Preliminary Biological Monitoring Report for
Sidalcea covillei

A cooperative study between the California Department of Fish and Game, The Nature Conservancy and the Bureau of Land Management

ELEMENT: *Sidalcea covillei*

COMMON NAME: Owens Valley Checkerbloom

FEDERAL LISTING: C1 STATE LISTING: Endangered

DATA STORAGE: California Department of Fish and Game, Natural Heritage Division, Sacramento, CA and the Bureau of Land Management, Bishop Resource Area, Bishop, CA.

PREPARED BY: Anne S. Halford, August 15, 1994

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Introduction

The Owens Valley checkerbloom is an endemic perennial species which inhabits distributionally limited alkali meadow and spring communities. *Sidalcea covillei* Greene was discovered in 1891 by Frederick V. Coville. The type specimen was subsequently collected in what is now known as Haiwee Reservoir, which had previously persisted as an extensive alkali meadow. The next collection of *Sidalcea covillei* did not occur until 1952 when Leo B. Hitchcock found large stands that totaled several thousand plants 1.5 miles north of Lone Pine (DeDecker 1985).

In 1978 concerns were raised regarding the long-term effects ground water pumping and diversions would have on the viability of *Sidalcea covillei* populations. At that time only one occurrence had been documented (DeDecker 1978). However, extensive field surveys conducted later by LA Department of Water and Power personnel provided information on more numerous locations (Novak 1992 pers. comm.), but detailed ecological site information was still limited.

Currently populations and subpopulations of *Sidalcea covillei* total between 35 and 40, and are scattered throughout approximately 125km of the Owens Valley in Inyo County, CA. The majority of these populations occur on lands administered by the Los Angeles Department of Water and Power. Field assessments conducted during the years of below normal precipitation (1987-1992) contained information regarding the loss of individual plant and population vigor (Manning and Novak 1992 pers. comm.). One population in particular, Five Bridges, showed a precipitous decline in numbers of individuals that has recently been attributed to improper timing and intensity of ground water pumping (Manning 1994).

Additional factors that may affect declines and fluctuations in *Sidalcea covillei* populations include; low annual precipitation, improper timing and intensity of cattle grazing, increased competition by upland shrubs and rhizomatous grass species, and diversions or depletions of water sources. In 1993 a cooperative study was initiated between the California Department of Fish and Game (CDFG), The Nature Conservancy and the Bureau of Land Management (BLM) to examine ecological parameters and plant response to vegetation removal treatments in two non-livestock grazed populations of *Sidalcea covillei* that occur on lands administered by the BLM. The study was financially supported by CDFG and The Nature Conservancy under the Drought Relief Project fund.

The primary goals of the study were to; 1) examine the effect of vegetation removal treatments on seedling recruitment and plant vigor, 2) monitor changes in soil temperature and soil water availability, 3) examine edaphic site characteristics, and 4) test different seed germination techniques. Three basic hypotheses were tested:

1) Removal of upland shrubs, reductions in herbaceous live cover and removal of accumulated dead litter does not affect, a) seedling establishment and b) the vigor of existing individuals as measured by number of flowering stems, length and number of flowers and fruits.

2) The type of vegetation removal treatment does not affect, a) seedling establishment and b) individual plant vigor.

3) Vegetation removal treatments do not affect soil water potential or temperature.

Methods

Vegetation Removal Treatments

Within each *Sidalcea covillei* population a total of 4 permanent 15m transects and 3 1.5m plots per transect were established. There were a total of 8 plot treatments and 4 controls for each population. Vegetation removal treatments which included hand removal of shrubs, perennial and annual grasses (30% litter left intact), and low intensity burns were randomly applied to plots along each transect.

The burning of plots occurred on December 8, 1993 at the Wilkerson site and on January 18, 1994 at the Diaz Creek site. Fires were ignited at one end of each plot and allowed to burn with existing fuel concentrations. The flames were extinguished when the flames moved into the water saturated buffer that was applied to the perimeter of each plot. Any persistent flames were lightly extinguished with shovels.

Hand removal of vegetation in treated plots was performed during the same dates as the burns. Hand removal employed confined and gentle uprooting of perennial grasses and shrubs as well as removal of dense litter thatch. Subsequent removal of new growth was performed again in April.

Age Class Distribution

Both seedlings and mature plants were counted within each plot by using a 1.5m x 5cm grid frame. Plants within 5cm grids were also tagged to facilitate determination of post-treatment survivorship.

Species Composition

Species composition within each population was determined on both a plot and transect level. Plot level composition was determined using Daubenmire cover estimates (Daubenmire 1959). Transect level composition which was characterized a 15 by 2m belt area, was determined using the point-intercept method (Bonham 1989). To obtain point-intercepts, an optical point bar device was placed at 0.5m intervals along each transect (Buckner 1985).

Soil Water Potential and Temperature

Soil water potential and temperature were monitored within each plot throughout the 1993 and 1994 growing seasons. Soil water potential was measured using a quick-draw tensiometer (Soil Moisture Corp., Santa Barbara, CA). Soil water potential measurements are indices of soil water availability. More negative Kilopascal values are indicative of drier soil conditions. Soil temperature measurements were made using a 30cm soil thermometer.

Edaphic Characteristics

Soil samples were taken within each plot at 5, 15 and 30cm depth increments. Soils were analyzed by Midwest Laboratories, Omaha, Nebraska for concentrations of; Organic matter, Phosphorus (P), Potassium (K), Calcium (Ca), Sodium (Na), pH, Cation Exchange Capacity (CEC) and Soluble salts.

Seed Germination and Propagation

Ripe seeds were collected in June 1993 from both the Wilkerson site and from a *Sidalcea covillei* population on private land, approximately 0.5 km from the Diaz Creek site. No seeds were collected from the Diaz Creek study population due to the lack of mature individuals with adequate seed set. The seeds were then given to horticulturalist, Jim Roberts at Sierra Gardens Nursery in Bishop, CA. Seeds were divided into separate lots with 249 seeds for the Wilkerson population and 288 for the Diaz Creek population. Seeds were weighed and a germination rate calculated for each 0.1g of seeds (Tables 1 and 2).

Seeds were further divided in sublots for treatment application. Diaz Creek lots were labeled; 1a, 1b, 1c and 1d. Wilkerson lots were labeled; 2a, 2b, 2c and 2d. Seed lots 1a, 1b, 2a and 2b were leached for 24 hours under running water and seeded immediately after leaching. Lots 1c, 1d, 2c and 2d were sown without leaching. Lots 1a, 1c, 2a and 2c were placed in cold stratification for 2 1/2 weeks then placed on heat mat plates. After being sown in 43 X 43cm germination flats, lots 1b, 1d, 2b and 2d were placed on heat mat plates.

> Leaching Process: Argyle P-17 a synthetic spun polyfiber material was used to wrap seed bundles. Seed bundles were then placed in 2.5 X 15cm tree tubes. Pepco 1/2 gallon/hour emitters which regulated flow rates were used to leach the seeds. The emitters were set up in a string array and hooked to a tap.

One week after sowing, seeds were checked daily for germination. Emergence of seed radicles were recorded for each seed lot. After approximately 6 weeks of growth in the germination flats, 3 seedlings were transplanted into 10 X 25cm pots for a total of 120-140 plants (Lawrence and Roberts 1994). Plants will continue growing in these pots until outplanting in Spring of 1995 (Study design in progress).

Table 1. Procedure used to estimate plant yield based on seed weight (Lawrence and Roberts 1994).

15.8 GRAMS FROM THE DIAZ LAKE SITE
(288 seeds/flat)

$$52+46+44+42+40+44=268$$
$$\frac{268}{6}=44.7$$

0.1 GRAMS = 45 SEEDS

$$\frac{28.34}{.1}\bullet .45=12753 \text{ SEEDS / OUNCE}$$

@ 60% GERM

$$12753\bullet .60=7651.8$$
$$\frac{7651.8}{8}=956.5$$

1/8 oz=approx. 1000 plants

Wt. sample #1	52 seeds
Wt. sample #2	46 seeds
Wt. sample #3	44 seeds
Wt. sample #4	42 seeds
Wt. sample #5	40 seeds
Wt. sample #6	44 seeds

2.3 GRAMS FROM THE WILKERSON SITE
(249 seeds/flat)

$$52+46+55+56+53+52=314$$
$$\frac{314}{6}=52.3$$

0.1 GRAMS = 52 SEEDS

$$\frac{28.34}{.1}\bullet 52=14736.8 \text{ SEEDS / OUNCE}$$

@ 60% GERM

$$14736.8\bullet .60=8842.1$$
$$\frac{8842.08}{8}=1105.3$$

1/8 oz=approx. 1000 plants

Wt. sample #1	52 seeds
Wt. sample #2	46 seeds
Wt. sample #3	55 seeds
Wt. sample #4	56 seeds
Wt. sample #5	53 seeds
Wt. sample #6	52 seeds

Table 2. (a) Calculations used to determine seed number per lot and expected results at 60% germination. (b) Range of germination results for the two lots (Lawrence and Roberts 1994).

(a)

 # OF SEEDS PER FLAT PROPOSED GERMINATION (60%)

Diaz Lake

$$\frac{52 \text{ seeds}}{.1 \text{ g}} \bullet \frac{.55 \text{ g}}{\text{flat}} = 288 \text{ seeds / flat}$$

@ 60% germination = **173 plants**

Wilkerson

$$\frac{45 \text{ seeds}}{.1 \text{ g}} \bullet \frac{.55 \text{ g}}{\text{flat}} = 249 \text{ seeds / flat}$$

@ 60% germination = **149 plants**

(b)

 # OF SEEDS PER FLAT ACTUAL GERMINATION (1.6%-12.5%)

Range for Diaz Lake

$$\frac{20 \text{ seeds}}{288 \text{ planted seeds}} = 6.9\% \text{ (lowest) to } \frac{36 \text{ seeds}}{288 \text{ planted seeds}} = 12.5\% \text{ (highest)}$$

Range for Wilkerson

$$\frac{14 \text{ seeds}}{249 \text{ planted seeds}} = 1.6\% \text{ (lowest) to } \frac{4 \text{ seeds}}{249 \text{ planted seeds}} = 5.6\% \text{ (highest)}$$

Statistical Analyses

Analyses incorporated Analysis of Variance procedures (ANOVA). STATISTIX version 3.5 was the statistical package incorporated. Values of significance were at the $P<0.05$ level.

Results

Site Descriptions

Site 1 - Wilkerson

The Wilkerson *Sidalcea covillei* population is located on an east to southeast facing slope (0-10%) 4.8km south of Bishop, at an elevation of 1,341m. The soils are of mixed alluvium and lacustrine sediment origin. Surface textures are loamy sands, sandy loams and silt loams. Dominant plants include both mesic alkali meadow species such as; alkali sacaton (*Sporobolus airoides),* beardless wild rye (*Leymus triticoides*), and salt grass (*Distichlis spicata*) as well as, plants indicative of drier upland sites such as; Great Basin sagebrush (*Artemisia tridentata* ssp. *tridentata*) rubber rabbitbrush (*Chrysothamnus nauseosus*) and cheat grass (*Bromus tectorum*) (Table 3).

Within a portion of the site, which represents the most western extent of *Sidalcea covillei* for this location, are also scattered Alkali mariposa lilies (*Calochortus excavatus*), another federal candidate species endemic to alkali meadow and spring sites.

Site 2 - Diaz Creek

The Diaz Creek population is located on an east to southeast facing slope (5-15%) in the Alabama Hills, approximately 7km west of Lone Pine at an elevation of 365m. Soil parent material and texture is similar to the Wilkerson population, but variations in plant composition do exist (Table 3), especially with regard to the lack of *Bromus tectorum. Calochortus excavatus* also occurs within the area, but with a wider distribution throughout the site than occurs at the Wilkerson site.

Vegetation Removal Treatments

Mean number of seedlings in control and treated plots at the Wilkerson site significantly declined between 1993 and 1994 (Figure 1). Control plots exhibited the highest decline in seedling numbers. The number of mature plants did not significantly decline between years. Treatment main effects were not significantly different among transects ($P<0.47$).

Table 3. Species Frequency for the Wilkerson and Diaz Creek *Sidalcea covillei* populations.

Wilkerson Population

Species	Number of Plots Species Were Found Per 12 Plots	% Species Frequency
Sidalcea covillei	12	100
Leymus cinereus	6	50
Bromus tectorm	5	41
Distichlis spicata	4	33
Carex praegracilis	3	25
Calochortus excavatus	3	25
Juncus baliticus	3	25
Chrysothamnus nauseosus	3	25
Sporobolus airoides	2	16
Thelypodium crispum	2	16
Hordeum brachyantherum	1	8
Artemisia tridentata ssp. *tridentata*	1	8
Bromus rubens	1	8

Diaz Creek Population

Species	Number of Plots Species Were Found Per 12 Plots	% Species Frequency
Sporobolus airoides	12	100
Distichlis spicata	8	66
Juncus balticus	7	58
Sidalcea covillei	4	33
Carex praegracilis	3	25
Chrysothamnus nauseosus	3	25
Helianthus nuttallii	3	25
Apocynum cannabinum	3	25
Poa nevadensis	3	25
Leymus cinereus	2	16
Artemisia tridentata ssp. *tridentata*	1	8
Cleomella sp.	1	8

Between 1993 and 1994 at the Diaz Creek site only burned plots showed a significant difference in mean number of seedlings (Figure 1). Overall treatment main effects were not significantly different among transects ($P<0.52$).

Comparisons of individual plant vigor between 1993 and 1994 for both the Wilkerson and Diaz Creek populations were not possible due to the lack of available stems and flowers on mature *Sidalcea covillei* individuals in 1994. Rabbit and other rodent herbivory levels at both sites was extreme in 1994, especially in plots that were adjacent to stands of rabbitbrush.

Soil Water Potential and Temperature

Commensurate with declines in seedling numbers at the Wilkerson population in 1993 and 1994 (Table 4), are significantly drier soil conditions that parallel lower annual precipitation levels in 1994. In January 1993 a total precipitation of 5.12 cm was recorded at the Bishop Airport compared to 0.10 cm in January of 1994. Overall transect level May soil water potential values became increasingly more negative and ranged from -6 KPa in 1993 to -18 KPa in 1994 (Figure 2). Soil temperatures were also significantly higher in 1994 than in 1993 (Figure 2).

Measurements of soil water potential and temperature throughout the growing season of *Sidalcea covillei* in 1994 demonstrate the significant declines in soil water availability and increases in soil temperatures that occur between March and May (Figure 3). Significant differences are also evident between transects, with transect 1 exhibiting the most negative water potential values.

At Diaz Creek where seedling declines were not significant, soil water potential values were not significantly more negative in 1994. Overall transect level soil temperatures between 1993 and 1994 however did demonstrate a significant decline from 16C to 8C (Figure 2). In 1994 soil water potential values significantly increased between March and May from -5.2 KPa to -10.0 KPa ($P<0.02$). Commensurate with these values are increases in soil temperature from 3.3C to 8.8C ($P<0.00$).

Although increases in soil water availability were expected in treated plots, no significant differences between treatments were found for either soil water potential or soil temperature values within the Wilkerson and Diaz Creek populations.

Edaphic Characteristics

Concentrations of Potassium, Calcium and soluble salts were significantly higher in soils from the Diaz Creek site. Associated pH values were significantly lower and Cation Exchange Capacity values higher than those from the Wilkerson site (Table 5).

Transect 1 concentrations of Phosphorus and Calcium were significantly different in soils from the Wilkerson site, whereas only % organic matter in Transects 1 and 3 were significantly different in soils from the Diaz Creek site (Table 2).

Table 4. Age Class Distribution for *Sidalcea covillei* populations in 1993 and 1994.

Wilkerson Population

Transect #	Seedlings 1993	Seedlings 1994	Mature 1993	Mature 1994	Total 1993	Total 1994
1	0	0	10	8	10	8
2	21	3	41	36	62	39
3	64	37	55	55	119	92
4	393	29	44	44	437	73

Diaz Creek Population

Transect #	Seedlings 1993	Seedlings 1994	Mature 1993	Mature 1994	Total 1993	Total 1994
1	31	15	54	32	89	47
2	4	3	2	3	6	6
3	1	2	1	2	2	4
4	0	0	1	1	1	1

Figure 1. Mean seedling densities in pre (1993) and post treatment (1994) plots. Means that are significantly different are represented by different letters (P<0.05).

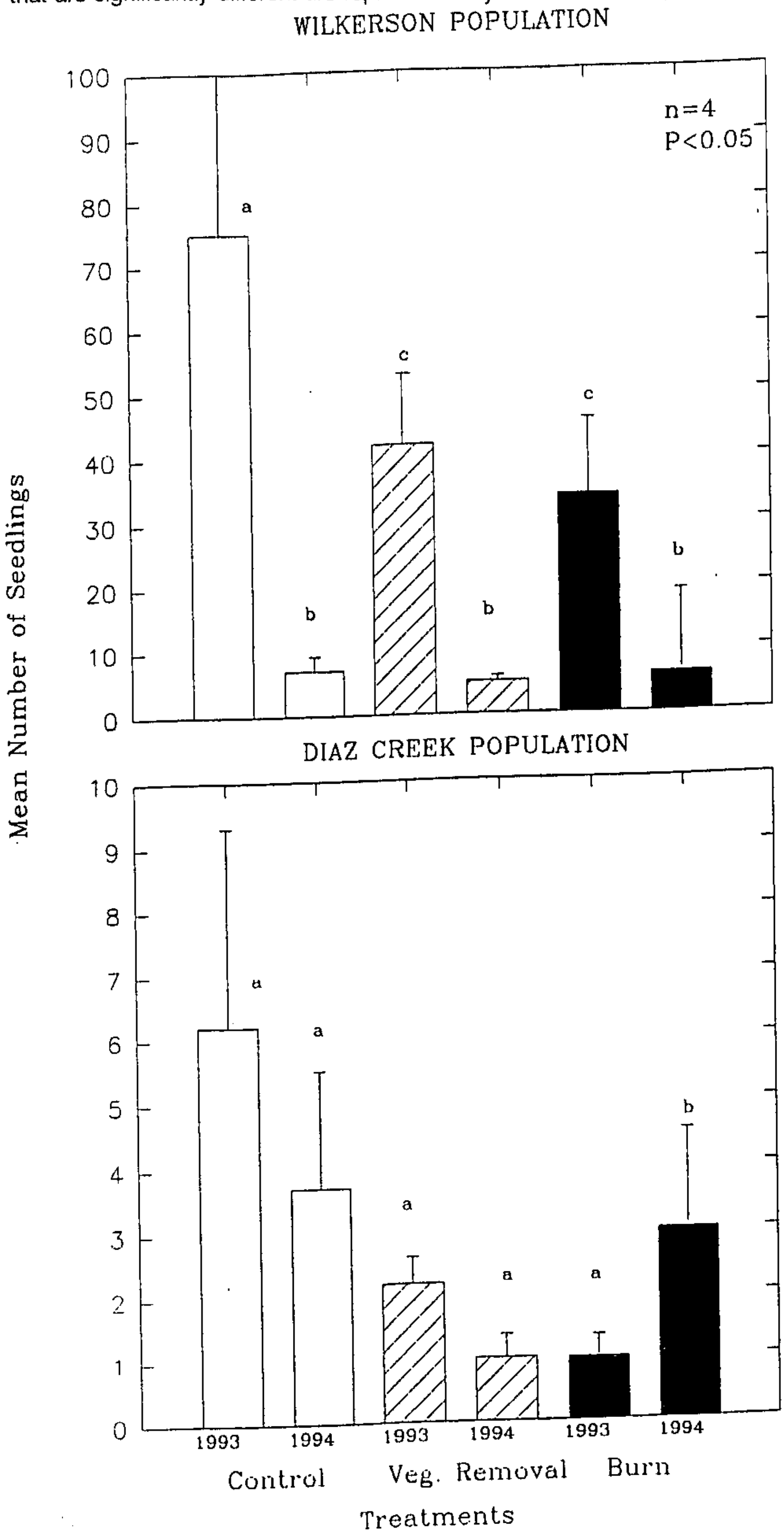


Figure 2. Soil water potential and soil temperature values for May 1993 and 1994. Means that are significantly different are represented by different letters (P<0.05).

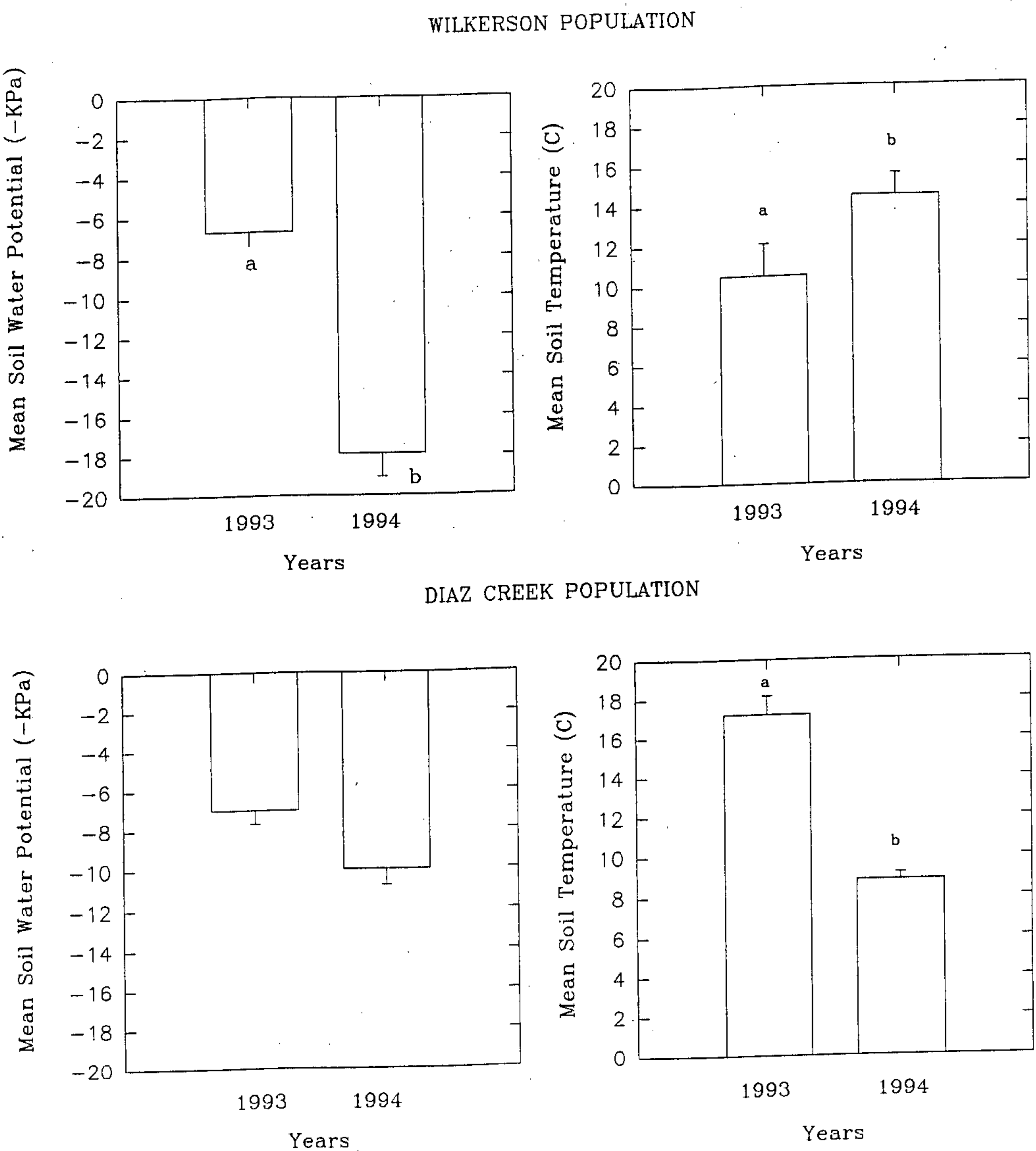


Figure 3. Range of soil water potential and temperature values for three dates at the Wilkerson *Sidalcea covillei* population. Means that are significantly different are represented by different letters (P<0.05).

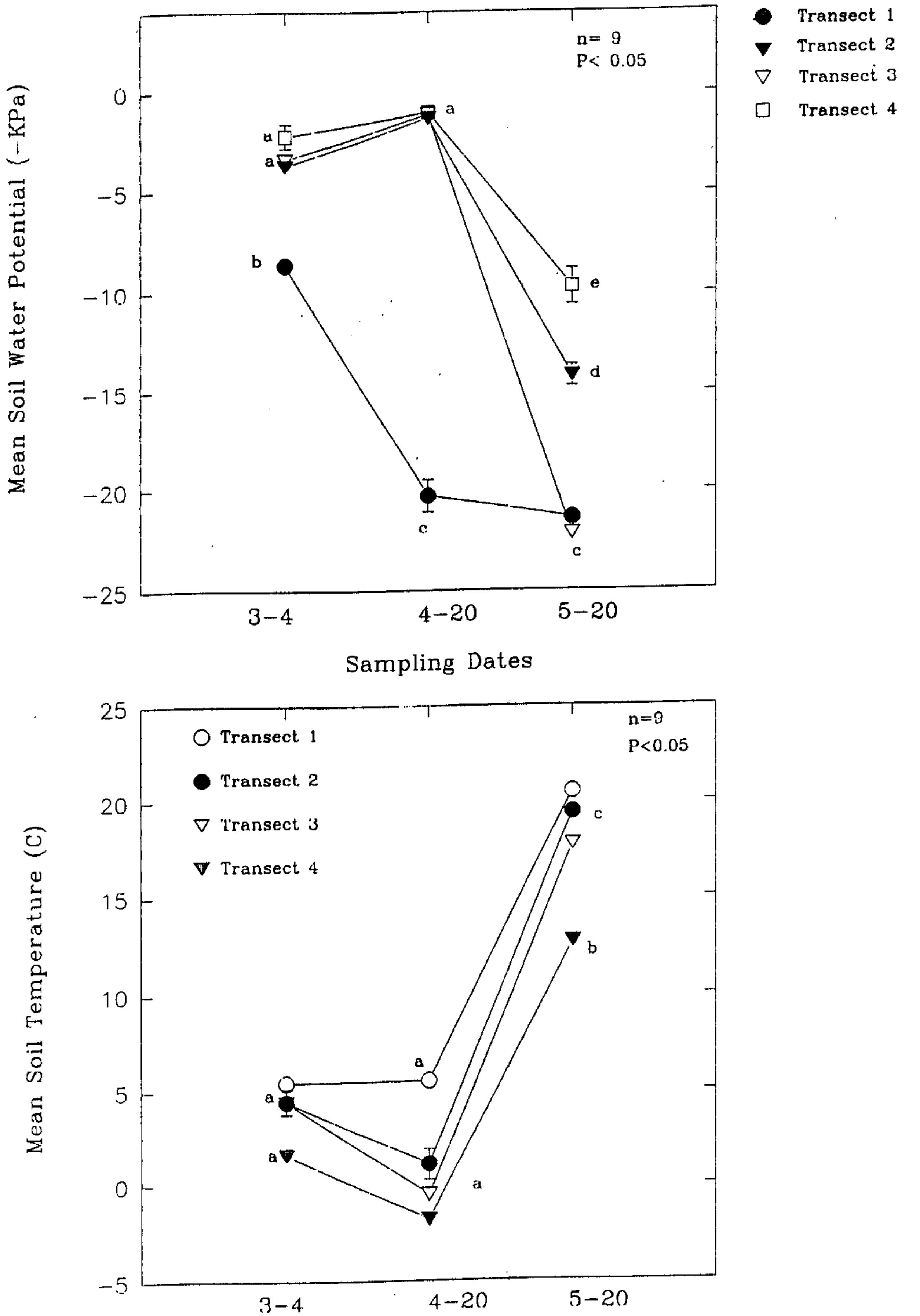


Table 5. Population level and transect level edaphic characteristics of the Wilkerson and Diaz Creek *Sidalcea covillei* populations. Mean ± confidence intervals over three depth increments are given for each population; means that are significantly different are followed by different letters.

Population	Organic Matter(%)	Strong Bray P(ppm)	K(ppm)	Ca(ppm)	Sodium(ppm)	pH	C.E.C. (meq kg^{-1})	Soluble Salts
Wilkerson	2.1±0.17	47.2±3.62	811±9.37a	1676±6.16a	559±18.48a	8.7±0.02a	13.7±0.07a	1.9±0.05a
Diaz Ck.	1.3±0.032	14.46±3.05	613±25.41b	1409±28.90b	2114±877b	9.2±0.027b	19.3±0.84b	6.1±0.44b

Wilkerson Population

Transect	Organic Matter(%)	Strong Bray P(ppm)	K(ppm)	Ca(ppm)	Sodium(ppm)	pH	C.E.C. (meq kg^{-1})	Soluble Salts
Transect 1	1.3±0.04	134±4.33a	906±23.93	1632±11.36a	539±63.31	8.6±0.72	13.4±0.32	1.4±0.02
Transect 2	5.4±2.76	5.3±1.64b	844±70.40	1667±4.85b	430±11.07	8.6±0.17	13.7±0.17	2.2±0.27
Transect 3	1.7±0.4	4±0.88b	760±35.06	1830±25.75b	285±76.70	8.5±0.12	13.8±0.34	1.8±0.27
Transect 4	1.4±0.11	2.1±0.06b	726±29.91	1646±21.80a	780±51.78	8.9±0.05	14.4±0.19	2.3±0.22

Diaz Creek Population

Transect	Organic Matter(%)	Strong Bray P(ppm)	K(ppm)	Ca(ppm)	Sodium(ppm)	pH	C.E.C. (meq kg^{-1})	Soluble Salts
Transect 1	1.6±0.04a	26±9.77	593±52.7	1631±27.56	2112±499.5	9.1±0.05	19.7±2.14	6.3±1.02
Transect 2	1.5±0.57b	6±2.09	543±146.5	1111±205.83	1024±308.9	9.3±0.10	14.4±1.20	3.6±1.32
Transect 3	1.3b	4	999	1022	3302	9.9	22.2	6.7
Transect 4	0.8±0.06c	2.6±0.19	592±110.1	1391±62.61	2814±646.33	9.4±0.04	22.5±2.55	7.9±1.46

Seed Germination and Propagation

Seeds collected from the site 0.5 km west of Diaz Creek site contained 45 seeds per 0.1g compared to 52 per 0.1g from the Wilkerson seed lots (Table 6). The heavier and more robust Diaz Creek seeds also exhibited the highest germination rates. Table 7 illustrates the dates of initial germination per seed lot, progression of seedling recruitment and dates of seedling transplant. On 4/12/94 Diaz Creek seed lots produced a higher number of seedlings under all treatments compared to Wilkerson seed lots (Table 7).

Overall germination success was highest for seeds that were leached and then placed in flats on heat mats (Figure 4). Out of an expected yield of 173 plants from the Diaz Creek, 36 seeds germinated with the leaching only treatment (Figure 5). Seeds from the Wilkerson population had a lower expected yield of 149. The leaching only treatment produced 10 germinated seeds compared with 14 seeds that germinated in control lots (Figure 5) (Lawrence and Roberts 1993).

Discussion

Species of the *Sidalcea* genus occupy diverse and ecologically unique habitats that include the serpentine rock and Sargent cypress forest communities of the rare *Sidalcea hickmanni* ssp. *parishii* and mesic pebble plain meadows of the endangered *Sidalcea pedata* (CNPS 1987). *Sidalcea covillei* is perhaps ecologically more similar with regard to habitat requirements, to other *Sidalcea* species that occupy meadow community types. The responses of these species to natural and human induced perturbations are influenced by a species; 1) genetic and demographic characteristics, 2) reproductive mechanisms, and 3) autecology.

With regard to autecology, evidence suggests that several species of *Sidalcea* and other members of the Malvaceae family are early successional species. For example *Sidalcea hickmanii* ssp. *parishii* has been found to respond favorably to fire (Griffin 1978, CNPS 1987) as have populations of a rare mountain mallow (*Iliamna corei*) in western Virginia (Stolzenburg 1994). Studies of populations of *Sidalcea nelsoniana*, a distributionally restricted endemic of transitional meadow and upland communities of the Willamette Valley in Oregon, suggest that higher densities of this species are associated with areas that have experienced surface soil disturbance (Mishaga *et. al.* 1987).

Although it is currently unknown what the specific seral status is for *Sidalcea covillei*, the treatments used in this study were designed to examine how reductions in plant cover influenced seedling densities and individual plant vigor. The overall seedling density declines in both control and treated plots at the Wilkerson site was influenced primarily by the significantly lower levels of soil water availability. The Diaz Creek site in contrast showed a lower decline in soil water availability. This may have been influenced by the population's greater proximity to a perennial water source and its less impacted site characteristics, e.g. lack of exotic grass component (*Bromus*

Table 6. Seed weight trails for 6 replicates taken from the Diaz Creek and Wilkerson seed lots. All samples weighed 0.1g each. Total weight of all seeds in each lot is also represented (Lawrence and Roberts 1994).

Sidalcea covillei **- Lot #1 Diaz Lake Seed Lot**

TOTAL ➢ 15.8 GRAMS

Wt. sample #1	52 seeds
Wt. sample #2	46 seeds
Wt. sample #3	44 seeds
Wt. sample #4	42 seeds
Wt. sample #5	40 seeds
Wt. sample #6	44 seeds

Sidalcea covillei **- Lot #2 Wilkerson Seed Lot**

TOTAL ➢ 2.3 GRAMS

Wt. sample #1	52 seeds
Wt. sample #2	46 seeds
Wt. sample #3	55 seeds
Wt. sample #4	56 seeds
Wt. sample #5	53 seeds
Wt. sample #6	52 seeds

Figure 4. Germination results showing differences between leaching treatments (Lawrence and Roberts 1994).

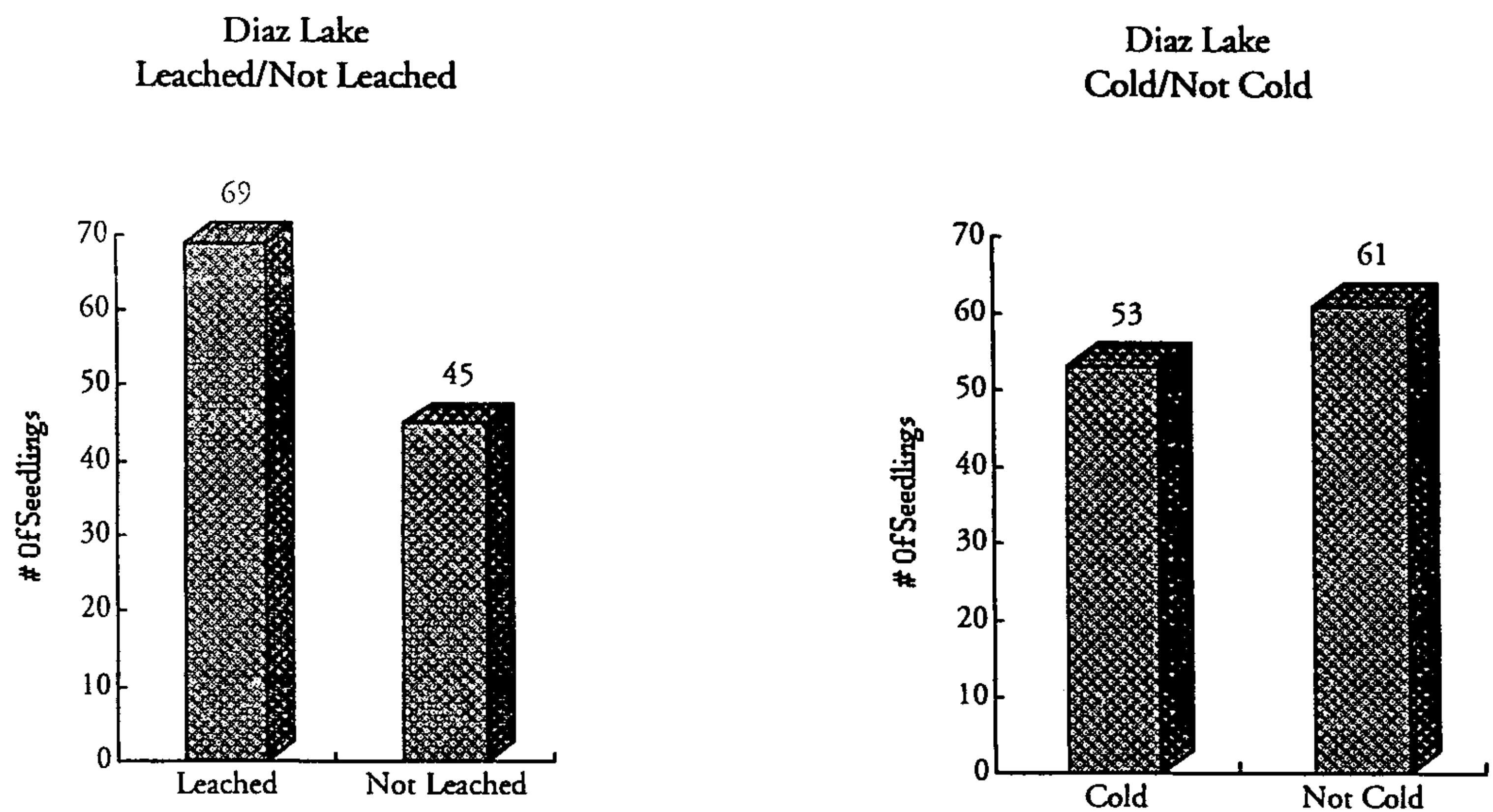
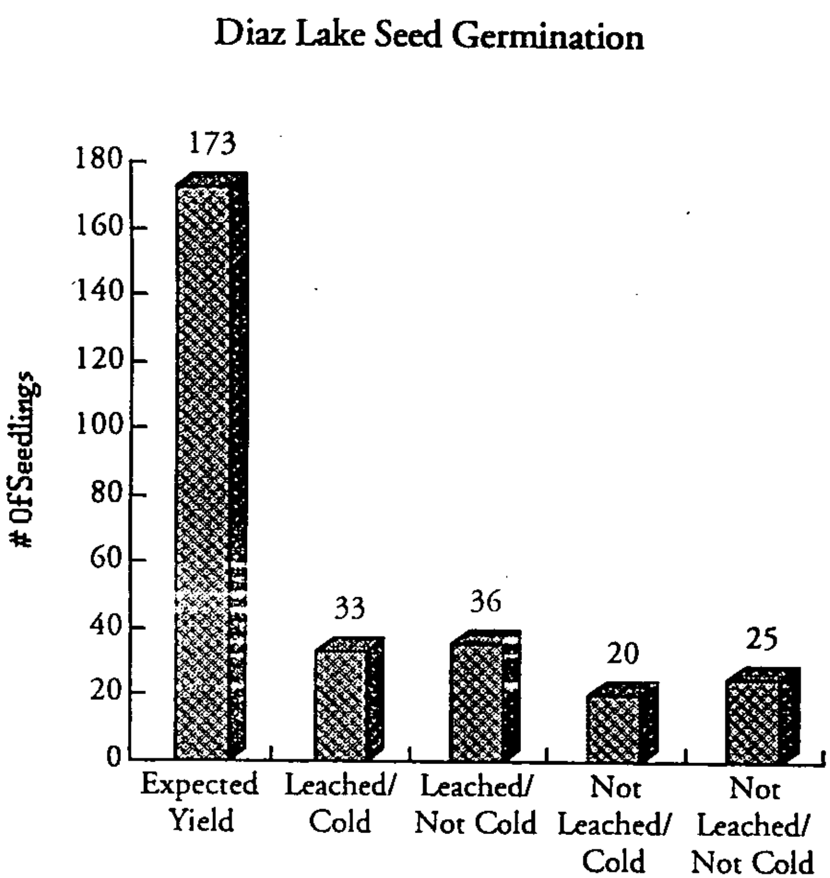


Figure 5. Expected versus actual results of seed germination trials for the Diaz and Wilkerson seed lots (Lawrence and Roberts 1994).



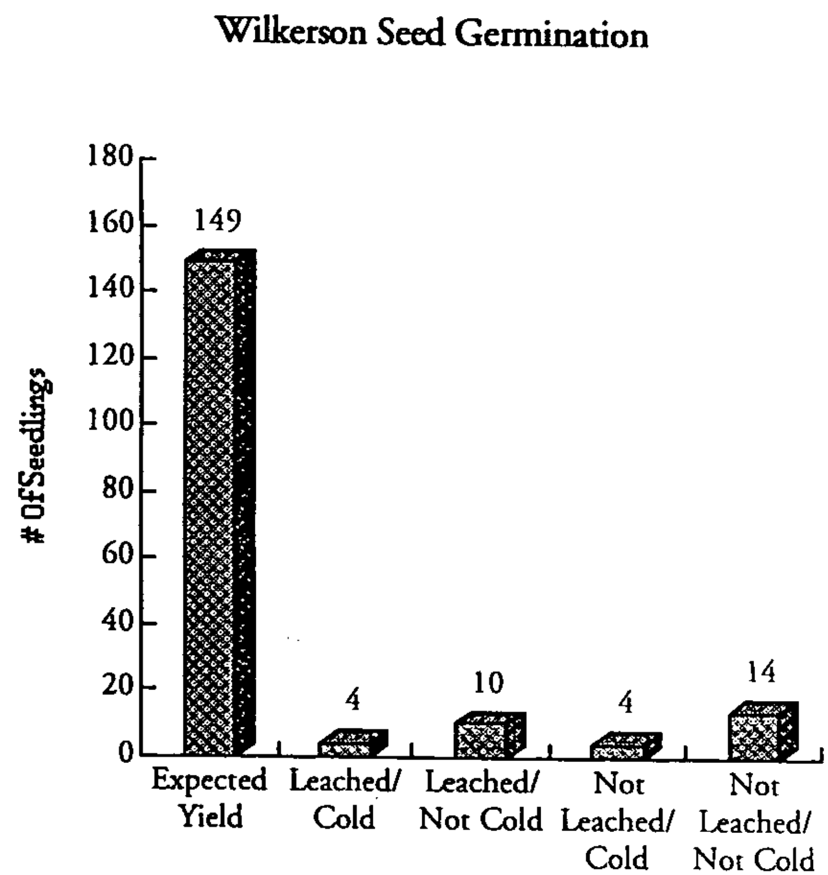


Table 7. Summary of germination pre-treatments results for the Diaz Creek and Wilkerson seed lots (Lawrence and Roberts 1994).

Sidalcea covillei

	LEACH DATE	SOW DATE	COLD STRATIFICATION	HEAT MAT DATE	1ST SIGN OF GERM	PLANT COUNT 3/23/94	PLANT COUNT 3/25/94	PLANT COUNT 3/28/94	PLANT COUNT 3/30/94	PLANT COUNT 4/7/94	PLANT COUNT 4/12/94	TRANSPLANT
Lot #1a DIAZ CREEK	3/2/94	3/5/94	3/5/94	3/23/94	3/28/94			13	21	31	33	4/21/94
Lot #1b DIAZ CREEK	3/2/94	3/5/94	N/A	3/5/94	3/16/94	22	26		31	36	36	4/21/94
Lot #1c DIAZ CREEK	N/A	3/5/94	3/5/94	3/23/94	3/28/94			6	12	17	20	4/21/94
Lot #1d DIAZ CREEK	N/A	3/5/94	N/A	3/5/94	3/16/94	17	20		24	23	25	4/21/94
Lot #2a WILKERSON	3/2/94	3/5/94	3/5/94	3/23/94	3/28/94			1	1	1	4	4/21/94
Lot #2b WILKERSON	3/2/94	3/5/94	N/A	3/5/94	3/16/94	5	6		8	8	10	4/21/94
Lot #2c WILKERSON	N/A	3/5/94	3/5/94	3/23/94	4/7/94					2	4	4/21/94
Lot #2d WILKERSON	N/A	3/5/94	N/A	3/5/94	3/19/94	4	4		5	13	14	4/21/94
							TOTAL		**102**	**131**	**146**	

tectorum and *Bromus rubens*) and lower soil compaction levels which may have increased water infiltration capacities.

Treatment effects were difficult to discern within one year of monitoring because of the variation in soil moisture conditions. In addition, comparisons of individual plant vigor measurements between 1993 and 1994 were hampered by intense herbivory levels therefore two hypotheses could not be sufficiently tested. However, the 3rd null hypothesis that stated that vegetation removal treatments do not affect soil water potential or temperature was accepted since no significant treatment effects were found.

Differences in existing age class distribution between the populations also may have also influenced results. For example, the Diaz creek population contains fewer mature plants compared to the Wilkerson population. This combined with low seed production in 1993 warranted seed collection from another population 0.5 km to the west. The lack of seedling recruitment at Diaz Creek in 1994 may have in turn resulted from a combination of lower soil moisture conditions and inadequate seed production from adjacent adult plants. As the age class distribution changes at Diaz Creek, recruitment in established study plots may increase. Continued monitoring of individual plant vigor, age class distribution, and seedling and mature plant survival will be necessary *in situ,* and should be coupled with more controlled greenhouse experiments to increase the precision of testing plant competition hypotheses.

The edaphic characteristics that were examined for the two *Sidalcea covillei* populations provide a preliminary baseline of components that; 1) *Sidalcea covillei* has adapted to, especially with regard to high soluble salt concentrations, and 2) components that can be monitored to determine variation between additional *Sidalcea covillei* populations and variations induced by changes in site hydrology.

Soil analyses were performed by Setaro (1991) at Fish Slough within similar plant association types that are found at the Wilkerson and Diaz Creek *Sidalcea covillei* populations. Mean pH values within the *Distichlis-Chrysothamnus* type at Fish Slough was 9.4 which is similar to the 8.7 (Wilkerson) and 9.2 (Diaz Creek) values found in this study. At Fish Slough higher salinity levels were also more restricted to the upper soil levels and increased commensurately with higher pH values (Melack 1991). A comparable trend existed in sampled transects from the Wilkerson and Diaz Creek populations.

The seed germination trials that were performed suggest that *Sidalcea covillei* will respond favorably to minor seed treatments. A previous study by Rehling (1982) found that germination rates were enhanced by an application of cold stratification and gibberellic acid. However, seeds that were soaked in water for a 24 hour period and then cold stratified exhibited the highest germination rates.

The leaching treatment that was used during this study produced similar results without the requirement of the cold-stratification to enhance germination. The leaching treatment likely enhances germination by neutralizing chemical inhibitors. Seeds in natural populations undergo a similar "leaching" process during the months of January through April when seasonal precipitation is highest.

Differences in germination rates between populations may have been influenced by seed weight. Because seed weights often influence germination success (Hendrix 1984), it is likely that the lower germination rates of the Wilkerson seed lots was related to the lower seed size and weight. Plants from the Diaz Creek population may have produced larger seeds due to favorable abiotic and biotic site characteristics or perhaps because of different reproductive partitioning investment strategies. This phenomena occurs in female plants of *Sidalcea oregana* ssp. *spicata* which differ from hermaphoroditic forms by partitioning higher proportions of their reproductive resource budgets to seeds versus to flowers or pollen (Ashman 1994).

Further study regarding the natural history of *Sidalcea covillei* is necessary to determine specific responses to grazing, susceptibility to changes in hydrologic regimes and plant competition. Field studies will require comparisons with more controlled *ex situ* greenhouse experiments. This cooperative study provided preliminary ecological site and seed germination information for two populations of *Sidalcea covillei*. More questions were inevitably generated during the course of the study than answered and these in turn will undoubtedly be addressed as future studies are initiated.

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