately 350 campgrounds and 190 marinas in the region. Assuming that most facilities are operating at or close to their capacity, there would need to be an overall increase of an additional 63 to 67 campgrounds and 34 to 36 marinas to provide for recreation needs over the next 20 years.

TVA would continue to provide land use agreements for public and commercial recreation facilities on TVA lands. Currently, TVA provides land for 24 state parks. In order to meet demand over the next 20 years, TVA would need to provide land and funding assistance for up to four additional state parks as the increasing population increases demand for recreation facilities in the region. Probable locations for these state parks include lands at Douglas, Watts Bar, Fontana, and Kentucky reservoirs.

TVA's current recreation strategy includes a process to ensure access to TVA's technical staff in support of recreation needs throughout the region. This process is known as the "Power Service Protocol." TVA staff provides planning and technical services for new or existing parks, recreational programs and other public-oriented facilities in the TVA power service area on a fee or sponsorship basis. Services include recreation consultation and access to TVA's library of standard plans and site plans.

4.1.2. Dispersed Recreation

TVA manages approximately 220,000 acres that are available for dispersed recreation activities. Examples of popular dispersed recreation activities on TVA lands include hiking, bank fishing,

wildlife observation, hunting, and primitive camping. Lands suitable for dispersed recreation are primarily those zoned for Natural Resource Conservation (Zone 4) and Sensitive Resource Management (Zone 3). Dispersed recreation opportunities also occur on several dam reservations (Zone 2) and on some lands zoned for Developed Recreation (Zone 6) but not yet developed. It is estimated that 6 million people engage in dispersed recreation activities on TVA lands annually (Cardno ENTRIX 2011). The general trend is rising participation rates for dispersed recreation in the Tennessee Valley region (Table 4-2).

Table 4-2. Dispersed Recreation Participation in the 125-County Tennessee River Watershed

Dispersed Recreation Activities	Participants in 2004, Millions	Projected Participants in 2010, Millions
Canoeing	0.35	0.5
Day Hiking	1.76	2.48
Migratory Bird Hunting	0.08	0.11
Kayaking	0.11	0.15
Rock climbing	0.2.0	0.27
Orienteering	0.06	0.08
Primitive Camping	0.84	1.12
Backpacking	0.44	0.58
Warmwater fishing	1.54	1.92
Swimming	1.78	2.02
View birds	1.57	1.96
Big Game Hunting	0.48	0.52
Small Game Hunting	0.51	0.65
Total All Activities	**9.72**	**12.36**

Source: Cordell et al. 2006

Most TVA land is in relatively narrow strips along the shoreline of TVA reservoirs. Of the approximately 11,000 miles of reservoir shoreline, approximately 6,800 miles is TVA-owned and managed and not encumbered by the access rights of adjacent residential landowners (TVA 1998). The spatial configuration of TVA lands is unique in that many large population centers are in close proximity to TVA land and dispersed opportunities. That is, for many Tennessee Valley residents, TVA land is the closest land to their residence which offers dispersed opportunities. While many dispersed recreation enthusiasts will travel once or twice a year to engage in their chosen activity, lands close to home provide “everyday” access to these activities.

In times of economic downturn and uncertainty recreational activities which are close to home and cost effective are often preferred. This highlights the importance of TVA lands being in close proximity to large population centers. In addition, dispersed activities on TVA lands do not require user fees which allow members from all economic classes to participate. With general trends in participation of dispersed recreation activities rising and these opportunities being available to a wide segment of the public, TVA lands are experiencing increased pressures and only become more valuable to the public as dispersed recreation assets.

TVA lands also serve as the conduit which allows the public access to the reservoirs. Recreationists who engage in water-based reservoir recreation utilize TVA lands to facilitate those activities. On many reservoirs, TVA lands are the only free public access to the water allowing for many dispersed opportunities.

TVA manages over 100 miles of trails for public use. Many trails offer multi-use opportunities such as hiking, horseback riding, and mountain biking while others are considered for foot traffic only. Trails are an important aspect of dispersed recreation management as they facilitate some of the most popular, and growing, dispersed activities such as day hiking. Trails also offer access to interior portions of TVA managed lands and facilitate other popular activities such as wildlife observation and bank fishing.

As discussed above, dispersed recreation use of TVA lands is growing. As use increases, the associated impacts resulting from this use increases as well. Impacts from use can damage the ecology of an area as well as diminish the experience of the user. For example, dispersed camping can alter or kill vegetation where tents and fire rings are placed and litter left behind after the activity is unsightly for the next user of that area. In addition, as different types of use increases the potential for user conflicts grows. Proper management is key to ensuring environmental impact is kept to a minimum and user experience remains positive.

4.2. Natural Areas

Natural areas are lands designated for a particular management objective or lands that are known to contain sensitive features or resources (TVA 2002e). For example, TVA has designated lands for protection and enhancement of sensitive resources and other features important to the area viewscape or natural environment (TVA 2010b). These lands are also managed for the enhancement of natural resources for human use and appreciation. Recreational activities, such as hunting, wildlife observation and camping on undeveloped sites, may occur in these areas. However, the overriding focus of the natural area is protecting and enhancing the sensitive resources. Natural areas may provide habitat for nationally or regionally rare species, contain exemplary biological communities and geological and important scenic features, and provide opportunities for ecological research, environmental education, or high-quality, nature-oriented recreation.

TVA natural areas (Figure A-9, Appendix A) include small wild areas (SWAs), habitat protection areas (HPAs), ecological study areas, and wildlife observation areas (WOAs) and are defined in the following paragraphs. TVA manages these areas to restrict activities that might alter or destroy significant natural elements. TVA conducts specific management activities that are suitable for a particular natural area designation (TVA 2002e). Examples of management activities are listed in Section 2.1.2. There are 31 TVA SWAs located throughout the TVA region (Figure A-9, Appendix A).

SWAs are locations with exceptional natural, scenic, or aesthetic qualities suitable for low impact public use. Appropriate development is undertaken (e.g., foot trails, signs, parking areas, backcountry campsites) to provide recreational opportunities for the public while also protecting and enhancing their exceptional qualities. SWAs require on-site assessments for determination of their condition and maintenance needs to ensure that management objectives are met and the integrity of the areas and their sensitive resources are intact.

There are 111 TVA HPAs (Figure A-9, Appendix A). HPAs are established to protect populations of species that have been identified as threatened or endangered by the USFWS or that are rare in the state in which they occur. Unusual or exemplary biological communities or

unique geological features may also be designated as HPAs. They normally have little to no development to accommodate public use. HPAs require on-site assessments for determination of their condition, status of their target species or features, and maintenance needs to ensure that management objectives are met and the integrity of the HPA and their sensitive resources are intact.

There are five TVA ecological study areas (Figure A-9, Appendix A). They consist of locations suitable for ecological research or environmental education. These areas are usually large enough to allow establishment of both experimental and control research plots. These areas typically contain plant or animal populations of scientific interest or are usually located near an educational institution that will utilize and manage the area. Ecological study areas require on-site assessments for determination of their condition, status of plant and animal populations and vitality, and maintenance needs to ensure that management objectives are met and the integrity of the ecological study area and sensitive resources protected there are intact.

There are six TVA WOAs (Figure A-9, Appendix A). The WOAs have concentrations of watchable wildlife (e.g., shorebirds, songbirds, and waterfowl) and typically are found in drawdown zones, dam reservations, urban wetlands, and bluffs. They are typically established in cooperation with TWRA's Watchable Wildlife Program. WOAs require on-site assessments for determination of their condition and maintenance needs to ensure that management objectives are met and the integrity of the WOA and resources located there are intact.

There are 229 natural areas and ecologically significant sites occurring on or adjacent to TVA lands and managed by other agencies under contractual agreements (Figure A-10, Appendix A). These non-TVA-managed areas consist of state parks, local city parks, county parks, state and national trails, state natural areas, potential and existing national natural landmarks, state wildlife management areas, national wildlife refuges, streams listed on the Nationwide Rivers Inventory, research natural areas, camps, state and national forests, mussel sanctuaries, fish hatcheries, historical areas, cultural areas, greenways, and WOAs.

There are an additional 2,379 non-TVA natural areas and ecologically significant sites throughout the TVA region not occurring on TVA lands. These additional non-TVA natural areas are not within the scope of this project.

Ecologically significant sites are areas that have some ecological or scenic significance occurring on or immediately adjacent to TVA lands. They are not necessarily managed by TVA. Several criteria are used to designate ecologically significant sites, including the following:

- Species that are listed or proposed for listing as endangered or threatened by the USFWS
- Species listed as endangered, threatened, or otherwise sensitive by any of the seven Valley states
- Unique or exemplary geological or scenic features and biological communities

Most ecologically significant sites have approximate boundaries and include designated critical habitats, potential national natural landmarks, nonessential experimental population status areas, colonial bird nesting areas, champion trees, and other areas deemed ecologically significant. Some of these locations may have a steward responsible for active or passive management of the site.

Status, Trends, and Management Needs of TVA Natural Areas
Several factors can affect the condition of natural areas. Natural events such as landslides, storm damage, wildfire, and plant succession can radically alter important habitat; human disturbance can eliminate plant and animal populations; and litter or overuse can destroy aesthetic qualities. Often a “hands off” policy with regular monitoring of significant elements is sufficient. However, some plant and animal populations and other natural features are vulnerable to human disturbance and stringent measures must be taken to protect them. Roads may have to be blocked, trails may need to be maintained or obscured, and cave entrances may need to be gated. Several species require active management to ensure their survival. Wetlands or meadows may have to be burned; other areas may require hand clearing.

Current management issues for TVA natural areas include: frequency of monitoring, lack of management plans, invasive species, vegetation management, trail maintenance, boundary marking and signage, maintenance of facilities, gates and barriers, litter and dumping, improper use, adjacent land-use and encroachment.

Because of budget constraints, TVA does not monitor its natural areas on a regular cycle. TVA staff has recently opportunistically assessed 9 of TVA’s 154 natural areas; these 9 areas comprise about 15 percent of the approximately 15,000 acres of TVA natural areas. An additional 19 natural areas totaling 1439 acres have been recently assessed as part of the Land Condition Assessment (LCA; see Section 2.1.3). Five TVA natural areas have area-specific management plans.

Vegetation management of natural areas is important in eradicating or controlling invasive plants, maintaining trails, and wildlife enhancement. Invasive species are a large threat to TVA Natural Areas and were present on 6 of the 9 opportunistically inspected areas. Based on the LCA invasive plant assessment criteria, 5.4 percent of the natural area acreage was considered poor (greater than 25% coverage of invasive plants), 53.4 percent considered fair (between 5% and 25% coverage), and 41.2 percent considered good (less than 5% coverage). Using these criteria estimates, 180 acres (12.5%) are infested with one or more invasive plants. Assuming the 12 assessed natural areas are representative of all TVA natural areas, approximately 1,875 acres of TVA’s approximately 15,000 acres of natural areas are infested with invasive plants.

Developed trails occur on 19 TVA natural areas. LCA results identified four natural areas with trails that needed maintenance in the form of tree removal or had recently had downed trees removed. Four of the nine opportunistically assessed natural areas contained formal trails; all of these trails were in relatively good shape with only minor repairs needed to hand railings and steps. This is not typical of SWA trails, where tree removal and minor to major repairs to bridges, steps, and hand railings are commonly needed. Other trail maintenance activities can include repairing erosion and washouts, installing and maintaining erosion control devices, and maintaining and restoring trail tread (footpath surface).

Boundary marking and signage maintenance is necessary for all TVA natural areas to ensure that the property and trails, if present, are properly marked. Signs are used to direct the public to the natural areas where low impact recreation is allowed and are placed on roads, trailheads, along trails for directional use. Signs also alert the public to use cautionary measures along bluffs or waterfalls. Of the 9 opportunistically assessed natural areas, 7 had proper boundary markers and the 4 with formal trails had proper trail markers. All 9 of these areas needed signs replaced or added and trail markers repainted due to fading. Twelve of the 19 areas assessed by the LCA needed signs replaced or added and boundaries marked.

A common problem at TVA natural areas is littering and illegal dumping; trash was noted at all 28 areas recently assessed by the two methods. Littering and illegal dumping are less of a problem at cooperatively managed TVA natural areas where there may be more frequent visitation by interested user groups and schedule trash clean-ups. Another improper use of high management concern is inappropriate use by off-road vehicles (ORVs), mountain bikers, horseback riders, rock climbers, and cavers and campers. Evidence of these improper uses, mainly from ORVs, was found on 10 of the recently assessed natural areas.

Incompatible adjacent land uses and encroachment are management issues due to their potential for introduction of invasive plants from urban and suburban gardens, tree-cutting, trampling of vegetation from heavy pedestrian or high-impact recreational use, and increased noise. Many TVA natural areas along shorelines have also been impacted by residential encroachment. Of the 9 opportunistically assessed natural areas, 3 had encroachments ranging from slight to major in severity. Encroachments were noted at 11 of the 19 assessed through the LCA.

Identification, protection and management of significant natural areas are a continuing process. As new information regarding occurrences of rare plant and animal species on TVA lands becomes available, additional areas are assessed and those judged significant are proposed for TVA natural area designation. Established natural areas that are consistently monitored are more likely to meet management objectives and ensure that significant elements of each area receive adequate protection. Condition assessments can then be analyzed for issues and resolutions to problems identified can be made. Management practices can be changed, if necessary, to benefit the natural area.

4.3. Terrestrial Ecology

4.3.1. Vegetation

For the purpose of this EIS, the terrestrial ecology discussion focuses on the lands within the combined watershed and power service area. This TVA region encompasses nine ecoregions as illustrated in Figure 4-1 and adapted from Omernik (1987). The terrain across the Valley is diverse from the mountains of the Blue Ridge to the bottomland hardwoods and cypress swamps of the Mississippi Alluvial Plain. This area, rich in biodiversity, is composed of numerous habitats and plant communities and approximately 4,000 species of herbs, shrubs, and trees (A. Weakley and B. E. Wofford, personal communication, July 6, 2010). Much of the region is heavily forested.

Ecoregions

The nine ecoregions spanned by the TVA region include the Blue Ridge, the Ridge and Valley, the Central Appalachians, the Southwestern Appalachians, the Interior Plateau, the Interior River Valley and Hills, the Southeastern Plains, Mississippi Valley Loess Plain, and the Mississippi Alluvial Plain (Omernik 1987).

The easternmost part of the TVA region is in the Blue Ridge ecoregion, an area composed of remnants of an ancient mountain chain. This region has a greater variation in terrain than other regions in the Valley. Terrain ranges from nearly level along floodplains to rugged mountains that reach elevations of more than 6,000 feet. The southern Blue Ridge ecoregion is one of the richest centers of biodiversity in the eastern U.S. and one of the most floristically diverse (Griffith

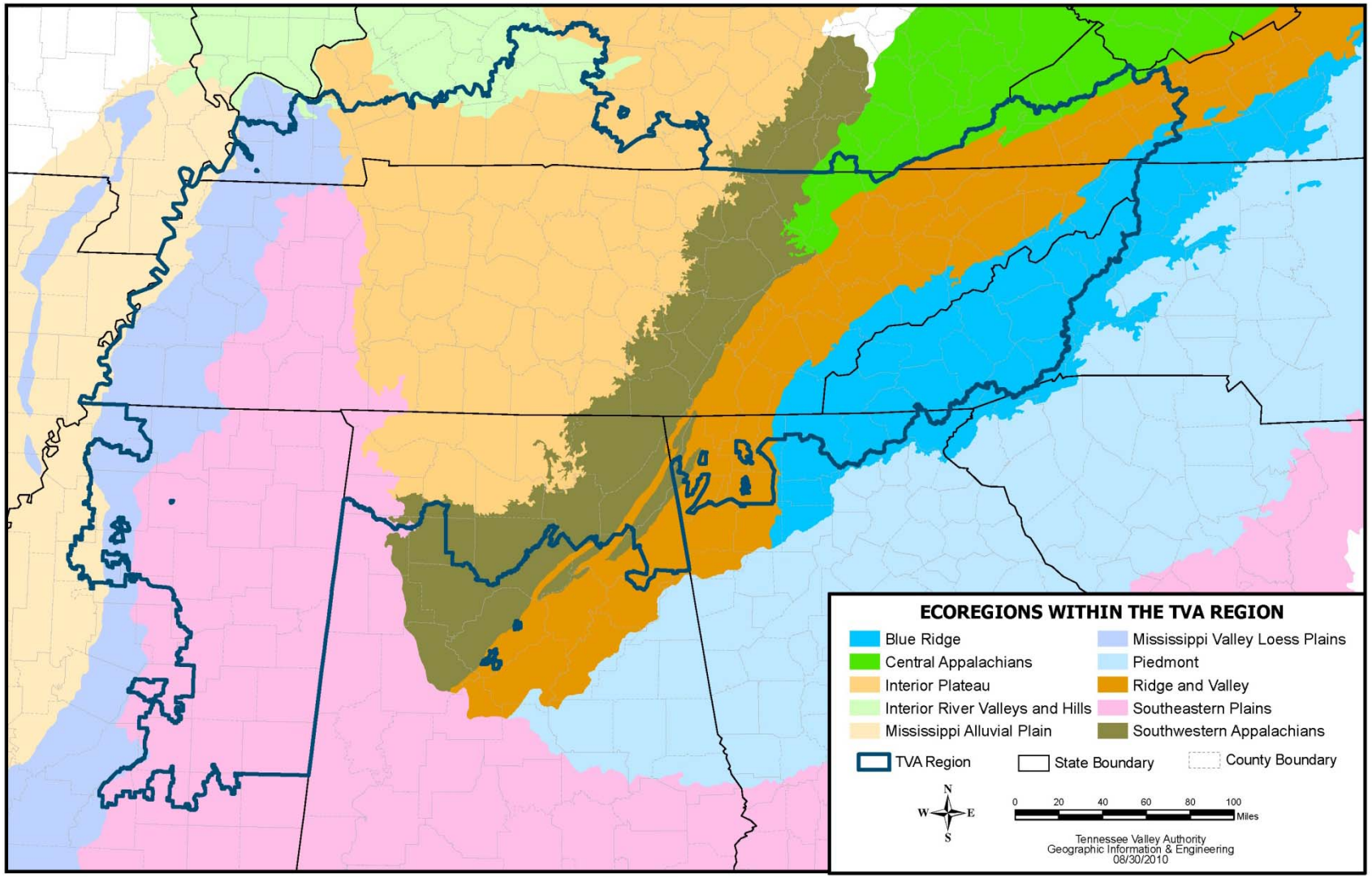


Figure 4-1. Ecoregions Within the TVA Region. Adapted from Omernik (1987).

et al. 1998). The land cover in this ecoregion is dominated (80 percent) by mesophytic forest, which includes the Appalachian oak forest, and 13.5 percent of the land cover is in the form of agriculture (Dyer 2006; USGS 2008). Within the forest regions are several significant plant communities such as the northern hardwood forests, and at the highest elevations in Tennessee and North Carolina, the southeastern spruce-fir forest. Shrub, grass, and heath balds, hemlock, cove hardwoods, and oak-pine communities are also significant. The 11 TVA reservoirs found within the Blue Ridge ecoregion include Apalachia, Blue Ridge, Chatuge, Fontana, Hiwassee, Nottely, Ocoees 1, 2, and 3, Watauga, and Wilbur.

The Ridge and Valley ecoregion is located east of the Southwestern Appalachians ecoregion and west of the Blue Ridge ecoregion. The Ridge and Valley ecoregion has complex folds and faults with alternating valleys and ridges trending northeast to southwest. Ridges have elevations of up to 3,000 feet and are generally capped by dolomites and resistant sandstones on the west sides, and valleys have developed in more soluble limestones and dolomites. The dominant soils in this province are residual clays and silts derived from in-situ weathering. Karst features such as sinkholes and springs are numerous in the Ridge and Valley ecoregion. Soils vary in their productivity, and 56 percent of the land cover is forested (USGS 2008). Mesophytic forest and Appalachian oak forest are the dominate forest regions; southern mixed forest and the oak-pine section occur in the southernmost area of the ecoregion (Dyer 2006). Land cover also includes pasture, intensive agriculture (30 percent), with 9 percent in urban and industrial areas (USGS 2008). Table 4-3 lists the TVA reservoirs and facilities located with the Ridge and Valley ecoregion.

Table 4-3. TVA Reservoirs and Facilities Located Within the Ridge and Valley Ecoregion

Beaver Creek Reservoir	Norris Reservoir
Boone Reservoir	South Holston Reservoir
Cherokee Reservoir	Tellico Reservoir
Chickamauga Reservoir	Watts Bar Reservoir
Clear Creek Reservoir	Bull Run Fossil Plant
Douglas Reservoir	Kingston Fossil Plant
Fort Loudoun Reservoir	John Sevier Fossil Plant
Fort Patrick Henry Reservoir	Buffalo Mountain Wind Farm
Melton Hill Reservoir	Watts Bar Nuclear Plant
Sequoyah Nuclear Plant	

The Central Appalachians ecoregion stretches from central Pennsylvania through West Virginia, Maryland, Virginia, and Kentucky, and into northern Tennessee (Omernik 1987). It is primarily a high, dissected, rugged plateau composed of sandstone, shale, conglomerate, and coal. The Cumberland Mountains of Tennessee and Kentucky are known for their rugged terrain, cool climate, and infertile soils. As a result, this limits agriculture, and most of the land cover is forested. According to USGS (2008), approximately 83 percent of the central Appalachians consist of mesophytic forests with areas of Appalachian oak forests covering the high hills and low mountains. The remaining land use is in the form of agriculture and urban or developed areas. No TVA reservoirs or power generating facilities occur within this ecoregion.

The Southwestern Appalachians ecoregion, subdivided into the Cumberland Plateau and Sequatchie River Valley, rises about 1,000 to 1,500 feet higher than the adjoining Ridge and

Valley ecoregion to the east and Interior Plateau to the west. It extends about 175 miles, ranging northeast to southwest across central Tennessee. The bedrock is a sequence of near horizontal Pennsylvanian sandstones, shales, conglomerates, and coals, underlain by Mississippian and older shale and carbonates. The area underlain by the resistant Pennsylvanian sandstones has produced a “table-top” landscape. Groundwater usually occurs in areas of shallow, sandy soils and in deeper cracks in the bedrock. At depth, the Mississippian carbonates possess mature Karst features. Sinkholes, large caves, sinking streams, and springs typify the landscape, resulting in a complex aquifer system. Rapid groundwater movement is typical. Approximately 75 percent of the land cover is mesophytic forest with 16 percent considered agricultural lands and almost 3 percent developed (USGS 2008). Guntersville and Nickajack reservoirs, Widows Creek Fossil Plant, Raccoon Mountain Pumped Storage Plant, and Bellefonte Nuclear Plant are in the Southwestern Appalachians ecoregion.

The Interior Plateau ecoregion is a series of grassland plateaus and forested uplands that are generally lower in elevation than the Appalachian Mountains to the east but higher than the plains to the south (USGS 2008). This ecoregion occupies much of central Tennessee and parts of Kentucky and northern Alabama. The Interior Plateau consists of the east and west Highland Rim and the Central Basin. The Highland Rim was formed from flat-lying Mississippian carbonates, and these formations constitute the most extensive aquifer in the Tennessee region. The Central Basin (Nashville Basin) is an oval area in middle Tennessee lying about 200 feet below the surrounding Highland Rim. The bedrock is carbonate rocks that are generally flat lying but are locally folded, and the soil cover is usually thin and home to a globally uncommon ecosystem, the Limestone cedar glades and barrens. The plant communities associated with the cedar glades and barrens within the Central Basin are home to 544 plant species, 448 of which are native, and of those, 21 are endemic to the glades/barrens (Baskin and Baskin 2003). The forested area of the Central Basin has closer affinities to the beech-maple-basswood forest of the Midwest than to the mesophytic forests of the other sections of the Interior Plateau. Fifty percent of the land use is in the form of agricultural practices, with 38 percent being forested and approximately 10 percent developed. TVA reservoirs found within the Interior Plateau include Great Falls, Normandy, Tims Ford, Wheeler, Wilson, and a portion of Kentucky. Power plants in the Interior Plateau are Cumberland and Gallatin Fossil Plants on the Cumberland River, and Colbert and Johnsonville Fossil Plants and Browns Ferry Nuclear Plant on the Tennessee River.

A small portion of the Interior River Valley and Hills ecoregion occurs in the TVA region in northwest Kentucky where it is comprised of nearly level lowlands dominated by agriculture and forested hills. It is characteristically underlain by carboniferous sedimentary rock drainage conditions, and terrain strongly affects land use. Wetlands are common on lowlands and bottomlands. Bottomland deciduous forests and swamp forests were once extensive on poorly drained, nearly level lowland sites, but most have been replaced by cropland and pastureland. Hilly uplands remain mostly forested. This ecoregion includes a portion of the Illinois Basin coalfield where both underground and surface coal mining are extensive. Siltation from mining and agriculture has increased flooding and prompted remedial channelization projects (Woods et al. 2002). Paradise Fossil Plant, located on the Green River in western Kentucky, and a portion of Shawnee Fossil Plant on the Ohio River occur within the Interior River Valley and Hills ecoregion.

The Southeastern Plains ecoregion, the largest ecoregion in the eastern U.S., extends from near the Gulf of Mexico in the south to Maryland in the north and up to Tennessee in the west. In the TVA region, this ecoregion is found in parts of western Alabama, eastern Mississippi, and

western Tennessee. The irregular, relatively flat plains of the region are covered by a mosaic of forests (51 percent), agricultural lands (22 percent), and wetlands (10 percent). Natural forests of pine, hickory, and oak once covered most of the ecoregion, but much of the natural forest cover has been replaced by heavily managed timberlands (USGS 2008). Three of TVA's combustion turbine facilities (Gleason, Caledonia, and Kemper) are found in the Southeastern Plains ecoregion. Reservoirs in the ecoregion are the Beech River projects, the Bear Creek projects, Pickwick, and a portion of Kentucky Reservoir.

Sandwiched between the Mississippi Valley Alluvial Plain to the west and the Southeastern Plains to the east, the Mississippi Valley Loess Plain ecoregion extends from western Kentucky south to Louisiana. The topography consists primarily of irregular plains. A highly erodible, thick layer of loess, a unique geologic deposit consisting almost entirely of wind-transported, silt-sized grains of quartz and other common minerals, is the distinguishing characteristic of this region (Omernik 1987). Forest, agriculture, and developed land account for more than 90 percent of the land cover in the ecoregion. Agriculture is the dominant land use in the northern portion. Trees, cotton, corn, soybeans, strawberries, and tobacco are common crops grown throughout the region (USGS 2008). The southern portion of the Shawnee Fossil Plant Reservation along with Brownsville, Lagoon Creek, and Marshall combustion turbine facilities occur within the Mississippi Valley Loess Plain ecoregion.

The Mississippi Alluvial Plain occurs along the Mississippi River floodplain on the very western edge of the TVA region. Bottomland hardwood forests and cypress swamps, also referred to as forested wetlands, are the dominant natural plant communities in this region. A key factor in the development and maintenance of these communities is their ability to survive extended periods of flooding. Much of land use within the region is agricultural, with some areas of deciduous forest. According to Griffith et al. (1998), soybeans, cotton, corn, sorghum, and vegetables are the main crops. The natural vegetation consists of southern floodplain forest (oak, tupelo, bald cypress). Allen Fossil Plant and Southhaven Combined-Cycle Plant occur within the Mississippi Alluvial Plain.

Forest Regions

Based on recent forest inventory and analysis plot data Dyer (2006) recognized three forest regions and two subregions in the TVA area. Much of the TVA region is dominated by the mesophytic forest, which is the most diverse among the regions with 162 tree species. No species assumes canopy dominance across the region, but red maple and white oak have the highest average importance values. Within the mesophytic forest, the Appalachian oak section is a subsection, which is dominated by various species of oak: black oak, chestnut oak, northern red oak, scarlet oak, and white oak. Dyer (2006) also notes, as previously mentioned, that the area of the Nashville Central Basin has close affinities with the beech-maple-basswood forests that dominate the Midwestern U.S. Species associated with this region are American basswood, American beech, American elm, black cherry, northern red oak, sugar maple, white ash, and white oak. The oak-pine section of the Southern Mixed forest region is found in portions of Alabama, Georgia, and Mississippi where the dominate species are loblolly pine, sweetgum, red maple, and southern red oak (Dyer 2006). The black belt area of Alabama and Mississippi has close affinities to the Mississippi Alluvial Plain and is known for its rich, dark soils. Much of the area has been cleared for agricultural purposes. The Mississippi Alluvial Plain is the final forest region found within the TVA region and is restricted to the Mississippi River Valley. The bottomland forests in this region are dominated by American elm, bald cypress, green ash, loblolly pine, sugarberry, and sweetgum.

Globally Rare Communities and Sensitive or Threatened Ecosystems
NatureServe (2009) recognizes 83 community associations (distinct assemblages of plants classified by their dominant and diagnostic species) within the TVA region as having a global ranking of G1. The G1 ranking defines communities that are critically imperiled and at a high risk of extinction due to extreme rarity (often five or fewer occurrences worldwide). A list of the G1-ranked communities can be found in Appendix J. The G1 communities are classified based on their NatureServe vegetation classification, the state in which they are found, whether they occur in rare ecosystems (described below), and in what ecoregion(s) they occur. Often, rare communities harbor endangered and native plant and/or animal species, as well as species not found outside the TVA region. Therefore, knowledge of these globally imperiled communities is important for the future implementation of the NRP.

These globally rare communities are often found in sensitive or threatened ecosystems such as the southern Appalachian spruce-fir forest; cedar glades; grasslands, prairies and barrens; Appalachian bogs, fens, and seeps (including ponds); and bottomland hardwood forests (Appendix J). Most of these sensitive ecosystems are being threatened by anthropogenic-related causes such as urban development, agricultural practices, and the introduction of exotic species. The Blue Ridge contains almost two-thirds of the globally rare communities reported from the TVA region, followed by the Interior Plateau with 17 percent and the Southwestern Appalachians with 10 percent.

Invasive Plants
Most lands in and around the TVA region have been affected by invasive plants. According to NatureServe (2009), invasive plants are the second-leading threat to imperiled native species. Not all nonnative plants pose threats to our native ecosystems. Many plants introduced by European settlers are naturalized additions to our flora and are considered nonnative noninvasive species. These “weeds” have very little negative impacts to native vegetation. Examples of these are Queen Anne’s lace and dandelion. However, other nonnative species are considered invasive and do pose threats to the natural environment. EO 13112 defines an invasive species as any species, including its seeds, eggs, spores, or other biological material capable of propagating that species, that is not native to that ecosystem and whose introduction does or is likely to cause economic or environmental harm or harm to human health (USDA 2007a). This executive order directs all federal agencies to address invasive species concerns and to refrain from actions likely to result in the introduction and/or spread of invasive species.

Invasive plants infest under and beside forest canopies and occupy small forest openings, increasingly eroding forest productivity, hindering forest use and management activities, and degrading diversity and wildlife habitat. They occur as trees, shrubs, vines, grasses, ferns, and forbs. Some have been introduced into this country accidentally, but most were brought here as ornamentals or for livestock forage. These robust plants arrived without their natural predators of insects and diseases that tend to keep native plants in natural balance. Now they increase across the landscape with little opposition, beyond the control and reclamation measures applied by landowners and managers on individual land holdings (Miller 2003).

Four plants designated as noxious weeds under the Federal Noxious Weed List of 2006 (USDA 2007b, 2009) occur in the TVA region: cogongrass, giant salvinia, hydrilla, and tropical soda apple. In addition, SE-EPPC (2008) provides a list of invasive plants that could pose threats to native ecosystems and human health in southeastern states. Currently, Georgia, Mississippi, and Tennessee have developed MOUs with federal and state agencies to create Cooperative Weed Management Areas to implement an Early Detection Rapid Response Program to assist public and private landowners with controlling invasive species. All three states have developed

these plans in hopes of controlling cogongrass. Cogongrass is an aggressive invader of natural and disturbed areas throughout the Southeast disrupting ecosystem functions, reducing wildlife habitat, decreasing tree seedling establishment and growth, and altering fire regimes and intensities (Evans et al. 2008).

Invasive plants are known to occur across southern Appalachian forests, accounting for 15-20 percent of the documented flora (USFS 2009). Miller et al. (2008) estimated the acres covered by 33 invasive plants within the southern states. These data show that 19 percent of Alabama, 5 percent of Georgia, 16 percent of Kentucky, 5 percent of North Carolina, 16 percent of Tennessee, and 10 percent of Virginia forests are estimated to be covered by one or more of the invasive plants listed in Table 4-4.

Table 4-4. Invasive Plants in the TVA Region

Growth Form	Species
Trees	Tree-of-heaven (*Ailanthus altissima*)
	Silktree or mimosa (*Albizia julbrissin*)
	Princesstree or paulownia (*Paulownia tomentosa*)
	Chinaberrytree (*Melia azedarach*)
	Tallowtree or popcorntree (*Triadica sebifera*)
	Russian olive (*Elaeagnus angustifolia*)
Shrubs	Silverthorn (*Elaeagnus pungens*)
	Autumn olive (*Elaeagnus umbellata*)
	Winged burning bush (*Euonymus alatus*)
	Chinese and European privets (*Ligustrum sinense* and *L. vulgare*)
	Japanese and glossy privets (*Ligustrum japonicum* and *L. lucidum*)
	Nonnative bush honeysuckles (*Lonicera maackii, L. morrowii, L., tartarica, L. fragrantissima,* and *L. xbella*)
	Nandina (*Nandina domestica*)
	Nonnative roses (*Rosa multifora, R. bracteata,* and *R. laevigata*)
Vines	Oriental bittersweet (*Celastrus orbiculatus*)
	Nonnative climbing yams (*Dioscorea oppositifolia* and *D. bulbifera*), Wintercreeper (*Euonymus fortunei*)
	English ivy (*Hedera helix*)
	Japanese honeysuckle (*Lonicera japonica*)
	Kudzu (*Pueraria montana*)
	Vincas or periwinkles (*Vinca minor* and *V. major*)
	Nonnative wisterias (*Wisteria sinensis* and *W. floribunda*)
Grasses and canes	Giant reed (*Arundo donax*)
	Tall fescue (*Lolium arundinaceum*)
	Cogongrass (*Imperata cylindrica*)
	Nepalese browntop or microstegium (*Microstegium vimineum*)
	Chinese silvergrass (*Miscanthus sinensis*)
	Nonnative bamboos (*Phyllostachys aurea,* other *Phyllostachys* spp., and *Bambusa* spp.)

Growth Form	Species
Ferns and forbs (broad-leaved plants)	Japanese climbing fern (*Lygodium japonicum*)
	Garlic mustard (*Alliaria petiolata*)
	Shrubby lespedeza (*Lespedeza bicolor*)
	Chinese lespedeza (*Lespedeza cuneata*)
	Tropical soda apple (*Solanum viarium*)

According to the Center for Invasive Plant Management (2009), the most effective, economical, and ecologically sound approach to managing invasive plants is to prevent them from invading. Land managers often concentrate on fighting well-established infestations, at which point management is expensive, and eradication is unlikely. Infestations must be managed to limit the spread of invasive plants, but weed management that controls existing infestations while focusing on prevention and early detection of new invasions can be far more cost-effective. Weed prevention depends on the following:

- Limiting the introduction of weed seeds
- Early detection and eradication of small patches of weeds
- Minimizing the disturbance of desirable plants along trails, roads, and waterways
- Maintaining desired plant communities through good management
- Monitoring high-risk areas such as transportation corridors and bare ground
- Revegetating disturbed sites with desired plants
- Evaluating the effectiveness of prevention efforts and adapting plans for the following year

Vegetation Types and Trends On TVA Lands

Major Vegetation Types — Based on an analysis of land use/land cover data for typical Zone 3 and Zone 4 reservoir lands, the dominant vegetation types are upland deciduous hardwood , bottomland hardwood, mixed, and evergreen forests (predominantly pine and eastern red cedar) (Figure 4-2). These four vegetation types cover about 85 percent of the land area. Four other vegetation types cover the remainder of the land area.

Forests on TVA lands are similar to forests found in Tennessee as reported by Oswalt et al (2009), where the most common forest type are deciduous hardwood forests dominated by oak-hickory. A large portion of the evergreen or pine-dominated forests on TVA lands are mature loblolly pine plantations in the southern and western Valley. Compared to Tennessee as a whole, TVA land contains a higher percentage of bottomland forest. This is largely due to the location of most TVA lands along the Tennessee River and its tributaries, where bottomlands can be extensive.

TVA has not collected Valley-wide forest inventory data since the 1990s and therefore the precise average age of its forests is not known. However, based on the most recent inventory data and the fact that TVA has only conducted very limited salvage timber harvests (primarily associated with storm or insect damage) in recent years, TVA's forested lands have likely increased in age class structure. In addition, similar trends reported in Tennessee forests (Oswalt et al. 2009) can be inferred to be occurring on TVA lands as well. These trends show the peak in age class distribution has shifted to the 56-60+ year old age class and acreage in most of the younger age classes has declined.

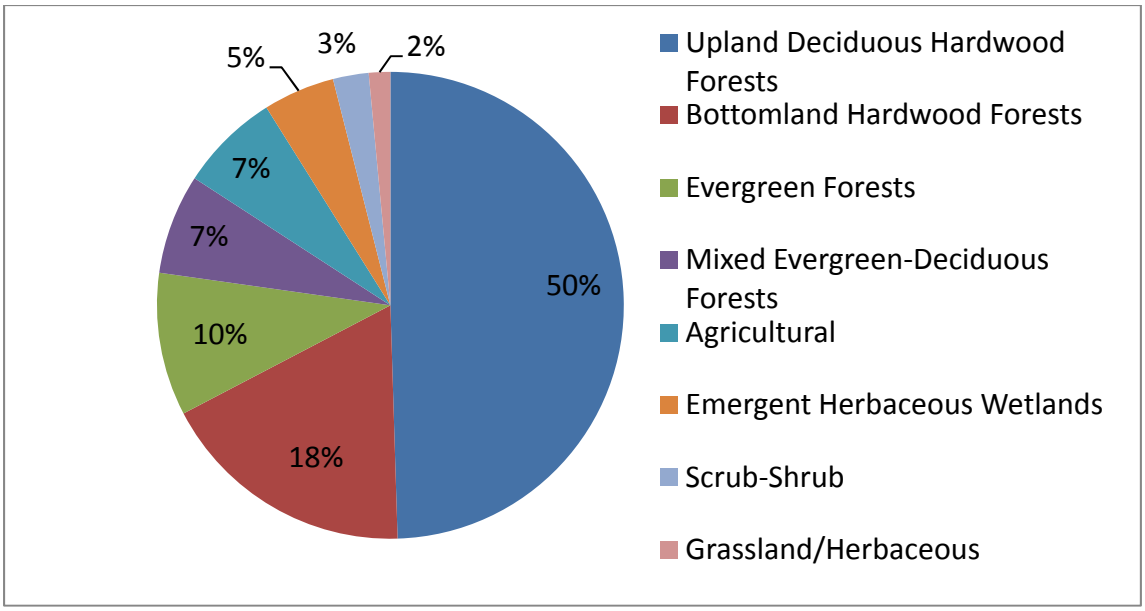


Figure 4-2. Vegetation Types on TVA Zone 3 and Zone 4 Reservoir Lands by Percent of Land Cover

In general, early successional vegetation types are decreasing across Tennessee Valley. One exception to this can be found in former agricultural license tracts in the southern and western Valley that are reverting back to bottomland hardwood forests, particularly sweetgum, green ash and red maple. Also, the loss of some loblolly pine plantations to southern pine bark beetle infestations has created pockets of early successional vegetation, particularly in the eastern portion of the TVA region. Unfortunately, much of the regenerating vegetation in these areas is impacted by the increase in nonnative invasive species that reduce plant diversity and value to wildlife habitat.

Trends in forest types between 2000 and 2010 on federal lands in Tennessee other than Forest Service and National Park Service lands were analyzed using Forest Inventory and Analysis data (USFS 2011). TVA lands make up the majority of these federal lands. This data shows large decreases in pine-dominated, other softwood, and oak-pine forest types and corresponding increases in oak-hickory and maple-beech-birch forest types to 57 percent and 13 percent of the forest area, respectively. Factors in the reduction of pine and other softwood forest types include mortality from southern pine beetle outbreaks and the hemlock wooly adelgid.

Invasive Plants

Land Conditions Assessments (LCA; see Section 2.1.3) conducted over the last three years on 33,113 acres on six reservoirs (Norris, Tellico, Melton Hill, Guntersville, Kentucky and Watts Bar) identified the extent of invasive plant infestation on TVA lands as follows:

- Good (between 0 and 5% invasive plant coverage): 11,174 acres (33.7 percent)
- Fair (between 5% and 25% invasive plant coverage): 17,435 acres (52.7 percent)
- Poor (greater than 25% invasive plant coverage): 4,504 acres (13.6 percent).

Based on these data, a total of 5,800 of the 33,113 acres (17.5%) assessed is infested with one or more invasive plant species. Using this estimate and assuming similar conditions across

other reservoir lands, at least 38,000 of the 220,000 acres of Zone 3 and 4 reservoir properties are likely infested with invasive plants.

The magnitude of invasive plant infestations on TVA lands is due in large part to the configuration of its land base. Much of TVA land is relatively linear and narrow with extensive edges where most invasive plants tend to become established. Invasive plants established for landscaping on adjacent private lands can spread onto TVA lands. Reservoirs, waterways, transmission and highway ROWs can serve as vectors for the transport of invasive plants Past efforts by TVA and other resource agencies to plant several species now considered invasive for erosion control, wildlife habitat improvement, and landscaping purposes have also contributed to the introduction and spread of invasive species.

4.3.2. Wildlife

The TVA region contains portions of nine ecoregions (see above section) providing a unique mixture of wildlife habitat. Ranging from bottomland hardwood swamps in the floodplains of the Mississippi Alluvial Plain to high elevation balds and spruce-fir/northern hardwood forests in the Blue Ridge Mountains, this diverse mixture of habitats supports a rich assemblage of wildlife communities.

Approximately 55 species of reptiles, 72 species of amphibians, 182 species of breeding birds, and 76 species of mammals occur in these regions throughout the TVA region (Ricketts et al. 1999, Stein 2002, Tennessee Ornithological Society 2007, TWRA 2005). Although some wildlife species have widespread distributions, others have restricted ranges unique to specific ecoregions (TWRA 2005). For example, forest habitats in the Blue Ridge Mountains provide globally significant habitat for many species, especially amphibians and land snails (Ricketts et al. 1999). The high elevations found in the Blue Ridge ecoregion also provide habitat for relict populations of animals typically found in more northern latitudes.

Federal legislation and policies that apply to wildlife in the TVA region include the Migratory Bird Treaty Act of 1918 and EO 13186—Responsibilities of Federal Agencies to Protect Migratory Birds. The Migratory Bird Treaty Act established the framework for regulated hunting of migratory birds and otherwise prohibited harm to migratory birds and their parts (including eggs, nests, and feathers). Conflicting decisions in various federal district courts disagree on whether this prohibition applies to the actions of federal agencies. EO 13186 requires federal agencies implementing or planning actions that could affect migratory birds and their habitats to “support the conservation intent of the migratory bird conventions by integrating bird conservation principles, measures, and practices into agency activities and by avoiding or minimizing, to the extent practicable, adverse impacts on migratory bird resources when conducting agency actions.” The EO requires federal agencies whose actions may negatively affect migratory birds to develop MOUs with the USFWS to promote migratory bird conservation. TVA has not developed this MOU. The Migratory Bird Treaty Act provides for the conservation of all native birds in the U.S. except non-migratory game birds that are managed by states.

Wildlife Trends

Many wide-ranging species occur throughout the TVA region; most species that are tolerant to humans continue to thrive in the region. Wildlife populations have been greatly altered by loss and modification of habitats due to agriculture, mining practices, forestry practices, urbanization, and the construction of impoundments. While some species flourish under these changes, others have shown marked declines (USFWS 2008). For example, grassland and woodland-dependent birds have shown dramatic decreases in their numbers (Southern Appalachian Man and Biosphere 1996). Approximately, 48 percent of grassland breeding birds are of

conservation concern, and 23 species are significantly declining in number (North American Bird Conservation Initiative [NABCI] 2009). Approximately, 22 percent of area-dependent woodland birds are of conservation concern. These numbers have declined by 10 percent through 1980 but have shown some increases in recent years (NABCI 2009). Habitats used by these species have been modified largely by urban development and agricultural practices.

In general, gulls, wading birds, waterfowl, raptors, game birds, game mammals, and nongame wildlife (reptiles, amphibians, and small mammals) exhibit stable or increasing numbers throughout the TVA region. Populations of white-tailed deer, wild turkey, coyote, and beaver have shown significant population increases. Species associated with river corridors such as osprey, herons, and Canada geese have also shown notable recoveries, largely since the ban of dichlorodiphenyltrichloroethane (DDT). This trend is quite noticeable on the Tennessee River, as breeding populations of these species had been relatively scarce in portions of northwest Alabama or northeast Tennessee up to the late 1990s. However, in recent years, breeding populations of these species have expanded into these areas and have become more evenly distributed throughout the Valley. Recent surveys show that shorebirds and waterfowl communities are quite diverse in portions of the Valley, especially during autumn and spring migrations. However, numbers of several species of songbirds continue to decline in the region, especially those typically found in grassland or unfragmented forests.

TVA Lands

While TVA manages lands across the region, most TVA lands are concentrated around its reservoirs. Habitats on TVA lands are just as complex as other lands found throughout the TVA region, supporting diverse communities of wildlife. Important habitats found in the Valley include riparian corridors, bluffs, swamps, grasslands, rivers, reservoirs, islands, large unfragmented forested landscapes, and karst habitats.

Riparian habitats associated with the Tennessee River and its tributaries provide important habitats for wildlife. Coupled with unique features such as vernal pools, oxbows, bluffs, and islands, these areas provide a diverse array of nesting and foraging habitats for wildlife.

Open lands are comprised of old-field, pasture, agricultural, and other early successional habitats. Most of these areas have been greatly modified by intensive row cropping and timber harvesting. Yet, these habitats also provide needed environment for species favoring early successional habitats.

Caves are abundant features throughout much of the Valley, especially in north Alabama, northwest Georgia, and the eastern half of Tennessee. These sites provide a unique mixture of microhabitats used by a diverse array of cave-dependent species, some endemic to single cave systems.

TVA partners with federal and state agencies to manage wildlife habitat on a number of wildlife management areas. In many cases, TVA lands are managed in conjunction with back-lying lands to form larger wildlife management units providing a more diverse and extensive land base to attract wildlife for both consumptive and nonconsumptive uses. Key Cave National Wildlife Refuge, for example, is managed collectively by USFWS, TVA, and the Alabama Department of Conservation and Natural Resources. The cave entrance is located on TVA land, and much of the aquifer underlies land owned by the USFWS. This site is used by a large maternity colony of endangered gray bats and is the only known locality of the endangered Alabama cavefish.

Hunting, Fishing, and Wildlife-Associated Recreation
Wildlife-related recreation is prevalent on TVA lands, especially on those properties surrounding TVA impoundments. The USFWS summarizes hunting, fishing, and wildlife-associated recreational trends at national and state levels. This comprehensive study began in 1955 and is performed every five years (USFWS and U.S. Census Bureau 2007). Statistics are developed using a study group ages 16 years and older. In 2006, 87.5 million Americans spent more than $122 billion on wildlife-related recreation. Approximately 30 million people fished, 12.5 million people hunted, and 71.1 million people participated in wildlife watching (USFWS 2006). While there were slight declines in hunting and fishing between 2001 and 2006, there were marked increases in wildlife-related recreation. These national trends were also observed in states within the TVA region. The TVA-region states had high participation rates in fishing, hunting, and wildlife watching relative to much of the rest of the country (USFWS and U.S. Census Bureau 2007).

TVA lands and reservoirs play an important role in supporting wildlife-related recreation. TVA works with federal and state agencies, universities, NGOs, and volunteers to support these activities. The dewatering projects on Kentucky and Wheeler reservoirs are examples of areas that are collectively managed by TVA and its partners. These areas provide a host of benefits for the public and wildlife that use them and provide economic benefits to surrounding communities.

Although hunting is not allowed at most TVA power generating facilities (Gallatin and Shawnee Fossil Plants are exceptions), several, such as Raccoon Mountain Pumped Storage Plant, provide opportunities for wildlife viewing, bank fishing, or access to waterways. Several generating facilities also allow access to warm-water discharge areas to provide additional fishing opportunities, especially during winter and spring. Ash handling and water treatment facilities at some TVA fossil plants also provide wildlife viewing opportunities.

TVA has several WOAs where the public can observe large aggregations of migratory birds or evening emergences of bats. Examples include WOAs at Kentucky Dam Reservation and Nickajack Cave TVA natural area, which is also a TWRA wildlife management area. Many of these sites are promoted by various state agencies and regional ornithological groups.

Nuisance Wildlife Management
TVA has a contract with the U.S. Department of Agriculture's Wildlife Services (USDA-WS) group to address nuisance animal issues throughout the TVA region. Based on review of annual and quarterly reports provided by USDA-WS, the most common species creating issues at TVA facilities (fossil, hydro and nuclear plants) and other infrastructure (e.g., transmission line towers) are pigeons, vultures and beavers. Species creating the most issues on TVA reservoir land and recreational areas are beavers and vultures. Based on review of USDA-WS 2010 annual report, nuisance animal issues were managed at 32 individual facility or infrastructure sites and at 24 different sites on TVA reservoir properties. Some sites, such as transmission line towers with vulture roosts, require almost constant surveillance and continuous actions while some others can be handled as one time occurrences. Additional species that can create damage and/or health and safety issues include striped skunk, raccoon, feral cat, groundhog, vole, muskrat, opossum, river otter, little brown bat, coyote, great blue heron, osprey, common grackle, Canada geese, red-tailed hawk, mourning dove, house finch, European starling and English sparrow. In general, issues with nuisance animals have increased over the last five to ten years particularly associated with increasing populations of certain species, in particular vultures, beaver, great blue heron and osprey.

4.4. Wetlands

Wetlands are highly productive and biologically diverse ecosystems that provide multiple public benefits such as flood control, reservoir shoreline stabilization, improved water quality, and habitat for fish and wildlife resources.

EO 11990 (Protection of Wetlands) directs federal agencies to minimize the destruction, loss, or degradation of wetlands and to preserve and enhance the natural and beneficial values of wetlands. In addition, activities in wetlands are regulated under the authority of the federal CWA and state regulations. Wetlands are defined by TVA Environmental Review Procedures (TVA 1983) as "those areas inundated by surface or groundwater with a frequency sufficient to support, and under normal circumstances do or would support, a prevalence of vegetation or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction. Wetlands generally include swamps, marshes, bogs, and similar areas such as sloughs, potholes, wet meadows, mud flats, and natural ponds."

Wetlands are typically transitional ecosystems between terrestrial and aquatic communities. The abundance of wetlands varies across the nine ecoregions encompassing the TVA region (Table 4-5). In the eastern portions of the TVA region, wetlands occupy a relatively small percent of the landscape relative to uplands within the Blue Ridge, Ridge and Valley, and Central Appalachians ecoregions. These ecoregions are typically marked by relatively steep topography and deeply incised stream channels; wetlands are typically small and isolated or linear in feature and associated with the floodplain areas of streams, rivers, and creeks (Hefner et al. 1994). Farther west, the topography levels out and wetlands become more common. Broad, flat floodplain areas are common features, and various types of wetland habitats, especially bottomland hardwood forested wetlands, are widespread.

Table 4-5. Regional Variation of Wetland Abundance by Ecoregion — 2000

Ecoregion	Proportion (Percent) of Ecoregion Covered by Wetlands (all types of wetlands)
Blue Ridge	>0.1
Ridge and Valley	>0.1
Central Appalachians	0.3
Southwestern Appalachians	0.2
Interior Plateau	>0.7
Interior River Valley and Hills	4.6
Southeastern Plains	10.3
Mississippi Valley Loess Plain	4.6
Mississippi Alluvial Plain	19.0

Source: U.S. Department of the Interior 2008

Palustrine wetlands are the predominant wetlands in the TVA region. As described by Cowardin et al. (1979), these are nontidal wetlands dominated by trees, shrubs, persistent emergent vegetation, and emergent mosses or lichens. These wetlands include bottomland hardwood forests and upland swamps (forested wetlands), scrub-shrub wetlands, beaver ponds (aquatic-bed or emergent wetlands), wet meadows and marshes (emergent wetlands), and highland bogs (forested, scrub-shrub, or emergent wetlands that have organic soils). Lacustrine

(i.e., related to a lake) and riverine (i.e., related to a river) systems are also wetland types found within the region. These wetlands consist of aquatic beds containing floating or submersed aquatic plants.

The type and extent of wetlands within the TVA region are estimated using aerial photography and remote sensing data. The primary data source is NWI maps produced by the USFWS. TVA maintains an in-house database of NWI maps for the TVA region. Produced in the 1980s, the NWI data have somewhat limited value because of age. For this EIS, as well as most other TVA environmental reviews, these data are supplemented by more recent aerial photography and land use/land cover analyses (Table 4-6).

Table 4-6. Proportion of TVA Lands With Wetlands — 2010

Location	Proportion (Percent) of Forested/Scrub-Shrub Wetlands in Study Area	Proportion (Percent) of Emergent Wetlands in Study Area
Adjacent to Reservoirs	16.0	<0.2
On Power Generation Facility Reservations	11.0	<0.4
Total	**15.0**	**0.8**

Source: TVA Data 2010

Approximately 90 percent of the wetlands on TVA lands are located on the mainstem Tennessee River reservoirs. Tributary reservoirs have few wetlands because of the steeper slope of the shorelines and the larger drawdown for flood control. The topography around mainstem reservoirs is flatter, lending itself to the establishment of wetlands. In addition, there is much less drawdown from summer pool elevation to winter pool elevation on mainstem reservoirs. In addition, there is about three times as much shoreline on mainstem reservoirs as there is on tributary reservoirs (Snoddy and Cooney 1999).

The above conclusions are supported by data prepared for the ROS (TVA 2004), as well as land use/land cover data compiled for this study. NWI data were analyzed to determine the type and extent of wetlands associated with the TVA system of reservoirs; this analysis was not limited to TVA lands and included land within groundwater influence of the reservoirs. The analysis showed approximately 197,000 acres of wetlands are found along the TVA reservoir system and within the groundwater influence area of the reservoirs.

The data showed that vegetated wetlands occur with greater frequency and size along the mainstem reservoirs and tailwaters than along the tributary reservoirs and tailwaters. This is due in part to the larger-sized watersheds of mainstem reservoirs resulting in a greater volume of water; greater predictability of the annual hydrologic regime; shoreline and drawdown zone topography (wider and flatter floodplains, riparian zones, and drawdown zones and large areas of shallow water); and larger sections of relatively still, shallow-water areas. Wetlands tend to be smaller and do not occur as frequently on tributary reservoirs because of the relatively steep drawdown zones, the rolling to steep topography of adjacent lands, shoreline disturbance caused by wave action, and the lower predictability and shorter duration of summer pool levels.

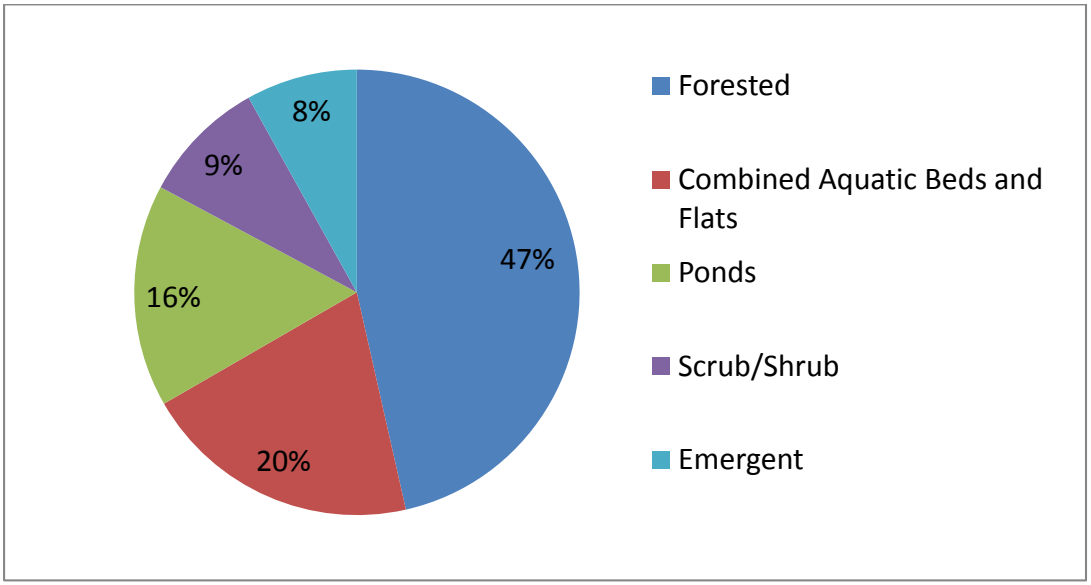
Within mainstem reservoirs, wetlands occur on flats between summer and winter pool elevations, on islands, along reservoir shorelines, in dewatering areas, in floodplains, on river terraces, along connecting rivers and streams, around springs and seeps, in natural depressions, in areas dammed by beaver, in and around constructed reservoirs and ponds

(diked and/or excavated), and in additional areas that are isolated from other surface waters. On tributary reservoirs, wetlands are typically located at the backs of coves where tributary streams enter the reservoir, and in very patchy, small (<0.01 acre) areas along the shoreline.

As shown in Figure 4-3, forested wetlands are the most common wetland type found on TVA land located adjacent to reservoirs and within the area of groundwater influence of the river system. Aquatic bed and pond wetlands are the next most common types of wetland, followed by scrub-shrub and emergent wetlands. Figure 4-4 shows the types and locations of wetlands along TVA reservoirs.

For the purposes of this EIS, an analysis was conducted of wetland types specific to TVA lands adjacent to reservoirs. This analysis showed that wetlands are less common on TVA lands than throughout the overall reservoir system. The percentage of forested and scrub-shrub wetlands is 16 percent of the overall land use/land cover. Emergent wetlands make up less than 0.2 percent as contrasted with 0.8 percent of the overall land use of the entire reservoir system.

TVA also manages lands associated with power generation facilities and dam reservations. In general, emergent wetlands (marshes) are common around ash disposal ponds and water treatment ponds at power generation facilities. Forested wetlands occur on lower-lying, undisturbed areas and along tributary streams on power generation sites. Land use/land cover data indicated forested and scrub-shrub wetlands comprise approximately 11 percent of the total land use/land cover status of the power properties. Emergent wetlands are much less common, comprising less than 0.4 percent of total land use.



Source: TVA data.

Figure 4-3. Wetlands of the TVA Reservoir System by Vegetation Class

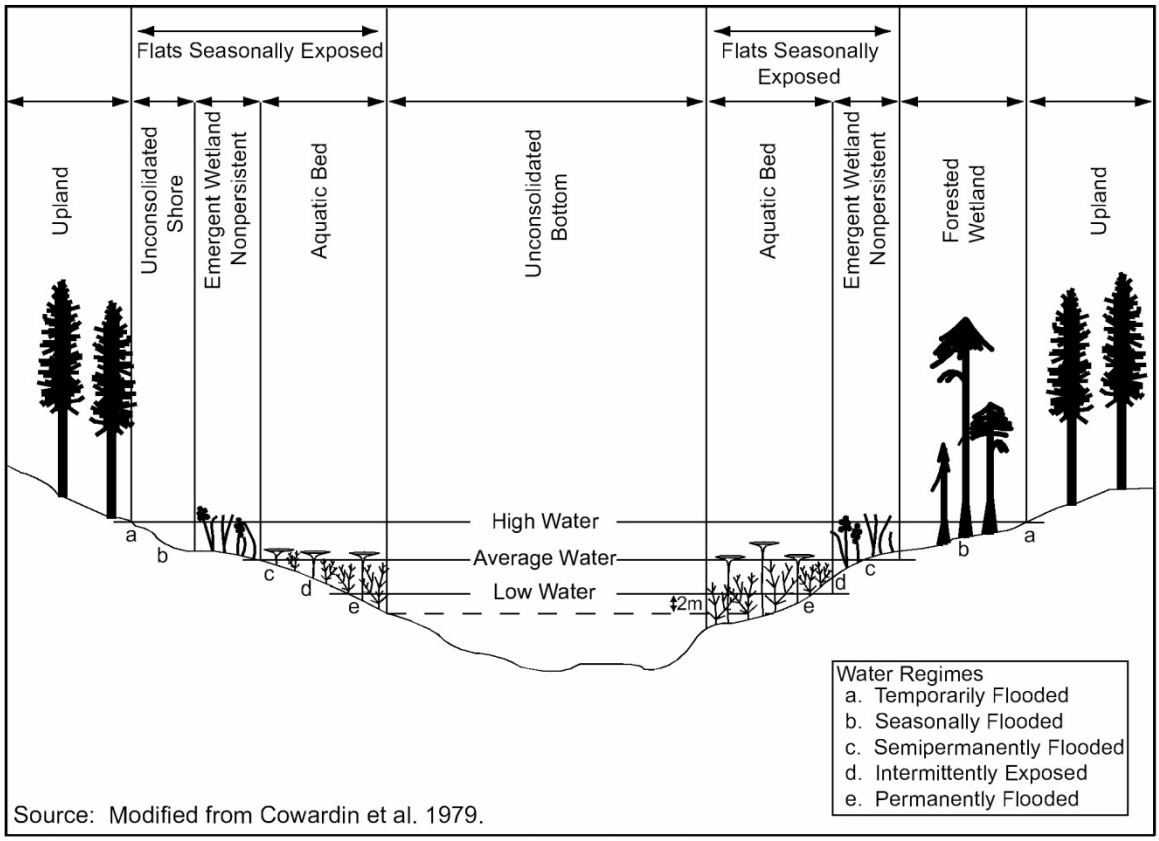


Figure 4-4. Reservoir Wetland Types and Locations

Status and Trends

Historically, the wetland acreage across the TVA region has declined over the past 30 years, but the rate of loss has slowed significantly over the past 10 years due to regulatory mechanisms for wetland protection. National wetlands trend studies (Dahl 2000) indicate that, between 1986 and 1997, freshwater forested wetlands declined 2.3 percent, and freshwater emergent wetlands declined 4.6 percent. Parts of these declines were due to conversion of forested and emergent wetlands to scrub-shrub wetlands and freshwater ponds during the study period. Timber harvesting, agriculture, natural succession, beaver activity, changes in land use (including urban and rural development, mining, and recreation such as golf courses), and conversion of bottomland forests to managed pine plantations played a role in these trends in wetland change. These trends are likely to continue to various degrees over the next 30 years. National trend data do not include analyses of flats and aquatic bed coverage; however, TVA data indicate an increase in coverage of aquatic beds between the 1960s and 2000s (TVA 2004).

National trends are mirrored by general trends in the Southeast. These data indicate that forested, emergent, and scrub-shrub wetlands have suffered a net loss in acreage. This is primarily due to transportation impacts, the continued growth of urban/suburban development associated with continued population growth, and to a lesser degree, agriculture and timber harvesting (Hefner et al. 1994; Dahl 2006; Keeland et al. 2004). These same data indicate a net increase in open water ponds created as agricultural impoundments, by urban and suburban

development, and as the result of compensatory mitigation for the loss of emergent wetlands for regulatory purposes (Dahl 2006).

The area of emergent, scrub-shrub, and forested wetlands (located on and immediately adjacent to TVA reservoirs) has remained relatively stable as compared to the trend for these wetland types in the Southeast (Hefner et al. 1994). Forested wetlands have been the most heavily impacted on private land throughout the TVA region over the last 50 years. The presence of wetlands on or adjacent to TVA reservoirs appears related to the development status of the shoreline. Within the 0.25-mile shoreline area, the proportion of total wetlands acreage was greater along undeveloped shorelines than along developed shorelines. This is partially explained by the fact that many wetlands occur in low-lying or flood prone areas where development is often restricted (TVA 1998).

Current Management Issues

In general, wetlands on TVA lands face less threat of direct impacts related to development than wetlands on private land. Where direct impacts do occur as the result of TVA projects or land disposal actions, impacts are typically mitigated to offset any immediate or cumulative effects. Common problems across TVA lands are typically more indirect types of impacts including:

- Invasive species
- Lack of buffer zones
- ATV impacts
- Encroachments, especially unauthorized removal or alteration of wetland vegetation
- Changes in vegetation community structure (e.g., decline of buttonbush on Kentucky reservoir)
- Impacts of beaver populations/impoundments on forested wetlands (e.g., conversion to open water, scrub/shrub and emergent wetlands)
- Impacts of climate change.

These types of problems are recorded during land condition assessments and their trends will be assessed in future assessment efforts. Overall, these management problems are not unique to TVA lands, and lead to subtle changes in the type, extent, and quality of wetland habitats.

4.5. Water Quality

The quality of the region's water is critical to protection of human health and aquatic life. These water resources provide habitat for aquatic life, recreation opportunities, domestic and industrial water supplies, and other benefits. Water quality can be affected through point sources, such as wastewater treatment plants and industries, and through nonpoint sources, such as air emissions and deposition, construction and development, urban runoff, mining, agriculture, and silviculture.

The Tennessee River basin contains all except one of TVA's dams. A series of nine locks and dams built mostly in the 1930s and 1940s regulates the entire length of the Tennessee River and allows navigation from the Ohio River to Knoxville. Virtually all the major tributaries have at least one dam. In addition to the nine reservoirs on the mainstem of the Tennessee River, TVA operates 38 tributary dams for various combinations of power generation, flood control, pumped storage, navigation, recreation, water supply, economic development, and fish and wildlife habitat. This system of dams and their operation is the most significant factor affecting water quality and aquatic habitats in the Tennessee River and its major tributaries.

Water quality is generally good in the TVA region. Most beneficial uses (as designated by the states) are supported in most water bodies, including fish and aquatic life, public and industrial water supply, waste assimilation, agriculture, and water-contact recreation. Of the approximately 42,000 perennial stream miles in the Valley (TVA 1971), 8,500 miles are not supporting their designated uses (compiled from seven Valley states 2008 and 2010 305(b) reports), and 113,000 acres of lakes and reservoirs (compiled from seven Valley states 2008 and 2010 305(b) reports) (out of approximately 660,000 total acres [compiled from 2000 U.S. census GIS coverage]) are not supporting their uses.

Ecological health in TVA reservoirs is monitored by the Vital Signs Monitoring Program. This program uses five metrics: chlorophyll concentration, fish community health, bottom life, sediment contamination, and DO. Values of good, fair, or poor are assigned to each metric. All TVA reservoirs have at least two monitoring locations, one in the deep area near the dam (forebay), and one in the upstream end of the reservoir (inflow). Larger reservoirs also have a midreservoir site, and some have sites in major embayments. These scores are combined for a representative summary score for each reservoir. The principal water quality concerns in TVA reservoirs identified by Vital Signs monitoring, along with state 303(d) and 305(b) information and state-issued fish consumption advisories, are summarized in Table 4-7.

TVA also monitors ecological health in the streams of the Valley. The STM Program assesses the condition of the biological community at sites throughout the Valley. The primary tool in this assessment is a fish IBI that uses 12 metrics to arrive at an overall score for the health of the fish community at each site. This program also collects data on the health of the benthic community. These data complement state monitoring programs and are frequently used by them to aid in assessing use support.

Of the 869 active monitoring stations, 544 have been matched to 11-digit HUs to track and evaluate the overall water quality on an HU basis. These HU stations are typically monitored on a five-year cycle. A combination of reservoir and stream monitoring data is used to rate a total of 598 HUs; the remaining seven Valley HUs have no suitable location for collecting data to characterize their condition (see Figure A-12, Appendix A).

Most of the state listings for impaired streams in the TVA region are ascribed to pollution from sediment or bacterial contamination. Sediment sources are mostly erosion from agriculture, silviculture, and construction activities. Bacteria are from contamination from fecal material from livestock, malfunctioning septic systems, leaking sewage collection systems, and urban runoff. Plant nutrients are also an important pollutant. These come from agriculture, wastewater treatment plants, and urban runoff. Nutrients stimulate the growth of algae and cause shifts in aquatic communities. In reservoirs, excessive algae growth consumes DO, which in turn limits available aquatic habitat in the reservoir and can influence the health of the aquatic community. Low DO levels in stream reaches downstream of TVA dams are associated with low DO within the reservoirs. Long stretches of river can be affected, especially in areas where pollution further depletes DO. In addition, flow in these sections of stream can be determined by the amount of water released from the upstream dams, and in the past, some of the tailwaters were subject to periods of little or no flow. Since the early 1990s, TVA has addressed these issues by installing equipment to increase DO concentrations below 16 dams. At the same time, TVA made operational changes and installed additional equipment to ensure minimum water flows through its dams.

Table 4-7. Ecological Health Ratings of TVA Reservoirs

Reservoir	Ecological Health Rating	Score	Latest Survey Date	Concerns	State Listing as Impaired	Causes	Sources	Fish Consumption Advisory
Apalachia	Good	84	2008		None			Hg North Carolina statewide
Bear Creek	Fair	64	2007	DO	AL, 654 acres	Organic enrichment, low DO		Hg
Beech	Poor	51	2008	DO, chlorophyll	None			None
Blue Ridge	Good	83	2007	DO	None			Hg
Boone	Poor	50	2007	DO, chlorophyll, bottom life	TN, 1968 acres	PCBs, Chlordane	Contaminated sediment	PCBs, chlordane
Cedar Creek	Fair	69	2007	DO	None			None
Chatuge	Fair	59	2008	DO, bottom life, sediment quality	None			Hg
Cherokee	Fair	63	2008	DO, chlorophyll, bottom life	TN, 2816 acres	Mercury	Atmospheric deposition-sources outside state	None
Chickamauga	Good	78	2009	Chlorophyll, bottom life	TN, total of 4,235 acres (Hiwassee River Embayment)	Mercury, E. coli	Industrial point source and/or atmospheric deposition (Hg); undetermined source (E. coli)	None
Douglas	Fair	59	2009	DO, chlorophyll	None			None
Fontana	Fair	69	2008	Bottom life	NC, 171 acres (Tuckasegee arm)	Fecal coliform		Hg North Carolina statewide
Fort Loudoun	Poor	50	2007	DO, chlorophyll, bottom life	TN, 14,066 acres PCBs; 534 acres Mercury and PCBs	Contaminated sediment (PCBs) Atmospheric deposition (Hg)		PCBs

Reservoir	Ecological Health Rating	Score	Latest Survey Date	Concerns	State Listing as Impaired	Causes	Sources	Fish Consumption Advisory
Fort Patrick Henry	Fair	60	2007	Chlorophyll, bottom life	None			None
Guntersville	Good	79	2009	Chlorophyll	None			None
Hiwassee	Fair	67	2008	DO, chlorophyll	NC, 143 acres	Low pH		None
Kentucky	Fair	70	2009	DO, chlorophyll	None			Hg Kentucky statewide
Little Bear Creek	Fair	70	2009	DO, bottom life	AL, 1,435 acres	Nutrients	unknown	None
Melton Hill	Fair	65	2008	Bottom life	TN, 5,690 acres	PCBs, Chlordane	Contaminated sediment	PCBs
Nickajack	Good	85	2009	Chlorophyll	TN, 10,370 acres	PCBs, Dioxin	Contaminated sediment	PCBs
Normandy	Poor	52	2008	DO, chlorophyll	None			None
Norris	Fair	60	2007	DO, chlorophyll, bottom life	TN, 23,198 acres (Clinch River portion)	Mercury	Atmospheric deposition	None
Nottely	Poor	50	2009	DO, chlorophyll, bottom life	None			Hg
Parksville	Good	81	2009	Sediment quality	TN, 1,280 acres	Copper, iron, zinc, loss of biological integrity due to siltation	Mill tailings, mine tailings, contaminated sediments, impacts from abandoned mines	None
Pickwick	Good	78	2006	Chlorophyll	None			None
South Holston	Fair	60	2008	DO, chlorophyll, bottom life	TN, 7,577 acres VA, 1,699 acres	Mercury (TN); mercury and PCBs in fish tissue (VA)	Atmospheric deposition (TN)	Hg (TN and VA); PCBs (VA)
Tellico	Poor	55	2009	DO, chlorophyll, bottom life	TN,16,500 acres	PCBs, mercury	Contaminated sediment (PCBs); atmospheric deposition (Hg)	PCBs
Tims Ford	Poor	52	2008	DO, bottom life	None			None
Watauga	Good	75	2008	DO	TN, 6,427 acres	Mercury	Atmospheric deposition	None

Reservoir	Ecological Health Rating	Score	Latest Survey Date	Concerns	State Listing as Impaired	Causes	Sources	Fish Consumption Advisory
Watts Bar	Fair	59	2008	DO, chlorophyll, bottom life	TN, Total of 36,050 acres	PCBs, low DO	Contaminated sediments (PCBs, 36,050 acres); upstream impoundment (low DO, 1,971 acres)	PCBs, Hg
Wheeler	Poor	57	2007	DO, chlorophyll, bottom life	AL, 1569 acres	pH, nutrients	pasture grazing, non-irrigated crop production	DDT
Wilson	Poor	54	2008	DO, chlorophyll	None			None

Abbreviations: DDT = Dichlorodiphenyltrichloroethane; DO = Dissolved oxygen; Hg = Mercury; PCBs = Polychlorinated biphenyls

Nine dewatering areas are associated with TVA reservoirs (see Section 2.1.2). To prevent mosquito breeding, certain areas that would be shallow backwater at normal summer pool elevations are regulated with dikes and pumps. These areas are kept dry and farmed during the summer and flooded to provide waterfowl habitat in the winter. Water discharged from these areas can contain fertilizer and other agricultural chemicals from summer farming, along with nutrients and bacteria from the large winter waterfowl populations. Most of these areas discharge directly to the reservoir and quickly diluted. However, 3.7 acres of the West Sandy Embayment is listed by the state of Tennessee as impaired by nutrients, low dissolved oxygen and siltation, caused at least in part by discharges from the West Sandy Creek Dewatering Area.

4.6. Aquatic Ecology

Rivers located in the TVA region support a large variety of freshwater fishes and invertebrates (including freshwater mussels, snails, crayfish, and insects). Due to the number of major river systems found in this region, the Southeastern U.S. is recognized as a globally important area for freshwater biodiversity (Stein et al. 2000). This discussion of affected aquatic environments focuses on two distinct categories of water bodies: the TVA reservoir system within the Tennessee River watershed and “free-flowing” streams that are unaffected (or relatively unaffected) by the presence of TVA’s dams and reservoirs.

The TVA Reservoir System

The construction of the TVA dam and reservoir system fundamentally altered both the water quality and physical environment of the Tennessee River and many of its tributaries. While dams promote navigation, flood control, power benefits, and river-based recreation by moderating the flow effects of floods and droughts throughout the year, they also disrupt the daily, seasonal, and annual flow patterns that are characteristic of a river. Damming of the rivers was done at a time when there was little regard for aquatic resources (Voigtlander and Poppe 1989). ROS (TVA 2004) describes in great detail the aquatic communities and resources present in the TVA reservoir system.

Prior to construction of the TVA reservoir system, aquatic communities were structured by water quality and physical habitat condition, which were driven by physiographic region and climate. Streamflow was proportional to rainfall, and flow regime followed the same trends as the annual rainfall pattern. Flow established physical habitat conditions (depth, velocity) within a stream and maintained stream shape and other habitat conditions (substrate). Relatively infrequent high-flow events (flows that only occur every one to two years) were responsible for maintaining large-scale habitat patterns such as the number of riffles or pools (Rosgen 1996). High water flows clean substrate by flushing out fine sediments, which may suffocate fish eggs or mussels and fill in the spaces between rocks needed by aquatic insects. These “free-flowing” streams and rivers represent the natural condition of these waterways. Because historical flow was proportional to rainfall, over short-time intervals, such as days, flow was relatively predictable—meaning that yesterday’s flow was likely to be similar to today’s flow, and from hour to hour, there was little change except during storm events.

Floods were common during spring, and flows decreased throughout the year with the lowest typically occurring August through October, the warmest part of the year. Spring flooding was an important component in the life cycles of some fish species that use flooded overbank areas for spawning or nursery areas. The Tennessee River was shallow, with expansive areas of rocky or gravel shoals, which are critical features that contribute to the great diversity of aquatic life (Etnier and Starnes 1993).

Tributary Reservoirs and Tailwaters — Reservoirs located on the tributaries to the Tennessee River are typically of the deep storage type that retains water for long periods of time. Little flow and regular periods of thermal stratification result in oxygen depletion in the deeper water. These aquatic habitats are simplified relative to undammed streams, and fewer species are found. Lack of minimum flows and low DO in the first few miles below tributary dams may severely limit the habitat needed by native fish. This may restrict their movement, migration, reproduction, and available food supply. Large seasonal fluctuations in reservoir levels also affect aquatic communities within the reservoir pool.

Dams located on tributary rivers affected the habitat of benthic invertebrates (benthos), which are a vital part of the food chain of aquatic ecosystems. Benthic life includes worms, snails, and crayfish, which spend all of their lives in or on the streambeds, and aquatic insects, mussels, and clams, which live there during all or part of their life cycle. Many benthic organisms have narrow habitat requirements that are not always met in reservoirs or tailwaters below dams. Further downstream from dams, the number of benthic species increases as natural reaeration occurs and DO and temperatures rise.

TVA has implemented several programs to improve the water quality of releases at tributary dams including establishment of minimum flows from all of its tributary dams and the addition of active and/or passive reoxygenation systems at many of its tributary dams. Improvements in habitat conditions and freshwater communities have occurred in over 300 miles of TVA's tailwater areas as a result of these actions.

Improved year-long cold-water discharges in seven TVA tailwaters in Tennessee has allowed development of highly valued put/grow/take trout fisheries and resulted in Tennessee's assigning these tailwaters a "Trout Stream" use designation, along with protective water quality criteria in its Water Quality Standards. This fishery resource has been developed and is managed by TWRA. TWRA has estimated the number of fishing trips in tailwaters on the Clinch, Duck, Elk, Hiwassee, and South Fork Holston rivers over comparable 26-week fishing seasons (2003 estimates) ranged from 2,722 on the Duck to 24,242 and 24,635 on the South Fork Holston and Clinch, respectively (Williams and Bettoli 2003). Total number of trips for the five rivers was 77,288, representing a "Travel Cost Method" total value of $4.5 million over a 26-week fishing season. Total 26-week expenditures for these five rivers were $2.2 million, ranging from $148,213 on the Elk to $1,513,043 on the Hiwassee. These tailwaters have unique value for supporting such fisheries, especially if natural trout habitats were to become impacted by climate change (higher temperatures and reduced flow).

Mainstem Reservoirs — The nine mainstem reservoirs on the Tennessee River differ from tributary reservoirs primarily in that they are shallower, have greater flows, and thus retain the water in the reservoir for a shorter period of time. They generally do not become as strongly stratified as tributary reservoirs. Although DO in the lower lake levels is often reduced, it is seldom depleted. Winter drawdowns on mainstem reservoirs are much less severe than tributaries, so bottom habitats generally remain wetted all year. This benefits benthic organisms but promotes the growth of aquatic plants in the extensive shallow overbank areas of some reservoirs.

Tennessee River mainstem reservoirs generally support healthy fish communities, ranging from about 50 to 90 species per reservoir. Good to excellent sport fisheries exist, primarily for black bass, crappie, sauger, white and striped bass, sunfish, and catfish. The primary commercial species are channel and blue catfish and buffalo. The benefit of the system

minimum-flow mode of operation has already been seen during a recent (2006-2008) drought period in the Valley. TVA monitoring data indicated that while there was a decline in aquatic communities across the Valley, these declines were somewhat mitigated in the regulated portions of the Tennessee River watershed.

The TVA Vital Signs Monitoring Program rates environmental conditions in reservoirs using a fish and benthic IBI (Dycus and Meinert 1991). TVA also monitors sport fish populations using the Sport Fishing Index (SFI), which incorporates the status of population quantity and quality along with available angler catch information. Within a reservoir, SFI scores monitor positive or negative trends in population status, relative to fishing experience (Hickman 2000). Beyond the SFI Monitoring Program, TVA operates certain hydropower operations in a manner that provides important flow levels for spring spawning grounds of certain fishes. For example, prescribed spring flows are provided downstream of Watts Bar Reservoir to enhance sauger spawning.

"Free-Flowing" Streams and Rivers in the Tennessee River Watershed
The "free-flowing" streams within the Valley hold a much higher diversity of aquatic life (including state- and federally listed species) than are found in the TVA reservoir system. The Clinch River and Duck River in Tennessee and Virginia are recognized as global "hotspots" for freshwater biodiversity.

While aquatic communities in these rivers and streams are much more diverse than within the reservoir system, it is recognized that these watersheds have their own water quality issues. Land management practices such as agriculture; industrial, residential and recreational development; and forestry have led to the degradation of water quality and habitat in many of the region's streams and rivers.

4.7. Endangered and Threatened Species

A total of approximately 94 aquatic animals, 33 terrestrial animals, and 44 plants listed under the Endangered Species Act as endangered, threatened, proposed for listing, or candidates for listing have been reported from the TVA region. Numerous additional species listed as endangered, threatened, or of other conservation concern by one or more of the TVA region states also occur in the TVA region. Several of these species would potentially be affected by the NRP alternatives. These species are described in more detail below.

4.7.1. Aquatic Animals

The Tennessee River and its tributaries contain 62 species of aquatic animals that are federally listed as endangered, threatened, or proposed or candidates for such listing. Many more species are listed by the states in the Tennessee River watershed. A summary of the number of state- and federally listed aquatic animal species known from the Tennessee River watershed is presented in Table 4-8. Because almost all proposed NRP activities that could result in direct physical impacts (beneficial or adverse) would be conducted on TVA lands, or within the Tennessee River watershed, only aquatic species known from the Tennessee River watershed are discussed here. The exceptions to this would be small-scale activities occurring on generation facility properties on the Cumberland River (Cumberland and Gallatin Fossil Plants), the Green River (Paradise Fossil Plant), the Ohio River (Shawnee Fossil Plant), and the Mississippi River (Allen Fossil Plant).

Detailed lists of the species reported from the Tennessee River watershed in each of the seven Valley states are presented in Appendix J. None of these species are known to occur on TVA lands that are a part of this plan. However, many of these species occur in streams and reservoirs adjacent to these lands.

Table 4-8. State- and Federally Listed Aquatic Animal Species Present in the Tennessee River Watershed

State	Crustaceans		Insects		Mollusks		Fish		Total	
	State	Federal	State	Federal	State	Federal	State	Federal	State	Federal
Alabama	8	1	14	0	73	26	38	6	133	33
Georgia	0	0	0	0	3	0	35	4	38	4
Kentucky	0	0	0	0	26	6	15	0	41	6
Mississippi	0	0	0	0	8	0	14	0	22	0
North Carolina	9	0	1	0	18	4	31	2	59	6
Tennessee	15	0	9	1	67	37	56	13	147	51
Virginia	10	1	2	0	41	18	46	6	99	25
Tennessee River Watershed	37	2	22	1	124	42	123	17	306	62

The Tennessee River watershed supports an unusually diverse group of aquatic animals. Although their diversity was historically higher, exceptional species diversity is still observed in fish; mollusks, crayfish, aquatic insects, and various other invertebrate groups. Even before impoundments were constructed on the Tennessee River system, human activities resulted in adverse impacts to streams and the animals living there. Hughes and Parmalee (1999) presented convincing evidence that the pristine stream habitats in the Tennessee River system that had been inhabited by nearly 100 freshwater mussel species were beginning to be affected by human activities by the mid-1800s, and that many of these freshwater mussels were already extirpated before the Tennessee River mainstem impoundments were constructed (see Ortmann 1918, 1925; van der Schalie 1939; Stansbery 1964; Isom 1969). The paucity of early fish collections do not allow a similar comment about the impact of these activities to Tennessee River mainstem fish assemblages, but Etnier et al. (1979) speculated that there are probably species of Tennessee River fish that became extinct before they were known to science.

The historic loss of the Tennessee River watershed's exceptional aquatic diversity is of global significance (Stein et al. 2000). Ichthyology books (Boschung and Mayden 2004, Etnier & Starnes 1993, Jenkins and Burkhead 1993, and Mettee et al. 1996) discuss the historic diversity of the Tennessee River watershed and the extirpation and extinction of various fish. Likewise, Parmalee and Bogan (1998) discuss the same topics with regard to mussels. There are no definitive texts, however, that describe the status of the other components of the aquatic community. Population trends vary among species groups with the majority of listed species experiencing declines across their ranges.

4.7.2. Terrestrial Animals

There are 33 federally listed, protected, or candidate terrestrial animal species occurring in the TVA region (Appendix J). Of these species, five occur on TVA lands (Table 4-9). A

sixth species, red-cockaded woodpecker, historically occurred on or near TVA lands. In recent decades, this species has only occurred in isolated pockets in extreme southern portions of the region. TVA's resource management activities would not result in impacts to this species.

Table 4-9. Federally Listed Endangered, Threatened, and Candidate Terrestrial Animals and Plants Potentially Impacted by the Natural Resource Plan

Common Name	Scientific Name	Federal Status
	Terrestrial Animals	
Bald eagle	*Haliaeetus leucocephalus*	PROT
Interior least tern	*Sterna antillarum athalassos*	LE
Piping plover	*Charadrius melodus*	LT/LE
Gray bat	*Myotis grisescens*	LE
Indiana bat	*Myotis sodalis*	LE
	Plants	
Cumberland rosemary	*Conradina verticillata*	LT
Fleshy-fruit gladecress	*Leavenworthia crassa*	C
Green pitcher plant	*Sarracenia oreophila*	LE
Large-flowered skullcap	*Scutellaria montana*	LT
Monkey-face orchid	*Platanthera integrilabia*	C
Morefield's leather-flower	*Clematis morefieldii*	LE
Price's potato-bean	*Apios priceana*	LT
Ruth's golden aster	*Pityopsis ruthii*	LE
Shorts bladderpod	*Lesquerella globosa*	C
Small whorled pogonia	*Isotria medeoloides*	LT
Virginia spiraea	*Spiraea virginiana*	LT

Federal status abbreviations: C=Candidate; LE=Endangered; LT=Threatened; PROT=Protected under the Bald and Golden Eagle Protection Act

Bald eagles are largely distributed throughout the region with the largest aggregations noted in the central and western ecoregions. TVA reservoirs and surrounding lands provide high quality habitat for this species and both breeding and wintering populations regularly occur on TVA lands (see Appendix J). Breeding pairs are especially prevalent on lands surrounding Kentucky and Guntersville reservoirs.

Bald eagles nest in a variety of habitats throughout the region. Some pairs select large solitary trees, often a loblolly pine, in open fields, while others select more hidden sites in pines or hardwoods on forested hillsides. They typically forage on fish, turtles, semiaquatic mammals, ducks, and herons. TVA biologists have observed remnants of these food items at eagles' nests throughout the Valley during routine monitoring activities.

Historically, the distribution of eagles was spotty throughout the Valley; however, results of recent surveys performed by TVA and others show that bald eagles have expanded their breeding range throughout much of the Valley. Population numbers have largely rebounded since DDT was banned from agricultural use. An intensive reintroduction program (hacking) initiated collectively by federal and state conservation agencies was also

instrumental in increasing the number of bald eagles in the Valley. TVA provided bald eagle hacking localities during this program in north Alabama and other sites along the Tennessee River.

Although the bald eagle was removed from the federal list of endangered and threatened species in 2007, it remains protected under the Bald and Golden Eagle Protection Act. TVA incorporates recommendations from the National Bald Eagle Management Guidelines (USFWS 2007) during planning and stewardship activities.

Gray bats are widely distributed throughout the region (see Appendix J); largest concentrations occur in central and eastern ecoregions. This species hibernates in cold caves (usually deep pits) and forms large maternity colonies in warmer caves during summer. Many significant maternity caves are found adjacent to TVA reservoirs. In the early 1990s, TVA partnered with the USACE and Auburn University to study gray bats on Guntersville Reservoir (Thomas and Best 2000; Best et al. 1995). This endangered species was found to routinely forage along TVA lands and adjacent to power generation properties throughout north Alabama. TVA routinely monitors and protects all known gray bat populations on TVA lands. Subsequent monitoring by the USFS, TVA, USFWS, state conservation agencies, and other universities has documented the species throughout the TVA region.

Interior least terns are largely associated with the Mississippi Alluvial Plains. They nest in colonies on exposed sandbars at numerous sites in the Mississippi River during summer months. There are a few records of them nesting on more mainland sites along the Mississippi River, including recently at the TVA Allen Fossil Plant. After breeding, least terns often disperse along adjacent tributaries and are occasionally observed on Kentucky Reservoir. Least terns are not known to nest on the Tennessee River.

Piping plovers are transient fall migrants in the interior Southeast during late July (females) and late September (males and juveniles). There are few reports of observations during spring migration. Piping plovers use exposed mudflats on the Mississippi, Ohio, Cumberland, and Tennessee rivers as stopover sites during migration. They are more prevalent along the Mississippi River than the Tennessee River. Solitary piping plovers are observed sporadically on Kentucky and Douglas reservoirs. Isolated observations have been reported on Chatuge and Nottely reservoirs in northern Georgia and Boone Reservoir in northeast Tennessee. Piping plovers have also been observed at Colbert and Kingston fossil plants.

Indiana bats are rare throughout the region; most recent records of this species are reported from areas in the Blue Ridge Province (i.e., Cherokee National Forest). They hibernate in caves and forms summer roosts usually in dead trees that are largely covered with exfoliating bark. Indiana bats typically roost in multiple trees having varying exposure to sunlight (Miller et al. 2002). Historic records of this species are reported from caves on TVA lands. TVA's Nickajack Cave is the type of locality for the species although it has not been observed there in recent years. Indiana bats have also been reported from TVA's Little Bayou Creek Ridge HPA at Shawnee Fossil Plant. A small maternity population occurs on USFS land near a TVA tract adjacent to Tellico Reservoir. The species has also been found recently at sites near Fontana Reservoir lands and in the Cherokee and Bankhead national forests.

TVA has routinely surveyed for Indiana bats while evaluating resource stewardship activities, land plans, and power-related projects. With one exception, no Indiana bats have been captured during these surveys. Recently, Indiana bats were captured along a transmission line corridor in middle Tennessee and Kentucky. Any forested habitat throughout the Valley with mature forest, a high density of snags, and open midstories could be suitable habitat for this species (Menzel et al. 2001; Romme et al. 1995). TVA surveys for Indiana bats when medium- or high-quality habitat is identified during field surveys.

Approximately 701 state-listed or state-ranked terrestrial animal species occur in the TVA region (Appendix J). The list is comprised of a diverse array of birds (28 percent), mammals (16 percent), reptiles (11 percent), and amphibians (14 percent). Over 31 percent of the list is comprised of invertebrates, mostly cave-dwelling species. Most species are found in the Blue Ridge, Southwestern Appalachians, and Interior Plateau ecoregions. Many species have widespread distributions; examples include osprey, southeastern shrew, and green treefrog. However, some species are endemic to specific ecoregions, states, or localities, especially cave-dwelling species. Although many of these species have no legal status, they are considered very rare and are often associated with very fragile habitats.

Many of the species listed in Appendix J occur on TVA lands and are considered during the TVA's stewardship and reservoir lands planning processes. For example, during lands planning efforts on Guntersville and Upper Bear Creek reservoirs, biologists located extensive sandstone outcrops, which is habitat used by green salamanders. Although common on these reservoir lands, this habitat is very limited on a regional scale, restricted largely to very narrow bands along portions of the Valley. TVA designated many sandstone outcrops at Upper Bear and Guntersville reservoirs as natural areas to protect recently discovered populations of green salamanders and other species that occur in these areas.

Trends of Listed Terrestrial Animals

Populations of several listed species have improved since the ESA was enacted. Results of surveys performed by TVA and others show that bald eagles and gray bats appear to have increasing or stable numbers in the TVA region. Numbers of some other species, such as Indiana bats, continue to decline or remain low despite protective measures implemented by various federal and state agencies. Recent discovery of a highly virulent disease (white-nose syndrome) impacting cave-dwelling bats could result in serious declines in numbers of gray and Indiana bats. Therefore, an initial move to downgrade the listing status of gray bats from endangered to threatened has been dropped, and both gray and Indiana bats are being monitored closely to see how they cope with this new threat. White-nose syndrome has spread throughout many states in the eastern U.S. and portions of Canada. It has recently been discovered in bat populations in Virginia, Kentucky, North Carolina and Tennessee. TVA has closed the caves on its lands to public access, as requested by the USFWS, in an effort to control the spread of this disease; and works with several conservation agencies to monitor the spread of the disease through the region.

Conservation efforts have stabilized or slowed the declines of the remaining listed species. However, little is known about the population trends of cave invertebrates in the region. If white-nose syndrome results in substantial reductions in populations of cave-dwelling bats, subsequent reductions in many cave invertebrates dependent on cave-dwelling bats are likely.

4.7.3. Plants

Forty-four plant species listed as endangered or threatened under the Endangered Species Act, 6 candidate plant species for such listing, and 996 state-listed plant species are known to occur within the TVA region. A complete listing of the federally and state-listed plant species reported from each ecoregion within the TVA region can be found in Appendix J.

Federally Listed Plants

Over 80 percent of the federally listed species occur within four of the nine ecoregions: Blue Ridge with 27 percent, Southwestern Appalachians with 18 percent, Interior Plateau with 18 percent, and Ridge and Valley with 17 percent. Figure 4-5 depicts a graph representing the percentage of federally listed species found in each ecoregion. Of the 44 federally listed plant species, 11 have the potential to be impacted by TVA actions associated with the NRP (Table 4-9). These species are discussed below.

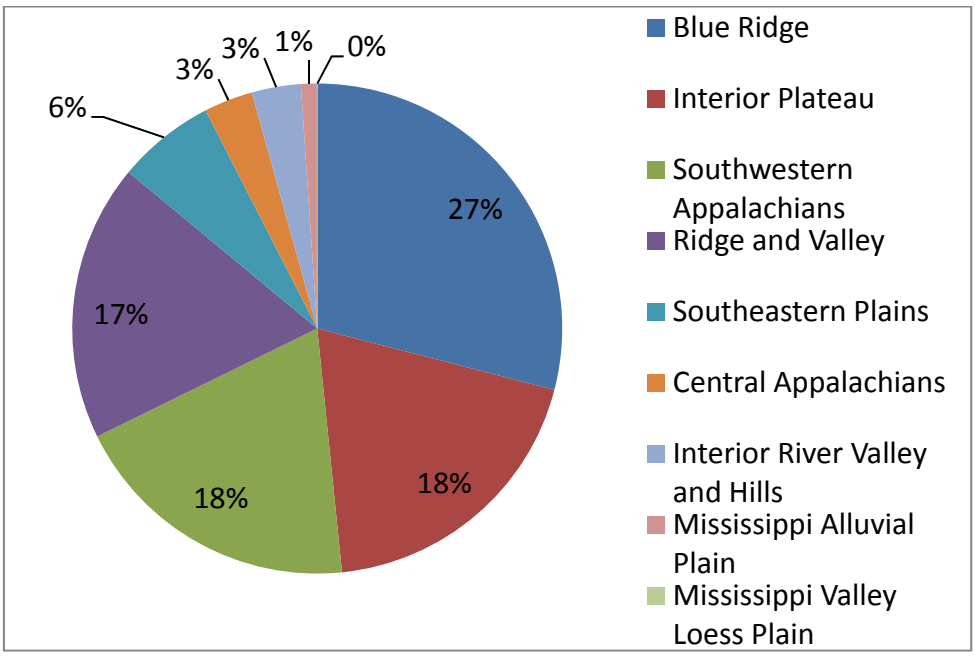


Figure 4-5. Percentage of Federally Listed Endangered, Threatened, and Candidate Species per Ecoregion

Cumberland rosemary, a member of the mint family, is a perennial evergreen shrub federally listed as threatened. Populations are restricted to boulder/cobble/gravel bars, sand bars and islands, sandy riverbanks, floodplains in river gorges, and similar sunny riparian areas where seasonal flooding minimizes competition and creates new gravel-bar habitats for colonization. Threats to this species include habitat destruction due to dam construction and water pollution from nearby coal mining. Intensive recreational use also poses a threat (NatureServe 2009).

Fleshy-fruit gladecress is endemic to Lawrence and Morgan counties in Alabama. It is locally abundant, but only a few localities are known. Highway construction and residential

development are major threats to this species, which NatureServe (2009) states is likely one of the most imperiled plant species in the Southeast and is in need of urgent protection.

Green pitcher plant is a carnivorous plant restricted to acidic seepage bogs and boggy stream edges in northeast Alabama, northeast Georgia, and southwest North Carolina. Threats include degradation of habitat by residential and road construction, encroachment of woody vegetation due to fire suppression, drainage from agricultural practices, flooding and streambank changes due to human disturbances, and commercial/amateur collection of live plants (NatureServe 2009). The populations on Chatuge Reservoir are monitored by the Georgia and North Carolina Nature Conservancy aided by TVA staff.

Large-flowered skullcap is a member of the mint family commonly encountered on wooded slopes with rocky outcrops within the Tennessee River Gorge in southeast Tennessee and northwest Georgia. Numerous occurrences are known from TVA lands along Chickamauga and Nickajack Reservoirs, on the Raccoon Mountain Pumped Storage Plant Reservation, and in close proximity to Sequoyah Nuclear Plant.

The monkey-face orchid grows in swamp forests and sandy stream margins. Even though this species is known to occur in most southern states, these plants are not commonly encountered. Major threats to the species are a result of habitat loss from development, canopy closure, improper timber harvest techniques, and the encroachment of exotic invasive plants such as Chinese privet and Japanese stiltgrass. This species has been reported to occur on TVA lands adjacent to Yellow Creek, but the population is now thought to have been extirpated.

Morefield's leather-flower is restricted to rocky limestone bluffs and boulder fields. Smoke tree is an indicator species. In several locations throughout the Valley, Morefield's leather-flower and Price's potato bean have been found growing together. Threats to the species include development and encroachment of invasive species.

Price's potato bean prefers disturbed portions of rocky limestone areas in forest openings, wood edges, and regions where bluffs descend to streams. Threats to the species include development and encroachment of invasive species.

Ruth's golden aster has a limited range and specific habitat. This rare member of the sunflower family can be found in cracks or crevices of phylite or greywacke boulders along the banks or within the Hiwassee and Ocoee rivers in Polk County, Tennessee (Kral 1983; USFWS 1990; NatureServe 2009). The construction of the dams on these rivers may have reduced the range of this species, and remaining populations are threatened by habitat changes resulting from postimpoundment river flows.

Short's bladderpod, a member of the mustard family, is endemic to the Interior Low Plateau from middle Tennessee through north central Kentucky and into southern Indiana. According to NatureServe (2009), this species exhibits wide population changes from year to year due to variable germination and seedling survival levels in its arid microhabitat. Road construction and maintenance activities such as herbicide use, grading of road shoulders, mowing during the growing season, and encroachment of exotic species continue to threaten many of the populations. Some sites adjacent to rivers are threatened by water-level manipulation.

Small whorled pogonia occurs in a variety of habitats throughout its range. It is typically found on acidic soils, in dry to mesic second-growth, deciduous or deciduous-coniferous forests. In addition, the plants prefer habitats that have light to moderate leaf litter, an open herb layer (occasionally dense ferns), moderate to light shrub layer, and relatively open canopy (NatureServe 2009; USFWS 2008). The main threats to this species are habitat destruction and excessive collecting. It is known from the vicinity of five mountain reservoirs (Apalachia, Blue Ridge, Chatuge, Hiwassee, and Nottely) but has not been reported as occurring on TVA lands.

Virginia spiraea is a shrub growing on rocky flood-scoured riverbanks and gravel bars in gorges or canyons in the central and southern Appalachian Mountains. It is often found growing with Cumberland rosemary on the Cumberland Plateau. Populations have been extirpated by impoundments, and other threats include riverbank development, habitat changes resulting from altered river flows and the encroachment of exotic invasive species. Sexual reproduction is uncommon, and plants rely almost completely on vegetative reproduction, which could also account for the declining health of known populations.

State-Listed Plants

More than 10,000 occurrences of 996 state-listed plant species are known from the TVA region (Appendix J). Thirty-two (4.1 percent) of these species are known to occur within a mile of TVA facilities (Table 4-10). The Yellow Creek site, on Pickwick Reservoir in Mississippi, has the most state-listed species (13) occurring within or directly adjacent to the reservation, followed by Melton Hill Dam with six species. TVA land surrounding the Raccoon Mountain Pumped Storage Plant not only is home to the federally listed large-flowered skullcap but also harbors five state-listed species.

Table 4-10. State-Listed Plant Species Found Within 1 Mile of TVA Facilities

Common Name	Scientific Name	State Rank	State Status	Facility
American ginseng	*Panax quinquefolius*	S3S4	S-CE	Melton Hill Dam, Raccoon Mountain
American pillwort	*Pilularia americana*	S1S2	SPCO	Dogwood Reservation Dam
Appalachian bugbane	*Cimicifuga rubifolia*	S3	THR	Norris Dam
Big shellbark hickory	*Carya laciniosa*	S2S3 (MS)	SLNS (MS)	Yellow Creek
Butternut	*Juglans cinerea*	S3	THR	Melton Hill Dam
Canada lily	*Lilium canadense*	S3	THR	Bull Run Fossil Plant
Crested fringed orchid	*Platanthera cristata*	S3 (MS)	SLNS (MS)	Yellow Creek
Dutchman's breeches	*Dicentra cucullaria*	S2 (AL)	SLNS (AL)	Wilson Dam
Dwarf larkspur	*Delphinium tricorne*	S2 (MS)	SLNS (MS)	Yellow Creek
Fame-flower	*Talinum mengesii*	S2	THR	Raccoon Mountain
Fetter-bush	*Leucothoe racemosa*	S2	THR	Kingston Fossil

Common Name	Scientific Name	State Rank	State Status	Facility
				Plant
Green violet	*Hybanthus concolor*	S2 (MS)	SLNS (MS)	Yellow Creek
Heavy-fruited sedge	*Carex gravida*	S1	SPCO	Melton Hill Dam; Tellico Dam
Horsesugar	*Symplocos tinctoria*	S2	SPCO	Ocoee 3 Dam
Meehania mint	*Meehania cordata*	S2	THR	Norris Dam
Mountain bush-honeysuckle	*Diervilla sessilifolia var rivularis*	S2	THR	Raccoon Mountain
Northern white cedar	*Thuja occidentalis*	S3	SPCO	Bull Run Fossil Plant
Purple cliff-brake fern	*Pellaea atropurpurea*	S1S2 (MS)	SLNS (MS)	Yellow Creek
Pursh's wild-petunia	*Ruellia purshiana*	S1S2	SPCO	Melton Hill Dam
Round-leaf serviceberry	*Amelanchier sanguinea*	S2	THR	Raccoon Mountain
Sedge	*Carex stricta*	S2 (MS)	SLNS (MS)	Yellow Creek
Shooting star	*Dodecantheon meadia*	S2 (MS)	SLNS (MS)	Yellow Creek
Slender toothwort	*Dentaria heterophylla*	S2S3 (MS)	SLNS (MS)	Yellow Creek
Spotted wintergreen	*Chimaphila maculata*	S2 (MS)	SLNS (MS)	Yellow Creek
Spreading false-foxglove	*Aureolaria patula*	S3	SPCO	Kingston Fossil Plant, Bull Run Fossil Plant, Melton Hill Dam
Stonecrop	*Sedum ternatum*	S2 (MS)	SLNS (MS)	Yellow Creek
Sullivantia	*Sullivantia sullivantii*	S1	END	Norris Dam
Tall larkspur	*Delphinium exaltatum*	S2	END	Bull Run Fossil Plant
Three-parted violet	*Viola tripartata*	S2S3	SPCO	Raccoon Mountain, Melton Hill Dam
Virginia pine	*Pinus virginiana*	S2 (MS)	SLNS (MS)	Yellow Creek
Wild hyacinth	*Camassia scilloides*	S2S3 (MS)	SLNS (MS)	Yellow Creek
Yellow trout-lily	*Erythronium rostratum*	S2S3 (MS)	SLNS (MS)	Yellow Creek

Rank abbreviations: S1 = Critically imperiled with five or fewer occurrences; S2 = Imperiled with six to 20 occurrences; S3 = Rare or uncommon with 21 to 100 occurrences; S4 = Widespread, abundant, and apparently secure with more than 101 occurrences; S#S# = Occurrence numbers are uncertain.
Status abbreviations: END = Endangered; S-CE = Special concern, commercially exploited; SPCO = Special Concern; THR = Threatened; SLNS = State listed, no status
State abbreviations: AL = Alabama; MS = Mississippi

TVA has surveyed many of its reservoir lands during the development of reservoir land management plans and for other purposes. These lands have relatively few plant species of conservation concern as compared to the many state-listed species known to occur within the vicinity of these reservoirs. For example, 109 state-listed plant species occur in the counties surrounding Guntersville Reservoir while 15 state-listed plants have been observed on the reservoir lands (TVA 2001). Three state-listed plants were observed on TVA lands included in the Northeastern Tributary Reservoirs land plan (TVA 2010) while 30 species have been reported within 5 miles of these reservoirs. Fourteen state-listed plant species have been found on reservoir lands included in the Mountain Lakes Reservoirs land plan (TVA 2009) while 67 species have been reported within 5 miles of these reservoirs. Many of the endangered and threatened plants on TVA lands are located on tracts allocated for Sensitive Resource Management or Natural Resource Conservation (see Section 4.2 on TVA Natural Areas).

Within the TVA region, 75 percent of the state-listed plant species are found in the Interior Plateau, the Blue Ridge, the and Southwestern Appalachians ecoregions (Figure 4-6). The three ecoregions with high numbers of state-listed plants also contain a large proportion of the rare plant associations known from the TVA region.

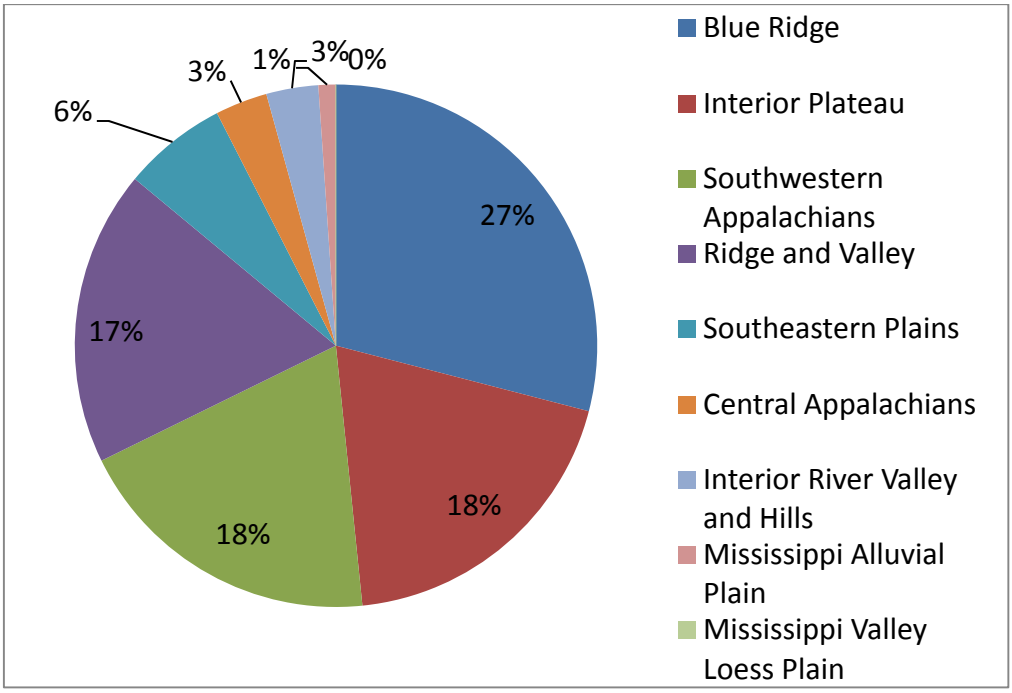


Figure 4-6. Percentage of State-Listed Plant Species per Ecoregion

Status of Endangered and Threatened Plants on TVA Lands

Three of the 46 TVA reservoirs, Chatuge, Chickamauga and Nickajack have known populations of federally listed plants along their shorelines. Green pitcher plant is managed on lands owned by the Georgia and North Carolina Nature Conservancy, and large-flowered skullcap occurs on private and public lands on Chickamauga and Nickajack Reservoirs in Tennessee and Georgia. The Ocoee and Hiwassee rivers, where river flow is

controlled by TVA (Ocoee 2 and Apalachia, respectively), both have populations of Ruth's golden aster growing on boulders in and adjacent to the rivers. TVA annually monitors populations of large-flowered skullcap in May, green pitcher plant in June, and Ruth's golden aster in September.

Raccoon Mountain Pumped Storage Plant and Sequoyah Nuclear Plant are the only TVA power plants with known records of federally listed plant species occurring within or in the immediate vicinity of their reservations. Recent field surveys have reported more than 30 records of large-flowered skullcap growing on the Cumberland escarpment of Raccoon Mountain.

Despite continued threats from invasive species and residential and commercial development within the TVA region, there are success stories about endangered and threatened plants being removed from the Endangered Species List or being proposed for removal. Previously unknown populations of other species have recently been discovered. One success story is Eggert's sunflower which when listed as threatened in 1997 was known from 34 populations in Kentucky and Tennessee. Due to conservation efforts on federal lands and surveys additional of additional, nearly 300 populations were known in three states by 2005. The newly discovered populations included several on TVA reservoir lands in northwest Alabama, and TVA has zoned several of these areas for Sensitive Resource Management. In 2006, Eggert's sunflower was removed from listing under the Endangered Species Act. A similar story is emerging for the Tennessee coneflower, listed as Endangered in 1979. After 30 years of conservation management, the USFWS considers this species as no longer in need of protection by the ESA. New populations have also recently been discovered for Braun's rock-cress, large-flowered skullcap, Morefield's leather-flower, and purple prairie clover.

Unfortunately there are also listed plant species in decline due to environmental and economic development stresses. These species include the green pitcher plant, Pyne's ground plum, small whorled pogonia, and Virginia spiraea.

Conservation efforts lead by TVA for spreading false foxglove contributed to its downlisting from Endangered to Species of Special Concern in Tennessee. Because insufficient population data are known for many state-listed plants, field surveys conducted by TVA staff have added to the distributional data for many of these species and aided in the reassessment of listing status by states within the TVA region.

4.8. Cultural Resources

TVA is obligated to protect the many historic properties under its stewardship or affected by TVA projects pursuant to several federal laws and regulations. These projects range from the management and construction of power plants to the issuance of approval under Section 26a of the TVA Act. Historic properties include historic sites, buildings, structures, and objects, and archaeological resources important to prehistory or history. These resources are collectively referred to here as cultural resources. Congress has recognized that cultural resources are important to the nation's heritage and that the government should act as a facilitator to the preservation of these important resources.

4.8.1. Archaeology

Archaeological investigations in the TVA region began in the 19th century with the explorations of Cyrus Thomas, C. B. Moore, and the Smithsonian Institution (Guthe 1952).

These early investigations focused on larger sites such as mound complexes and laid the foundation for the future role of archaeology in the U.S. The cultural history that was written as a result of these investigations along with other research that has been conducted in the Valley has been summarized elsewhere (TVA 1998; TVA 2004).

TVA's stewardship of archaeological resources began at its inception with the archaeological surveys conducted in the Norris, Wheeler, Pickwick, Guntersville, Hiwassee, Chickamauga, Gilbertsville (Kentucky), and Watts Bar basins through the efforts of local universities (Olinger and Howard 2009). Archaeological surveys conducted on TVA lands from 1940-1960 were sporadic until the NHPA was passed by Congress in 1966.

Following the passage of NHPA, numerous large-scale excavations were conducted as a result of agency undertakings that supported over 40 research volumes published by TVA and local universities. In 1983, TVA initiated an experimental archaeological stabilization program that explored various methodologies for the protection of archaeological sites eroding along the banks of its reservoirs. In addition, TVA conducted experiments on the placement of protective signage near sensitive archaeological sites being exposed to illegal looting.

As large-scale undertakings and excavations have been reduced in the recent decades and with the growing awareness of the sensitive nature of these nonrenewable resources, TVA has moved toward a preservation focus to protect those archaeological resources remaining under its management.

Pursuant to Section 110 of the NHPA, TVA is responsible for the identification, evaluation, and nomination of archaeological sites (in addition to other historic properties) to the NRHP. Toward that goal, TVA conducts identification surveys each year on its managed lands.

TVA manages approximately 293,000 acres surrounding TVA reservoirs and 470,000 acres of inundated land totaling over 763,000 acres of public lands subject to the laws and regulations protecting archaeological resources. Archaeological survey of lands inundated by TVA reservoirs varies across the Valley, and over 4,144 archaeological sites have been recorded below normal summer pool elevation (Table 4-11). Because survey coverage below normal summer pool elevation is inconsistent and due to the lack of comprehensive data on survey coverage throughout TVA's history, it is not possible to estimate the percentage of TVA lands that have been systematically surveyed within this 470,000-acre area. Many additional archaeological sites are likely present that have not been recorded as a result of the limited surveys conducted prior to construction of most TVA reservoirs. TVA often conducts identification surveys during temporary drawdown periods to identify those sites not normally exposed in regular reservoir operations.

Table 4-11. Approximate Number of Archaeological Sites Identified on and Percent of TVA Lands Systematically Surveyed

Location	Percent of Land Systematically Surveyed	Number of Inundated Sites	Number of Sites Above Normal Summer Pool	Total Number of Sites Recorded*
TVA Reservoir Lands				
Apalachia	16	14	2	16
Bear Creek Project	75	152	454	606
Beaver Creek	2	0	1	1

Location	Percent of Land Systematically Surveyed	Number of Inundated Sites	Number of Sites Above Normal Summer Pool	Total Number of Sites Recorded*
Blue Ridge	51	111	7	118
Boone	0	36	20	56
Chatuge	40	185	158	343
Cherokee	16	599	164	763
Chickamauga	8	103	455	558
Clear Creek	0	0	0	0
Douglas	Unknown	103	12	115
Fontana	Unknown	146	11	157
Fort Loudoun	0	65	31	96
Fort Patrick Henry	Unknown	35	37	72
Great Falls	0	0	0	0
Guntersville	<1	219	776	995
Hiwassee	40	248	16	264
Kentucky	1	500	1,335	1,835
Melton Hill	44	14	104	118
Nickajack	15	38	72	110
Nolichucky	0	0	0	0
Normandy	Unknown	0	43	43
Norris	Unknown	314	738	1,052
Nottely	12	168	56	224
Ocoee #1	10	20	1	21
Ocoee #2	0	0	0	0
Ocoee #3	0	0	0	0
Pickwick	29	222	596	818
South Holston	54	17	87	104
Tellico	7	285	368	653
Tims Ford	36	39	78	117
Watauga	Unknown	106	37	143
Watts Bar	41	151	477	628
Wheeler	8	254	1,077	1,331
Wilbur	0	0	0	0
Wilson	0	0	0	0
Fossil Plants				
Allen	0	N/A	0	0
Bull Run	<1	N/A	4	4
Colbert	10	N/A	11	11
Cumberland	8	N/A	4	4
Gallatin	37	N/A	1	1
John Sevier	18	N/A	3	3
Johnsonville	10	N/A	0	0
Kingston	27	N/A	0	0
Paradise	<1	N/A	0	0
Saltillo	0	N/A	15	15
Shawnee	17	N/A	17	17

Location	Percent of Land Systematically Surveyed	Number of Inundated Sites	Number of Sites Above Normal Summer Pool	Total Number of Sites Recorded*
Watts Bar	15	N/A	1	1
Widows Creek	0	N/A	2	2
Nuclear Plants				
Bellefonte	38	N/A	5	5
Browns Ferry	23	N/A	6	6
Sequoyah	100	N/A	1	1
Watts Bar	0	N/A	4	4
Other Properties				
Raccoon Mountain	27	N/A	8	8
Hartsville	27	N/A	14	14
Total	**--**	**4,144**	**7,309**	**11,453**

*Most of these totals are approximate due to lack of consolidated data across the Valley at the time of this publication.

In the last 30 years, over 40 large-scale archaeological surveys have been conducted by TVA using varying levels of intensity. Over the last few decades, archaeological survey techniques have improved due to scientific and technological advancements, and as a result, archaeological survey coverage and site documentation on TVA lands varies across the Valley. To date, TVA has documented approximately 11,500 archaeological sites on its lands. While the number of resources is quite large, less than 25 percent of these sites have been assessed for eligibility for the NRHP. These data are approximate due to a lack of consolidated data across the Valley.

TVA manages a number of significant archaeological sites that have had an important contribution to the understanding of prehistory in the Southeast. These include the Seven Mile Island Archaeological District (listed in the NRHP) and Dust Cave in Alabama, Hiwassee Island and Ledbetter sites in Tennessee, Jonathon Creek site in Kentucky, and Yellow Creek in Mississippi, as well as hundreds of other sites that have been the subject of academic research since the inception of TVA. TVA manages 22 historic properties listed in the NRHP. These include the pre-TVA dams (Ocoee #1 and #2, Blue Ridge, Wilson, Great Falls, and Wilbur), Seven Mile Island, numerous iron furnace sites across the Valley, and several archaeological sites excavated and inundated on Tellico Reservoir.

Humans have prehistorically and historically tended to settle near main river channels in order to be to close the necessary resources for survival (i.e., food and water). TVA lands are primarily located along the Tennessee River and its tributaries and consequently contain numerous archaeological sites. While the total acreage of TVA land is small in comparison with many other Federal agencies, the archaeological resources are dense and their vulnerability to various threats significant (most being easily accessible by water and land and exposed to substantial annual erosion). With only about 30 percent of its lands systematically surveyed, TVA must make prudent choices in its annual inventory allowance while making a good-faith effort to meet its responsibilities under the laws and regulations protecting these resources.

Current conditions of archaeological sites on TVA lands vary according to their location within the TVA system. Inundated site conditions vary depending on local erosion or siltation. TVA has limited data on the condition of sites that are normally inundated

throughout the year. In a recent survey conducted during an unusually deep drawdown of Bear Creek Reservoir, a large percentage normally inundated sites had been destroyed by heavy erosion. This situation may not be typical of other TVA reservoirs.

Archaeological sites located within the normal drawdown zones or on shorelines are subject to a different level of disturbance. These sites are easily accessible to looting and vulnerable to erosion from reservoir fluctuations, discharges from dams, and wave action from boat traffic. With limited funding available to monitor and protect these resources annually, there has been an overall deterioration of archaeological resources.

4.8.2. Historic Structures

Approximately 5,320 historic structures have been recorded on or near TVA lands (Table 4-12). Examples of these structures include gristmills, dams, powerhouses associated with the dams, diversion flumes, fossil plants, homes, bridges, and cemeteries. Approximately 230 of the 5,320 historic structures are considered either eligible or potentially eligible for listing in the NRHP and 85 historic structures are currently listed in the NRHP. Nine NRHP historic districts are on TVA lands; these include districts at Little Bear, Normandy, Pickwick, Tims Ford, and Wheeler reservoirs, and four districts at Wilson Reservoir. In addition, Wilson Dam is listed as a national historic landmark. This is the only such designated TVA property, as well as the only such property within the study area. The study area is described in Section 1.5.

The majority of the historic structure data came from individual county surveys on file at State Historic Preservation Offices and from past TVA surveys, primarily associated with TVA's reservoir lands planning efforts. Many of these surveys are incomplete or out of date. Comprehensive work at South Holston, Douglas, Chatuge, Normandy, and Tims Ford reservoirs and partial coverage at Boone, Fort Patrick Henry, and Norris reservoirs supplemented these surveys.

The number of historic structures varies substantially among the reservoirs (Table 4-12). This reflects a wide variation in the availability of information about these structures. Some areas have been surveyed more than other areas, and NRHP eligibility has not been assessed for many structures. More comprehensive surveys and structure assessments would likely result in a more equal distribution of structures and NRHP-eligible structures at each reservoir. Consequently, the variation in the distribution of historic structures was not a major consideration in the impact analysis.

TVA's fossil plants are potentially eligible for listing in the NRHP like all other TVA power-generating facilities. These plants have not been systematically surveyed. Historical resource surveys of the fossil plants and associated contiguous lands are conducted on a case-by-case basis as TVA proposes projects.

Table 4-12. Numbers of Historic Structures Surveyed

Reservoir and Location	Recorded Historic Structures	NRHP-Eligible or Potentially Eligible Historic Structures	NRHP-Listed Historic Structures/Districts
Mainstem Reservoirs			
Kentucky, KY/TN	438	1	12
Pickwick, AL/MS/TN	151	2	1
Wilson, AL	21	1	4
Wheeler, AL	546	1	7
Guntersville, AL/TN	1,223	64	6
Nickajack, TN	50	1	0
Chickamauga, TN	138	1	10
Watts Bar, TN	91	1	10
Fort Loudoun, TN	139	1	2
Total Mainstem	**2,797**	**73**	**52**
Tributary Reservoirs			
Norris, TN	421	22	0
Melton Hill, TN	19	1	5
Douglas, TN	413	47	4
South Holston, TN/VA	184	17	1
Boone, TN	89	4	5
Fort Patrick Henry, TN	73	1	0
Cherokee, TN	362	12	8
Watauga, TN	67	1	0
Wilbur, TN	0	1	0
Fontana, NC	28	1	3
Tellico, TN	269	6	3
Chatuge, NC	25	4	2
Nottely, GA	23	5	2
Hiwassee, NC	25	1	2
Apalachia, NC	1	1	0
Blue Ridge, GA	38	1	0
Ocoee #1, TN	1	2	0
Ocoee #2, TN	0	1	0
Ocoee #3, TN	1	1	0
Tims Ford, TN	158	3	1
Normandy, TN	93	1	4
Great Falls, TN	111	1	0
Upper Bear Creek, AL	63	2	0
Bear Creek, AL	2	2	1
Little Bear Creek, AL	14	1	1
Cedar Creek, AL	45	21	0
Total Tributary	**2,525**	**160**	**42**
Total Reservoirs	**5,322**	**233**	**94**

Current conditions of the historic structures on TVA lands vary and limited inventory data is available to fully describe the current state of most of them. In general, TVA has conducted little maintenance or management of the historic structures under its control. Those historic structures that are currently occupied are in good condition. TVA's dams and power facilities are maintained for general safety and, as a result, are mostly in good condition. Others, such as those located in remote locations or those that are unoccupied have fallen into a state of disrepair.

4.9. Land Use

The Tennessee River watershed includes approximately 40,913 square miles. This area lies mostly in the state of Tennessee, with portions in six other states—Alabama, Georgia, Kentucky, Mississippi, North Carolina, and Virginia. The TVA power service includes a total of 76,738 square miles, with 44,783 square miles extending outside the Tennessee River watershed. TVA lands adjacent to reservoirs include approximately 293,000 acres (458 square miles) encompassing parts of the seven Valley states.

TVA manages land around most of the reservoirs it operates. In all, approximately 293,000 acres of TVA land is associated with 46 dams and reservoirs. This land is managed for project operations, sensitive resource management, natural resource conservation, industrial, developed recreation, and shoreline access. Nearly all of this land is in a band adjacent to the 11,000 miles of reservoir shoreline. In addition, TVA manages approximately 9,100 acres of land located adjacent to TVA's power facilities throughout the region.

Land use and land cover on TVA reservoir lands, as well as on a 0.25-mile surrounding area of influence, was quantified from 2008 and 2009 aerial photography from the USDA's National Agricultural Imagery Program and GIS mappings. The current land cover on TVA reservoir lands is dominated by "natural" habitats, with 81 percent of TVA lands forested (Figure 4-7a). Compared to adjacent non-TVA lands (Figure 4-7b), TVA lands are more heavily forested, have lower proportions of pasture and cropland, and are less developed.

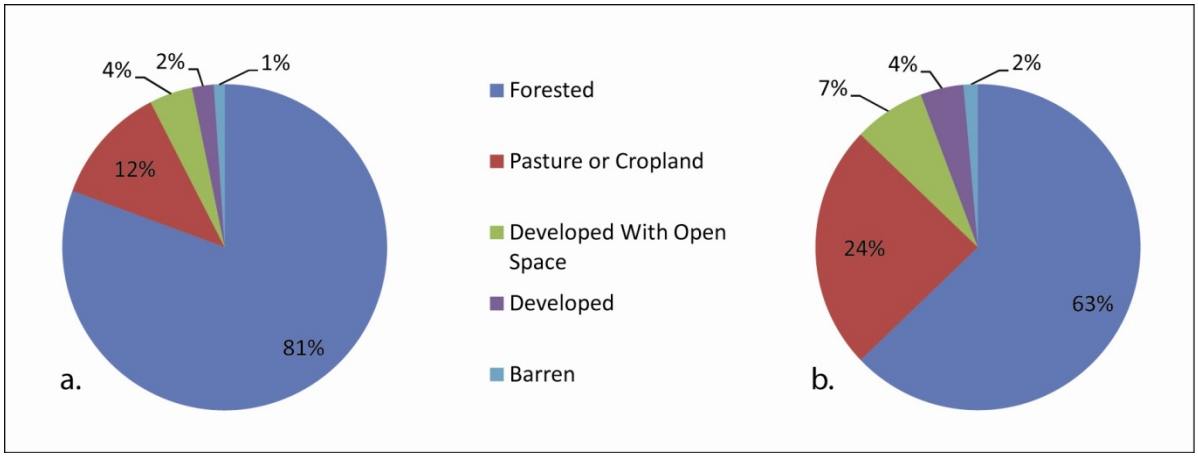


Figure 4-7. Land Use/Land Cover of TVA Reservoir Lands (a) and Non-TVA Lands within 0.25 Mile of TVA Reservoir Lands (b).

Across the TVA reservoir system, approximately 38 percent of the total shoreline is available for residential development, and a third of that shoreline had been developed by

the mid-1990s (TVA 1998). SMI identified three times as many miles of residentially developed shoreline as all other developed uses combined (TVA 1998). Shoreline residential development is ongoing and would continue at some rate until complete buildout (the point at which the available shoreline property has been consumed by residential development). SMI anticipated that buildout would occur by 2023.

4.10. Prime Farmland

Prime farmland is defined by the USDA as land that has the best combination of chemical and physical soil characteristics for meeting the nation's short- and long-range needs for food and fiber. Prime farmland can consist of cultivated land, pastureland, or forestland, but it is not urban land, built-up land, or land covered by water. The FPPA requires that all federal agencies evaluate impacts to farmland prior to converting such land permanently to nonagricultural land use.

The States of Georgia, Kentucky, North Carolina, and Tennessee and the Commonwealth of Virginia have designated additional land as farmland of statewide and/or local importance. Generally, state agencies have identified these additional farmlands as those areas that economically produce high yields of crops when treated and managed according to acceptable farming practices. Some may produce as high a yield as prime farmland if conditions are favorable. In some states, additional farmlands of statewide or local importance may include tracts of land that have been designated for agriculture by state law. Consideration for protection under the FPPA extends to farmland of statewide and local importance.

To evaluate any possible effects to prime farmland, farmland of statewide and local importance, TVA identifies soil classifications using the USDA NRCS *Web Soil Survey* (NRCS 2010). The FPPA encourages federal agencies, with assistance from the NRCS, to complete Form AD 1006 (*Farmland Conservation Impact Rating*) before an action is taken.

In the TVA region, approximately 17,360,515 acres are designated as prime farmland, farmland of statewide importance, or farmland of local importance (Table 4-13). On average, this represents 33.2 percent of the total area farmed within the seven-state power service area.

Table 4-13 Acreage of Prime/Unique Farmland and Farming Trends in the Seven States Comprising the TVA Power Service Area

State	Percent of Total Area in Farms	Acres Protected by FPPA	Percent of Farmland Protected by FPPA	Percent Change From 1987 to 2007*		
				Number of Farms	Land in Farms (Acres)	Average Size of Farms (Acres)
Alabama	39.9	2,105,732	33	25.6	8.5	-12.7
Georgia	18.8	864,307	30	17.4	-6.2	-20
Kentucky	64.9	2,389,406	50	6.9	13.3	6.6
Mississippi	41.7	4,470,380	49	24.7	15.2	-6.8
North Carolina	12.2	852,691	28	-3.5	-17.8	-12.3
Tennessee	42.0	6,050,627	22	2	-6.2	-5.6
Virginia	39.4	627,372	21	4.8	9.5	5.9

*USDA, Agriculture Census, http://agcensus.mannlib.cornell.edu/

Agricultural census data show that during the 20 years between 1987 and 2007, the number of farms in six of the seven states that make up the TVA power service area increased between 2 to 25 percent. During the same period, the average size of farms within these same states decreased. These data suggest that larger family-owned and -operated farms are being sold or subdivided into smaller farms, possibly through inheritance. This practice may place added pressure on prime farmlands by reducing the "connectivity" of adjoining farmland and promoting the expansion of utilities, which may lead to further nonfarm uses. North Carolina had the greatest decline in the number of farms and the land area committed to farming, and Alabama and North Carolina both had large declines in the average size of farms (Table 4-13).

Prime farmland and farmland of statewide or local importance make up about 12 percent of TVA reservoir lands. For those reservoirs with available soil survey data, the proportion of this farmland ranges from 0 to 48 percent (Table 4-14).

Table 4-14. Area of Prime/Unique Farmland Surrounding TVA Reservoirs

Reservoir	Total Area (acres)	Percent of Farmland Protected by FPPA	Prime Farmland (acres)	Farmland of Statewide Importance (acres)	Farmland of Local Importance (acres)
Apalachia	897	12.0	107.3	0	0
Beaver Creek	290	47.6	18.2	120	0
Beech River Project	5,218	*			
Big Bear Creek	2,295	*			
Blue Ridge	470	2.2	10.7	0	0
Boone	880	6.6	58.5	0	0
Cedar Creek	2,747	*			
Chatuge	1,765	7.4	132.1	0	0
Cherokee	8,187	3.1	254.1	0	0
Chickamauga	15,947	*			
Clear Creek	14	17.8	0	2.5	0
Douglas	2,055	11.9	244.5	0	0
Fontana	931	0.0	0	0	0
Fort Loudoun	1,574	*			
Fort Patrick Henry	283	17.5	49.6	0	0
Great Falls	362	*			
Guntersville	37,282	6.7	2,498.5	0	0
Hiwassee	1,007	10.4	105.6	0	0
Kentucky	75,216	11.4	8,297.0	276.2	0
Little Bear Creek	1,181	*			
Melton Hill	2,579	*			
Nickajack	3,573	26.6	952.4	0	0
Nolichucky	1,132	17.0	193	0	0
Normandy	4,795	*			
Norris	27,928	1.5	433.5	0	0

Reservoir	Total Area (acres)	Percent of Farmland Protected by FPPA	Prime Farmland (acres)	Farmland of Statewide Importance (acres)	Farmland of Local Importance (acres)
Nottely	829	0.0	0	0	0
Ocoees	375	5.2	19.6	0	0
Pickwick	19,238	*		0	
South Holston	2,270	14.8	291.6	44.6	0
Tellico	12,644	16.6	2,102.1	0	0
Tims Ford	4,414**	11.7	518	0	0
Upper Bear Creek	2,955	*			
Watauga	1,137	1.0	12.4	0	0
Watts Bar	13,240	21.6	2871	0	0
Wheeler	36,178	8.3	2,994.4	0	0
Wilbur	58	0.0	0	0	0
Wilson	119	*			

* Data unavailable; ** Includes TVA lands allocated for conservation partnerships

Many of TVA's non-hydroelectric generating facilities were established 40 to 50 years ago and have experienced considerable changes to the soil and the surface hydrology during construction and operation. If prime farmland were present, these disturbances and the absence of active farming during this extended period would negate any negative impacts that conversion to nonagricultural land use might have on the farm service sector and surrounding farmland. Any land conversion activities within the existing boundaries of these sites would fall under the FPPA's exclusionary clause dealing with land already under (urban) development.

4.11. Visual Resources

Overview

The physical, biological, and man-made features seen in the landscape provide any selected geographic area with particular visual qualities and aesthetic character. The varied combinations of natural features and human alterations that shape landscape character also help define their scenic importance. The presence or absence of these features along with aesthetic attributes such as uniqueness, mystery, variety, pattern, vividness, contrast, and harmony make the visual resources of an area identifiable and distinct. The scenic value of these resources is based on human perceptions of intrinsic beauty as expressed in the forms, colors, textures, and visual composition seen in each landscape.

Consistent with its objectives for environmental leadership, TVA ensures that, to the extent practicable, land use and natural resource management activities proposed for lands under its control would not significantly degrade or destroy outstanding visual resources. In those limited situations where no practicable alternatives are identified and substantial visual impacts would definitely occur, TVA may take reasonable and prudent measures to accomplish mitigation of the anticipated impacts.

The evaluation of the extent and magnitude of potential changes in the visual environment that could result from a proposed action is typically based on:

- The scenic and aesthetic character of the existing landscape.
- The degree of discernible contrast between the proposed action and the existing landscape.
- The location and sensitivity levels of viewpoints available to the public.
- The visibility of the proposed action from the public's viewpoint.
- Any potential cumulative changes to the visual landscape.

The visual attributes of existing scenery, along with the anticipated attributes resulting from the proposed action are reviewed and classified in the visual analysis process. The classification criteria are adapted from a scenic management system developed by the USFS, and integrated with planning methods used by TVA. The classifications are based on methodology and descriptions from USFS (1995).

Four categories of visual attributes are evaluated individually as described below, and the results help determine an overall scenic value.

- Scenic attractiveness is the measure of outstanding natural features, scenic variety, seasonal change, and strategic location. It is based on the intrinsic beauty of landforms, rock outcrops, water bodies, and vegetation. Attractiveness is ranked in one of three classifications from distinctive to minimal.
- Scenic integrity is the measure of visual unity and wholeness of the natural landscape character. It is based on the degree of disturbance in natural patterns, the presence of disruptive or discordant elements, and the relative harmony of human alterations. Integrity is ranked in one of four classifications from high to very low.
- Human sensitivity is the expressed concern of people for the scenic qualities of the project area. Sensitivity includes considerations such as the type and number of viewers, frequency, and duration of views, and viewer context of adjacent scenery. Concerns are also derived or confirmed by public input. Sensitivity is ranked in one of three classifications from high to low.
- Viewing distance is the measure of how far an area can be seen by observers and the degree of visible detail. It is ranked in one of three classifications from foreground to background.
- Foreground is 0 to 0.5 mile from the observer where details of objects are clearly seen. Details are most distinct in the immediate foreground of 0 to 300 feet.
- Middleground is 0.5 to 4 miles where single objects or groups tend to merge into larger patterns with less distinguishable details. When viewed in this broader context, alterations may contrast strongly with larger natural patterns and make some middleground views more sensitive than the foreground.
- Background is 4 miles to the horizon where objects are seen as broad outline patterns and forms. Details and colors are not normally discernible unless they are quite large, stand alone, or provide strong contrast.

The term "scenic visibility" is sometimes used in visual analyses. Scenic visibility is composed of *human sensitivity* and *viewing distance*, which are interrelated, but evaluated and classified separately.

Visual absorption capacity is also considered when determining scenic value of a landscape. Absorption capacity indicates the relative ability of a landscape to accept

human alteration with the least loss of scenic quality. It is based on characteristics of the natural features seen in the project area. As an example, alterations on a steep woodland slope with dense evergreen cover would create much greater visual contrast than similar actions on a gentle slope with a cover of mixed woodlands and pastures. Areas of greatest scenic value frequently have the least capacity to absorb visual change without substantial devaluation.

Overall, scenic value is determined by evaluating the combined levels of the four attributes, along with absorption capacity. It is ranked in one of four classes ranging from excellent to poor.

Visual Characteristics of TVA Lands

TVA lands and areas of jurisdiction include power plants, dam reservations, reservoirs, and tracts of land adjacent to the reservoirs that range in size from tenths of an acre to several hundred acres. Because the scenic features of the landscape are not limited by land boundaries, the attractive landscape character extends across TVA lands and other public and private lands alike. The natural elements together with the communities and other cultural development often provide a scenic, rural countryside.

Land uses adjacent to the reservoirs include residential development, public parks, commercial development, and sporadic industrial facilities. The reservoirs offer abundant water-recreation opportunities along with a variety of scenery. Most embayments are broadly open at the mouth, and some wind over a mile to their headwaters.

Among the scenic resources of each of the reservoirs, the water body itself is the most distinct and outstanding aesthetic feature. The horizontal surface provides visual balance and contrast to the islands and wooded hillsides. The reservoirs weave around ridges and bends, changing views periodically seen from the water. It also links the other landscape features together. Views across the water are satisfying and peaceful to most observers.

As noted in the ROS (TVA 2004), lower winter pool levels often result in the exposure of reservoir bottoms and flats. This visual change in reservoir character is created in shallower portions of the reservoir and becomes most evident in the headwater and embayment areas. Headwater areas often revert to characteristics of the original river environment, including wide, barren shorelines and discolored rock bluffs along the former river channel. Exposure of reservoir bottom areas is common to both tributary and mainstem reservoirs.

The visual effect for mainstem reservoirs from lower winter pool levels can range from the occurrence of sandbars and small islands to extensive flat areas that are dry with exposed ground. Many of these large, exposed flat areas are associated with wildlife management areas or other areas that exhibit wetland characteristics. Consequently, their appearance tends to blend in an acceptable degree with the surrounding landscape. In other cases, the flats are a notable part of residential viewsheds, where the change in landscape character is not as acceptable and is interpreted as creating a lower level of scenic integrity.

Each reservoir exhibits its own combination and degree of visual effects with respect to its operating plan. Its existing character and level of scenic attractiveness is maintained throughout the year. The same can be said for reservoirs classified as run-of-river projects. Reservoirs with similar landscape characteristics display a combination of effects related to

both shoreline rings and exposed reservoir bottoms. These combinations create lower levels of scenic integrity.

Exposed shorelines or reservoir bottoms alone do not create the lowest level of scenic integrity, but rather exposure of other visible elements from lower water levels. Woody debris, trash, riprap, underwater structures such as tires used for fish habitat, and floating structures sitting on the bottom add unattractive visual contrast to the area viewed.

It is also important to note that, for some of the mainstem reservoirs, flood conditions create shoreline conditions that do not appear natural. For example, vegetated areas, normally above water, are covered; shoreline structures float higher than their moorings; and parking lots or other recreational facilities are submerged in water.

Various combinations of development and land use patterns that are present in the viewed landscapes along the shorelines contribute to the overall visual character of the project area. These can range from the more urban and industrial developments often associated with the mainstem reservoirs to residential developments that are common to both mainstem and tributary reservoirs. Urban and industrial developments generally create a lower level of scenic integrity. Residential areas and water-related facilities that include docks, boathouses, stairways, and shoreline protection structures are becoming more common. The presence of these facilities in the landscape reduces scenic integrity.

Islands are another significant feature that provide scenic accents and visual reference points throughout the reservoirs and serve as visual buffers for less desirable views. They also provide a pleasing foreground frame for the distant shoreline or background.

Other important scenic features include the secluded coves and steep, wooded ridges that occur around the reservoirs. The isolated coves with wooded shoreline provide relatively private locations for dispersed recreation activities. Significant elevation changes along some stretches of shoreline provide a dramatic contrast to the surrounding reservoir and gently sloping countryside, particularly when they are viewed from background distances. Most shorelines upstream of the dams appear natural. Slopes and ridgelines seen from the reservoirs are generally heavily vegetated with mature hardwood and evergreen trees and provide positive visual contrast to the reservoirs. There is usually little development in the foreground distances.

TVA's dam reservations contrast visually with the lands that border them. The dam reservations appear predominately industrial near the dams and switchyards. Most buildings are broadly horizontal and can be seen in the foreground. Transmission structures, including towers and lines, and fossil and nuclear plant structures generally can be seen up to middleground distances depending upon topography and viewer position. The most significant focal point in the landscape is generally the smokestacks and cooling towers, which can be up to 800 feet in height. Farther away, closer to the borders on all sides, the landscape becomes natural appearing with slight human alterations. Residents and motorists along local roads would have views up to middleground distances of the dam reservations depending upon seasonal variations of vegetation and atmospheric conditions.

4.12. Floodplains

As stated in the TVA Act, one of the primary reasons that TVA was established was to "control the destructive floodwater in the Tennessee River and the Mississippi River Basins." A series of dams and reservoirs was constructed to make flood control a reality.

The operation of the integrated reservoir system provides substantial protection against flooding in the Valley and in the Ohio River and Mississippi River basins.

A common misconception about dams is that they prevent flooding. Floods cannot be prevented, but the operation of the TVA reservoir system can reduce damages. Efforts are made to reduce the peak flood elevations that would occur naturally without the dams. This is done by holding backwater upstream in the storage tributary reservoirs until the rains have subsided and then gradually releasing water until normal reservoir operations can be resumed. These actions substantially reduce the peak water elevations that would occur without the reservoir system.

Even with the system of dams, there is a floodplain adjacent to the reservoir. A floodplain is that relatively level land area along a stream, river, or reservoir that is subjected to periodic flooding. The 100-year floodplain is defined as that area inundated by the 100-year flood. The 100-year flood is the level of flooding that has a 1 percent chance of being equaled or exceeded in any given year and does not indicate a time period of 100 years between floods of this magnitude. Floodplain areas along reservoir shorelines normally encompass TVA lands and other lands where TVA owns flowage easements.

Floodplains provide and support many natural resources and functions of considerable economic, social, and environmental value. These values and benefits include wetlands and wildlife habitat, improved water quality, storm water management, recreational opportunities, and aesthetics.

As a federal agency, TVA is subject to the requirements of EO 11988 (Floodplain Management). The objective of EO 11988 is “to avoid to the extent possible the long- and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative” (43 *Federal Register* 6030 [10 February 1978]). The EO is not intended to prohibit floodplain development in all cases, but rather to create a consistent government policy against such development under most circumstances. The EO requires that agencies avoid development in the 100-year floodplain unless there is no practicable alternative.

4.13. Socioeconomics and Environmental Justice

The NRP has the potential for social and economic impacts to virtually any area within the TVA region. Therefore, this analysis includes the 201 counties within these areas, plus Muhlenberg County, Kentucky, site of Paradise Fossil Plant, and DeSoto County, Mississippi, site of Southaven Combined-Cycle Plant. The 203-county area is further noted as the study area.

Population

The total population of the TVA region is about 10.7 million, as reported by the 2010 Census (U.S. Bureau of the Census, http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml). Appendix K includes a table showing historical and projected population for the counties in the region.

The total population of the TVA region increased by 10.9 percent from 2000 to 2010. This was a slower growth rate than the 15.5 percent increase from 1990 to 2000. Nevertheless, these growth rates exceeded the national rates of 9.7 percent from 2000 to 2010 and 13.2

percent from 1990 to 2000. If recent trends continue, the region will have a total population of about 11.6 million in 2020 and 12.5 million in 2030 (Table 4-15).

Table 4-15. Resident Population, Tennessee Valley States

Area	Census Results		Projected Population	
	2000	2010	2020	2030
TVA Region	9,674,255	10,732,758	11,586,384	12,548,086
Alabama	4,447,100	4,779,736	5,088,401	5,410,837
Georgia	8,186,453	9,687,653	10,756,852	12,048,802
Kentucky	4,041,769	4,339,367	4,575,877	4,838,109
Mississippi	2,844,658	2,967,297	3,171,981	3,354,460
North Carolina	8,049,313	9,535,483	10,357,770	11,465,210
Tennessee	5,689,283	6,346,105	6,868,376	7,462,676
Virginia	7,078,515	8,001,024	8,783,469	9,627,145
United States	281,421,906	308,745,538	333,510,007	360,104,340

Source: Historical data from http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.
Projections are trends based on 1970 to 2010 Census of Population data.

The larger population concentrations in the region tend to be located along the corridors of the Tennessee, French Broad, Cumberland, and Tennessee rivers (Figure A-13, Appendix A). The areas of upper east Tennessee through Knoxville and Chattanooga, Tennessee, and North Alabama are situated along the Tennessee River and its tributaries. The Asheville, North Carolina, area is located along the French Broad River. The Nashville and Memphis, Tennessee, areas are located along the Cumberland and Mississippi rivers, respectively.

About 6.7 million people live in the 16 metropolitan areas located within the study area (Table 4-16; see Figures A-13 and A-14, Appendix A). Notable clusters of counties with relatively low populations are located on the Cumberland Plateau in Tennessee, along the Tennessee River in western Tennessee, and in Mississippi and western North Carolina.

Table 4-16. Metropolitan Area Population, 2009

Metropolitan Area	Total Population	Population Within Study Area	Population Outside Study Area
Memphis, Tennessee	1,316,100	1,254,420	61,680
Jackson, Tennessee	115,425	115,425	
Florence-Muscle Shoals, Alabama	147,137	147,137	
Decatur, Alabama	153,829	153,829	
Huntsville, Alabama	417,593	417,593	
Chattanooga, Tennessee-Georgia	528,143	528,143	
Dalton, Georgia	142,227	142,227	
Cleveland, Tennessee	115,788	115,788	
Knoxville, Tennessee	698,030	698,030	
Morristown, Tennessee	136,608	136,608	

Metropolitan Area	Total Population	Population Within Study Area	Population Outside Study Area
Kingsport-Bristol-Bristol, Tennessee-Virginia	309,544	309,544	
Johnson City, Tennessee	198,716	198,716	
Bowling Green, Kentucky	125,953	125,953	
Clarksville, Tennessee-Kentucky	273,949	273,949	
Nashville-Davidson-Murfreesboro, Tennessee	1,589,934	1,589,934	
Asheville, North Carolina	424,858	424,858	
Total	**6,693,834**	**6,632,154**	**61,680**

Source: http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.
Note: Metropolitan and Micropolitan Statistical Areas are defined by the U. S. Office of Management and Budget. Such areas have a high degree of social and economic integration with an urban core (http://www.whitehouse.gov/sites/default/files/omb/assets/bulletins/b10-02.pdf).

Employment

In 2009, the total employment for the TVA region was 5.74 million (http://www.bea.gov/regional/reis/). Regionally, manufacturing accounted for approximately 10.4 percent of all employment, somewhat higher than the national average of 7.1 percent. Manufacturing accounts for a substantial share of employment in many rural areas of the region (see Figure A-15, Appendix A) and exceeds 20 percent of all employment in some counties.

However, the level of employment in manufacturing has been declining, both regionally and nationally, for a number of years. As of 2009, the estimated manufacturing employment in the region was about 596,000. This figure is a sharp decrease from about 852,000 a decade ago. This decline is a national phenomenon, with a similar decline at the national level. The mix of manufacturing in the region has been gradually shifting to relatively more durable goods, including items such as automobiles. The durable goods share of total employment in manufacturing has increased from about 48 percent of the total to more than 55 percent. This trend is expected to continue. Manufacturing is an important source of employment, and its importance is expected to continue, although its share of total employment is likely to continue to decline.

Farming accounted for 2.8 percent of total employment in the study area, also higher than the national average of approximately 1.5 percent (see Figure A-16, Appendix A). Much farming in the study area is part time and not a primary source of income. Earnings from farming account for less than 1 percent of all earnings in the study area. In 2007, the average farm in Tennessee was 138 acres, and half of all farms were 58 acres or less. Average reported sales per farm in Tennessee were $33,015, and the average net cash farm income was reported to be $3,075 per farm (USDA 2007c). In comparison, the national average farm was 418 acres, and the net cash farm income per farm nationwide was $33,827, more than 10 times the Tennessee average.

Income

In 2009, the per capita personal income for the study area was $32,643, about 82 percent of the national average of $39,635 (http://www.bea.gov/regional/reis/). However, the 2009 average income levels vary widely across the study area. For example, the average income for Williamson County, Tennessee, was 135 percent of the national average at

$53,392, and Hancock County, Tennessee, was 48 percent of the national average at $19,186 (see Figure A-17, Appendix A).

Most counties with relatively high per capita income levels are in metropolitan or metropolitan areas. Economic and social ties with urban centers often provide greater opportunities and easier access to many goods and services. However, these areas also are likely to have somewhat higher costs of living, especially for housing.

Minority Populations
Minorities constitute 22.2 percent of the population within the study area, well below the national average of 36.3 percent (http://factfinder.census.gov/home/saff/aff_transition.html). However, the distribution within the region is very uneven (see Figure A-18, Appendix A). Minorities are a relatively large share of the total population in most counties located in the western portion of the study area. In the rest of the region, with some exceptions, minority shares are low except in or around metropolitan areas. In particular, the Mississippi portion and most of Tennessee west of the Tennessee River as it flows north to Kentucky has a larger share of minorities than the regional average. Most other counties with large minority shares are located in metropolitan areas.

Poverty
In 2009, the poverty level for the study area is estimated to be 17.4 percent, higher than the national average of 14.3 percent (Figure A-19, Appendix A) (http://www.census.gov/did/www/saipe/). County poverty levels are higher than the regional average more frequently in the western part of the region and in counties along or near the Tennessee-Kentucky border. Relatively low poverty levels occur most often in metropolitan areas.

4.14. Navigation

The TVA Act authorized the construction and operation of dams and reservoirs in the Tennessee River and its tributaries to promote navigation and provide flood control. Development of the Tennessee River navigation channel was essentially completed in 1945 with the construction of a series of 10 dams and navigation locks, extending commercial navigation from Knoxville, Tennessee, to Paducah, Kentucky, a distance of 652 miles (see Table 4-17). The Tennessee River waterway is an integral part of the interconnected, 12,000-mile National Inland Waterway System.

Table 4-17. Navigation Locks on the Tennessee River Waterway

Lock	River Mile
Kentucky	Tennessee River Mile 22.4
Pickwick (Main and Auxiliary)	Tennessee River Mile 206.7
Wilson (Main and Auxiliary)	Tennessee River Mile 259.4
Wheeler (Main and Auxiliary)	Tennessee River Mile 274.9
Guntersville (Main and Auxiliary)	Tennessee River Mile 349.0
Nickajack	Tennessee River Mile 424.7
Chickamauga	Tennessee River Mile 471.0
Watts Bar	Tennessee River Mile 529.9
Fort Loudoun	Tennessee River Mile 602.3
Melton Hill	Clinch River Mile 23.1

The Tennessee River provides a year-round minimum depth of 11 feet, sufficient for 9-foot-draft vessels while allowing for 2 feet of overdepth. The minimum channel width in the dredged cuts is 300 feet with some widening on bends.

There are about 374 miles of secondary navigation channels in the Tennessee River system. On average, secondary channels provide at least 3 feet of depth at minimum pool levels and have a minimum width of approximately 50 feet.

Commercial Navigation

There are 187 commercial waterfront terminals located on the Tennessee River waterway. In 2007, the most recent year for which detailed data are available, waterborne commerce on the Tennessee River system totaled 49.6 million tons. Coal comprised 38 percent of all traffic, 18.9 million tons, much of which was delivered to TVA fossil plants. According to USACE (2007), other commodities moved on the system in 2007 included aggregates (12.5 million tons); grains (3.4 million tons); chemicals (3.4 million tons); iron and steel (3.3 million tons); ores and minerals (2.4 million tons); petroleum fuels (1.7 million tons); and all others (4.0 million tons).

It is estimated that shippers save about $461 million per year by using the waterway over other modes of transportation. In addition, shippers benefit from a competitive advantage provided by the availability of the waterway as a transportation option. This advantage is known as the water-compelled rate effect and provides an additional savings of about $486 million. For 2008, total navigation benefits for the Valley were estimated to be about $950 million (TVA data).

Navigation Aids

On the Tennessee River system, the United States Coast Guard (USCG) is responsible for installing and maintaining navigation aids marking the commercial navigation channel, including channel buoys and daymarkers. TVA is responsible for those navigation aids marking secondary or recreational navigation channels. Responsibilities for navigation aids on the Tennessee River and its tributaries are described in a 1982 memorandum of agreement between the USCG and TVA.

TVA maintains approximately 2,500 navigation aids, marking 374 miles of secondary navigation channels on mainstem reservoirs. Secondary channel navigation aids help boaters avoid underwater obstructions, while accessing marinas, waterfront recreational areas, public launching ramps, and residential property. The majority of the secondary channels lead off the commercial channel into large creeks and embayments. Secondary navigation aids include buoys, dayboards, pipes, hazard buoys, direct-read elevation gages, directional signs, and overhead power line buoys.

On TVA's tributary reservoirs, where there can be a large fluctuation between summer and winter pool levels, it would be impossible to install channel buoys that would be functional year-round. Instead, TVA installs and maintains hazard (danger) buoys to warn boaters of most isolated underwater hazards on the "main channel," as well as numbered dayboards placed at various locations around the reservoir. Tributary reservoirs with navigation aids include Apalachia, Bear Creek, Blue Ridge, Boone, Chatuge, Cherokee, Douglas, Fontana, Fort Patrick Henry, Hiwassee, Normandy, Norris, Nottely, Ocoee No. 1, South Holston, Tims Ford, and Watauga.

Safety Harbors and Safety Landings
On the Tennessee River, there are designated shoreline areas called safety harbors and safety landings where commercial traffic can tie off during fog and other inclement weather, equipment malfunctions, and emergencies. These safety harbors greatly minimize the risk of damage to private property. Over 160 safety harbors and landings are maintained along the mainstem reservoirs and two tributary reservoirs (Tellico and Melton Hill).

4.15. Air Quality

Air quality is a valuable environmental resource. Poor air quality can affect our health, ecosystem health, forest and crop productivity, economic development, as well as our enjoyment of scenic views. Through its passage of the Clean Air Act, Congress has mandated the protection and enhancement of our nation's air quality resources. NAAQS establish concentration limits in the ambient air for the following criteria pollutants to protect the public health and welfare:

- Sulfur dioxide
- Ozone
- Nitrogen dioxide
- Particulate matter whose particles are $\leq$ 10 micrometers
- Particulate matter whose particles are $\leq$ 2.5 micrometers
- Carbon monoxide
- Lead

The primary NAAQS were promulgated to protect the public health, and the secondary NAAQS were promulgated to protect the public welfare from any known or anticipated adverse effects associated with the presence of pollutants in the ambient air. Ambient air monitors measure concentrations of these pollutants to determine attainment with these standards. Areas in violation of the NAAQS are designated as nonattainment areas, and new sources to be located in or near these areas may be subject to air permitting requirements that are more stringent. Figure A-20 (Appendix A) shows the current nonattainment areas for particles less than 2.5 microns. Figure A-21 (Appendix A) shows the areas that are currently nonattainment for ozone, as well as the areas that are expected to be designated nonattainment for the revised ozone standard. The USEPA promulgated new, more restrictive standards for particulate matter in 2006 and for ozone in 2008. There are currently no nonattainment areas for carbon monoxide, lead, nitrogen dioxide, sulfur dioxide, and particles less than 10 microns in the TVA region. However, USEPA adopted a more stringent lead standard in 2008, and nonattainment areas have not yet been designated for this standard. Consequently, there may be nonattainment areas for lead in the TVA region in the future. In 2009, the USEPA proposed new air quality standards for GHGs such as carbon dioxide. These regulations for GHGs have not yet been implemented. In 2010, USEPA adopted a 1-hour nitrogen dioxide standard. A listing of the NAAQS is presented in Table 4-18. National standards, other than annual standards, are not to be exceeded more than once per year (except where noted).

Table 4-18. National Ambient Air Quality Standards

Pollutant	Primary Standards[a]		Secondary Standards[b]	
	Level	Averaging Time	Level	Averaging Time
Carbon Monoxide	9 ppm (10,000 μg/m^3)	8-hour (1)	None	
	35 ppm (40,000 μg/m^3)	1-hour (1)		
Lead	0.15 μg/m^3 (2)	Rolling 3-Month Average	Same as Primary	
	1.5 μg/m^3	Quarterly Average	Same as Primary	
Nitrogen Dioxide	0.053 ppm (100 μg/m^3)	Annual (Arithmetic Mean)	Same as Primary	
	100 ppb	1-hour(3)	None	
Particulate Matter (PM_{10})	150 μg/m^3	24-hour (4)	Same as Primary	
Particulate Matter ($PM_{2.5}$)	15.0 μg/m^3	Annual (5) (Arithmetic Mean)	Same as Primary	
	35 μg/m^3	24-hour (6)	Same as Primary	
Ozone	0.075 ppm (2008 standard)	8-hour (7)	Same as Primary	
	0.08 ppm (1997 standard)	8-hour (8)	Same as Primary	
	0.12 ppm	1-hour (9) (Applies only in limited areas)	Same as Primary	
Sulfur Dioxide	0.03 ppm (80 μg/m^3)	Annual (Arithmetic Mean)	0.5 ppm (1300 μg/m^3)	3-hour (1)
	0.14 ppm (365 μg/m^3)	24-hour (1)		
	75 ppb (10)	1-hour	None	

Source: 40 CFR 50 (USEPA 2008a)

Abbreviations: ppb = parts per billion ppm = parts per million μg/m^3 = micrograms per cubic meter

(a) Standards set to protect public health

(b) Standards set to protect public welfare

(1) Not to be exceeded more than once per year

(2) Final rule signed October 15, 2008

(3) To attain this standard, the three-year average of the 98th percentile of the daily maximum 1-hour average at each monitor within an area must not exceed 100 ppb (effective January 22, 2010)

(4) Not to be exceeded more than once per year on average over three years

(5) To attain this standard, the three-year average of the weighted annual mean $PM_{2.5}$ concentrations from single or multiple community-oriented monitors must not exceed 15.0 μg/m

(6) To attain this standard, the three-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area must not exceed 35 μg/m^3 (effective December 17, 2006)

(7) To attain this standard, the three-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.075 ppm (effective May 27, 2008)

(8) (a) To attain this standard, the three-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.08 ppm (b) The 1997 standard—and the implementation rules for that standard—will remain in place for implementation purposes as USEPA undertakes rulemaking to address the transition from the 1997 ozone standard to the 2008 ozone standard

(9) (a) USEPA revoked the 1-hour ozone standard in all areas, although some areas have continuing obligations under that standard ("anti-backsliding").

(b) The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is $\leq$1.

(10) Final rule signed June 2, 2010. To attain this standard, the 3-year average of the 99th percentile of the daily maximum 1-hour average at each monitor within an area must not exceed 75 ppb.

The implementation of some NRP activities may be affected by several air quality considerations. One of the factors is regulatory status or attainment of air quality standards. Sources locating in clean air areas are subject to the Prevention of Significant Deterioration (PSD) New Source Review (NSR) rules, whereas those locating in or affecting areas failing to attain air quality standards must comply with nonattainment NSR. An overriding constraint in both NSR programs is that no source may cause or significantly contribute to a violation of an ambient air quality standard.

PSD regulations restrict the increment by which ambient pollutant levels may increase due to emissions from major new sources, or the modification of existing sources, and require the use of best available control technology on such sources. A memorandum listing pollutants currently subject to PSD review was published in the *Federal Register* (USEPA 1992).

PSD regulations include protection of national parks and wilderness areas that are designated as PSD Class I air quality areas. A new or expanding major air pollutant source is required to estimate the potential impact of its emissions on the air quality of any nearby Class I area, as specified by the state or local air regulatory agency, with input from the federal land manager(s) having jurisdiction over the given Class I area(s). There are eight PSD Class I areas in the vicinity of the TVA region: the Great Smoky Mountains and Mammoth Cave national parks and the Joyce Kilmer, Shining Rock, Linville Gorge, Cohutta, Sipsey, and Upper Buffalo wilderness areas. The location of these Class I areas are shown in Figure A-22, Appendix A. Generally, dispersion modeling is required to demonstrate that pollution levels do not increase beyond the allowable increments. Ambient air quality data necessary for PSD analysis purposes are available for the region.

In 1999, USEPA established the Regional Haze Rule to improve visibility in Class I areas. This regulation requires states to develop long-term strategies to improve visibility with the ultimate goal of restoring natural background visibility conditions by 2064.

The air quality in the Valley and across the country has greatly improved. Some clean air standards, by which we judge progress, are much tougher now. The regulatory “bar” has been raised. Recent record low emission levels are due in part to manageable operations, as well as uncontrollable variables. TVA is undertaking one of the largest emission-reduction programs in the nation. Sulfur dioxide emissions have been reduced by 91 percent since the peak in 1977. Annual nitrogen oxide emissions have been reduced by 89 percent, and ozone season nitrogen oxide emissions have been reduced by 90 percent from the peak in 1995.

4.16. Climate

The TVA region spans the transition between a humid continental climate to the north and a humid subtropical climate to the south. This provides the region with generally mild temperatures (i.e., a limited number of days with temperature extremes), ample rainfall for agriculture and water resources, vegetation-killing freezes from midautumn through early spring, occasional severe thunderstorms, infrequent snow, and infrequent impacts—primarily in the form of heavy rainfall—from tropical storms. The seasonal climate variation induces a dual peak in annual power demand, one for winter heating and a second for summer cooling. Rainfall does not fall evenly throughout the year, but tends to peak in late winter/early spring and again in midsummer. Winds over the region are generally strongest during winter and early spring and lightest in late summer and early autumn. Solar radiation (insolation) varies seasonally with the maximum sun elevation above the horizon

and longest-day length in summer. However, insolation is moderated by frequent periods of cloud cover typical of a humid climate.

Prediction of the future trends in climate change is not an exact science. Global climate change and its relationship to GHGs are items of intense study and are important to TVA. In common usage, "global warming" often refers to the warming of the earth that may occur as a result of emissions of GHG in the atmosphere. Global warming may occur from a variety of both natural and anthropogenic causes. "Climate change" refers to any substantive change in measures of climate, such as temperature, precipitation, or wind. The two terms are often used interchangeably, but the climate change is broader as it conveys that there are other changes in addition to rising atmospheric temperature.

It is believed that certain substances present in the atmosphere act like the glass in a greenhouse to retain a portion of the heat that is radiated from the surface of the earth. The common term for this phenomenon is the "greenhouse effect," and it is essential for sustaining life on earth. Water vapor and, to a lesser extent, water droplets in the atmosphere are responsible for 90 to 95 percent of the greenhouse effect. The most abundant long-lived GHGs are CO_2, methane, and nitrous oxide. Both man-made and natural processes produce GHG. According to some sources, increases in the earth's average surface temperatures are linked in part to increasing concentrations of GHG, particularly CO_2, in the atmosphere. This has been a cause for concern among scientists and policymakers. This phenomenon has been studied internationally since 1992 by the United Nations Framework Convention on Climate Change, Intergovernmental Panel on Climate Change (IPCC).

The global carbon cycle is made up of large carbon sources and sinks. Billions of tons of carbon in the form of CO_2 are absorbed by oceans and living biomass (i.e., sinks) and are emitted to the atmosphere annually through natural and man-made processes (i.e., sources). When in equilibrium, carbon fluxes among these various reservoirs are roughly balanced. According to the IPCC (2007), since the Industrial Revolution (i.e., about 1750), global CO_2 atmospheric concentrations have risen about 36 percent, principally due to fossil fuel use.

The remainder of this section describes the current climate and recent climate trends of the TVA region in more detail. Identifying recent trends in regional climate parameters such as temperature and precipitation is a complex problem because year-to-year variation may be larger than the multidecadal change in a climate variable. Climate is frequently described in terms of the climate "normal," the 30-year average for a climate parameter (National Climatic Data Center 2008). The climate normals described in the following sections are for the 1971-2000 period. Earlier and more recent data are also presented, where available. The primary sources of these data are National Weather Service (NWS) records and records from the rain gauge network maintained by TVA in support of its reservoir operations. NWS records, unless stated otherwise, are for Memphis, Nashville, Chattanooga, Knoxville, and Tri-Cities, Tennessee, and Huntsville, Alabama.

Temperature

1971-2000 Climate Normals — Average monthly temperatures for the TVA region during 1971-2000 ranged from 38.4°F in January to 79.1°F in July (Table 4-19).

Table 4-19. Monthly, Seasonal, and Annual Temperature Averages for Six National Weather Service Stations in the TVA Region for 1971-2000

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
°F	38.4	42.6	50.9	59.2	67.5	75.3	79.1	78.0	71.7	60.3	50.1	41.7
°C	3.5	5.9	10.5	15.1	19.7	24.1	26.2	25.6	22.1	15.7	10.0	53.9

	Winter	Spring	Summer	Autumn	Annual
°F	40.9	59.2	77.5	60.7	59.6
°C	5.0	15.1	25.3	16.0	15.3

Recent Trends — There is significant year-to-year variability in temperature. As suggested by the plot in Figure 4-8, annual temperature in the TVA region appears to have increased approximately 1°F (0.56°C) over the 30-year period between 1970 and 2000 (this is equivalent to a change of about 0.19°C per decade). This increase is most prominent in the winter and summer seasons. Spring and autumn experienced little change in temperatures. However, the overall annual change in temperature for the longer 1958-2008 period was not statistically significant (runs test [Bendat and Piersol 1986], $r^2 = 0.0994$, $p>0.05$). This implies that average temperature during the 50-year period was within the expected range of variability, and the long-term trend could not be distinguished from random variation.

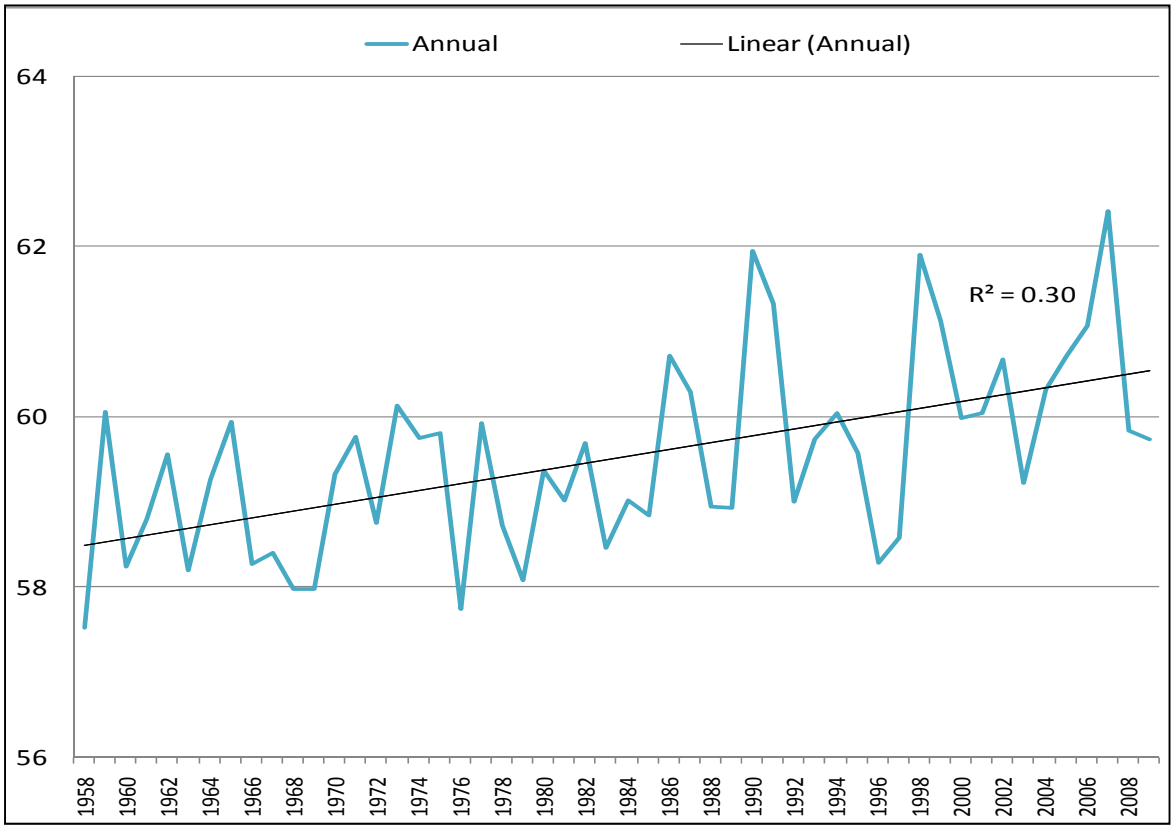


Figure 4-8. 1971-2000 TVA Region Annual Average Temperature (°F) Based on Data from Six National Weather Service Stations

There are some inconsistencies with these observations. For example, the number of days during the year with temperatures at or above 90°F increased by about 12 days during 1971-2000. However, the number of days experiencing 90+°F decreased during both 1958-2004 (by six days) and 1979-2004 (by 10 days). For 1958-2009, the number of days essentially remained unchanged.

The U.S. Climate Change Science Program (Lanzante et al. 2006) reports that global surface temperature through 2004 has increased at a rate of about 0.12°C per decade since 1958 and about 0.16°C per decade since 1979. Regional differences from the global trends are expected. In the tropics, for example, the observed surface temperature trends have increased about 0.11°C per decade since 1958 and about 0.13°C per decade since 1979. These rates represent an acceleration of temperature changes that during the entire 20th century were estimated by the IPCC as being in the range of 0.06 to 0.09°C per decade (Trenberth et al. 2007).

For the southeastern U.S., Trenberth et al. (2007) indicate that temperature change during the 20th century (through 2005) was slightly negative with a mean cooling rate of about 0.2-0.3°C per decade in the vicinity of the TVA region. Their data indicate a warming rate of 0.3-0.4°C per decade for 1979-2005 for the TVA region, greater than the global average trend. The lack of significant temperature change (i.e., +0.19°C per decade) during 1958-2008 for the TVA region is consistent with these published findings.

Precipitation

1971-2000 Climate Normals — The average annual precipitation in the Tennessee River watershed during 1971-2000 was 49.92 inches; monthly averages ranged from 3.04 inches in October to 5.42 inches in March (Table 4-20).

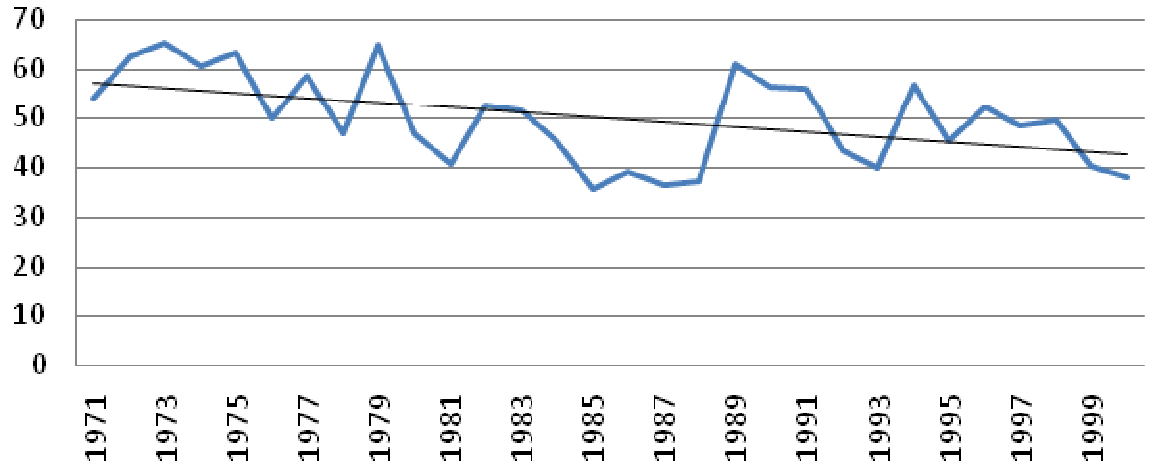
Table 4-20. Monthly, Seasonal, and Annual Precipitation Averages in the Tennessee River Watershed for 1971-2000

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Inches	4.87	4.31	5.42	3.97	4.52	3.84	3.97	3.24	3.59	3.04	4.32	4.85
Centimeters	12.4	10.9	13.8	10.1	11.5	9.8	10.1	8.2	9.1	7.7	11.0	12.3

	Winter	Spring	Summer	Autumn	Annual
Inches	14.03	13.91	11.04	10.95	49.92
Centimeters	35.6	35.3	28.0	27.8	126.8

Source: TVA rain gage network data

Recent Trends — Although there is significant year-to-year variability, there appears to be a decrease in precipitation during the approximately 30-year period (Figure 4-9). The overall annual change in precipitation was deemed not statistically significant (with 95 percent confidence) based on results from a standard statistical test (Bendat and Piersol 1986) applied to the annual mean precipitation over the period of 1958-2008. This implies that average precipitation during the 50-year period was within the expected range of variability, and the long-term change could not be assumed anything other than random variation in the data. Note that precipitation information is highly variable and contradictory. Data for 1958-2004 indicate that annual precipitation is decreasing. However, data for 1979-2004 indicate that precipitation is increasing.



Source: TVA rain gauge network data
Note: Straight line represents the mean change in annual precipitation for the period.

Figure 4-9. Annual Average Precipitation (Inches) for the Tennessee River Basin

Recent changes in precipitation around the world are more variable than changes in temperature. Such behavior is expected as changes in atmospheric circulation (wind patterns) and temperature combine differently in different regions to influence the basic physical processes that control precipitation. The IPCC 2007 climate assessment reported that a few regions in North America, southern South America, Eurasia, and Australia experienced precipitation increases during the 1901-2005 period (Trenberth et al. 2007). However, changes since 1979 have been less pronounced except in Australia. Over the southeastern U.S., precipitation since 1901 has shown a small increase of generally less than 10 percent overall, and since 1979 the changes have been near zero. These results are consistent with a U.S. Global Change Research Program summary of recent and projected climate change in the Southeast (Karl et al. 2009), which shows small precipitation increases across Tennessee during the 20th century offset by decreases over Alabama, Georgia, and North Carolina. Hoerling et al. (2008), in describing the 1951-2006 interval, state "The spatial variations and seasonal differences in precipitation change are *unlikely* [sic] to be the result of anthropogenic greenhouse forcings alone." On a related issue, they further state "It is *unlikely* [sic] that a systematic change has occurred in either the frequency or area coverage of severe drought over the contiguous United States from the mid-twentieth century to the present." This does not mean that anthropogenic warming of the climate has not exacerbated the effects of drought. To the contrary, Hoerling et al. (2008) concluded that an anthropogenic link to worsening drought effects (through the enhanced drying effects of warming) is likely.

Wind

1971-2000 Climate Normals — Wind speed and direction are important indicators of weather patterns and dispersion of air pollutants. Wind speed is also a factor in determining the potential of an area for wind energy development. Average surface wind speeds (measured 33 feet [10 meters] above the ground) for nine NWS stations in the TVA region for 1973-2000[2] are relatively light with higher speeds in winter and spring and lower speeds in summer and autumn (Table 4-21). In general, wind speeds at higher elevations

[2] Data for 1971 and 1972 are not available from the National Climatic Data Center.

are greater than those shown in the table. Average wind speeds in winter, spring, and autumn were slightly less than the 1961-1990 seasonal norms. A similar decrease is also shown in the maximum, minimum, and annual average wind speeds. The months of occurrence for the maximum and minimum wind speed remain unchanged, with highest wind recorded in March and lowest wind in August.

Table 4-21. Monthly, Seasonal, and Annual Wind Speed Averages for Nine Sites in the TVA Region for 1973-2000

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Miles/Hour	8.3	8.4	8.9	8.4	7.1	6.3	5.8	5.4	5.8	6.2	7.3	7.9
Meters/Second	3.7	3.7	3.9	3.7	3.1	2.8	2.6	2.4	2.6	2.8	3.2	3.5

	Winter	Spring	Summer	Autumn	Annual
Miles/Hour	8.2	8.1	5.8	6.4	7.1
Meters/Second	3.6	3.6	2.6	2.7	3.2

Surface wind directions in the TVA region for the same period are shown in the wind rose diagram (Figure 4-10). A wind rose is a diagram with spokes representing directions (e.g., north, north-northeast, northeast). The frequency with which the measured wind blows from a given direction is illustrated by the distance between the point where a heavy line crosses a spoke and the center of the diagram. The most frequent wind directions are from the south and north sectors. This occurs at Memphis, Tennessee; Tupelo, Mississippi; Paducah, Kentucky; Nashville, Tennessee; Chattanooga, Tennessee; and Asheville, North Carolina. Prevailing wind directions at Knoxville, Tennessee, and Tri-Cities, Tennessee, are from northeast and/or southwest sectors, which reflect the down-valley and up-valley flow pattern seen in the area. Wind directions at Huntsville, Alabama, are more variable than at other sites. Overall, the prevailing wind directions in the TVA region during 1973-2000 are nearly identical to those during 1961-1990.

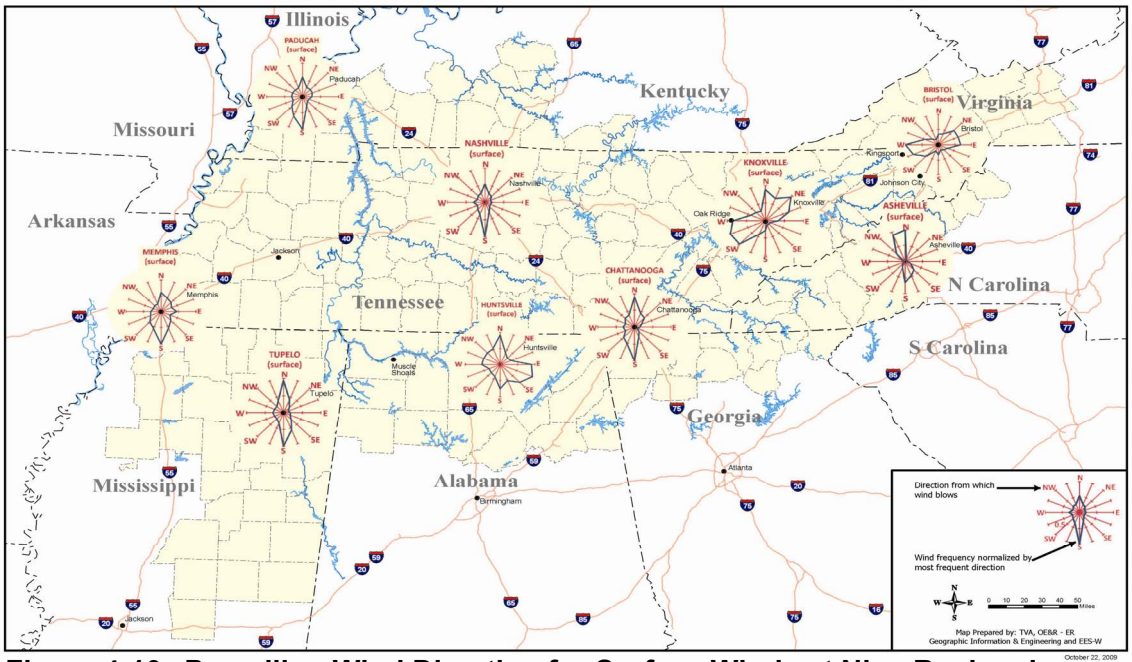


Figure 4-10. Prevailing Wind Direction for Surface Winds at Nine Regional Airports, 1973-2000

Solar Radiation

1971-2000 Climate Normals — Solar radiation (insolation) received at the earth's surface is a function of two factors—cloud cover and atmospheric particles (aerosols). Clouds generally decrease insolation by scattering and reflecting incoming solar radiation back into space. Aerosols scatter and absorb solar radiation. Absorbed radiation tends to be reradiated by aerosols in longer wavelengths with some of the energy reaching the earth surface, some warming the atmosphere, and some going back into space.

Solar radiation is measured at few NWS weather stations, and most of the data in the National Solar Radiation database produced by the National Renewable Energy Laboratory are based on modeling rather than original measurements. Cloud cover, however, is measured at all NWS weather stations and ranges from zero (totally clear sky) to 100 percent (completely covered by clouds). Table 4-22 shows mean cloud cover for nine sites in the TVA region during 1973-2000. The nine sites are Asheville, North Carolina; Tri-Cities, Knoxville, Chattanooga, Nashville, and Memphis, Tennessee; Huntsville, Alabama; Tupelo, Mississippi; and Paducah, Kentucky.

Table 4-22. Monthly, Seasonal, and Annual Cloud Cover Averages for Nine Sites in the TVA Region for 1973-2000

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Percent (%)	66	64	63	57	59	56	53	51	53	49	59	63

	Winter	Spring	Summer	Autumn	Annual
Percent (%)	65	60	53	53	58

TVA has monitored solar radiation at Sequoyah Nuclear Plant and Browns Ferry Nuclear Plant since the 1970s. Figure 4-11 shows these monitoring results as well as cloud cover measurements at the Chattanooga airport (about 15 miles from Sequoyah) and at the Huntsville airport (about 21 miles from Browns Ferry). Cloud cover at the Chattanooga airport was negatively correlated (correlation coefficient of -0.35) with solar radiation at Sequoyah, and cloud cover at Huntsville airport was negatively correlated (correlation coefficient of -0.38) with solar radiation at Browns Ferry. The decreasing trends in cloud cover at both Chattanooga and Huntsville are significantly different ($p \leq 0.05$) from random variability. However, no trend is detected in solar radiation at the two plants at the same level of significance. Due to this weak relationship between measured solar radiation and cloud cover, cloud cover is, at best, a weak proxy for solar radiation at specific sites in the TVA region.

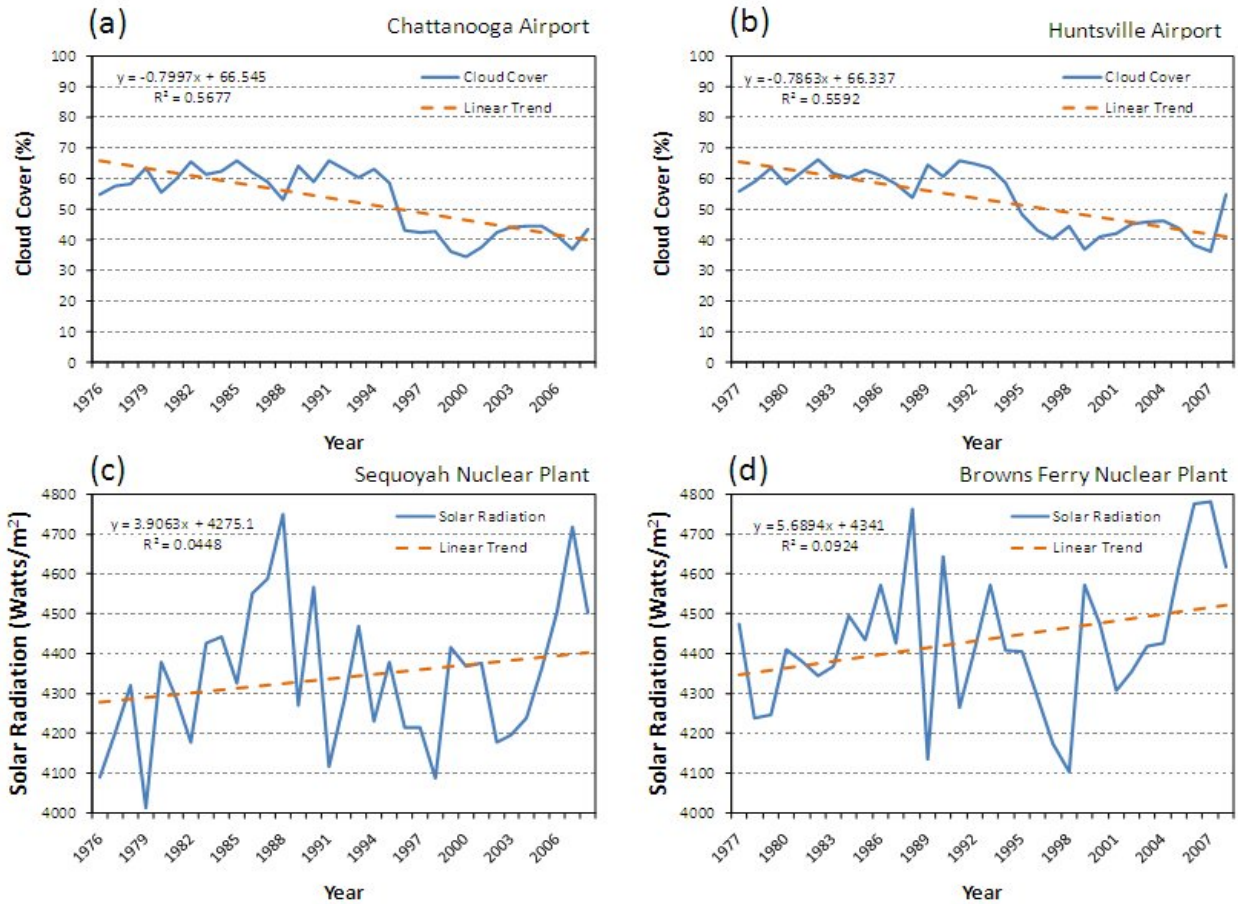


Figure 4-11. Annual Observations and Fitted Trend Lines for Cloud Cover at Selected Airports (a and b) and Solar Radiation at Selected Nuclear Plants (c and d) for 1976/1977-2008