The Status of *Lepidospartum burgessii* (Burgess Broomshrub or Gypsum Broomscale)

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Abstract: *Lepidospartum burgessii* is designated a Species of Concern by the U.S. Fish and Wildlife Service. This shrub is endemic to gypsum soils in north Culberson County, Texas and southern Otero County, New Mexico. In 1991-92 the condition and number of plants in New Mexico were examined but otherwise little was known about the ecology or biology of this species. Our objectives were to define its habitat characteristics and status. We found that *L. burgessii* colonizes more diverse habitats than previously thought. In New Mexico the plants generally grew on stabilized, microbiotic-covered, gypsum soils with approximately 5 percent basal vegetation–litter cover. In Texas, and at one site in New Mexico, shrubs grew on mobile gypsum dunes with an average of 20 percent basal vegetation–litter cover. In 1997 plants were counted in seven colonies in New Mexico. Approximately 15 percent of the individuals counted within those colonies in 1991-92 were dead in 1997 and the number of juvenile plants had declined. Recruitment was only by clonal propagation. No seeds formed, although there were abundant flowers. Involucre length was significantly longer from plants in Texas than from those in New Mexico, which suggests genetic diversity between the two populations. Two potential disease problems were identified: *Corythuca marmorata* (Tingidae, Hymenoptera), a known pathogen of some Asteraceae species, caused leaf loss and stem necrosis, and *Alternaria alternata* (Dematiaceae, Monilialales), a potential pathogenic fungus, was observed within some flowers.

Lepidospartum burgessii (Burgess broomshrub or gypsum scalebroom) has been identified by the U.S. Fish and Wildlife Service, Region 2, as a Species of Concern. It is a silvery-white shrub belonging to the Asteraceae (Compositae) family. It was described in 1977 and was considered to be a local endemic in extreme western Texas, although the number of plants growing in Texas was never accurately determined. In 1982 it was discovered in extreme southern Otero County, New Mexico, on a few small alkaline playas. Even though these discoveries somewhat expanded its range it still remains a rare endemic to this approximately 420 sq mile area. The plants occur singly or in scattered colonies on the tops of stabilized gypsum sand dunes. In May of 1996 the Bureau of Land Management (BLM) proposed to designate the area within the Caballo Resource Area that encompassed the majority of plants known in New Mexico as an Area of Critical Environmental Concern (ACEC; Bureau of Land Management 1997).

Lepidospartum burgessii is found only on gypseous soils at the fringe of the northern Chihuahuan Desert. Dick-Peddie (1992) designated the region Chihuahuan desert scrub. Some authorities have regarded the whole area as part of the desert plains grassland (Humphrey 1958). The latter designation may be more appropriate for the relatively small areas where *L. burgessii* occurs because creosote bush, which is the dominant shrub of the Chihuahuan desert scrub vegetation type, does not occur with *L. burgessii*. The climate in this area is relatively extreme with summer temperature highs of 34–41° C and winter temperatures ranging from lows of –2° C to highs of 14° C. Freezing is common at this time. Precipitation comes primarily during the summer (ranging from 131 mm to 468 mm). However, substantial spring rains have been reported and there is a high degree of year-to-year variability, which is characteristic of most arid and semi-arid climates (Noy-Mier 1973). In 1997 local residents reported that there had been very little precipitation over the Alkali Lakes during the last few years.

There are two other species in the genus *Lepidospartum* but neither are sympatric with *L. burgessii* (Munz 1974). It is noteworthy that *L. burgessi* has been mistaken for a species of *Chrysothamnus*, but the three rounded bracts of the involucre on the heads clearly distinguish it from that genus. The biological relationships of *L. burgessii* with its surrounding community are poorly understood and the habitat preferences of the plant are known at only a general level. One critical biological concern for *L. burgessii* is its lack of reproduction. Seed

set (sexual reproduction) appeared to be absent or extremely low, and clonal propagation appeared to be infrequent. This project consisted of three integrated objectives: to define the habitat characteristics and status of the plant in New Mexico, to determine the range of the species and its status in west Texas, and to determine the cause of the apparent absence of reproduction of the species. This paper reports on the habitat characteristics and status of the species.

Methods

Field work for this project was conducted during eight visits in 1997. Visits to the ACEC and Dell City were made July 14 –19, August 4–8 and 15–19, August 29–September 2, September 7–12 and 18–20, October 20–24, and November 20–21. *Lepidospartum burgessii* flowers from June to October with the peak during late July through early September. More than 10 years ago, three *L. burgessii* plants had been transplanted from private land in Texas to a garden in front of commercial offices in central Dell City. These plants comprise the Dell City site. The surveys in Texas were all conducted September 7–12, 1997.

Surveys outside the ACEC were conducted only in Texas. Surveys were conducted on foot by two or three field botanists. Potential habitat was targeted but some areas that had marginal habitat (e.g., very mobile dune fields) were also examined. Permission was obtained from the respective landowners in Texas before any survey was undertaken. Guadalupe Mountains National Park granted us permission to survey National Park Service (NPS) land to relocate historic occurrences within the Guadalupe National Park boundary. Permission was also granted by the Nature Conservancy to survey Gypsum Dunes Preserve land and by one local ranch owner. One other ranch manager said he had no objection to our surveying portions of his land through binoculars from the road. Two discrete populations 1–2 miles apart were located on private land. The southernmost population has since been acquired by the National Park Service.

Most of the studies on *L. burgessii* were conducted on plants within the ACEC on BLM land. Previous data collected by BLM and New Mexico State University (NMSU) personnel (Huenneke 1991) were used to re-locate the sites, and these data were also used for comparison to assess the current status of the plants. Approximately 18 months prior to this study the BLM erected livestock exclosures around at least seven colonies of plants. Livestock grazing is permitted within the ACEC outside of the exclosures. We studied 12 clusters of plants (sites) within a 10 m^2 area in detail. Six sites were within livestock exclosures and six were unfenced within the ACEC. Nine sites were within larger BLM-designated colonies (Bureau of Land Management 1988). The sites in exclosures were designated 41, 45, 43, 31, 29, and 20. Unfenced sites were designated 40, 42, 47, 30, 30B, and 25.

Measurements were taken to characterize the habitat occupied by *L. burgessii.* Plots within the ACEC were established within the chosen sites by selecting a plant at random and measuring a 10 x10 m area with the selected plant at the center of the square. Ground cover and number of *Lepidospartum* plants within each 100 m^2 plot were recorded during the first visit in July, 1997. The amount of dead wood on each plant and indications of disease were also recorded. Samples of leafless branch tissue were taken and stored in ethanol (70%). In Texas, two 100 m^2 plots were established by selecting a plant at random in both the northern (private land) and southern (newly acquired NPS land) populations, and measurements were made in September similar to those on the plants in the ACEC.

Soil samples taken within 2 m of a *Lepidospartum* shrub and at a depth of 15–20 cm were used to determine soil pH. Seven samples were taken from the ACEC and four from Dell City. Soil (4–6 g) from each sample was measured in the laboratory and stirred for 10 minutes with 12–18 ml distilled water (1:3 parts soil:water weight/volume). After filtering through Whatmans no. 3 filter paper, the filtrate was measured using a pH meter.

In addition to the measurements within the plots, measurements similar to those taken in 1991 and 1992 (Huenneke 1993) were made on the plants in colonies 14, 20, 25, 29, 31, 43, and 45. The total number of plants were counted and their heights, maximum and perpendicular diameter, phenological state, and distance to the nearest neighbor were measured so that comparisons between the years could be made.

Flower size was quantified by measuring the height (length) of the involucre. A total of 459 flowers from Dell City, Texas private land (from which the Dell City plants originated), and the ACEC were measured using a ruler and a microscope on return to the laboratory.

For studies on the reproductive organs, flowers were placed in preservative solution (70%

ethanol: acetic acid 3:1) in vials that were stored in ice chests in such a way that the contents did not freeze. The tissue was transferred to 70% ethanol (aqueous) solution after 24 hours. The vials were transferred to the refrigerator on arriving back at the laboratory. After refrigerated storage, the flowers were rehydrated and dissected. The gynoecia were placed in 0.8 M sodium hydroxide in a 60° C water bath for approximately 35 minutes to clear. Gynoecia were rinsed with double distilled water and placed in 1.0 mg/ml aniline blue in 0.1 M K_3PO_4 buffer overnight (Martin 1959). The tissue was then put on a slide with some clear phosphate buffer and examined under light and fluorescent light (395–440 nm) with a Zeiss Axioskop microscope. Examination of the carpels was made at 200x and 400x magnification.

Fifteen seed heads were taken from 33 shrubs that had more than 300 flowers for viability analysis. To avoid collecting immature seeds, the seed heads were taken only when the pappus was brown and fully emerged and the receptacle fully open and dry. The flower heads were examined and there did not seem to be any filled seeds. However, 20 seeds that appeared to be partially filled were taken from plants from 10 colonies, including one on Texas private land. In the laboratory half the seeds were surface sterilized by stirring in a 5% aqueous Chlorox™ (5.25% sodium hypochlorite) solution to which one drop of Tween 80 had been added. All the seeds were then rinsed with double distilled water and placed on moist germination paper in petri plates (10 seeds per plate). The plates were wrapped in aluminum foil and kept at approximately 22° C. In addition, 60 seeds were planted in a gypsum–potting soil (1:1) mix and kept in a greenhouse. Approximately one year elapsed between seed harvest and testing the germination rate.

Many of the data, even after appropriate transformations, violate the assumptions that permit use of the analysis of variance (ANOVA). Therefore to determine the level of statistical significance, values were statistically analyzed by non-parametric methods (Kruskall-Wallis and Mood Median Tests). However, because it frequently helps to have mean values to appreciate the biology, mean values are often presented along with the standard error or standard deviation of the mean, which are good indicators of the variability encountered. A simple linear regression model was used to estimate the rate of decline of the population using 1997 and 1991-92 data.

Results

Historic records indicate that *L. burgessii* grew immediately west of the Guadalupe Mountains in Texas. A thorough pedestrian survey was conducted on the Nature Conservancy preserve and in the general area where the historic records indicated that *Lepidospartum* was found in Guadalupe Mountains National Park; however, none were found on either property. The area within the National Park boundaries was very sandy and the most prominent shrub was *Poliomintha incana*. It may be that the authors of earlier reports found small gypsum outcrops that were missed during our survey or that the earlier locations were not accurately mapped.

Lepidospartum plants were found in Texas near the National Park on private land on which we had permission to survey. There were two general areas approximately 1–2 miles apart. There were 576 plants in the first, northern, area distributed among 13 colonies that ranged in size from groups of 3 to 205 individuals. A colony is defined as a group of plants isolated by at least 20 m. Most of the plants were in good condition and we noted only five that appeared to be dead. The plants grew on both microbiotic-stabilized gypsum soils and more mobile sandy dunes. It was from this population that the flowers were taken to compare the size to those on BLM land and in Dell City. Since this survey was made in 1997 the National Park boundaries have been extended and now include a second (southern) population of *Lepidospartum* plants that were originally on private land. Within this area there were 446 plants distributed among 11 colonies that ranged in size from 1 to groups of 113 individuals.

Morphology

Lepidospartum burgessii shrubs varied in size from small single-stemmed plants to large shrubs with high amounts of dead wood. The single-stemmed plants appeared relatively young and were probably clones of adjacent plants. An exposed root on private land in Texas indicated that *Lepidospartum* is capable of producing innumerable suckers.

Single-stemmed plants were particularly evident on the private land. The number of flowers per shrub was variable; from one flower head to literally hundreds of flower heads were counted on any given shrub. There did not appear to be a close relationship between the size of the plant and the number of flowers, which was not surpri-

sing because the largest shrubs were often in a decadent (> 50% dead wood) condition (Table 1). Some of the shrubs, e.g., at site 41, did not flower all season.

Habitat

The majority of *Lepidospartum* shrubs grew on stabilized gypsum soils with a well-developed microbiotic crust. However, they were also found on more mobile sandy gypsum soils both in Texas and in one area in New Mexico. The species was observed to be in as good, and perhaps in an even more vigorous condition, on the more mobile soils as on the stabilized soils.

Lepidospartum burgessii habitat was initially characterized by 5 percent vegetation cover comprising *Tiquilia hispidissima, Commicarpus scandens, Sporobolus airoides, L. burgessi,* and *Yucca elata* (Soreng 1986). However, our studies have shown that *L. burgessii* grows in a greater variety of habitat. Shrubs and sub-shrubs associated with *L. burgessii* included *Atriplex canescens, Opuntia leptocaulis,* and *Yucca elata,* as well as *Tiquilia hispidissima.* In Texas, *Poliomintha incana* was a common associate. *Allenrolfia occidentalis* was also observed within one of the plots in Texas. Associated grasses included *Bouteloua breviseta, Sporobolus neeleyi,* and *Sporobolus airoides. Gaillardia multiceps, Mentzelia* sp., *Isocoma* sp., and *Senecio warnockii* were common forbs associated with *L. burgessi* although their contribution to the ground cover was very low.

There was more vegetation cover in the regions occupied by *L. burgessii* in Texas than in New Mexico. In the former, litter and basal vegetation was approximately quadruple (20% vs. 5%) that of the latter region and vascular plant canopy cover was also significantly higher. The total shrub canopy cover was, on average, approximately 6 percent in the ACEC and 34.5 percent in Texas. In both areas, *L. burgessii* canopy contributed approximately half the total shrub canopy cover. The average *L. burgessii* canopy cover was only 3.4 percent of the total plot (100 m^2) area on the ACEC but was 19 percent on the Texas land. In the ACEC, grass canopy was less than 2 percent on average and forb cover approximately one tenth of the grass cover. In Texas, grass canopy was variable, ranging from 2 to 23 percent, but forb cover was always less than 3 percent. The difference in time of year (early summer compared to fall) may account for slight differences, especially in the grass and annual forb cover, but it is most likely that the differences reflect a more vegetated habitat on the Texas land. The reason for the differences in vegetation cover was not immediately obvious. Greater groundwater availability or differences in local precipitation or microclimate may be speculated. The heights of the *Lepidospartum* plants were similar among all populations but, as the canopy cover suggests, the plant volumes were larger in Texas, especially on the private land (Table 2). Litter was mainly around the base of living plants in all regions. Basal vegetation–litter cover ranged from 2 to 20 percent in the ACEC and 10–30 percent in Texas. At many of the sites in the ACEC more than 70 percent of the soil was covered by a complex microbiotic flora. As would be expected, the dunes (colony 20) had significantly less microbiotic cover. Total lichen cover, rather than total microbiotic cover, was estimated for three of the four plots in Texas

Table 1. The number of buds and open flowers on a sample of randomly selected *Lepidospartum burgessii* shrubs within the ACEC, New Mexico.

Date	Site in the ACEC	Plant number	Total flowers	Number of flowers		Percent flowers open	Shrub height (m)	Shrub volume* (m^3)
				open	pre-emergent			
8/17/97	29	29-10	316	29	287	10	1.05	1.42
8/17/97	29	29-a	132	36	96	38	0.84	0.79
8/17/97	28	28-b	—	76	not measured	—	1.00	1.50
8/17/97	28	28-c	—	56	not measured	—	0.66	0.37
8/17/97	28	28-d	—	30	not measured	—	1.00	0.56
8/18/97	43	43-11	684	181	503	36	1.05	1.18
8/18/97	43	43-10	90	12	78	15	0.84	0.30
8/18/97	30B	30B-C	210	39	171	23	0.97	0.73
8/18/97	30B	30B-a	121	17	104	16	0.71	0.46
8/18/97	30B	30B-b	132	36	96	38	0.82	0.66
8/30/97	20	20-265	96	70	26	73	0.61	1.08

*Volume was estimated as though the shrubs were rectangular as in 1991-92 (Huenneke 1993).

Table 2. The average height, volume, and number of *Lepidospartum burgessii* plants observed to suffer from branch dieback on 100 m^2 plots within the ACEC, on Texas private land, and in the newly acquired National Park Service land.

Location	Number of plants	Average height (median)	Average volume	Average deadwood/shrub (median)*	Number of plants with dieback
ACEC	69	0.62 m (0.6)	0.63 m^3	22.0% (15) a	51
Texas land – NPS	23	0.67 m (0.6)	1.63 m^3	37.6% (30) b	21
Texas land - private	32	0.79 m (0.7)	5.77 m^3	13.7% (10) a	20**

*Values followed by the same letter are not significantly different (P = 0.000).
** Significantly less dieback using the Moods median statistical test (P = 0.046).

due to changes in survey personnel. From considering one plot in Texas and the plots on the ACEC (where survey personnel remained the same) it was estimated that the amounts of total microbiotic cover are approximately 38 percent higher than lichen cover. A substantial unidentified algal component and a very small moss component accounts for the difference. Therefore, even allowing for this underestimate, due to considering lichen cover only, there was significantly less microbiotic cover on the plots chosen at random on the Texas land. This was likely due to the more mobile nature of the soils. Colony 20 in the ACEC has the most similar habitat and plant morphology to that observed in Texas.

A southeastern aspect appeared to be most common but a strong preference for a particular aspect was not observed. The pH of the soil in Dell City and in six of the colonies within the ACEC was measured from soil samples within 2 m of a *L. burgessii* shrub. The pH was, on average, slightly (but significantly) higher in Dell City (pH 7.78, variance 0.02, n = 4) than on the ACEC (pH 7.38, variance 0.03, n = 7).

Comparison of Status, 1991-92 and 1997, in the ACEC, New Mexico

These results directly pertain only to colonies 14, 20, 25, 29, 31, 43, and 45, as all plants in the ACEC could not be counted in the time available. However, these colonies were distributed throughout the ACEC and it is likely that they are representative of the other colonies in the ACEC. In total, 557 plants were counted in 1997, compared to 570 in 1991-92. Therefore, 13 plants were unaccounted for in 1997. The phenotypes of the plants were designated as juvenile (J), mature (M), decadent (greater than 50% dead wood, D), and fully dead (DD). In all years surveyors were unsure if some plants were mature or decadent and notes were made to that effect. These plants were scored MD. Therefore, two statistical analyses were made, one considering the plants in question as mature, and the second considering the plants as decadent. The phenotype scores for each colony are tabulated in Table 3. Because the data violated many of the assumptions for the ANOVA, nonparametric methods were applied to determine if differences existed between years. Phenotypic classes were statistically analyzed by the Kruskall Wallis and Mood Median tests. There were appreciably more dead plants (100% dead wood) in 1997 than in 1991-92 and fewer juveniles (Figure 1). In the first analysis, where questionable (MD) plants were rated "mature," all the median phenotypes in both years were mature except for colony 43 in 1997 where the median value was decadent. When the MD plants were designated "decadent," the median values remained the same for all colonies and years. However, the variation observed in colony 43 was such that there were no statistically significant differences between years, which suggests that all those MD plants in 1991-92 were in fact decadent. (Totally dead plants in 1991-92 = 0, in 1997 = 24; MD plants in 1991-92 = 22, in 1997 = 1; Decadent in 1991-92 = 16, in 1997 = 40; Mature in 1991-92 = 55, in 1997 = 37; and Juvenile in 1991-92 = 1; in 1997 = 1.)

The nearest neighbor distance was significantly more in 1997 (median = 1.25 m) than in the previous years (median = 0.46 m) which is consistent with the higher number of dead and unaccounted for plants in 1997. Particularly, colonies 20, 25, and 43 all showed significantly greater distances between plants in 1997 than in the previous years (see Table 3).

If the decline in the number of total plants, the number of mature plants, and the number of juveniles is assumed to be linear, a simple prediction can be made as to when the three classes of indi-

Table 3. The phenotype status of the *Lepidospartum* plants in selected colonies within the ACEC in 1991-92 and 1997.

Colony (Site) in the ACEC	Date	Median nearest neighbor distance (m)	Number of plants					Total live plants	Total plants
			D	MD	M	J	DD		
14	09/14/97	0.6 ab	4	0	27	0	2	31	33
20	09/13/97	1.2 a	44	20	165	7	42	236	278
25	09/08/97	1.5 a	15	0	53	2	5	70	75
29	09/14/97	1.5 a	0	0	10	0	1	10	11
31	09/14/97	1.6 a	4	0	22	1	1	27	28
43	09/14/97	1.2 a	40	3	37	1	22	81	103
45	09/14/97	2.0 a	1	0	19	7	2	27	29
Total	1997	1.25	108	23	333	18	75	482	557
14	02/09/92	0.35 ab	0	0	25	0	0	25	25
20	11/17/91	0.41 b	54	11	207	53	1	325	326
25	10/24/91	0.61 b	0	0	67	1	0	68	68
29	02/22/92	1.30 ab	0	0	10	0	0	10	10
31	02/23/92	1.05 ab	0	0	26	1	0	27	27
43	02/23/92	0.50 b	16	22	55	1	0	94	94
45	08/21/91	1.61 a	0	0	15	5	0	20	20
Total	1992	0.46	70	33	405	61	1	569	570

*Values followed by the same letter are not significantly different; Mood median test, P = 0.000.

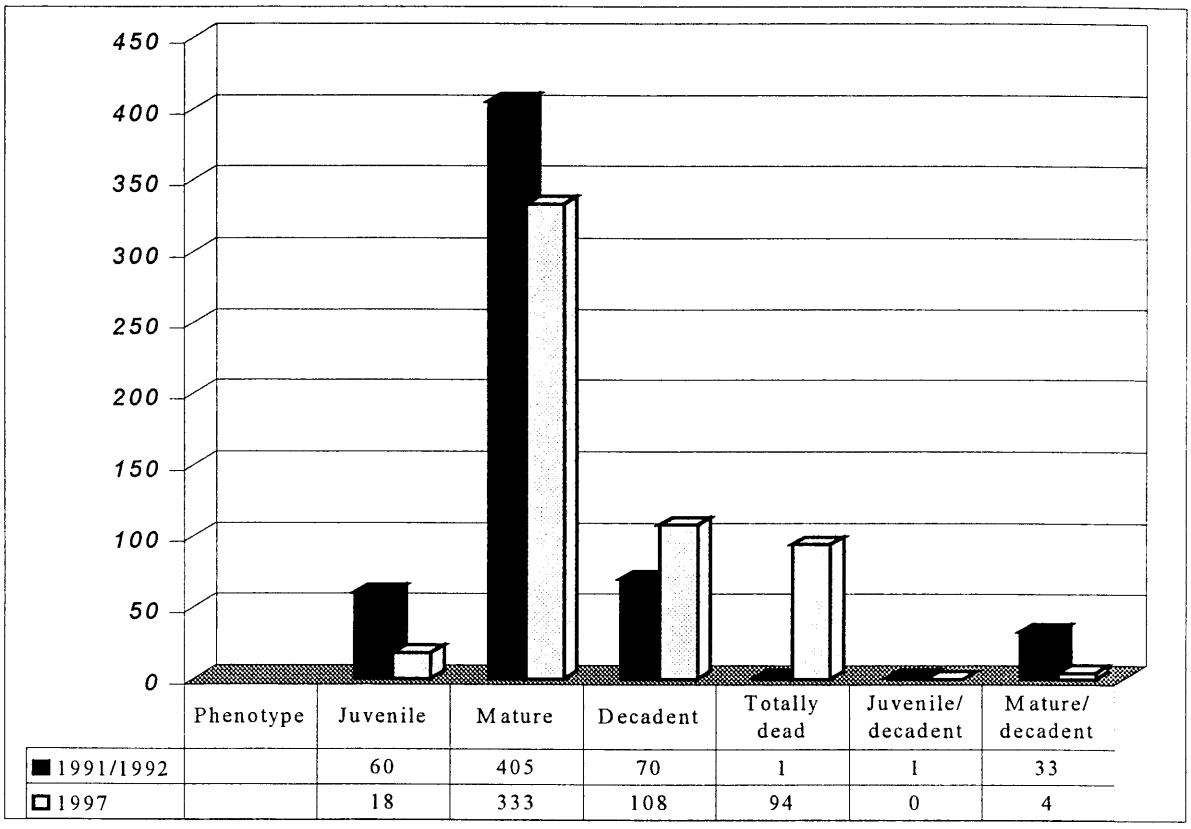

Figure 1. The number of *Lepidospartum burgessii* plants (y-axis) in each of the phenotype classes in 1997 and 1991-92 combining the data from all colonies.

viduals will reach zero (Figure 2): For total plants it is 33 years, for mature plants 35 years, and for juveniles only 10 years. Supposing the rate of death is also linear, then after 31 years all 463 individuals would be dead. Obviously a linear model is too simple and from only two points in time predictive power is very limited. For example, considerable precipitation may be required for successful reproduction and seedling emergence. In this region precipitation is highly variable and years of high precipitation are likely relatively few. However, further consideration of these data may provide insight to the behavior of this population, which appears to be declining relatively rapidly.

Flower Size Differences, Private Land in Texas and ACEC

The flowers on the Dell City plants were noticeably larger than those on the plants within the ACEC. I initially ascribed the difference to the frequent irrigation and fertilization that plants in Dell City received. However, when surveying the lands in Texas it seemed that the flowers on plants on the private land were as large as those in Dell City. Therefore, a limited number of flowers were taken from plants in Dell City, the Texas private land, and the ACEC, and the length of the receptacles was measured. The mean and median lengths of the receptacles from both the Texas populations were significantly larger (Table 4).

Observations on Disease

Two notable observations were made on the disease status of the *L. burgessii* plants. Microscope observations of the flowers and pollen showed that a common fungal spore was frequently present on the stigma surface (Figure 3) and that sometimes the spore germinated to form a tangle of mycelium on some of the stigmas (Figure 4). The

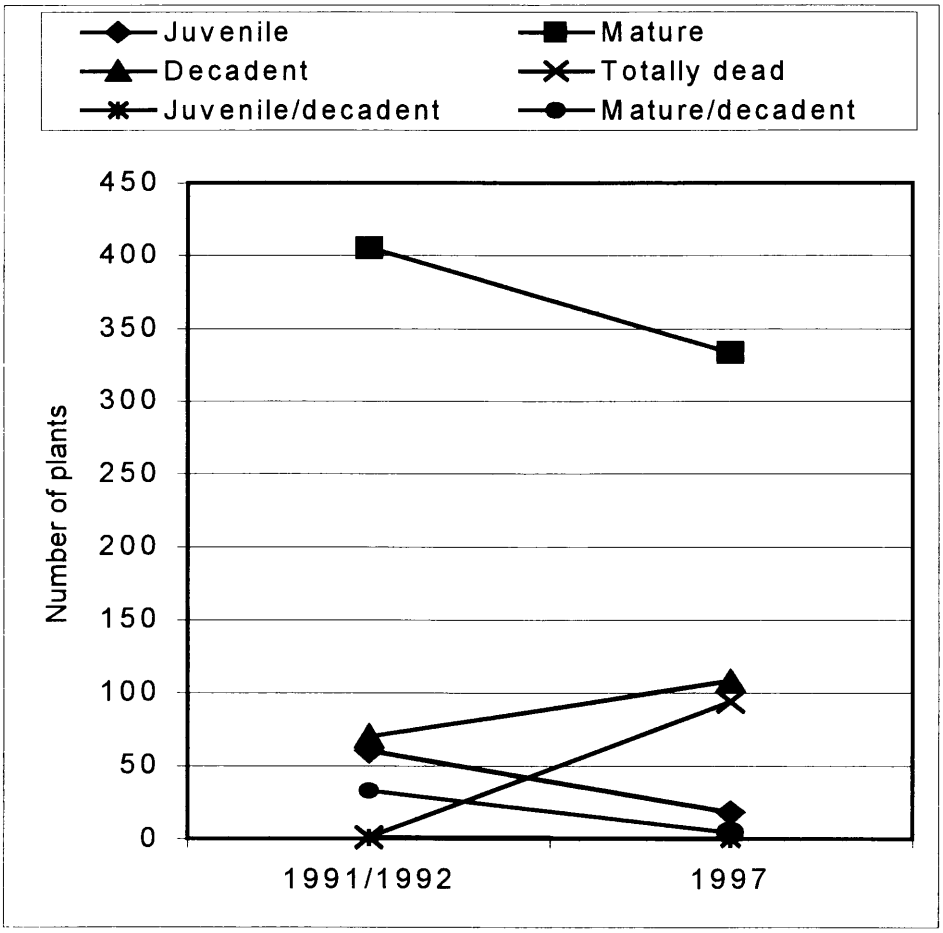

Figure 2. A graphical description of the changes observed in the phenotype classes between 1991-92 and 1997.

Table 4. The size of flower involucres in New Mexico and Texas populations.

Location	No. of flowers	Mean (1/32 inch)	Median (1/32 inch)
ACEC	375	10.3	10
Dell City	56	12.6	12.5
Texas Land	28	12.3	12.5

spore was identified as a species of *Alternaria*, probably *A. alternata* (Dr. Natalie Goldberg, plant pathologist, New Mexico State University, personal communication).

In the field the presence of branch tip dieback was scored as present or absent on individual plants. Branch tip dieback was observed on many of the plants in the ACEC and on the land in Texas. The condition appeared to be negligible on the plants in Dell City and less severe on plants on the Texas private land. In addition, there were significantly fewer individuals with any tip dieback on the private land in Texas (see Table 2). When using a hand lens or dissection scope the branch surface seemed to be a little "bumpy," but it was not obvious what was causing the leafless brown branches. However, a few weeks after the leafless branches were put in 70% ethanol, numerous little insects were found in the solution. No insects were found in the solution in which leafy tissue had been placed. These insects were identified as a type of lace bug (*Corythuca marmorata*, Tingidae family). They are known to particularly infest members of the Asteraceae, notably goldenrod and asters. They also cause severe damage to chrysanthemums (Richard Fagerland, entomologist and IPM specialist, University of New Mexico, personal communication). No information is readily available on their relationship with *Lepidospartum* species.

Scale was also noticed but it was primarily on the four-wing saltbush (*Atriplex canescens*) that was growing amongst or intertwined with the *Lepidospartum* shrubs. Unlike the other two pathogenic organisms, this infection does not seem to pose a serious threat to *Lepidospartum*.

Seed Germination

Forty-two petri plates (with 10 seeds per plate) from nine colonies in the ACEC and from six plants in Texas were examined. There were an equal number of plates with sterilized and non-sterilized seeds. All of the seeds looked poorly formed but were judged to be in relatively "good" condition. The petri plates were observed after 2, 4, and 8 weeks. Fungal contamination began to be observed on some of the seeds after only 2 days. After 10 weeks an average of 6.7 seeds per petri dish (std dev 2.6) had fungal mycelial growth, but only 1.7 sterilized seeds per petri dish (std dev 2.3) had fungal contamination. Therefore, the surface sterilization procedure did inhibit molding of the seeds. However, no seeds from either treatment were observed to germinate. Similarly no seedlings have been observed in the pot experiment at the time of writing. It may be that the length of time (approximately one year) between harvest and testing germination ability contributed to the poor germination results.

Discussion

The depletion of groundwater within the last 150 years must have had a major effect on the area hydrology. An amateur local historian and member of a long-time ranching family in the area reported that extensive changes had taken place in the Alkali Flats region over the last 150 years (Mrs. Isobel Gilmore, personal communication, 1997). For example, in 1858 Crow Springs and an adjacent well were important sources of water for settlers in the area. Mrs. Gilmore described how 1,000–1,500 head of cattle were commonly watered at a single time in 1889 and 1890. At the turn of the century the springs were used extensively by the Butterfield Stage Coach. Apparently by 1928, or 1929, 35 springs in the general area around Alkali Flats had gone dry from overuse. The intensive irrigated farming practices first adopted in Dell City in 1948 also took their toll on groundwater availability. In the 1940s the wells in Dell City were approximately 10 feet deep, by the 1950s potable water was to be found only at about 60 feet, and then a decade or so later the wells had to be at least 90 feet deep. Now, many of the wells on her extensive properties are yielding only saline and undrinkable water. The impact of this situation on *L. burgessii* cannot be judged. Whether the receding water table has influenced the availability of water to the plants in some regions is unknown.

A significant cause for concern is the infestation of *Corythuca marmorata* (Tingidae wasps) on the plants, which causes dieback of the stems and branches. This was especially unmistakable on the plants in the ACEC although it was also evident on all the plant colonies except those in Dell City,

Figure 3. A photomicrograph of *Alternaria* spores amongst the stigmatic hairs of *Lepidospartum burgessi*. The photograph was taken at 400x with black and white Kodak 5052 TMX film.

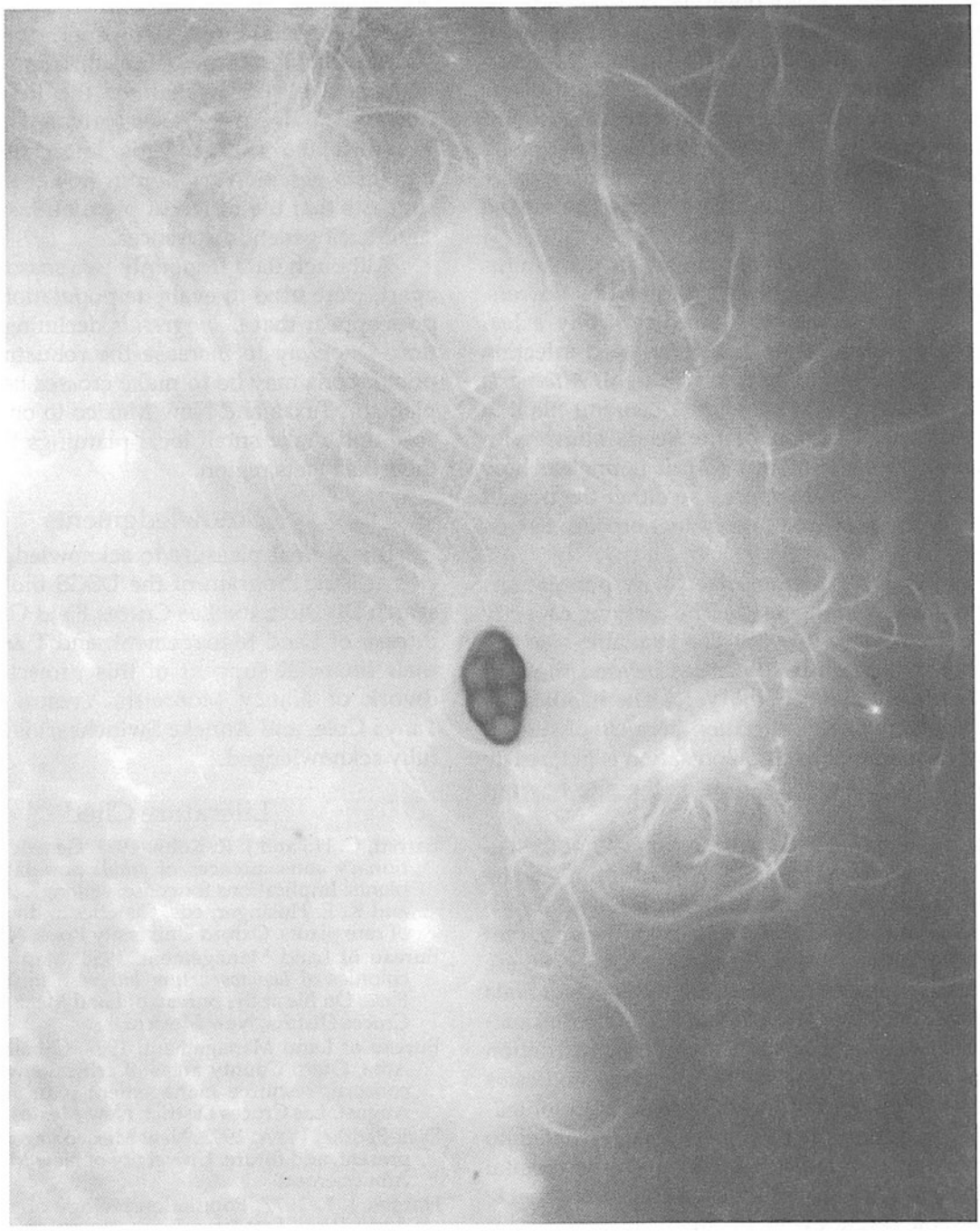

Figure 4. A photomicrograph of *Alternaria* spores and dense mycelial growth on the stigmatic surface of *Lepidospartum burgessi*. The photograph was taken at 400x with black and white Kodak 5052 TMX film.

which were receiving water from a garden irrigation system. Although these insects were also found on a number of branch tips that were examined during the one visit in 1998, the plant population was closely observed during only one year and it may be that this level of infestation is in a state of equilibrium for this species. Monitoring the progress of this infestation over the next several years is the only reliable way to determine the importance of this infestation. A problem with field observations is that the insects themselves are not very evident and the stems need to be soaked in ethanol to release the insects.

The other potential pathogen is the fungus *Alternaria* which seemed to target the flowers, although it is apparently more typically a leaf pathogen (Rotem 1994). However, seed infection has been reported to be common to all *Alternaria* species and is a variation of quiescent infection. In all cases the infection of the seeds starts with infected flowers (Rotem 1994). It is unclear how significant this observation is to either the overall health or the absence of reproduction of *L. burgessii.*

Harper (1977) summarized why populations may be small as follows: (a) The carrying capacity of the site may be low. (b) The available sites are few and separated by distances beyond the species' normal dispersal ability. (c) The habitability of the site is of short duration because of successional displacement. (d) Colonization is in its early stages, and full exploitation of the site has not occurred.

It is likely that the carrying capacity of the Alkali Lakes region is low and this condition may be partially responsible for *L. burgessii* rarity. Available sites may also be few but when the apparent potential habitat is considered it appears that there is room for greater exploitation of the Alkali Flats area by *L. burgessii.* There is no indication that successional displacement is a significant restriction on the species, and the state of the plants indicates that *L. burgessii* is not in early stages of colonization. It may be that this species is restricted to relatively small refugia owing to an environmental change that precipitated a genetic bottleneck, which is a single event in time that describes a sharp reduction in the genetic diversity of the species (Barrett and Kohn 1991). Such a bottleneck event would add to a loss of diversity that could result in lowered resistance to disease and an inability to adapt to a changing environment. Not only has a very low level of clonal propagation been observed, but genetic variability is likely low in these populations given that field observations over many years have suggested no or low seed production (Michael Howard, personal communication). During 1997 no filled seeds developed and none of the partially filled seeds that we collected germinated. However, there was a statistically significant 1 mm difference between the average size (length of the involucre) of flowers on shrubs in Texas (private land) and in New Mexico (BLM). This latter observation implies a genetic variation in flower size, which suggests that the different populations may have significant genetic differences.

Although data from only two seasons, 6 years apart, were used to evaluate population trends, it does appear that *L. burgessi* is declining to extinction. One way to increase the robustness of the populations may be to make crosses between the plants in Texas and New Mexico to obtain viable seed and make small local plantings throughout the Alkali Flats region.

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