FINAL REPORT

As Required by

THE ENDANGERED SPECIES ACT, SECTION 6

TEXAS
Project No: E-1-4

ENDANGERED AND THREATENED SPECIES CONSERVATION

Job No. 6.1

White Bladderpod (*Lesquerella pallida*) Management Procedures

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FINAL REPORT

STATE: TEXAS PROJECT NO.: E-1-4

PROJECT TITLE: Endangered and Threatened Species Conservation.

PERIOD COVERED: September 1, 1991 through August 31, 1992

JOB NUMBER: 6.1

JOB TITLE: White Bladderpod Management Procedures

JOB OBJECTIVE: Define the reproductive phenology of white bladderpod (*Lesquerella pallida*) and analyze the effects of grazing, shading, and herbaceous layer competition on growth and reproduction; encourage landowners to implement management procedures designed to ensure the survival of the species (i.e. prescribed burn, selective brush removal, grazing management); monitor eproductive success under various management regimes; and refine management recommendations.

SEGMENT OBJECTIVES:

Evaluate various management procedures in an attempt to determine which practice would best insure the survival of the species using standard ANOVA and other statistics. Evaluation of the effects of grazing. Field surveys were also completed and landowners contacted to locate possible unknown populations and potential reintroduction locations.

ACCOMPLISHMENTS

See Attachment

SIGNIFICANT DEVIATIONS

All experimental manipulations were carried out for the 1991 season with two exceptions. Spring burning within the spring burn plot was not completed to prevent killing a significant number of individuals which growing in the plot during that time. The spring burn plot then became a control. Additionally, the fall of 1991 was a period of very high precipitation, and the fall burning could not be initiated until mid-December when white bladderpod had already established. Therefore, the fall burns were not completed, and the management experiment was altered to assess prescribed burning and brush clearing on the second season after treatment.

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Report to Texas Parks & Wildlife Department
on
Study of Lesquerella pallida S. Wats. (white bladderpod)
during the 1992 field season, and summary of 1990-1992 studies.

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ABSTRACT

Effects of various management regimes for Lesquerella pallida (Torrey & A. Gray) S. Wats. (white bladderpod) were examined in an attempt to determine which management practices could best be utilized to insure the survival of the species. Specifically, seven major questions were addressed: 1) What are the effects of prescribed burning on reproduction of L. pallida? 2) What are the effects of various methods of removing woody vegetation on reproduction of L. pallida? 3) What are the primary competing species with L. pallida? 4) What are the effects of grazing on reproduction of L. pallida? 5) What additional factors impact reproduction of L. pallida? 6) Do previously unreported populations of L. pallida exist? 7) Are sites available for reintroduction of L. pallida? 8) What are germination and survival rates for L. pallida seeds and seedlings?

Prescribed burning was determined to have a beneficial impact on reproduction. Most mechanical means of brush removal appeared to have a positive effect on reproduction, while chemical treatments and disking or plowing produced a negative impact. Major competing (or at least negatively correlated) taxa appear to be Andropogon virginicus L., Dracopis amplexicaulis (Vahl) Cass., Lonicera japonica Thunb., Satureja arkansana (Nuttall) Briq., Sisyrinchium langloisii E. Greene, Trifolium dubium, Vulpia octoflora (Walt.) Rydb., and Weissia controversa Hedw. Light to moderate grazing had little effect except to delay reproduction. Heavy grazing would be expected to prevent reproduction. Climatic variability (rainfall amounts and timing, and temperature, each and probably in combination) and pocket gopher activity influence reproduction. Two previously unreported localities for L. pallida were found. Several apparently suitable but unoccupied sites for L. pallida were located.

INTRODUCTION

Lesquerella pallida (Torrey & A. Gray) S. Wats. (Brassicaceae) was (at the onset of this study) known only from five populations. All are within a small area of San Augustine County, Texas. The species is listed by the U.S. Fish and Wildlife Service as endangered. Plants are found in "glade" situations on outcrops of the Weches Formation (Eocene). Although Weches outcrops are not extensive, a number of Weches outcrops occur in the area surrounding the location of known L. pallida populations. To date, L. pallida has been found on only a limited subset of the habitats apparently available to it. Five

major questions were addressed during the course of this study: 1) What are the effects of prescribed burning on reproduction of L. pallida? 2) What are the effects of various methods of removing woody vegetation on reproduction of L. pallida? 3) What are the primary competing species with L. pallida? 4) What are the effects of grazing on reproduction of L. pallida? 5) What additional factors impact reproduction of L. pallida? 6) Do previously unreported populations of L. pallida exist? 7) Are sites available for reintroduction of L. pallida? 8) What are germination and survival rates for L. pallida seeds and seedlings?

MATERIALS AND METHODS

Study Site.

The primary study site was on the Halley Property, ca. 2 km SE of the center of San Augustine, San Augustine Co., Texas (ca. 31 degrees 31' N, 94 degrees 06' W). Populations of Lesquerella pallida were located on edges of a "glade" area on an outcrop of the Weches Formation. The site was concurrently in use as a pasture for cattle. Much of the formerly open outcrop area has been invaded by woody vegetation, such that well over 70% of the area was dominated by woody plants > 2 m tall. Areas remaining open were where the soil is very thin (< 5 cm).

Sites for assessment of past management practices were on and near each of the five known sites for Lesquerella pallida. Germination experiments were completed in the greenhouse at Sam Houston State University, and on the Halley property near San Augustine.

Experimental design.

Seven 5 X 5 m sampling sites were selected in order to institute a factorial experimental design (Steele & Torrie 1980), and studied for the duration of the season. Five of these sites were established during the 1990 growing season and are the same sites used during the 1991 field studies. All sites were located on approximately the same contour on a heavily brush covered, 5-7 degree slope, facing 30-40 degrees west of north. Sites were located in a band of relatively less dense woody vegetation along a contour on the slope. Some unavoidable heterogeneity in woody vegetation type and density was apparent within and between the sampling sites. Site 1 (spring burn) was the most open site and was chosen for the spring burn treatment because of the relative abundance of grasses which would provide the best fuel for the spring fire (during a time of year when burning would likely be difficult due to high moisture levels). Site 2 (control--no clearing or burning) was intermediate in woody vegetation cover). Sites 3 (brush removal--no burning), 4 (fall burning--no brush removal), and 5 (fall burning and brush removal) had approximately equal amounts of woody vegetation, at a density greater than either site 1 or 2. Prescribed burning was completed by the Texas Forest Service (San Augustine Office). Brush removal was completed using bow saws and axes. With the exception of spring burning, all experimental manipulations were completed for the 1991 season by 15 December 1990. Spring burning was not completed because a significant number of individuals of L. pallida would have been killed during a burn in the spring. Therefore, site 1 became a second control site. Additional sites were established to represent each of the following treatments: 6) early fall burn (prescribed burn in October 1991); 7)

consecutive burn and clear (repeat preparation for part of site 5 above, in October 1991). These sites were marked, however, the fall of 1991 was a period of very high rainfall in the area, and burning could not be initiated until mid-December 1991. By this time, L. pallida plants were already growing and would have been killed by the fire. Therefore, no burning was completed, and the management part of the experiment was altered to assess prescribed burn and brush clearing the second season after treatment.

Within each sampling site (block), three 1.5 X 1.5 m subsites were designated, each of which contained fifteen 50 X 25 cm plots. The sampling areas were in an active pasture, therefore, exclosures were necessary to prevent damage by grazing animals. Fencing was impractical because of thin soils over underlying rock. Exclosures were constructed from reinforcing wire formed into a box shape and placed over sampling areas. Corners of the areas containing plots were permanently marked in each treatment of each block, and plots located within a treatment by placing a movable grid at marked corners each time sampling was initiated. This method of locating plots provided consistency of locating plots from one sampling period to the next, with a minimum of disturbance to sites or livestock.

Contact was made with landowners of sites where Lesquerella pallida is either now found, or where physical conditions appear favorable for growth of L. pallida. Interviews were conducted with the landowners and local Soil Conservation Service (SCS) agents, and SCS records accessed to determine past (most recent 25 years) land use (brush hogging, burning, herbicide use, grazing, pasture seeding, cultivation, and bulldozing) on paired sites, in order to compare for correlations between long term use and management for L. pallida. Pairwise comparisons were made between sites with L. pallida and sites on adjacent Weches outcrops with similar slopes, etc., supporting 0(typically)-5 plants of L. pallida in the best growth season (1991) of the study. Differences between management practices were determined by comparative density of Lesquerella pallida plants found in four 1.5 x 0.5 m plots in each study site (except pocket gopher comparisons, where adjacent nonpocket gopher sites of the same size as pocket gopher mounds were used for comparison).

Germination and survival rate for Lesquerella pallida were assessed in greenhouse and field trials. Using seed collected in May 1991, sowing was completed in greenhouse plots (with cold stratified seed [5 degrees C for 30 days]) and field plots (unstratified seed) on a site ca. 200 m south-southwest of the parent population. The field site was apparently suitable for L. pallida, but without plants of the species during the past two years. This experiment was designed to estimate feasibility of introduction of L. pallida into apparently suitable but unoccupied sites. Ten 50 X 50 cm plots with 100 seeds each were established and monitored. Based on previous data suggesting that L. pallida grows well in association with recent pocket gopher mounds, five greenhouse plots were produced by collecting loose soil from pocket gopher mounds and placing the soil in wooden flats, while five field plots were produced by clearing 1 X 1 m sites, raking, and locating a plot in the center of each site. If reintroduction of L. pallida is determined to be feasible, the possibility exists of reintroducing the plant to other sites which occur in east Texas. Ultimately, this could lead to downlisting of the species.

Data collection.

Data were recorded from each management plot and germination plot at approximately two week intervals from mid-January to mid-June. Sampling was completed on 26 January 1992, 1,15, and 29 February 1992, 14 and 28 March 1992,

11 and 25 April 1992, and 16 and 25 May 1992. Additional sampling was conducted on 7, 19, and 20 March, 4 and 18 April, and 8 and 16 May 1992. For each Lesquerella pallida plant found in the plots, number of leaves, height of plant, number of buds, number of flowers, and number of fruits were recorded.

Data analysis.

Data were entered into the VAX computer system at Sam Houston State University. Analysis of variance and Pearson correlations were the primary statistical tools used to assess relationships between management and Lesquerella reproductive success. Correlations and significance tests were generated by the SAS Data Analysis System.

Identification.

Plant identification utilized Correll & Johnston (1970) and Gould (1978).

RESULTS AND DISCUSSION

Lesquerella plants were found in all sites through the 20 March sampling. However, fewer plants (< 10%) were observed than during the same time periods in 1991. The reason for the reduced number of plants was not clear, since temperatures had been warm and rainfall had been average or above average since early autumn 1991. Unusually high rainfall during the months of September through mid-November 1991 may have adversely affected seed survival and germination. Dry weather during late November and December 1991 may have contributed to reduced numbers of plants in January and February 1992. Lack of cold temperatures during November through February may have reduced germination rates.

Populations of Lesquerella pallida suffered a severe decline apparently due to a late frost on 23 March 1992. Effect of the frost was surprising since the plants normally germinate in November and December, and the rosettes overwinter. However, January and February were unusually warm and wet, and this may have contributed to the susceptibility of the plants. In addition, when the frost occurred, most plants had already begun to bolt, and they may be more susceptible at this stage than in the rosette stage.

Examination of other known populations showed that they also had greatly reduced numbers of plants. The population located south of highway 21, west of San Augustine, had more than 5000 plants in both 1990 and 1991, and fewer than 100 (26 counted on about one third of the site) in 1992. The site north of highway 21, and west of San Augustine, had more than 200 plants in 1990, 150-200 in 1991, and 10 in 1992. The site near Ford's Corners had more than 500 plants in 1990 and 1991, and 22 in 1992 (none seen in pasture adjacent to right-of-way in any year). The primary study site had more than 2000 plants in 1990, more than 4000 in 1991, and fewer than 200 in 1992. The site approximately 1 km east of the primary study site had 0 plants in 1990, 8 in 1991, and 0 in 1992.

Peak flowering period was delayed 2-3 weeks in 1992 compared to 1990 and 1991. This may have been due to preferential frost resistance by plants less advanced in growth rates.

Effect of experimental treatments on growth parameters of Lesquerella pallida.

Analysis of the complete data set for the 1992 Lesquerella pallida management study is summarized in Table 1. Due to the small size of the data matrix (many fewer plants found in plots than 1991), confidence levels were generally lower than those reported in 1991. In addition, computed correlations and analysis of variance were affected by the sudden elimination of most of the plants due to frost in the midst of the study.

Table 1.

ANOVA results (F statistics) and Pearson correlation coefficients (rounded to two decimals) comparing measures of Lesquerella pallida growth features to sampling date, experimental treatment, pocket gopher activity, and shading by shrubs. N=136.

		time	burn	clear	pocket gophers	shade
leaf number	F	25	.41	.02	1.6	1.7
	sig. F	<.1	53	88	21	20
	correlat.	-.11	.06	.01	.11	.11
	sign.	not	not	not	not	not
plant height	F	9.5	.32	.05	.53	6.6
	sig. F	<.1	57	82	47	1.1
	correlat.	.28	-.05	-.02	.06	.22
	sign.	<1	not	not	not	<5
bud number	F	4.4	1.2	1.9	.93	5.2
	sig. F	.6	28	18	34	2.4
	correlat.	.23	-.09	-.12	.08	.19
	sign.	<1	not	not	not	<5
flower number	F	7.4	4.7	.02	.30	8.6
	sig. F	<.1	3.3	89	58	.4
	correlat.	.29	-.18	-.01	.05	.25
	sign.	<1	<5	not	not	<1
fruit number	F	2.5	1.7	1.1	1.9	4.6
	sig. F	6.0	19	29	17	3.4
	correlat.	.18	-.11	-.09	.12	.18
	sign.	<5	not	not	not	<5

As might be expected, since growth produces more material (leaves, stems, buds, flowers, fruits) over the lifetime of a plant, time of sampling was generally significantly correlated and covariant with each of the growth measures. The exception being leaf number, which decreased dramatically after the frost, producing poor correlation, but retaining significant covariance. Correlations of other growth measures were less affected by the frost, since relatively few buds, and no flowers or fruits had yet been produced by the time of frost. Stem length was closely associated with time, because plants that survived continued to show stem elongation.

Poor correlations and insignificant F-test results were the rule for comparison of each of the growth and reproductive success measurements with the three experimental variables (prescribed burn, brush clearing, and pocket

gopher activity). The only exception to this was a significant negative association of flower production with prescribed burning (F significance at 3.3% and correlation significance at <5%). This result suggesting that prescribed burning had some detrimental effect, at least in this atypical growing year.

Similar to the results for 1991, positive correlations were noted between pocket gopher activity and Lesquerella growth parameters. However, in contrast to 1991 data, 1992 data did not show significant associations between pocket gopher activity and L. pallida growth. This lack of relationship may be explained by the climatically unusual year, in which L. pallida growing close to shrubs were more likely to reproduce and the negative association between pocket gopher activity and shrub density.

Although not as strong as the association with time, strong associations were computed between each of the growth parameters (except leaf number) and the location of Lesquerella plants directly under shrubs. This result can be explained by the protection from a light frost, that a shrub might provide to the plants growing under it. If shrubs provide protection from frost, then lack of shrubs in the cleared and/or burned areas could explain the lack of association (or negative association) between L. pallida growth variables and these treatments.

Table 2.

ANOVA results (F statistics) and Pearson correlation coefficients (rounded to two decimals) comparing summarized measures of Lesquerella pallida growth features to sampling date, experimental treatment, pocket gopher activity, and shading by shrubs. N=34.

		time	burn	clear	pocket gophers	shade
leaf number	F	2.4	1.5	.02	1.3	.09
	sig. F	11	24	89	27	76
	correlat.	.34	.21	-.03	.19	.05
	sign.	<5	not	not	not	not
plant height	F	17	.46	.28	.89	5.9
	sig. F	<.1	50	60	35	2.1
	correlat.	.71	-.12	-.09	.16	.40
	sign.	<1	not	not	not	<5
bud number	F	6.0	.77	1.9	.53	4.3
	sig. F	.6	39	21	47	4.6
	correlat.	.51	-.15	-.22	.13	.35
	sign.	<1	not	not	not	<5
flower number	F	100	6.0	.02	.34	12
	sig. F	<.1	.2	89	56	.1
	correlat.	.86	-.40	-.02	.10	.53
	sign.	<1	<5	not	not	<1
fruit number	F	6.5	1.8	1.2	2.1	5.2
	sig. F	.4	19	29	16	2.9
	correlat.	.50	-.23	-.19	.25	.37
	sign.	<1	not	not	not	<5

Some of the effects of frost were eliminated by producing a summary data set for each plant in the sample (summarizing peak production of leaves, buds, flowers, fruits, and stem length), rather than retaining all data for each plant for each sampling period. These results are shown in Table 2. Comparison of the two tables will show the same basic pattern in Table 2 as in Table 1, with slightly more statistical significance from the summary data.

Effect of past management on growth parameters of Lesquerella pallida.

Long term management studies produced the results shown in Table 3. Prescribed burning was shown to be significantly positively associated with increased Lesquerella pallida density in each case where this variable was examined. Grazing (apart from "pasture improvements") appeared to have little effect on L. pallida density. Pasture improvements (including broadleaf herbicide use, cultivation, and seeding of pasture grasses--typically all in combination) had a dramatic negative impact on density of L. pallida plants. Presence of pocket gophers had a significant positive influence on L. pallida density, although since fresh pocket gopher mounds occupy only a small fraction of the space available to L. pallida, these animals may not be critical to L. pallida success on a larger scale. Brush-hogging alone had a significant positive effect on L. pallida density. However, brush-hogging in combination with "pasture improvements" has a detrimental effect. Although not sampled in this study (because none of the study sites had received this treatment), brush-hogging operations when the ground is saturated might likely have similar effects as bulldozing. Bulldozing had a pronounced negative effect on L. pallida density, even though the bulldozed site for this study had been bulldozed over twenty years previously and was directly adjacent to a large population of L. pallida.

Results of germination experiments.

Mean germination rate in greenhouse plots was 62.5%, while in field plots, mean germination rate was 8.2%. F-test on greenhouse vs. field plots showed a significant difference at $p<.1$. Correlation of greater likelihood of growth in greenhouse plots over field plots was also highly significant at .98 ($p<.1$). None of the plants in field plots reached reproductive maturity. Plants in the greenhouse reaching reproductive maturity did not differ in size or number of leaves, buds, and flowers from field plants measured in 1990 or 1991. However, greenhouse plants were significantly larger and with more leaves, buds, and flowers than 1992 field plants. Fruit set per flower was not significantly different between field and greenhouse plants.

Table 3.

ANOVA results (F statistics) and Pearson correlation coefficients (rounded to two decimals) comparing effects of various long term management practices. Each row in the table represents an individual pairwise comparison of a specific management practice or combination of management practices. Differences between management practices are determined by density of Lesquerella pallida plants found in four 1.5 x 0.5 m plots in each study site.

treatment	F	signif F	correlation	signif corr
prescribed burn	15.	<.1	.38	<.1
prescribed burn	4.9	2.8	.32	<.1
prescribed burn	7.7	.8	.38	<.1
prescribed burn	4.5	3.2	.31	<.1
prescribed burn	17.	<.1	.86	<.1
grazing	1.7	20	-.18	not
grazing	3.7	10	.22	not
pasture improvement	20.	<.1	-.55	<.1
pasture improvement	19.	<.1	-.87	<.1
pasture improvement	67.	<.1	-.96	<.1
pasture improvement	26.	<.1	-.90	<.1
pocket gopher presence	11.	<.1	.38	<.1
brush-hog	26.	<.1	.90	<.1
bulldozing	19.	<.1	-.87	<.1

CONCLUSIONS AND MANAGEMENT RECOMMENDATIONS

Effects of prescribed burning.

Prescribed burning was determined to have a beneficial impact on reproduction. Fire appears to be useful to stimulate growth of Lesquerella pallida, possibly both by triggering germination and by removing competing plants from the burned sites. Fire appears to have at least a short term detrimental effect on pocket gopher activity. This effect is likely to be temporary in that the fire does not directly affect the animals, and the gophers become more active in the burned area once vegetation begins to recover after the burn.

Effects of removal of woody vegetation.

In addition to prescribed burns, most mechanical means (brush-hog, saw, ax, etc.) of brush removal appeared to have a positive effect on reproduction, while chemical treatments and disking or plowing produced a significant negative impact.

Associated species.

A total of 151 plant species were found on the primary study site, in addition to Lesquerella pallida. Many were found in very low frequency, others were abundant. Closely associated with Lesquerella on a microscale (50 x 25 cm) were Allium canadense, Astragalus leptocarpus, Chaerophyllum tainturnieri, Gaura parvifolia, Geranium carolinianum, Muhlenbergia schreberi, Petalostemum

pulcherrimum, Physalis viscosa, Salvia lyrata, Sanicula canadensis, Sporobolus asper, and Viola rafinesquii. Plants with greatest frequency of occurrence within populations of L. pallida (10 x 10 m scale) were Aesculus pavia, Andropogon virginicus, Bouteloua curtipendula, Cacalia plantaginea, Calylophus drummondii, Dracopis amplexicaulis, Hedyotis nigricans, Ipomopsis rubra, Lonicera japonica, Manfreda virginica, Onosmodium occidentale, Petalostemum pulcherrimum, Prunus mexicana, Rhus glabra, Rudbeckia triloba, Satureja arkansana, Schizachyrium scoparium, Sisyrinchium langloisii, Thelesperma filifolia, Trifolium dubium, Vulpia octoflora, Weissia controversa, and Yucca arkansana.

Several of the latter plants were negatively correlated with Lesquerella pallida growth on a microscale. Both Andropogon and Weissia are probably significant competitors with Lesquerella for growing sites. Andropogon is a perennial grass, forming dense stands in which Lesquerella does not grow well. Seeds may germinate and plants grow, but they tend to be small. Prescribed burn appears to be an effective management tool to open stands of Andropogon and allow growth of L. pallida. Weissia is a moss that forms dense mats on the soil surface. This mat makes successful growth of young Lesquerella plants difficult (hence the negative correlation with plant number). However, when a Lesquerella plant is able to penetrate the mat of Weissia the Lesquerella does quite well (possibly due to lower evaporation rates from the soil). Satureja is probably less a competitor than an indicator of unsuitable sites for Lesquerella. Satureja is abundant on thin (< 3 cm) soils where water stands after precipitation, while Lesquerella is found on somewhat deeper soils with better drainage (often on slopes). The situation with Dracopis and Sisyrinchium is probably similar to that with Satureja. Vulpia is an annual grass and probably competes with Lesquerella, however Vulpia is phenologically somewhat later than Lesquerella. Trifolium dubium and Lonicera japonica are important introduced competitors on the study site. Rosa bracteata is a significant competitor on other sites. Each of these three latter species can be expected to increasingly impact L. pallida unless steps are taken to control their spread.

Effects of grazing.

Light to moderate grazing had little effect except to possibly delay reproduction. Heavy grazing would be expected to prevent reproduction.

Additional factors impacting Lesquerella pallida reproduction.

Chemical treatments and disking or plowing produced a significant negative impact. Climatic variability (rainfall amounts and timing, and temperature, each and probably in combination) and pocket gopher activity influence reproduction. Pasture improvement (cultivation, herbicides) had a significant negative impact on occurrence of Lesquerella pallida. Use of heavy equipment (brush hogging or other) should be avoided during the months of November through June, and when the ground is very wet, in order to limit large scale disturbances of the soil. Quarrying activity also poses a potential threat to the species as this activity (probably permanently) alters sites where L. pallida might grow. Construction and general urbanization activities pose threats to L. pallida through loss and/or alteration of habitat. A likely site for the original collection of L. pallida is now a housing development and park on the south side of San Augustine. Pocket gopher activity is positively correlated with reproductive success of L. pallida. Maintenance of viable

pocket gopher colonies may have a significant impact on long term survival of L. pallida, in that disturbance by these animals provides sites for seed germination and growth of white bladderpod in areas where vegetation might otherwise be too dense for the plant to grow well. Fire appears to have at least a short term detrimental effect on pocket gopher activity.

Previously unreported populations of Lesquerella pallida.

Two previously unreported localities for Lesquerella pallida were found. Each is in pasture on the Halley property southeast of San Augustine. One contained one plant in 1991, the other had three plants in 1991. No plants were observed in either population in 1992.

Available reintroduction sites.

Several apparently suitable but unoccupied sites for Lesquerella pallida were located. The most promising of these are contiguous or nearly so with existing populations. Other possible reintroduction sites are found in the general areas of San Augustine and Nacogdoches counties (see map included in Mahler 1985).

Germination and survival rates.

Greenhouse grown plants germinated and grew at a significantly greater rate than field grown plants. It was not clear from the experiment whether the difference was due to overall experimental setting (greenhouse vs. field), the unusual meteorological conditions in the field, or the difference in preplanting treatment (cold stratification vs. none).

Recovery recommendations.

Due to the effect of genetic bottlenecks on genetic variability, a minimum number of individuals (say 150) in the worst years would probably be a useful measure of potential for recovery of the species, and threshold level for monitoring purposes. If it can be shown that seeds remain viable and can contribute individuals beyond the succeeding growing season, then the numbers can be adjusted accordingly (i.e., if it can be shown that more than 50% of the seeds survive to provide seed for the second year after they are produced, then a viable minimum in the worst years might be 80 plants). The numbers given here are rather arbitrary, since no information is currently available on the genetic make-up of populations of Lesquerella pallida.

All known sites for Lesquerella pallida are either on private land or roadside rights-of-way. While the fact that the plants are present indicates that these sites have been managed in a manner compatible with the survival of L. pallida, no guarantee exists that such management will continue. Efforts should be made to educate landowners about the presence or potential presence of L. pallida on their properties, obtain commitments from the landowners to manage the properties for survival of L. pallida, to assist these landowners (with expertise, funds, equipment, labor, etc.) in their efforts to manage the sites for the benefit of L. pallida, and reintroduce L. pallida to suitable sites where it does not now occur.

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