# TENNESSEE CONEFLOWER RECOVERY PLAN

Prepared by

The Tennessee Coneflower Recovery Team

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LITERATURE CITATIONS SHOULD READ AS FOLLOWS:

U.S. Fish and Wildlife Service. 1983. Tennessee Coneflower Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Georgia. 42 pp.

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# 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. It is endemic to a few localities in central Tennessee.

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, 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. All species of *Echinacea* can be crossed experimentally but the hybrids are highly sterile and this is true of hybrids between *E. angustifolia* and *E. tennesseensis*." McGregor (pers. comm., September 30, 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 consists of a group of colonies in which the probability of gene exchange through cross pollination is high. A colony is defined as all of those E. tennesseensis plants found at a single site and is separated from other colonies within the population by unsuitable habitat. Each colony consists of no more than an acre or two. 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, Somers 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...," which 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 a housing subdivision on Moss Spring Drive, were discovered in 1972 by Dr. John Churchill of Birmingham, Michigan, and Dr. John Wurdack of the Smithsonian Institution. These colonies were destroyed by housing before they were revisited by Wurdack in May 1975 (pers. comm., September 19, 1980). These two colonies were very close to one another and are 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. Cronquist (pers. comm., November 1, 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 possible large mammals, is unlikely. There remains, however, 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 plants of E. tennesseensis in each of the five extant populations varies from one to hundreds. One of the populations has two distinct colonies of the coneflowers that are about 0.3 miles apart. The Recovery Team considers the colonies at each site to be parts of a single population, however, because of the potential for gene exchange among them. The five populations, on the other hand, are each more than 3.5 miles apart and are considered to be distinct. However, one population has currently only one plant, and thus gene exchange via insect pollinators would be unlikely. The populations can be described as follows:

Population I: Historically included at least three colonies but 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 either 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. The present owner does not live on the property, but adult grandchildren have interest in future use of the land. A paved, dead-end road is the northern border.

e. Description of site: It 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 a few hundred mature plants and is located along the lower edge of the glade openings. A smaller clump (20-30 mature plants) is situated in a smaller adjacent glade opening. It is 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 extant today.

Colony 2-1

a. Location: Wilson County

b. Ownership: All of the coneflowers are on privately owned land.

c. Approximate acreage: The entire privately owned tract is 171 acres, but nearly all the coneflowers occur within about five to ten acres adjacent to the State land.

d. Land use: The site has been used by the present and past owners for pasturing. The present owner, who purchased the tract in 1978, has also bush-hogged shrubs, and in the past year planted soy beans adjacent to the main clusters of coneflowers. A dirt road bisects the tract.

e. Description of site: The private tract is mainly open farm land. Glade species occur in only a few localities where the soils are especially thin or absent exposing the underlying limestone. The coneflowers on the private tract occur in two dense clusters, each with a couple hundred mature plants. These have been left alone by the owner and the grazing cattle thus far.

f. Dangers to integrity: Although the private landowner has been cooperative thus far, his land use activities could ultimately harm the coneflower population. The shallow soils do not make the site very suitable for row crops, but the land has potential for grazing, housing development, etc.

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 1/8 to 1/4 acre.

d. Land use: Managed currently 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 (ca 200-300 plants) at the edge of a small glade opening about 100 x 150' in size.

f. Dangers to integrity: None, probably most protected for all of sites.

Population 3: Consists of one historical colony which is still extant.

Colony 3-1

a. Location: Wilson County

b. Ownership: One private tract and Tennessee Department of Conservation, Division of Forestry.

c. Approximate acreage: The segment of the colony on private land occupies 1½-2 acres, and those on the State forest 2-4 acres. Plants on the State forest are separated into two groups by a block of forest. For this reason the Division of Forestry has wisely zoned approximately 18 acres 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, thus 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 the private tract 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. Approximately half of the thousand or so coneflowers at the site occur in this field and along the road.

e. Dangers to integrity: The private tract is vulnerable to future development or more intensive farming practices.

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

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 a ¼ 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 100-200 coneflower plants, occupying an area of 50'x100', were observed at this site on August 22, 1978. The plants are growing on crushed limestone gravel placed on the site by the owners 7-8 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 result from activities of the workers. Also, the owners could decide that expansion of the industry outweighs the importance of the coneflowers.

Population 5: Today, this population consists of a single plant.

Colony 5-1

a. Location: Davidson County

b. Ownership: Tennessee Department of Conservation, Division of Parks.

c. Approximate acreage: Only one plant has been located on a 10 acre glade at this site.

d. Description of site: The coneflower plant occurs near the edge of the glade, but it is in an open spot without competing vegetation. The next nearest plants are approximately 5 miles away.

e. Dangers to integrity: Encroachment from succession changes is a long-term threat. Development at the site or overuse of the area for recreational or environmental education activities could result in inadvertent destruction of the single plant.

Environmental Factors Relating to Endangerment

All of the known natural colonies for Echinacea tennesseensis, past and present, are cedar glades. They are openings in forest 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. It is an extremely harsh environment subject to extremes in light, temperature and moisture (Freeman 1933, Turner 1966). Taxa living in this xeric environment have evolved special adaptations to overcome these factors.

Hemmerly (1976) examined the habitats at two of the coneflower colonies. Mean soil depth at one colony ranged from 2.9 - 4.9 inches and at the other from 1.9 - 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 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 (N.O.A.A.) stations were detectable in all seasons except winter. Glade temperatures were as much as 31o (F) higher on one exceptionally hot day (129o F vs. 98o F). Air temperature minima, on the other hand, usually did not differ much between the glades and N.O.A.A. 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 N.O.A.A. 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 Site 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 - 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 Petalostemum 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

What 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. It 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 in the larger size classes (2-8 mg) and are seldom dispersed by wind, at least more than one meter beyond the parent plant. No evidence of seed predation by animals was observed by Hemmerly (1976).

The number of flower heads per plant is limited to a few. Usually there is a single head terminating each branch. Older plants 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 stratification in light at 15/25oC. 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 more 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 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 may vary with 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 being encroached upon by competitive vegetation.

Perhaps the greatest threat to coneflowers is the conversion of their habitat to intensely developed sites such as housing, industrial facilities or roads. This is a serious threat to Colonies 1-1 and 4-1. The former is being encroached upon by Nashville suburbia developing rapidly on the western edge of Percy Priest Lake. Coneflowers at Colony 4-1 survive amazingly well amidst heavy industrial disturbance. Judging from this colony, it appears that coneflowers can survive a lot of physical abuse to their habitat. It is the outright destruction of the glades by paving, building, or establishment of lawns that has destroyed other coneflower colonies.

A horticultural demand for E. tennesseensis could develop in the future, perhaps as a result of its recognition as a rare species. This could become a serious threat to natural populations if other sources of seed are not developed.

Actions Taken to Date

All private landowners and the State's Division of Forestry have been notified of the significant rare plants on their properties. For all privately owned colonies, the State Heritage Program staff has met sympathetic and at least somewhat cooperative landowners. All have said they would not disturb the coneflowers, but none has agreed, thus far, to register his land as a natural area, or signed conservation easements or management agreements, with the Department of Conservation. At present there are no State laws that prohibit the taking of endangered plant taxa from privately owned land. The State's options for protecting rare plants depend on successful negotiations with the landowners that could result in either acquisition as a natural area, a conservation easement, a cooperative management agreement, or registration of the site as a natural area. The latter is an agreement with the landowner(s) that is not legally binding.

The colonies on State-owned land are managed by the Division of Forestry. Personnel from the division have been participating in the recovery planning effort and they assure us that they will manage for the coneflower by zoning the 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 might be recommended by the Recovery Team.

On certain State-owned lands, namely parks, natural areas, scenic rivers and trails, the removal of plant material without permission is considered a violation of the Department of Conservation's regulations requiring a collecting permit (Chapter 0400-2-3-21 and Rules and Regulations governing the use of State Parks, Section 2.26). There are no laws or regulations pertaining to the taking of native plants from lands administered by the Division of Forestry (in the Department of Conservation), where Tennessee coneflowers are known to occur, or by the Tennessee Wildlife Resources Agency. There is, however, Executive Order 11, signed by Governor Alexander on March 7, 1980, that gives the Department of Conservation "...the authority to oversee the management of significant plant species on all State-owned land in Tennessee...." The department has not tested its authority yet on State lands managed primarily by other agencies.

Attempts to establish new colonies in natural settings or additional plants in an existing colony have occurred a couple of times in the recent past. Hemmerly (1976) established three new experimental plantings, two of them were within existing colonies and they are treated as satellites of a colony. The third experimental planting was a new colony started at Stone's River National Battlefield but this has not survived. A recent attempt by a member of the Tennessee Native Plants Society has resulted in a small new colony of juvenile plants that she is monitoring on her glade property.

Work on propagating E. tennesseensis was begun by Dr. Robert Farmer at the Tennessee Valley Authority (TVA) nursery in 1978. About 500-1000 plants now growing at the nursery were started from seeds taken from Colonies 2-1 and 3-1. Approximately 75 juvenile plants (1-2 years old) were transferred from TVA's nursery to garden and glade localities at Cheekwood Botanic Garden and a wildflower garden at the Warner Nature Center, both in Nashville. Those remaining at TVA's nursery may need to be transferred to new sites since Dr. Farmer's program was terminated in 1980. Seeds were harvested from the TVA populations in 1980 and 1981, and the Cheekwood plants produced abundant seeds in 1981. A small quantity of the 1980 harvest and a large amount of the 1981 harvest of TVA plants were sent to the U.S. Forest Service (USFS) seed storage facility in Macon, Georgia.

A number of private landowners have obtained seeds from the coneflower and have it growing successfully in their home gardens. The Tennessee Native Plants Society has dispensed about 10 small packets of seeds obtained from Dr. Farmer to members through its seed exchange program. Discussions have taken place with the members of the Hobby Greenhouse Association regarding the possibility of their assisting with the propagation of the taxon as part of a general volunteer effort by them to help with endangered species preservation.

# II. 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 coneflowers over 2500 sq. ft. of suitable habitat. Reclassification to Threatened will be considered when each population has two colonies.

## Step-down Outline

1. Conduct systematic searches for new colonies.
    11. Identify potential cedar glade habitat.
    12. Investigate unexplored glades.
2. Secure each colony.
    21. Negotiate with private landowners to protect colonies.
    22. Zone State sites.
    23. Establish regulations to protect sites and plants.
    24. Restrict access to colony.
3. Provide a seed source representative of each natural population.
    31. Establish and/or maintain colonies representing populations 1 through 5 in cultivation.
    32. Maintain viable seeds from each natural colony.
    33. Make excess seeds available to greenhouse owners willing to assist in the recovery effort.
4. Establish new colonies.
    41. Identify suitable sites.
    42. Plant seeds or young plants.

43. Provide water, if necessary, to improve survivorship the first year or two.

44. Secure as in Step 2.

5. Monitor colonies and do management activities, if necessary, to maintain the recovered state in each colony.

51. Establish baseline data.

511. Map glade vegetation at natural colonies.

512. Establish permanent plots, grids, transects, or photo points at one or more colonies.

52. Identify limiting factors.

521. Analyze water relations and budget.

522. Study light relations.

523. Examine effects of allelopathy.

53. Check sites on a periodic basis.

531. Evaluate cover and viability.

532. Check for evidence of disturbance, poaching, disease, etc.

54. Determine effective management options on colonies eatablished for experimental purposes.

541. Do experimental burns.

542. Test grazing as a management tool.

543. Test removal of competing taxa by manual or mechanical means.

544. Prepare management recommendations and plan(s).

6. Do public education projects.

61. Make interpretive displays and gardens.

62. Write articles for magazines, newsletters, and newspapers.

Narrative

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 coneflowers over 2500 sq. ft. 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.

1. Conduct systematic searches for new colonies.

   The cedar glades of middle Tennessee have been intensively studied by Quarterman, Rollins, J. & C. Baskin, et al., 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 past few years, 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) and, therefore, the search should be concentrated on cedar glades within these counties.

11. Identify potential cedar glade habitat.

Quarterman (1950) provided a general map of cedar glades area in the Central Basin of middle Tennessee. This will be useful in selecting areas of focus using aerial photos and geologic maps. Sources of aerial photos include the Agricultural Stabilization and Conservation Service, Equalization Board, Tennessee Department of Transportation, and Army Corps of Engineers. All but the latter are available at the State's Berry Field Airport mapping facility in Nashville. Ground searches and information from local residents may also prove useful.

12. Investigate unexplored glades.

Since the known sites are clustered within close proximity to one another, priority should be given to searching unexplored sites in their vicinities. Ground and/or air searches should expand out from there as time and money allows. The populations in Davidson and Rutherford Counties are totally on private land and in an area that is rapidly developing, therefore, the western portion of the range should be searched ahead of the Wilson County glades that are better protected.

2. Secure each colony.

Protecting the extant colonies probably represents the best opportunity for assuring survival of the taxon. They have, no doubt, existed at these sites for a considerable length of time. Most colonies 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 insure their success.

21. Negotiate with private landowners to protect 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 is applicable and will adequately protect the species should be used. A cooperative management agreement, in general, will be cheaper than purchasing a conservation easement or the land outright, but landowner(s) might not be agreeable to all the necessary restrictions imposed in such an agreement. Some flexibility should be allowed in the negotiation process so that the landowner's needs and the species' needs are both met.

Representatives from the Department of Conservation's Natural Heritage Program have already met with the owners of the private land sites to discuss the significance of the coneflower and whether or not they are willing to help with its protection. All landowners have informally stated that they would not disturb the coneflowers, but no formal agreements have been reached, legal or otherwise; none have agreed to place their property on the Natural Area Registry as yet. Under the registry agreements the landowners promise to notify the Department of Conservation should they decide to sell their property or impact

the habitat in any way. This should not be regarded as adequate protection for "recovery," since it is a voluntary, non-legal agreement between landowners and the State, but it is better than no agreement with the landowner at all.

The Tennessee Chapter of the Nature Conservancy has discussed acquisition of Colony 1-1 with its landowner but the owner has decided not to sell. No one has tried to acquire the other colony sites for protection purposes. 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 landowners property taxes. Three of the demes, however, are in the rapidly developing Nashville/Percy Priest Lake area, and thus owners may be unwilling to sell easements now since that would preclude more lucrative prices for development later. The private portion of the two Wilson County demes could be adversely affected by private development. The Conservation Easement Act of 1981, passed by the 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 recovery if the terms of agreements are strict.

22. Zone State sites

Portions of Colonies 2-2 and 3-1 are on State land managed by the Department of Conservation's Division of Forestry. Zoning restrictions for the forest compartments involved should reflect the division's decision to manage for the coneflower habitat where it occurs. New unit plans are scheduled for the forest areas containing coneflower populations. Special management designations should be shown in these plans. At present the best policy is probably 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.

23. Establish regulations to protect sites and plants.

A Department of Conservation rulemaking, possible in conjunction with establishing the official list of rare plants in Tennessee, should be made that prohibits the taking of any federally listed species of plant from State-owned land. This will need to be done in accordance with the Uniform Administration Procedures Act, which allows for public input.

24. Restrict access to colonies.

The use of off-road-vehicles (ORVs) is prelevant 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 ORV 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 5-1, currently there are 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 with anyone found disturbing the species or its habitat.

3. Provide a seed source representative of each natural population.

The Recovery Team considers it 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.

31. Establish and/or maintain colonies representing populations 1 through 5 in cultivation.

Dr. Farmer of TVA germinated seeds taken from Colonies 2-1 and 3-1 and established colonies of each in adjacent flower beds at the TVA Nursery. About 500-1000 plants from these colonies are growing there still. Cross-pollination between populations 2 and 3 probably has occurred, so seeds derived should not be regarded as representing pure examples of the original populations. Nevertheless, it represents an excellent seed

source, and should be maintained in situ, if at all possible, since transplanting would be expensive, time consumimg, and detrimental to the plants. Unless TVA is supported financially through this Recovery Plan, it may be necessary to seek volunteer assistance from the Tennessee Native Plant Society for tasks such as weeding and seed harvest, since Dr. Farmer has left TVA and his program was terminated. Transplanting should be a last resort.

Cheekwood has plantings representing Colony 2-1 in its Howe Wildflower Garden and a few plants started from Colony 2-1 seeds planted behind Botanic Hall and in a small glade on the grounds. These plants flowered in 1981, and thus represent another seed source. A potential problem at this site might be the proximity of Echinacea purpurea with which it may hybridize. About a dozen 1-year old plants originally from the TVA Nursery and representing Colony 3-1, were transplanted to a wildflower garden at Warner Nature Center in Nashville in 1980. Only one plant flowered at this somewhat shady garden in 1981, but there is certainty a potential for developing a seed reserve at this site with the continued cooperation of the center's staff.

The Tennessee Division of Forestry has a nursery facility in Jackson, Tennessee, that could be used for propagating plants, especially ones representing populations 1, 4, and 5.

Since maintenance of the TVA Nursery is somewhat in question, an alternative, large-scale seed source is advisable. Mr. Robert Churchwell, director of the nursery, says there is space available for such plantings.

32. Maintain viable seeds from each natural colony.

Dr. Andrew Robinson with the U.S. Fish and Wildlife Service has initiated this step by placing thousands of seeds from the 1980 and 1981 harvests at the TVA Nursery in cold storage at the USFS's Macon, Georgia, facility. The 1980 harvest yielded at least 30,000 seeds, and the 1981 harvest yielded many more than that. In addition, he placed a small quantity of seeds from Colony 1-1, received from Dr. Robert Kral of Vanderbilt University, in storage about 1979. Fresh seeds from each colony should be stored here as it becomes available. 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. Each planting should receive seeds from a single population in order to maintain any genetic distinctions, and a log should be maintained recording inflow and outflow of seeds. Dates, names of individuals and agencies, populations and colonies represented, and the number of seeds are important facts to record.

33. Make excess seeds available to greenhouse owners willing to assist in the recovery effort.

A program to propagate endangered plant species has been initiated by Dr. Rolf Martin of Brooklyn College in conjunction with the Hobby Greenhouse Association. 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. Dr. Martin, Coordinator for the Rare and Endangered Native Plant Exchange, proposed to use the City University of New York's computer facilities to maintain records of seed lineages, but it might be preferable for our purposes to have the initial distribution of seed controlled and logged by an agency more directly involved in the Recovery Plan. Cultivation is not considered to be critical to "recovery," but since the Tennessee coneflower is an attractive wildflower 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 1½ mile of existing colonies in order to allow movement of pollinators between colonies of a population.

41. 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, Forest and Natural Area, Longhunter State Environmental Education Area and other public property adjacent to Percy Priest Reservoir, 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 anticipated. Select the most suitable glades based primarily on two major criteria: (1) quality of habitat, and (2) potential for protecting the site. Habitat characteristics to look for should be plant taxa, geologic, and soil features, and light and moisture conditions in common with the known sites. Hemmerly (1976) has made pertinent observations on habitat characteristics. Size of the glades might also be considered. The ability to protect a site will depend on factors such as inaccessibility and monitoring capability of the management agencies.

42. 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.

43. Provide water, if necessary, to improve survivorship during first year or two.

Mortality is expected to be very high during the first two years. Survivorship studies done by Hemmerly (1976) showed a low 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.

44. Secure as in Step 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. Hopefully this will be an easy step as at least the initial work would have been completed during site selection.

5. Monitor colonies and do 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.

51. Establish 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), and Werner and Caswell (1977), are recommended as guides for experimental design.

511. Map glade vegetation at natural colonies.

It will be valuable to record data on glade succession. By carefully mapping and monitoring vegetation patterns on the glades, we might learn more about optimum habitat for the coneflowers and what successional changes are detrimental to the colony.

512. Establish permanent plots, grids or transects or photo points at one or more colonies.

The purpose of permanent sampling stations is to monitor changes in the colonies themselves. Increases or decreases of colony size will be detectable. By reexamining Hemmerly's experimental stands we might obtain some early indications of how successfully new colonies might be established. We can assess the spread of the stands over the 12+ years and examine reproductive capabilities. At several coneflower sites markers could be installed at suitable points for photographing the colonies. Pictures should be taken at least annually and possibly on a seasonal basis, repeating at approximately the same dates each year.

The height and compass direction should be logged for each photograph. This should be one of the easiest ways to follow changes through time.

52. 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.

521. 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 is instructive. It is useful to know when water becomes a limiting factor. The wilting point needs to be identified for E. tennesseensis.

522. Study light relations.

Hemmerly (1967) 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.

523. Examine effects of allelopathy.

Hemmerly (1976) has already found in vitro evidence of allelopathic inhibition of E. tenneessensis 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 new experimental design. Other common associates could be tested.

53. Check sites on a periodic basis.

Site monitors should examine each site and its colonies 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.

531. Evaluate cover and viability.

In order to be considered recovered certain criteria regarding colony number, size, and viability must be met. The criteria for self-sustaining colony is two juvenile plants for each flowering one. This should be checked yearly, in October-November. Number and percent cover of colonies can be checked at the same time.

532. Check 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.

54. Determine effective management options on colonies established for experimental purposes.

The most practical research that can be undertaken concerns experimenting with management techniques. The State 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. 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.

541. Do experimental burns.

Fire is a natural and common phenomenon on the cedar glades because of the dry conditions that frequently occur there. It is uncertain how E. tennesseensis responds to fire, but it is speculated that because of its deep fibrous taproots it would, at least, survive the quick low temperature burns that occur on glades. Also, fire might improve the habitat by eliminating competitors. Observations should be made over many years to determine long-term effects.

542. Test grazing as a management tool.

It is apparent that cattle grazing has happened in the past at Colony Sites 2-1 and 3-1, but we know nothing about the 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 some amount of grazing could be beneficial as a method of removing competing vegetation. Like 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 kinds, numbers of grazers, and time of year.

543. Test removal of competing taxa by manual or mechanical means.

Can we improve the habitat by periodic selective removal of all or some of the associated taxa? 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. Bush-hogging, mowing, or other mechanical methods, while not selective, could be explored as alternative methods of controlling competing vegetation.

544. Prepare management recommendations and plan(s).

Making use of the findings from the above autecological research, recommendations should be made regarding the best way(s) to maintain habitat for the coneflowers. A management plan, 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. Do public education projects.

Being an attractive wildflower has advantanges 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 wildflower enthusiasts could be beneficial to the species and might result in new populations being discovered.

61. Make interpretive displays and gardens.

Cedars of Lebanon State Park already has an exhibit featuring the Tennessee coneflower, which explains the plight of the species to many area visitors. In conjunction with this it would be desirable to have a live planting in a cedar glade planned for an area adjacent to the Nature Center. This garden could also

feature other taxa endemic to the cedar glades, many of which are being considered for Federal endangered or threatened status. Likewise, places that have garden plantings, such as Cheekwood Botanic Garden and Warner Nature Center, are good candidates for an accompanying interpretive display.

62. Write articles for magazines, newsletters, and newspapers. There have already been several articles in magazines (Smithsonian, American Horticulturist, Tennessee Conservationist), newsletters (Tennes-Sierran, Cheekwood Mirror), and newspapers (Tennessean and Nashville Banner) that featured the Tennessee coneflower. This publicity resulted in the discoveries of Colonies 3-1 and 4-1 being reported. Thus far no adverse impacts to the coneflowers have resulted from the publicity. To help prevent them, 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.

## IMPLEMENTATION SCHEDULE

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

Priority 1 - Those actions absolutely necessary to prevent extinction of the species.

Priority 2 - Those actions necessary to maintain the species' current population status.

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

IMPLEMENTATION SCHEDULE

TENNESSEE CONEFLOWER

| General Category | Plan Task | Task Number | Priority | Task Duration | Responsible Agency | | | Estimated Fiscal Year Costs | | | Comments/Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | FWS Region | FWS Program | Other | FY 1 | FY 2 | FY 3 | |
| I 1 | Search for new colonies. | 1. | 3 | 2 yrs. | 4 | | TDC* Contract | | 5,000 | 5,000 | Estimated funding is for 2 man-months per year. |
| A2,A3 | Protection agreements with private landowners. | 21. | 1 | Cont'g. | 4 | | TDC, TNC* | | | | |
| O 3 | Zone State sites. | 22. | 1 | 1 yr. | | | TDC | | | | |
| O 3 | Establish regulations to protect State-owned sites. | 23. | 1 | 1 yr. | | | TDC | | | | |
| M 7 | Restrict access to sites. | 24. | 1 | 1 yr. | 4 | | TDC | | | | Funding for fences on private property may be necessary. |
| M 1 | Develop sources for artificially cultivated seeds. | 3.,31. 32,33. | 3 | Cont'g. | | | TDC Private* USFS* | | | | The USFS's only involvement is in allowing the use of their seed storage facility. |
| M 2 | Establish new colonies. | 4.,41. 42,43. 44. | 2 | 5 yrs. | | | TDC, Private | | | | See p. 26, task 41., for other potential cooperators. |
| I1, I3 | Establish baseline data for monitoring & management. | 51., 511. 512. | 3 | Cont'g. | 4 | | TDC | | 2,500 | | Indicated funding is for baseline survey. |

TENNESSEE CONEFLOWER

IMPLEMENTATION SCHEDULE

| General Category | Plan Task | Task Number | Priority | Task Duration | Responsible Agency | | | Estimated Fiscal Year Costs | | | Comments/Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | FWS Region | FWS Program | Other | FY 1 | FY 2 | FY 3 | |
| I 14 | Identify limiting factors. | 52.<br>521.<br>522.<br>523. | 3 | 2 yrs. | 4 | | TDC, Contract | -- | 10,000 | 10,000 | |
| I 1,<br>I 2 | Monitor colonies. | 53.<br>531.<br>532. | 2 | Cont'g. | | | TDC, Private | | | | |
| I 4 | Determine management options. | 54.<br>541.<br>542.<br>543.<br>544. | 3 | 5 yrs. minimum | | | TDC | | | | |
| O 1 | Public education. | 6.<br>61.<br>62. | 3 | Cont'g. | | | TDC, Private | | | | |

*Abbreviations:

TDC = Tennessee Department of Conservation
TNC = The Nature Conservancy
Private = Conservation groups, plant enthusiasts, others
USFS = U.S. Forest Service

GENERAL CATEGORIES FOR IMPLEMENTATION SCHEDULES *

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

Management - M

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

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

* (Column 1) - Primarily for use by the U.S. Fish and Wildlife Service.

# PART IV

# APPENDIX

LIST OF REVIEWERS FOR TENNESSEE CONEFLOWER RECOVERY PLAN - TECHNICAL DRAFT

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