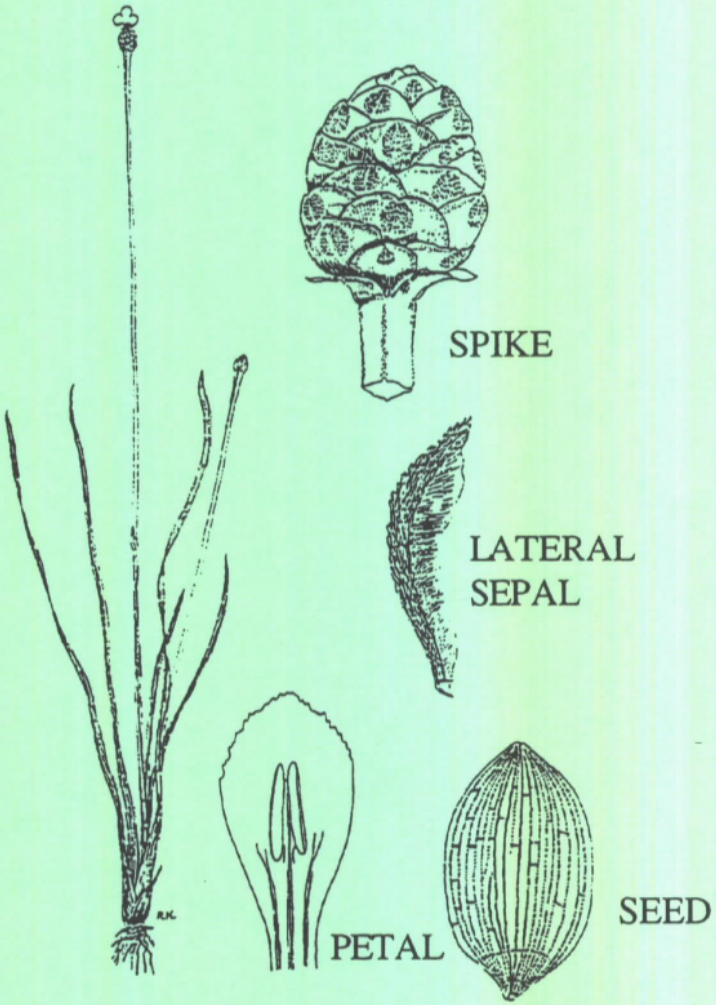
RECOVERY PLAN

TENNESSEE YELLOW-EYED GRASS

(*Xyris tennesseensis* Kral)



U.S. Fish and Wildlife Service
Southeast Region

TENNESSEE YELLOW-EYED GRASS
(*Xyris tennesseensis* Kral)

RECOVERY PLAN

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for

U.S. Fish & Wildlife Service
Jackson, Mississippi

and

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Approved: _____
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Date: June 24, 1994

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Literature citations should read as follows:

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The line drawing on the cover was done by Dr. Robert Kral of Vanderbilt University.

EXECUTIVE SUMMARY

Current Status: *Xyris tennesseensis* is listed as an endangered species. There are 14 populations known to be extant, including eight in Alabama, two in Georgia, and four in Tennessee. With the exception of three sites which occur all or partially on Federal lands, sites are on privately owned lands. Several of the populations are small and in need of active management.

Habitat Requirements and Limiting Factors: Suitable habitat for long-term survival of this species appears to be very limited. Populations are located in spring meadows or along small streams. All sites feature nearly permanent moisture regimes, open, sunny conditions, and calcareous bedrock (shale, limestone, dolomite) or thin calcareous soils. Much suitable habitat has been lost or impacted due to drainage and the conversion of these habitats for agricultural or silvicultural practices. Active management appears to be needed to maintain appropriate habitat for this species.

Recovery Objective: Delisting.

Recovery Criteria: *Xyris tennesseensis* will be considered for delisting when there are 15 adequately protected and managed, self-sustaining populations of the species distributed throughout the historical range and maintained for 10 years. A population will be considered adequately protected when it is legally protected and actively managed. A population will be considered "self-sustaining" if monitoring data support the conclusion that it is reproducing successfully and maintaining stable numbers or increasing.

Actions Needed:

1. Protect and manage populations.
2. Search for new populations.
3. Investigate potential management techniques.
4. Conduct research on species' ecological requirements and life history.
5. Maintain plants and seed *ex situ*.
6. Provide public education.

Total Estimated Cost of Recovery: Implementation of the recovery tasks for which cost estimates have been made totals $134,000.

Date of Recovery: It is not possible to determine a date of recovery at this time since the achievement of recovery depends upon the outcome of several of the recovery tasks.

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I. INTRODUCTION

Background

Tennessee yellow-eyed grass (*Xyris tennesseensis* Kral) was first described in 1978 by Dr. Robert Kral of Vanderbilt University. It was discovered during his comprehensive review of 21 members of the genus in the Southeastern United States (Kral in Godfrey and Wooten 1979). *Xyris* is the only representative of the Xyridaceae, the yellow-eyed grass family, in the Southeast. It is a group of small herbs with grasslike basal leaves and leafless, unbranched, flowering stalks each bearing a terminal, conelike inflorescence comprised of spirally arranged bracts enclosing small flowers with yellow or occasionally white petals. The species is currently known from 14 sites in three States: Alabama, Georgia, and Tennessee. Populations occur in springy meadows and on the banks of small streams.

Kral (1990) surveyed for this species during the field seasons of 1989 and 1990. He completed a status report in 1990 which documented the current conditions of seven extant and three historical sites. Because of the rarity and perceived threats to Tennessee yellow-eyed grass, it was proposed for Federal listing in July 1991 as an endangered species (U.S. Fish and Wildlife Service 1991a) and later approved and officially listed as such (U.S. Fish and Wildlife Service 1991b).

Description and Taxonomic Status

Robert Kral has provided excellent technical descriptions of *Xyris tennesseensis* (Kral 1978, 1983, 1990), as well as non-technical ones (Kral 1990). The type description article (Kral 1978) also included an illustration by the author. The general description given below represents a paraphrasing from the above description with slight modifications to allow for the reduced stature of Bibb County, Alabama plants (Allison, pers. comm.).

Xyris tennesseensis is a perennial which typically occurs in clumps of few to many bulbous-based individuals. The soft, bulbous bases are comprised of small, dark outer scales and fleshy, white to rose or purplish inner scales. The leaves are all basal; the outermost ones are short and scalelike, whereas the others are linear, 9 to 45 centimeters (cm), or 3.5 to 18 inches (in.) long, and 0.15 to 1.0 cm (0.06 to 0.4 in.) wide. The slightly twisted, flat, bright green leaf blades taper at base and apex. The leaf blades overlap one another in the basal one-eight to one-third of their length and often show pink, red, or purplish coloration in this region as well as pale, thin margins and finely papillose surfaces. The leaf apices and upper margins are entire and slightly thickened.

Unbranched flowering scapes rise above the linear leaves to heights of 30 to 70 cm, or 1 to 2.3 feet, or occasionally 100 cm (3.3 ft.) at the time of anthesis. They are nearly round at the base but flattened distally with 1 to 5 raised ribs that are tuberculate-scabrid. Scape sheaths, which typically are reddish or brownish toward the base, possess short blades, and

do not exceed the length of the principal leaves. The solitary, terminal spikes are mostly broadly ovoid with blunt to acute apices and range from 0.6 to 1.5 cm (0.2 to 0.6 in.) at maturity. They are composed of numerous tightly and imbricate bracts, most of which shelter a single axillary flower. The fertile bracts are suborbicular and tan or brown except for a greenish, ovate-triangular dorsal area; their margins are entire or slightly ragged.

The bisexual flowers are irregular with a three-parted calyx: the inner sepal is membranous and enfolding the bud; the outer (lateral sepals) clasp the whole bud and are curved, boat-shaped structures with thin narrow keels that are reddish-brown, and broader and lacerate in the upper part. The three distinct yellow petals are obovate with long-clawed bases, about 4.5 millimeters (mm) long by 3 mm broad (0.2 X 0.1 in.), with rounded-lacerate apices. Flowers open in late morning and wither by mid-afternoon and only one or a few flowers are emergent at any time. Staminodes are three with bi-brachiate branches with long, beadlike hairs. There are three fertile stamens which arise just above the petal claw and are erect; the anthers are lance-linear, about 2 mm (0.1 in.) long, with nearly parallel sacs. The ovary is superior, tricarpellate, compressed-ovoid, the many ovules are marginal in three placental lines within the single locule. The style is elongate and trifid above the middle into convolute, horseshoe-shaped, hairy stigmas.

Fruits are obovoid or broadly ellipsoid capsules with thin, plano-convex walls and three sutures. The numerous seeds are ellipsoid, about 0.5 to 0.6 mm (0.02 in.) long, slightly to very farinose (mealy surfaced), with 18 to 20 fine, longitudinal lines that are sometimes interconnected.

Taxonomically, this species is nearest the *Xyris difformis* complex (Kral 1978, 1983, 1990). Species in this complex differ in having foliage which is generally more flattened and fanlike, leaves that are generally scabrid throughout, and more acute spikes with darker, fertile bracts (Kral 1983). In addition, those species in the *X. difformis* complex with farinose seeds (var. *floridana*) have a different seed sculpture from the farinose seeds of *X. tennesseensis* (Kral 1990).

Xyris tennesseensis superficially resembles *Xyris torta* J.E. Sm. and *Xyris platylepis* Chapm. because they also possess somewhat bulbous, fleshy bases and twisted leaf blades. *Xyris torta* differs, however, in having lateral sepals that are ciliate (not lacerate), strongly curvate, and apically tufted with crisped red hairs on the keel. In addition, the leaves of *X. torta* are strongly raised-nerved which is not a feature of *X. tennesseensis*. It can be distinguished from *X. platylepis* by many features; e.g., *X. platylepis* has scape sheaths that are castaneous or pale brown toward the base, scapes that are twisted, flexuous and only one-ridged above, spikes that are 1.5 to 3.0 cm (0.6 to 1.2 in.) long, petals which are broadly obovate, yellowish or white and opening in the afternoon, and translucent seeds with 10 to 12 rather

irregular longitudinal lines together with a scattering of less distinct vertical lines (Kral 1979). *Xyris jupicai* L.C. Rich., with which it grows sympatrically at one Alabama site, differs in that it is an annual over most of its range, has non-twisted leaves, possesses non-bulbous bases that lack red pigmentation, and has smaller, non-farinous seeds.

Distribution

The historical and current distribution of *Xyris tennesseensis* encompasses portions of three States and three physiographic provinces (Figure 1). The most consistent or widespread area of distribution appears to be the Ridge and Valley physiographic province extending from northwestern Georgia (Bartow, Gordon, and Whitfield Counties) to northeast Alabama (Calhoun County) and then to central Alabama (Bibb County). Another concentration of occurrences is located in the southwestern portion of the Highland Rim physiographic province, part of the Interior Low Plateau; this consists of four sites, all in Lewis County, Tennessee. One population discovered in northwest Alabama (Franklin County) by Dr. David Webb is near the border of the Highland Rim as well as the Cumberland Plateau, but was reported by Kral (1990) to be actually in the Coastal Plain. The Gordon County, Georgia population is considered to be extirpated, as is one of the Bartow County populations (Kral 1990).

Extant populations occur at 14 sites in the five localized areas described above, which can be summarized as: (1) Northwest Georgia (Bartow and Whitfield Counties - one population each; (2) Northeast Alabama (Calhoun County - two populations); (3) Central Alabama (Bibb County - five populations); (4) Northwest Alabama (Franklin County - one population); and (5) South central Tennessee (Lewis County - four populations). In a couple of instances, sites recognized here as distinct populations are only about 0.5 mile apart but separated by physical barriers such as forest and roads, thus making cross-pollination or movement of propagules from one site to another unlikely or highly infrequent. Even where populations occur on separate parts of the same stream system, continuous corridors of suitable habitat are not available. In these instances, propagules may move downstream to mix with those of the other population, but seldom would there be opportunity for upstream movement of propagules or pollinators from site to site. For protection and planning purposes, they will be treated here as separate populations.

Figure 1. Current distribution of Tennessee yellow-eyed grass

Habitat

Suitable habitat for long-term survival of this species appears to be very limited. All sites feature nearly permanent (all year) moisture regimes, open, sunny conditions, and calcareous bedrock (shale, limestone, dolomite) or thin calcareous soils. The four Tennessee populations are concentrated in very small calcareous fens on steep to gentle slopes adjacent to headwater streams. The bedrock appears to be thin layered shale. The best, and one of the largest, of these fen sites measures approximately 15 by 21 meters or 315 sq. meters (50 by 70 ft. or 3500 sq. ft). Because the sites are wet and relatively steep, soils are slow to establish and, no doubt, are prone to erode during heavy rain events. This sloughing action may be critical in maintaining the early successional, open habitat considered important to *Xyris tennesseensis*. The *Xyris* colonies appear to be denser where there is contact between vegetation and substrate. The fen sites generally have a dense cover of herbs. Dominants often include *Parnassia grandifolia* (grass-of-parnasus), *Rudbeckia fulgida* (coneflower), and *Amphicarpaea bracteata* (hog-peanut). Frequently present and relatively common at these sites were *Oxypolis rigidior* (hog-fennel), *Thelypteris palustris* (marsh fern), *Solidago patula* (goldenrod), *Phlox glaberrima*, *Ludwigia alternifolia* (rattle-box), *Cyperus strigosus* (flat-sedge), *Scirpus atrovirens* (bul-rush), *Carex* sp., *Juncus* spp. (*effusus*, *diffussimus*, and/or *brachycarpus*), and *Rhynchospora capitellata* and/or *caduca* (beak-rushes). Woody shrubs and tree species observed in the fens are few and include *Alnus serrulata* (alder), *Cornus amomum* (swamp dogwood), and *Salix* sp. (willow). In the vicinity of the fens, small colonies can sometimes be found along the creek edges growing in shallow sand/soil deposits or cracks in the limestone. The Tennessee sites are all surrounded by oak-hickory forest.

The five Bibb County, Alabama sites are all found along small to medium sized streams with exposed dolomite forming their beds (Allison 1993). The *Xyris* colonies are in full sun or partial shade. Some of the larger colonies occur in narrow sand and gravel bars mixed with other herbs. Associated herbs frequently are *Justicea americana* (water-willow), *Eupatorium coelestinum* (purple mistflower), *Rhynchospora caduca* or *mixta*, *Cynoctonum mitreola* (miterwort), *Eleocharis obtusa* (spikerush), *Ludwigia microcarpa*, *Lycopus* sp. (bugle-weed), *Mecardonia acuminata*, *Oxypolis rigidior*, *Parnassia grandifolia*, *Hypericum mutilum* (St. John's wort), *Cyperus strigosus*, *Fuirena squarrosa* (umbrella grass), *Phlox glaberrima*, and *Rudbeckia laciniata*. This habitat supports many other rare or unusual plant taxa such as *Marshallia mohrii* (Mohr's Barbara's buttons), *Marshallia trinervia*, *Rhynchospora thornei*, *Jamesianthus alabamensis*, and *Croton alabamensis* var. *alabamensis* (Alabama croton). Some plants are partially shaded by shrubs such as *Alnus serrulata*, *Cornus amomum*, or *Salix* spp. Streamside forests are comprised mainly of hardwoods such as *Liriodendron tulipifera* (tulip-tree), *Liquidambar styraciflua* (sweet gum), *Magnolia virginiana* (white bay), *Acer rubrum* (red maple), *Acer leucoderme* (striped maple), and *Salix nigra* (black willow). *Juniperus virginiana* (eastern red cedar) is also present at some sites. Much of the surrounding terrain has been timbered; what effects this had on the populations are unknown.

The other Alabama sites are less distinctive. The large population in Franklin County occurs on a gentle slope and wet ditch adjacent to a highway. The seep habitat on the slope has many of the associated herbs noted for Bibb County, but none of the rare or unusual taxa. The site was clearcut in the recent past and now supports a thin stand of loblolly pine and hardwood saplings. The two sites in Calhoun County are also open, wet, disturbance related habitats with some of the same wetland associated herbs described above.

The primary extant site in Georgia is a marshy area along a small stream passing through the center of an abandoned farmstead. The terrain is relatively flat and pastoral in appearance. Bedrock is not evident as with most of the other sites. Much of the marshy habitat is above a low concrete dam, now dilapidated and partially functioning, across the stream. Other plants occur between it and a bridge. The associated herbs include many of the taxa seen at the Alabama sites; e.g., *Cynoctonum mitreola*, *Cyperus strigosus*, *Ludwigia alternifolia*, *Oxypolis rigidior*, and *Eleocharis obtusa*. Taxa not noted elsewhere, but present at this site, include *Nasturtium officinale* (watercress), *Sparganium americanum* (bul-reed), *Alisma subcordatum* (water-plantain), and *Veronica anagallis-aquatica*. A few alders and willows were present at the edge of the marsh. The surrounding land is open with only occasional trees, with many of the same taxa as noted for Bibb County, Alabama streams. The only other Georgia population, which is located in Whitfield County, occurs on an earth dike in an impounded swamp. Only a couple clumps of *Xyris* grow at this disturbed site, perhaps survivors of the impoundment.

Life History

Xyris tennesseensis is a perennial, but most other details about its life history are yet to be researched. When observing a clump of *X. tennesseensis*, one is often unsure of how many individuals are present. Dense clumps have been observed with over 70 flowering culms. Do they represent one or more individuals? Kral (1990) stated that "they increase by production of lateral buds from axils of crown leaves," but in the field it is often difficult to tell what represents a single plant. Besides the basic question of what constitutes an individual, other questions yet to be answered are as follows: How well do the seeds germinate under different conditions? Kral (1990) noted that seed set "is high but the seedlings have a high light requirement for germination." Otherwise little is known. Does the species produce a seed bank? When do the seeds germinate? How serious is mortality among seedlings? At what age does flowering and fruiting begin? What do long-term survivorship curves for the species look like? At what age does fruiting peak? Answers to some of these basic questions would aid in recovery planning and site management.

Reasons for Listing

At the time of final listing (July 26, 1991) seven populations were known to exist and two or three other sites were known to have been extirpated. Field work in conjunction with the Status Report by Kral (1990) included updates on each of the known sites. Four of the seven populations were considered to be in decline. Off-road vehicles were impacting one of the Tennessee fens; timbering had recently occurred at the site with the largest population in Tennessee, and herbicide spraying for weed control had occurred at the Franklin County, Alabama site. Kral (1990) speculated that the currently known habitats may be mainly upland remnants of what might have been a more widespread species associated with valley wetlands. He cited many common land use practices, such as timber management, drainage of lowland wetlands and conversion to agricultural fields, and the impoundment of wetlands as reasons for the loss of habitat.

Dr. Kral's field investigations include searches for potential habitat in Hardin, Perry, and Wayne Counties in the Southwestern Highland Rim of Tennessee; Itawamba and Monroe Counties of Northeastern Mississippi; and Calhoun, Cherokee, Cleburne, Colbert, Cullman, Franklin, Marion, Morgan, Pickens, Shelby, St. Clair, and Walker Counties, Alabama, without a single new *Xyris* find. Finally in Bartow County, Georgia, after two field seasons of searches, Kral found a new population. This review is not to deride his efforts but to point out the extensive areas searched by an outstanding field botanist and author of this species. From the recent Bibb\Calhoun County, Alabama discoveries of Jim Allison (Georgia Department of Natural Resources) and Chris Oberholster (Alabama Natural Heritage Program), respectively, it now appears that the Ridge and Valley physiographic region is a key area for this species. Kral did explore several Ridge and Valley Counties (Calhoun, Cherokee, Shelby, and St. Clair Counties, Alabama; and Chattooga, Floyd, and Polk Counties, Georgia) as part of his survey, so evidently it is a rare entity in this region despite the new finds.

Conservation Measures

Very little special protection or management exists for *Xyris tennesseensis* populations at the present time, and except for the funded studies for basic inventory and recovery planning, there has been no intensive research on the species. Efforts have been made in Tennessee by both the Department of Environment and Conservation and The Nature Conservancy to establish contact with landowners and seek natural area registries, easements, or acquisitions, but such has been met with only marginal success, overall. A registry is in place between the National Park Service and the State of Tennessee for The Natchez Trace Parkway, but only a few *Xyris* plants were seen on their property in 1992 and more than a signed agreement may be necessary. Another apparently successful measure was The Nature Conservancy's intervention in a timber operation in 1988 at the largest of the Tennessee populations. The landowners cooperated by allowing the fens on one side of the watershed to be flagged off from timbering. Followup attempts to register and secure a right of first

refusal, however, were not successful. A third successful action in Tennessee was the Department of Transportation's extension of a piece of guardrail along a highway adjacent to the type location (a fen) which was being impacted by motorcycles accessing it through a gap in the rail.

Efforts are underway also in Alabama and Georgia to protect the newly discovered populations there. All are on privately owned land with the exception of the Calhoun County, Alabama sites which are on Federal land (Fort McClellan). A preliminary management plan has been developed for populations of this species on Fort McClellan. Staff there have inventoried the populations, evaluated potential threats, and taken corrective actions for any imminent threats which have been identified for populations on their lands. This management plan is in the process of being finalized by Fort McClellan.

Strategy for Recovery

To ensure the long-term survival of *Xyris tennesseensis*, it will be important both to protect and properly manage, in a long-term stable manner, a number of viable populations. It will be necessary to define what a viable population is and what constitutes normal fluctuation in population size. The strategy should focus on efforts to determine how much genetic variation exists between and within the isolated populations. A general objective should be to assure survival of gene pools at each of the five main geographic centers of distribution. Even if genetic studies do not justify this strategy, it may still have long-term value for the species' survival in the face of unpredictable changes in land use and abuse, along with those delivered by nature's own stochastic events.

Protection afforded to endangered plants through Section 7 of the Endangered Species Act will facilitate protection of those plants on Federal lands. The highest level of protection (i.e. land acquisition, conservation easements) should be sought for key populations on private lands; however, voluntary management agreements should be pursued if these more permanent measures are not available. The design of effective management and protection needs is dependent upon an understanding of this species' biology and habitat needs. Thus, research should be done to document the effects of light and shade on the species' reproduction and survival. Likewise, we need to know more about the effects of soil disturbance and erosion at and near the sites. If opening the canopy or disturbance of the substrate have value in maintaining the habitat, it might be a better strategy to use conservation easements or cooperative management agreements that establish acceptable forms of timbering and other land use practices.

The strategy developed, should be based on sound research into the species' life history, reproductive biology, genetics, and ecological requirements. Much of this is unknown at present.

II. RECOVERY

A. Recovery Objective

Xyris tennesseensis (Tennessee yellow-eyed grass) will be considered for delisting when there are 15 adequately protected and managed, self-sustaining populations of the species distributed throughout the historical range and maintained for 10 years. A population will be considered adequately protected when it is legally protected and actively managed. A population will be considered "self-sustaining" if monitoring data support the conclusion that it is reproducing successfully and maintaining stable numbers or increasing. The minimum number of individuals necessary for a self-sustaining population should be determined by demographic studies implemented through this recovery plan.

B. Narrative

1. Protect known populations. All of one population and portions of two others are on federally owned land; the remainder are on private land. One of the Lewis County, Tennessee populations is partially on National Park Service (NPS) land, and a Natural Area Registration agreement with the Tennessee Department of Environment and Conservation (TDEC) is in effect to protect the plants found there. Nevertheless, the number of *Xyris* plants on the NPS land is low and possibly declining; the largest segment of the population is on private land upstream where there is no protection or planned management. A Memorandum of Agreement between NPS, the Fish and Wildlife Service, and TDEC, based in part on those measure outlined in the existing agreement, should be developed to ensure the protection and enhancement of the NPS population. The other two federally owned sites are totally or partially on a military reservation in Alabama (Fort McClellan). A preliminary protection/management plan has been developed and implemented for those populations on Fort McClellan. Efforts should also be made to protect each privately owned site through protection tools such as acquisition, conservation easement, cooperative management agreement, or natural area registry.

   1.1. Enforce protective legislation. The Endangered Species Act (ESA) provides protection for listed plants through Section 7 and Section 9. Section 7 provides that Federal agencies shall carry out programs for the conservation of endangered species. In addition, Section 7 provides for protection of individuals and their habitat from impacts related to federally funded or authorized projects. Section 9 prohibits the taking of *Xyris tennesseensis* from Federal lands without a permit and regulates trade. The 1988 amendments provided additional protection for endangered plants by prohibiting: (1) their malicious damage or destruction on Federal lands and (2) their removal, cutting, digging, damage, or destruction on any other lands in knowing violation of any State law or regulation, including State criminal trespass law.

1.2. Prioritize sites. All sites should be compared using criteria that include population size, area, vigor, and viability, along with quality of the habitat and perceived threats to it. Judgements about how protectable each site is should be made by assigning a rank. Genetic diversity within and between the populations should be taken into consideration as data become available. Relative ranks should be assigned in order to establish protection priorities globally and within each State where it occurs.

1.3. Negotiate protection with landowners. Landowners should be contacted and informed about the endangered species on their property, why it is important to protect it, and how they can help to assure its survival. Taking into consideration the relative rank of the population, an appropriate level of protection should be attempted. In each case, an evaluation must be made to determine the boundaries of the primary habitat (where the population resides) and secondary habitat (essential buffer that ensures the stability of the primary habitat). Negotiations with landowners and managers should aim for the best ways that primary and secondary habitat can be safeguarded and managed for both short-term and long-term population stability. Important to these decisions will be knowing what is needed for management, and knowing which agencies, organizations, or individuals are committed to the species' protection or are in the best position with staff and resources to carry out any necessary management activities. For each viable population on private lands, involvement of a conservation agency or organization in a cooperative management agreement, conservation easement or restrictions, or outright ownership is recommended in order to assure some degree of legal control of land use and assistance with management.

1.4. Develop management plans for each protected population. Until biological studies (Task 3) and management studies (Task 4) are completed for *Xyris tennesseensis*, management plans should be aimed at maintaining conditions perceived to be important to a viable habitat including current moisture and light regimes. In addition, efforts should be made to eliminate exotic weeds, prevent excessive erosion or siltation, and reduce trampling and off-road vehicle abuses. As more is learned about the species' requirements, plans can be revised with bolder objectives aimed at enhancing the habitat. Management plans are being implemented for the populations on federal lands.

2. Search for new populations. Since additional populations have been discovered in the past 2 years, there is reason to believe that more sites may be found by conducting thorough searches of potential habitat.

2.1. Search for new populations within the known range. Priorities should be on searching in the States and physiographic provinces where the species is known to occur. The area of highest potential, where nine populations are now known, is the Ridge and Valley physiographic province of Alabama and Georgia. The last nine discoveries have been from this area. Also, working with geological and soils maps, plus knowledge of vegetational associates from known sites, additional searches should be made in or adjacent to Lewis County, Tennessee and Franklin County, Alabama. Suitable habitat should be identified and searched in the southern portion of Tennessee's Ridge and Valley, particularly along the Georgia and northeastern Alabama borders. Seeps and streams associated with Silurian limestone formations in Decatur and Perry Counties, Tennessee should be searched, too. Searches should be coordinated with Robert Kral to avoid areas he has examined already.

2.2. Search for new populations in other States. Kral (1990) noted a "continuum of habitat" and "a strong floristic overlap" between the Coastal Plain of northeastern Mississippi and northwestern Alabama, and therefore conducted searches for *Xyris* in portions of Tishimingo, Itawamba, and Monroe Counties, Mississippi. Although his searches were unsuccessful, the idea still has merit and additional searches are warranted. Limestone regions of Mississippi, especially in the northeastern portions of the State, should be checked. Other regions of the country that represent remote possibilities for this taxon are limey seeps, fens, and creeks of Arkansas, southeastern Missouri, Louisiana, eastern Texas, and the Florida panhandle. Calcareous streambanks in the Black Belt of Alabama are also a possibility (Allison, pers. comm.).

3. Conduct autecological research. In order to wisely manage this endangered species, it is imperative that we understand its basic biology. To date, no fundamental research has been conducted on the species' ecological requirements or life history.

3.1. Identify physical parameters of the species' habitat. The geological formations underlying each of the populations should be identified using existing maps or samples, then characterized as to mineral composition, pH, etc. The soils should be characterized in a similar manner with organic content being noted. Aspects, slope angles, elevations, and relationship to water sources should be noted. Investigations into hydrological relationships, e.g. water table dynamics, should also be explored. Average rainfall and temperature means and extremes for the sites could be compared as well.

3.2. Conduct demographic studies. A permanent sampling design should be established in order to obtain demographic data for populations in each of the three States. In Georgia, since the Bartow County site is the only sizable population, only one site can be sampled. However, in Alabama and Tennessee, the populations are more numerous and large enough to allow sampling; therefore, at least two sites per State should be selected. In Alabama, since there are three centers of distribution and eight populations, monitoring three sites is not unreasonable. The sampling should be designed to obtain reliable data to adequately assess recruitment, mortality, longevity, population size, and the mean number of flowering culms per individual or clump of individuals. Identifying what constitutes an individual is often difficult to determine in the field without disturbing the plants, so the practical unit of measure may have to be each dense clump that can be distinguished. By mapping and tracking individual plants through time, we should learn about the formation of the large clumps or tussocks of leaves and stems seen in some of the better established populations.

We also need to learn about site dynamics from the sampling. All of the sites are particularly vulnerable to the effects of high rainfall events, thus, whole colonies can be washed or sloughed away, possibly to new sites which they colonize downstream. Reference markers for transects or plots will need to be well anchored in rocks or trees for relocation purposes. Because of the fragility of the sites, sampling designers should seek the least intrusive method(s) possible.

3.3. Study reproductive biology. Since the species is so rare, it is reasonable to suspect a problem with reproduction. Both sexual and asexual reproductive capabilities of the species need to be assessed.

3.3.1. Investigate pollination biology. Flowering occurs from July through September. Kral (1978, 1990) reported that the flowers open in the morning but later than its nearest relatives in the *X. difformis* complex. He also stated that it seldom is found with other *Xyris* taxa. No one has reported observations of floral visitors. The kinds of pollinators and the frequency of their visits should be determined. Hand pollinations should be performed to see if flowers of *Xyris tennesseensis* can be selfed and if the addition of supplemental pollen increases seed production.

3.3.2. Examine asexual forms of reproduction. An investigation into anatomical processes within some of the large clumps is needed. Lateral buds form in the axils of crown leaves (Kral 1990). Are

multiple new shoots typically produced at the base each year in healthy individuals? Are there forms of apomixis involving the flowering heads?

3.4. Study seed biology. Kral (1990) reported that "the amount of seed set in *Xyris tennesseensis* is high, but the seedlings have a high light requirement for germination." A basic investigation of seed production and germination needs to be done to substantiate Dr. Kral's observations and to investigate the topics of seed dispersal and banking in the soil.

3.5. Examine genetic diversity within and between populations. Using currently available techniques to analyze and compare DNA and proteins, a genetic study should be done on this species. Such studies will indicate which populations are genetically more diverse and in that sense more likely to successfully sexually reproduce. Also, the genetic data can help set priorities for preservation of genetic diversity. Spot samples from each of the populations should be examined, and at least one population from each of five physically separated areas should be examined in detail to determine how genetically diverse individual populations are.

4. Investigate potential management techniques. While all or nearly all of the known *Xyris tennesseensis* sites share certain attributes such as open, wet, calcareous conditions, there has been no experimental manipulation of its habitat to determine what effect various perturbations have on its growth, reproduction, and survival. Careful monitoring of populations will be necessary in order to detect changes in treatment and control areas.

4.1. Determine effect of shading. Shading by canopy trees and shrubs is suspected to be detrimental to *Xyris*, but it is possible that other factors contribute to its absence in shady situations. This can be tested by conducting growth chamber or greenhouse studies using regulated light conditions. Using the results of this study, corresponding field studies can be undertaken to determine the effects of various levels of overstory and shrub layer removal. Such research would be useful in determining whether or not various forms of timbering adjacent to the populations would be helpful or detrimental to them. Thinning the canopy around one of a pair of similar fen sites in Lewis County, Tennessee could serve as a treatment vs. control experiment to test the effect of increasing light.

4.2. Determine tolerance to drought. While the soils in *Xyris* habitat are usually saturated, they are also shallow and, therefore, vulnerable to drought. What effect does water depletion have on *Xyris* during different stages of its life history? This can be investigated best by growth chamber or greenhouse

studies. By monitoring populations in the field and noting the response to real drought conditions, we can learn about the effects of water depletion to a degree, but the research is made more difficult by the variable microenvironment of each plant and the difficulty of designing a control situation. By using soil moisture hygrometers and comparing results from wet years to dry years, some general trends can be derived from monitoring programs. Hydrological information obtained from Task 3.1 will be useful in completing this task.

4.3. Determine the effects of competition. Herb and sometimes shrub cover are dense at most *Xyris tennesseensis* sites. What effects do various species have on the growth, reproduction, and survival of *Xyris tennesseensis*? Some dominant associates that should be tested are: *Rudbeckia fulgida*, *Parnassia grandifolia*, *Amphicarpaea bracteata*, *Alnus serrulata*, *Ludwigia microcarpa*, and *Cyperus strigosus*. Also, two exotic grasses, *Arthraxon hispidus* and *Eulalia viminea*, were abundant at several sites and could be competitors now or in the future. Carefully designed greenhouse competition studies involving pairs of these plants in containers may shed light on which taxa represent the most serious problems for *Xyris tennesseensis*. In the field, it would be useful to test the effects of removing competitors from patches or strips of substrate, such as in the Tennessee fens. How well would *Xyris* establish itself in the open patches or along their edges as compared to control areas? At some of the Tennessee fens in 1992, dense mats of the delicate vine, *Amphicarpaea bracteata*, were seen overtopping *Xyris*, *Parnassia*, and other fen herbs. Experiments should be designed to test the effects of removing this competing herb from plots in the fens.

4.4. Test management techniques to control invasive species. The two exotic grasses, *Arthraxon hispidus* and *Eulaliaf viminea*, have not usurped much of the *Xyris* habitat so far, but they have the potential to expand. It would be worth testing techniques to control the spread of these grasses. Similarly, consideration should be given to removing a colony of cattails, *Typha latifolia*, from the roadside ditch at the Franklin County, Alabama site, since it is encroaching on a portion of the *Xyris* population.

4.5. Attempt to enhance, restore, or create new colonies. In Lewis County, Tennessee, seepage fens lacking *Xyris* but possessing *Parnassia* and other associates of *Xyris* can be found. In other cases, *Xyris* is present, but the number of plants is very low. For seeps lacking *Xyris*, but where there are cooperative landowners or managers, consideration should be given to starting new colonies or populations, if a sufficient number of additional populations are not discovered. One potential transplant site would be the

site on National Park Service land where the species was collected for the first time in 1945, but has since disappeared. A few individuals could be transplanted to this site from a nearby fen with many *Xyris* plants.

The two historical Georgia sites have been altered too much by major land use changes to serve as restoration sites. The main options in Georgia are to either create new sites in close proximity to the historical ones (if suitable conditions can be found) or attempt to enhance the current Whitfield County site through cooperative efforts with the landowner. The latter population consists of two clumps of plants and is not considered to be viable without intervention. Since there is only one viable population known in Georgia, new colonies may need to be established in that State. The results of the management studies (Tasks 4.1 to 4.4) and the biological studies (Task 3) will help determine what, if any, site preparation would be useful. These results should also provide guidance for how to manipulate the various sites in order to enhance dwindling populations.

Management/enhancement of natural sites and restoration of historical sites should take precedent over the creation of new sites. Creation of new sites will be considered only after extensive surveys for natural populations have been conducted.

4.6. Conduct long-term site and population monitoring. Plans and schedules for annual monitoring should be established in each of the States where the species occurs. An effective, low cost design should be developed that provides basic information about population size, area, and reproductive success, as well as information about any changes in habitat management or external threats.

5. Maintain plants and seeds *ex situ*. To guard against natural or human caused destruction of one or more populations, seeds should be kept in long-term storage and living collections should be maintained at botanical gardens. The Center for Plant Conservation can provide guidance.

5.1. Maintain seeds. Seed collections from each population should be placed in long-term storage at the U.S. Department of Agriculture's Agricultural Research Service National Seed Storage Laboratory in Fort Collins, Colorado. Viability of the seed should be checked periodically by Lab staff and seed should be replaced with fresh collections by in-State biologists as necessary.

5.2. Maintain plants in cultivation. *Xyris tennesseensis* should be placed in the Center for Plant Conservation's living collections of endangered or threatened plant species. If possible, plants representing at least three of the natural populations should be maintained at physically separated sites as sources of fresh seeds and living plants for education and research purposes. Live specimens at botanical gardens and nature centers in the Southeast would serve an educational purpose.

6. Provide public information about the species. General information about the species and its conservation needs should be provided to landowners, schools, parks, nature centers, and the media. Such education can lead to the discovery of new populations and results in a public that is more aware and understanding of conserving endangered species.

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PART III: IMPLEMENTATION SCHEDULE

The following Implementation Schedule outlines recovery actions and their estimated costs for the first 3 years of the recovery program. It is a guide for meeting the objective discussed in Part II of this plan. This Schedule indicates task priorities, task numbers, task descriptions, duration of tasks, the responsible agencies, and lastly, estimated costs.

Priorities in column one of the following Implementation Schedule are assigned as follows:

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

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.

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

Key to Acronyms used in Implementation Schedule

USFWS - U.S. Fish and Wildlife Service
TE - Endangered Species Division, U.S. Fish and Wildlife Service
HC - Habitat Conservation, U.S. Fish and Wildlife Service
ALNHP - Alabama Natural Heritage Program
GADNR - Georgia Department of Natural Resources - Natural Heritage Inventory
TDEC - Tennessee Department of Environment & Conservation - Ecological Services Division
SHPs - State Heritage Programs in Arkansas, Florida, Louisiana, Mississippi, Missouri, Texas
TNC - The Nature Conservancy
CPC - Center for Plant Conservation
NPS - National Park Service
DOA - Department of Army (Fort McClellan)
Pvt. - Private individual, university, or other research organization

IMPLEMENTATION SCHEDULE

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION	RESPONSIBLE PARTY			COST ESTIMATES ($K)			COMMENTS/NOTES
				USFWS						
				Region	Division	Other	FY 1	FY 2	FY 3	
1	1.1	Enforce protective legislation.	continuous	4	TE, HC	GADNR, TDEC, DOA, NPS				
1	1.2	Prioritize sites.	1 year	4	TE	ALNHP, GADNR, TDEC	1.0			
1	1.3	Negotiate protection with landowners.	3 years	4	TE, HC	ALNHP, GADNR, TDEC, TNC	2.0	2.0	2.0	Cost of possible acquisitions not included.
1	1.4	Develop management plans.	3 years	4	TE	ALNHP, TGADNR, TDEC, TNC,NPS, DOA	4.0	4.0	4.0	To be conducted in conjunction with Task 1.3. Initiated on NPS, DOA lands.
2	2.1	Search for populations in known range.	2 years	4	TE	ALNHP, GADNR, TDEC, NPS,DOA	7.5	7.5		Surveys ongoing on Fort McClellen (DOA).
2	2.2	Search for populations outside known range.	1 year	4	TE	ALNHP, SHPs	6.0			Focused survey during field season for 5-7 days/State.
2	3.1	Identify physical parameters of habitat.	2 years	4	TE	ALNHP, GADNR, TDEC, Pvt.	5.0	5.0		
2	3.2	Conduct demographic studies.	3 years	4	TE	ALNHP, GADNR, TDEC, Pvt.	5.0	5.0	5.0	

IMPLEMENTATION SCHEDULE

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION	RESPONSIBLE PARTY			COST ESTIMATES ($K)			COMMENTS/NOTES *
				USFWS						
				Region	Division	Other	FY 1	FY 2	FY 3	
2	3.3 - 3.4	Study reproductive and seed biology.	2 years	4	TE	ALNHP, GADNR, TDEC, Pvt.	8.0	8.0		
2	3.5	Examine genetic diversity.	2 years	4	TE	Pvt.	3.0	3.0		
2	4.1 - 4.4	Investigate and test various management techniques.	3 years	4	TE	ALNHP, GADNP, TDEC, Pvt.	8.0	8.0	8.0	Monitoring results will continue in following years.
2	4.5	Enhance, restore, or create new colonies.	-	4	TE	ALNHP, GADNR, TDEC	-	-	-	The need for this activity will be determined later.
2	4.6	Monitor populations.	continuous	4	TE	ALNHP, GADNR, TDEC	3.0	3.0	3.0	
3	5.1	Maintain seed collection.	continuous	4	TE	ALNHP, GADNR, TDEC, CPC	1.0			Cost reflects 1 year effort to collect seeds.
3	5.2	Maintain plants in cultivation.	continuous	4	TE	CPC	7.0			Estimated 1 time fee.
3	6	Public education.	continuous	4	TE, HC	ALNHP, TDEC, GADNR, NPS, COE, CPC, TNC	2.0	2.0	2.0	

IV. APPENDIX

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