GROWTH OF *STIPA PULCHRA* IN EXPERIMENTAL FIELD CONDITIONS

Emilia A. Parra

It is the opinion of many authors that the composition of the California Valley grassland was dominated by perennial bunch grasses, particularly species of *Stipa*, *Poa* and *Festuca*, before the arrival of Spanish settlers and their livestock. Destruction of grassland habitat occurred very rapidly, due to heavy grazing pressure and introduction of Mediterranean annual grasses, which successfully outcompeted native grassland species. Few of these perennial grasslands remain in Southern California today. Isolated populations of *Stipa* grassland occur in the Santa Monica and Santa Ana mountain ranges of Los Angeles, and most likely occurred at one time in the area where the Sepulveda Flood Control Basin now exists. This basin is located in the San Fernando Valley at an elevation of about 250 m. (820 ft.). This project was undertaken to examine the germination and growth of *Stipa pulchra* (purple needlegrass) under various environmental and cultural conditions. This three year study will provide crucial information necessary to establish a proposed 8.8 ha. (2.5 acre) *Stipa* grassland within the Sepulveda Wildlife Reserve.

MATERIALS AND METHODS

The *Stipa* grassland project is located within the Sepulveda Wildlife Reserve in Van Nuys, California, approximately 23 km. (14.3 mi.) northwest of Los Angeles. The 0.4 ha. study site is situated in an "open" area, currently managed for raptor foraging. The perimeter of the foraging area is lined with several species of riparian trees (*Populus fremintii*, *Platanus racemosa* and *Alnus rhombifolia*). The interior is characterized by a cover of various annual ruderal grasses and forbs with isolated clumps of mulefat. The area is mowed twice a year to maintain its open character.

In January 1986, the study site was sprayed with Round-up (a non-selective systemic herbicide) which effectively killed all of the existing vegetation. Ten study plots (17 x 15 m.) were marked out within the treated area. Pathways, 1.25 m. wide, were established between and around the perimeter of the plots to provide access for monitoring and irrigation. Six of the ten plots were pretreated prior to planting; three were rototilled and three were treated with pre-emergent herbicides (Ronstar and Eptam), and four remaining plots received no pretreatments, as can be seen in Figure 1.

To obtain a measure of herbivore pressure, upon completion of the plot treatments, a poultry wire fence to prevent access by rabbits was installed around eight of the ten plots. This fence was buried to a depth of 20 cm. and stood 70 cm high. The two plots remaining outside the fence would be control plots to monitor damage to *Stipa* plants from rabbit herbivory.

The test plots were established using one of three planting techniques: (1) transplanting 10 cm. paper pot specimens from nursery grown stock, (2) direct seeding, and (3) hand broadcast of seed. Six plots were planted with transplants, two were direct seeded, and two were broadcast seeded. The transplant stock was planted at three months of age using 10 cm. diameter hand auger, at a density of one individual per sq. meter (255 individuals/plot). The two direct seeded plots were prepared in a similar manner, using the auger. Five cm. pots, with the bottoms removed to allow unrestricted root growth, were inserted into the holes and soil was added to the pot. Five *Stipa* seeds were placed in each container and lightly covered with soil, using seed collected from several local areas, but with the majority of seed from commercial sources. The hand broadcast plots used 28 g. of *Stipa* seed/plot, as uniformly spread as possible, and the soil was lightly raked to cover the seed. All plots were watered upon completion.

The broadcast plots were done in February. Direct seeded plots were also completed in February and transplants were finished by March, 1986. Water was provided to six of the ten plots by rainbird sprinklers installed in each irrigation plot. Each irrigated plot was watered for an 18 hour period (overnight) on a biweekly basis. The four non-irrigated plots received moisture from rainfall and dew. There was a total of 3.1 cm. of rainfall during the months of March and April, 1986.

Three methods of plant sampling were used to measure germination, growth and survival. Percent germination was determined during the first month after seeding in the direct seeded plots. The number of individuals germinated per pot were counted over a one month period, and not after because the seedlings quickly grew and it became too difficult to differentiate between individuals. Growth data were determined by height and width measurements of the vegetative portions of the clump (excluding the inflorescence). Twenty-five randomly selected plants per plot were measured every two weeks. The width determination was based upon perpendicular cross-sections and the mean of the two values recorded as the clump width. Survival data, excluding the broadcast plots, were taken, as all other measurements, on a monthly basis throughout the growing season (April-September).

RESULTS

Growth data taken from all plots except the broadcast plots were analyzed using a two-way analysis of variance (ANOVA). This test was selected as more than two plots can be compared simultaneously along with multiple variables. The broadcast plots were not included. As the *Stipa* plants grew it became too difficult to differentiate them from other species. These plots were surveyed at the end of the growing season for the total number of plants in the plot. For the remaining plots, two crucial factors were analyzed. The first was growth versus water availability (irrigated and non-irrigated plots), within the fenced area. The second was growth between protection from herbivores (fenced and non-fenced plots). As can be seen in Tables 1 and 2, there was no significant difference between the fenced and non-fenced plots, but there was a significant difference between irrigated plots and those that were dependent upon only rainfall and dew. The percent survival and flowering for *Stipa* are shown in Fig. 2. The change in biomass for the 1986 growing season is shown in Fig. 3. Survival data for all the plots were not quantitatively analyzed. Survival and flowering percentages for *Stipa* are shown in Fig. 4, and the results of the direct seeded plots appear in Fig. 5.

DISCUSSION

The results of the ANOVA tests indicate that there is a significant difference in width between the irrigated and non-irrigated plants. The variable for height had a p value of 0.69, which was no significant, but a p value of 0.018 for the variable of width does indicate significance, implying that the two means (9.69 and 10.4, respectively) were statistically different. Noting that the plots included both transplanted and direct seeded groups, when transplanted plots alone were tested for a difference between irrigated and non-irrigated areas, neither the height ($p = 0.101$), nor the width ($p = 0.986$) of the plants showed a statistically significant difference. The results thus indicate that all transplanted plots grew equally well. This suggests that the small size of the direct seeded plants (especially their width) was enough to cause a significant difference, and irrigation is not seen as a critical factor for establishment. Still, there may be important trends that were not revealed by the statistical tests used that are worthy of discussion. Data shown in Figure 3 do suggest that the growth differences between Test Plots 9 and 10 do differ based upon a qualifiable examination alone in that all other plots had negative growth.

Table 1

Irrigated vs. Non-irrigated Plots

Non-irrigated = 0
Irrigated = 1

	VARIABLE: HEIGHT		VARIABLE: WIDTH	
	0	1	0	1
MEAN	8.16	8.23	9.69	10.4
STD. DEV.	3.95	3.27	5.82	4.71
SAMPLE SIZE	755	663	755	663

ANOVA SUMMARY: HEIGHT*

SOURCE	SUM SOS.	DF	MEAN SQ.	F	P
Between	1.987	1	.15	.15	.6962
Within	18902.902	1411	1.00		

ANOVA SUMMARY: WIDTH*

SOURCE	SUM SOS.	DF	MEAN SQ.	F	P**
Between	153.601	1	5.55	5.55	0.018
Within	40263.3124	1407	1.00		

* The Welch and Brown-Forsythe tests were used instead of the standard ANOVA because the data do not conform to the assumption of equal variances. The Levene test for equal variances showed $p < .0001$ in all cases.

** Indicates a significant value at the 0.05 level.

Table 2

Fenced vs. Non-fenced Plots

Non-fenced = 0
Fenced = 1

	VARIABLE: HEIGHT		VARIABLE: WIDTH	
	0	1	0	1
MEAN	4.77	8.99	5.53	9.42
STD. DEV.	2.07	3.88	2.41	5.75
SAMPLE #	202	500	202	500

ANOVA SUMMARY: HEIGHT

SOURCE	SUM SOS.	DF	MEAN SQ.	F	P
Between	2556.98	1	345.88	345.88	0.000
Within	8387.45	650	1.00		

ANOVA SUMMARY: WIDTH

SOURCE	SUM SOS.	DF	MEAN SQ.	F	P
Between	2174.15	1	159.27	159.27	0.000
Within	17672.21	699	1.00		

STIPA PLOT TREATMENTS

UNFENCED	FENCED
1. Transplant Non-Irrigated Pre-Emergent	3. Transplant Irrigated Mowed
2. Transplant Irrigated Pre-Emergent	4. Transplant Non-Irrigated
	5. Broadcast - 1 oz. Seed Irrigated Herbicide
	6. Broadcast - 1 oz. seed Non-Irrigated
	7. Direct Seed Irrigated Herbicide
	8. Direct Seed Non-Irrigated Herbicide
	9. Transplant Non-Irrigated Pre-Emergent
	10. Transplant Irrigated Herbicide

Figure 1

PERCENT SURVIVAL AND FLOWERING FOR STIPA JULY 1986

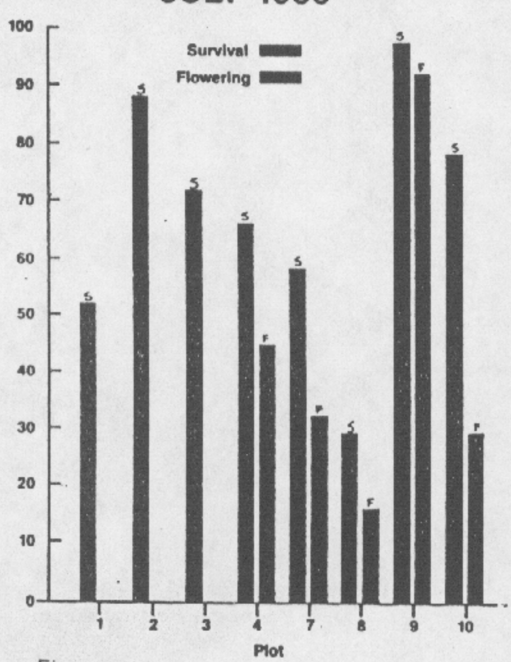

Figure 2

CHANGE IN STIPA BIOMASS MARCH—AUGUST 1986

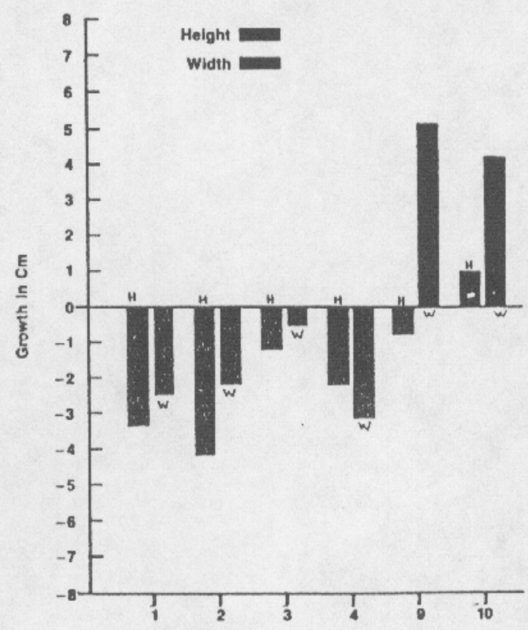

Figure 3

PLOTS 7 AND 8: DIRECT SEEDED PLOTS

Planted: February 22, 1986
1275 Seeds/plot
255 Pots/plot

GERMINATION		
	Irrigated	Non-irrigated
March 11	24% seed germination 52% pots with seedlings	15% seed germination 38% pots with seedlings
March 26	43% seed germination 88% pots with seedlings	38% seed germination 83% pots with seedlings

Figure 4

PERCENT SURVIVAL: DIRECT SEED PLOTS MARCH—JULY 1986

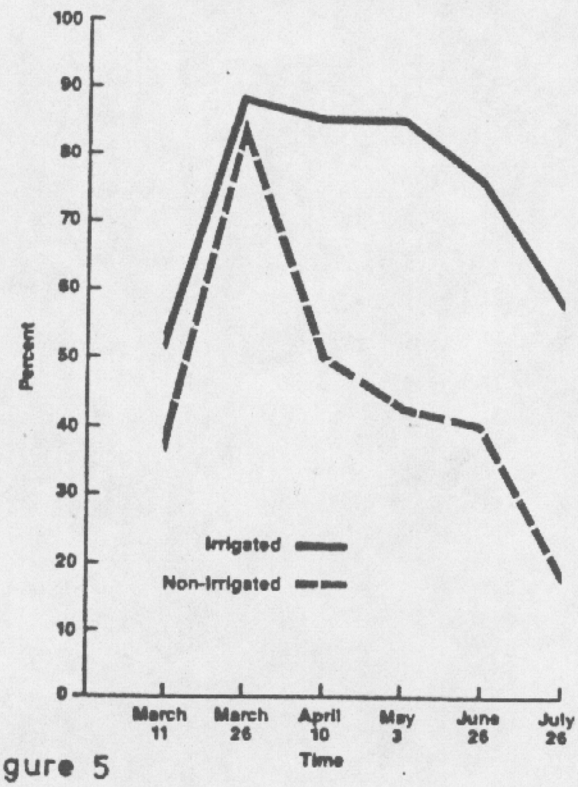

Figure 5

Figure 3 displays the change in biomass during the 1986 growing season. As noted, all plots, except 9 and 10, showed decreases in biomass. Refer to Fig. 1 for a summary of plot treatments. Plots 3-10 were within the fenced area, so rabbit and rodent herbivory do not account for the loss in biomass exhibited by plots 3 and 4. These plots had no weed control of any kind and had to compete with annual weeds. Weeds were prevalent in all plots not treated in some manner for weeds, but were especially dense in the irrigated plots. Plot 3 was mowed late in the growing season after the weeds had completed their life cycles. Plots 1 and 2 both show large decreases in biomass, but this is due almost entirely to herbivory. As can be seen in Table 2 there was a significant difference in growth between fenced and non-fenced areas. Plants in both of these plots rarely reached more than 2 cm. in height. Plots 9 and 10 showed gains in biomass. Both of these plots had weed control. Plot 9, which did the best overall, was non-irrigated and the pre-emergent chemical Ronstar was used prior to planting. A pre-emergent prevents the germination of seeds present in the soil at the time of application. We feel that Ronstar works best under non-irrigated conditions because in plot 2 many more weeds were present, using Ronstar under irrigated conditions. Plot 10 was treated with a broadleaf herbicide that controls dicot weed growth only. This chemical was applied as a foliar spray three times during the growing season. It effectively removed dicot weeds and reduced competition for resources.

Referring to Fig. 2, the percentages for survival and flowering for the plots is illustrated. Again, though plants were alive in plots 1 and 2, no individuals flowered (no seed production) because of intense herbivore pressure. Plot 3 is misleading because no flowering data were available because the plot was mowed before the data were gathered. My own personal observation indicated that 50% of the plants flowered. Plot 4 was moderate in survival and flowering rates, possibly due to competition with weeds. Again, plot 9 had high percentages of both individuals and seed production, with almost all individuals producing infloresences. Plot 10 showed moderate survival rates with a relatively low level of flower production. The results of the direct seeded plots are shown in Figs. 4 and 5. Germination was highest in the irrigated plot with 88% of pots with at least one seedling. And, over the course of the growing season, the irrigated plot had the highest survival rate. Water is very important in the establishment of seedlings, while it does not seem to be such a critical factor for young transplants with a developed root system. A plot that also did well was 5. This was the irrigated broadcast plot. A count taken at the end of the 1986 growing season showed 667 individuals present. These were found in distinct clumps and personal observation indicated that 60% produced flower stalks. Plot 6 produced no visible *Stipa* plants.

CONCLUSIONS

It is hard at this point to make concrete statements concerning *Stipa* growth from only one year of results. But, some trends are evident. Transplanted plants seem to do well with minimal irrigation, but need some form of weed control for optimal growth and seed production. This would be very important for the continued establishment of the grassland from natural seedling recruitment. Seedlings will have a difficult time competing with the more vigorous and fast growing annuals. A mowing schedule may be effective in controlling annual weed growth, if mowing is done early in the season and once again after *Stipa* seed set.

Direct seeding is time consuming and the results were poor. Even under irrigated conditions, only 53% of the plants survived. The broadcast plot produced many more productive individuals and is less time consuming. Without going into detail, the results from the second year substantiate findings from the first year. We have used herbicides (per-emergents) in conjunction with mowing and have reduced weed growth. The broadcast plot is producing more young plants from last years, seed set. Plants must have some protection from herbivores (mainly rabbits at the Sepulveda Wildlife Reserve), but as the density of the *Stipa* plants increase the need for protection decreases. More data are still needed to analyze the successes and failures of our methods over time.

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