

Missouri Bladder-pod

Recovery Plan



Missouri Bladder-pod (Lesquerella filiformis Rollins) Recovery Plan

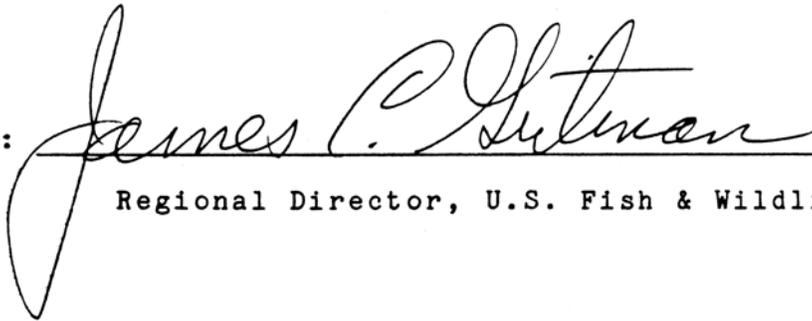
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DISCLAIMER

This is the completed Lesquerella filiformis recovery plan. It has been approved by the U.S. Fish and Wildlife Service. It does not necessarily represent official positions or the approval of cooperating agencies. It has been prepared by Sharon W. Morgan and Virginia K. Wallace, Missouri Department of Conservation, in cooperation with the U.S. Fish and Wildlife Service to delineate reasonable actions required to recover and protect the species. This plan is subject to modification dictated by new information, changes in species status, and completion of tasks described in the plan. Goals and objectives will be attained and funds expended contingent upon appropriations, priorities and other budgetary constraints.

Literature citations should read as follows:

U.S. Fish and Wildlife Service 1988. Lesquerella filiformis Recovery Plan. U.S. Fish and Wildlife Service, Twin Cities, Minnesota. 33pp.

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Fish and Wildlife Reference Service
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Cover illustration: Martha Daniels

SUMMARY

- Recovery Goal:** To prevent the extinction and enhance the status of Lesquerella filiformis by protecting, restoring and managing populations so that the species may be removed from the Federal List of Endangered and Threatened Species.
- Recovery Criteria:** The protection and management of thirty scattered, self-sustaining populations of L. filiformis, fifteen of which must be in secure ownership, occupy a minimum of one-half acre of habitat each and show self-sustaining populations for at least seven years.
- Actions Needed:** Recovery goals may be accomplished through: 1) protection and management of existing populations, 2) inventory of suitable habitat to find new populations, 3) continuing to monitor and conduct research on the species, 4) developing and initiating management programs on protected sites, 5) establishing new populations on public land, 6) developing public awareness and support for conservation of the species.

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Part I

INTRODUCTION

Brief Overview

Lesquerella filiformis Rollins is an annual plant species in the mustard family (Brassicaceae) that is endemic to Missouri. Federal listing as an endangered species became effective February 9, 1987 (U.S. Fish and Wildlife Service, 1987). The species presently occurs on limestone glades and outcrops in three southwestern Missouri counties. Current land-use patterns threaten most known populations.

Description

Annual plants with stems numerous from the base. Stems slender, branched and erect with the outer stems somewhat reclining; 4-8 inches tall, densely covered with stellate hairs, with leaves scattered on the stem and in a rosette at the base. Basal leaves spatulate, tapering to a narrow stem, 3/8 to 7/8 in. long, 1/8 to 3/8 in. wide, with hairs on both surfaces. Stem leaves densely covered with stellate hairs on both surfaces (appearing silvery), 3/8 to 1 1/4 in. long, 1/16 to 1/4 in. wide, often becoming narrower and lacking petioles near the top of the plants. Flowers occur at the tops of the stems in indeterminate inflorescences; individual flowers are 1/4 to 3/8 in. long, densely covered with hairs and have four bright yellow petals.

Fruits are round capsules, initially pale green, turning tan with age; about 1/8 in. in diameter and contain four flattened brown seeds. Flowering: April-May. See illustration in Figure 1. For a complete technical description, see Rollins and Shaw (1973).

Taxonomy

Initial collections of L. filiformis in Missouri date from 1887. In a 1921 monograph of the genus, the name L. angustifolia was applied to these specimens (Payson, 1921). Reed Rollins of Harvard University noted the misapplication of the name while working on a revision of Payson's monograph. Rollins published the name and description of L. filiformis in 1956, citing a 1929 collection as the type specimen (Rollins, 1956). This taxonomy was maintained in the recent monograph of North American species of Lesquerella (Rollins and Shaw, 1973).

Distribution and Land Ownership

Steyermark (1963) recorded L. filiformis from Dade, Greene, Jasper and Lawrence counties in southwest Missouri. No specimens from either Jasper or Lawrence counties were found in a search of five major herbaria outside of Missouri and fourteen herbaria in the state (Morgan, 1980). In the most recent monograph of the genus (Rollins and Shaw, 1973) the authors did not locate specimens from those two counties after examining specimens from many herbaria in North America and Europe.



Figure 1. Lesquerella filiformis (Missouri bladder-pod). Illustration by Martha Daniels.

Presently, L. filiformis is known from eleven locations in Dade, Greene and Christian counties (Figure 2). Historical records also exist for Dade and Greene counties. Information on all known locations and collections is provided in Table 1.

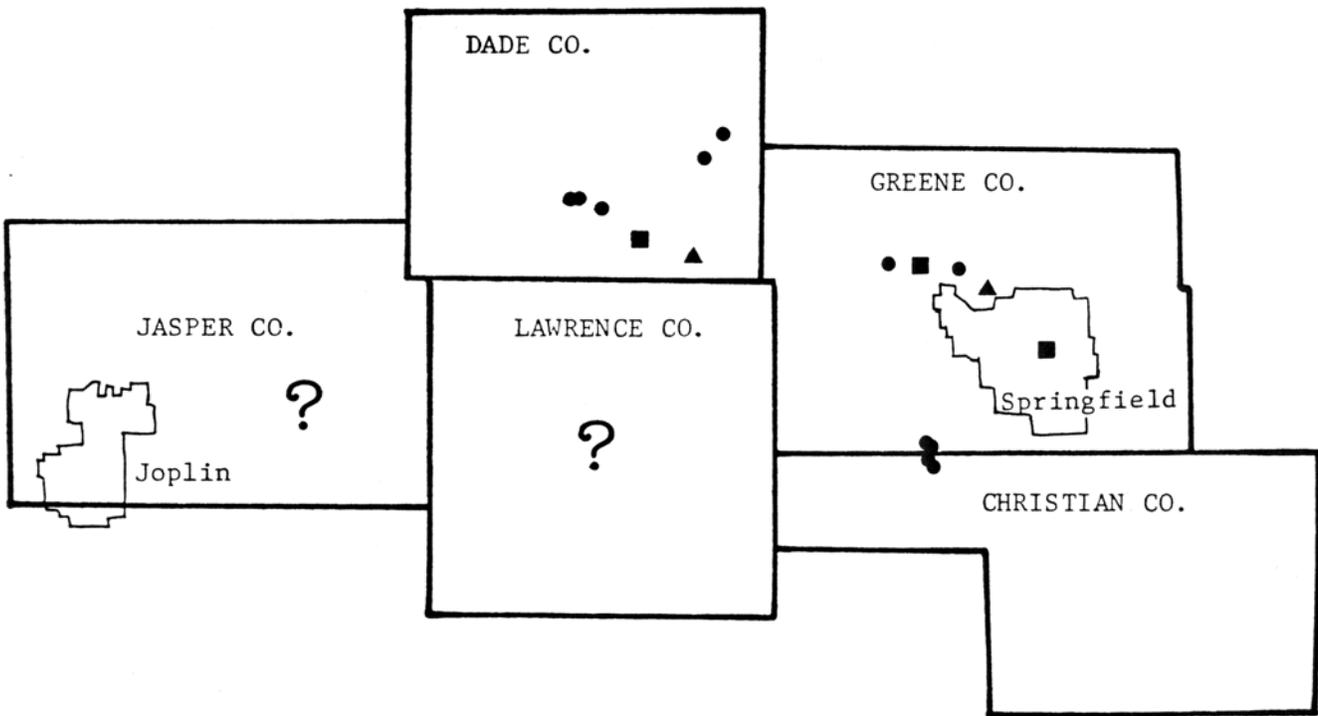
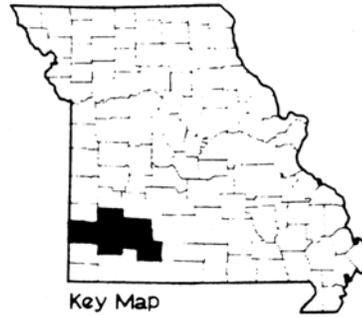
Most populations of L. filiformis occur on private land. Three occur on Wilson's Creek National Battlefield (National Park Service) and half of one is owned by The Nature Conservancy (TNC). Two populations occur on highway rights-of-way and adjacent private land, while a third occurs only on the highway right-of-way. An additional population occurs on a power line right-of-way. All other known populations are presumed to be in private ownership.

Habitat

L. filiformis occurs in shallow soils on limestone glades, outcrops in pastures and rarely in rocky open woods. These glades are fairly small in extent because the limestone bedrock fractures readily, allowing invasion by woody species. L. filiformis grows in the shallowest soils with other annual species where bare soil occurs and few perennial plants are present. The underlying geologic substrate is Burlington limestone of Mississippian Age (Missouri Geological Survey, 1979).

Species Biology

Lesquerella filiformis is a winter annual, germinating in the fall and overwintering in the form of basal rosettes. Plants



Legend

- ? County record never verified.
 - Extant records.
 - ▲ Historic record, not relocated.
 - Historic record, location information vague.
- Scale: 1 inch = approx. 13.5 miles.

Figure 2. Distribution of Lesquerella filiformis.

Table 1. Collection Records of Lesquerella filiformis

COUNTY	SITE NAME/LEGAL DESCRIPTION	USGS QUAD	COLLECTION/OBSERVATION DATA*	OWNERSHIP/COMMENTS
Christian	Wilson's Creek National Battlefield	Republic	First Observed: 1984 Source: MDC Last Observed: 1987	National Park Service
Christian	Terrell Creek	Republic	First Observed: 1984 Source: MDC	Private
Dade	Honey Creek Outcrops	South Greenfield	First Observed: 1935 Source: Specimen, Steyermark, MO Last Observed: 1984 Source: MDC	Highway Dept. /Private
Dade	Turnback	South Greenfield	First Observed: 1929 Source: Specimen, Palmer, MO	Exact location of Turnback unknown. Suitable habitat has been searched.
Dade	Greenfield Glade	South Greenfield	First Observed: 1981 Source: MDC	The Nature Conservancy /Private
Dade	Buffalo Branch Glade	South Greenfield	First Observed: 1981 Source: MDC	Private
Dade	Cave Spring Outcrops	Dadeville	First Observed: 1981 Source: MDC	Highway Dept.
Dade	Fairview Glade	Dadeville	First Observed: 1961 Source: Specimen, Rollins, MO Last Observed: 1985 Source: MDC	Highway Dept. /Private
Dade	Jordan Creek	Everton	First Observed: 1961 Source: Specimen Rollins, MO	Glade along roadcut searched several times. Species not found.

Greene	Halfway Hill Glade	Ebenezer	First Observed: 1975 Source: Specimen, Redfearn, SMS Last Observed: 1984 Source: MDC	Private
Greene	Fantastic Caverns Glade	Ebenezer	First Observed: 1939 Source: Specimen Steयरmark, FM	Fantastic Enterprises; glade searched several times. Species not found.
Greene	Wilson's Creek National Battlefield	Republic	First Observed: 1979 Source: Specimen, Key SMS Last Observed: 1985 Source: MDC	National Park Service
Greene	Wilson's Creek National Battlefield	Republic	First Observed: 1987 Source: NPS	National Park Service
Greene	Springfield	Springfield	First Observed: 1887 Source: Specimen, Blankenship, MO	Historic record.
Greene	Willard	Willard	First Observed: 1887 Source: Specimen, Blankenship, MO	Historic record.
Greene	Sand Mountain	Ash Grove	First Observed: 1987 Source: Lincoln Univ.	Private/Power Company right-of-way

* Codes

MDC = Missouri Department of Conservation
MO = Missouri Botanical Garden, St. Louis, MO
SMS = Southwest Missouri State University, Springfield, MO
FM = Field Museum of Natural History, Chicago, IL

send up flowering stems in late April and flower, fruit and senesce by the end of June. Seeds lie dormant on the limestone glades through the summer and germinate in the fall, starting the life cycle over again.

There is considerable variation in these life history details from year to year. The following observations resulted from a three-year study conducted by the Missouri Department of Conservation (Morgan, 1986).

Flowering generally starts during the last two weeks of April and is most likely influenced by early spring temperatures and/or rainfall. Following a mild, wet winter in 1987, L. filiformis plants were observed blooming at Wilson's Creek National Battlefield in March. Numbers of plants vary widely from year to year, as do number of stems per plant and numbers of flowers and fruits produced. In optimal years, plants may also occur in open woods and are more widespread throughout available habitat. In some years plants do not appear. In 1982, no plants were observed at any known locations, while in 1986 some populations were present, while others were not.

Inflorescences are indeterminate and flower from the base up. As plants age, new inflorescences initiate from upper leaf axils and additional stems sprout from the base. Length of the flowering period is probably influenced by temperature and rainfall. Plants flower longer when there is adequate soil moisture. Temperature quickly affects available moisture since plants occur in very shallow soils.

Flowers close at night and open again the following morning by about 10:00 a.m. Plants are insect pollinated and several species were observed visiting the flowers. Small bees in the family Halictidae (Figg, pers. comm.) were observed most often, though it is not known if they are pollinators. These insects also visited other species in flower in addition to L. filiformis.

Since inflorescences are indeterminate, capsules begin developing while plants are still flowering. Capsules are initially pale green in color and turn light tan with age. The capsules split open when dry and seeds are dispersed leaving the papery septum (wall between capsule halves) attached to the pedicel. Capsules produce a maximum of four seeds each. Seeds are mainly dispersed by falling from dried capsules although some dispersal occurs by seeds being washed downhill by rainwater runoff.

In 1983, flowering, fruiting and seed dispersal occurred in marked plants within six weeks after the first flowers were observed (Morgan, 1983a). Flowering was first observed on April 25 and the peak of flowering occurred between May 5 and 17. The peak of seed dispersal occurred between May 17 and 24. Only a very few capsules remained on the plants by June 6. Seed dispersal in individual flowers occurs two to three weeks after the flower first opens.

Insect predation of developing and mature fruits was observed in 1983. Insect larvae were found in capsules, and empty capsules with holes in the capsule wall were also observed.

In addition, two common genera of fungi (Alternaria and Botrytis spp.) were observed on developing seeds. Seed counts made on three plants showed a 60% loss of seeds to either insect predation or fungal infestations (Morgan, 1983b). Very little insect predation was observed in 1984, although individual plants were not marked and monitored through the growing season. This predation and fungal infestation probably varies greatly from year to year.

After seed dispersal occurs, seeds lie dormant on the hot, dry glades throughout the summer. Germination occurs in the fall, and basal rosettes were first observed in November 1984, confirming that L. filiformis is a winter annual. Seed germination experiments conducted by Jerry and Carol Baskin at the University of Kentucky correlate with these observations. Seeds were observed to germinate only in the fall and not during the summer or the following spring (Baskin and Baskin, pers. comm.). Plants overwinter as basal rosettes and then initiate flowering stems in the spring, starting the life cycle over again.

Significant research on the life cycle of winter annuals has been conducted by Jerry and Carol Baskin at the University of Kentucky in addition to their preliminary work with L. filiformis. Many of their conclusions about the life cycle and ecology of winter annuals occurring on glades may be applicable to L. filiformis. Two recent summary papers are worth noting (see Baskin and Baskin, 1985a and 1985b). They have found that temperature is the most important environmental factor regulating

the timing of life cycles of winter annuals on glades. Winter annuals can tolerate low winter temperatures, but not the drought conditions and high temperatures of summer.

Seeds of winter annuals undergo afterripening during the summer, causing the optimum and maximum germination temperatures to increase. This prevents seed germination during the hot, dry summer months, and postpones it until fall when soil moisture is more favorable to seedling survival. Seeds not germinating in the fall reenter dormancy when exposed to low winter temperatures and require another period of exposure to high temperatures in order to germinate, preventing spring germination. This cycle is likely to apply for L. filiformis. This information will be important in storing L. filiformis seed in seed banks and in propagation and colonization efforts.

In addition, Baskin and Baskin (1985b) note that most winter annuals receive full or near full sunlight and are apparently poor competitors with taller species that shade them. Rollins (1963) observed that plants of Leavenworthia spp. (also a winter annual) were killed by Poa annua apparently by shading, in an unweeded portion of a study plot. Cheat grass (Bromus tectorum) potentially poses a similar threat to L. filiformis at several sites.

Threats and Limiting Factors

Several existing or potential threats to the continued existence of L. filiformis are known. There are a limited number of known sites for the species, and few are in protected, secure

ownership, while mowing and herbiciding may threaten populations found on highway right-of-way. Invasion of exotic species such as Bromus tectorum threatens several sites in public ownership. These threats cannot be adequately addressed without additional life history information which might answer questions concerning management of the species and its habitat.

L. filiformis is presently restricted to eleven sites, most of which are less than one acre in size, in three counties. Collection records indicate that the species may never have been more widespread. Of the eleven sites presently known, eight have been discovered since 1979. Although new populations have been found in the last eight years, low numbers of individual plants make the species vulnerable to exotic plant invasion and human activities. An estimate of a total of 550 plants within four sites was made in 1980 (Morgan, 1980). In 1986, the total number of plants at the then nine known sites was estimated to be less than 5000 (U.S. Fish and Wildlife Service, 1987).

Of the eleven sites presently known, seven occur on private land or along highway rights-of-way. The sites on private land are not protected from development, conversion to cropfields or other changes in land management. Most of the sites in private ownership are presently being grazed or hayed. While grazing and haying may prohibit invasion by woody species, the effects of these activities on L. filiformis populations are unknown. In addition, grazing and haying may enhance populations of exotic species that compete with L. filiformis. Management of highway rights-of-way may potentially threaten those populations

occurring along roadsides. These populations need protection from mowing at the wrong time of year and/or use of herbicides.

Four populations occur on National Park Service property and land owned by The Nature Conservancy, however these populations are also threatened. Woody species are encroaching on the glade habitat near the Lyon Marker at Wilson's Creek National Battlefield. A system of interpretive trails occurs in this glade, although present visitor use does not appear to adversely impact the L. filiformis population. However, visitor use is expected to increase from 124,000 people in 1984 to 500,000 per year by 1990 (U.S. Fish and Wildlife Service, 1987). In addition, an exotic species of cheat grass (Bromus tectorum) is aggressively invading the open glade habitat where L. filiformis occurs. Management plans for this population must consider all of these factors. Woody invasion will also have to be controlled at the site owned by The Nature Conservancy. Twenty-one exotic plant species that may impact the L. filiformis population are recorded from this site (Ladd, pers. comm.).

Lack of information about specific details in the population dynamics of the species presently hinders management and recovery work. In 1982, no plants were observed at any known locations and in 1986, plants were present at some locations but not others. Information on the size and extent of populations, size of seed banks, amount of genetic variability, factors influencing seed germination, survival of overwintering rosettes, and effects of insect predation need to be determined. These factors will help quantify minimum viable population numbers, and the number

of secure populations needed for long-term survival of L.
filiformis.

Part II

RECOVERY

Recovery Plan Objective

The primary objective of this recovery plan is to protect and maintain thirty scattered, self-sustaining populations of Lesquerella filiformis. Fifteen of the thirty populations must be in secure ownership, occupy a minimum of one-half acre of habitat each, and show self-sustaining populations for at least seven years. The species may be considered for removal from the Federal List of Endangered and Threatened Species only after these goals are met.

The recovery goals can be accomplished by: 1) protection and management of existing populations, 2) inventory of suitable habitat for new populations, 3) continuing to monitor populations and conduct research on the species, 4) developing and initiating management programs on protected sites, 5) establishing new populations on public land, and 6) developing public awareness and support for conservation of the species.

Step-down Outline

1. Protect existing populations.
 11. Enlist the cooperation of the Missouri Highway and Transportation Department in protecting and managing for the species where it occurs on highway rights-of-way.
 12. Determine ownership of all extant populations and encourage conservation by private landowners.
2. Survey suitable habitat for additional populations.
 21. Identify and survey suitable habitat in Christian, Dade, Greene, Jasper and Lawrence counties.
 22. Identify and survey suitable habitat in surrounding counties.
 23. Protect through purchase or registry newly located populations where possible.
3. Monitor and conduct research on the species.
 31. Conduct autecological studies.
 311. Determine demography and population dynamics by sampling population numbers, frequency and reproduction, and by monitoring at least one population from fall germination through subsequent flowering.
 312. Conduct seed viability and longevity experiments.
 313. Collect soil samples to determine the number and viability of seeds present in the seed bank.
 314. Determine basic habitat characteristics by collecting data on temperature, rainfall and soil moisture at monitored populations.

315. Identify pollinators and causes of seed predation.
316. Determine the species' breeding system and conduct genetic analyses of selected populations.
32. Conduct management studies.
 321. Research the effectiveness of techniques such as controlled burning, timber cutting and cultivation in the control and suppression of woody vegetation, and determine their effects on L. filiformis populations.
 322. Research the effectiveness of techniques such as herbicide application, controlled burning, timber cutting, grazing and cultivation in the control of exotic species and determine their effects on L. filiformis populations.
4. Develop and initiate management programs on protected sites.
5. Establish new populations in areas not currently occupied.
 51. Develop propagation techniques.
 52. Identify and evaluate suitable habitat on public lands in the five-county area, including lands owned or managed by the Missouri Department of Conservation, the U.S. Forest Service and the National Park Service.
 53. Establish new populations.
 54. Monitor success of newly established populations.
 55. Provide seed to other organizations for storage and subsequent cultivation and/or research.
6. Develop public awareness programs and support for conservation of the species.

Narrative

1. Protect existing populations.

Extant population of Lesquerella filiformis must be protected and managed to ensure the survival of the species.

11. Enlist the cooperation of the Missouri Highway and Transportation Department (MHTD) in protecting and managing for the species where it occurs on highway rights-of-way.

Three populations of L. filiformis are known to occur on highway rights-of-way. MHTD officials have indicated a willingness to cooperate in managing these rights-of-way. Current policy calls for mowing after September 1 at a height of eight inches. These practices will not adversely affect the species, however the species is threatened by potential herbicide spraying done by MHTD to control woody vegetation. Woody vegetation should be controlled by hand cutting and stump treatment on those rights-of-way on which L. filiformis occurs.

12. Determine ownership of all extant populations and encourage conservation by private landowners.

Ownership of all extant populations of L. filiformis must be identified. Where the species occurs on private property, landowners should be contacted and apprised of the occurrence on their property and its significance. Landowners should be encouraged to participate in the conservation of the species through sale or donation to an appropriate agency or The Nature Conservancy, or registration and/or long-term

management agreements. Populations should be evaluated for size, viability and the potential for long-term survival in order to determine the best protection strategy for each. The Nature Conservancy has initiated landowner contacts and one privately owned population has been registered as a natural area with The Nature Conservancy.

2. Survey suitable habitat for additional populations.

Additional suitable habitat exists within the present range of the species. High priority should be given to identifying and searching these areas for additional populations. Searches should be conducted when the species is in flower. Due to the short two to three week flowering period and annual fluctuations in population numbers, some areas may need to be searched in more than one year.

21. Identify and survey suitable habitat in Christian, Dade, Greene, Jasper and Lawrence counties.

The Missouri Department of Conservation has an approved project with the U.S. Fish and Wildlife Service under Section 6 of the Endangered Species Act to conduct this search. These five counties constitute the historic and present range of the species, although records from Jasper and Lawrence counties have never been documented. Burlington limestone outcrops and glades will be identified, mapped and surveyed for L. filiformis.

22. Identify and survey suitable habitat in surrounding counties.

Burlington limestone is also mapped in parts of a few counties surrounding the five-county range of the species. This subtask should be completed after 21, as these are peripheral areas of the mapped Burlington limestone region.

23. Protect through purchase or registry newly located populations where possible.

Where new locations for the species are found on private property, landowners should be contacted as in subtask number 12.

3. Monitor and conduct research on the species.

An understanding of the ecology and life history of L. filiformis is necessary to manage and protect the species. The Missouri Department of Conservation conducted a three-year study to document life history information of the species on a population at Wilson's Creek National Battlefield (Morgan, 1986). Information was gathered on plant height, and numbers of stems, buds, flowers and fruits. A two-year research project to study the population ecology of L. filiformis is currently underway at Wilson's Creek National Battlefield through a contract with Missouri Southern State College. Additional information is needed, however, to manage for self-sustaining populations.

31. Conduct autecological studies.

Naturally occurring populations should continue to be studied to better understand the demographics and population dynamics of the species.

311. Determine demography and population dynamics by sampling population numbers, frequency and reproduction, and by monitoring at least one population from fall germination through subsequent flowering:

The lack of populations in some years may be due to lack of seed germination or mortality of overwintering rosettes. This research, coupled with information gathered from subtasks 312, 313, 314, 315 and 316 may lead to an understanding of why populations do not appear every year, and indicate individual population's chances of long-term survival. These monitoring studies should be conducted on approximately five populations but not at all known populations.

312. Conduct seed viability and longevity experiments.

Long-term survival of the species depends in part on longevity of the seeds in the seed bank, as well as an understanding of conditions required for germination to occur. This subtask must be completed before establishment of new populations can occur (subtask 53). These studies are being conducted by the CPC through the Missouri Botanical Garden and the University of Kentucky as part of subtask 55.

313. Collect soil samples to determine the number and viability of seeds present in the seed bank.

Long-term survival of populations is dependent on the size and viability of the seed bank. Adjacent

habitat should be checked for the presence of seeds also. If seeds are present, some populations may be expanded through appropriate management of surrounding habitats.

314. Determine basic habitat characteristics by collecting data on temperature, rainfall and soil moisture at monitored populations.

Seed germination, survival of overwintering rosettes, time and length of flowering are presumably affected by local temperature, rainfall and soil moisture. Understanding the relationship between biotic and abiotic factors will be important in management of the species.

315. Identify pollinators and causes of seed predation.

Identifying pollinators and their distribution will be important in projecting long-term chances of survival in newly established populations. The identification of species causing seed predation and their impacts on seed production need to be determined and their impact on the long-term survival of the species and individual populations evaluated.

316. Determine the species' breeding system and conduct genetic analyses of selected populations.

These factors are important in determining minimum viable population numbers. There is evidence to suggest that species which are self-compatible may survive at lower population levels than species that are obligate outcrossers. The amount of

genetic variability within populations is important in assessing long-term chances of survival.

32. Conduct management studies.

Management of L. filiformis populations will involve control of woody vegetation and exotic species, and management options will have to be compatible with the life history attributes of the species.

321. Research the effectiveness of techniques such as controlled burning, timber cutting, and cultivation in the control and suppression of woody vegetation, and determine their effects on L. filiformis populations.

This research should include gathering data on the affects of the techniques on all stages of the life history of L. filiformis including the seed bank. Research should be conducted on one population at Wilson's Creek National Battlefield in cooperation with the National Park Service.

322. Research the effectiveness of techniques such as herbicide application, controlled burning, timber cutting, grazing and cultivation in the control of exotic species and determine their effects on L. filiformis populations.

This research can be conducted in part in conjunction with subtask 321. Exotic species may respond differently to management practices necessary for control of woody species. All of these factors must be carefully assessed in research studies,

and some of these studies may need to be conducted on planted populations. These research studies may contribute to the demise of L. filiformis populations; however, this research is important for long-term management and survival of the species.

4. Develop and initiate management programs on protected sites.

L. filiformis is an annual species that occurs in successional habitats. These habitats may require disturbance to be maintained. As appropriate management practices are identified and developed in research conducted in subtask 32, they should be applied to the populations at Wilson's Creek National Battlefield and on The Nature Conservancy lands. Such practices may include controlled burning, timber cutting, selective grazing or cultivation. Additional management considerations should include visitor use impacts and competition from exotic species.

5. Establish new populations in areas not currently occupied.

Populations will need to be established on suitable habitat not currently occupied in order to meet the recovery goal of 30 scattered populations. The number of populations to be established will depend on the number of naturally occurring populations identified in subtasks 21 and 22. Populations should be established on protected, secure ownerships.

51. Develop propagation techniques.

Successful establishment of new populations depends in part on an understanding of conditions required for germination to occur. Studies are needed to test this as well as determine the best propagation methods. The

Center for Plant Conservation (CPC), through the Missouri Botanical Garden, has a formal agreement with Carol and Jerry Baskin through the University of Kentucky by which the Baskins conduct research on the propagation of L. filiformis, maintain a protected population in cultivation, and provide seeds to the Missouri Botanical Garden (MBG) for placement in the USDA seedbank and to support a population of the species at MBG.

52. Identify and evaluate suitable habitat on public lands in the five-county area, including lands owned or managed by the Missouri Department of Conservation, the U.S. Forest Service and the National Park Service.

Most public land occurring over Burlington limestone in the five-county range of the species is owned or managed by the Missouri Department of Conservation (MDC). Some lands surrounding Stockton Reservoir (U.S. Army Corps of Engineers) are managed by MDC. In addition, MDC has the responsibility for endangered species protection in Missouri and has a successful history of introducing and managing populations of rare species. Therefore, most of the planted populations will probably be established on MDC lands. However, additional habitat exists at Wilson's Creek National Battlefield and populations may be established there as well as on U.S. Forest Service land if suitable habitat is found.

53. Establish new populations.

After suitable sites on public land have been identified (subtask 52) and cultivation techniques have been determined (subtask 51), populations should be established to help achieve the recovery goal of 15 half-acre populations on protected public land.

54. Monitor success of newly established populations.

Newly established populations should be monitored to determine the success of the establishment effort, to monitor population trends, and to identify management needs.

55. Provide seeds to other organizations for storage and subsequent cultivation and/or research.

Lesquerella filiformis is presently known from only eleven sites, and population numbers fluctuate widely from year to year. The Missouri Botanical Garden, as a participating institution in the Center for Plant Conservation (CPC), has received seeds of the species for research, cultivation and long-term storage as described in subtask 51. Efforts of this type should be encouraged and continued.

6. Develop public awareness programs and support for conservation of the species.

Education of the public is an important part of the recovery process. Public interest groups such as the Missouri Native Plant Society, The Nature Conservancy, the Missouri Botanical Garden, the Wilson's Creek National Battlefield Foundation, and local Audubon groups and garden clubs should be kept informed of recovery efforts. Establishing a

population of L. filiformis on the glade at the MDC Springfield Nature Center (to be opened in 1988) followed by interpretive programs concerning rare species conservation would reach audiences within the range of the species. Programs and brochures could also be developed for use at Wilson's Creek National Battlefield. A short video could be developed for use at television stations in the Springfield and Joplin area, the MDC nature center and Wilson's Creek National Battlefield.

In addition to fostering a public awareness of the species, it is important to give particular attention to private landowners of L. filiformis populations. This includes maintaining liaison and cooperation with public utility companies to encourage recovery on their property.

Literature Cited

- Baskin, J.M. and C.C. Baskin. 1985a. The annual dormancy cycle in buried weed seeds: a continuum. *Bioscience* 35:429-498.
- _____. 1985b. Life cycle ecology of annual plant species of cedar glades of southeastern United States. pp. 371-398. In White, J. (ed.). *The Population Structure of Vegetation*. Dr. W. Junk Publishers, Dordrecht.
- Missouri Geological Survey. 1979. *Geologic Map of Missouri*. Department of Natural Resources, Division of Geology and Land Survey. Rolla, Missouri.
- Morgan, S.W. 1980. Status report on Lesquerella filiformis Rollins. Missouri Department of Conservation. Unpub. report. 15pp.
- _____. 1983a. Field investigations of Lesquerella filiformis, Spring 1983. Missouri Department of Conservation. Unpub. report. 12pp.
- _____. 1983b. Species accounts; Lesquerella filiformis: an endemic mustard. *Natural Areas Journal* 3:59-62.
- _____. 1986. A study of a population of Lesquerella filiformis Rollins in Missouri. Missouri Department of Conservation. Unpub. report. 11pp.
- Payson, E.R. 1921. A monograph of the genus Lesquerella. *Ann. Mo. Bot. Garden* 8:103-236.
- Rollins, R.C. 1956. On the identity of Lesquerella angustifolia. *Rhodora* 58:199-202.
- _____. 1963. The evolution and systematics of Leavenworthia (Cruciferae). *Contr. Gray Herb.* 192.
- Rollins, R.C. and E.A. Shaw. 1973. The genus Lesquerella (Cruciferae) in North America. Harvard University Press, Cambridge, pp. 92-95.
- Steyermark, J.A. 1963. *Flora of Missouri*. Iowa State University Press, Ames, pp. 746-747.
- U.S. Fish and Wildlife Service. 1987. Determination of endangered status for Lesquerella filiformis (Missouri bladder-pod). *Federal Register* 52:679-682.

PART III

IMPLEMENTATION SCHEDULE

The Implementation Schedule that follows outlines actions and costs for the Lesquerella filiformis recovery program. It is a guide for meeting the objectives elaborated in Part II of this plan. This schedule indicates the general category for implementations, recovery plan tasks, corresponding outline numbers, task priorities, duration of tasks, ("ongoing" denotes a task that once begun should continue on an annual basis), which agencies are responsible to perform these tasks, and lastly, estimated costs for FWS tasks. These actions, when accomplished, should bring about the recovery of Lesquerella filiformis and protect its habitat.

General Categories for Implementation Schedule

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. Dispersal
9. Predation
10. Competition
11. Disease
12. Environmental contaminant
13. Reintroduction
14. Other information

Management - M

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

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

Recovery Action Priorities

- 1 = an action that must be taken to prevent extinction or to prevent the species from declining irreversibly.
- 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.

Abbreviations Used

- FWS - USDI Fish and Wildlife Service
SE - Office of Endangered Species
CPC - Center for Plant Conservation
MDC - Missouri Department of Conservation
MHTD - Missouri Highway and Transportation Department
NPS - National Park Service
TNC - The Nature Conservancy
TBD - To Be Determined

IMPLEMENTATION SCHEDULE

GENERAL CATEGORY	PLAN TASK	TASK #	PRIORITY #	TASK DURATION	RESPONSIBLE AGENCY		FISCAL YEAR COSTS (EST.)			COMMENTS	
					FWS REGION	PROGRAM	OTHER	FY 1	FY 2		FY 3
R4, M3, M4	Conduct management studies	32	2	TBD	3	SE	MDC NPS TNC MHTD	5000	6250	6250	
I1, I2	Survey suitable habitat for additional populations.	2	2	3 yrs	3	SE	MDC MHTD	3750	8750	8750	
R1, R3, R6 R7, R9, R13, R14	Conduct monitoring studies on natural populations.	31	2	TBD	3	SE	MDC NPS TNC MHTD	3750	8750	8750	
R4, M3	Develop and initiate management programs on protected sites.	4	1	ongoing	3	SE	MDC TNC NPS	7500	7500	7500	
A1, A2, A3, A6, M3	Protect and manage existing populations.	1	1	ongoing	3	SE	TNC NPS MHTD	50,000	150,000	150,000	
M7	Protect gene pool by providing seed to CPC.	55	2	1 yr.			MDC CPC		625		
I2, M2	Establish populations on public land.	5	3	ongoing	3	SE	MDC	6250	6250	6250	

IMPLEMENTATION SCHEDULE

GENERAL CATEGORY	PLAN TASK	TASK #	PRIORITY #	TASK DURATION	RESPONSIBLE AGENCY			FISCAL YEAR COSTS (EST.)			COMMENTS
					FWS REGION	PROGRAM	OTHER	FY 1	FY 2	FY 3	
01	Develop public awareness and support for conservation of the species.	6	3	ongoing	3	SE	MDC TNC NPS		5,000	7,500	

Costs are estimated and these schedules can be updated as needed.

APPENDIX

AGENCIES AND ORGANIZATIONS ASKED TO PROVIDE REVIEW COMMENTS

Superintendent, Wilson's Creek National Battlefield, National
Park Service, Postal Drawer C, Republic, Missouri 65738-
0403

Chief Engineer, Missouri Highway and Transportation Department,
P.O. Box 270, Jefferson City, Missouri 65102

Director, Missouri Department of Conservation, P.O. Box 180,
Jefferson City, Missouri 65102

U.S. Forest Service, Eastern Region, 310 W. Wisconsin Ave.,
Milwaukee, Wisconsin 53203

George Rogers, Missouri Botanical Garden, P.O. Box 299, St.
Louis, Missouri 63166-0299

Linda R. McMahan, The Center for Plant Conservation, 125 The
Arborway, Jamaica Plain, Massachusetts 02130

James D. Jacobi, Hawai'i Research Station, P.O. Box 44, Hawai'i
National Park, Hawai'i 96718