MONITORING POPULATIONS OF SHOSHONEA PULVINATA IN THE PRYOR AND BEARTOOTH MOUNTAINS, CARBON COUNTY, MONTANA

1991 ESTABLISHMENT REPORT

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INTRODUCTION

Passage of the Federal Endangered Species Act of 1973 and subsequent recognition of the value of conserving biotic diversity (Wilson 1988) have resulted in many government agencies becoming active in species conservation. Surveys to determine the location and size of populations of rare species are being conducted on public lands throughout the west. These surveys are necessary in any species conservation program; however, knowing the location and size of populations at any one point in time is only the first step in a long-term protection strategy (Sutter 1986). Understanding the population dynamics of long-lived perennials is especially difficult because noticeable changes usually occur slowly, and important growth-limiting population-level events, such as bouts of recruitment or catastrophic mortality may occur only at infrequent intervals (Braughman and Murphy 1990). Thus, long-term monitoring of growth, fecundity, recruitment and mortality is essential for understanding the condition and trends of plant populations, particularly long-lived, slow-growing species.

Shoshonea (Shoshonea pulvinata Evert & Constance) is a long-lived, mat-forming perennial in the Carrot Family (Apiaceae). This recently described species (Evert and Constance 1982) comprises a monotypic genus endemic to the Beartooth and Pryor mountain ranges of Carbon County, Montana and the Absaroka and

Owl Creek ranges of Park and Fremont counties, Wyoming (Lesica and Shelly 1988). In Montana, shoshonea is generally restricted to shallow, calcareous soils of exposed limestone outcrops, rims, ridgetops and talus slopes at 6,800-7,800 ft (Lesica and Shelly 1988). In Montana, there are no apparent, immediate threats to populations of shoshonea. However, the species is threatened in the Beartooth Mountains by potential mining or oil and gas development and, in the Pryor Mountains, by grazing of wild horses. The species is ranked as G2G3/S1 (globally threatened, state endangered) by the Montana Natural Heritage Program and is considered sensitive in Montana (Lesica and Shelly 1991). Shoshonea is listed as sensitive by Region One of the U.S. Forest Service (Lesica and Shelly 1991) and is a candidate for listing as a threatened or endangered species by the U.S. Fish and Wildlife Service (USDI-FWS 1990).

This report describes the establishment of long-term monitoring studies at three sites in Carbon County, Montana. We also detail the methods used in reading the permanent transects and present the first year's data. Finally, we discuss statistical methods for analyzing the data.

METHODS

Study Sites

Grove Creek

Location: From the town of Belfry, take Hwy 72 south ca. 9 miles to the secondary road that crosses the Clark's Fork Yellowstone River. After crossing the river proceed west ca. 1 mile to a T-intersection. Proceed north, following the signs for the Meeteetse Trail. Continue for ca. 11 miles to the crossing of the South Fork of Grove Creek. Cross the creek and go west for a short distance and then go right and continue along the face of the mountains rather than going up into the canyon. Continue for ca. 1 mile to the North Fork of Grove Creek. Cross the creek and take the road into the canyon as far as it goes. At this point follow the trail up into the canyon, and once the cliffs are passed, turn north and climb to the ridge just west of the cliff-forming ridge (see Fig. 1). T8S R20E S26, NE1/4 of NW1/4; ca. 7,000 ft.

The transect is on a narrow portion of the ridge ca. 100 yds west of the highest point of the ridge in Section 26. The two ends of the transect are marked by

reinforcing bar pounded into the ground and painted red on top.

Line Bearing: start to end 353° Line Length: 10 meters

Instructions: start at north end of transect; read west side of transect line.

Mystery Cave Ridge

Location: From Big Ice Cave turnout on top of the Pryor Range, proceed north and east ca. 5 miles on the main secondary road towards Dryhead Vista Point. One mile west of Dryhead Vista the road forks; take the right fork and proceed on this deteriorating road east and south 4.1 miles to an old cabin. Continue south for ca. 3/10 mile to a fork in the road. Follow the left fork of the road ca. 1 mile to the end (the right fork goes to Mystery Cave Road site). From the end of the road, hike east ca. 1/6 mile to a north-south ridge. Follow this ridge downhill to the south for ca. 1/3 mile to the site (Fig. 2). The ridge forks just north of the site, so stay on the west side of the ridge. T8S R28E S21, SE1/4 of SW1/4; ca. 7,550 ft.

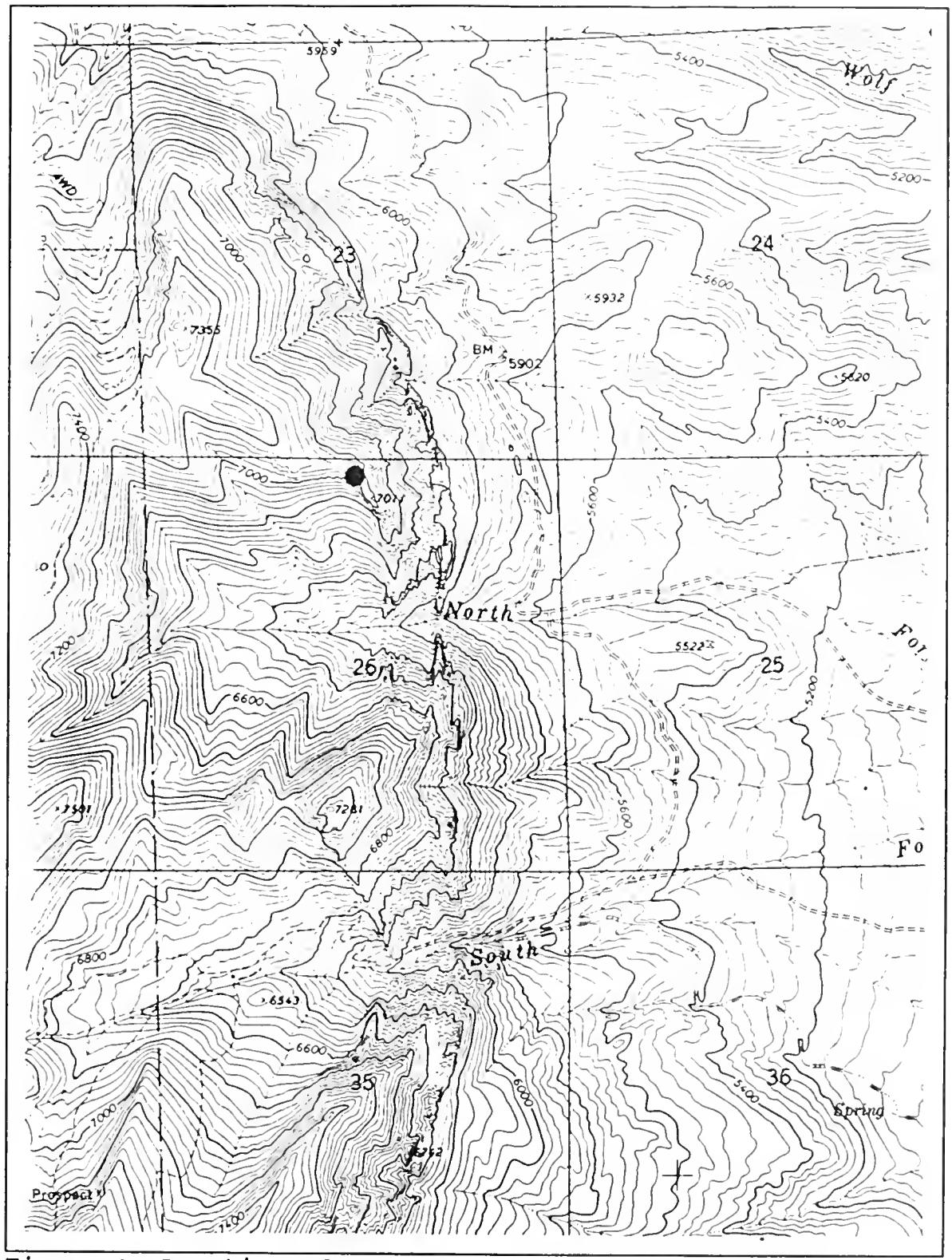


Figure 1. Location of Grove Creek Shoshonea pulvinata monitoring transect.

The transect is on the west edge of the ridge in an area where it is relatively broad and open. Both ends of the transect are marked by reinforcing bar pounded into the ground and painted red on top.

Line Bearing: Not recorded Line Length: 10.15 meters

Instructions: Start at north end of transect; read the west (downhill) side of the transect.

Mystery Cave Road

Location: From Big Ice Cave turnout on top of the Pryor Range, proceed north and east ca. 5 miles on the main secondary road towards Dryhead Vista Point. One mile west of Dryhead Vista the road forks; take the right fork and proceed on this deteriorating road east and south 4.1 miles to an old cabin. Continue south for ca. 3/10 mile to a fork in the road. Follow the right fork of the road ca. 1.5 mile to a narrow section of the ridge where the road is just slightly to the east of the exact crest. Just east of the site on the east side of the road is a stump with a board that is painted red on top. T8S R28E S20, SE1/4 of SE1/4; ca. 7,520 ft.

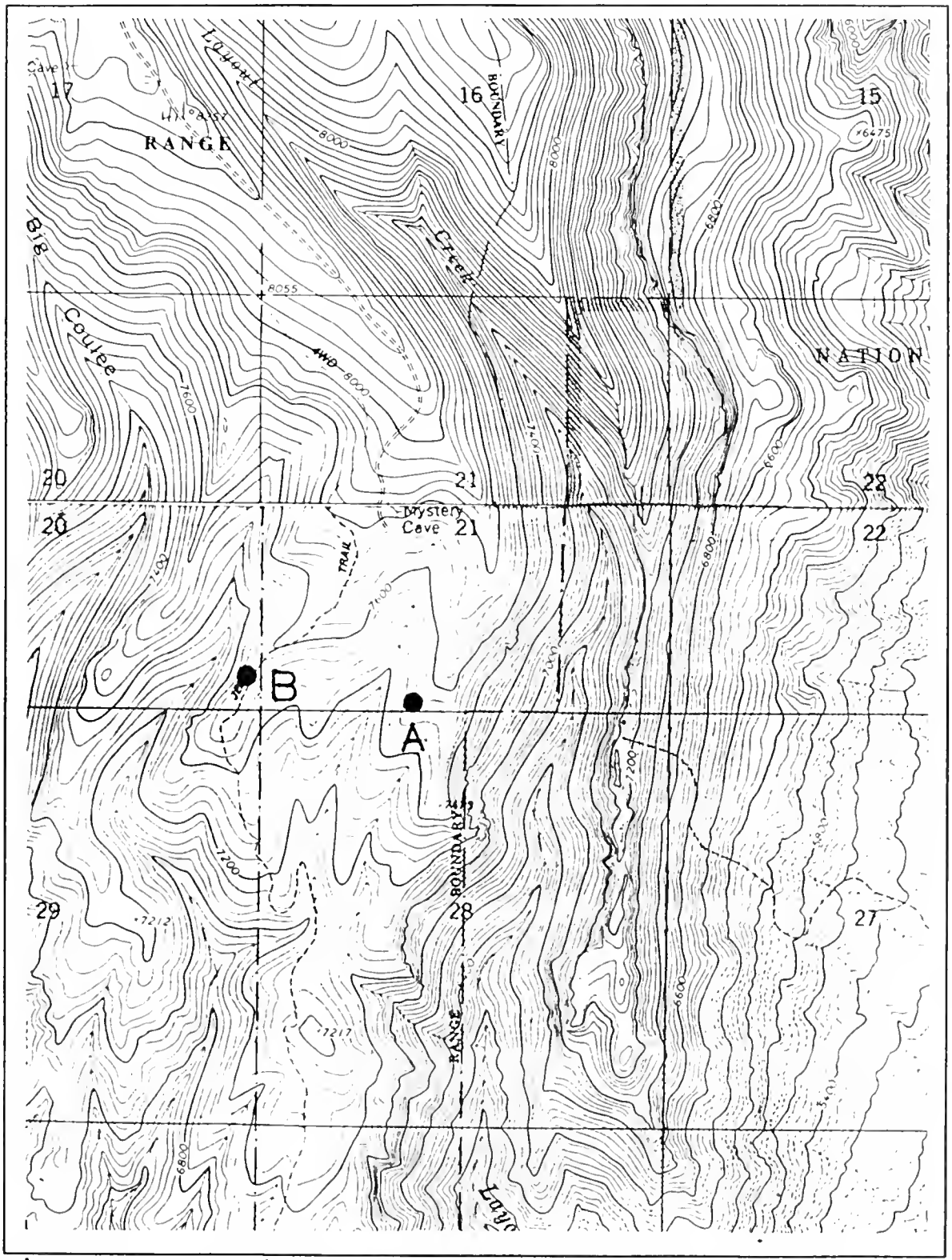


Figure 2. Location of (A) Mystery Cave Ridge and (B) Mystery Cave Road Shoshonea pulvinata monitoring transects.

The transect is in open Douglas fir forest on the west side of the ridge. Both ends of the transect are marked by reinforcing bar pounded into the ground and painted red on top.

Line Bearing: Not recorded Line Length: 12 meters

Instructions: Start at north end of transect; read west (downhill) side of transect line.

Field Procedures

At each site place the end ring of the meter-tape over the start pin and stretch the tape to the end pin, making sure that the tape is taut. Using a meter-stick and the meter-tape, record the coordinates (in centimeters) for the center of each plant that occurs along the line and within 50 cm of the line on the west side. After the coordinates of each plant have been recorded, its size is estimated using a 50 cm X 50 cm sheet of clear plexiglass marked into a grid of squares that are 4 cm X 4 cm each. Place this grid on top of the shoshonea cushion in a random orientation and count the number of 1/4-squares that are filled by green vegetation (Fig. 3). Many larger plants have died out in the center; this dead region is not counted. Finally, for each plant, count the number of inflorescences.

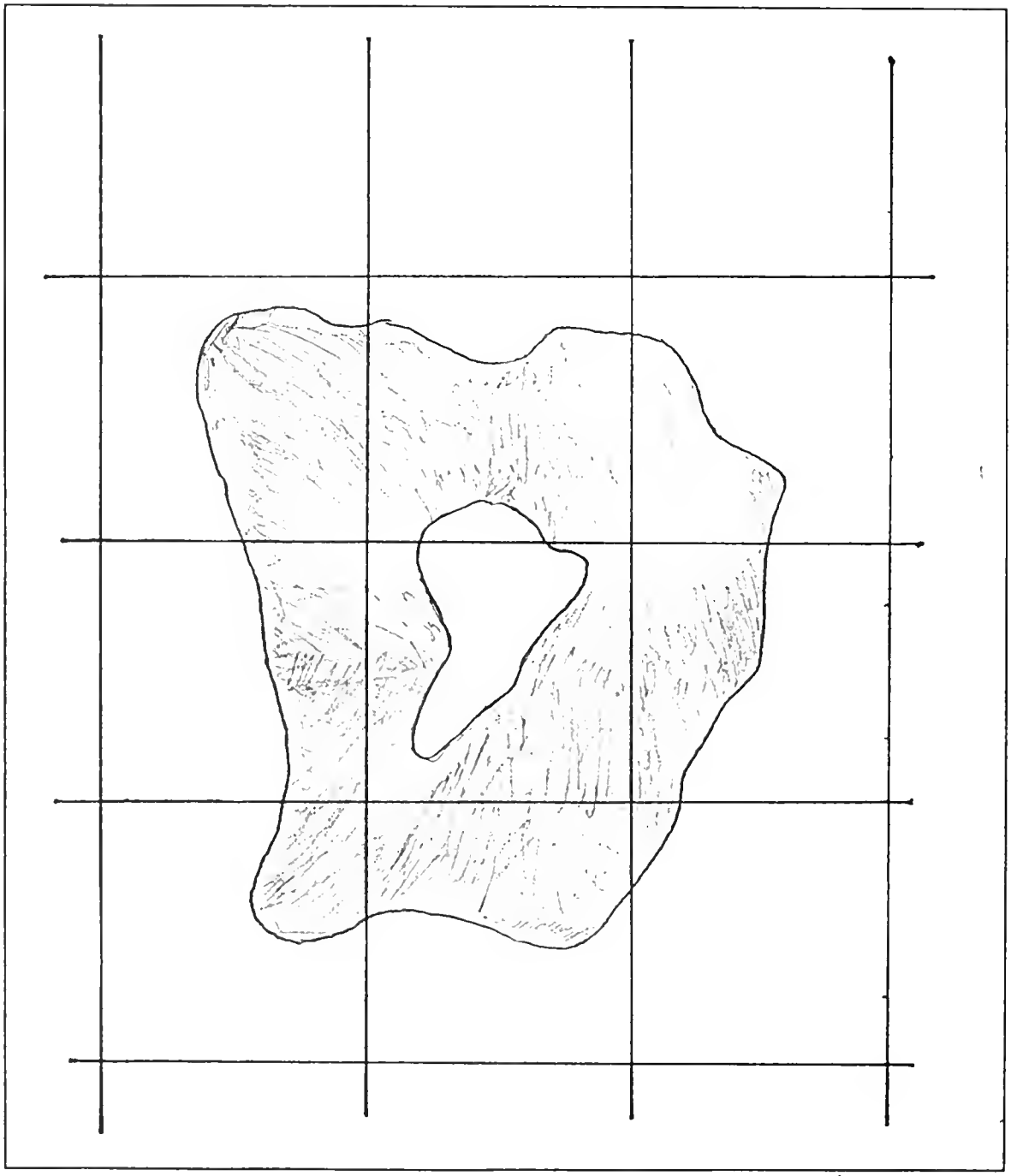
Repeat this procedure for every shoshonea plant in the 50-cm wide belt transect defined by the tape.

Data Reduction

In each transect, each shoshonea plant is assigned a unique alpha-numeric code that identifies it. If the plant occurs in the first meter of the belt transect, it is given the code "1" followed by a letter assigned in order. In 1991 there were six plants recorded in the first 1 meter of the Grove Creek transect. We have assigned these six plants the following codes 1a, 1b, 1c, 1d, 1e and 1f (Appendix A). These unique codes remain assigned to the plant at that location for the duration of the study. If a new plant appears in the first meter of this belt transect in subsequent years, it will be assigned the code 1g, etc. Assigning a unique alpha-numeric code to each plant allows us to easily follow the fate of individuals during the course of the study.

For each plant, count the number of 1/4-squares and multiply the total by 4. This gives the area of the foliage in square-centimeters. Each plant's size and reproductive status can now be summarized using the following codes:

Figure 3. Use of plexiglass grid to estimate area of S. pulvinata plant. From left to right and top to bottom, the number of filled 1/4-squares are 2,2,2,1,3,2,1,2,0; 15 1/4-squares=60 cm^2.



A (area) = area of vegetation in square-cm

I (inflorescences) = number of inflorescences

Thus, a plants with an area of 6 1/4-squares and 3 inflorescences is coded, A24-I3.

Statistical Analysis

For the purpose of analysis, each plant is treated as an independent observation. Two dependent variables may be derived from the data: (1) plant size, a measure of plant vigor, and (2) number of inflorescences, a measure of fecundity. Both variables can be analyzed with a mixed-model analysis of variance (ANOVA) (Sokal and Rohlf 1981) with year as the fixed factor and plant as the random factor. If only two years are being analyzed, the ANOVA reduces to a paired-samples t-test. If more than two years are analyzed, the ANOVA is followed by a contrast or multiple range test to determine which pairs of years are significantly different.

There are three sources of variation for these dependent variables in a long-term study: (1) experimental error, resulting from counting or measuring inaccuracies, (2) short-term changes resulting from year-to-year climatic fluctuations, and (3) long-term changes - positive or negative trends resulting from habitat

enhancement or degradation (e.g. climate change, gradual changes in predation pressure, introduction of a pathogen, etc.). It is only the last source of variation that is of interest in a long-term monitoring study; (1) and (2) are "noise" that must be removed to reveal the long-term trends. The long-term changes can be separated by using a temporally stratified sampling design. Transects are read for 2-4 consecutive years and then reread for 2-4 consecutive years at 5 to 10-year intervals following the baseline period. For example transects might be read yearly in 1991-1993 and then again in 1998-1999. A mixed-model ANOVA can be used to analyze these data. Period (1991-1993 and 1998-1999) is the fixed factor with years within period as replications, and plant is the random factor. A significant effect due to period would indicate a trend. Variation due to experimental error and short-term fluctuations comprise the error term in the ANOVA. Data may have to be transformed before analysis.

A less rigorous analysis for two years of data may be performed by scoring each plant as either bigger or smaller (disregarding those that stayed the same) and examining the data array visually to determine if equal numbers of plants are increasing and decreasing in size.

Results and Discussion

Summary statistics for sample size, reproduction and fecundity for Shoshonea pulvinata are presented in Table 1. There was a great deal of variation in reproduction and fecundity among the three sites, suggesting that these sites provide significantly different environmental conditions for S. pulvinata.

Table 1. Sample size, reproduction and fecundity of Shoshonea pulvinata in three monitoring transects.

	Grove Creek	Mystery Ridge	Mystery Road
Total no. plants	59	37	57
No. reproductive plants	17	26	32
% reproductive plants	29%	70%	56%
Mean no. inflorescences/ reproductive plant (±SD)	5.8±6.4	14.1±16.0	3.5±4.1

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Appendix A. Scores for vegetation area (A, cm^2) and number of inflorescences (I) for plants of Shoshonea pulvinata at three sites.

Grove Creek

1991

1a	A144-I0
b	A4-I0
c	A16-I0
d	A8-I0
e	A4-I0
f	A16-I0
2a	A4-I0
b	A4-I0
c	A4-I0
d	A4-I0
e	A228-I6
f	A4-I0
g	A40-I5
h	A28-I2
i	A16-I1
j	A4-I0
k	A4-I0
3a	A4-I0
b	A20-I0
c	A36-I3
d	A4-I0
4a	A8-I0
b	A4-I0
c	A4-I0
d	A4-I0
e	A20-I1
f	A4-I0
g	A4-I0
h	A4-I0
i	A104-I2
j	A4-I0
5a	A40-I1
b	A64-I7
c	A8-I0
6a	A116-I11
b	A68-I12
c	A16-I0
d	A80-I5
e	A108-I7
f	A4-I0
g	A4-I0
h	A4-I0
i	A4-I0
7a	A24-I0

b A12-I0
c A16-I0
8a A112-I0
b A116-I4
9a A52-I0
b A20-I0
c A16-I0
10a A532-I27
b A4-I0
c A16-I3
d A4-I0
e A4-I0
f A4-I0

Mystery Cave Ridge

1991

1a A40-I3
b A24-I5
c A36-I11
d A16-I1
e A196-I12
f A348-I24
2a A20-I0
b A244-I43
c A408-I21
d A80-I6
e A16-I1
f A44-I31
3a A80-I20
b A16-I4
4a A16-I4
b A28-I9
5a A16-I5
b A16-I3
c A14-I0
d A4-I0
6a A56-I0
b A64-I11
c A28-I0
d A16-I0
7a A16-I0
b A32-I2
c A16-I0
d A24-I0
8a A128-I23
b A88-I11

9a A16-I0
b A16-I0
c A160-I34
d A48-I11
10a A236-I69
11a A16-I1
b A16-I1

Mystery Cave Road

1991

2a A24-I1
b A24-I1
c A16-I1
d A20-I2
e A60-I5
f A48-I1
3a A16-I0
b A16-I1
c A20-I1
d A16-I0
e A24-I1
f A16-I0
g A24-I0
h A16-I0
i A16-I1
j A4-I0
k A32-I0
l A24-I2
m A56-I4
n A16-I1
4a A52-I0
b A20-I2
c A16-I0
d A40-I3
e A16-I0
f A24-I5
g A16-I0
h A16-I0
i A16-I0
j A16-I1
5a A56-I4
b A60-I0
c A96-I1
d A132-I20
6a A80-I7
7a A24-I2
b A24-I2
8a A80-I11
b A36-I5
c A64-I12

d	A20-I0
e	A16-I0
11a	A20-I0
b	A64-I0
c	A48-I1
d	A24-I0
e	A44-I3
f	A4-I0
g	A16-I0
h	A16-I0
i	A16-I0
j	A16-I0

SHOSHONEA MONITORING FORM

Date 29 June 1991 Site Grove Creek

Recorder(s) Legace, Ackuff Page No. 1

ID = alpha numeric code; Tape = position on transect tape; Stick = distance off of baseline; Infl. = No. of inflorescences; 1/4-squares = No. of 1/4 squares filled by vegetation; Total = total 1/4-squares.

ID	Tape	Stick	Infl.	1/4-squares	Total	Comments
1A	0	32	0	2,1,1,2,2,3,1,4,4,3,3,4,4,2,	36	
1B	0	22	0	1	1	
C	5	41	0	4	4	
D	14	7	0	2	2	
E	84	19	0	1	1	
F	93	28	0	4	4	
2A	108	50	0	1	1	
B	108	42	0	1	1	
C	109	47	0	1	1	
D	113	43	0	1	1	
E	113	33	6	1,1,3,4,3,1,2,4,4,4,2,1,3,3,4	57	
	—	—	—	2,3,4,3,3,2	—	
F	130	32	6	1	1	
G	138	30	5	3,2,2,3	10	
H	141	21	2	2,1,2,2	7	
I	151	27	1	4	4	
J	186	38	0	1	1	
K	187	41	0	1	1	
3A	204	33	0	1	1	
B	246	26	0	3,1,1	5	
C	297	37	3	4,2,1,3	9	
D	299	22	0	1	1	
4A	305	39	0	2	2	
B	309	50	0	1	1	
C	309	37	0	1	1	
D	340	41	0	1	1	
E	340	26	1	3,1,1	5	
F	346	25	0	1	1	
G	347	43	0	1	1	

SHOSHONEA MONITORING FORM

Date 29 June 1991 Site Grove Creek

Recorder(s) Lesica, Achuff Page No. 2

ID = alpha numeric code; Tape = position on transect tape; Stick = distance off of baseline; Infl. = No. of inflorescences; 1/4-squares = No. of 1/4 squares filled by vegetation; Total = total 1/4-squares.

ID	Tape	Stick	Infl.	1/4-squares	Total	Comments
4H	364	22	0	1	1	
I	376	33	2	2,3,3,1,2,4,3,2,4,2	26	
J	388	31	6	1	1	
5A	433	43	1	4,1,1,2,2	10	
B	456	12	7	4,2,3,4,1,2	16	
C	490	37	0	2	2	
6A	500	34	11	1,3,1,2,4,4,2,1,4,4,1,2	29	
B	517	30	12	4,1,4,4,1,2,1	17	
C	524	26	0	4	4	
D	531	21	5	3,2,1,4,4,2,2,2	20	
E	536	50	7	2,4,1,1,2,4,4,4,4,1	27	
F	557	41	1	1	1	
G	560?	10	0	1	1	
H	567	46	0	1	1	
I	585	32	0	1	1	
7A	616	9	0	4,2	6	
B	625	2	0	3	3	
C	635	24	0	4	4	
8A	773	27	0	1,4,4,1,3,4,4,1,1,2,3	28	
B	777	39	4	4,3,1,3,4,3,1,4,4,1,1	29	
9A	818	22	0	4,2,4,3	13	
B	845	21	0	2,2,1	5	
C	853	12	0	3,1	4	
10A	943	19	27	1,2,2,3,1,2,4,4,4,4,4,1,4	133	
				4,4,4,4,4,1,2,4,4,4,4,4,1,2		
				4,4,4,4,4,1,2,4,4,4,4,3,1,		
				2,3,2,1		
B	961	18	0	1	1	
C	973	30	3	4	4	

SHOSHONEA MONITORING FORM

Date 29 June 1991 Site Grove Creek

Recorder(s) Lesica, Achuff Page No. 3

ID = alpha numeric code; Tape = position on transect tape; Stick = distance off of baseline; Infl. = No. of inflorescences; 1/4-squares = No. of 1/4 squares filled by vegetation; Total = total 1/4-squares.

ID	Tape	Stick	Infl.	1/4-squares	Total	Comments
10D	973	43	0	1	1	
E	982	32	0	1	1	
F	988	39	0	1	1	

SHOSHONEA MONITORING FORM

Date 23 July 1991 Site Mystery Cave Ridge

Recorder(s) Achuff Page No. 1

ID = alpha numeric code; Tape = position on transect tape; Stick = distance off of baseline; Infl. = No. of inflorescences; 1/4-squares = No. of 1/4 squares filled by vegetation; Total = total 1/4-squares.

ID	Tape	Stick	Infl.	1/4-squares	Total	Comments
1A	14	5	3		10	
B	14	14	5		6	
C	19	9	11		9	
D	19	16	1		4	
E	27	22	12		49	
F	76	27	24		87	
2A	101	40	0		5	
B	110	36	43		61	
C	164	18	21		102	
D	177	15	6		20	
E	177	40	1		4	
F	179	45	31		11	
3A	259	41	20		20	
B	268	43	4		4	
4A	323	42	4		4	
B	397	36	9		7	
5A	424	42	5		4	
B	424	48	3		4	
C	427	34	0		4	
D	431	42	0		1	very small
6A	501	38	0		14	
B	536	36	11		16	dead center
C	537	48	0		7	
D	544	39	0		4	
7A	612	42	0		4	
B	634	29	2		8	
C	643	20	0		4	
D	649	31	0		6	
8A	724	22	23		32	dead in center

SHOSHONEA MONITORING FORM

Date 23 July 1991 Site Mystery CAVE Ridge

Recorder(s) Achuff Page No. 2

ID = alpha numeric code; Tape = position on transect tape; Stick = distance off of baseline; Infl. = No. of inflorescences; 1/4-squares = No. of 1/4 squares filled by vegetation; Total = total 1/4-squares.

ID	Tape	Stick	Infl.	1/4-squares	Total	Comments
8B	798	7	11		22	dead in center
9A	803	16	0		4	
B	825	21	0		4	small
C	847	26	34		40	
D	892	19	11		12	
10A	907	18	69		58	
11A	1012	46	1		4	
B	1013	46	1		4	

SHOSHONEA MONITORING FORM

Date 23 July 1991 Site Mystery Cave Road

Recorder(s) Achuff Page No. 1

ID = alpha numeric code; Tape = position on transect tape; Stick = distance off of baseline; Infl. = No. of inflorescences; 1/4-squares = No. of 1/4 squares filled by vegetation; Total = total 1/4-squares.

ID	Tape	Stick	Infl.	1/4-squares	Total	Comments
2A	111	13	1		6	
B	113	9	1		6	
C	112	31	1		4	
D	115	25	2		5	
E	116	33	5		15	
F	118	18	1		12	
3A	200	49	0		4	
B	204	4	1		4	
C	230	25	1		5	dead center
D	235	21	0		4	
E	237	3	1		6	
F	241	21	0		4	
G	243	39	0		6	
H	249	19	0		4	
I	266	33	1		4	
J	271	21	0		1	Very small
K	273	48	0		8	
L	280	38	2		6	
M	289	26	4		14	
N	292	6	1		4	
4A	300	13	0		13	
B	307	18	2		5	
C	312	35	0		4	
D	314	41	3		10	
E	318	19	0		4	plant on line at 325 not counte
F	343	33	5		6	
G	385	27	0		4	
H	388	25	0		4	
I	386	31	0		4	

SHOSHONEA MONITORING FORM

Date 23 July 91 Site Mystery CAVE Road

Recorder(s) Achuff Page No. 2

ID = alpha numeric code; Tape = position on transect tape; Stick = distance off of baseline; Infl. = No. of inflorescences; 1/4-squares = No. of 1/4 squares filled by vegetation; Total = total 1/4-squares.

ID	Tape	Stick	Infl.	1/4-squares	Total	Comments
4J	389	31	1		4	
5A	406	43	4		14	dead center
B	406	28	0		15	" + ants
C	423	31	1		24	"
D	445	12	20		34	"
6A	587	28	7		20	"
7A	691	22	2		6	clone broken into next 6 plants
B	695	28	2		6	"
8A	706	10	11		20	"
B	703	30	5		9	"
C	707	17	12		16	"
D	710	28	0		5	"
E	757	50	5		5	
11A	1024	32	0		5	
B	1027	38	2		10	
C	1057	35	1		6	
D	1091	38	1		9	
E	1091	47	0		4	
12A	1124	10	4		16	
B	1132	5	0		16	
C	1132	28	1		12	
D	1148	9	0		6	
E	1152	30	3		11	
F	1149	15	0		1	3 leaves
G	1148	43	0		4	small
H	1164	34	0		4.	
I	1174	33	0		4	
J	1172	50	0		4	

SHOSHONEA MONITORING FORM

Date ____________________ Site ____________________________

Recorder(s) ____________________________________ Page No. __________

ID = alpha numeric code; Tape = position on transect tape; Stick = distance off of baseline; Infl. = No. of inflorescences; 1/4-squares = No. of 1/4 squares filled by vegetation; Total = total 1/4-squares.

ID	Tape	Stick	Infl.	1/4-squares	Total	Comments