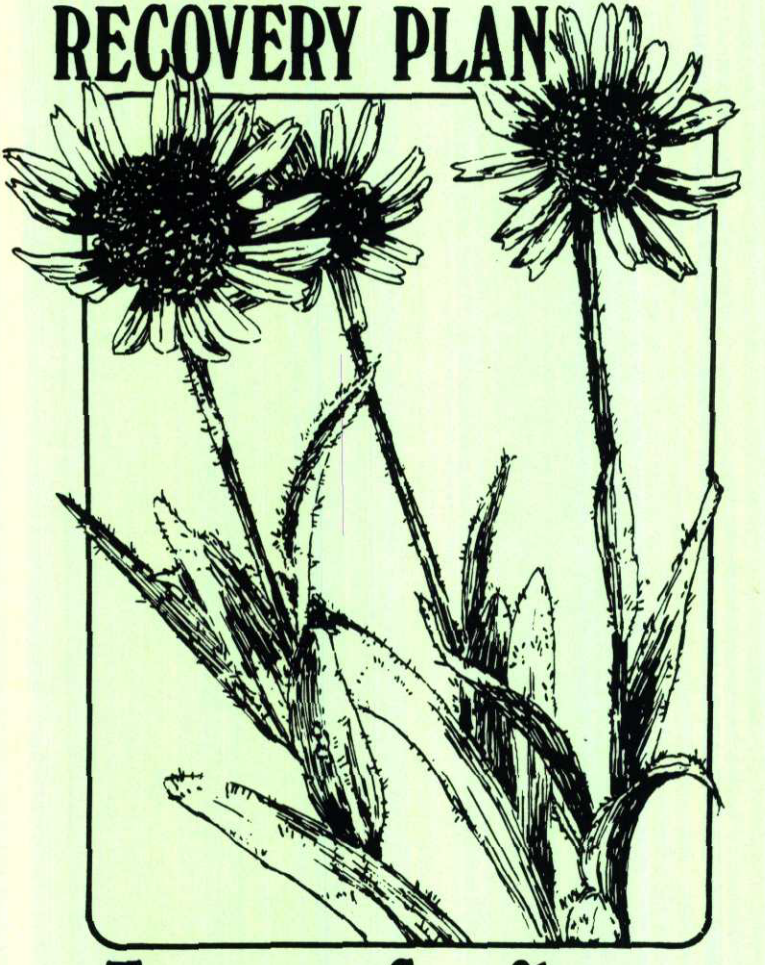
RECOVERY PLAN



Tennessee Coneflower

TENNESSEE CONEFLOWER RECOVERY PLAN
(Original Approval: February 14, 1983)

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Recovery plans delineate reasonable actions which are believed to be required to recover and/or protect the species. Plans are prepared by the U.S. Fish and Wildlife Service, sometimes with the assistance of recovery teams, contractors, State agencies, and others. Objectives will only be attained and funds expended contingent upon appropriations, priorities, and other budgetary constraints. Recovery plans do not necessarily represent the views nor the official positions or approvals of any individuals or agencies, other than the U.S. Fish and Wildlife Service, involved in the plan formulation. They represent the official position of the U.S. Fish and Wildlife Service only after they have been signed by the Regional Director or Director as approved. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery tasks.

Literature citations should read as follows:

U.S. Fish and Wildlife Service. 1989. Tennessee Coneflower Recovery Plan. U.S. Fish and Wildlife Service, Asheville, NC. 30 pp.

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Fish and Wildlife Reference Service
5430 Grosvenor Lane, Suite 110
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EXECUTIVE SUMMARY

Current Status: There are currently five known populations of the Tennessee coneflower. All are located within 14 miles of one another in a small portion of middle Tennessee. Portions of two populations are in public ownership and thereby receive some protection.

Recovery Goals: Downlisting and eventual delisting of the species as the recovery criteria listed below are met.

Recovery Criteria: The Tennessee coneflower will be considered recovered when there are at least five secured wild populations, each with three self-sustaining colonies. Reclassification to threatened status will be considered when each population has at least two self-sustaining colonies.

Recovery Actions Needed: In order to reach the recovery goals cited above the Service and cooperating agencies must obtain long-term protection of the known colonies, establish a sufficient number of new colonies to meet the recovery criteria, determine the management actions needed to insure the long term survival of the species at each site.

Date of Recovery: Provided that adequate funds are available to complete the recovery actions listed in the plan, full recovery of the Tennessee coneflower can be accomplished by September 30, 1993.

Total Cost of Recovery: Implementation of the recovery tasks for which cost estimates have been made total $ 114,000.00. Site protection actions that require acquisition of land will probably increase actual recovery costs for this species.

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PART I

INTRODUCTION

Taxonomic Background

On June 6, 1979, the U.S. Fish and Wildlife Service officially listed the Tennessee coneflower, Echinacea tennesseensis (Beadle) Small, as an endangered species (U.S. Department of the Interior 1979). It is endemic to a few localities in central Tennessee (Somers 1983).

As is often the case, taxonomists have had various opinions about the status of the taxon. Dr. Ronald L. McGregor (1968), in his monograph of the genus, concluded that it merited species status. He said, "It is morphologically similar to E. angustifolia var. angustifolia but is smaller in all respects. The pubescence is softer, pollen grains smaller (18.5u vs. 21u), and stem more leafy." In a letter to Ms. LaVerne Smith (March 12, 1979) of the Office of Endangered Species in Washington, D.C., he further defended its species status by writing:

> "...since the publication of my paper...in 1968, my field and experimental garden studies have convinced me that Echinacea tennesseensis is a good species. Its closest relative is E. angustifolia of the Great Plains region of North America. I have grown the two species together in the common experimental garden and have found them to be distinct in every way."

Ronald McGregor (University of Kansas, personal communication, 1980) further suggests that there are physiological differences, since E. tennesseensis plants grew poorly in the Kansas climate with very low survival through the winter, whereas E. angustifolia plants did well under similar conditions.

Distribution

There are, at present, only five known populations for E. tennesseensis, all in cedar glade communities and located within 14 miles of one another in Davidson, Rutherford, and Wilson Counties in middle Tennessee. A population is defined as a group of colonies in which the probability of gene exchange through cross pollination is high. A colony is defined as all E. tennesseensis plants found at a single site that is separated from other plants within the population by unsuitable habitat. Most colonies consist of no more than 1 or 2 acres. There are historical records of additional colonies within the same general area. One was in Rutherford County along Stones River Road at what is now a trailer park. Dr. Robert Kral was familiar with this colony and had confirmed its presence as recently as 1967 according to Hemmerly (1976). During his doctoral research, Hemmerly searched unsuccessfully for remnants of this colony. On October 18, 1978, Paul Somers of the Tennessee Department of Conservation (Department) also examined land around the trailer park without finding any coneflowers. On August 19, 1897,

H. G. Eggert collected the type specimen(s) and described the site as a "...dry gravelly hill near La Vergne, Tennessee..." (Beadle 1898) that is in Rutherford County. This colony has not been relocated and may have been destroyed. Also, two colonies in Davidson County--one about where Castlegate Drive now ends and another at what is now a housing subdivision on Moss Spring Drive--were discovered in 1972 by Dr. John Churchill of Johnson City, Tennessee, and Dr. John Wurdack of the Smithsonian Institution. These colonies were destroyed by housing before they were revisited by Wurdack in May 1975 (personal communication, 1980). Both colonies were very close to one another and were considered parts of the same population.

There is only one report of E. tennesseensis occurring outside the middle Tennessee range. Small (1933) reported that it occurred in Arkansas, but no specimens have been found to support this.

It is conceivable that in the distant past the distribution of coneflowers was more continuous, and the middle Tennessee colonies were linked to those in the midwestern prairies. Arthur Cronquist (New York Botanical Garden, personal communication, 1978) postulated:

> "...that during the hypsothermal period several thousand years ago the range of E. pallida var. angustifolia [= E. angustifolia var. angustifolia of McGregor] extended much farther eastward than it does now. (The same was true of many other species of the Great Plains.) With the return of cooler, more pluvial conditions, var. angustifolia was excluded from the more eastern segment of its range, except that it was able to survive in the cedar barrens of central Tennessee...."

This seems like a plausible explanation for the existence of the Tennessee colonies, especially since long distance dispersal of the large seeds by vectors, other than birds and possibly large mammals, is unlikely. There remains the possibility that Indians or early settlers introduced the plants to the east. One argument against such a recent introduction, however, is the evidence from McGregor's studies that there are morphological and physiological differences between E. tennesseensis and the midwestern taxon.

The number of E. tennesseensis plants in each of the five extant populations varies from approximately 3,700 to approximately 89,000 (Mark Drew, University of Tennessee, personal communication, 1988). Two populations have distinct colonies that are from 0.3 to 1.5 miles apart. The five populations, on the other hand, are each more than 3 miles apart and are considered to be distinct because gene exchange via insect pollinators would be unlikely. The populations can be described as follows:

Population 1: Historically included at least three colonies. Today there is only one known colony left.

Colony 1-1

a. Location: Davidson County.

b. Ownership: Privately owned.

c. Approximate acreage of key tracts: 20 acres.

d. Land use: Undeveloped adjacent land had been used for limited grazing or for single-family dwellings. The remains of an old homestead are barely discernible on a corner of the property belonging to the primary landowner. A paved, dead-end road is the northern border. The tract was sold in 1988 and is currently slated for intensive development.

e. Description of site: This site is one of the best examples of a cedar glade ecosystem. Unlike many glades in the Central Basin, it has not been abused by off-road-vehicle use, trash dumping, overgrazing, or construction activities. The site supports many cedar glade endemics.

The coneflowers occur in a few dense patches. The main cluster consists of about 12,000 mature plants and is located along the lower, down-slope edge of the glade opening. A smaller group of plants (about 2,000) exists in a smaller adjacent glade opening in an experimental plot established by Hemmerly. Additional coneflower plants are located along the north side of the road near this glade.

Population 2: Historically included two colonies which are still extant.

Colony 2-1

a. Location: Wilson County.

b. Ownership: The Tennessee Department of Conservation, Division of Forestry, owns 85 percent of this site. The remainder is privately owned. The portion of the site owned by the Department is a designated natural area and is managed by its Division of Forestry and Ecological Services.

c. Approximate acreage: The entire tract is about 100 acres in size.

d. Land use: Portions of the site have been used by past owners for pasture and row crops. A dirt road bisects the tract.

e. Description of site: Most of this site was primarily open farm land prior to its acquisition by the Department. Glade species occur in only a few localities where the soils are especially thin or absent exposing the underlying limestone. Most of the approximately 16,000 coneflower plants are on State-owned land. With the purchase of approximately 15 more acres, the whole colony

will be protected. The coneflowers are localized in two areas that appear to be natural and in a third area believed to have been established from seeds planted by Dr. Elsie Quarterman and Mr. G. E. Jones about 1979.

f. Dangers to integrity: This site is threatened by off-road-vehicle use. Additionally, the privately owned portion is vulnerable to housing development since road access was recently improved and a water line installed.

Colony 2-2

a. Location: Wilson County.

b. Ownership: State of Tennessee, Department of Conservation, Division of Forestry.

c. Approximate acreage: The glade occupied by the plants is approximately 0.25 acre in size.

d. Land use: Currently managed for protection of the coneflower.

e. Description of site: The plants are scattered, occurring in small openings among the cedar and hardwood species. Several small clumps of plants that Hemmerly established occur here, as well as one large, natural population (approximately 5,000 plants) at the edge of a small glade opening about 100 by 150 feet in size.

f. Dangers to integrity: None, this site is probably the most protected of all the sites.

Population 3: Historically included three colonies which are still extant.

Colony 3-1

a. Location: Wilson County.

b. Ownership: Two tracts are privately owned, and the rest of the colony is owned by the Tennessee Department of Conservation, Division of Forestry.

c. Approximate acreage: The portions of the colony on private land occupy approximately 2 acres, and that portion on the State forest covers 2 to 4 acres. Plants on the State forest are separated into two groups by a block of forest. The Division of Forestry has wisely zoned approximately 18 acres here as a restricted area in order to encompass all the plants.

d. Description of site: A dead-end gravel lane bisects this colony. It runs along the edge of the State forest forming an obvious boundary between the State and private portions of the colony. Coneflowers are abundant in the gravel along the roadsides. They

are prevalent in a large glade and several smaller glade openings on the State forest. On one of the private tracts adjacent to the State forest, they are growing in a field with shallow soil that has apparently been fallow for several years. Adjacent to this field is a small wood-frame house leased out by the landowner. It is estimated that half of the 20,000 coneflowers at the site occur in this field and along the road. The 1,000 to 2,000 plants on the other private tract are located about 0.5 mile north of this site. A jeep road runs through the site, and trash and debris disposal are adversely affecting it.

e. Dangers to integrity: The private tracts are vulnerable to future development or more intensive farming practices. Off-road-vehicle use on part of the State-owned site has caused a population decline in the recent past. Trash dumping and off-road-vehicle use are adversely affecting at least part of the privately owned portions of the colony.

Colony 3-2

a. Location: Wilson County.

b. Ownership: This colony occurs on three privately owned tracts.

c. Approximate acreage: The plants that occur in this colony are dispersed in small groups over a 100-acre area.

d. Description of site: A gravel road transects this colony. Except for two small groups of plants, most of the coneflowers at this site are found on the south side of the gravel road. A small creek flows through the area, and the coneflowers are primarily found on typical limestone glades within 500 feet of this creek. Additionally, some plants are found growing in regularly grazed pasture, on the creek banks, and on unusually moist sites adjacent to the creek. During the summer of 1989, Jay Raveill (Biology Department, Vanderbilt University, personal communication, 1989) estimated that the colony contained approximately 5,000 flowering stems. Based upon experience at other sites, it appears that this colony may contain 50,000 coneflowers when seedlings, juveniles, and nonflowering individuals are included.

e. Dangers to integrity: Overgrazing and development of the site for residential or industrial purposes are the greatest threats to this site.

Colony 3-3

a. Location: Rutherford County.

b. Ownership: One privately owned tract.

c. Approximate acreage: The plants occupy less than 1 acre. Most occur within an 800-square-foot area.

d. Description of site: This colony occurs at the edge of a gravel glade just north of a paved secondary road. The plants are found in the ecotone between a pasture and the glade. A total of 300 to 500 plants were present at this site in 1989.

e. Dangers to integrity: Encroachment of woody vegetation, conversion to pasture, and development of the site.

Population 4: Historically included at least three colonies but today there is only one known extant colony.

Colony 4-1

a. Location: Rutherford County.

b. Ownership: Privately owned by an industry.

c. Approximate acreage: The portion of the lot occupied by the coneflowers is less than 0.25 acre in size.

d. Description of site: The corporation owns a couple of acres which they use intensively. The back portion of the lot, where the coneflowers grow, has been used as a discard site for an assortment of old engine parts and other junk. When one of the owners discovered the coneflowers and learned of their significance, she had some of the debris cleared from a portion of the colony. About 3,700 coneflower plants are estimated to occur at this site by Mark Drew (personal communication, 1988). The plants are growing on crushed limestone gravel placed on the site by the owners 7 to 8 years ago. Since many of the plants are large with well-established root stocks, it is possible that the colony is an old one that survived deposition of the gravel. This might have helped the colony, in fact, by excluding competitors and by providing more surface area for trapping moisture and stratification of seed, which is important for germination (Hemmerly 1976).

e. Dangers to integrity: Although the corporation lot is fenced and the owners care about protecting the coneflowers, there is no guarantee that inadvertent destruction will not occur or that the site will not be converted to other use. The population has, for unknown reasons, declined by about 50 percent in the past 10 years.

Population 5: This is the largest known population, consisting of one colony.

Colony 5-1

a. Location: Davidson County.

b. Ownership: Approximately eight privately owned tracts.

c. Approximate acreage: This population occurs on approximately 150 acres.

d. Description of site: The approximately 89,000 coneflower plants that occur at this site represent the highest quality population known for the species (Drew, personal communication, 1988). The barrens and glades found here also support 10 other species that are candidates for Federal listing and are on the State's list of protected plants.

e. Dangers to integrity: Encroachment from plants associated with successional changes is a long-term threat. Development is a much more immediate threat. Rapid suburban growth is occurring in the vicinity, and land values are increasing rapidly. Trash dumping and off-road-vehicle use are also significant problems at this site.

Artificially established colonies such as those in Cedars of Lebanon State Forest and Stones River National Battlefield Park are not addressed in the above description of populations and colonies. These colonies are regularly monitored, and they may or may not play a significant role in the recovery of the Tennessee coneflower. At the present time it is planned to use these colonies for research to determine management requirements for the species.

Environmental Factors Relating to Endangerment

All of the known natural colonies for Echinacea tennesseensis, past and present, are in cedar glades. Cedar glades are openings in forests that are dominated by red cedar (Juniperus virginiana) and where the bedrock, Lebanon limestone of Ordovician age, is exposed or covered by a very thin layer of soil. These glades provide an extremely harsh environment subject to extremes in light, temperature, and moisture (Freeman 1933, Turner 1966). Taxa living under these xeric conditions have evolved special adaptations to overcome these factors.

Average soil depth, as determined by Drew (Clebsch 1988), for the five coneflower populations ranged from 2.0 inches at Population 1 to 3.4 inches at Population 5. The average soil depth for all populations was 2.6 inches.

Hemmerly (1976) examined the habitats at two of the coneflower colonies. Soil depth at one colony ranged from 2.9 to 4.9 inches and at the other from 1.9 to 2.9 inches. Soil depth "...varied greatly at both sites..." he stated, but "...many small pockets of soil were found in which

Echinacea roots penetrated to a depth of 6-8 inches...." The roots themselves, he found, were considerably longer, averaging 15.1 inches, but the impenetrable bedrock often forced them to grow horizontally. The stout, fibrous roots are probably well adapted for absorbing and storing any water that is available in the rock crevices.

Hemmerly (1976) also obtained microclimatic data for these two colonies and for one experimental transplant colony that he started in a glade at the Stones River National Battlefield. Differences in maximum temperatures between the three glade areas and the nearby National Oceanographic and Atmospheric Administration (Administration) stations were detectable in all seasons except winter. Glade temperatures were as much as 31°F higher on one exceptionally hot day (129°F vs. 98°F). Air temperatures minima, on the other hand, usually did not differ much between the glades and Administration stations, but on one exceptionally cold day the temperatures were in the low twenties at the glade sites yet were slightly above zero at the Administration stations.

Soil moisture at various depths was measured by Hemmerly (1976) using Bouyoucos soil moisture blocks. During the 5 weeks which included the dry month of October 1971, the blocks planted at 6 or 8 inches at Population 2 gave 100 percent readings, indicating the presence of deep moisture in the glades during drought. To survive in the open glades, coneflowers must be able to compete successfully for this moisture, but they are under considerable stress during severe drought. Juvenile plants, which lack the long roots necessary to reach the moisture at 6 to 8 inches, may succumb.

Echinacea tennesseensis is seldom seen growing in habitat where there is more than 50 percent shade (Hemmerly 1976). Whether or not this is due primarily to the shading itself remains to be proven. Competition for water or light might be responsible for its exclusion from the areas with denser, taller vegetation. Hemmerly's (1976) allelopathic studies using extracts of Petalostemon gattingeri, a common associate, indicate that some inhibitory action on seed germination occurs in vitro and suggest that the same might be occurring in the field. Another common associate, the grass Sporobolus vaginiflorus, caused only slight reduction in germination. Extracts of Juniperus also inhibited germination of E. tennesseensis seed in vitro.

The research done by Hemmerly (1976) described the natural habitat of E. tennesseensis and suggested environmental factors that might be impeding its growth and reproduction. The niche parameters and limiting factors, however, have not been defined in precise terms. There is still some basic ecological research to be done.

Biological Limiting Factors

Inherent characteristics of Echinacea tennesseensis may have contributed to its decline in numbers and restricted range. It will grow well in regular potting or garden soil, so the glades are not providing a special nutrient condition not found elsewhere. It is more likely a matter of what the glades lack that makes the habitat special to coneflowers.

It may be an example of a K-selected taxon; i.e., one that has invested its reserve energy supplies in competitive strategies rather than reproductive capability. The species produces a limited number of relatively large "seeds" (achenes) that are not easily dispersed by common vectors, such as wind and water, and that lack appendages that would make them adhere to animal fur. Hemmerly (1976) found that the viable seeds are large (2 to 8 mg) and are seldom dispersed by wind more than 3 feet beyond the parent plant. No evidence of seed predation by animals was observed by Hemmerly (1976), but Drew (personal communication, 1987) has observed goldfinches feeding on them, and Foster (in litt.) reports that whitetailed deer have grazed on the mature seed heads of plants in his garden.

In its natural habitat the species has a limited number of flower heads per plant. Usually there is a single head terminating each branch. Older plants and those grown in garden situations may have many branches arising from the root base. While seed number per plant is limited, Hemmerly (1976) found that a relatively high percentage (67 percent) are capable of germination under optimum laboratory conditions. These conditions were found to be 16 weeks of seed stratification at about 41°F followed by germination in light at 59° to 77°F. He also demonstrated that dry storage for up to 60 months resulted in only a moderate loss of viability.

The specialized nature in some of the morphological and physiological characteristics that make E. tennesseensis so well adapted to the glade environment might be inhibiting its escape from the glades or growth in other habitats. For instance, by having stout fibrous taproots, they have forfeited the ability to spread vegetatively by surficial rhizomes, stolons, or other asexual means of propagation. Likewise, by slowly growing a short, woody stalk, they are poorly evolved for competing with tall, fast-growing taxa that can shade or crowd them. It is also conceivable that their narrow hairy leaves or stomatal arrangements could be ill-suited for adequate photosynthetic productivity under shadier or moister regimes.

One physiological factor observed by Hemmerly (1976) is that apparently they utilize the relatively inefficient C3 photosynthetic pathway instead of the more efficient C4 route. The C4 pathway requires less water, so being a C3 plant in a xeric environment might represent a disadvantage.

Some carefully designed experiments should add to our knowledge about the role of certain E. tennesseensis anatomical and physiological features in delineating the taxon's niche and survival problems.

Threats from Man's Activities

All of the known coneflower localities have been affected by man's activities to some degree. The impact from some of the agricultural practices, such as grazing and bush-hogging (mowing), is not documented beyond casual observations. It is apparent, however, that they can survive

limited use of these practices. If not too intensive, such land manipulations may prove to be advantageous because they arrest succession. The effects of grazing may vary, dependent upon the types of livestock used. Likewise, the effects of fire on coneflowers has not been studied. It might prove to be another useful tool for restoring coneflower habitat in glades which are being threatened by competing vegetation.

Perhaps the greatest threat to coneflowers is the development of their habitat for residential housing, industrial facilities, or roads. Development poses serious threats to Colony 4-1 and Populations 1 and 5. Populations 1 and 5 are being encroached upon by Nashville suburbia, which is developing rapidly on the western edge of Percy Priest Lake. Coneflowers at Colony 4-1 have declined by approximately 50 percent in the past 10 years. Judging from this colony, it appears that although coneflowers can survive a lot of physical abuse to their habitat, heavy industrial disturbance of this nature has a significant adverse effect. Most important, however, is the outright destruction of glades by paving, building, or establishment of lawns that has destroyed other coneflower colonies.

A horticultural demand for E. tennesseensis has developed, perhaps as a result of its recognition as a rare species. This could become a serious threat to natural populations if adequate sources of seed are not developed through propagation.

Action Taken to Date

All private landowners and the State's Division of Forestry have been notified of significant rare plants on their properties. For some privately owned colonies, the State Heritage Program staff has met sympathetic and at least somewhat cooperative landowners, but only one (the owner of the experimental population) has agreed, thus far, to register the land as a natural area with The Nature Conservancy. Such registration is an agreement with the landowner(s) that is not legally binding. Acquisition of the privately owned sites containing viable or potentially viable populations or colonies will probably be the most successful means of obtaining long-term protection for the species.

Two of the three colonies on State-owned land (Colonies 2-2 and 3-1) are managed by the Division of Forestry. The third (Colony 2-1) is managed jointly by the Department's Divisions of Forestry and Ecological Services. Personnel from the Division of Forestry participated in the recovery planning effort. They have managed the coneflower populations by zoning their habitat as restricted areas where no timber management will occur. They have also indicated a willingness to assist with any habitat maintenance or experimental manipulations, such as burning, that are determined to be necessary in the future.

On certain State-owned lands; i.e., parks, natural areas, scenic rivers, and trails, the removal of plant material without permission is considered a violation of the Department's regulations requiring a collecting permit (Chapter 0400-2-8-21 and Rules and Regulations Governing

the Use of State Parks, Section 2.26). The Tennessee coneflower is listed as an endangered species under the State's Rare Plant Protection and Conservation Act of 1985. Regulations developed under this act prohibit trade in the species without appropriate permits and taking from State lands without a permit from the agency responsible for managing the land.

Several attempts to establish new colonies in natural settings or additional plants in existing colonies have been made. Hemmerly (1976) established three new experimental plantings (two of them were within existing colonies and are treated as satellites of the colony). The third experimental planting was a new colony started at Stone's River National Battlefield. This is now a healthy population of several hundred plants. A member of the Tennessee Native Plants Society has established a small colony of plants on her glade property. The plants are regularly monitored and are protected as a registered natural area. The Department made several attempts to establish new colonies on Cedars of Lebanon State Forest in 1983. Only one of five of these attempts has been successful. In 1989, three colonies were successfully established in Long Hunter State Park. The seed for these colonies was derived from propagated sources.

Work on propagating E. tennesseensis was begun by Dr. Robert Farmer at the Tennessee Valley Authority (Authority) nursery in 1978. About 500 to 1,000 plants were grown from seeds taken from Colonies 2-1 and 3-1. Approximately 75 juvenile plants (1 to 2 years old) were transferred from the Authority's nursery to garden and glade localities at Cheekwood Botanical Garden and a wild flower garden at the Warner Park Nature Center, both in Nashville. Seeds were harvested from the Authority populations in 1980 and 1981, and the Cheekwood plants produced abundant seeds in 1981. Unfortunately, hybridization with Echinacea purpurea occurred at Cheekwood, making this an unsuitable future seed source. A small quantity of the 1980 harvest and a large amount of the 1981 harvest of Authority plants were sent to the U.S. Forest Service seed storage facility in Macon, Georgia. In 1983, all or most of this seed was later provided to the Department for their propagation efforts.

A number of private landowners have obtained seeds from licensed nurseries with Federal permits and have the Tennessee coneflower growing successfully in their home gardens. Also, the Tennessee Native Plants Society has dispensed about 10 small packets of seeds obtained from Dr. Farmer to members through its seed exchange program. In 1987, a program was started to establish one cultivated population for each of the known colonies. Funds for this project were either donated by the cooperating institutions or individuals or were provided by the Service's Section 6 grant-in-aid program.

PART II

RECOVERY

A. Recovery Objective

The Tennessee coneflower will be considered recovered when there are at least five secure wild populations, each with three self-sustaining colonies of at least a minimal size. A colony will be considered self-sustaining when there are two juvenile plants for every flowering one. Minimal size for each colony is 15 percent cover of flowers over 800 square yards of suitable habitat. Reclassification to threatened will be considered when each population has two colonies.

In determining this recovery objective, the assumption was made that several of the existing colonies on natural cedar glades are already large and healthy enough for recovery. These were measured and sampled in order to provide quantitative estimates for the objective. Since cedar glades are successional ecosystems, some form of active management may be necessary to achieve and/or maintain the "recovered" state. The preparation and implementation of management plans, therefore, are imperative to completion of the recovery objective. Management planning should be based upon scientific research.

B. Narrative Outline

1. Continue systematic searches for new colonies. The cedar glades of middle Tennessee have been intensively studied, but there has never been a thorough effort to map and systematically search them. Since three of the five known populations were discovered in the relatively recent past, it is conceivable that there are other populations or colonies to be found. Historically all of the extant and extirpated sites of E. tennesseensis have been confined to a narrow area within three counties (Davidson, Rutherford, and Wilson); therefore, the search should be concentrated on cedar glades within these counties.

   Searches for additional populations were initiated in 1987. These initial searches were directed to areas identified by review of a general cedar glades map prepared by Quarterman (1950), aerial photographs, and geological maps. To date, ground searches have proven to be more effective than air searches. Potential sites in Davidson and Rutherford Counties were checked first because of the threats to these areas from the rapidly expanding Nashville urban area. Several new colonies were discovered near Populations 2 and 3 during the searches. Searches in Rutherford, Davidson, and Wilson Counties should continue until all suitable habitat has been investigated.

2. Secure each colony. Protecting the extant colonies presents the best opportunity for assuring survival of the taxon. They have existed at these sites for a considerable length of time and appear to be healthy and self-sustaining in relatively stable cedar glade ecosystems. One exception might be the Rutherford County population, which has a history of disturbance. If left alone, these sites should require very little special management to maintain optimum habitat. Newly established colonies should be given special attention to ensure their success.

   2.1 Obtain long-term protection of privately owned colonies. There are a variety of methods by which the colonies can be protected. These include registry of the colony as a Registered State Natural Area, cooperative management agreements, conservation easements, and acquisition. The cheapest protection tool that will provide the required long-term protection of the colony should be used. A cooperative management agreement, in general, will be cheaper than purchasing a conservation easement or purchasing the land outright, but landowner(s) might not be agreeable to all the necessary restrictions imposed in such an agreement. In most cases the only feasible method of obtaining long-term protection will be acquisition of the land or of a conservation easement on the land.

   Representatives from the Department's Division of Ecological Services have met with the owners of the privately owned sites

to discuss the significance of the coneflower and to request their help in its protection, but no formal agreements on natural populations have been reached, legal or otherwise; none has agreed to place their property on the Natural Area Registry as yet. Despite past discussions with the former owner of Colony 1-1, it was recently sold and slated for development. One transplanted population is protected by a registry agreement. Under registry agreements, landowners promise to notify the Department should a decision be made to sell the property or to impact the habitat in any way. These agreements should not be regarded as adequate permanent protection for "recovery" since they are voluntary, nonbinding agreements between landowners and the State. The Tennessee Chapter of The Nature Conservancy had discussed acquisition of Colony 1-1 with its previous owner, but the owner was not interested in selling the property to the Conservancy. The Conservancy has initiated contacts with the owners of Population 5 and will acquire all or part of the site if possible. This site is adjacent to Long Hunter State Park which is owned by the U.S. Army Corps of Engineers. Therefore, once acquired, the site could be transferred to the State or Federal government. Conservation easements and cooperative management agreements offer an opportunity to manage for the species without actually owning the land. Theoretically, conservation easements should be relatively inexpensive and acceptable to the landowners, since the glade sites are essentially barren and devoid of resources to be exploited and because they usually reduce the landowner's property taxes. Three of the populations, however, are in the rapidly developing Nashville and Percy Priest Lake area; thus, owners may be unwilling to sell easements now since that would preclude more lucrative prices for development later. The private portions of the two Wilson County populations could be adversely affected by private development. The Conservation Easement Act of 1981, passed by the State Legislature, makes it possible for either public bodies or any private organization "...which has received a determination of exemption from the Internal Revenue Service under Sections 501(c)(3) and Section 509(a)(1) or (a)(2) of the Internal Revenue Code...," to hold a conservation easement. Cooperative management agreements with landowners represent another option for protecting certain colonies. Although it is not as strong a protection tool as an easement or outright ownership, it might be considered adequate for permanent recovery if the terms of agreements are strict.

2.2 Maintain protective zoning of State-owned colonies. Portions of Colonies 2-1, 2-2, and 3-1 are on State land managed by the Department's Division of Forestry. Current zoning restrictions for the forest compartments involved reflect the Division's decision to manage for the coneflower habitat where it occurs. At present the best policy may be to leave the

areas alone and restrict access to them. In the future, however, management manipulations may be recommended. The Division of Forestry will be consulted for assistance with any of the above activities.

2.3 Restrict access to colonies. The use of off-road vehicles is prevalent on cedar glades, especially where there is easy access. All of the known colony sites are accessible to four-wheeled vehicles, except for Colony 2-2. Heavy use by livestock represents another threat, and this should be controlled.

The fences that exist at Colonies 1-1, 2-1, and 3-1 are old and inadequate for excluding off-road-vehicle users and livestock. The plants at Colony 4-1 are within a high fenced-in compound, but they are not well separated from the industrial activities within it. At Colony Site 2-2 and Population 5 there are currently no protective fences. Restricting access by improving fencing or barriers at all colony sites should be considered. "No trespassing" signs should be placed where it would be beneficial. Posting of land, where acceptable to owners, serves notice that someone cares about the property. Theoretically, it should discourage some would-be trespassers and help landowners and authorities in dealing within anyone found disturbing the species or its habitat.

3. Provide a seed source representative of each natural colony. It is very important to minimize disturbance of the natural colonies. For this reason, the seed necessary for quickly establishing new and experimental colonies should be obtained from cultivated stock.

3.1 Maintain colonies representing populations 1 through 5 in cultivation. During 1987 and 1988, representative material from all known colonies was placed into cultivation. This material should be maintained indefinitely to ensure a source of plants or seeds, the use of which will not adversely affect the wild populations. Additionally, this material can be used to reestablish populations that are inadvertently lost in the future.

3.2 Maintain viable seeds from each natural colony. The Service initiated this step by placing thousands of seeds from the 1980 and 1981 harvests at the Authority's nursery in cold storage at the U.S. Forest Service's Macon, Georgia, facility. The 1980 harvest yielded at least 30,000 seeds, and the 1981 harvest yielded many more than that. In 1983, most of these seeds were used by the Department for propagation purposes. New seeds are being generated through 3-year contracts or agreements that were initiated in 1987. Fresh seeds from each colony should be stored here as they become available. A small reserve for each population should be sent to and

maintained at the National Seed Storage Lab in Ft. Collins, Colorado. When seeds are requested for research or for establishing new colonies to meet the recovery objective, the older seeds should be dispensed first as a general rule. If appropriate, each glade reintroduction should receive seeds from a single population in order to maintain any genetic distinctions. A log should be maintained recording inflow and outflow of seeds. The dates of receipt or dispersal, names of individuals and agencies involved, and the populations and colonies represented should be recorded in the log.

3.3 Make excess seeds available to greenhouse owners willing to assist in the recovery effort. This represents an inexpensive way to maintain small colonies of coneflowers. As in the above section, each grower should receive seeds from a single population, and careful records should be kept identifying who has what seed. Cultivation is not considered to be critical to recovery, but since the Tennessee coneflower is an attractive wild flower and has been successfully grown in lawns and gardens, this offers a secondary avenue for assuring at least temporary survival of the taxon. Also, it might reduce seed and plant poaching from the wild.

4. Establish new colonies. In order to meet the recovery objective, new colonies, within the historical range of the coneflower, need to be established. Cedar glades exist on a number of publicly owned sites. Using some of these sites for establishing new colonies would save the cost of acquiring land specifically for this purpose. Also, arrangements for maintaining and monitoring the new colonies might be easy to make using staff already managing the public land. Private land, however, should be considered too. Efforts should be made to locate suitable sites within about 1.5 miles of existing colonies in order to allow movement of pollinators between colonies of a population.

4.1 Identify suitable sites. The most suitable sites would probably be public lands relatively close to known colonies. Logical places to examine, therefore, would be Cedars of Lebanon State Park, Cedars of Lebanon State Forest, and Cedars of Lebanon State Natural Area; Long Hunter State Park and other public property on or adjacent to Percy Priest Reservoir area; Stones River National Battlefield; and the Hermitage Historical Area. Informal contacts with most of these management agencies involved indicate a willingness to cooperate. No formidable bureaucratic restrictions are expected. Selection of the most suitable glades should be based primarily on two major criteria: (1) quality of habitat and (2) potential for protecting the site.

4.2 Plant seeds or young plants. Working with seed should be more cost effective than transplanting young plants into the rocky glades. Populations should be kept genetically distinct.

4.3 Provide water, if necessary, to improve initial survivorship. Mortality is expected to be very high during the first 2 years. Survivorship studies done by Hemmerly (1976) showed a low survival percentage of seedlings (10.7 percent maximum) the first spring from seed sown in November but a fairly high survival rate (68 percent) among the seedlings through the second growing season. Occasional watering, if feasible, could be helpful for increasing germination and assisting seedling establishment during this critical phase of the life cycle, especially during periods of drought.

4.4 Secure as in Task 2. In order to reach the recovery objective, each newly established colony should be protected. All measures used to protect the original colonies should be applied to the new ones.

5. Monitor colonies and conduct management activities, if necessary, to maintain the recovered state in each colony. Since ecosystems are dynamic, populations will change in size, number, and location. The status of the colonies, successional changes, and any man-made disturbances should be monitored before and after recovery. A method for accomplishing this should be outlined and initiated. The existing colonies on natural cedar glades appear to be healthy and relatively stable, so very little habitat manipulation is expected to be required for them during the next decade or two. If habitat improvement is deemed necessary (when a colony is declining below the recovered state), however, action should be taken. The management techniques applied should be based on the conclusions of management research.

5.1 Obtain baseline data. As part of the plan to monitor the colonies, it is essential to gather baseline data on each colony and its habitat. Outlines of the data that can be gathered are given by Lawrence (1950), Pelton (1951), and Penfound (1952). These references, as well as recent papers, such as Werner (1976), Harper and White (1974), Werner and Caswell (1977), Menges and Gawler (1986), Menges (1988a, 1988b), and Travis and Sutter (1986), are recommended as guides for experimental design. A contract to map glade vegetation and establish permanent plots was issued by the Department in 1987. Work on this contract will continue through 1989.

5.2 Identify limiting factors. Knowing what limits the growth and reproduction of an organism is vital for anyone interested in managing it. Any physical, chemical, or biological factor suspected of limiting some aspect of E. tennesseensis growth or reproduction deserves investigation. Research contracts

addressing the tasks below are scheduled for completion in 1990.

5.2.1 Analyze water relations and budget. Echinacea tennesseensis is well adapted to surviving drought conditions on the glades, but no doubt many plants, especially young ones, succumb to or are limited by lack of water. A quantitative evaluation of how this unique taxon budgets its limited water supply would be instructive. It is useful to know when water becomes a limiting factor. The wilting point needs to be identified for E. tennesseensis.

5.2.2 Study light relations. Hemmerly (1976) observed that the natural populations are never in more than 50 percent shade, so it is reasonable to hypothesize that light is a limiting factor at times. Light relations need to be examined experimentally to determine in quantitative and qualitative terms when light is limiting growth and reproduction. Baskin and Baskin (1982) demonstrated that vernalization is not required for flowering and that Echinacea tennesseensis is a long-day plant.

5.2.3 Examine effects of allelopathy and competition. Hemmerly (1976) has already found in vitro evidence of allelopathic inhibition of E. tennesseensis seeds by extracts of two common glade associates, Juniperus virginiana and Petalostemum gattingeri. The common glade grass Sporobolus vaginiflorus also caused slight reduction in germination. Determining how large a role these inhibitors play in vitro should be the basis for future experiments. Other common associates could be tested. Experiments to determine its ability to compete with various grasses and forbs should be conducted.

5.3 Monitor sites on a periodic basis. Each site and its colonies should be examined for signs of growth or decline. By careful and frequent monitoring, problems can be detected early and corrective measures begun at a time when they are, hopefully, easier and less costly. Monitoring should be conducted through the use of permanent plots, grids, transects, and photographs.

5.3.1 Evaluate cover and viability. In order to be considered recovered, certain criteria regarding colony number, size, and viability must be met. The self-sustaining criteria and colony size should be checked yearly between October and November.

5.3.2 Monitor for evidence of disturbance, poaching, disease, etc. Sites should be checked frequently for signs of damage and/or problems. Since the colonies are small and localized, the opportunities for quick destruction are great.

5.4 Determine management required for maintenance of colonies established for experimental purposes. The most practical research that can be undertaken concerns experimenting with management techniques. The Division of Forestry and other land managers need to be advised on how to maintain the optimal habitat for the coneflowers. These experimental studies should be done on newly established colonies and not on existing natural colonies. The use of State Forest and Natural Area land at Cedars of Lebanon would be a logical place to do these long-term studies because of the management personnel and facilities already there.

5.4.1 Conduct experimental burns. Fire is a natural and common phenomenon on the cedar glades and barrens because of the dry conditions that frequently occur there. It is uncertain how E. tennesseensis responds to fire, but it was speculated by Kral (1983) that its "knotty strong rhizome enables this species to resist fires such as frequently ignite the dry vegetation of open and closed cedar glades in summer." Fire might improve the habitat by eliminating competitors. Observations should be made over many years to determine long-term effects.

5.4.2 Test grazing as a management tool. It is apparent that cattle grazing has happened in the past at Colonies 2-1 and 3-1, but we know nothing about its duration or intensity. Casual observations at Colony 2-1 suggest that the coneflowers were not being browsed in preference to other plants, so it is conceivable that limited grazing could benefit the species by removing competing vegetation. As with the burn studies, long-term observations are important to detect all effects of the treatment. Some key variables to consider in the experimental design are the kind and numbers of grazers and the time of year.

5.4.3 Test removal of competing taxa by manual or mechanical means. It needs to be determined if we can improve the habitat by periodic selective removal of all or some of the associated taxa. Kral (1983) states: "The species appears to be part of the perennial forb stage of plant succession in the central basin" and that it "may be increased by clearing away of the forest or by any forest treatment that did not involve removal of the thin layer of soil overlying the limestone

bedrock." Although hand-removal of vegetation would be laborious, it might prove to be better than burning or grazing for maintaining the coneflowers while retarding succession at some sites. Bush-hogging, mowing, or other mechanical methods, while not selective, could be explored as alternative methods of controlling competing vegetation.

5.4.4 Prepare management recommendations and plan(s). Utilizing the findings from autecological research, recommendations should be made regarding the best way(s) to maintain habitat for the coneflowers. Management plans, based on these recommendations and practical concerns, should be prepared to guide activities by agencies and individuals who own and/or manage the coneflower colonies.

6. Conduct public education projects. Being an attractive wild flower has advantages and disadvantages for the Tennessee coneflower. The advantage is that people can sympathize with the idea of protecting something beautiful. The disadvantage is that it is subject to taking by those unfamiliar with its rarity. A modest public education effort aimed at informing wild flower enthusiasts could be beneficial to the species and might result in the discovery of new populations.

6.1 Make interpretive displays and gardens. Cedars of Lebanon State Park already has a Tennessee coneflower exhibit that explains the plight of the species to many area visitors. In conjunction with this it would be desirable to have a live coneflower planting in a cedar glade adjacent to the Park's Nature Center. This garden could also feature other taxa endemic to the cedar glades, many of which are officially listed in Tennessee and are being considered for Federal endangered or threatened status. Likewise, places that have garden plantings, such as Cheekwood Botanical Garden and Warner Park Nature Center, are good candidates for an accompanying interpretive display.

6.2 Write articles for magazines, newsletters, and newspapers. There have already been several articles in magazines (Smithsonian, American Horticulturist, Sierra, Natural Areas Journal, Tennessee Conservationist), newsletters (Tennes-Sierran, Cheekwood Mirror), and newspapers (Nashville Tennessean and Nashville Banner) that featured the Tennessee coneflower. This publicity resulted in the discoveries of Colonies 3-1 and 4-1. Thus far no adverse impacts to the coneflowers have resulted from the publicity. To help prevent adverse impacts, it is imperative that localities not be given beyond the county names. Future articles should be in the same vein and have a strong conservation message.

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PART III

KEY TO IMPLEMENTATION SCHEDULE - COLUMNS 1 AND 4

General Category (Column 1):

Information Gathering - I or R (Research)

1. Population status
2. Habitat status
3. Habitat requirements
4. Management techniques
5. Taxonomic studies
6. Demographic studies
7. Propagation
8. Migration
9. Predation
10. Competition
11. Disease
12. Environmental contaminant
13. Reintroduction
14. Other information

Acquisition - A

1. Lease
2. Easement
3. Management agreement
4. Exchange
5. Withdrawal
6. Fee title
7. Other

Other - O

1. Information and education
2. Law enforcement
3. Regulations
4. Administration

Management - M

1. Propagation
2. Reintroduction
3. Habitat maintenance and manipulation
4. Predator and competitor control
5. Depredation control
6. Disease control
7. Other management

Priorities within this section (Column 4) have been assigned according to the following:

Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 2 - An action that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction.

Priority 3 - All other actions necessary to provide for full recovery of the species.

IMPLEMENTATION SCHEDULE

*1 GENERAL CATEGORY	PLAN TASK	TASK NUMBER	PRIORITY	TASK DURATION	RESPONSIBLE AGENCIES *2			ESTIMATED FISCAL YEAR COSTS *4			COMMENTS/NOTES
					FWS						
					REGION	DIVISION	OTHERS *3	FY 1	FY 2	FY 3	
R14	Continue systematic searches for new colonies.	1	2	2 years	4	FWE	TDOC	5	5	---	Initiated in FY 1988.
A1-3, A6	Obtain long-term protection of privately owned colonies.	2.1	1	3 years	4	FWE	TDOC, TNC	#	#	#	#Undetermined.
O3	Maintain protective zoning of State-owned colonies.	2.2	1	Continuous	4	FWE	TDOC	None	---	---	Completed.
M7	Restrict access to colonies.	2.3	1	3 years	4	FWE	TDOC, TNC, NPS	.5	1	1	Will be initiated in FY 1989.
M1	Maintain colonies representing populations 1 through 5 in cultivation.	3.1	2	Ongoing	4	FWE	TDOC	1	1	1	Initiated in FY 1988.
M7	Maintain viable seeds from each natural colony.	3.2	2	Ongoing	4	FWE	TDOC, USFS	1	1	1	
M1	Move excess seeds available to greenhouse owners willing to assist in the recovery effort.	3.3	3	Ongoing	4	FWE	TDOC	1	1	1	
R13	Identify suitable sites.	4.1	2	1 year	4	FWE	TDOC	.5	---	---	
M2	Plant seeds or young plants.	4.2	2	3 years	4	FWE	TDOC	1.5	1.5	1.5	
M3	Provide water, if necessary, to improve initial survivorship.	4.3	2	3 years	4	FWE	TDOC	.5	.5	.5	

IMPLEMENTATION SCHEDULE

*1 GENERAL CATEGORY	PLAN TASK	TASK NUMBER	PRIORITY	TASK DURATION	RESPONSIBLE AGENCIES *2 FWS REGION	FWS DIVISION	OTHERS *3	ESTIMATED FISCAL YEAR COSTS *4 FY 1	FY 2	FY 3	COMMENTS/NOTES
A1-3, A6	Secure as in Task 2.	4.4	1	2 years	4	FWE	TDOC, TNC	#	#	#	#Undetermined.
R1-4	Obtain baseline data.	5.1	2	3 years	4	FWE	TDOC	5	7.5	7.5	Initiated in FY 1988.
R3	Analyze water relations and budget.	5.2.1	2	1 year	4	FWE	TDOC	5	---	---	
R3, R6	Study light relations.	5.2.2	2	1 year	4	FWE	TDOC	5	---	---	
R10	Examine effects of allelopathy and/or competition.	5.2.3	2	2 years	4	FWE	TDOC	5	5	---	Initiated in FY 1989.
R3	Evaluate cover and viability.	5.3.1	2	1 year	4	FWE	TDOC	2.5	---	---	
I1-2, O2	Monitor for evidence of disturbance, poaching, disease, etc.	5.3.2	2	Ongoing	4	FWE, LE	TDOC	5	4	4	
R4	Conduct experimental burns.	5.4.1	1	3 years	4	FWE	TDOC	4	2	2	
R4	Test grazing as a management tool.	5.4.2	1	3 years	4	FWE	TDOC	5	2	2	Costs may be reduced if combined with Task 5.4.1.
R4	Test removal of competing taxa by manual or mechanical means.	5.4.3	1	3 years	4	FWE	TDOC	4	2	2	Costs may be reduced if combined with Tasks 5.4.1 and 5.4.2.
R4, M3	Prepare management recommendations and plan(s).	5.4.4	1	1 year	4	FWE	TDOC	---	---	6	

IMPLEMENTATION SCHEDULE

*1 GENERAL CATEGORY	PLAN TASK	TASK NUMBER	PRIORITY	TASK DURATION	RESPONSIBLE AGENCIES *2 FWS REGION	FWS DIVISION	OTHERS *3	ESTIMATED FISCAL YEAR COSTS *4 FY 1	FY 2	FY 3	COMMENTS/NOTES
01	Make interpretive displays and gardens.	6.1	3	Ongoing	4	FWE	TDOC, TNC	#	#	#	#Undetermined. See page 38 for task accomplishments.
01	Write articles for magazines, newsletters, and newspapers.	6.2	3	Ongoing	4	FWE	TDOC, TNC, private researchers	#	#	#.	#Undetermined. See page 38 for task accomplishments.

*1 - See page 43 entitled "Key To Implementation Schedule - Columns 1 and 4."

*2 - FWS - U.S. Fish and Wildlife Service
FWE - Fish and Wildlife Enhancement
LE - Law Enforcement
USFS - U.S. Forest Service
NPS - National Park Service
TDOC - Tennessee Department of Conservation
TNC - Tennessee Nature Conservancy

*3 - Other agencies' responsibility would be of a cooperative nature or projects funded under a contract or grant program. In some cases contracts could be let to universities or private enterprises.

*4 - All estimates are for FWS funds only (in thousands).

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