1 of 4

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STATUS OF THE FLORA AND FAUNA ON THE NEVADA TEST SITE, 1992

Results of Continuing Basic Environmental Monitoring January through December 1992

Compiled By
Richard B. Hunter

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Prepared by
Reynolds Electrical & Engineering Co., Inc.
Post Office Box 98521
Las Vegas, Nevada 89193-8521

TABLE OF CONTENTS

SECTION	Chapter & Page

SECTION	Chapter & Page

EXECUTIVE SUMMARY

This report documents changes in the populations of plants and animals on the Nevada Test Site (NTS) for calendar year 1992. It is part of a Department of Energy (DOE) program (Basic Environmental Compliance and Monitoring Program - BECAMP) that also includes monitoring DOE compliance with the Endangered Species Act, the Historic Preservation Act, and the American Indian Freedom of Religion Act. Ecological studies were to comply with the National Environmental Policy Act and DOE Order 5400.1, "General Environmental Protection Program."

Rainfall in 1992 was better than any year since 1988, and was somewhat higher than the long-term average. A majority fell during winter, and supported germination of annual plants (ephemerals) throughout the NTS. Densities were approximately equal to those of 1991, on the order of 10% of 1988 densities. Biomass produced on undisturbed areas was generally more than ten-fold greater than in 1991, and ranged from 2.6 to 47 g/m^2. Ephemeral plants demonstrated complex interactions with disturbance - production was generally greater where shrubs had been removed, and growth was greater on south-facing slopes of subsidence craters.

Among small mammals, the kangaroo rat species continued to recover from drought-depleted levels of 1990 and 1991. Their numbers were greater than any year since monitoring began in 1987. Several other low-density species increased in density as well. The little pocket mouse, however, anomalously decreased to a five-year low in Yucca Flat, and declined throughout the NTS for unknown reasons. There is a complex interaction between weather, disturbance, and small mammal populations. In 1992, more species and greater numbers of rodents were found on undisturbed areas than on disturbed sites.

Lizard populations also reflected effects of the 1989-1991 drought. Juvenile numbers increased, indicating good reproduction, and juvenile weight also increased. Data from subsidence craters suggest they were a less-favorable habitat, and drought effects appeared exaggerated within them.

Although total rainfall was good, shrub growth was limited by severely drought-depleted sizes and limited summer rainfall. Indian ricegrass and fourwing saltbush germinated sparsely in scattered locations in the Mojave Desert sections and sagebrush species germinated in large numbers on Pahute Mesa. In subsidence craters, a few new shrubs and grasses germinated, largely on north-facing slopes. Shrub sizes were generally smaller in both craters and control areas in 1992 than in 1989 and control areas in 1992 than in 1989, indicating a failure to recover to pre-drought conditions.

Numbers of birds and deer appeared to increase in 1992. Horse numbers were stable, as adult survival was good, but 100% of foals produced disappeared. The loss of foals was hypothesized to be due to mountain lion predation.

STATUS OF EPHEMERAL PLANTS ON THE NEVADA TEST SITE, 1992

Richard Hunter

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ABSTRACT

Ephemeral populations on the Nevada Test Site in 1992 were favored by a relatively wet winter. Densities increased moderately over 1991, and biomass produced was considerably greater. The populations in subsidence craters were largely the same as on control plots, though growth on the south-facing crater slopes was increased late in the season. The dominance of the ephemeral flora by introduced species continued, though *Bromus rubens* populations were greatly decreased by drought from 1989 - 1990. *Salsola australis* grew well in several areas during summer. Monitoring results are beginning to show significant competition for resources between ephemeral and perennial plants.

INTRODUCTION

1992 was the sixth year of monitoring ephemeral plants on the Nevada Test Site (NTS) under the Basic Environmental Compliance and Monitoring Program (BECAMP), funded by the U. S. Department of Energy. Monitoring results for 1987 through 1991 are reported in Hunter and Medica (1989), Hunter (1992), and Hunter (in press). The program examines ephemerals on both baseline and disturbed areas, with most sampled on a three year cycle.

In 1992 29 sites were sampled, including all five baseline sites and one historical monitoring plot. This was a change from measuring annually only one baseline site and one historical plot (Beatley plot 3), and was initiated late in the 1991 season because of the relative ease of sampling ephemerals and the explanatroy value of the continuous records. No new plots were added, but plots near established ones were treated for the first time with a grass-specific herbicide to begin determining the effects of introduced annual grasses on the NTS ephemeral flora.

Following two years of drought and one of late rains, 1992 was a relatively wet year. Relatively sparse germination occurred in January and early February, and growth to maturity occurred throughout the NTS. Reduced shrub cover, a result of the drought, may have contributed to good growth of those ephemerals which did germinate.

The prime focus of ephemeral studies in 1992 was on three subsidence craters, but two scraped and compacted areas, one shrub-removal plot, and the herbicide plots were also censused.

STUDY SITES AND METHODS

Sites censused and their characteristics are shown in Table 1. More exact locations are given in Saethre (small mammal section of this report) and the distribution of plots is shown in Figure 1.

Censusing methods were not changed from previous years. The census technique involved harvesting 20 0.025 m^2 quadrats randomly placed along a 50 m tape. (Herbicide plots used 19 quadrats, and the shrub removal plots 25.) Nested areas of 100 m^2 and 1000 m^2 surrounding the tape were then searched for species not encountered in the smaller areas. The harvested specimens were dried, weighed, and identified to determine mean biomass by species.

Table 1. Nevada Test Site plots ampled for ephemerals in 1992.

Site designation	Location	Type	Elevation (meters)
JAF001	Jackass Flats	Baseline	954
FRF001	Frenchman Flat	Baseline	965
ROV005	Rock Valley	Beatley plot 3	1036
YUF001	Yucca Flat	Baseline	1237
PAM001	Pahute Mesa	Baseline	1923
RAM001	Rainier Mesa	Baseline	2283
YUF019N	Yucca Flat	Crater U3cn (N facing slope)	1213
YUF019S	Yucca Flat	Crater U3cn (S facing slope)	1213
YUF020	Yucca Flat	U3cn control	1241
YUF021N	Yucca Flat	Crater U7au (N facing slope)	1234
YUF021S	Yucca Flat	Crater U7au (S facing slope)	1234
YUF022	Yucca Flat	U7au control	1251
YUF023N	Yucca Flat	Crater U10af (N facing slope)	1277
YUF023S	Yucca Flat	U10af control	1300
MID004	Mid Valley	MX scraped area	1439
MID005	Mid Valley	MID004 control	1445
PAM002	Pahute Mesa	U20ao drill pad	1911
PAM003	Pahute Mesa	U20ao control	1910
MER001W	Mercury Valley	Shrub removal plot	1161
MER001E	Mercury Valley	MER001 control	1161
MER002XS	Mercury Valley	herbicide, sprayed	1076
MER002XC	Mercury Valley	herbicide, control	1076
ROV005XS	Rock Valley	herbicide, sprayed	1036
ROV005XC	Rock Valley	herbicide, control	1036
FRF001XS	Frenchman Flat	herbicide, sprayed	965
FRF001XC	Frenchman Flat	herbcide, control	965
YUF001XS	Yucca Flat	herbicide, sprayed	1237
YUF001XC	Yucca Flat	herbicide, control	1237

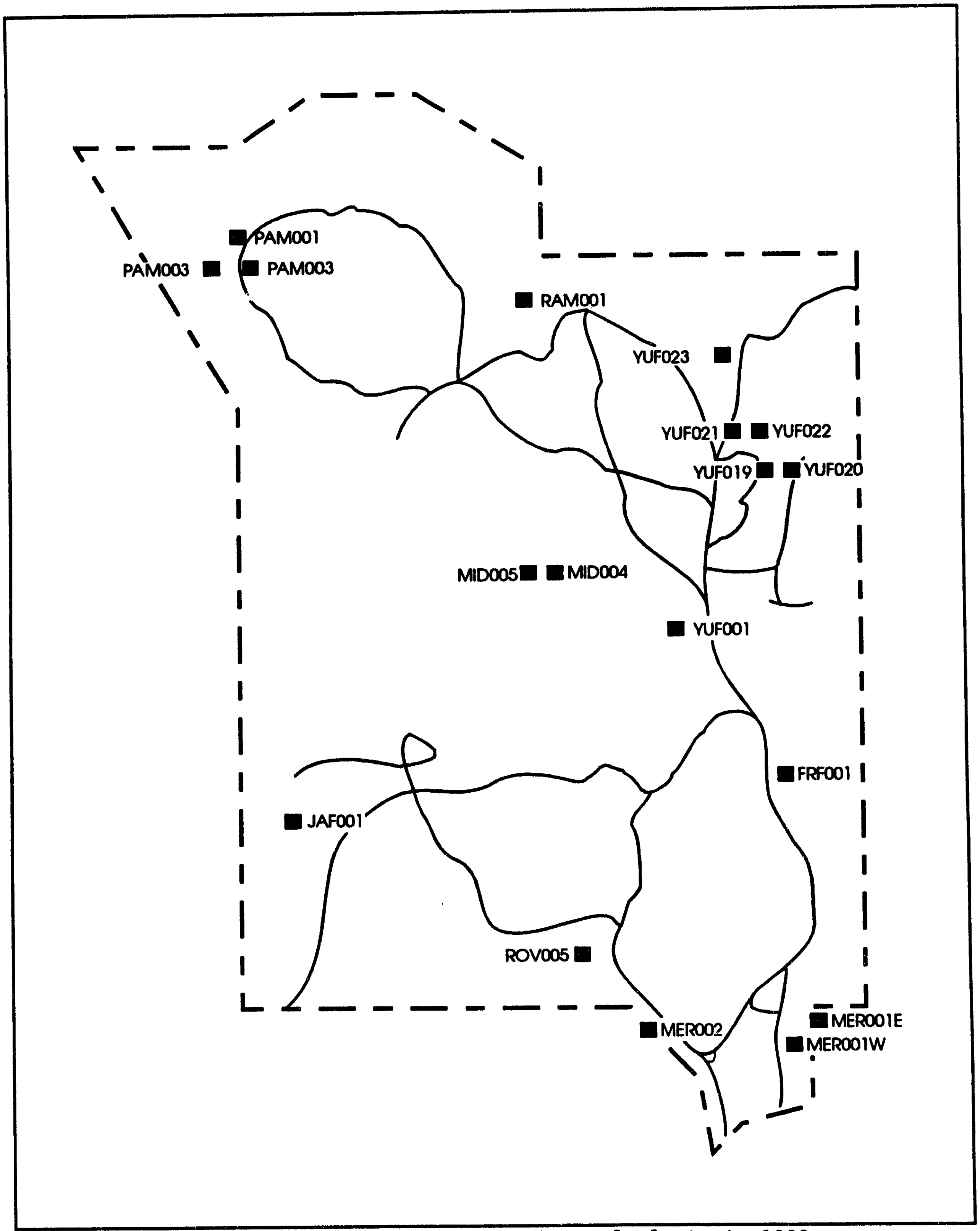

Figure 1 - Sample sites for ephemeral plants in 1992.

Salsola australis was sampled in spring with ephemerals. Its biomass was also estimated on 10 m^2 of perennial plant transects during summer by measuring plant heights and widths to determine approximate canopy volumes. Biomass of *Salsola* was approximated as 1 g/l of canopy, considered a conservative average for the two growth forms, which have 0.7 and 2.1 g/l (Hunter, in press).

Plant taxonomy followed Kartesz and Kartesz (1982), after identification following Munz (1974) or Welsh et al. (1987). Specimens were taken of all species from each plot and identification was confirmed by comparison to herbarium specimens. *Salsola* is all referred to as *S. australis*, following Young (1991).

Statistics were done in RS1 (BBN software); for non-normal populations at test based on Iglewicz (referred to below as "t_i") was used to compare medians using the interquartile range to estimate confidence limits.

Soil moisture was monitored with Colman Fiberglass block electrical resistance probes (Soil Test, Lake Bluff, IL), using techniques reported in Hunter and Greger (1986). The method involves measuring electrical resistance of fiberglass wafers, which varies with adsorbed water. Sensors were at 1, 5, 10, 30, 50, and 100 cm depths in Mercury, and those depths plus 75, 125, and 150 cm in Frenchman Flat, Yucca Flat, and Jackass Flats. Several assumptions were made to convert the readings for Mercury plots to available moisture in the top 30 cm of soil. These assumptions include a) soil is uniformly wet to a point halfway between 2 sensors, b) the bulk density of soil fines (<2 mm) for which the sensors were calibrated is 1.0 g/cm^3, c) the volumetric percent water at the lower limit of sensor readings (3 megaohm) was equal to the soil moisture when the sensor reading was greater than three megaohms, and d) plants cannot use water at a soil water content of 5% or below. These assumptions are sometimes clearly inexact, and result in some distortions in the estimate of "available" soil water. The assumptions were necessary in order to make the estimation. The temperature sensitivity of the sensors resulted in an annual fluctuation in the sensor limits between about 4% (mid-summer) and 6% (mid-winter) soil moisture, resulting in a potentially false winter estimate of available moisture. However, because the temperature gradient during winter should cause condensation in the near-surface soils, we could not dismiss higher winter estimates, even when rain had not fallen. In Mercury, soils at 1 m and presumably greater depths were near 8.0% moisture (above the lower sensor limits) both summer and winter.

Herbicide plots were established in 1989 to try to determine if the introduced grass *Bromus rubens* significantly competes with native species. There were insignificant numbers of *Bromus* in 1989 through 1991, but in 1992 four randomly selected (of eight) plots were sprayed with the grass-specific herbicide Ornamec (Gordon Corp., Kansas City, KA; active ingredient Fluazifop-P-butyl(R)-2[4[[5-(triflouromethyl)-2 pyridinyl]oxy]phenoxypropanoate]).

RESULTS

Patterns of winter rainfall for the areas censused were relatively consistent among sites (Table 2). Some germination (monitored on soil-moisture sites) occurred in mid-December in Yucca Flat, but in late January and early February at lower altitudes.

Table 2. Fall and winter rainfall (mm) on the NTS. September 1991 through April 1992 (NOAA - NTS support office). (Valleys and Mesa's are abbreviated with codes used for plots, see Saethre, this report).

AREA→	MER	ROV	JAF	FRF	YUF	MID	PAM	RAM
SEP	23.4	10.7	8.9	14.0	8.6	20.3	31.2	20.8
OCT	7.4	3.6	5.8	4.3	6.6	21.1	19.6	24.1
NOV	5.1	0.5	4.1	0.5	0	0	0.5	1.5
DEC	25.1	20.8	24.6	13.5	23.4	24.1	16.8	36.1
JAN	14.2	21.6	30.0	8.1	10.7	22.1	14.2	39.1
FEB	31.0	83.1	72.9	33.3	38.9	84.3	30.0	117.1
MAR	49.5	58.9	75.4	38.4	47.2	64.0	57.9	116.6
APR	0	1.3	0	0.5	0	0	1.3	0
TOTAL	156	200	222	112	135	236	171	355

Mercury soil moisture levels estimated for the top 30 cm reached 10mm in early January (Table 3), and germination began in mid-January. Rainfall in March and April prolonged the season, but did not appear to cause new germination.

Table 3. Soil water available to plants (mm, see methods) in the top 30 cm estimated for plot MER001 in Mercury, Nevada.

DATE	mm H_2O	DATE	mm H_2O	DATE	mm H_2O
3 JUL 91	-0.9	31 OCT	8.5	19 FEB	19.7

Table 3, continued.

Date	mm H_2O	Date	mm H_2O	DATE	mm H_2O
11 JUL	0.2	6 NOV	4.1	27 FEB	11.2
17 JUL	-0.4	13 NOV	3.4	5 MAR	13.0
24 JUL	-0.9	22 NOV	5.8	10 MAR	16.0
6 AUG	1.5	29 NOV	6.1	25 MAR	19.7
14 AUG	2.4	6 DEC	4.8	1 APR	22.4
22 AUG	-0.3	16 DEC	9.7	16 APR	7.1
4 SEP	-0.6	26 DEC	9.6	18 MAY	1.0
18 SEP	0.2	2 JAN 92	10.3	2 JUN	-0.6
25 SEP	0.2	9 JAN	20.1	9 JUN	-0.6
9 OCT	0.7	22 JAN	10.2	17 JUN	-0.1
21 OCT	1.3	30 JAN	8.6	23 JUN	-0.2

The Yucca Flat baseline site, sampled annually since 1988, is representative of much of the NTS. Winter ephemerals germinated there in December 1991 and again in February 1992. Both cohorts persisted into early May. Their mean biomass in late April (26±26 g/m^2 ± 2 sem) was greater than in any year since BECAMP monitoring began (Table 4). Beatley (1969) reported results from the same location for 1964-66 (5.1, 0.4, and 13.1 g/m^2, respectively). Densities were 172±133 (n/m^2 ± 2 sem), up 120% from 1991, but only 9% of the 1988 values (Table 4). Considering the relatively abundant rainfall and its favorable seasonal distribution, this density was quite low. One of the primary reasons appeared to be that a regionally dominant introduced species (*Bromus rubens*) declined dramatically during the two drought years, when germination was negligible. The seeds of *Bromus* apparently do not persist long enough to weather extended drought, and as a result it declined from 97% in 1988 to 62% of the much-reduced 1992 population. The population of *Bromus rubens* declined especially severely in quadrats that were not under shrubs. The densities (n/m^2) in quadrats with some shade fell from 3160 to 224 (-93%), while in the unshaded quadrats they declined from 1052 to 11 (-99%) (Table 5). In 1988, 67% of the *Bromus* population was under shrubs, but in 1992, 95% was under shrubs. There are several plausible explanations, for example that seed predation was more intense in the open, or that surface temperatures were too high in the open, or that 1992 germination conditions were less favorable in the open.

Table 4. Species richness (#/1000 m^2), densities (n/m^2 ± 2 standard errors of the mean [sem]) and total above-ground biomasses (g/m^2 ± 2 sem) of spring ephemerals in southwestern Yucca Flat, sampled in April, 1988-1992.

	1988	1989	1990	1991	1992
SEP-Apr rain, mm	120	30	29	57	135
Species	21	0	0	22	35
Density, n/m^2	1956±1114	0	0	78±70	172±133
Biomass, g/m^2	21	0	0	0.5±0.5	26±26
% *Bromus* (n/m^2)	97	-	-	82	62
% *Bromus* (g/m^2)	86	-	-	86	61

Table 5. *Bromus rubens* densities in Yucca Flat with and without shade. 1988-1992.

YEAR	COVER	DENSITY
1988	+	79±30
1988	-	26±9
1991	+	2.8±1.5
1991	-	0±0
1992	+	5.6±2.9
1992	-	0.3+0.1

Ephemeral production on other baseline sites in 1992 varied. Jackass Flats, which had better production than most areas in 1991, had approximately the same numbers and biomass in 1992 (Table 6). It was sampled very early in 1992, and late in 1991. It is likely that biomass increased several-fold after sampling in 1992, as soil was wet in Jackass Flats at least until the end of April.

Overall, ephemeral densities in 1991 and 1992 were quite similar (Table 4, Table 6). Biomass was highly variable from point to point in both years, indicated by large error terms on baseline plots in 1992 (Table 6). Error terms in 1988, when densities were generally greater than $500/m^2$, were proportionately smaller (Hunter 1992; Table 4).

Table 6. Rainfall, total density, and total biomass of spring ephemeral plants on baseline plots and Beatley's plot 3 ROV005), 1991 and 1992. Errors are ± 2 sem.

		1991				1992			
PLOT	ELEV. (m)	RAIN	DATE	n/m^2	g/m^2	RAIN	DATE	n/m^2	g/m^2
JAF001	954	98	MAY 7	164± 76	10±10	222	APR 8	164±101	7± 8
FRF001	965	57	APR 11 11	18± 21	0.1±0.1	112	APR 8	28± 14	3± 4
ROV005	1036	83	APR 3	106± 62	0.5±0.4	200	APR 16	386±251	24± 21
PAM001	1923					171	MAY 27	154±61	2.6± 1.4
RAM001	2283					355	JUN 24	1.5±2.2	0.02±0.02

Subsidence Craters

Three subsidence craters first sampled in 1989 were resampled in 1992. The craters were formed in 1963 (U3cn), 1967 (U10af), and 1978 (U7au). They are shallow, bowl-shaped, rimless depressions with slopes generally less than 45°. Runoff has created a silty playa-like deposit in the center of each, and the slopes are eroded. They are in the northeastern portion of Yucca Flat, which slopes gently towards the south, and the north slopes of each crater (the south-facing slopes) are all eroded significantly more than the south slopes, partially at least due to runoff from outside the craters. (The erosion of Sedan crater, surrounded by a throwout berm, is slight in comparison.) The insides of the craters have areas where the surface was scraped, graveled, or ponds constructed prior to collapse. Ephemerals were studied on the north- and south-facing slopes. Control plots were adjacent to the craters in undisturbed vegetation.

Ephemeral plant populations in the craters were almost absent ($<2/m^2$) when last sampled in 1989, but in 1992 average densities ranged from 162 to 460 plants per square meter inside the craters and 122 to 454 on the control plots (Table 7). Crater U3cn was sampled April 13-15, before full growth and reproduction. Craters U10af and U7au were sampled May 4 and May 6, respectively, just before the ephemerals dried up. Mean plant sizes in the latter two craters were significantly higher than in U3cn ($F = 7.80$, df = 2,142, $p = 0.001$), which we tentatively attribute to the longer period of growth. Individual plant sizes were greater on south-facing slopes ($F = 4.90$, d.f. = 2,117, $p = 0.009$), as was total ephemeral biomass ($F = 4.69$, d.f. = 2,117, $p = 0.011$). Four to fourteen species were found in 20, 0.025 m^2 quadrats sampled on each of nine plots. In all three craters the number of species was higher on north-facing slopes, but the difference was not statistically significant. Although generalizations are difficult because of the interacting factors of species, slope, aspect, disturbance regime, and perennial population parameters, it appeared germination was largely independent of aspect, but that growth of ephemerals was enhanced late in the season on the south-facing (warmer) slopes.

Most subsidence craters, including the three studied by BECAMP, are in the northeastern portions of Yucca Flat. Disturbed sites in this area have been dominated by the introduced weed *Salsola australis* (Russian thistle) since at least 1957 (Shields and Rickard 1957). The subsidence craters interact in several ways with *Salsola*. First, they are collection sites for wind-blown

Table 7. Summary characteristics of ephemeral plants in three subsidence craters and adjacent control plots in spring 1992. Error terms are ± 2 sem.

		NORTH FACING			SOUTH FACING			CONTROLS		
DATE	CRATER	n/m^2	g/m^2	mg/plant	n/m^2	g/m^2	mg/plant	n/m^2	g/m^2	mg/plant
14 Apr	U3CN	206 ± 98	6 ± 3	29 ± 10	162 ± 117	4 ± 4	22 ± 3	124 ± 59	5 ± 3	47 ± 22
4 May	U10AF	398 ± 250	29 ± 11	200 ± 139	328 ± 191	80 ± 45	380 ± 249	454 ± 200	47 ± 23	102 ± 24
6 MAY	U7AU	460 ± 206	25 ± 14	76 ± 34	266 ± 180	73 ± 52	325 ± 100	325 ± 100	38 ± 32	395 ± 247

dead remains, which are deposited in erosion channels on the sides of the craters. Second, seeds germinate and grow well inside craters, favored by various disturbances and runoff water which collects in the bottoms.

Table 8 shows the estimated mid-summer (June-July) biomass of *Salsola* in the three craters and their controls. These values compare to zero to five g/m^2 the summer of 1989 (Hunter, in press), and are significant production values for this area. It is reasonable to conclude that shrub growth in both crater and control areas (Figure 2) was inhibited by the use of summer water resources by *Salsola*, and that recovery of the shrub populations from drought was delayed by the presence of this introduced species. Because *Salsola* dies every fall, it will eventually again be restricted to the disturbed sites (lacking shrubs) in this area.

Table 8. Production (g/m^2 ± 1 sem) of *Salsola australis* in three subsidence craters in northeastern Yucca Flat.

CRATER	DATES	NORTH FACING	CENTER	SOUTH FACING	CONTROL
U3cn	JUN 11-24	66 ± 34	88 ± 13	83 ± 34	72 ± 11
U7au	JUL 13-16	9 ± 4	0	109 ± 18	399 ± 156
U10af	JUL 9	197 ± 59	26 ± 8	68 ± 23	122 ± 58

Although it might be expected that certain ephemeral species might do better on either the north-facing or south-facing slopes, there were no obvious instances of this. Species which fruit in summer (*Eriogonum deflexum*, *Salsola australis*, *Astragalus lentiginosus*) did not appear preferentially on the south-facing slopes. Most species which occurred on only one aspect were low-density and could easily have been missed in the quadrats on the opposite face. Numbers of species on the 1000 m^2 areas were not uniformly higher on north-facing slopes, as the south-facing slope of U7au had more (40) than the north-facing one (28). Thus, except for the noted greater individual size late in the season on the south-facing slopes, and the resulting increased biomass, no significant differences were found between ephemeral populations within the craters or between craters and control plots.

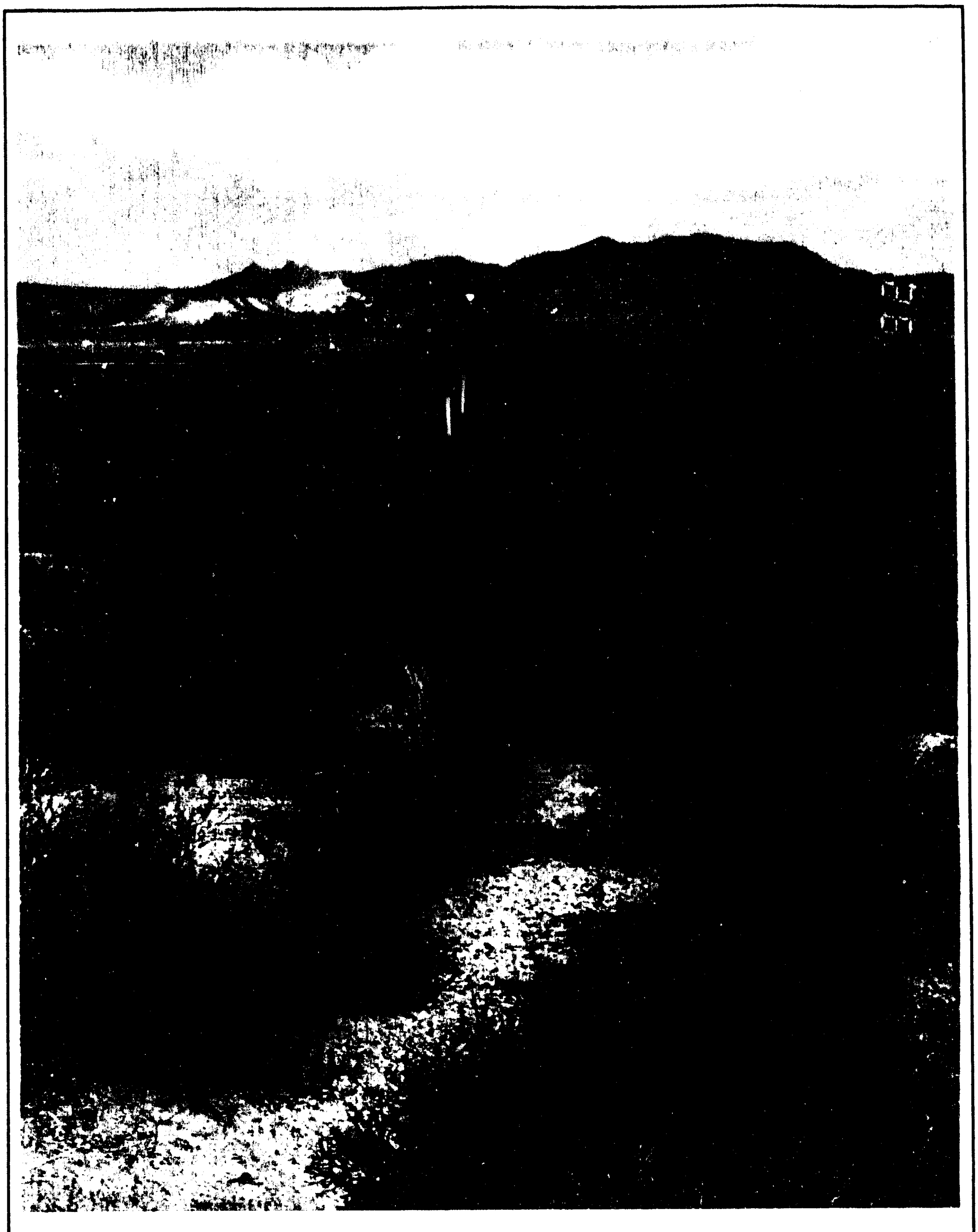

Figure 2 - Russian thistle (*Salsola australis*, tumbleweed) grew in 1992 in undisturbed desert near subsidence crater U7au.

Scraped Sites

Two scraped and compacted sites were examined in 1992. In both cases the adjacent undisturbed areas differed in ephemeral populations. In Mid Valley, plots MID004 and its control MID005 both had numerous ephemerals, but biomass differed between the two (t_s = -2.87, d.f. = 38, p = 0.0067). Species were also vastly different. The scraped plot population was dominated by *Eriogonum deflexum* (468 ± 268/m^2) and *Salsola australis* (294 ± 186/m^2), but these two species were totally absent from the adjacent mature *Coleogyne ramossissima* (blackbrush) community where the dominant ephemerals were *Bromus rubens* (290 ± 151/m^2) and *Mentzelia albicaulis* (272 ± 173/m^2; Appendix 2). Numbers of species within the 20 0.025 m^2 quadrats were 7 on the scraped area and 20 on the undisturbed plot. There were 16 species found on the undisturbed area which were absent from the 1000 m^2 sampled on the scraped plot, which itself had 10 unique species. These were relatively dramatic differences that probably relate primarily to clearing of the shrubs and partially to soil compaction. The near-absence of *Bromus rubens* and *B. tectorum* on the scraped area can tentatively be attributed to absence of shrub cover during the drought (see discussion under baseline plots). Many species absent from the scraped area are normally found growing under and into the shrub canopies, and their seeds might require shade to germinate.

The other scraped area, drillpad U20ao on Pahute Mesa, showed similarly dramatic differences. Densities were significantly different (t_s = 5.51, d.f. = 38, p < 0.0001)(Table 9) between the two areas, and there were 20 species in 1000 m^2 in the undisturbed plot, versus only 5 on the scraped plot. *Halogeton glomeratus* was the most numerous ephemeral species on both plots, but biomass on the control plot (an *Artemisia tridentata* community) was dominated by *Astragalus lentiginosus* var. *fremontii* (9.5 ± 9.3 g/m^2) and *Gilia transmontana* (3.9 ± 2.1 g/m^2). Halogeton biomass was 16 ± 7 g/^{2} on the scraped area, and 1.1 ± 0.7 g/m^2 on the control.

Table 9. Ephemeral Population Characteristics on Sites Scraped and Compacted by Heavy Equipment and on Adjacent Sites. Error terms are ± 2 sem.

	MID004-5		PAM002-3	
	SCRAPED	CONTROL	SCRAPED	CONTROL
		1989		
DATE	4/20/89	4/20/89	4/17/89	4/17/89
SEP-APR RAIN	42mm	42mm	-	-
n/m^2	0	0	3396±1894	0
g/m^2	0	0	3.9±2.2	0
mg/plant	-	-	3±5	-
species/1000 m^2	1	0	2	0
		1992		
DATE	5/12/92	5/12/92	6/2/92	6/2/92
SEP-APR RAIN	236 mm	236 mm	171 mm	171 mm
n/m^2	774±270	1028±369	3548±1398	506±157
g/m^2	19±8	78±31	18±7	15±18
mg/plant	48±22	134±83	8±2	111±189
species/1000 m^2	26	32	5	20

Shrub Removal Plot

A plot in Mercury set up by UCLA in 1985 has been sampled annually from 1986 through 1992. This plot had shrubs removed and soil moisture probes installed December 1984 - March 1985 to determine the effects of shrubs on soil water removal. New perennials growing on the shrub-removal plot have been removed annually when small, but annual plants have been allowed to grow at will. The only disturbance has been weekly to bi-weekly measurement of soil moisture (Table 10). Foot traffic has been minimized, and was virtually limited to censusing the ephemerals in spring of each year.

Several paramaters on these two plots have diverged significantly since sampling began (Table 10). Total numbers of ephemerals were greater on the plot without shrubs since 1988, excluding 1989, when none germinated on either plot. Biomass of ephemerals was greater without shrubs except during 1989 and

Table 10. Summary ephemeral population characteristic for a shrub removal plot (MER001W) and its adjacent control (MER001E) in Mercury, Nevada, 1986-1992.

YEAR	1986	1987	1988	1989	1990	1991	1992
SEP-APR RAINFALL,	139	103	157	28	36	74	156
SAMPLE DATE	3/28	4/14	4/05	3/24-27	4/05-5	4/04	4/28-29
			SHRUBS REMOVED				
n/m²	1099±577	616±401	3070±1044	0	8±7	269±151	594±178
g/m²	21±10	36±17	32±11	0	0.08±0.08	0.54±0.26	27±11
mg/plant (*Bromus*)	25±6	70±31	12±2	-	4	-	76
spp./0.6m²	12	14	17	0	3	8	19
spp./plot	-	-	-	0	5	22	35
Bromus, % of n	72	74	62	-	25	-	0.5
			CONTROL				
n/m²	358±191	395±249	581±306	0	0	22±16	58±24
g/m²	2.6±1.5	5±4	10±5	0	0	0.04±0.02	2.7±1.5
mg/plant (*Bromus*)	13±3	14±2	25±4	-	-	2.1±0.2	134
spp./0.6m²	7	6	11	0	0	3	9
spp./plot	-	-	-	0	2	12	32
Bromus, % of n	47	89	76	-	-	43	3

1990. Numbers of species in the 25 0.025 m^2 quadrats were greater without shrubs each year except 1989. These plots demonstrate that presence of shrubs reduces numbers and biomass of ephemerals.

Different species interacted differently with shrubs. *Eriogonum deflexum* dramatically increased on the plot without shrubs, as did *Erodium cicutarium* (Hunter 1992), *Schismus arabicus*, and *Vulpia octoflora*. In 1992 at least eight species were more numerous on the shrub-removal plot than the control. One species, *Ipomopsis polycladon*, was equally dense on both plots, apparently unaffected by the removal of shrubs. *Bromus rubens* essentially disappeared from both plots during the drought years of 1989 and 1990, declining from a peak density in 1988 of 1912 ± 950 (mean ± 2sem; Hunter 1992) to 3 ± 6 in 1992 (Appendix 2). On the control plot it declined over that time from 443 ± 260 to 2 ± 3.

Herbicide Plots

Except for reducing the *Bromus* densities, herbicide had little apparent effect the first year (Table 11). There was no significant increase in native numbers, biomass, or individual size, within the measurement error limits. This is to be expected for the first year, since germination occurred before spraying, and the error limits were relatively large. In future years we would expect a trend for the native species to increase on the sprayed plots relative to the controls. First size should increase, then numbers, as seed reserves build up.

Species distributions

In 1992 134 species were identified on and near the 29 ephemeral plots, the same number as seen from 1989 through 1991 (Hunter in press). These species, the plots they occurred on, densities to an order of magnitude, and range in elevation are in Appendix 1. The 29 plots sampled, when corrected for controls and north and south-facing slopes, represent only 13 independent sites, and cover only 0.01% of the NTS. The species sampled therefore represent the more common ones, of approximately 300 occurring on the NTS (Beatley 1976).

The year 1992 was the second consecutive relatively productive year for ephemerals, and there were some significant changes occurring. The two dominant *Bromus* species, *Bromus rubens* and *B. tectorum*, both increased in

Table 11. *Bromus rubens* and native plant populations on plots sprayed with grass-specific herbicide in 1992.

	1991				1992			
	SPRAYED		CONTROL		TO BE SPRAYED		CONTROL	
	Bromus	native	*Bromus*	native	*Bromus*	native	*Bromus*	native
				n/m² ± 2 sem				
ROV005	88±60	30±24	104±59	82±43	44±37	253±179	393±122	200±231
MER002	16±12	69±31	8±9	70±31	13±9	212±76	76±62	149±73
FRF001	0	6±6	0	2±4	0	141±79	8±8	118±42
YUF001	42±34	6±9	8±9	22±20	8±7	64±33	114±89	31±37
				g/m² ± 2 sem				
ROV005	1.4±1.1	0.7±0.5	3±2	3±2	4±5	54±37	32±25	14±20
MER002	0.9±0.8	5±3	0.1±0.2	1.7±0.5	1.7±1.5	26±22	18±18	21±14
FRF001	0	0.9±0.4	0	0.1±0.1	0	8±7	1±2	20±13
YUF001	1.3±1.1	0.4±0.5	0.1±0.2	0.9±0.9	1.3±1.0	28±20	16±15	3±4
				mg/plant ± 2 sem				
ROV005	12±2	31±17	19±3	76±56	75±40	266±129	71±18	85±58
MER002	58±12	74±43	17±9	47±27	135±74	171±113	274±137	173±52
FRF001	-	146±203	-	32	-	57±31	104	297±208
YUF001	33±8	58±36	16±3	45±38	156±2	420±275	103±48	149±102

density and frequency. *B. rubens* was the most frequently encountered species (Table 12), occurring on 12 of the 13 possible sites, with the highest median density of the ten most common species (Table 12). Only Rainier Mesa had none, although it was also very sparse on Pahute Mesa. The native species *Cryptantha circumscissa* and *Mentzelia albicaulis* were near the top of the ten most frequent list, as in 1991 (Hunter in press). Species added to the list in 1992 were *Cryptantha pteocarya*, *Gilia transmontana*, *C. gracilis*, and *Chaenactis stevioides*, while those deleted were *Machaeranthera canescens*, *Astragalus lentiginosus* variety *fremontii*, *Phacelia fremontii*, and *Erodium cicutarium*. Two introduced species, *Bromus rubens* and *Salsola australis*, were the most dense on the list.

Table 12. The ten most frequently encountered ephemeral species on the Nevada Test Site in 1992, with number of sites (of 13) occupied, elevational ranges where seen, and median densities on the sampled plots. Asterisks mark introduced species.

SPECIES	# of sites	RANGE (m)	median density
*Bromus rubens**	12	954-1923	202
Cryptantha circumscissa	12	954-1923	2
*Bromus tectorum**	12	954-1923	0.01-2
Mentzelia albicaulis	11	954-1923	2
Cryptantha pterocarya	11	954-1923	0.01-2
Gilia transmontana	10	954-1923	0.01-2
Descurainia pinnata	10	954-1923	2
Cryptantha gracilis	10	1036-1445	0.01-2
*Salsola australis**	9	954-1911	68
Chaenactis stevioides	9	1036-1910	0.01-2

Several species appeared to be increasing in the NTS flora. *Chenopodium incanum* and the very similar *C. atrovirens* were not collected in 1988 but were common in 1991 and 1992. Also, with many of the shrubs dead, the introduced tumbleweed *Salsola australis* grew in 1992 on some undisturbed areas to appreciable size (Figure 2), emerging through the dead shrub canopies. It is rarely large enough to be visible on undisturbed sites, though seeds may germinate there. Another introduced species, *Halogeton glomeratus*, was also growing among the live shrubs on Pahute Mesa (See plot PAM003, appendix 2), attributable to significant seed dispersal from the nearby disturbed areas (dirt roads and drill pad U20ao).

Two species apparently new to the NTS were collected in 1992. A cluster of small onion-like plants of *Muilla coronata* was found in Mercury (plot MER001W), and a small hairy aster, *Eriophyllum wallacei* was found in Mid Valley (MID005). A third new species, *Stephanomeria virgata*, should be considered tentative, as the only specimen lacked the fruit necessary for a firm identification.

DISCUSSION

A relatively large number of factors affects ephemeral populations, including weather, shrub populations, surface disturbance, seed pools, and animal activities. Ephemerals also interact with each other, and the introduction of new species is currently of significant importance. The numerous ephemeral species on the NTS have differing interactions with these influencing factors, so that teasing apart the various influences is difficult. With six years of data from the BECAMP program available, some of the influences are becoming distinguishable.

Weather

In 1992 rainfall was adequate for germination almost everywhere on the NTS (Table 2). The lowest December-January total was in Frenchman Flat, which coincided with the lowest ephemeral density (28 ± 14, FRF001) on any of the baseline and control plots. There was not, however, a significant linear correlation of rainfall with ephemeral density ($R^2 = +0.002$; $F = 0.014$, d.f. = 1,6; $p >> 0.05$ the regression is not significant) on the baseline plots. This may be explained both by the low variation in total rainfall between 950 and 1900 m (21 to 75 mm) and by the many confounding factors, including rainfall history, at the various sites.

F. W. Went, working in Joshua Tree and Death Valley national monuments, studied the germination and establishment of desert ephemerals for many years. In late 1946 many species germinated in large numbers, over a range in altitude from <0 to approximately 1000 m (Went and Westergaard 1949). They estimated, from laboratory germination studies, there were about 500 viable seeds per m^2 on the Death Valley floor, but noted up to 5000 seedlings per m^2 at 800 m.

I attribute the relatively low numbers of ephemerals ($<500/m^2$) germinating in 1992 to the recent drought history, rather than low rainfall. In the late

1980's the ephemerals were dominated by *Bromus rubens*, which declined precipitously during the drought of 1989 and 1990 (Table 5). One of the possible explanations for improved *Bromus* survival under shrubs is that soil temperatures in the open are too high for long-term seed survival. The 1992 densities of ephemerals, low in comparison to values in the 1980's, are relatively high when compared to earlier densities, which never exceeded 125/m^2 between 1963 and 1974 (Figure 3).

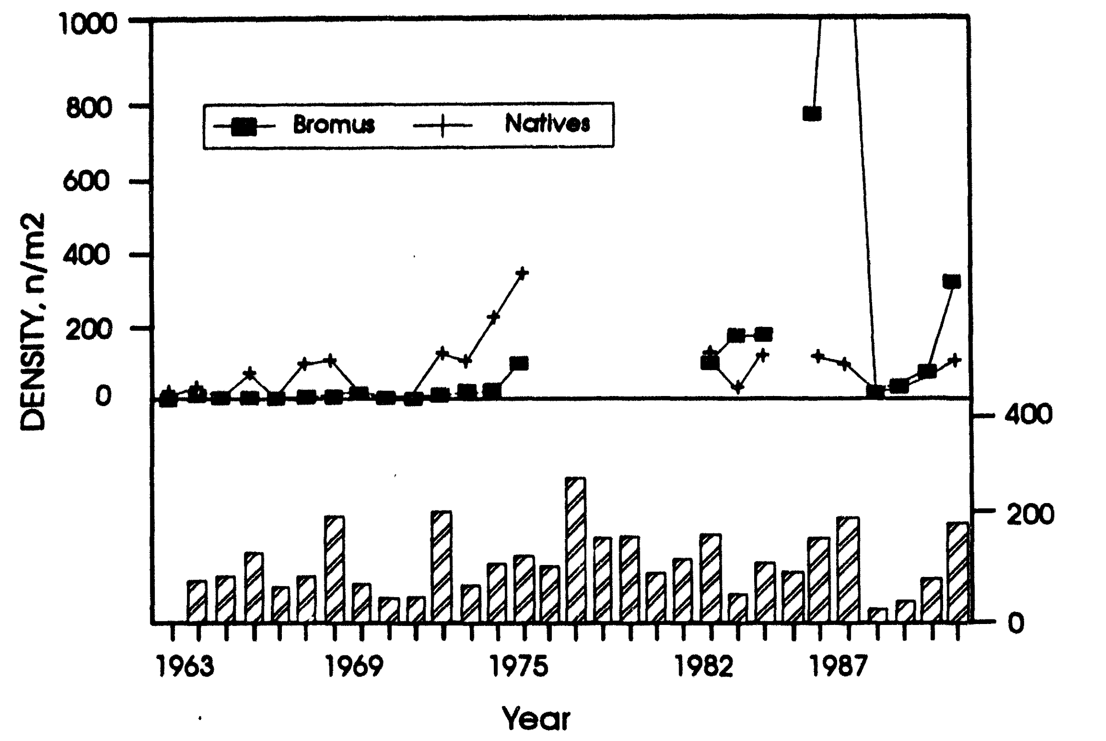

Figure 3 - Densities of *Bromus rubens* and native species (n/^{2}) in Rock Valley and rainfall (mm, bargraph) from 1963 through 1992.

In 1992 there was a clear effect of sample date on estimated biomass (see crater discussion). The herbicide plots, sampled late in the season (4/20 - 5/04/1992 - appendix 2; 5/01 - 5/06/1991 - Hunter, in press) both years, suggest there was considerably more production in 1992. It is not presently possible to correct production estimates for sample dates, because we have too few plots sampled both early and late in the season to demonstrate a growth trend. Further analysis of weight per plant for certain species across many plots might allow a more rigorous comparison of productivity between years. Such a comparison for *Bromus rubens* (Table 10) on the shrub-removal plot failed due to the low densities of that species in the later years of sampling.

Disturbance

Disturbance was shown in earlier BECAMP reports (Hunter in press) to lead to an increased density and biomass of ephemerals. In 1992 studies were conducted of craters and scraped areas. The densities of ephemerals inside and outside of the craters were not significantly different (Table 7; e.g. U3cn, t = 0.98, d.f. = 29, p = 0.34). Biomass, as noted, differed between the north- and south-facing slopes, but not between the craters and their controls (e.g. U10af, t = 0.37, d.f. = 29, p = 0.71). Thus, though the change in slope has an effect, when averaged over the two faces of the crater there was not a discernible effect.

As noted above, there were a number of species, density, and biomass differences between the two scraped sites and their controls. The most significant is probably the dominance of the open areas by *Salsola australis* and *Halogeton glomeratus*, two introduced species. Both are well adapted to disturbed sites (Rhoads et al. 1967), and have been noted on NTS disturbances since the first botanical studies by Shields and Rickard (1957). *Halogeton glomeratus* is toxic to grazing animals (it accumulates sodium oxalate crystals in its cells), and *Salsola australis*' tumbling habit causes accumulation of flammable materials along barriers and roadsides. Neither species, however, can compete with natives in undisturbed desert, so they are in most years restricted to disturbed sites. The organic matter they produce may hasten recolonization of disturbed sites by other species. They are thus not the threat to native species represented by *Bromus rubens*, which invades undisturbed desert and comes to dominate the ephemeral flora.

Shrubs

The shrub-removal plot in Mercury shows dramatically that shrubs and ephemerals compete for the same resources. In the absence of shrubs the ephemeral biomass and densities were ten-fold higher on the bare plot after seven years. Again, species present on the two sites were different, but when the only disturbance was shrub removal, neither *Salsola* nor *Halogeton* invaded. This may be partly due to the absence of loose soils (Rhoads et al. 1967), but more likely is related to the continued presence of the native seed bank and top soil.

Shrub removal is a concomitant of other disturbances, including fire, atmospheric nuclear weapons tests, road construction and maintenance, and many construction activities. One area denuded by animal activities (Hunter et al. 1980) had the highest *Bromus rubens* densities in 1988 (Hunter 1992). Hunter (in press) discusses the favorable effects of "disturbance" on ephemeral populations, and the majority of those favorable effects can probably be attributed largely to the removal of shrubs.

Early botanists working in the Mojave Desert were impressed by the preferential occurrence of ephemeral plants under shrubs (Went 1942; Muller 1953; Muller and Muller 1956) and attempted to explain it by reference to the improved soil fertility in the wind-collected mound under shrubs (the "fertile island" effect). I believe it is considerably more complex than that. The concentration of *Bromus rubens* under shrubs appears to be a response to seed protection there. Other factors involved might be shading and wind protection, which prevent rapid surface drying after rains (and therefore improves germination) and the tendency for litter (and thus seeds) to be wind-trapped under the shrubs.

Some species may indeed depend upon shrubs. The difference in species composition between cleared and control areas in Mercury, Mid Valley, and Pahute Mesa (MER001e, MID004, PAM002) suggest there are many different adaptations among the 300+ ephemeral species.

In 1992 one noteworthy observation was the apparent association in Rock Valley of *Phacelia vallis-mortae* with long-lived shrubs. It was visible growing through the tops of several shrub species, but only if they had a significant mound under them. The newer shrubs, often small *Ambrosia dumosa*, had none. *Lycium andersonii*, a desert shrub which tends to build up nitrate salts under the canopy (Hunter et al. 1982), was frequently the "host" for this species.

Bromus rubens

The circumstantial evidence showing that *Bromus rubens* competes significantly with native species continues to grow. It is difficult to tease out all the influences affecting native species, but 1992 provided a third year of September-April rainfall of near 200 mm. Production of native ephemeral biomass with this fairly constant rainfall was negatively correlated with *Bromus* biomass in Rock Valley (Table 13). The regression is not significant ($R^2 = 0.717$; $F = 2.54$, d.f = 1,4; $p > 0.25$), probably because of the small sample size, but these data suggest again that the high *Bromus* densities in 1988 had a detrimental effect on natives. The six years of BECAMP data and a similar run of six years of data collected in 1970-1976 under the U.S. International Biological Programme in Rock Valley also suggest the high *Bromus* densities were indeed detrimental to the natives. In the 1970's there was a significant linear correlation between precipitation and native ephemeral biomass ($R^2 = 0.90$; $F = 36$, d.f. = 1,4; $p<.01$), while from 1987 through 1992 there was not ($R^2 = 0.28$; $F = 1.59$, d.f.= 1,4; not statistically significant).

Table 13. Native and *Bromus rubens* biomass production (g/m^2) in Rock Valley for three years when September - April rainfall was near 200 mm.

YEAR	*BROMUS*	NATIVE	RAIN
1973	1.29	78.9	220
1988	34.0	0.9	203
1992	13.5	10.1	200

The decline in numbers of the introduced *Bromus* species following the 1989-90 drought was ecologically significant. It appears, however, that it is again increasing, considerably more rapidly than following the last drought in 1971-72 (Figure 3). The herbicide plots (Table 11) should in the future give a more definitive picture of *Bromus*-native interations.

Altitude

There was a near absence of ephemerals on Rainier Mesa (Plot RAM001; Table 6), even though precipitation was 355 mm. This might be thought due to physical conditions such as temperature and rainfall, but the evidence suggests it is due to competition with established plants. Although no disturbed plots were sampled in 1992 above 1911 m (PAM002), plots sampled on Pahute Mesa in 1990 (PAM004 - 2103 m; 1194 ± 512/m^2) and 1991 (PAM006 - 2134 m; 2618 ± 1406/m^2) had numerous ephemerals, dominated by *Salsola australis* and *Bromus tectorum*. At these high altitudes the pinyon-juniper communities include significant shading and an understory of shrubs and small woody and herbaceous perennials. The ephemeral populations were under 20/m^2 in 1990 and 91 on the undisturbed plots. It appears that higher altitudes are not intrinsically inimical to the growth and maturation of ephemerals, but the competition from perennials is. This suggests the ecological problems caused by introduced species like *Bromus* *tectorum* in the Northwestern U.S.A. may be related to inhibition of native perennial species by grazing, logging, and other disturbances, and also that it may be ameliorated in years of more mesic conditions.

Animals

Animals do not appear to be a major influence on desert ephemerals. There was very little grazing damage seen on the ephemerals we harvested. Insect populations occasionally produce noticeable damage, and rabbits rarely do. Part of the procedure for sampling ephemerals includes counting of rabbit fecal pellets. The results for 1992 (Table 14) show that one set of herbicide plots (MER002X) had an unusually high number of pellets. This may be partly due to the presence on that site (a "rodent-denuded" site in Mercury Valley) of a higher than normal ephemeral density, leading to increased grazing.

Table 14. Densities ($n/m^2 \pm 2$ sem) of rabbis pellets at ephemeral study sites in 1992.

PLOT	CONTROL	TREATED
JAF001	8 ± 9	
FRF001	20 ± 26	
FRF001X	11 ± 8	15 ± 11
ROV005	48 ± 42	
ROV005X	22 ± 23	16 ± 23
MER002X	64 ± 28	232 ± 60
MER001	58 ± 24	18 ± 17
YUF001	18 ± 12	
YUF001X	2 ± 4	13 ± 9
YUF020	0 ± 0	14 ± 16
		32 ± 44
YUF022	8 ± 7	19 ± 14
		8 ± 7
YUF024	0 ± 0	4 ± 6
		12 ± 14
MID005	6 ± 9	16 ± 16
PAM003	2 ± 4	32 ± 28
PAM001	4 ± 6	32 ± 28
RAM001	18 ± 12	

This is not to say that animals don't have 18 ± 12 large effects on ephemeral populations, just that those effects are subtle. Brown (1990) has shown there are significant long-term vegetation changes caused by removal of granivorous rodents from Sonoran Desert plots. Such evidence for Mojave Desert ephemerals is not currently available.

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APPENDIX A

This table includes locations and rough densities of all annual and below-ground herbaceous perennial species sampled on the Nevada Test Site in 1992. Entries after each species are plots (see Appendix B of Saethre, Trends in Small Mammals...,this report, for locations, altitudes, and descriptions). The letter codes XS and XC refer to herbicide plots, sprayed and control, respectively. N and S refer to the north- and south-facing slopes of subsidence craters. The final A = present in the 20 0.025 m^2quadrats (ie. $>2/m^2$), B = present in the 100 m^2 area ($> 0.01/m^2$), C = present in the 1000 m^2 area ($>0.001/m^2$), D = absent from 1000 m^2 but seen while walking to or from the study site.

Agropyron desertorum MID004C
Allium nevadense JAF001D
Amsinckia tessellata FRF001B, FRF001XCB, FRF001XSB, MER002XCB, MER002XSA, MID004C, MID005A, ROV005B, ROV005XCB, ROV005XSB, YUF001C, YUF021NB, YUF021SB, YUF022A, YUF023NB, YUF023SB, YUF024B
Androstephium breviflorum YUF020B
Anisocoma acaulis FRF001B, YUF020A, YUF021SC
Astragalus acutirostris MER001WA
Astragalus calcosus RAM001C
Astragalus didymocarpus FRF001B, MER001EA, MID005B, YUF001XCB, YUF001XSB
Astragalus lentiginosus fremontii MER002XSB, PAM001C, PAM003A, YUF001A, YUF001XCA, YUF001XSA, YUF019NB, YUF019SC, YUF020B, YUF021NB, YUF021SA, YUF022B, YUF023NB, YUF023SA, YUF024B
Astragalus purshii PAM001A
Astragalus tidestromii MER001EB, MER001WB, ROV005C, ROV005XCA, ROV005XSB
Atrichoseris platyphylla YUF001B
Baileya pleniradiata YUF001XSB
Brassica sp. ROV005XSA
Bromus rubens FRF001A, FRF001B, FRF001XCA, FRF001XSB, JAF001B, MER001EA, MER001WA, MER002XCA, MER002XSA, MID004A, MID005A, PAM001D, PAM002C, ROV005A, ROV005XCA, ROV005XSA, YUF001A, YUF001XCA, YUF001XSA, YUF019SB, YUF020B, YUF021NA, YUF021SA, YUF022A, YUF023NA, YUF023SA, YUF024A
Bromus sp. YUF019NA, YUF019SA, YUF021NA
Bromus tectorum FRF001XCB, JAF001B, MER001EB, MER001WB, MID005A, PAM001B, PAM002C, PAM003C, RAM001C, ROV005XCB, YUF001B, YUF001XCB, YUF001XSD, YUF019NB, YUF019SB, YUF020A, YUF021NA, YUF021SB, YUF022B, YUF023NB, YUF023SB, YUF024A

Bromus trinii ROV005C, ROV005XCB
Calochortus flexuosus MID004C, MID005A, PAM001B, PAM003C
Calycoseris wrightii YUF020A
Camissonia boothii MER001WB, ROV005A, YUF001XCB, YUF001XSB
Camissonia claviformis FRF001B, FRF001XCB, FRI001XSB, MER001EB, ROV005A, ROV005XCA, ROV005XSA, YUF001A, YUF019SB, YUF021NB, YUF023SB, YUF024A
Camissonia kernensis YUF021SC
Camissonia munzii MER001WB
Camissonia pterosperma MID005B, PAM001A, PAM003A
Camissonia pusilla FRF001SXD
Castilleja chromosa PAM001C
Caulanthus cooperi JAF001A, MER001EB, MER001WB, ROV005B, ROV005XCB, ROV005XSB
Caulanthus lasiophyllus ROV005A, ROV005XCA, ROV005XSA
Caulanthus lasiophyllus utahensis YUF023SC
Caulanthus pilosus FRF001B, YUF019NC, YUF020B
Chaenactis carphoclinia MER001WA, ROV005B, ROB005XCB, YUF001XSA
Chaenactis douglasii RAM001A
Chaenactis fermontii FRF001A, FRF001XCA, FRF001XSB, JAF001A, MER001EB, MER002XSB, ROV005XSA, ROV005XSB, YUF022A
Chaenactis macrantha MER001WA
Chaenactis sp. YUF001XSA
Chaenactis stevioides MER001EB, MER002XCA, MER002XSA, MID004C, MID005A, PAM003B, ROV005B, YUF001A, YUF001XCB, YUF001XSA, YUF020B, YUF032NA, YUF021SA, YUF022A, YUF023NB, YUF023SB, YUF024B
Chaenactis xantiana PAM001B, ROV005B, YUF001A
Chenopodium atrovirens YUF021NA, YUF023NA, YUF024A, YUF021SC, YUF023NA, YUF023NA, YUF023SA
Chenopodium leptophyllum RAM001C
Chorizanthe brevicornu MER001WA, MER002XCB, MER002XSA, MID004C, MID005C, PAM003B, ROV005A, ROV005XCA, ROV005XSB
Chorizanthe rigida FRF001XCB, MER001EA, MER001WB, YUF001XCB, YUF021SC, YUF022C
Chorizanthe thurberi YUF001C, YUF024B
Chorizanthe watsonii FRF001B, JAF001B, MID004C, MID005B, PAM001B
Cryptantha angustifolia MER001EA
Cryptantha circumscissa FRF001XCB, FRF001XSB, JAF001A, MER001WA, MER002XCA, MER002XSA, MID004A, MID005A, PAM001C, PAM003C, ROV005A, ROV005C, ROV005XCA, ROV005XSA, YUF001B, YUF001XCA, YUF019SB, YUF021NB, YUF023SB, YUF024A

Cryptantha dumetorum FRF001XCB, FRF001XSB
Cryptantha flavoculata PAM001D, YUF020A
Cryptantha gracilis FRF001B, FRF001XCB, FRF001XSB, MER001EB, MER002XSB, MID005A, PAM001B, ROV005A, YUF001A, YUF001XCA, YUF021SB, YUF023NB, YUF024B
Cryptantha maritima YUF019NB
Cryptantha micrantha FRF001B, FRF001XCA, FRF001XSA, JAF001A, PAM003B, YUF019NB, YUF019SA, YUF020A, YUF022B
Cryptantha nevadensis JAF001B, MER001WB, MER002XSA, MID004C, PAM003C, ROV005XCA, ROV005XSA
Cryptantha pterocarya FRF001C, FRF001XCB, FRF001XSA, JAF001B, MER001EB, MER002XSB, MID004C, MID005A, PAM001C, PAM003B, ROV005A, ROV005XSA, YUF001B, YUF001XCA, YUF001XSB, YUF019NB, YUF019SC, YUF020B, YUF021NC, YUF021SB, YUF022B, YUF023NB, YUF023SC, YUF024
Cryptantha recurvata MER001EB, MER001WA, ROV005XCA, ROV005XSA, YUF001XSB, YUF022A
Cryptantha sp. YUF019NA
Cryptantha sp2. YUF019NA
Cryptantha utahensis ROV005B
Cryptantha virginensis MER001WA, RAM001C
Cuscuta nevadensis ROV005XCD
Cymopteris ripleyi YUF020B, YUF021SC
Delphinium andersonii MID005A
Delphinium parishii PAM001B, ROV005B, ROV005XSB, YUF001C
Descurainia pinnata FRF001A, FRF001XCB, FRF001XSB, MER001EB, MER001WA, MER002XCB, MER002XSA, PAM001C, PAM002C, PAM003A, ROV005A, ROV005XCA, ROV005XSB, YUF001A, YUF001XCA, YUF001XSB, YUF019NB, YUF019SC, YUF020B, YUF021SC, YUF022C, YUF024C
Descurainia sophia MER002XCB, YUF019ND, YUF021NB, YUF021SB, YUF022B, YUF023NB, YUF024C
Dichelostemma pulchellum MER002XCA, MER002XSA, MID004C, MID005C, PAM001D, YUF023SC, YUF024B
Eriastrum eremicum FRF001A, FRF001XSB, MER002XCB, MER002XSB, MID004C, PAM001D, PAM003A, ROV005B, YUF019NA, YUF020A, YUF021SB
Erigeron pumilus PAM001A
Eriogonum brachypodum MER001EB, MER002XCA
Eriogonum deflexum MER001EB, MER001WA, MID004A, ROV005B, YUF019NA, YUF019SA, YUF020A, YUF021NA, YUF021SA, YUF022B, YUF023NA, YUF023SB, YUF024A
Eriogonum inflatum MER001WB, ROV005C, ROV005XSB

Eriogonum maculatum FRF001B, FRF001XCB, FRF001XSB, JAF001B, MID005A, ROV005B, ROV005XCB, YUF001A, YUF001XCB, YUF001XSA, YUF021SB, YUF022C, YUF023SB, YUF024B

Eriogonum nidularium MER002XSA, MID004B, MID005A, PAM003C, ROV005XCA, YUF001B, YUF001XCB, YUF001XSD, YUF021NC, YUF021SB, YUF022B

Eriogonum sp. YUF019NA

Eriogonum trichopes MER001EB, MER001WB, ROV005B, ROV005XCA

Erioneuron pulchellum MER001WA

Eriophyllum pringlei FRF001A, FRF001XCA, FRF001XSA, JAF001A, ROV005B, ROV005XCA, YUF001A, YUF001XCA, YUF001XSA, YUF021NC, YUF021SB, YUF022B, YUF024A

Eriophyllum sp. PAM001D

Eriophyllum wallacei MID005B, PAM003C,

Erodium cicutarium MER001EB, MER001WA, MID004C, ROV005C, ROV005XCB

Eschscholzia glyptosperma FRF001C, FRF001XCB, FRF001XSB, MER001WB, MER002XCB, MER002XSB, ROV005B, ROV005XCB, ROV005XSB

Eschscholzia minutifl0ra FRF001A, MID005B

Euphorbia albomarginata JAF001D, MER002XCA, MER002XSA, YUF001B, YUF019SA, YUF020B, YUF021SC, YUF023SC, YUF024B

Gilia campanulata YUF020A

Gilia cana FRF001XSA, MER002XCA, MER002XSA, ROV005B, YUF001XCB, YUF020A

Gilia filiformis YUF020B, YUF023NB, YUF023SB, YUF024A

Gilia scopulorum FRF001C, PAM001A

Gilia sinuata FRF001XCA, FRF001XSB, MID004A, ROV005A, YUF001A, YUF021SB, YUF023NA, YUF023SB, YUF024B

Gilia transmontana FRF001B, JAF001B, MER001EB, MER001WB, MER002XCA, MER002XSB, YUF021NA, YUF001XCB, MID005A, PAM001A, PAM003A, ROV005A, ROV005XCA, ROV005XSA, YUF001XSB, YUF021NA, YUF021SA, YUF022B

Glyptopleura marginata FRF001C, FRF001XCB, FRF001XSB, YUF001C, YUF021NB, YUF021SC

Halogeton glomeratus PAM002A, PAM003A, YUF021NA, YUF021SB,

Ipomopsis congesta RAM001A

Ipomopsis polycladon MER001EA, MER001WA, MER002XSB, PAM001A, PAM003A, ROV005A, YUF001A, YUF001XCA, YUF001XSA, YUF022B, YUF023NA

Lactuca serriola YUF019SD, YUF021NC

Langloisia schottii ROV005B, YUF001XSA, YUF019NB, YUF021SC, YUF024A

Langloisia setosissima MER001EB, MER001WA, YUF001A, YUF001XCA, YUF001XCB

Lepidium lasiocarpum ROV005A, ROV005XCA, ROV005XSA, YUF001B, YUF001XCB, YUF001XSB, YUF020A, YUF021NC, YUF021SA

Linanthus demissus FRF001XCB, MER001EB, MER001WB, MID004C, ROV005XCB
Linanthus dichotomus MID004A, MID005A
Linanthus jonesii FRF001A, MER002XCB, MER002XSA, PAM001B
Linanthus sp. YUF019NB
Linum lewisii PAM001D
Lomatium nevadense MID004B
Lomatium parryi MID005C
Lupinus argenteus YUF021SB
Lupinus flavoculatus YUF001A, YUF001XCA, YUF001XSB, YUF021NC, YUF022B
Lupinus shockleyi FRF001B, FRF001XCB, FRF001XSB, JAF001B, ROV005B, YUF024B
Machaeranthera canescens MER002XCA, MER002XSA, PAM003B, YUF001A, YUF001XSD, YUF019NB, YUF019SB, YUF020B, YUF021NA, YUF023NA, YUF023SB, YUF024A
Malacothrix glabrata FRF001B, FRF001XCA, FRF001XSB, JAF001B, ROV005A, ROV005XCB, ROV005XSB, YUF001B, YUF001XCB, YUF001XSA, YUF019NB, YUF019SB, YUF020B, YUF021NB, YUF021SB, YUF022B, YUF023SB, YUF024C
Malacothrix sonchoides FRF001C, JAF001B, PAM001A, YUF021SB, YUF022C
Mentzelia albicaulis FRF001A, FRF001XCA, FRF001XSA, JAF001B, MER002XCB, MID004B, MID005A, PAM001C, PAM003B, ROV005B, ROV005XSA, YUF001A, YUF001XCB, YUF001XSA, YUF019NA, YUF019SA, YUF020A, YUF021NA, YUF021SA, YUF022A, YUF023NA, YUF023SB, YUF024A
Monoptilon bellidiforme FRF001B, FRF001XCA, FRF001XSA, MER002XCA, MER002XSA
Muilla coronata MER001WB
Nama aretoides YUF020A, YUF020B, YUF021SA, YUF024B
Nama demissum FRF001XCA, FRF001XSA, MER001EB, MER001WB, ROV005D, ROV005XCA, YUF021NA, YUF021SA, YUF022B, YUF023NB
Nama densum PAM001B, RAM001B
Nemacladus glanduliferus MER002XCA, MER002XSA, MID005A, ROV005XCA, YUF001A
Nemacladus rubescens FRF001XSA, ROV005XSA
Nemacladus sp. FRF001A, FRF001XCA, JAF001A, MER001EA
Orobanche cooperi PAM001B, PAM003B
Oxytheca perfoliata MID004D, MID005A, ROV005B, YUF001C, YUF001XSB, YUF021NB, YUF021SB, YUF022A, YUF023NB
Pectocarya heterocarpa MER001EB, MER001WA, MER002XCA, MER002XSB, ROV005A, ROV005XCA, ROV005XSA
Pectocarya platycarpa MER001EB, MER001WB, ROV005A, ROV005XCA, ROV005XSA
Pectocarya setosa MID004B, MID005A

Penstemon floridus PAM001D

Phacelia crenulata PAM001D

Phacelia fremontii MER001EA, MER001WA, MER002XCB, MER002XSD, MID005A, PAM001A, PAM003A, ROV005B, ROV005XCA, ROV005XSA, YUF001A, YUF001XCA, YUF001XSA, YUF021NA, YUF021SB, YUF022A

Phacelia vallis-mortae MID005B, ROV005B, ROV005XCA, ROV005XSB, YUF001XCB, YUF001XSB, YUF021SB, YUF022A

Phlox stansburyi MID004C, PAM001B

Plantago insularis MER001EA

Psathyrotes annua YUF021SC, YUF022C

Rafinesquia neomexicana FRF001XCB, FRF001XSD, ROV005B, ROV005XCB, ROV005XSB

Salsola australis FRF001B, FRF001XSD, JAF001B, PAM002A, PAM003A, YUF001B, YUF001XSA, YUF019NA, YUF020A, YUF021NA, YUF021SA, YUF022A, YUF023NA, YUF023SA, YUF024A

Schismus arabicus JAF001C, MER001EB, MER001WA, MID004D, ROV005D

Sisymbrium altissimum MID004A, YUF001B, YUF020B, YUF021SB, YUF022C

Stephanomeria exigua JAF001A, MID005B, RAM001C, ROV005A, ROV005C, YUF001XSB,

Stephanomeria parryi FRF001A, YUF001C, YUF021NB, YUF022C, YUF023NC, YUF024B

Stephanomeria virgata YUF021NB

Streptanthella longirostris FRF001B, FRF001XSB, JAF001B, ROV005A, YUF001XCB, YUF001XSB

Stylocline micropoides MID004B, MID005A

Tricardia watsonii MID005B, YUF001D

Unknown unknown MER001WA, PAM001A, ROV005A, ROV005XSA, YUF019NA, YUF019NB, YUF019SC

Vulpia octoflora FRF001XCB, FRF001XSB, JAF001A, MER001EA, MER001WA, MER002XCA, MER002XSA, MID004B, MID005A, PAM001B, ROV005A, ROV005XCA, ROV005XSA, YUF001B, YUF001XCA, YUF001XSB

APPENDIX B

The following tables include summary data for ephemerals harvested from 0.025 m^2 quadrats (usually 20) on the Nevada Test Site during 1992. Numbers are reported as means for the quadrats ($\bar{X}$), as densities (n/m^2), biomass ($grams/m^2$), and weights per plant (milligrams). The percent of a sample reproductive (having buds, flowers, or fruit) is averaged over the 20 quadrats, as are total number per quadrat, total weight per quadrat, and mean weight per plant. Error terms (± 2 sem) are presented without checking for normal distribution. Species abbreviations are the first three letters of the genus combined with the first three of the species, and can be determined from Appendix 1. Results are presented in alphabetical order by plot name, as listed below.

Abbreviations used in the following tables for species names are as follows:

AMSTES	*Amsinckia tessellata*
ANIACA	*Anisocoma acaulis*
ASTACU	*Astragalus acutirostris*
ASTDID	*Astragalus didymocarpus*
ASTLEN	*Astragalus lentiginosus fremontii*
ASTPUR	*Astragalus purshii*
ASTTID	*Astragalus tidestromii*
BRAsp	*Brassica* species
BRORUB	*Bromus rubens*
BROsp	*Bromus* species
BROTEC	*Bromus tectorum*
CALFLE	*Calochortus flexuosus*
CALWRI	*Calycoseris wrightii*
CAMBOO	*Camissonia boothii*
CAMCLA	*Camissonia claviformis*
CAMPTE	*Camissonia pterosperma*
CAUCOO	*Caulanthus cooperi*
CAULAS	*Caulanthus lasiophyllus*
CHACAR	*Chaenactis carphoclinia*
CHADOU	*Chaenactis douglasii*
CHAFRE	*Chaenactis fremontii*
CHAMAC	*Chaenactis macrantha*
CHAsp	*Chaenactis* species
CHASTE	*Chaenactis stevioides*
CHAXAN	*Chaenactis xantiana*
CHEATR	*Chenopodium atrovirens*
CHEINC	*Chenopodium incanum*

Abbreviations used in the following tables for species names are as follows:

CHOBRE	*Chorizanthe brevicornu*
CHORIG	*Chorizanthe rigida*
CRYANG	*Cryptantha angustifolia*
CRYCIR	*Cryptantha circumscissa*
CRYFLA	*Cryptantha flavoculata*
CRYGRA	*Cryptantha gracilis*
CRYMIC	*Cryptantha micrantha*
CRYNEV	*Cryptantha nevadensis*
CRYPTE	*Cryptantha pterocarya*
CRYREC	*Cryptantha recurvata*
CRYsp	*Cryptantha* species
CRYVIR	*Cryptantha virginensis*
DELAND	*Delphinium andersonii*
DESPIN	*Descurainia pinnata*
DICPUL	*Dichelostemma pulchellum*
ERIBRA	*Eriogonum brachypodum*
ERIDEF	*Eriogonum deflexum*
ERIERE	*Eriophyllum eremicum*
ERIMAC	*Eriogonum maculatum*
ERINID	*Eriogonum nidularium*
ERIPRI	*Eriophyllum pringlei*
ERIPUL	*Erioneuron pulchellum*
ERIPUM	*Erigeron pumilis*
ERIsp	*Eriogonum* species
ERITRI	*Eriogonum trichopes*
EROCIC	*Erodium cicutarium*
ESCMIN	*Escholzia minutifolia*
EUPALB	*Euphorbia albomarginata*
GILCAM	*Gilia campanulata*
GILCAN	*Gilia cana*
GILFIL	*Gilis filiformis*
GILSCO	*Gilia scopulorum*
GILSIN	*Gilia sinuata*
GILTRA	*Gilia transmontana*
HALGLO	*Halogeton glomeratus*
IPOCON	*Ipomopsis congesta*
IPOPOL	*Ipomosis polycladon*
LANSCH	*Langloisia schottii*

Abbreviations used in the following tables for species names are as follows:

LANSET	*Langloisia setosissima*
LEPLAS	*Lepidium lasiocarpum*
LINDIC	*Linanthus dichotomus*
LINJON	*Linanthus jonesii*
LUPFLA	*Lupinus flavoculata*
MACCAN	*Machaeranthera canescens*
MALGLA	*Malacothrix glabrata*
MALSON	*Malacothrix sonchoides*
MENALB	*Mentzelia albicaulis*
MONBEL	*Monoptilon bellidiforme*
NAMARE	*Nama aretoides*
NAMDEM	*Nama demissum*
NEMGLA	*Nemacladus glanduliferus*
NEMRUB	*Nemacladus rubescens*
NEMsp	*Nemacladus* species
OXYPER	*Oxytheca perfoliata*
PECHET	*Pectocarya heterocarpa*
PECPLA	*Pectocarya platycarpa*
PECSET	*Pectocarya setosa*
PHAFRE	*Phacelia fremontii*
PHAVAL	*Phacelia vallis-mortae*
PLAINS	*Plantago insularis*
SALAUS	*Salsola australis*
SCHARA	*Schismus arabicus*
SISALT	*Sisymbrium altissimum*
STEEXI	*Stephanomeria exigua*
STEPAR	*Stephanomeria parryi*
STRLON	*Streptanthella longirostris*
STYMIC	*Stylocline micropoides*
UNK	Unknown
VULOCT	*Vulpia octoflora*

	$\bar{X}$ ± 2sem	SPECIES	n/m² ± 2sem	g/m² ± 2sem	wt/plant ± 2sem	%REPRO ± 2sem
PLOT FRF001		BRORUB	2.0 ± 4.0	0.02 ± 0.04	10	0
DATE 4/08/92		CHAFRE	4.0 ± 5.5	1.8 ± 2.8	459 ± 382	100 ± 0
%ROCK	53 ± 13	DESPIN	2.0 ± 4.0	0.09 ± 0.18	45	100
%LITTER	2.8 ± 2.2	ERIERE	2.0 ± 4.0	0.01 ± 0.02	6	100
%COVER	18 ± 16	ERIPRI	4.0 ± 5.5	0.08 ± 0.15	36	100 ± 0
%MOUND	23 ± 18	ESCMIN	2.0 ± 4.0	0.05 ± 0.10	25	0
PELLETS/M2	20 ± 26	LINJON	2.0 ± 4.0	0.05 ± 0.09	23	0
		MENALB	2.0 ± 4.0	0.5 ± 1.0	254	100
TOTAL N/M2	28 ± 14	NEM sp	6.0 ± 6.6	0.006 ± 0.007	1 ± 0	33 ± 67
TOTAL G/M2	3.4 ± 4.0	STEPAR	2.0 ± 4.0	0.6 ± 1.1	286	100

	$\bar{X}$ ± 2sem	SPECIES	n/m^2 ± 2sem	g/m^2 ± 2sem	wt/plant ± 2sem	%REPRO ± 2sem
PLOT FRF001XC		BRORUB	8 ± 17	0.9 ± 1.8	104	75
DATE 4/21/92		CHAFRE	10 ± 13	7.7 ± 9.8	1081 ± 1161	100 ± 0
%ROCK	16 ± 9	CRYMIC	10 ± 17	0.5 ± 0.9	43 ± 21	100 ± 0
%LITTER	11 ± 9	ERIPRI	2 ± 4	0.1 ± 0.2	48	100
%COVER	29 ± 20	GILSIN	4 ± 6	0.6 ± 0.9	146 ± 121	100 ± 0
%MOUND	21 ± 19	MALGLA	2 ± 4	4.8 ± 9.6	2286	100
PELLETS/M2	11 ± 8	MENALB	6 ± 7	5.4 ± 7.5	856 ± 881	67 ± 67
		MONBEL	4 ± 6	0.2 ± 0.4	57 ± 70	100 ± 0
TOTAL N/M2	122 ± 41	NAMDEM	48 ± 26	3.0 ± 2.1	81 ± 68	100 ± 0
TOTAL G/M2	25 ± 16	NEMsp	25 ± 16	1.4 ± 2.0	36 ± 37	100 ± 0

	$\bar{X}$ ± 2sem	SPECIES	n/m^2 ± 2sem	g/m^2 ± 2sem	wt/plant ± 2sem	%REPRO ± 2sem
PLOT FRF001XS		CRYMIC	6 ± 13	0.2 ± 0.3	26	100
DATE 4/21/92		CRYPTE	2 ± 4	0.7 ± 1.4	327	100
%ROCK	30 ± 12	ERIPRI	6 ± 7	0.09 ± 0.11	14 ± 9	100 ± 0
%LITTER	4 ± 3	GILCAN	2 ± 4	0.05 ± 0.09	22	0
%COVER	18 ± 15	MENALB	13 ± 25	2.4 ± 4.7	187	100
%MOUND	32 ± 21	MONBEL	2 ± 4	0.15 ± 0.30	72	100
PELLETS/M2	15 ± 11	NAMDEM	97 ± 64	4.1 ± 2.7	50 ± 29	96 ± 5
		NEMRUB	13 ± 17	0.22 ± 0.32	16 ± 3	100 ± 0
TOTAL N/M2	141 ± 79					
TOTAL G/M2	8 ± 7					

	$\bar{X} \pm 2sem$	SPECIES	$n/m^2 \pm 2sem$	$g/m^2 \pm 2sem$	wt/plant ± 2sem	%REPRO ± 2sem
PLOT JAF001		CAUCOO	2 ± 4	0.08 ± 0.16	41	0
DATE 4/08/92		CHAFRE	10 ± 10	6.1 ± 7.8	586 ± 645	75 ± 50
%ROCK	32 ± 10	CRYCIR	2 ± 4	0.08 ± 0.17	42	100
%LITTER	9 ± 8	CRYMIC	66 ± 60	0.23 ± 0.25	4 ± 2	64 ± 25
%COVER	21 ± 15	ERIPRI	2 ± 4	0.02 ± 0.03	8	100
%MOUND	24 ± 17	STEEXI	2 ± 4	0.01 ± 0.02	6	0
PELLETS/M2	8 ± 9	UNK3	2 ± 4	0.001 ± 0.002	1	0
		VULOCT	78 ± 47	0.64 ± 0.49	7 ± 4	81 ± 17
TOTAL N/M2	164 ± 101					
TOTAL G/M2	7 ± 8					

	$\bar{X}$ ± 2sem	SPECIES	n/m^2 ± 2sem	g/m^2 ± 2sem	wt/plant ± 2sem	%REPRO ± 2sem
PLOT MER001C		ASTDID	1.6 ± 3.2	0.03 ± 0.06	18	100
DATE 4/29/92		BRORUB	1.6 ± 3.2	0.21 ± 0.43	134	100
%ROCK	48 ± 11	CHORIG	8 ± 8	0.31 ± 0.31	42 ± 25	100 ± 0
%LITTER	10 ± 7	CRYANG	1.6 ± 3.2	0.04 ± 0.07	22	100
%COVER	20 ± 15	IPOPOL	13 ± 9	0.40 ± 0.33	31 ± 15	86 ± 29
%MOUND	24 ± 15	NEMsp	2 ± 3	0.006 ± 0.013	4	100
PELLETS/M2	40 ± 25	PHAFRE	3 ± 4	0.20 ± 0.30	64 ± 44	100 ± 0
		PLAINS	2 ± 3	0.01 ± 0.02	6	0
TOTAL N/M2	58 ± 24	VULOCT	26 ± 17	1.53 ± 1.4	48 ± 22	100 ± 0
TOTAL G/M2	2.7 ± 1.5					

	$\bar{X}$ ± 2sem	SPECIES	n/m² ± 2sem	g/m² ± 2sem	wt/plant ± 2sem	%REPRO ± 2sem
PLOT MER001W		ASTACU	2 ± 3	0.08 ± 0.16	50	100
DATE 4/28/92		BRORUB	3 ± 6	0.24 ± 0.49	76	100
%ROCK	36 ± 7	CHACAR	13 ± 9	1.15 ± 1.85	101 ± 160	79 ± 30
%LITTER	2.1 ± 0.5	CHAMAC	3 ± 4	0.35 ± 0.48	108 ± 13	100 ± 0
%COVER	1 ± 2	CHOBRE	2 ± 3	0.03 ± 0.07	21	100
%MOUND	27 ± 18	CRYCIR	3 ± 4	0.08 ± 0.13	26 ± 22	100 ± 0
PELLETS/M2	18 ± 15	CRYREC	2 ± 3	0.04 ± 0.07	22	100
		CRYVIR	2 ± 3	0.12 ± 0.24	76	100
TOTAL N/M2	594 ± 178	DESPIN	45 ± 40	1.11 ± 0.80	39 ± 26	100 ± 0
TOTAL G/M2	27 ± 11	ERIDEF	205 ± 87	5.34 ± 2.06	29 ± 8	0 ± 0
		ERIPUL	2 ± 3	0.02 ± 0.04	13	0
		EROCIC	11 ± 10	3.57 ± 3.52	309 ± 185	100 ± 0
		IPOPOL	22 ± 12	0.50 ± 0.39	21 ± 9	70 ± 31
		LANSET	83 ± 41	1.32 ± 0.66	20 ± 12	0 ± 0
		PECHET	18 ± 17	0.47 ± 0.42	34 ± 25	100 ± 0
		PHAFRE	2 ± 3	0.51 ± 1.01	317	100
		SCHARA	64 ± 41	7.7 ± 9.0	89 ± 66	96 ± 7
		UNK1	2 ± 3	0.008 ± 0.016	5	0
		VULOCT	112 ± 56	5.38 ± 2.81	61 ± 30	93 ± 10

	$\bar{X}$ ± 2sem	SPECIES	n/m² ± 2sem	g/m² ± 2sem	wt/plant ± 2sem	%REPRO ± 2sem
PLOT MER002XC		BRORUB	76 ± 62	18 ± 18	274 ± 137	70 ± 31
DATE 4/20/92		CHASTE	25 ± 16	6.1 ± 5.2	274 ± 223	100 ± 0
%ROCK	29 ± 8	CHFINC	2 ± 4	1.0 ± 2.0	466	100
%LITTER	10 ± 9	CRYCIR	2 ± 4	0.12 ± 0.25	59	100
%COVER	2 ± 3	DICPUL	4 ± 6	1.08 ± 1.5	257 ± 116	0 ± 0
%MOUND	12 ± 14	ERIBRA	2 ± 4	0.2 ± 0.4	92	100
PELLETS/M2	64 ± 28	EUPALB	80 ± 37	12.4 ± 7.2	162 ± 59	60 ± 24
		GILCAN	4 ± 6	0.8 ± 1.2	179 ± 166	100 ± 0
TOTAL N/M2	240 ± 84	GILTRA	15 ± 11	2.2 ± 1.6	161 ± 65	100 ± 0
TOTAL G/M2	45 ± 24	MACCAN	15 ± 9	0.8 ± 0.6	55 ± 17	0 0
		MONBEL	2 ± 4	0.06 ± 0.13	30	100
		NEMGLA	6 ± 13	0.01 ± 0.03	2	67
		PECHET	4 ± 8	0.7 ± 1.4	170	100
		VULOCT	4 ± 6	1.4 ± 2.6	323 ± 580	100 ± 0

	$\bar{X}$ ± 2sem	SPECIES	n/m^2 ± 2sem	g/m^2 ± 2sem	wt/plant ± 2sem	%REPRO ± 2sem
PLOT MER002XS		AMSTES	4 ± 6	7 ± 11	1610 ± 1720	100 ± 0
DATE 4/20/92		BRORUB	13 ± 9	1.7 ± 1.5	135 ± 74	33 ± 42
%ROCK	43 ± 7	CHASTE	6 ± 7	2.3 ± 2.9	370 ± 242	100 ± 0
%LITTER	4 ± 3	CHOBRE	2 ± 4	0.04 ± 0.08	18	100
%COVER	0.8 ± 1.6	CRYCIR	10 ± 17	0.6 ± 0.9	70 ± 43	100 ± 0
%MOUND	2 ± 4	CRYNEV	2 ± 4	1.0 ± 2.0	478	100
PELLETS/M2	42 ± 25	DESPIN	2 ± 4	0.25 ± 0.49	117	100
		DICPUL	6 ± 9	0.9 ± 1.3	141 ± 1	0 ± 0
TOTAL N/M2	232 ± 60	ERINID	2 ± 4	0.20 ± 0.41	97	100
TOTAL G/M2	27 ± 15	EUPALB	114 ± 43	9.5 ± 5.1	94 ± 62	80 ± 15
		GILCAN	4 ± 6	0.29 ± 0.51	69 ± 101	50 ± 100
		LINJON	2 ± 4	0.03 ± 0.06	13	0
		MACCAN	4 ± 6	0.12 ± 0.18	27 ± 31	0 ± 0
		MONBEL	2 ± 4	0.23 ± 0.47	111	100
		NEMGLA	2 ± 4	0.03 ± 0.06	15	100
		VULOCT	55 ± 34	2.9 ± 2.2	55 ± 23	85 ± 13

	$\bar{X} \pm 2sem$	SPECIES	$n/m^2 \pm 2sem$	$g/m^2 \pm 2sem$	wt/plant ± 2sem	%REPRO ± 2sem
PLOT MID004		BROsp	2 ± 4	0.01 ± 0.03	7	0
DATE 5/12/92		CRYCIR	2 ± 4	0.22 ± 0.43	107	100
%ROCK	53 ± 8	ERIDEF	468 ± 214	7.5 ± 2.3	32 ± 19	7 ± 11
%LITTER	5 ± 2	GILSIN	2 ± 4	0.6 ± 1.3	281	100
%COVER	0 ± 0	LINDIC	2 ± 4	0.3 ± 0.6	152	100
%MOUND	0 ± 0	SALAUS	294 ± 187	10 ± 7	42 ± 34	0 ± 0
PELLETS/M2	16 ± 16	SISALT	4 ± 8	0.4 ± 0.8	98	50
TOTAL N/M2	774 ± 270					
TOTAL G/M2	19 ± 8					

	$\bar{X}$ ± 2sem	SPECIES	n/m^2 ± 2sem	g/m^2 ± 2sem	wt/plant ± 2sem	%REPRO ± 2sem
PLOT MID005		AMSTES	6 ± 9	2.1 ± 4.1	257 ± 509	50 ± 100
DATE 5/12/92		BRORUB	290 ± 151	35 ± 10	135 ± 68	100 ± 0
%ROCK	30 ± 15	BROTEC	6 ± 7	0.9 ± 1.6	152 ± 248	100 ± 0
%LITTER	35 ± 18	CALFLE	4 ± 6	3.2 ± 4.6	805 ± 366	100 ± 0
%COVER	67 ± 19	CHASTE	4 ± 8	0.16 ± 0.33	41	100
%MOUND	35 ± 20	CRYCIR	40 ± 52	3.4 ± 4.8	69 ± 32	100 ± 0
PELLETS/M2	6 ± 9	CRYGRA	30 ± 41	1.2 ± 1.6	42 ± 19	100 ± 0
		CRYPTE	14 ± 12	0.8 ± 0.8	77 ± 58	90 ± 20
TOTAL N/M2	1028 ± 369	DELAND	2 ± 4	6.7 ± 6.7	3362	100
TOTAL G/M2	78 ± 31	ERIMAC	4 ± 8	0.02 ± 0.04	5	100
	0.13 ± 0.08	ERINID	2 ± 4	0.03 ± 0.06	15	100
		GILTRA	66 ± 42	4.1 ± 3.2	72 ± 35	100 ± 0
		LINDIC	92 ± 101	1.2 ± 1.2	16 ± 8	100 ± 0
		MENALB	272 ± 173	16 ± 5	68 ± 32	100 ± 0
		NEMGLA	2 ± 4	0.003 ± 0.007	2	100
		OXYPER	30 ± 60	0.5 ± 0.9	16	100
		PECSET	62 ± 112	1.5 ± 1.9	79 ± 60	100 ± 0
		PHAFRE	4 ± 6	0.14 ± 0.21	35 ± 24	100 ± 0
		STYMIC	86 ± 128	0.7 ± 1.1	7 ± 3	100 ± 0
		VULOCT	12 ± 20	0.4 ± 0.6	68 ± 108	100 ± 0

	X̄ ± 2sem	SPECIES	n/m² ± 2sem	g/m² ± 2sem	wt/plant ± 2sem	%REPRO ± 2sem
PLOT PAM001		ASTPUR	2 ± 4	0.05 ± 0.09	23	0
DATE 5/27/92		CAMPTE	14 ± 9	0.07 ± 0.07	5 ± 4	100 ± 0
%ROCK	61 ± 14	ERIPUM	4 ± 8	0.01 ± 0.02	3	0
%LITTER	13 ± 11	GILSCO	2 ± 4	0.007 ± 0.014	4	0
%COVER	27 ± 15	GILTRA	120 ± 49	2.3 ± 1.2	20 ± 10	89 ± 11
%MOUND	25 ± 17	IPOPOL	2 ± 4	0.03 ± 0.06	15	100
PELLETS/M2	4 ± 6	MALSON	2 ± 4	0.04 ± 0.07	18	100
		PHAFRE	6 ± 12	0.08 ± 0.16	13	100
TOTAL N/M2	154 ± 61	UNK4	2 ± 4	0.008 ± 0.015	4	100
TOTAL G/M2	2.6 ± 1.4					
AVG AVG WT/P	0.01 ± 0.01					

	$\bar{X} \pm$ 2sem	SPECIES	$n/m^2 \pm$ 2sem	$g/m^2 \pm$ 2sem	wt/plant ± 2sem	%REPRO ± 2sem
PLOT PAM002		HALGLO	3446 ± 696	16 ± 7	5 ± 1	0 ± 0
DATE 6/2/92		SALAUS	102 ± 43	1.3 ± 0.6	11 ± 3	0 ± 0
%ROCK	42 ± 7					
%LITTER	9 ± 4					
%COVER	0 ± 0					
%MOUND	0 ± 0					
PELLETS/M2	32 ± 28					
TOTAL N/M2	3548 ± 699					
TOTAL G/M2	18 ± 7					
AVG AVG WT/P	0.008 ± 0.001					

	$\bar{X}$ ± 2sem	SPECIES	n/m^2 ± 2sem	g/m^2 ± 2sem	wt/plant ± 2sem	%REPRO± 2sem
PLOT PAM003		ASTLEN	8 ± 7	9.5 ± 9.3	1192 ± 2305	25 ± 50
DATE 6/2/92		CAMPTE	6 ± 12	0.03 ± 0.06	5	100
%ROCK	38 ± 11	DESPIN	24 ± 19	0.20 ± 0.18	7 ± 3	100 ± 0
%LITTER	16 ± 12	ERIERE	18 ± 16	0.29 ± 0.30	14 ± 6	100 ± 0
%COVER	34 ± 18	GILTRA	210 ± 134	3.9 ± 2.1	26 ± 12	100 ± 1
%MOUND	31 ± 18	HALGLO	234 ± 126	1.1 ± 0.7	4 ± 1	0 ± 0
PELLETS/M2	2 ± 4	IPOPOL	2 ± 4	0.03 ± 0.06	14	100
		PHAFRE	2 ± 4	0.04 ± 0.07	18	100
TOTAL N/M2	506 ± 157	SALAUS	2 ± 4	0.012 ± 0.024	6	0
TOTAL G/M2	16 ± 18					
AVG AVG WT/P	0.11 ± 0.19					

	$\bar{X}$ ± 2sem	SPECIES	n/m^2 ± 2sem	g/m^2 ± 2sem	wt/plant ± 2sem	%REPRO ± 2sem
PLOT RAM001		CHADOU	1 ± 2	0.003 ± 0.007	3	0
DATE 6/24/92		IPOCON	0.5 ± 1.0	0.01 ± 0.03	0	
%ROCK	49 ± 14					
%LITTER	31 ± 14					
%COVER	46 ± 19					
%MOUND	6 ± 10					
PELLETS/M2	18 ± 12					
TOTAL N/M2	1.5 ± 2.2					
TOTAL G/M2	0.02 ± 0.03					
AVG AVG WT/P	0.02 ± 0.02					

	$\bar{X}$ ± 2sem	SPECIES	n/m² ± 2sem	g/m² ± 2sem	wt/plant ± 2sem	%REPRO ± 2sem
PLOT ROV005		BRORUB	294 ± 227	13 ± 10	42 ± 15	93 ± 7
DATE 4/16/92		CAMBOO	2 ± 4	0.03 ± 0.06	15	100
%ROCK	63 ± 13	CAMCLA	2 ± 4	0.06 ± 0.12	28	100
%LITTER	9 ± 9	CAULAS	10 ± 11	6.8 ± 10.9	575 ± 777	100 ± 0
%COVER	25 ± 19	CHOBRE	2 ± 4	0.02 ± 0.05	12	100
%MOUND	24 ± 18	CRYCIR	2 ± 4	0.04 ± 0.08	19	100
PELLETS/M2	48 ± 42	CRYGRA	10 ± 14	1.9 ± 3.5	159 ± 265	100 ± 0
		CRYPTE	2 ± 4	0.08 ± 0.15	38	
TOTAL N/M2	386 ± 251	DESPIN	2 ± 4	0.02 ± 0.04	11	100
TOTAL G/M2	24 ± 21	GILSIN	4 ± 8	0.05 ± 0.09	11	50
		GILTRA	2 ± 4	0.25 ± 0.49	123	100
		IPOPOL	2 ± 4	0.03 ± 0.06	15	100
		LEPLAS	6 ± 12	0.08 ± 0.17	14	100
		MALGLA	2 ± 4	0.18 ± 0.36	91	100
		PECHET	16 ± 24	0.16 ± 0.23	19 ± 33	100 ± 0
		PECPLA	2 ± 4	0.06 ± 0.12	30	100
		STEEXI	4 ± 6	0.026 ± 0.036	6 ± 1	0 ± 0
		STRLON	4 ± 8	0.06 ± 0.12	16	100
		UNK3	2 ± 4	0.04 ± 0.08	20	0
		VULOCT	16 ± 11	0.24 ± 0.21	14 ± 8	100 ± 0

	$\bar{X} \pm 2sem$	SPECIES	$n/m^2 \pm 2sem$	$g/m^2 \pm 2sem$	wt/plant ± 2sem	%REPRO ± 2sem
PLOT ROV005XC		ASTTID	2 ± 4	0.11 ± 0.23	51	0
DATE 4/30/92		BRORUB	393 ± 244	32 ± 24	71 ± 18	97 ± 3
%ROCK	63 ± 13	CAMCLA	2 ± 4	0.7 ± 1.4	322	100
%LITTER	13 ± 14	CAULAS	7 ± 7	0.31 ± 0.40	47 ± 37	100 ± 0
%COVER	20 ± 18	CHOBRE	2 ± 4	0.34 ± 0.68	152	100
%MOUND	9 ± 13	CRYCIR	64 ± 106	0.9 ± 1.2	25 ± 17	100 ± 0
PELLETS/M2	22 ± 23	CRYNEV	2 ± 4	0.02 ± 0.04	9	0
		CRYREC	2 ± 4	0.02 ± 0.04	10	100
TOTAL N/M2	762 ± 257	DESPIN	9 ± 8	0.31 ± 0.38	34 ± 33	100 ± 0
TOTAL G/M2	54 ± 27	ERINID	2 ± 4	0.04 ± 0.08	18	100
		ERIPRI	4 ± 6	0.08 ± 0.12	19 ± 2	100 ± 0
		ERITRI	40 ± 26	4.8 ± 8.0	242 ± 448	57 ± 33
		GILTRA	2 ± 4	0.15 ± 0.31	69	100
		LEPLAS	9 ± 10	0.5 ± 0.8	40 ± 49	100 ± 0
		NAMDEM	2 ± 4	0.02 ± 0.03	7	100
		NEMGLA	2 ± 4	0.018 ± 0.036	100	
		PECHET	73 ± 42	3.1 ± 2.4	70 ± 74	100 ± 0
		PECPLA	58 ± 47	2.0 ± 1.7	50 ± 39	100 ± 0
		PHAFRE	29 ± 53	5.2 ± 10.4	106 ± 176	100 ± 0
		PHAVAL	2 ± 4	0.9 ± 1.9	427	100
		VULOCT	53 ± 41	2.1 ± 1.6	60 ± 49	100 ± 0

	$\bar{X}$ ± 2sem	SPECIES	n/m^2 ± 2sem	g/m^2 ± 2sem	wt/plant ± 2sem	%REPRO ± 2sem
PLOT RUV005XS		BRAsp	2 ± 4	0.03 ± 0.07	16	100
DATE 4/30/92		BRORUB	44 ± 37	4.0 ± 4.6	75 ± 40	86 ± 29
%ROCK	54 ± 12	CAMCLA	4 ± 8	1.1 ± 2.2	256	100
%LITTER	22 ± 15	CAULAS	10 ± 21	3.4 ± 6.7	319	100
%COVER	43 ± 22	CHAFRE	6 ± 13	0.14 ± 0.27	22	
%MOUND	15 ± 15	CRYCIR	6 ± 7	0.09 ± 0.11	15 ± 7	100 ± 0
PELLETS/M2	16 ± 23	CRYNEV	4 ± 6	2.4 ± 3.7	568 ± 550	100 ± 0
		CRYPTE	6 ± 9	3.1 ± 5.8	397 ± 578	100 ± 0
TOTAL N/M2	240 ± 116	CRYREC	4 ± 6	1.5 ± 3.0	360 ± 701	100 ± 0
TOTAL G/M2	40 ± 25	ERITRI	13 ± 17	8.0 ± 8.9	1041 ± 807	100 ± 0
		LEPLAS	8 ± 10	0.20 ± 0.24	23 ± 13	100 ± 0
		MENALB	2 ± 4	2.1 ± 4.3	1014	100
		NEMRUB	2 ± 4	0.05 ± 0.09	22	100
		PECHET	48 ± 68	5.4 ± 7.9	201 ± 244	100 ± 0
		PECPLA	17 ± 16	1.8 ± 2.1	97 ± 93	100 ± 0
		PHAFRE	38 ± 63	5.6 ± 8.6	423 ± 602	100 ± 0
		UNK1	2 ± 4	0.02 ± 0.04	10	100
		VULOCT	21 ± 18	0.83 ± 0.72	53 ± 42	100 ± 0

	$\bar{X} \pm 2sem$	SPECIES	$n/m^2 \pm 2sem$	$g/m^2 \pm 2sem$	wt/plant ± 2sem	%REPRO ± 2sem
PLOT YUF001		ASTLEN	4 ± 6	0.05 ± 0.08	11 ± 17	0 ± 0
DATE 4/22/92		BRORUB	106 ± 111	16. ± 21.	106 ± 77	81 ± 32
%ROCK	56 ± 15	CAMCLA	2 ± 4	0.12 ± 0.24	61	100
%LITTER	14 ± 10	CHASTE	4 ± 6	0.07 ± 0.10	18 ± 2	50 ± 100
%COVER	23 ± 16	CHAXAN	2 ± 4	0.16 ± 0.33	82	0
%MOUND	22 ± 18	CRYGRA	4 ± 6	0.37 ± 0.52	92 ± 41	100 ± 0
PELLETS/M2	18 ± 12	DESPIN	2 ± 4	0.014 ± 0.028	7	100
		ERIMAC	6 ± 12	0.10 ± 0.20	16	
TOTAL N/M2	172 ± 133	ERIPRI	4 ± 8	0.10 ± 0.20	25	100
TOTAL G/M2	26 ± 26	GILSIN	10 ± 20	1.4 ± 2.7	135	100
		IPOPOL	2 ± 4	0.04 ± 0.09	22	0
		LANSET	2 ± 4	0.02 ± 0.04	10	0
		LUPFLA	4 ± 6	1.1 ± 1.6	279 ± 67	100 ± 0
		MACCAN	2 ± 4	0.004 ± 0.008	2	0
		MENALB	2 ± 4	2.4 ± 4.7	1177	100
		NEMGLA	2 ± 4	0.004 ± 0.008	2	100
		PHAFRE	12 ± 10	2.5 ± 3.3	245 ± 291	100 ± 0
		PHAVAL	2 ± 4	1.9 ± 3.7	928	100

	$\bar{X} \pm 2sem$	SPECIES	$n/m^2 \pm 2sem$	$g/m^2 \pm 2sem$	wt/plant ± 2sem	%REPRO ± 2sem
PLOT YUF001XC		ASTLEN	6 ± 9	0.40 ± 0.55	70 ± 40	0 ± 0
DATE 4/30/92		BRORUB	114 ± 89	16. ± 15.	103 ± 48	100 ± 0
%ROCK	51 ± 16	CRYCIR	2 ± 4	0.10 ± 0.20	48	100
%LITTER	15 ± 12	CRYGRA	4 ± 6	0.9 ± 1.6	209 ± 358	100 ± 0
%COVER	40 ± 20	CRYPTE	2 ± 4	1.5 ± 3.0	711	100
%MOUND	26 ± 20	CRYREC	2 ± 4	1.0 ± 2.1	493	100
PELLETS/M2	2 ± 4	DESPIN	2 ± 4	0.07 ± 0.14	34	100
		ERIPRI	4 ± 6	0.06 ± 0.11	15 ± 21	100 ± 0
TOTAL N/M2	158 ± 98	IPOPOL	2 ± 4	0.18 ± 0.35	84	100
TOTAL G/M2	22 ± 19	LANSET	2 ± 4	0.01 ± 0.02	6	0
		LUPFLA	2 ± 4	1.1 ± 2.1	502	100
		PHAFRE	10 ± 10	0.46 ± 0.55	48 ± 49	100 ± 0
		VULOCT	4 ± 8	0.06 ± 0.11	13	100

	$\bar{X}$ ± 2sem	SPECIES	n/m² ± 2sem	g/m² ± 2sem	wt/plant ± 2sem	%REPRO ± 2sem
PLOT YUF001XS		ASTLEN	6 ± 7	0.39 ± 0.43	61 ± 15	33 ± 67
DATE 5/04/92		BRORUB	8 ± 13	1.3 ± 2.0	156 ± 1	100 ± 0
%ROCK	52 ± 11	CHACAR	6 ± 13	1.2 ± 2.3	185	100
%LITTER	8 ± 9	CHASTE	4 ± 6	8.9 ± 12.2	2102 ± 318	100 ± 0
%COVER	17 ± 15	CHAsp	2 ± 4	2.8 ± 5.6	1329	100
%MOUND	11 ± 12	ERIMAC	2 ± 4	0.06 ± 0.11	27	100
PELLETS/M2	13 ± 9	ERIPRI	2 ± 4	0.04 ± 0.08	19	100
		IPOPOL	13 ± 11	2.4 ± 2.8	208 ± 210	100 ± 0
TOTAL N/M2	72 ± 35	LANSCH	4 ± 6	0.27 ± 0.47	65 ± 94	50 ± 100
TOTAL G/M2	27 ± 18	MALGLA	4 ± 8	3.9 ± 7.8	923	100
		MENALB	2 ± 4	0.7 ± 1.3	313	100
		PHAFRE	15 ± 16	4.8 ± 8.9	263 ± 445	100 ± 0
		SALAUS	2 ± 4	0.22 ± 0.43	102	0

	$\bar{X} \pm 2sem$	SPECIES	$n/m^2 \pm 2sem$	$g/m^2 \pm 2sem$	wt/plant ± 2sem	%REPRO ± 2sem
PLOT YUF019N		BROsp	22 ± 19	1.8 ± 2.2	69 ± 44	0 ± 0
DATE 4/13/92		CHEINC	4 ± 6	0.02 ± 0.04	6 ± 6	0 ± 0
%ROCK	9 ± 4	CRYsp	2 ± 4	0.05 ± 0.10	26	0
%LITTER	21 ± 14	CRYsp2	2 ± 4	0.03 ± 0.06	14	0
%COVER	23 ± 17	ERIDEF	16 ± 17	0.3 ± 0.3	24 ± 22	0 ± 0
%MOUND	18 ± 18	ERIERE	2 ± 4	0.09 ± 0.18	45	100
PELLETS/M2	14 ± 16	ERIsp	6 ± 9	0.010 ± 0.014	2 ± 0	0 ± 0
		MENALB	82 ± 60	2.1 ± 1.9	27 ± 16	35 ± 23
TOTAL N/M2	206 ± 98	SALAUS	68 ± 58	1.2 ± 0.7	26 ± 13	0 ± 0
TOTAL G/M2	5.6 ± 3.0	UNK4	2 ± 4	0.001 ± 0.002	1	0
AVG AVG WT/P	0.03 ± 0.01					

	$\bar{X}$ ± 2sem	SPECIES	n/m^2 ± 2sem	g/m^2 ± 2sem	wt/plant ± 2sem	%REPRO ± 2sem
PLOT YUF019S		BROsp	6 ± 12	0.10 ± 0.20	16	0
DATE 4/13/92		CHEINC	8 ± 7	0.18 ± 0.20	23 ± 14	25 ± 50
%ROCK	18 ± 8	CRYMIC	4 ± 6	0.04 ± 0.08	10 ± 17	0 ± 0
%LITTER	13 ± 14	ERIDEF	84 ± 73	1.1 ± 0.9	17 ± 9	0 ± 0
%COVER	11 ± 14	EUPALB	2 ± 4	0.01 ± 0.02	4	0
%MOUND	0 ± 0	MENALB	20 ± 23	1.8 ± 3.3	53 ± 77	25 ± 50
PELLETS/M2	32 ± 44	SALAUS	38 ± 38	0.5 ± 0.5	14 ± 12	0 ± 0
TOTAL N/M2	162 ± 117					
TOTAL G/M2	3.7 ± 4.1					
AVG AVG WT/P	0.02 ± 0.01					

	$\bar{X} \pm$ 2sem	SPECIES	n/m^2 ± 2sem	g/m^2 ± 2sem	wt/plant ± 2sem	%REPRO ± 2sem
PLOT YUF020		ANIACA	2 ± 4	0.07 ± 0.14	35	0
DATE 4/15/92		BROTEC	2 ± 4	0.4 ± 0.9	218	100
%ROCK	4 ± 3	CALWRI	2 ± 4	0.02 ± 0.04	11	100
%LITTER	9 ± 9	CHEINC	2 ± 4	0.002 ± 0.004	1	0
%COVER	15 ± 14	CRYFLA	22 ± 36	0.37 ± 0.55	22 ± 20	41 ± 61
%MOUND	25 ± 18	CRYMIC	4 ± 8	0.02 ± 0.04	5	50
PELLETS/M2	0 ± 0	ERIDEF	8 ± 9	0.18 ± 0.20	24 ± 6	0 ± 0
		ERIERE	8 ± 7	1.2 ± 1.6	155 ± 152	25 ± 50
TOTAL N/M2	124 ± 59	GILCAM	4 ± 6	0.008 ± 0.012	2 ± 2	0 ± 0
TOTAL G/M2	4.8 ± 2.8	GILCAN	2 ± 4	0.04 ± 0.08	20	0
AVG AVG WT/P	0.04 ± 0.02	LEPLAS	6 ± 7	0.06 ± 0.07	10 ± 3	67 ± 67
		MENALB	18 ± 15	1.3 ± 1.2	73 ± 33	30 ± 40
		NAMARE	10 ± 10	0.05 ± 0.06	5 ± 6	0 ± 0
		SALAUS	34 ± 36	1.0 ± 0.8	39 ± 13	0 ± 0

	$\bar{X}$ ± 2sem	SPECIES	n/m^2 ± 2sem	g/m^2 ± 2sem	wt/plant ± 2sem	%REPRO ± 2sem
PLOT YUF021N		BRORUB	20 ± 25	1.7 ± 2.1	94 ± 29	100 ± 0
DATE 5/6/92		BROTEC	4 ± 8	0.26 ± 0.51	64	100
%ROCK	39 ± 14	BROsp	4 ± 6	0.18 ± 0.26	45 ± 23	0 ± 0
%LITTER	6 ± 5	CHASTE	6 ± 9	4.1 ± 7.3	578 ± 655	100 ± 0
%COVER	3 ± 3	CHEATR	4 ± 6	0.28 ± 0.40	70 ± 33	100 ± 0
%MOUND	6 ± 7	ERIDEF	150 ± 105	7.5 ± 5.3	63 ± 31	0 ± 0
PELLETS/M2	19 ± 14	GILSIN	8 ± 12	0.8 ± 1.4	71 ± 90	100 ± 0
		GILTRA	4 ± 6	0.44 ± 0.86	111 ± 212	100 ± 0
TOTAL N/M2	460 ± 206	HALGLO	44 ± 34	0.63 ± 0.70	10 ± 6	0 ± 0
TOTAL G/M2	25 ± 14	MACCAN	2 ± 4	0.19 ± 0.38	95	0
AVG AVG WT/P	0.08 ± 0.03	MENALB	6 ± 9	0.9 ± 1.6	120 ± 157	100 ± 0
		NAMDEM	2 ± 4	0.11 ± 0.23	57	100
		PHAFRE	4 ± 8	0.25 ± 0.50	62	100
		SALAUS	202 ± 126	7.9 ± 3.1	53 ± 14	0 ± 0

	$\bar{X}$ ± 2sem	SPECIES	n/m^2 ± 2sem	±g/m^2 ± 2sem	wt/plant ± 2sem	%REPRO ± 2sem
PLOT YUF021S		ASTLEN	10 ± 10	1.8 ± 1.7	181 ± 19	25 ± 50
DATE 5/06/92		BRORUB	14 ± 13	7.8 ± 8.1	551 ± 299	100 ± 0
%ROCK	15 ± 9	CHASTE	6 ± 7	2.6 ± 3.0	432 ± 187	100 ± 0
%LITTER	10 ± 7	ERIDEF	8 ± 12	2.1 ± 3.7	231 ± 144	50 ± 100
%COVER	11 ± 12	GILTRA	6 ± 9	1.3 ± 2.6	175 ± 292	100 ± 0
%MOUND	10 ± 14	LEPLAS	2 ± 4	0.25 ± 0.50	126	100
PELLETS/M2	8 ± 7	MENALB	2 ± 4	2.0 ± 4.0	1005	100
		NAMARE	2 ± 4	0.11 ± 0.22	56	100
TOTAL N/M2	266 ± 180	NAMDEM	2 ± 4	0.14 ± 0.28	71	100
TOTAL G/M2	73 ± 52	SALAUS	214 ± 160	55. ± 46.	294 ± 161	14 ± 18
AVG AVG WT/P	0.33 ± 0.10					

	$\bar{X}$ ± 2sem	SPECIES	n/m² ± 2sem	g/m² ± 2sem	wt/plant ± 2sem	%REPRO ± 2sem
PLOT YUF022		AMSTES	4 ± 8	10.0 ± 20.0	2496	100
DATE 5/05/92		BRORUB	44 ± 65	7.3 ± 9.6	186 ± 59	98 ± 3
%ROCK	26 ± 11	CHAFRE	4 ± 6	1.2 ± 1.8	293 ± 310	100 ± 0
%LITTER	16 ± 13	CHASTE	4 ± 8	0.43 ± 0.85	107	100
%COVER	26 ± 18	CRYREC	2 ± 4	0.27 ± 0.55	137	100
%MOUND	38 ± 20	MENALB	4 ± 6	0.22 ± 0.35	55 ± 63	100 ± 0
PELLETS/M2	8 ± 7	OXYPER	2 ± 4	0.12 ± 0.24	60	100
		PHAFRE	2 ± 4	0.24 ± 0.49	122	100
TOTAL N/M2	122 ± 93	PHAVAL	6 ± 9	9.1 ± 7.5	1380 ± 773	100 ± 0
TOTAL G/M2	38 ± 32	SALAUS	50 ± 28	9.5 ± 7.4	287 ± 288	14 ± 19
AVG AVG WT/P	0.40 ± 0.25					

	$\bar{X}$ ± 2sem	SPECIES	n/m^2 ± 2sem	g/m^2 ± 2sem	wt/plant ± 2sem	%REPRO ± 2sem
PLOT YUF023N		BRORUB	8 ± 12	1.0 ± 1.3	158 ± 151	100 ± 0
DATE 5/5/92		CHEATR	2 ± 4	0.01 ± 0.02	4	0
%ROCK	12 ± 6	CHEINC	4 ± 8	1.1 ± 2.1	265	100
%LITTER	19 ± 15	ERIDEF	56 ± 66	2.2 ± 1.9	82 ± 84	0 ± 0
%COVER	18 ± 16	GILSIN	2 ± 4	0.4 ± 0.7	175	
%MOUND	10 ± 14	IPOPOL	2 ± 4	0.09 ± 0.17	43	100
PELLETS/M2	4 ± 6	MACCAN	4 ± 6	0.12 ± 0.18	30 ± 25	0 ± 0
		MENALB	4 ± 6	4.5 ± 8.5	1113 ± 2016	100 ± 0
TOTAL N/M2	398 ± 251	SALAUS	316 ± 200	19.7 ± 6.7	177 ± 117	0 ± 0
TOTAL G/M2	29 ± 11					
AVG AVG WT/P	0.20 ± 0.14					

	$\bar{X}$ ± 2sem	SPECIES	n/m² ± 2sem	g/m² ± 2sem	wt/plant ± 2sem	%REPRO ± 2sem
PLOT YUF023S		ASTLEN	2 ± 4	0.27 ± 0.53	133	0
DATE 5/04/92		BRORUB	2 ± 4	1.2 ± 2.4	609	100
%ROCK	10 ± 5	CHEINC	8 ± 9	1.6 ± 2.3	169 ± 112	100 ± 0
%LITTER	9 ± 10	SALAUS	316 ± 190	77 ± 22	420 ± 322	0 ± 0
%COVER	8 ± 2					
%MOUND	0.05 ± 0.10					
PELLETS/M2	12 ± 14					
TOTAL N/M2	328 ± 191					
TOTAL G/M2	80 ± 45					
AVG AVG WT/P	0.38 ± 0.25					

	$\bar{X}$ ± 2sem	SPECIES	n/m^2 ± 2sem	g/m^2 ± 2sem	wt/plant ± 2sem	%REPRO ± 2sem
PLOT YUF024		BRORUB	10 ± 8	1.6 ± 1.6	156 ± 118	100 ± 0
DATE 5/04/92		BROTEC	4 ± 6	0.5 ± 0.7	119 ± 52	100 ± 0
%ROCK	22 ± 8	CAMCLA	2 ± 4	0.2 ± 0.4	109	100
%LITTER	7 ± 6	CHEATR	54 ± 46	1.1 ± 1.1	19 ± 15	59 ± 33
%COVER	3 ± 3	CRYCIR	10 ± 16	0.5 ± 0.8	102 ± 159	100 ± 0
%MOUND	8 ± 10	CRYPTE	2 ± 4	0.17 ± 0.34	86	
PELLETS/M2	0 ± 0	ERIDEF	26 ± 40	2.8 ± 3.6	155 ± 98	0 ± 0
		ERIPRI	2 ± 4	0.23 ± 0.46	114	100
TOTAL N/M2	454 ± 200	GILFIL	6 ± 7	0.12 ± 0.14	20 ± 11	100 ± 0
TOTAL G/M2	47 ± 23	LANSCH	2 ± 4	0.10 ± 0.19	48	0
AVG AVG WT/P	0.10 ± 0.02	MACCAN	24 ± 15	1.1 ± 0.8	52 ± 34	22 ± 29
		MENALB	4 ± 6	0.6 ± 0.9	155 ± 114	100 ± 0
		SALAUS	308 ± 168	38 ± 23	141 ± 46	0 ± 0

STATUS OF REPTILE AND AMPHIBIAN POPULATIONS ON THE NEVADA TEST SITE, 1992

Bruce Douglas Woodward

ACKNOWLEDGEMENTS

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ABSTRACT

In 1992, lizard densities were examined on two baseline plots (YUF001, PAM001), and on three disturbed plots in subsidence craters and their three associated control plots (YUF019-24). The study focused on the side-blotched lizard, *Uta stansburiana*, which is common and widely distributed on the Nevada Test Site (NTS). *Uta* densities on baseline plots in 1992 fell within the range of *Uta* estimates in past years, implying numbers are remaining relatively constant.

PAM001 on Pahute Mesa and YUF001 on Yucca Flat are the two most studied plots. These plots have been through a complete predrought - drought - postdrought cycle over the last six years. Adult and juvenile *Uta* densities differed across the predrought, drought, and postdrought periods, and adult densities were on average higher on Pahute Mesa relative to Yucca Flat. The effect of drought on lizards was not consistent across the two plots. The drought had essentially no effect on average adult *Uta* densities on Yucca Flat, and was associated with an increase in density on Pahute Mesa. Densities of juvenile *Uta* were markedly lower during the drought. Adult and juvenile snout-vent lengths (SVLs), and weights also differed across sites and drought regimes. Drought effects on juvenile SVL were not consistent across sites and drought regimes, whereas differences between sites in adult SVLs were consistent across years. Adult *Uta* on Pahute Mesa were slightly longer but almost 20 percent heavier than adults on Yucca Flat. Adult *Uta* were approximately 15 percent heavier during the postdrought period relative to the predrought or drought periods. Weight/SVL, an estimate of leanness or body condition was higher for adults on Pahute Mesa than on Yucca Flat, and higher after the drought than before or during it. This implies that conditions may be harsher for lizards at low elevation sites, and during or prior to the drought. Juvenile *Uta* were 14 percent longer and 40 percent heavier on Pahute Mesa relative to those on Yucca Flat. Similarly, juvenile weight/SVL, an estimate of leanness, was 30 percent lower on Yucca Flat relative to Pahute Mesa. Juvenile *Uta* were about 5 percent shorter and 22 percent lighter during the drought relative to pre- or postdrought periods. Juvenile weight/SVL was about 8 percent lower during the drought relative to the periods before or after it. Finally, neither adult nor juvenile ages differed across sites or across drought regimes.

These results suggest two things. First, drought has a major effect on lizard traits and on lizard densities. Second, it implies that site specific factors

(potentially including prior history of human use, elevation, vegetative cover, etc.) can have large effects on how perturbations like drought events can influence lizards. This has implications for the spatial scale of monitoring programs on the NTS, in that it implies that a wide range of habitats should be monitored as organisms in different habitats may respond differently to perturbations.

Mark-recapture studies of *Uta* in subsidence craters suggest that adult densities were lower in 1992 relative to 1989 whereas juvenile densities appear to show a reversed pattern. A four way ANOVA reveals that spring and summer *Uta* populations are quite different with the summer population on average containing more, younger and smaller individuals relative to the spring population. This implies that perturbations in different seasons could lead to markedly different effects on a *Uta* population.

Our three measures of adult body size (SVL, weight, weight/SVL) all differed across years with larger lizards present in 1992 (a normal precipitation year) relative to 1989 (a drought year). The pattern was not consistent across treatments with differences across years more exaggerated in subsidence craters relative to control plots, suggesting that the craters were amplifying the drought effects. Juvenile weight and juvenile weight/SVL also were higher in 1992 relative to 1989. Both sets of differences imply that the drought in 1989 was hard on *Uta*.

Adult *Uta* on the control plots were approximately 10 percent heavier than adult *Uta* in subsidence craters; this relatively large difference was marginally nonsignificant. The number of juveniles on the control plots was also nonsignificantly greater than those in the subsidence craters. Finally, adult weight/SVL was almost 15 percent greater for *Uta* on control plots as opposed to individuals in the subsidence craters. The subsidence crater results suggest that crater formation may have a negative effect on *Uta*, and that the effect is approximately as large as that imposed by drought.

INTRODUCTION

Populations in nature undergo constant flux, alternatively increasing or decreasing in size (Pianka 1986, Polis 1991, Vitt 1991, Wiens 1991, Hunter 1992). Biology is largely concerned with revealing patterns from this flux. Four types of factors can cause population fluctuations: chance events, physical factors, nonhuman biological factors, and human factors. The mission of the Department of Energy's BECAMP program is to maintain an understanding of changes over time of flora and fauna on the NTS. Understanding these changes is not a simple process because organisms on the test site are simultaneously exposed to all four types of factors. As such, changes observed on site, such as population decline, could be due to human activities, but this need not be so. This confounding, or confusion of causes is the driving force behind BECAMP methods.

Because of confounding, BECAMP performs two types of studies: those physically isolated from current disturbances (BECAMP's baseline plots), and those purposefully placed in physical association with these disturbances (disturbance plots). The former are designed to examine long term changes on site, the latter to enable us to remove those changes due to specific effects (biological factors, physical factors, road construction, subsidence events, etc.).

Bomb testing is a complex activity which involves many people, much equipment, and considerable support activities. As a consequence, DOE activities on site have many potential ramifications for plants and animals. Examples include direct effects like long term actions of fallout or effects of roads, as well as less obvious (but potentially important) factors like increased predator populations in association with NTS dump sites. BECAMP has both long and short term projects in progress in order to examine these factors and distinguish man-induced effects on flora and fauna from the underlying physical and biological effects (Hunter 1992, Hunter and Medica 1989).

Documenting population change is a difficult task. Four characteristics of each population influence the direction of this change: immigration (migration in), emigration (migration out), birth rate (a measure of average number of young produced), and death rate (probability of the average individual dying). These population characteristics are in turn influenced by characteristics of individuals. As examples, larger individuals usually produce more young than smaller ones, and old animals are typically more likely to die than younger ones. Man's potential influence on populations and thus our necessity for monitoring them, occurs because our activities somehow influence the reproductive rates (birth rates), probability of survival (death rates), or migration patterns (immigration or emigration) of individuals. As a consequence, these attributes of individuals are central to BECAMP's monitoring program.

Monitoring population changes involves sampling in succeeding time intervals. Monitoring programs enable us to tell if the numbers of individuals of a given species are staying relatively constant, increasing, or declining. Interpretation of these patterns of population change is fraught with the problems of confounding of causes, and sampling variation (sampling error). BECAMP's monitoring program is designed to surmount these problems. In the following pages we discuss the ongoing program for reptiles and amphibians. We present data summaries for 1992, and draw conclusions where subsets of the program have reached fruition.

Reptile studies were centered on lizards, because this group is the most abundant, and thus easiest of the reptiles and amphibians to study. Lizards form a conspicuous part of the NTS desert fauna (Tanner and Jorgensen 1963, Pianka 1986, Hunter and Medica 1989). They are important in this system as major consumers of invertebrates, and as an important prey base for many mammals, birds and snakes (Pianka 1986). Lizards are also potentially useful for BECAMP monitoring purposes because they are strongly influenced by radiation (Turner et al. 1973, Turner and Medica 1977).

In 1992, lizards were monitored on baseline plots on Pahute Mesa and Yucca Flat and also studied in subsidence craters and their associated control plots. Goals were two fold, to continue to look for long term changes in lizard populations, and to directly examine shorter term impacts of human activities. We comment on other species, but focus on *Uta stansburiana* (the side-blotched lizard) because it is found essentially everywhere on the NTS and it is abundant enough that meaningful use can be made of these data.

METHODS

Lizards were sampled in one of two ways, either by surveying transects or plots. The basic sampling technique (Medica 1992) was for two or more investigators to walk across an area and capture all lizards they encountered. The lizards were marked with paint, individually numbered by toe clipping, measured, weighed and released. The same plot was resampled for three to six (more or less) consecutive days. On resampling trips, painted individuals were recorded as present (and considered recaptured), and unmarked individuals were captured and processed as noted. For each captured lizard we recorded species identification, sex, snout-vent length to nearest mm (a measure of body size), tail length to nearest mm, body mass to nearest 0.05 g, and age to nearest month. Females were palpitated to estimate number and size of egg follicles or eggs. Means and se (standard error of the mean) were computed for each of these lizard traits on all plots studied. In 1992, lizards were monitored for 6 days from 30 March to 7 April, and for 5 days from 27 to 31 July, on a 1.1 ha square plot on Yucca Flat (YUF001), and for 4 days from 4 to 11 May and for 5 days from 24 to 31 August on a 1.1 ha square plot on Pahute Mesa (PAM001). Lizard plots and transects are nested inside the small mammal grids. Detailed site locations can be found in Appendix B of Saethre (1993). The data were used in several ways. Counts of number of individuals captured or recaptured were used in mark-recapture estimation techniques (Seber 1982) to describe *Uta* densities on each plot. Although other lizard species were present, their numbers were too small to allow a meaningful density estimate. This was the fifth and sixth years of study on these plots, and it was now possible to ask how several biological or physical factors might influence *Uta* densities or traits of individuals. A major physical factor, precipitation, had varied sharply over this sampling period with two years of relatively normal precipitation (1987 - 1988), followed by two drought years (1989 - 1990), and ending with two relatively normal years (1991 - 1992). The two sites used in the analysis, Yucca Flat (elevation 1237 m, *Lycium-Grayia* community, located within 2 km of both above and below ground atomic blasts), and Pahute Mesa (1923 m elevation, *Artemisia* dominated area, located approximately 2 km from below ground tests), are quite different. We ran a crossed analysis of variance test (two study sites x three drought periods) to ask if location of a *Uta* population, or precipitation regime could influence *Uta*. Variables examined were number present per date, mean SVL per date, mean weight per date, mean age per date, and mean weight per date/mean SVL per date (an estimate of relative health). Data were analyzed separately for juvenile (= < 7 months old) and adult lizards.

Subsidence Craters

In 1992, three 0.56 ha square plots in three subsidence craters (YUF019, YUF021, YUF023) and their three respective (YUF020, YUF022, YUF024) 0.56 ha controls were monitored. Each plot was sampled for 3 to 5 days between 13

April to 1 May or from 3 to 20 August. The purpose in collecting these data was to examine the effect of land subsidence and crater formation on plants and animals. Craters form after underground nuclear blasts. These three craters occur on Yucca Flat, are 25, 16, and 23 m deep, 393, 398, and 347 m wide, and 30, 15, and 26 years old. Although these craters are older than most, they are well within the range of depths and breadths of subsidence craters on the NTS. Study plots were first sampled in these craters and their associated controls from 4 to 28 April 1989 and 27 July to 18 August 1989. A crossed ANOVA with location, treatment (=crater or control), season, and date as factors was performed. The following *Uta* traits were examined: number present per date, mean SVL per date, mean weight per date, mean age per date, and mean weight per date/mean SVL per date. This approach separates variation in *Uta* traits into four components: location, season, treatment (in crater or on adjoining control plot) and year. Treatment and year are the main factors of interest as they ask if the craters influence *Uta* traits, or if differences in traits occur between 1989 (a drought year) and 1992 (a year of normal precipitation). The location-factor is used to pool the data into three groupings each representing data collected from one crater and its nearby control. One aspect of the location-effect would therefore be due to spatial differences across Yucca Flat. A second aspect of the location-effect is temporal changes. Lizard studies take several days to complete on each plot. The lizard data were collected over 25 days in spring 1989, 23 days in summer 1989, 19 days in spring 1992, and 18 days in summer 1992. Eighteen to 25 days is a long enough time frame that many *Uta* traits could change over this span. The temporal and spatial aspects of the location factor are confounded. Location is included as a factor to remove these sources of variation and allow us a better look at effects due to treatment (our primary interest).

Season was included as a factor for two reasons. First, to get a feel for how different *Uta* populations can be during the spring and summer. Second, to see if any effects of the subsidence craters on *Uta* were similar across the seasons. This latter effect can be examined by testing for a significant treatment x season interaction. The year x treatment interaction was also examined, to see if the effects of crater formation on lizard traits were similar in a drought and a normal precipitation year.

Transect Sampling

Transect sampling yields relative density estimates for those species that are too uncommon to generate a reliable estimate from mark-recapture studies. The technique is especially appropriate for highly mobile species, and species that are difficult to capture. Five, 500 m long transects were walked on PAM001 on Pahute Mesa from 8 - 12 June 1992, and on YUF001 on Yucca Flat from 1 - 5 June 1992. Each transect was 100 m from its closest neighbor (see Medica 1992 for plot layout). Three people walked abreast approximately 7.5 m apart and visually searched an area about 22.5 m wide. Thus each transect represents 22.5 x 500 m or 1.125 ha. Each lizard was identified to species and described as a juvenile or an adult. Care was maintained not to double count any lizards. Transects were searched at a brisk pace and took 10 to 15 minutes apiece. Mean values were calculated for each plot and are expressed on a per hectare basis.

Tortoise Sampling

Tortoises were sampled in Rock Valley enclosures in spring and fall 1993. These are three 341 m diameter circular enclosures. Marked tortoises have been examined annually in these enclosures since 1962 (see history of Rock Valley tortoise studies in Saethre and Medica 1993). Tortoises were captured, weighed, measured (plastron and carapace lengths), and released. In addition to the Rock Valley work, opportunistic tortoise sightings were recorded for other areas of the NTS.

Incidental Sightings

BECAMP personnel travel extensively across the NTS. Any unusual reptiles or amphibians encountered were recorded.

RESULTS

Mean densities estimated via mark-recapture techniques (Seber 1982) for either baseline plot (YUF001 or PAM001) fell within historical standard errors of the means (Tables 1, 2), implying that densities fell within prior norms.

An examination of variation in number of *Uta* or adult *Uta* traits revealed sizeable variation attributable to year to year and site to site differences.

Table 1. Estimated densities (n/ha, 2 se (= standard error of the mean), and numbers of distinct *Uta stansburiana* captured in summer on the YUF001 baseline plot on Yucca Flat.

	Adults				Juveniles			
Year	Male	Female	Total	Density	Male	Female	Total	Density
1987	16	17	33	33, 6	57	56	113	123, 18
1988	17	19	36	41, 13	39	29	68	101, 34
1989	24	33	57	77, 26	5	5	10	11, 5
1990	9	12	21	22, 7	19	19	38	51, 24
1991	16	9	25	32, 12	53	49	102	121, 25
1992	33	27	60	70, 16	100	88	188	268, 53

Table 2. Estimated densities (n/ha, 2 se), and numbers of distinct *Uta stansburiana* captured in late summer on the PAM001 baseline plot on Pahute Mesa.

	Adults				Juveniles			
Year	Male	Female	Total	Density	Male	Female	Total	Density
1988	8	16	24	28, 11	62	55	117	142, 28
1989	43	38	81	83, 15	33	37	70	80, 19
1990	51	42	93	93, 8	40	56	96	97, 10
1991	52	23	75	80, 12	31	38	69	72, 11
1992	15	29	34	38, 9	60	37	97	122, 27

Site Differences

Over the 1987 to 1992 sampling period there were significantly more adult *Uta* present per year on the Pahute Mesa site ($F = 21.7$, 1, 49 d.f., $p < 0.0001$) than on the Yucca Flat site, demonstrating sizeable spatial variation in lizard densities (Figs. 1, 2). Juvenile *Uta* also were more abundant on Pahute Mesa ($F = 12.5$, 1, 49 d.f., $p < 0.001$, Figs. 3, 4). Average adult SVLs differed across sites ($F = 37.2$, 1, 48 d.f., $p < 0.0001$, Figs. 5, 6) as did adult weights ($F = 64.5$, 1, 48 d.f., $p < 0.001$, Figs. 7, 8), and weight/SVL, an index of leanness ($F = 42.0$, 1, 48 d.f., $p < 0.0001$, Figs. 9, 10). Adult SVLs were about four percent greater on Pahute Mesa relative to Yucca Flat, while weights on Pahute Mesa were almost 20 percent heavier than on Yucca

Flat. Yucca Flat *Uta* also tended to be leaner (lower weight/SVL values) than those on Pahute Mesa. Results for juvenile *Uta* were quite similar with Pahute Mesa juveniles being 14 percent longer ($F = 56.4$, 1, 48 d.f., $p < 0.0001$, Figs. 11, 12), 40 percent heavier ($F = 64.6$, 1, 48 d.f., $p < 0.0001$, Figs. 13, 14), and 30 percent fatter (higher weight/SVL values, $F = 63.1$, 1, 48 d.f., $p < 0.001$, Figs. 15, 16) relative to juveniles on Yucca Flat. Ages of adults ($F = 1.6$, 1, 48 d.f., $p = 0.21$, Figs. 17, 18) or juveniles ($F = 3.25$, 1, 48 d.f., $p = 0.08$, Figs. 19, 20) did not differ across sites.

Precipitation Differences

Adult *Uta* densities varied across drought periods ($F = 18.7$, 2, 49 d.f., $p < 0.0001$, Figs. 1, 2) and there was a significant interaction term ($F = 17.4$, 2, 49 d.f., $p < 0.0001$) implying that densities on the two plots did not shift in a similar manner across drought periods. On Pahute Mesa adult densities started out low, increased 400 % during the drought, and dropped to about 200 percent of initial densities after the drought. On Yucca Flat adult densities remained essentially constant over the whole study period. Juvenile *Uta* densities also differed across drought periods ($F = 19.6$, 2, 49 d.f., $p < 0.0001$, Figs. 3, 4) and exhibited a significant interaction between site and drought regime ($F = 15.8$, 2, 49 d.f., $p < 0.0001$, Figs. 3, 4). Number of juveniles on Yucca Flat dropped 72 percent during the drought, then rose to 168 percent of initial density during the postdrought period. On Pahute Mesa, on the other hand, juvenile density dropped 25 percent during the drought and remained at that level during the postdrought period.

Average adult SVLs differed across drought periods ($F = 6.0$, 2, 48 d.f., $p < 0.005$, Figs. 5, 6). Juvenile results were similar (Figs. 11, 12, $F = 12.7$, 2, 48 d.f., $p < 0.0001$) except there was a significant interaction between drought period and site ($F = 5.03$, 2, 48 d.f., $p = 0.02$) suggesting that differences across sites did not remain similar across drought periods. Variation in adult SVL was quite small, only around 1 percent across the drought periods. Juveniles were more strongly affected with a five percent decrease in SVL during the drought. Juvenile SVLs on Yucca Flat increased after the drought, while those for Pahute Mesa lingered at drought levels.

Patterns for body weight were similar to those for SVL, with adults experiencing differences across drought periods ($F = 13.4$, 2, 48 d.f., $p < 0.0001$, Figs. 7, 8), with no significant interaction term, while juveniles also exhibited differences across drought periods ($F = 13.1$, 2, 48 d.f., $p <$

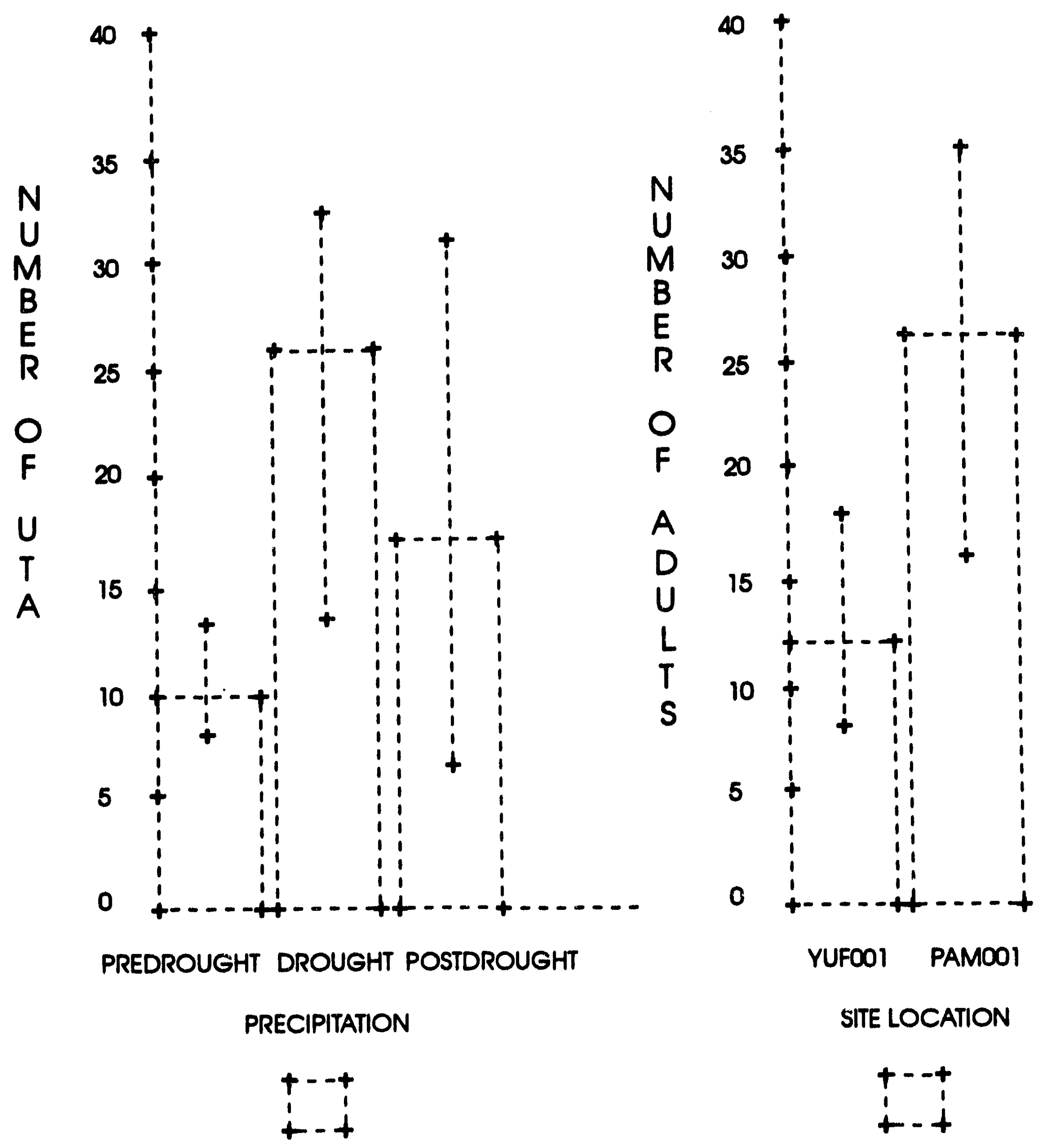

Figure 1 - Number of adult *Uta* compared across sites or across precipitation regimes. Mean ± 2 se in all figures.

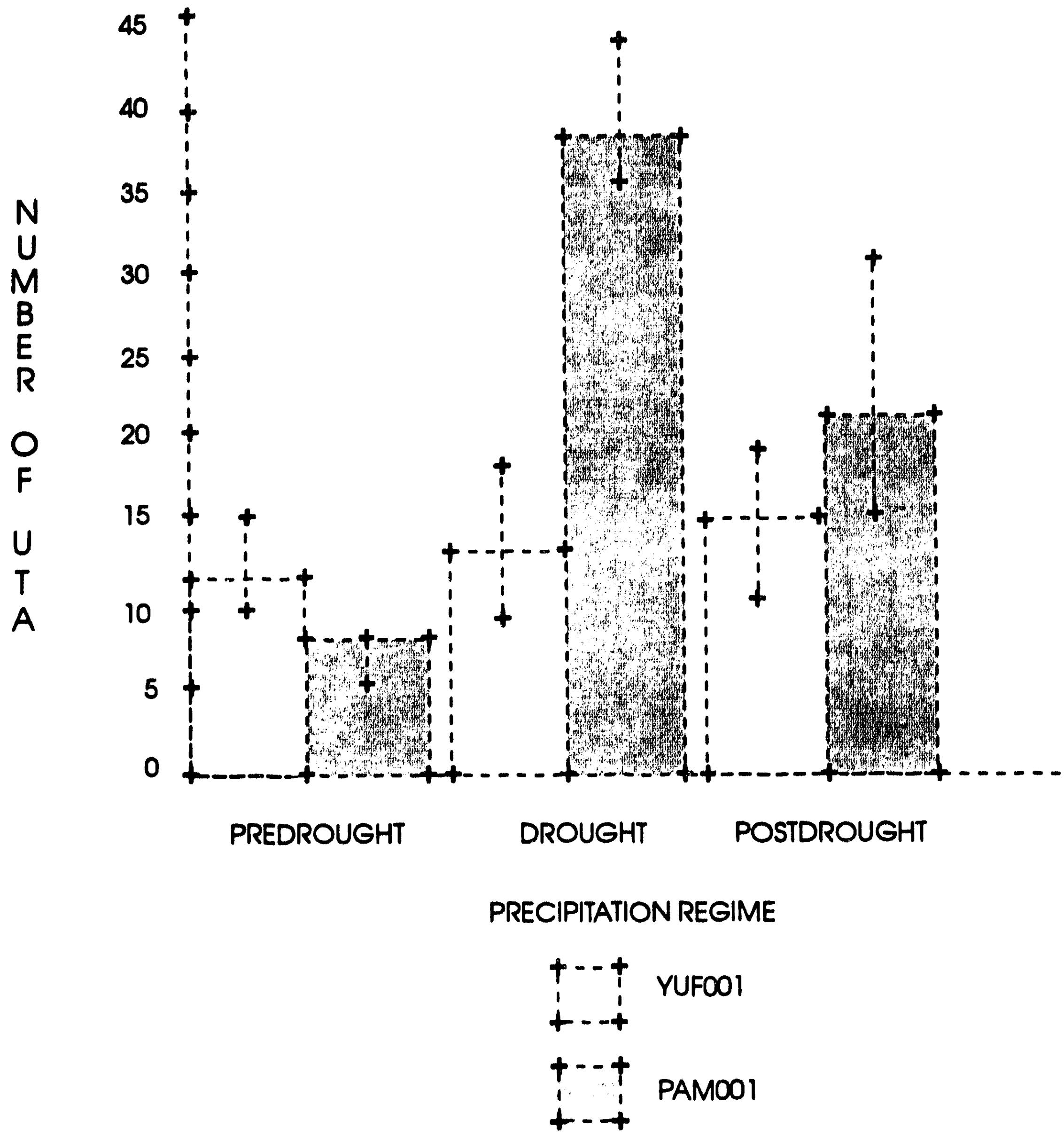

Figure 2 - Number of adult *Uta* observed on YUF001 and PAM001 across precipitation regimes.

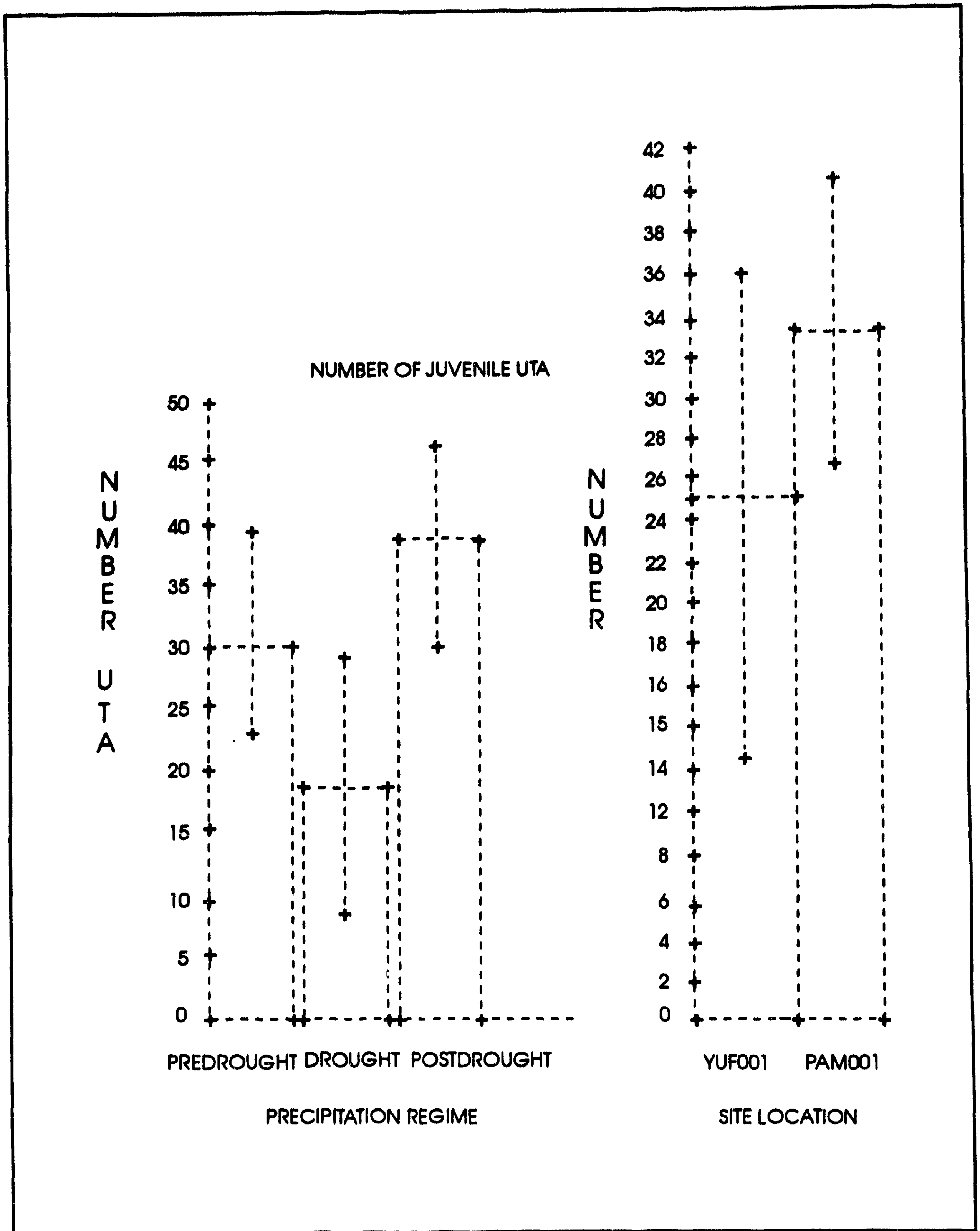

Figure 3 - Number of juvenile *Uta* compared across two plots or across three precipitation regimes.

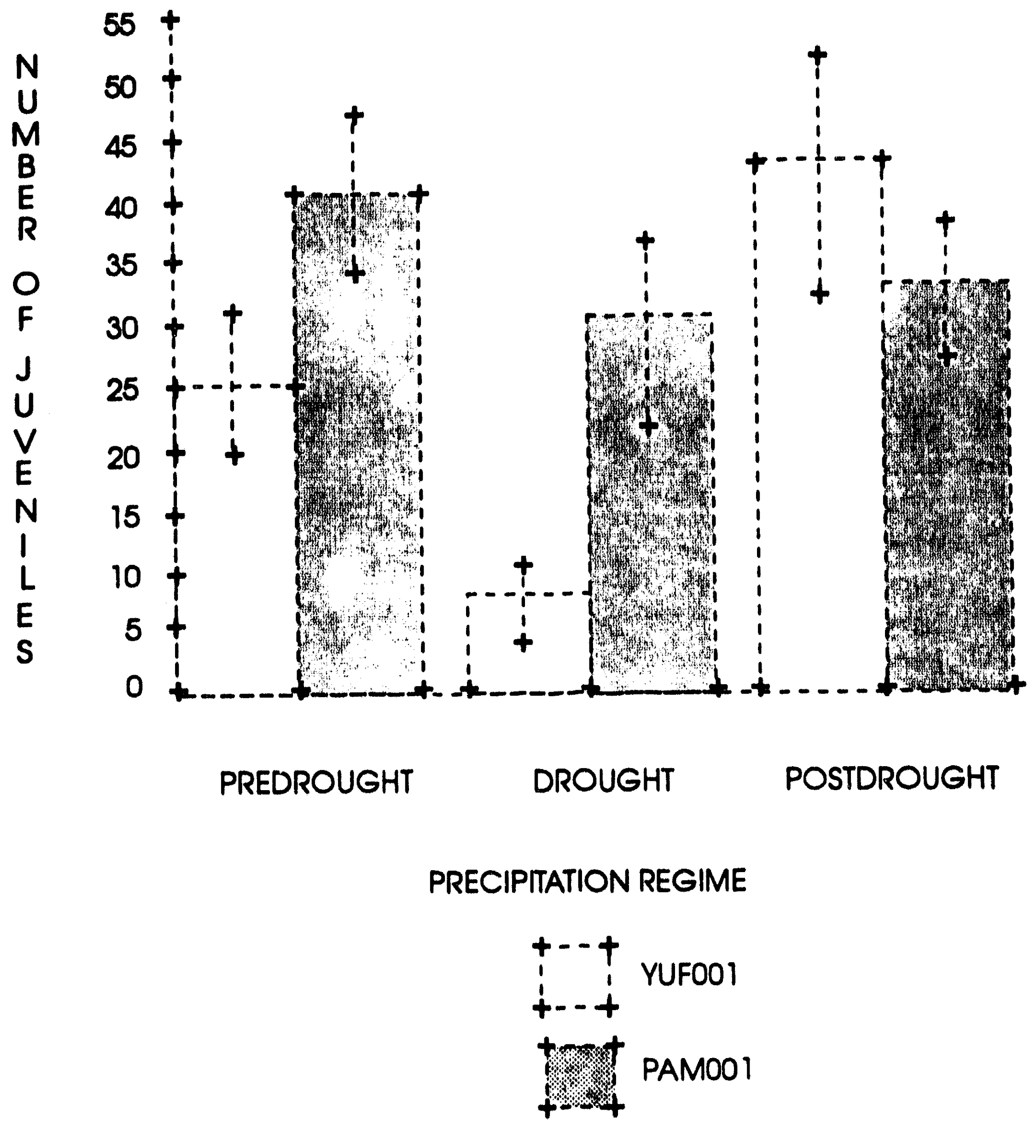

Figure 4 - Number of juvenile *Uta* present on YUF001 and PAM001 across three precipitation regimes.

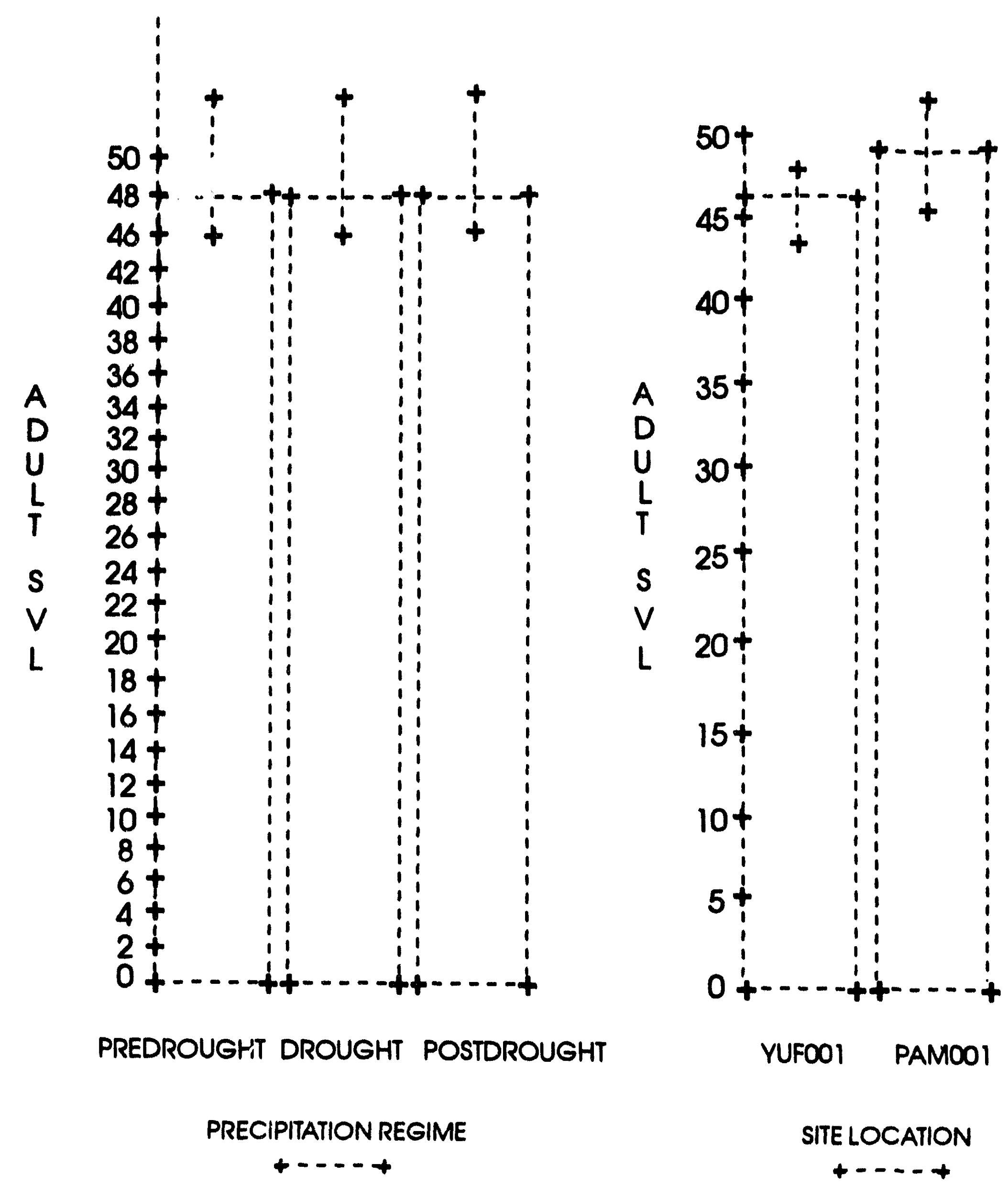

Figure 5 - Adult SVL compared across sites and across precipitation regimes.

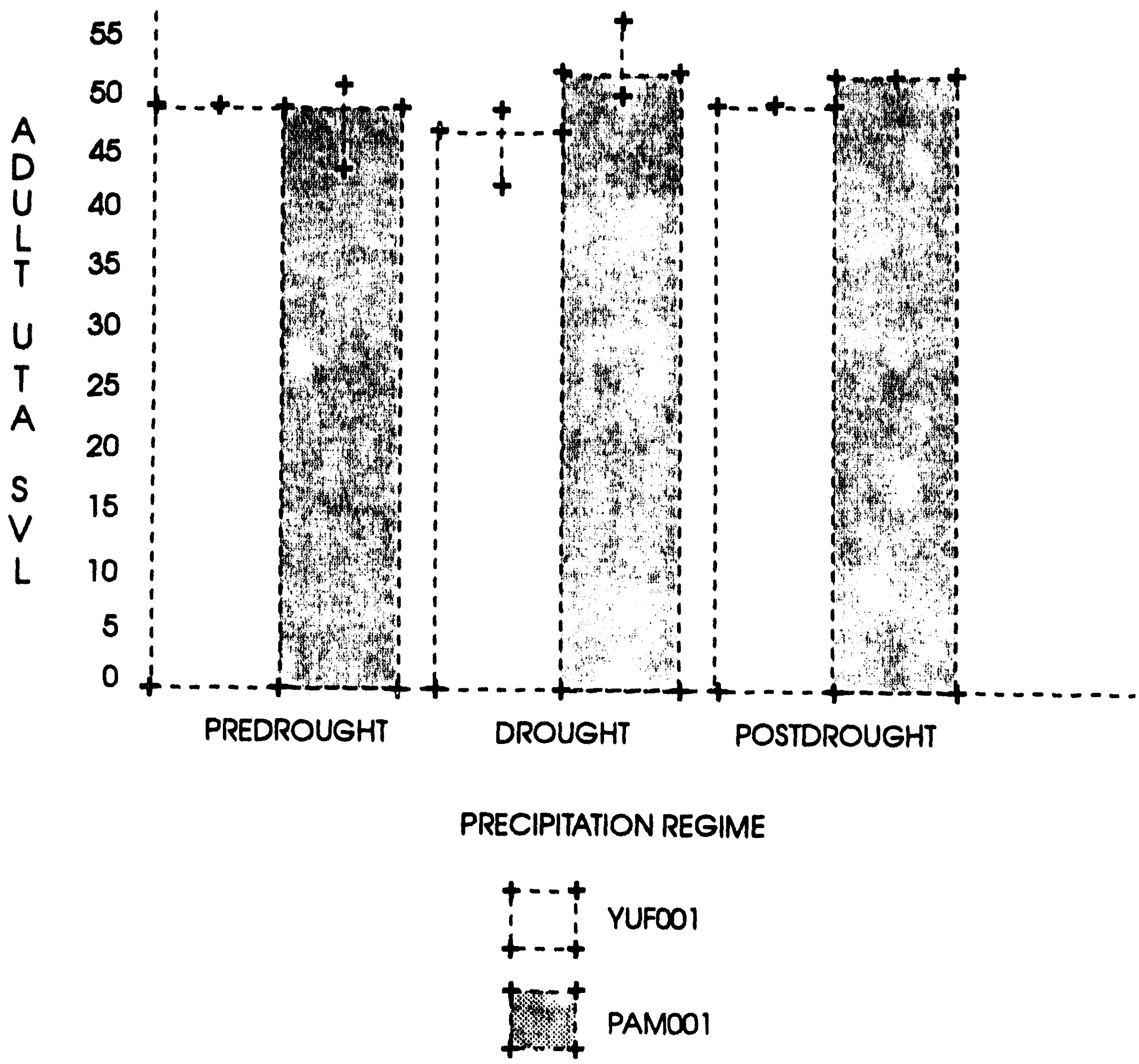

Figure 6 - Adult SVL of *Uta* on YUF001 and PAM001 across precipitation regimes.

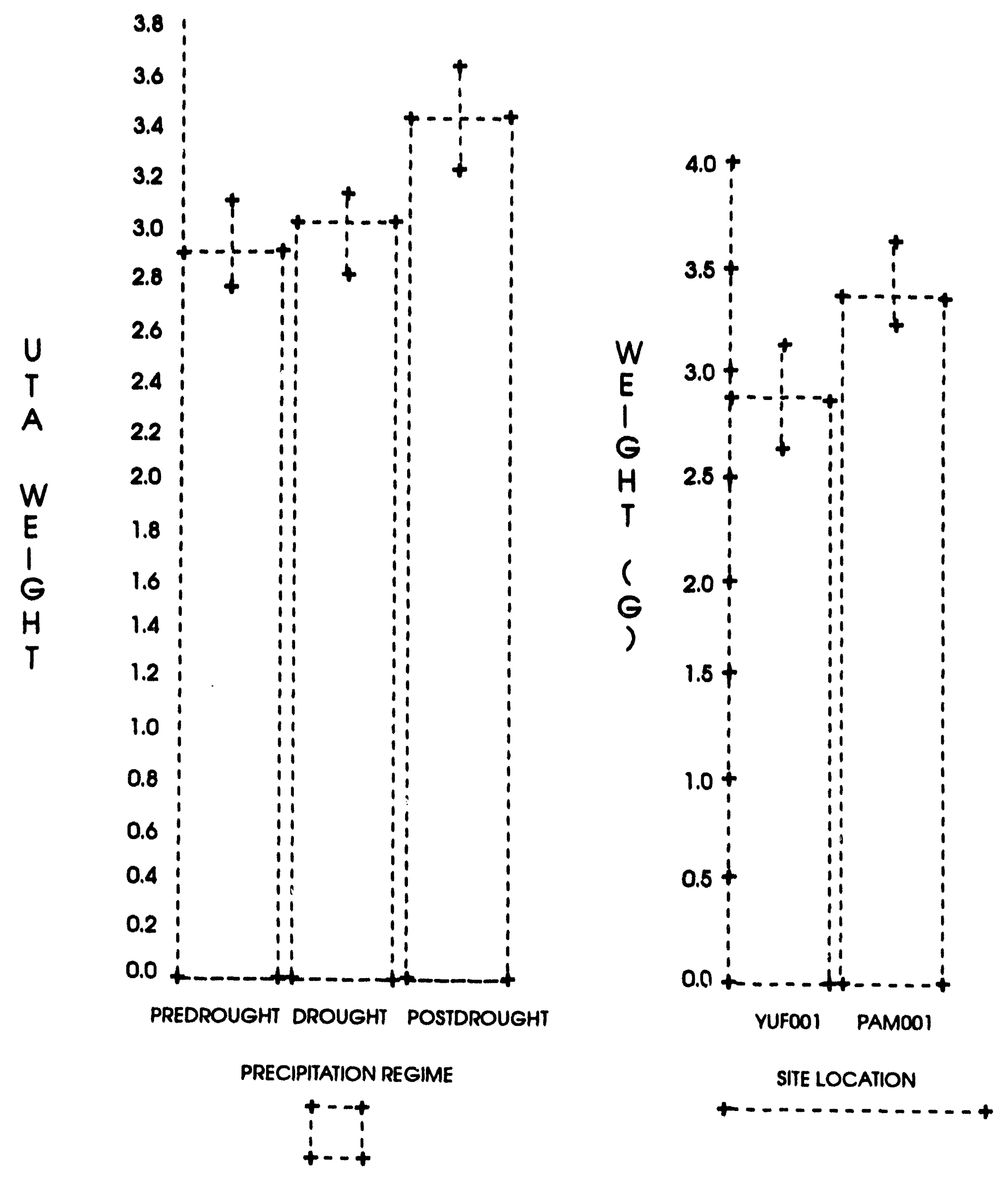

Figure 7 - Adult *Uta* weight (g) compared across sites and across precipitation regimes.

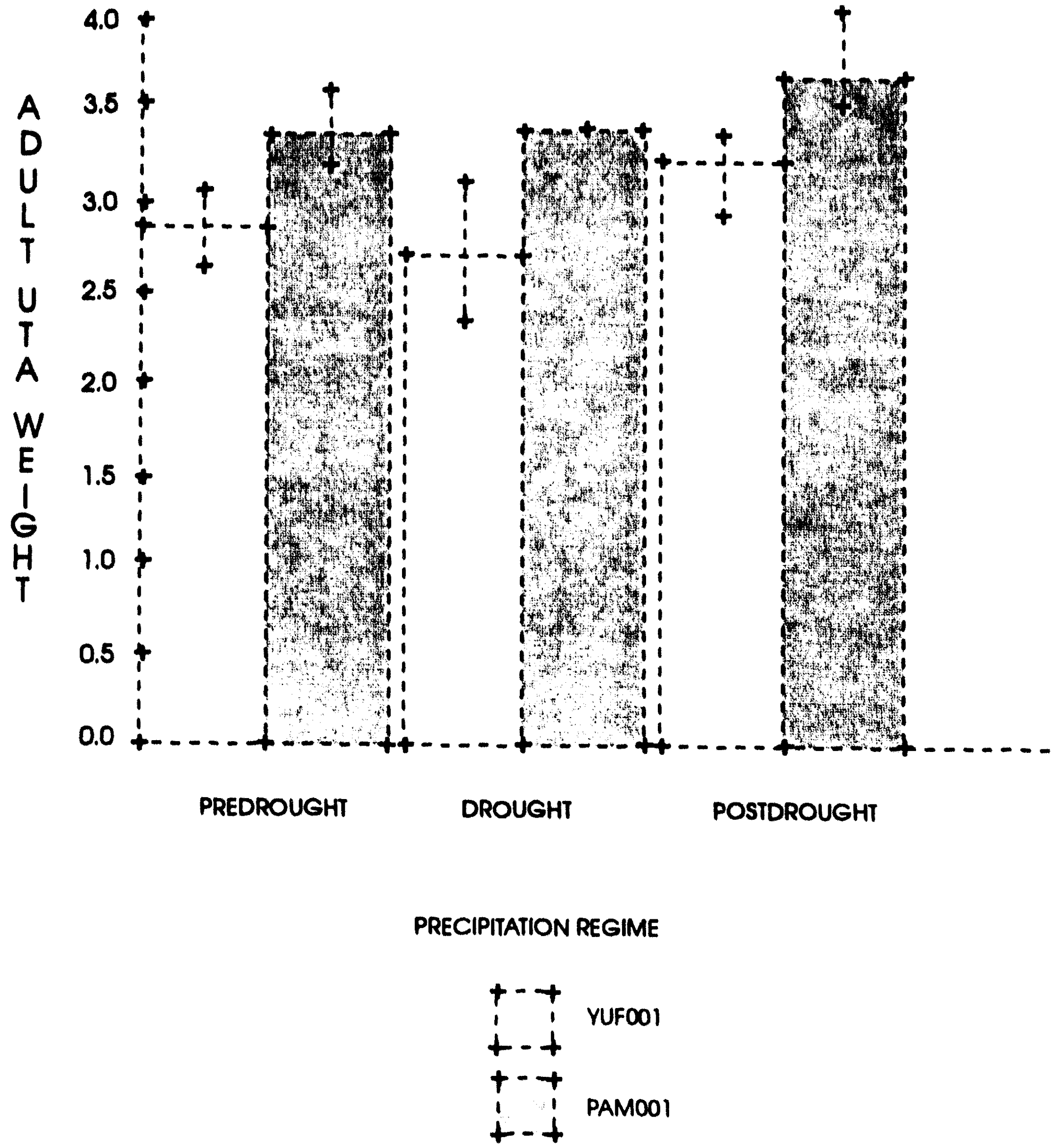

Figure 8 - Adult *Uta* weight (g) for YUF001 and PAM001 across precipitation regimes.

2 of 4

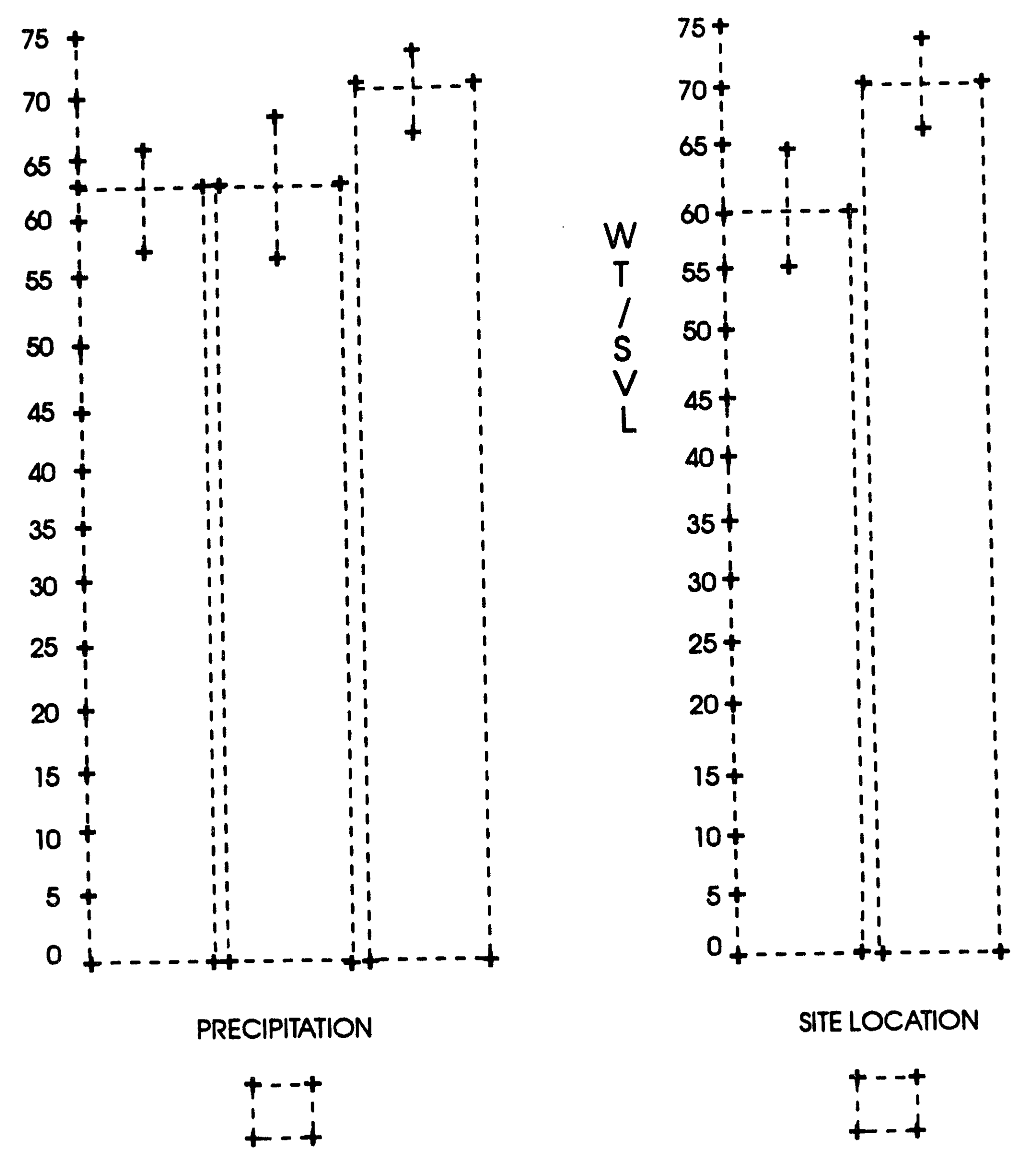

Figure 9 - Adult *Uta* leanness (weight/SVL x 1000 in g/mm) compared across sites and across precipitation regimes.

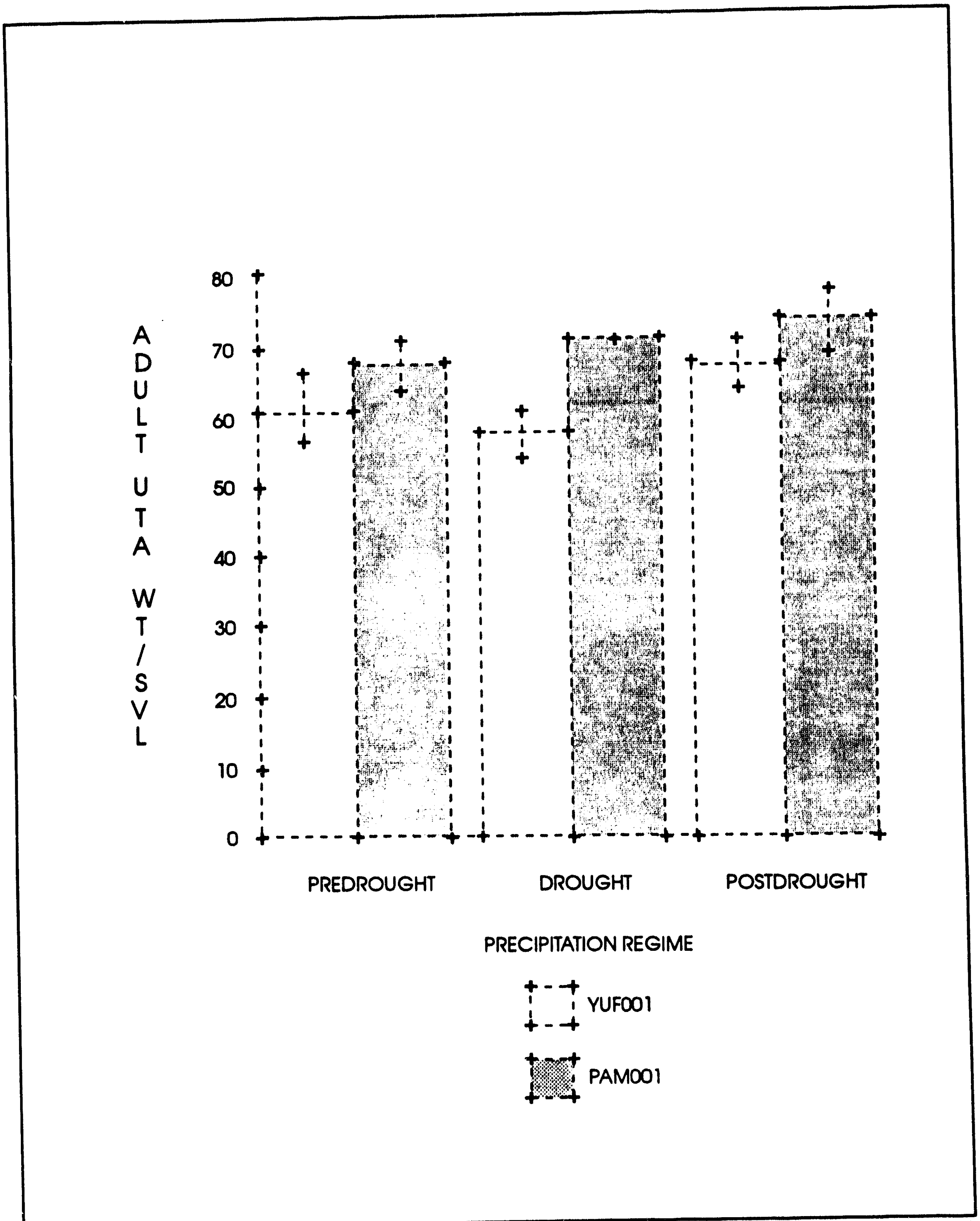

Figure 10 - Adult *Uta* leanness (weight/SVL x 1000 in g/mm) for YUF001 and PAM001 across precipitation regimes.

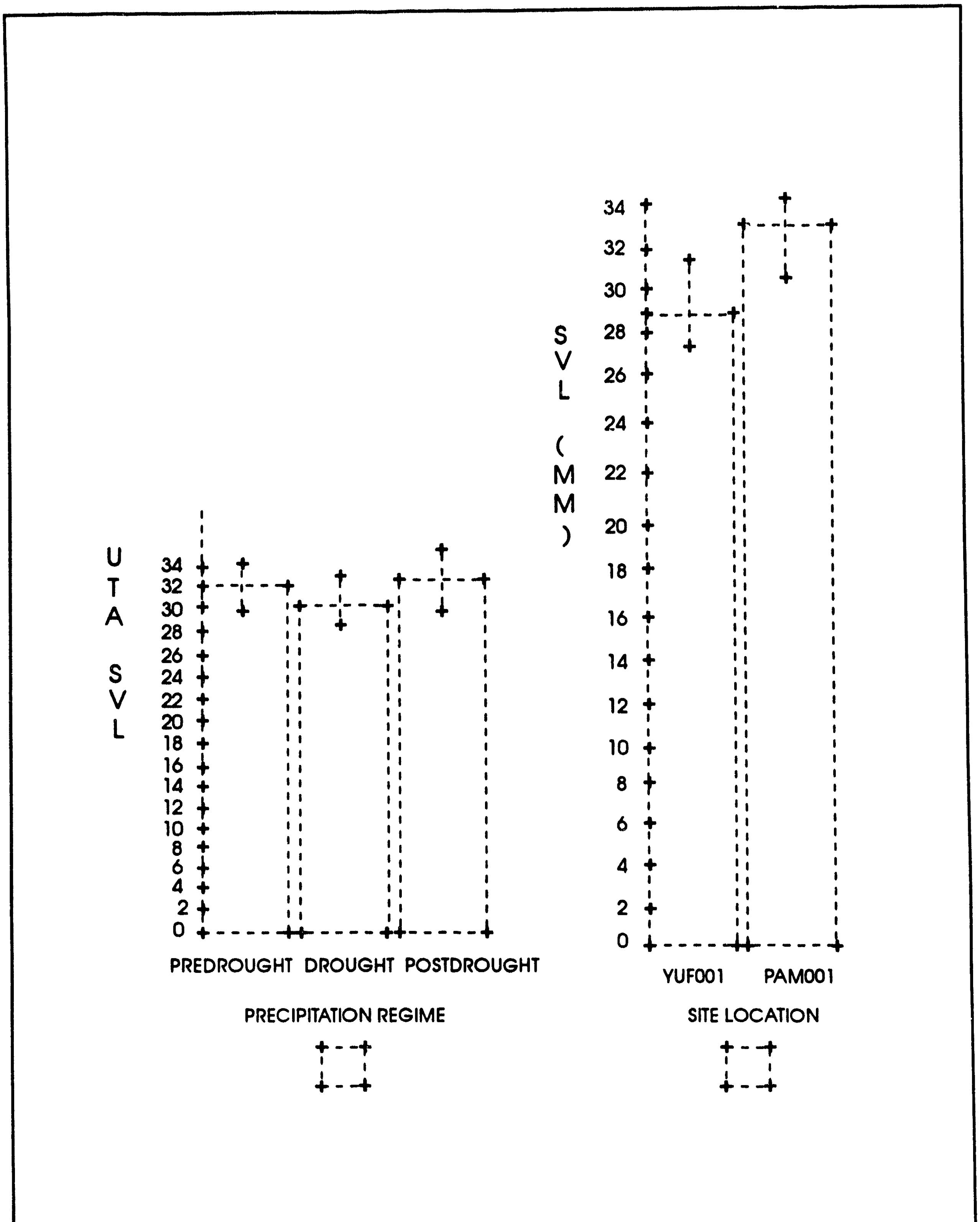

Figure 11 - Juvenile *Uta* SVL (mm) compared across sites and across precipitation regimes.

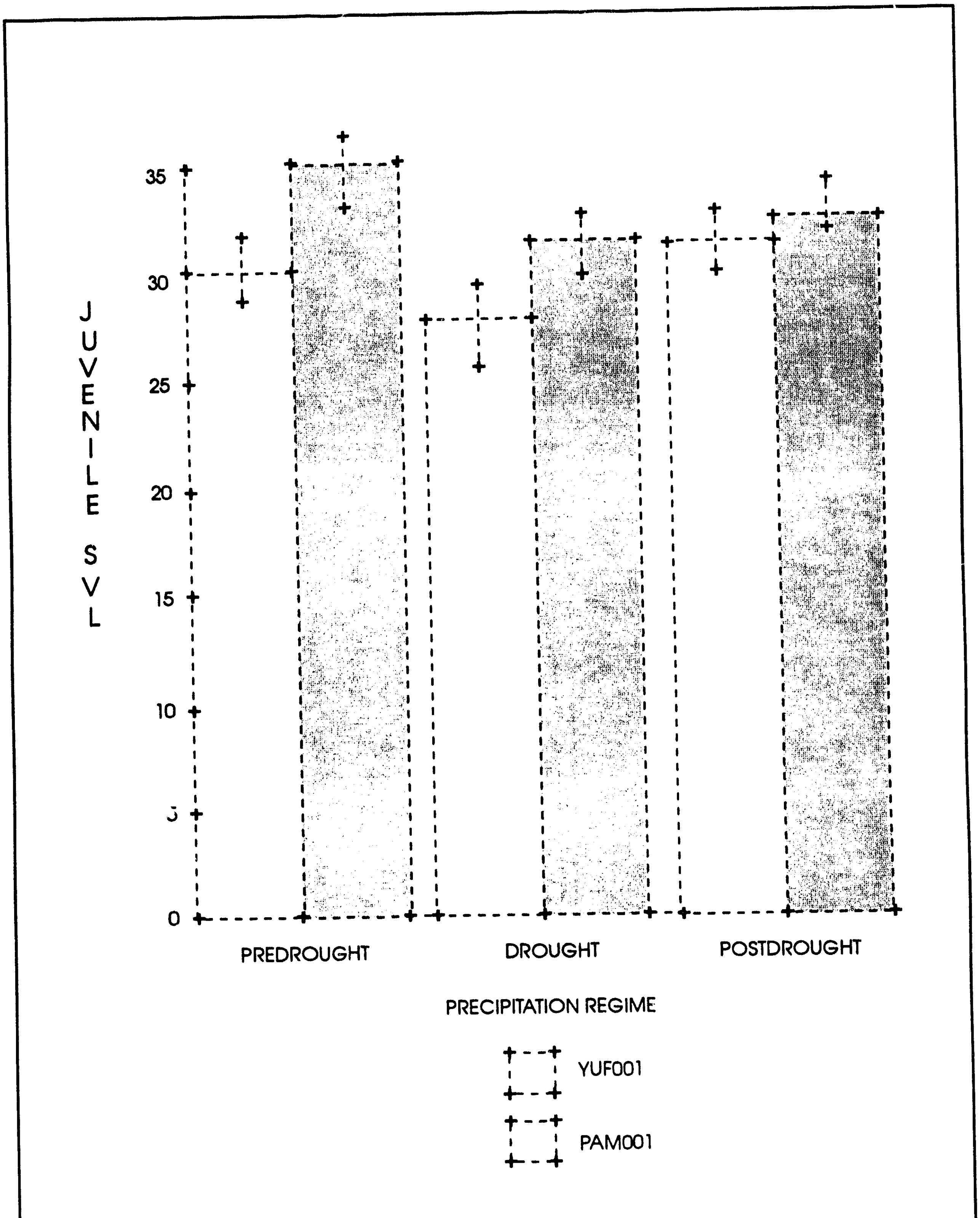

Figure 12 - Juvenile *Uta* SVL (mm) for YUF001 and PAM001 across precipitation regimes.

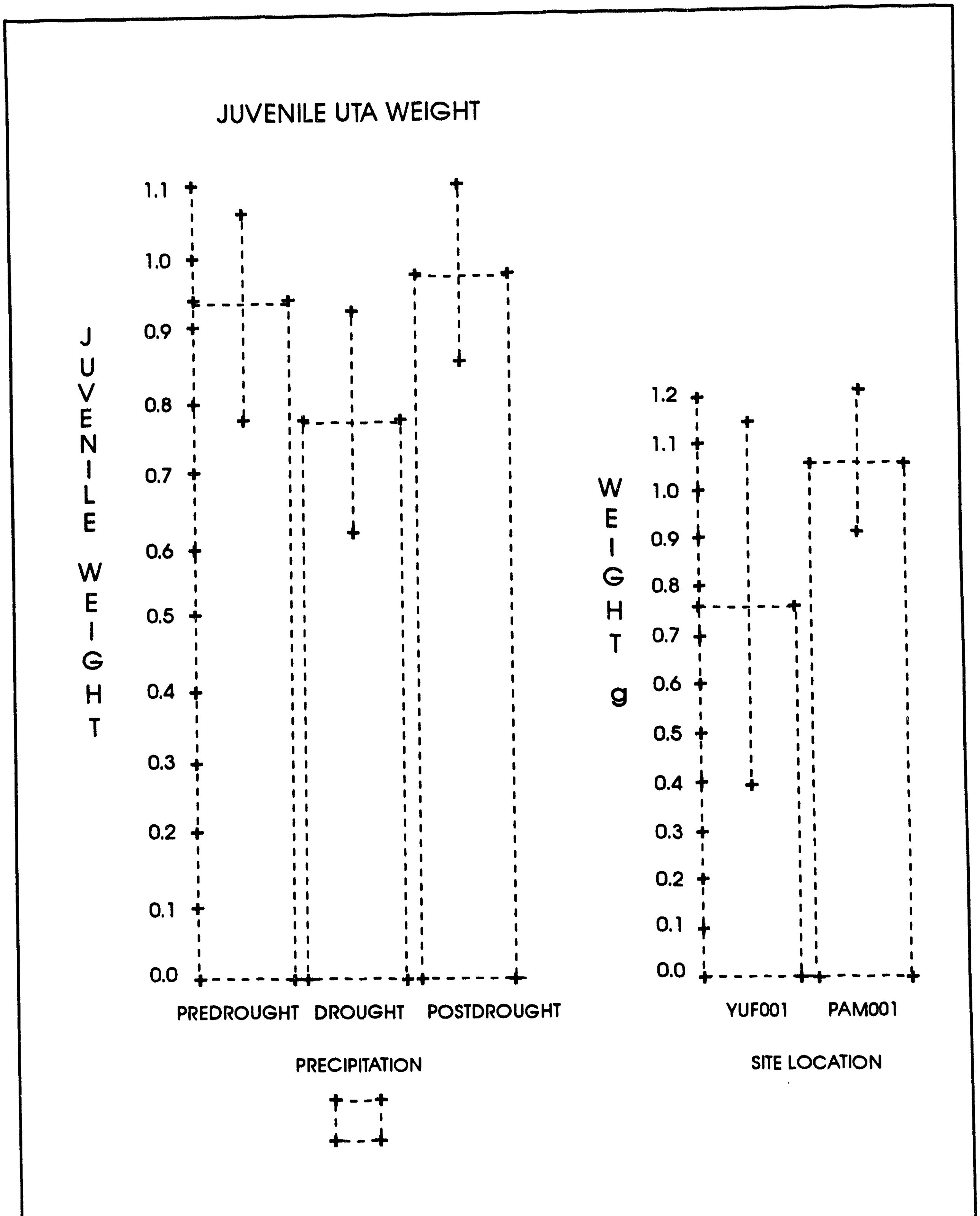

Figure 13 - Juvenile *Uta* weight (g) compared across sites and across precipitation regimes.

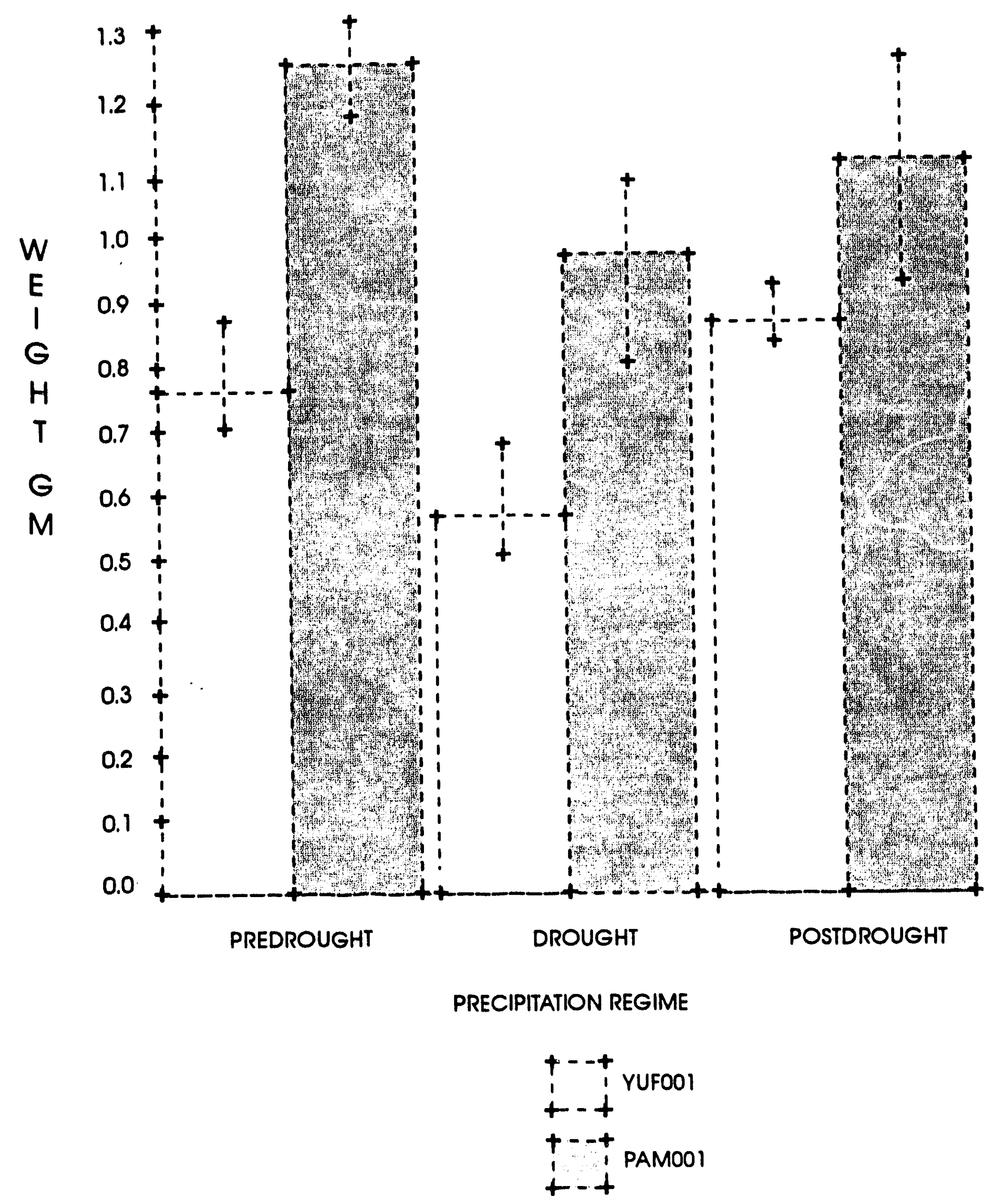

Figure 14 - Juvenile *Uta* weight (g) for YUF001 and PAM001 across precipitation regimes.

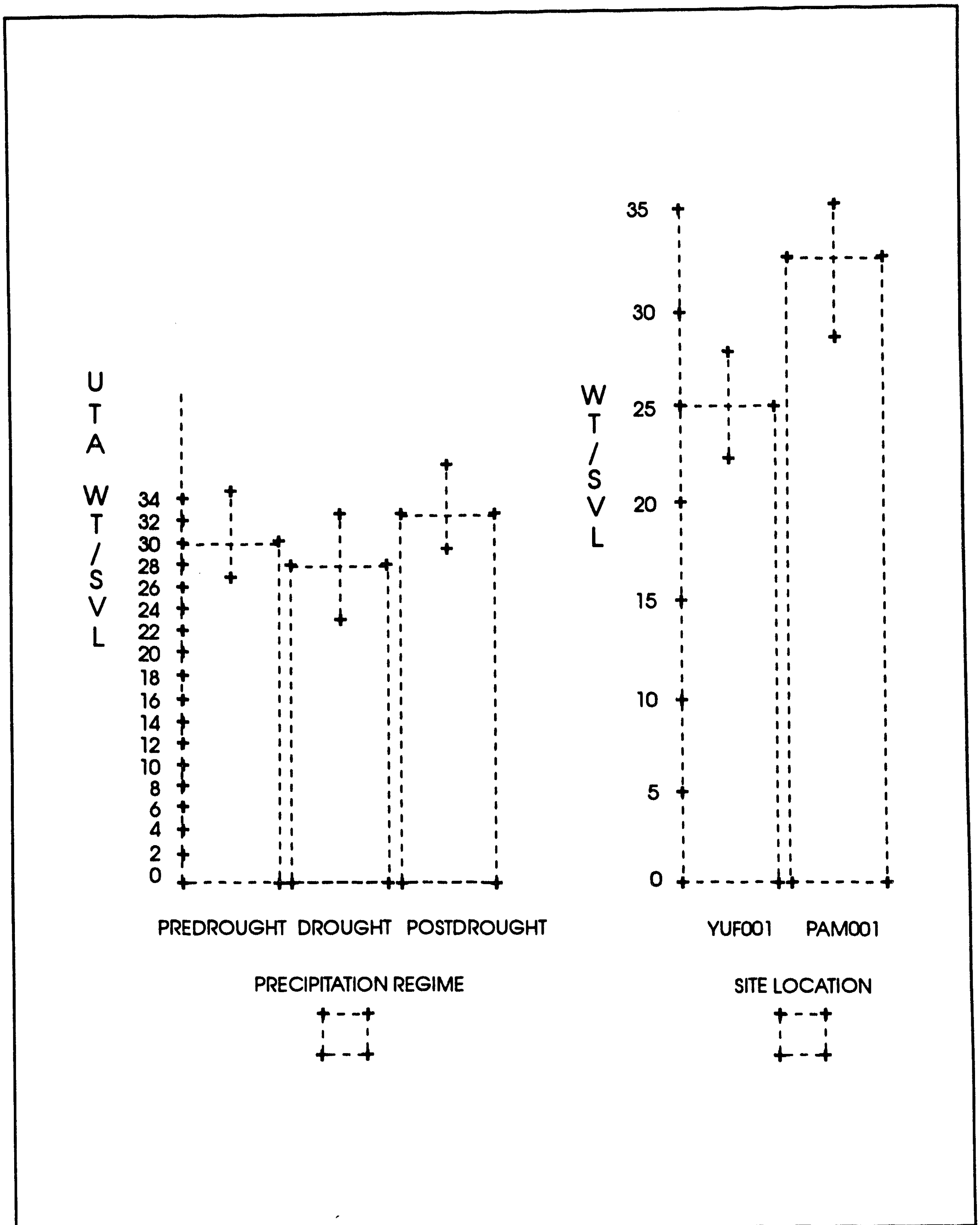

Figure 15 - Juvenile *Uta* leanness (weight/SVL x 1000 in g/mm compared across sites and across precipitation regimes.

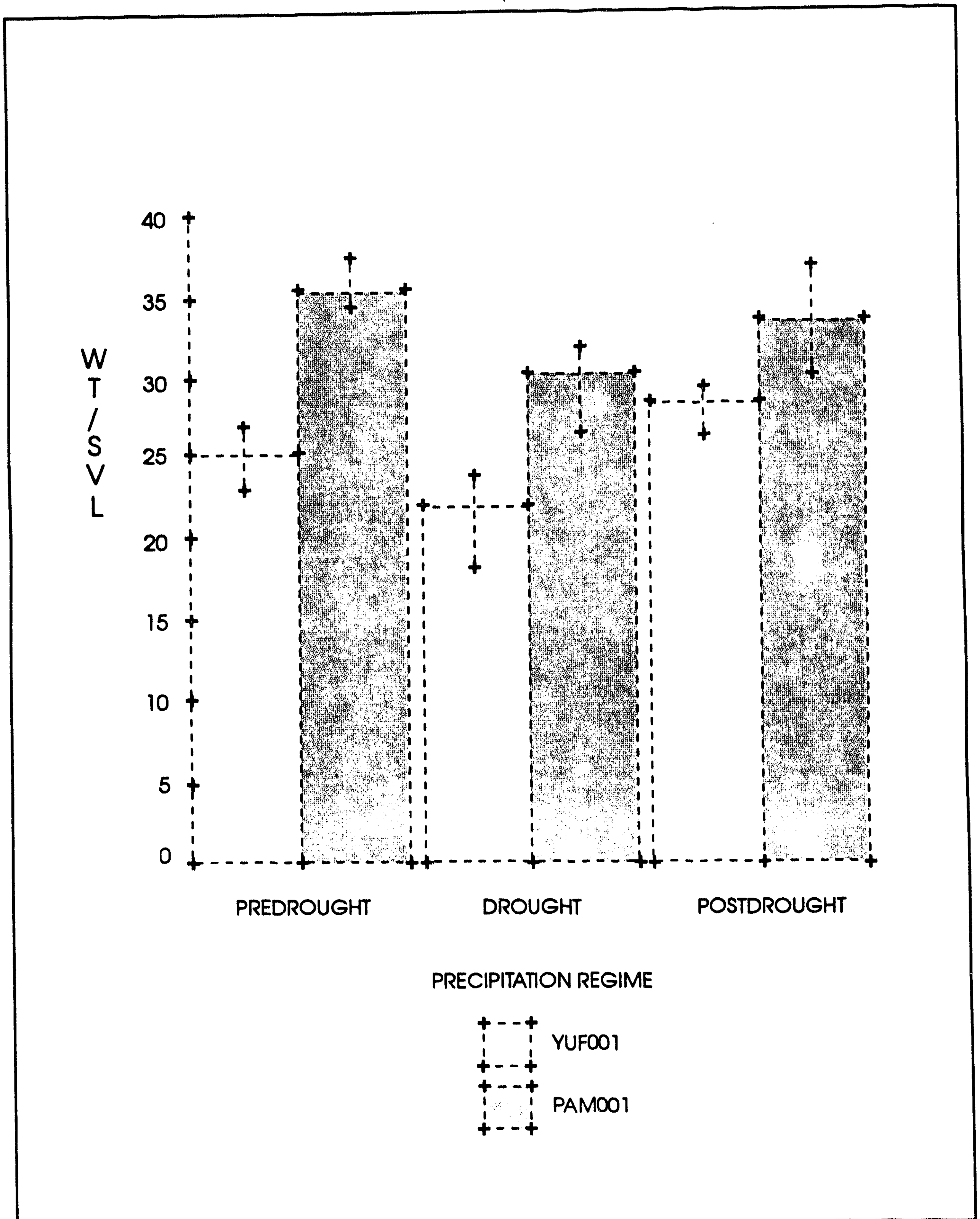

Figure 16 - Juvenile *Uta* leanness (weight.SVL x 1000 in g/mm for YUF001 and PAM001 across precipitation regimes.

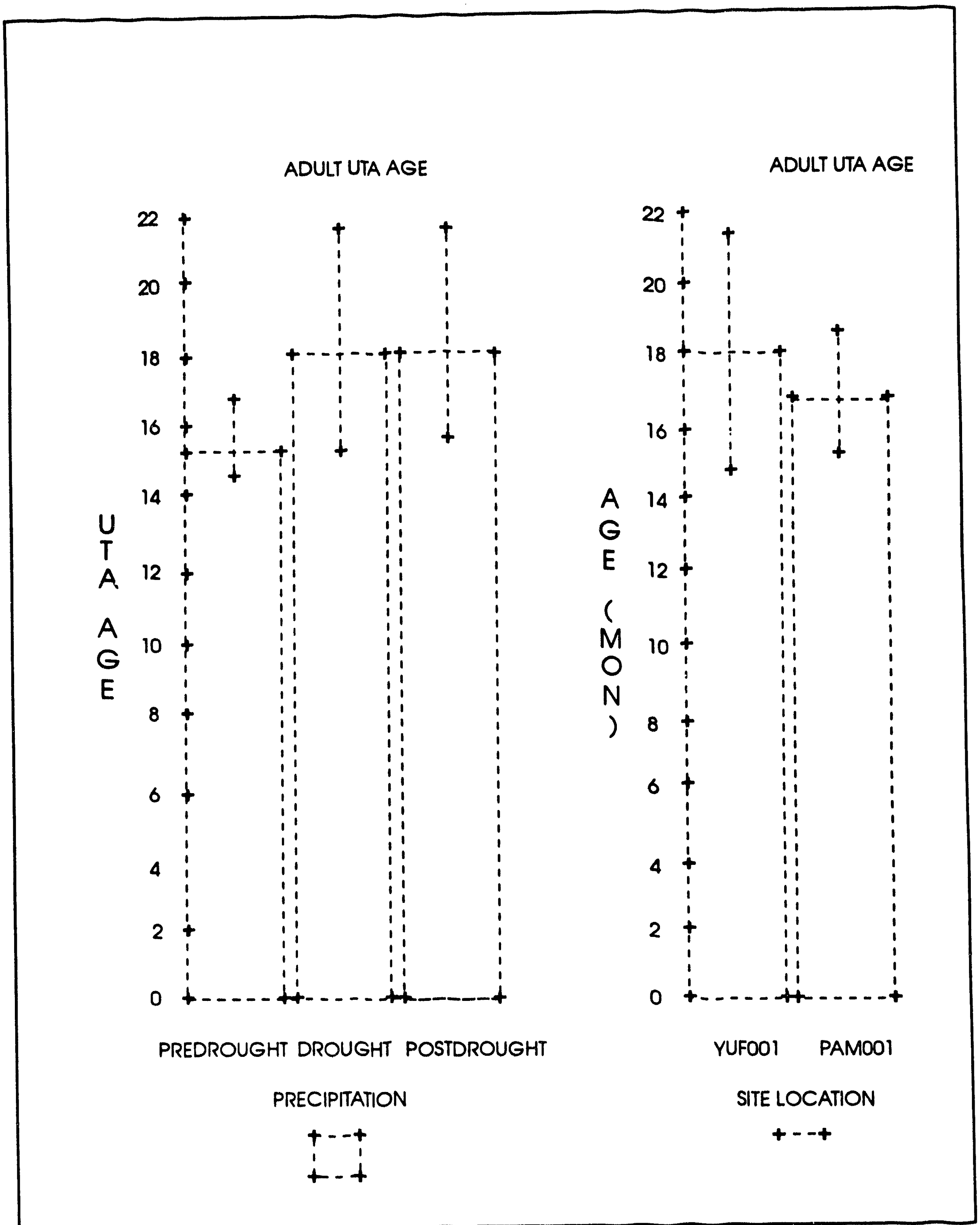

Figure 17 - Adult *Uta* age (months) compared across sites and across precipitation regimes.

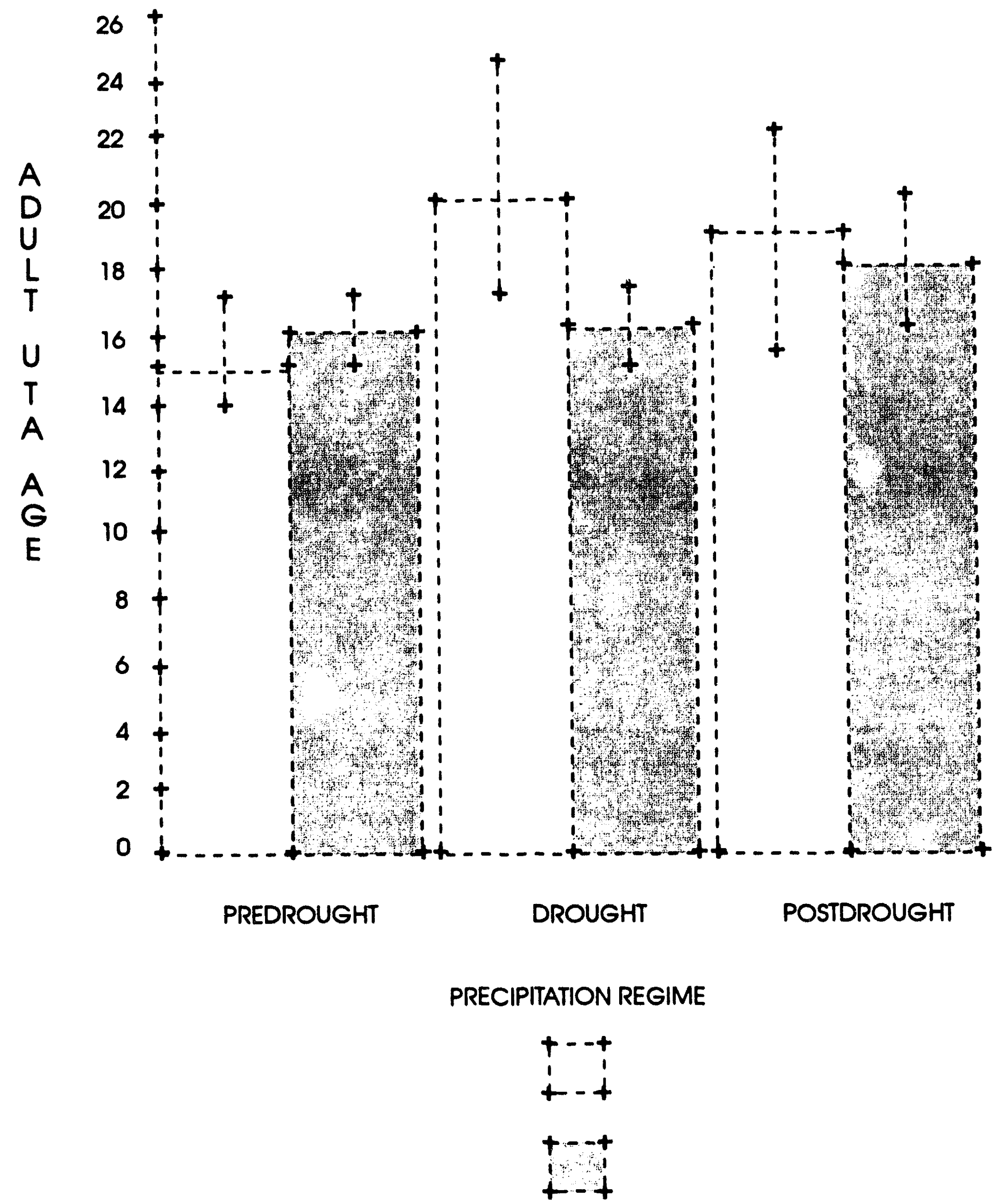

Figure 18 - Adult *Uta* age (months) for YUF001 and PAM001 across precipitation regimes.

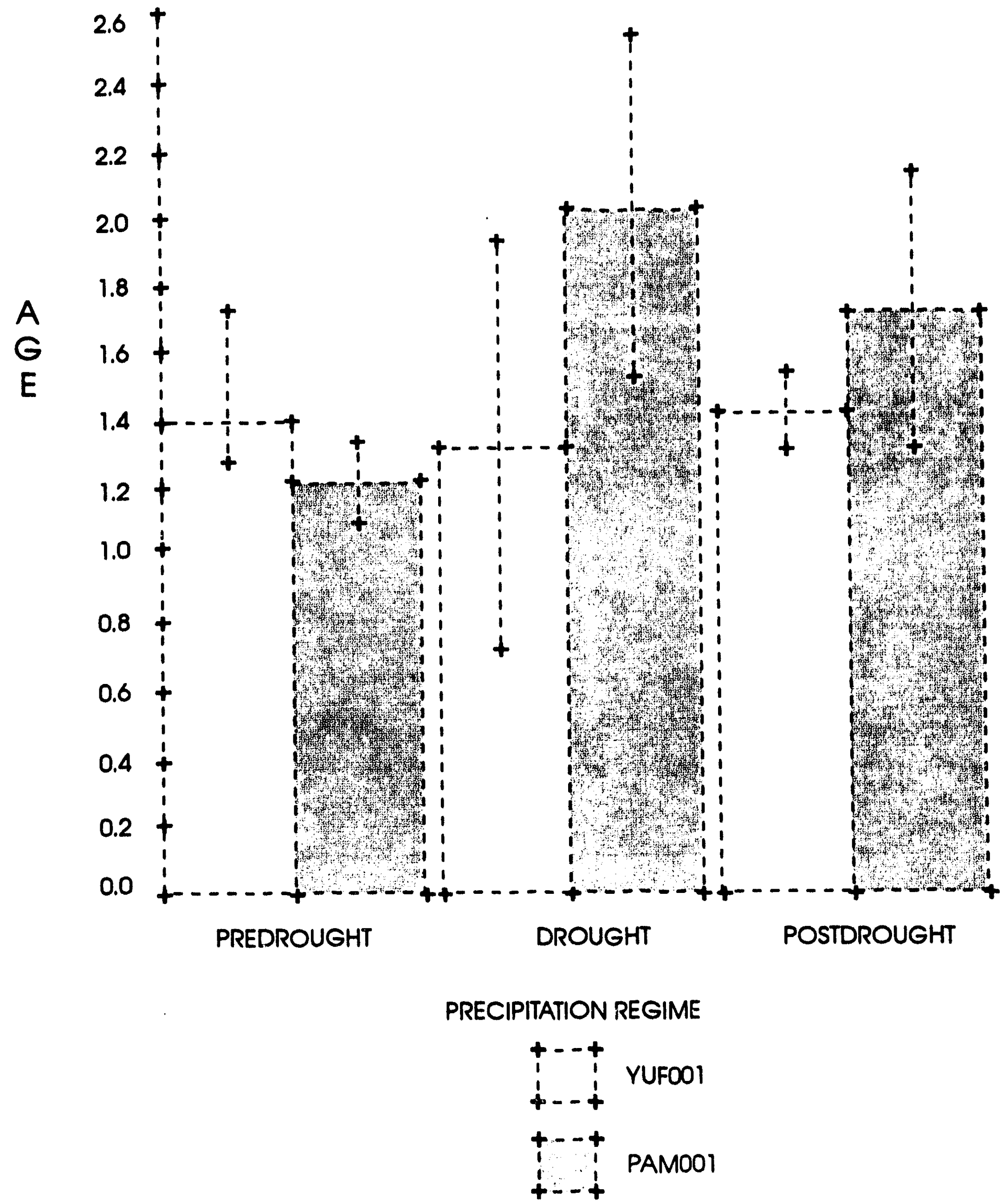

Figure 19 - Juvenile *Uta* age (months) compared across sites and across precipitation regimes.

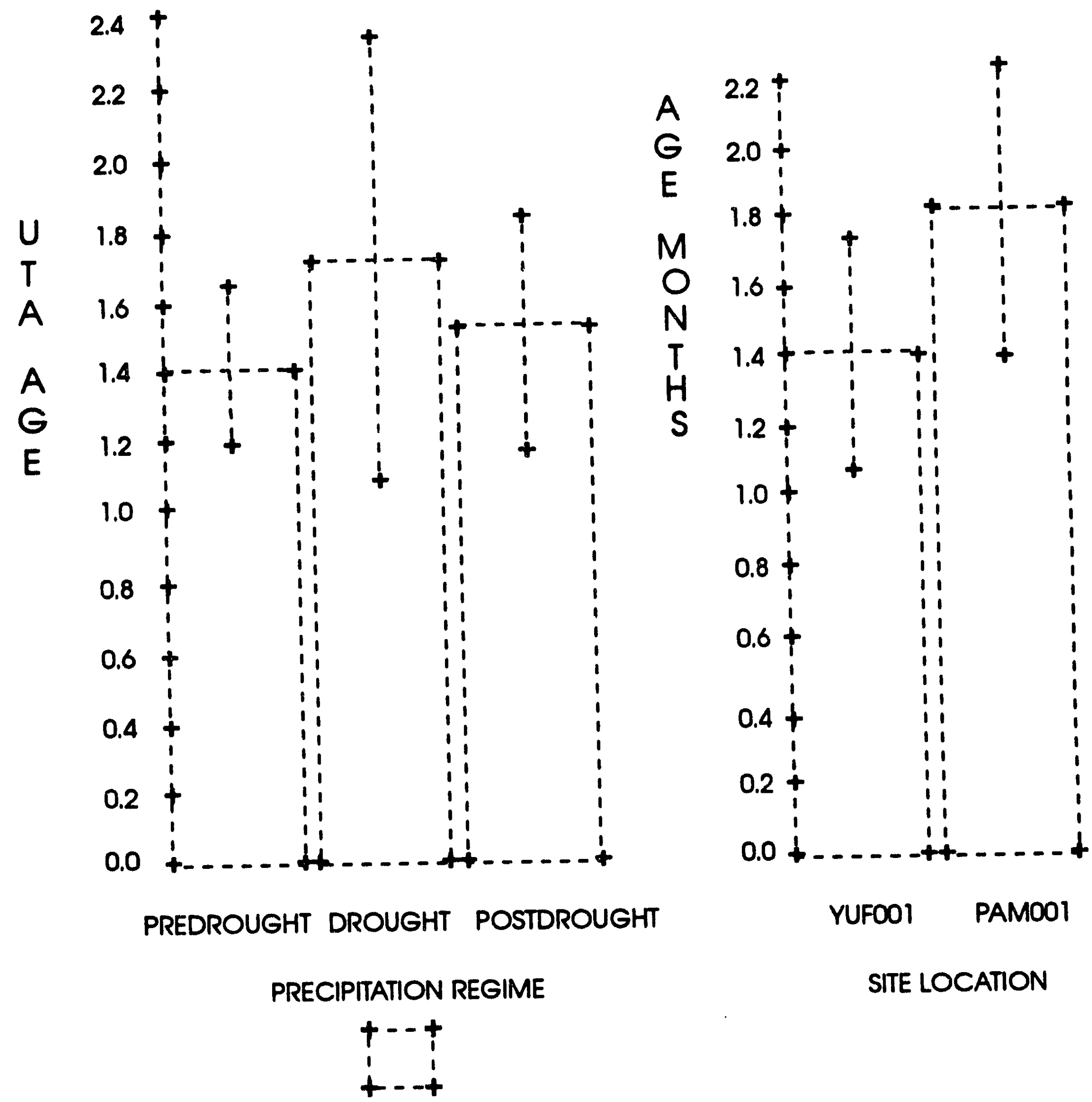

Figure 20 - Juvenile *Uta* age (months) for YUF001 and PAM001 across precipitation regimes.

0.0001, Figs. 13, 14). Unlike the case for SVL, the interaction term for juvenile weight was nonsignificant, although only marginally so. Adult weights did not differ between predrought and drought periods, but were almost 15 percent higher during the postdrought period. Juvenile weights before and after the drought were similar, but juveniles experienced a 22 percent drop in weight during the drought.

Ages were not different across drought regimes for either adults ($F = 1.99$, 2, 48 d.f., $p = 02$, Figs. 17, 18) or juveniles ($F = 1.19$, 2, 48 d.f., $p = 0.3$, Figs. 19, 20).

Adult weight/SVL, an estimate of leanness, differed across drought regimes ($F = 14.3$, 2, 48 d.f., p, < 0.0001), with an overall pattern of adult lizards being less lean after the drought than prior to or during it. There was a significant interaction between site and drought regime ($F = 3.2$, 2, 48 d.f., $p = 0.05$, Figs. 9, 10) because Yucca Flat adults deviated from the overall pattern by being leaner during the drought relative to predrought and postdrought conditions. Juvenile weight/SVL also differed across drought periods ($F = 13.9$, 2, 48 d.f., $p < 0.0001$, Figs. 15, 16), with juveniles during the drought being approximately eight percent leaner during the drought relative to predrought or postdrought periods.

Subsidence Craters

Mark recapture estimates of Uta densities on the subsidence craters and their associated controls (Tables 3 - 5) appear to differ from 1989 estimates. On U3cn and U7au craters and associated control plots adult densities in 1992 appear low, while juvenile densities appear high relative to 1989 results. On U10af crater and control, adult densities in 1992 appear similar to those in 1989, while juvenile densities appear to be much greater.

The four way ANOVA revealed differences in many *Uta* traits across locations, seasons, treatments, and years. Seasonal changes were pronounced. Both number of adults ($F = 11.3$, 1, 83 d.f., $p < 0.001$) and number of juveniles ($F = 5.1$, 1, 83 d.f, $p = 0.027$) differed from April to August (Tables 6 - 7). The number of adults and number of juveniles (for this analysis individuals less than 7 months old) increased from spring to summer either as the current year class hatched and became juveniles, or as last years juveniles aged into the adult category. The aging of juveniles into adults leads to adult SVLs

Table 3. Estimated densities (n/ha, 2 SEM), and number of distinct *Uta stansburiana* captured on 0.56 ha U3cn crater (YUF0019) and its control (YUF0020) in eastern Yucca Flat. *Total captured < 7, or estimate impossible to calculate.

	Spring 1989		Summer 1989		Spring 1992		Summer 1992	
	U3CN	CONTROL	U3CN	CONTROL	U3CN	CONTROL	U3CN	CONTROL
Adults								
Male	29	7	12	7	8	11	5	4
Female	19	5	11	10	9	6	1	4
Total	48	12	23	17	17	17	6	8
Estimate	85, 0	48, 42	44, 8	41, 19	30, 0	35, 9	13, 6	20, 12
Juveniles								
Male	0	0	2	5	0	0	13	12
Female	0	0	2	3	0	0	8	6
Total	0	0	4	8	0	0	21	18
Estimate	0	0	12, 12*	20, 12	0	0	42, 9	48, 25

Table 4. Estimated densities (n/ha, 2 se), and number of distinct *Uta stansburiana* captured on 0.56 ha plots in U7au crater (YUF021) and its control plot (YUF022) in central Yucca Flat. *Totals captured < 7 and/or estimate impossible to calculate.

	Spring 1989		Summer 1989		Spring 1992		Summer 1992	
	U7AU	CONTROL	U7AU	CONTROL	U7AU	CONTROL	U7AU	CONTROL
Adults								
Male	10	11	5	12	0	4	3	3
Female	12	12	7	23	0	4	4	5
Total	22	23	12	35	0	8	7	8
Juveniles								
Male	0	0	0	1	0	0	4	6
Female	0	0	2	2	0	0	11	13
Total	0	0	2	3	0	0	15	19
Estimate	0	0	5, 5*	5, 0*	0	0	35, 16	52, 25

Table 5. Estimated densities (n/ha, 2 SEM), and number of distinct *Uta stansburiana* captured on a 0.56 ha plot in U10au crater (YUF023) and on its control (YUF024). *Total caputred < 7 and/or estimate impossible to calculate.

	Spring 1989		Summer 1989		Spring 1992		Summer 1992	
	U10AF	CONTROL	U10AF	CONTROL	U10AF	CONTROL	U10AF	CONTROL
Adults								
Male	2	2	1	1	2	3	1	0
Female	4	2	0	0	3	1	1	1
Total	6	4	1	1	5	4	2	1
Estimate	11, 0*	7, 0*	5, 5*	*	5, 2*	4, 2*	2, 0*	1, 0*
Juveniles								
Male	0	0	1	0	0	0	5	10
Female	0	0	2	1	0	0	7	11
Total	0	0	3	1	0	0	12	21
Estimate	0	0	3.6, 0*	1.8, 0*	0	0	27, 13	56, 20

(F = 42.1, 1, 41 d.f., p < 0.0001) weights (F = 55.9, 1, 41 d.f, p < 0.0001), ages (F = 16.7, 1, 41 d.f., p < 0.0001), and degree of leanness (F = 17.1, 1, 41 d.f., p < 0.0001) all being lower in the summer relative to spring time conditions. The influx of hatchlings into the juvenile class also decreases juvenile SVL (F = 89.1, 1, 57 d.f., p < 0.0001), weight (F = 76.4, 1, 57 d.f., p < 0.0001), age (F = 126.4, 1, 57 d.f., p < 0.0001) and leanness (F = 67.7, 1, 57 d.f., p < 0.0001). Taken together these seasonal changes in *Uta* traits suggest that annual reproduction leads to the *Uta* population in the spring being quite different from the one present in the summer. The summer population had higher densities, and younger and smaller individuals relative to the spring population.

Table 6. *Uta* traits from the spring season from subsidence craters and control plots on Yucca Flat. Data presented is mean, 2 se.

TRAIT	ALL SUBSIDENCE CRATERS	ALL CONTROL PLOTS
Adults	**Mean ± 2 SE**	
Number	1.3, 1.5	1.4, 1.4
SVL (mm)	48.1, 1.8	49.0, 1.7
Weight (g)	3.24, 0.62	3.73, 0.28
Age (months)	22.1 2.2	23.2, 10.1
Weight/SVL	67.2, 10.5	76.1, 5.0
Juveniles	**Mean ± 2 SE**	
Number	5.0, 5.9	2.5, 2.3
SVL (mm)	41.7, 4.0	41.0, 4.2
Weight (g)	2.19, 0.81	2.14, 0.74
Age (months)	8.6, 0.9	8.2, 1.0
Weight/SVL (g/mm x 1000)	51.4, 4.2	50.9, 3.3

Table 7. *Uta* traits from the summer season from subsidence craters and control plots on Yucca Flat. Data presented is mean, 2 se.

TRAIT	ALL SUBSIDENCE CRATERS	ALL CONTROL PLOTS
Adults	**Mean ± 2 SE**	
Number	2.5, 2.7	4.0, 6.2
SVL (mm)	45.2, 3.3	45.6, 1.7
Weight (g)	2.80, 0.65	3.00, 0.43
Age (months)	14.0, 2.0	17.0, 4.6
Weight/SVL	56.4, 17.4	65.5, 7.7
Juveniles	**Mean ± 2 SE**	
Number	5.6, 4.8	5.1, 3.6
SVL (mm)	30.5, 5.5	31.5, 3.7
Weight (g)	0.91, 0.51	1.00, 0.33
Age (months)	2.0, 3.1	2.4, 2.4
Weight/SVL (g/mm x 1000)	28.1, 3.0	31.2, 2.1

Location also had a sizeable effect on some traits. The number of adults varied across locations ($F = 15.5$, 2, 83 d.f., $p < 0.0001$) with much of the difference apparently attributable to the extremely low numbers on U10af and its control plot (Tables 8 - 11). Number of juveniles also varied across locations ($F = 24.3$, 2, 83 d.f., $p < 0.0001$) with unusually high densities at the U3cn location. Juvenile age differed across locations ($F = 3.3$, 2, 57 d.f., $p = 0.045$). Adult leanness varied across locations ($F = 3.8$, 2, 41 d.f, $p = 0.03$) with adults on the U7au location appearing to be considerably more lean than those at the other two locations. Many of these differences appear to be due to the sampling schedule (see dates in tables), with some plots sampled early and others two or three weeks later.

Table 8. *Uta* traits at three locations (each representing a subsidence crater and its nearby control plot) in spring 1989.

TRAIT	LOCATION		
		Date sampled	
	4 - 10 April	11 - 21 April	20 - 28 April
	U3cn AREA	U7au AREA	U10af AREA
Adults		**Mean ± 2 SE**	
NUMBER	1.8, 1.5	1.3, 0.7	0.1, 0.4
SVL (MM)	48.4, 1.6	47.9, 1.4	51.0, 0.0
WEIGHT (g)	3.36, 0.38	3.14, 0.42	3.60, 0.0
AGE (MONTHS)	20.5, 1.4	21.8, 0.4	22.0, 0.0
WEIGHT/SVL (g/MM X 1000)	69.2, 6.1	65.5, 7.5	70.6, 0.0
Juveniles		**Mean ± 2 SE**	
NUMBER	8.3, 8.2	3.1, 1.7	1.6, 1.2
SVL (MM)	35.7, 2.3	40.1, 1.2	42.6, 1.5
WEIGHT (g)	1.23, 0.25	1.74, 0.22	2.33, 0.34
AGE (MONTHS)	7.3, 0.34	9.6, 0.2	8.1, 0.2
WEIGHT/SVL	34.1, 5.1	43.3, 4.5	54.7, 6.8

Table 9. *Uta* traits at three locations (each representing a subsidence crater and its nearby control plot) in spring 1992.

TRAIT	LOCATION		
		Dates sampled	
	13 - 16 April	27 April - 1 May	20 - 22 April
	U3cn AREA	U7au AREA	U10af AREA
Adults		**Mean ± 2 SE**	
NUMBER	1.9, 1.1	1.3, 2.2	1.0, 2.0
SVL (MM)	48.1, 2.3	50.5, 2.1	50.0, 0.0
WEIGHT (g)	3.92, 0.40	4.22, 0.46	3.97, 0.0
AGE (MONTHS)	30.6, 16.8	19.5, 0.8	19.5, 0.0
WEIGHT/SVL (g/MM X 1000)	81.4, 5.1	65.5, 4.5	79.4, 0.0

Table 9, continued.

TRAIT	LOCATION		
		Dates sampled	
	13 - 16 April	27 April - 1 May	20 - 22 April
Juveniles		**Mean ± 2 SE**	
NUMBER	6.5, 3.0	0.9, 1.9	1.2, 1.5
SVL (MM)	45.1, 1.9	44.6, 0.8	45.4, 1.3
WEIGHT (g)	3.01, 0.50	2.74, 0.13	2.98, 0.25
AGE (MONTHS)	8.6, 1.0	7.6, 0.8	8.6, 0.5
WEIGHT/SVL (g/MM X 1000)	66.4, 8.3	61.4, 1.7	65.6, 6.0

Table 10. *Uta* traits at three locations (each representing a subsidence crater and its nearby control plot) in summer 1989.

TRAITS	LOCATION		
		Dates sampled	
	27 July - 2 Aug.	7 - 11 Aug.	14 - 18 Aug.
	U3cn AREA	U7au AREA	U10af AREA
Adults		**Mean ± 2 SE**	
NUMBERS	1.3, 1.0	11.8, 6.1	0.25, 0.5
SVL (MM)	44.3, 3.1	43.4, 2.8	44.5, 0.7
WEIGHT (g)	2.38, 0.39	2.46, 0.49	2.68, 0.04
AGE (MONTHS)	13.0, 0.0	16.5, 4.2	12.0, 0.0
WEIGHT/SVL (g/MM X 1000)	53.5, 4.9	56.4, 8.3	60.1, 3.7
Juveniles		**Mean ± 2 SE**	
NUMBER	11.0, 3.5	0.8, 1.0	0.9, 0.8
SVL (MM)	40.0, 2.3	24.0, 1.0	27.3, 3.1
WEIGHT (g)	1.89, 0.20	0.44, 0.09	0.63, 0.16
AGE (MONTHS)	8.5, 0.92	0.1, 0.2	0.0, 0.0
WEIGHT/SVL	47.2, 2.5	18.3, 2.8	22.7, 1.8

Table 11. *Uta* traits at three locations (each representing a subsidence crater and its nearby control plot) in summer 1992.

TRAITS	LOCATION		
		Dates sampled	
	3 - 7 Aug.	11 - 13 Aug.	17 - 20 Aug.
	U3cn AREA	U7au AREA	U10af AREA
Adults		**Mean ± 2 SE**	
NUMBER	2.8, 1.5	3.8, 0.8	0.3, 0.5
SVL (MM)	48.7, 1.6	46.0, 2.0	47.0, 1.4
WEIGHT (g)	3.60, 0.28	3.01, 0.46	3.13, 0.11
AGE (MONTHS)	16.0, 4.2	14.7, 1.8	18.5, 7.8
WEIGHT/SVL (g/MM X 1000)	74.0, 3.3	65.3, 8.0	66.5, 3.8
Juveniles		**Mean ± 2 SE**	
NUMBER	9.8, 4.0	7.7, 2.2	6.1, 2.4
SVL (MM)	27.6, 1.7	31.8, 2.7	31.0, 3.2
WEIGHT (g)	0.63, 0.14	0.95, 0.26	0.91, 0.28
AGE (MONTHS)	0.6, 0.4	1.1, 0.5	1.3, 1.0
WEIGHT/SVL	22.7, 4.0	29.7, 5.4	28.9, 6.5

Adult SVL ($F = 10.9$, 1, 41 d.f., $p = 0.002$), weight ($F = 48.5$, 1, 41 d.f., $p < 0.0001$), and weight/SVL ($F = 8.9$, 1, 41 d.f., $p = 0.005$) all differed across years. Adult *Uta* were smaller in 1989 (a drought year) relative to 1992 (a year of normal precipitation). There also were significant interactions in a similar manner, juvenile weight was lower ($F = 7.9$, 1, 57 d.f., $p = 0.007$), and juveniles were leaner ($F = 3.9$, 1, 57 d.f., $p = 0.05$) in the crater relative to those on control plots.

A comparison of *Uta* in subsidence craters and on adjoining control plots revealed one statistically significant difference, and two cases where differences were marginally nonsignificant. Adults in subsidence craters were leaner than those on control plots ($F = 6.0$, 1, 41 d.f., $p = 0.019$). The number of juveniles seen on control plots was (nonsignificantly $F = 3.6$, 1, 83 d.f., $p = 0.061$) higher than the number observed in craters. Adults on the control plot were (nonsignificantly $F = 3.3$, 1, 41 d.f., $p = 0.076$) heavier than their counterparts in subsidence craters.

Lizard Transects

Relatively few lizards were seen on the transects (Tables 12, 13). These numbers are likely an underestimate for some species, especially secretive ones. As an example, the *Uta* mark-recapture estimate for the PAM001 plot was 38/ha, while the transect estimate was only 3.8 lizards/ha. Density estimates in 1992 were within 200 percent of estimates in prior years implying some degree of constancy over years. As in prior years, the Yucca Flat plot appeared to contain more *Cnemidophorous* and *Phrynosoma* than the Pahute Mesa plot.

Table 12. Lizard relative abundance (mean number of lizards observed per hectare) searched on transects on the Pahute Mesa baseline plot (PAM001) during late spring 1988, 1991, and 1992.

	YEAR		
	1988	1991	1992
Cnemidophorus			
Adults	0.07	0.12	0.13
Juveniles	0.04	0.06	0.00
Total	0.11	0.18	0.13
Gambelia			
Adults	0.11	0.21	0.29
Juveniles	0.04	0.00	0.12
Total	0.15	0.21	0.41
Phrynosoma platyrhinos			
Total	0.04	0.00	0.03
Crotaphytus collaris			
Total	0.07	0.00	0.00
Sceloporus occidentalis			
Total	0.11	0.24	0.10

Table 13. Lizard relative abundance (mean number of lizards observed per hectare searched) on transects on the Yucca Flat baseline plot (YUF001) during late spring, 1987 - 1992.

	YEAR					
SPECIES	1987	1988	1989	1990	1991	1992
Cnemidophorus tigris						
Adults	9.67	3.41	3.96	3.41	5.98	7.12
Juveniles	2.12	1.00	2.00	1.39	0.59	7.92
Total	11.79	4.41	5.96	4.80	6.57	15.04
Gambelia wislizenii	0.48	0.26	0.04	0.15	0.24	0.60
Callisaurus draconoides	0.13	0.15	0.22	0.03	0.03	0.00
Phrynosoma platyrhinos	0.20	0.19	0.11	0.00	0.03	0.20

Tortoise Sampling

Desert tortoise work focused on tortoises inhabiting three 341 m diameter enclosures in Rock Valley, and opportunistic captures of free-roaming tortoises along roadsides (Table 14).

Table 14. Distribution of tortoise captures by site type.

YEAR	TRANSECTS, WASHES OR OTHER TORTOISE HABITAT	ROADS			TOTAL
		REMOTE DIRT AND GRADED	MAJOR PAVED	ABANDONED PAVED	
1987	8	1	0	0	9
1988	21	10	3	0	34
1989	3	1	1	0	5
1990	3	1	7	5	16
1991	6	1	1	3	11
1992	0	1	0	4	5
Total	41	15	12	12	80

An abandoned paved road in southern Frenchman Flat ('Burma Road') continued to be an excellent location for capturing tortoises during or just after a rain shower. In 1992, four new tortoises were captured along this road. The only other free-ranging tortoise captured in 1992 was found along a little-used road in Rock Valley. From 1987 though 1992, BECAMP has marked, measured and released 80 tortoises on the southern third of the NTS (Figure 21). None of the 75 marked tortoises was recaptured in 1992.

All new tortoises captured in 1992) were juveniles or adults of plastron length (PL) greater than 100 mm (Table 15). Small tortoises are hard to detect from a moving vehicle.

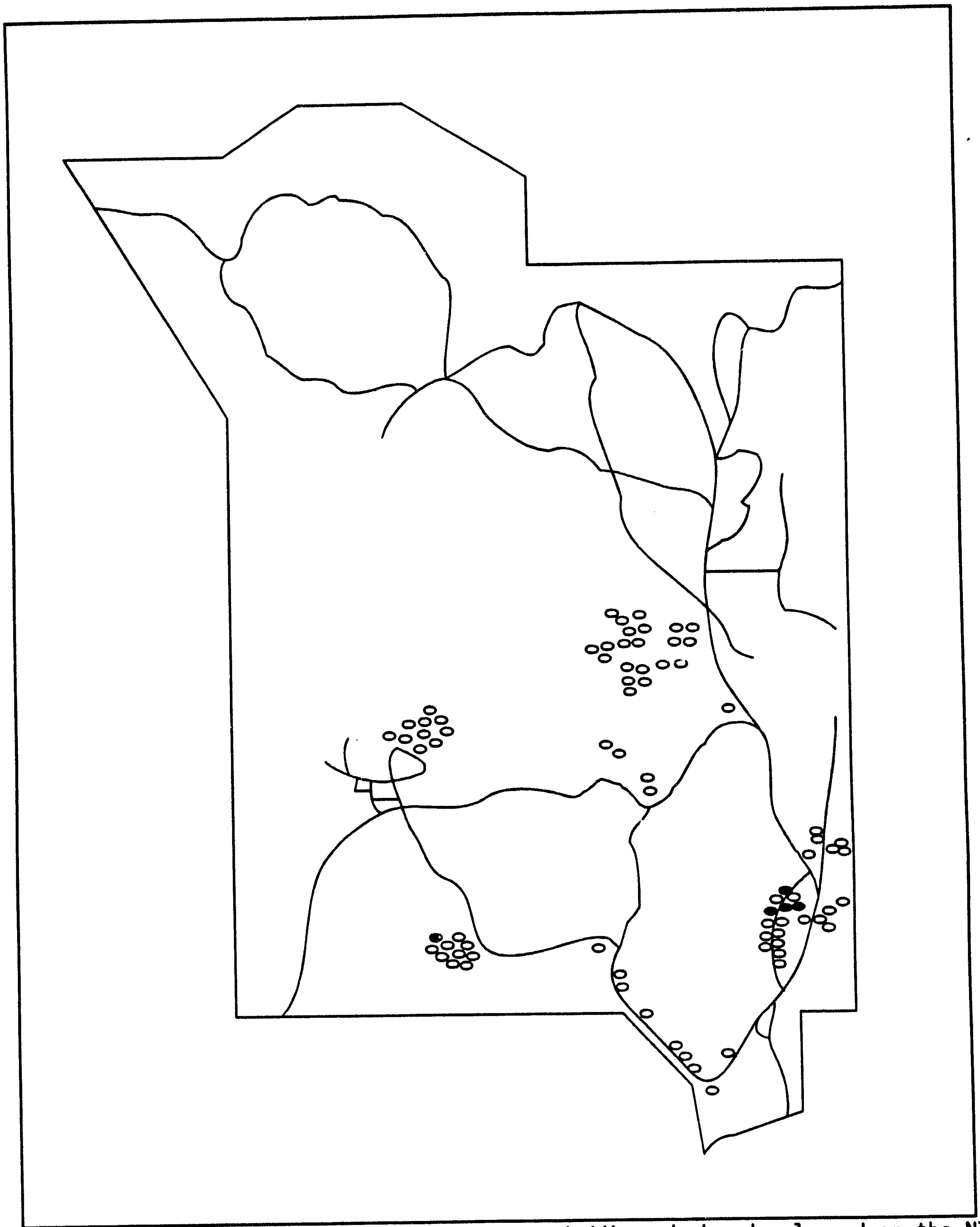

Figure 21 - Desert tortoises (*Gopherus agassizii*) marked and released on the NTS by BECAMP from 1987 through 1992. Closed circles are 1992 locations. N = 80.

Table 15. Characteristics of new tortoises captured in 1992. I = indeterminate sex.

LOCATION	ANIMAL NUMBER	SEX	PLASTRON LENGTH (mm)	CARAPACE LENGTH (mm)	WEIGHT (g)
	74	♀	257	274	3775
	75	I	148	153	925
	76	I	160	155	975
	77	♀	248	264	3450
Rock Valley	73	♀	188	192	1525

All 17 marked tortoises in Rock Valley enclosures (plots A, B, and C) were captured in 1992. Fifteen were measured in the spring (March - May) and six in autumn, including two not captured in spring. In addition, two unmarked juvenile tortoises were captured and measured in the spring in plot A. These are the first evidence of successful reproduction in Rock Valley plots since 1963. On 2 February 1990, a juvenile tortoise was observed inside a burrow in plot A, but could not be handled due to a lack of a U.S. Fish and Wildlife Service endangered species permit. Before the permit was received on 13 March 1990, this tortoise had left the burrow and could not be located. It is possible that one of the juveniles captured in 1992 could be this individual. No signs of URTD (a tortoise disease) were observed in 1992.

Most tortoises inhabiting the Rock Valley plots were <3 years of age when first marked and have been captured on an irregular basis for 30 years, maintaining records on growth and survival on a tortoise population of known age (Turner et al. 1987; Germano 1989). During the severe drought of 1989 and 1990, Rock Valley tortoises showed little or no growth in plastron length (mean <0.1 mm and 0.2 mm respectively). After adequate winter precipitation and growth of annual plants, growth resumed in (1991 (mean 1.3 mm). Growth increased in 1992 with the mean of 6.0 ± 0.6 mm (range = 2 to 15) for the six animals captured in the autumn of 1992 (Table 16). This is an important data set because little is known about growth in older tortoises, or about tortoise longevity, and these factors play an important role in tortoise management in the southwestern U.S. (Germano 1989).

Table 16. Measurements and growth of tortoises in Rock Valley fenced plots in 1992.

PLOT	ANIMAL NUMBER	ESTIMATED AGE[1] (years)	SEX	SPRING (MARCH - APRIL) PLASTRON LENGTH (mm)	SPRING (MARCH - APRIL) CARAPACE LENGTH (mm)	SPRING (MARCH - APRIL) WEIGHT (g)	AUTUMN (SEPTEMBER - OCTOBER) PLASTRON LENGTH (mm)	AUTUMN (SEPTEMBER - OCTOBER) CARAPACE LENGTH (mm)	AUTUMN (SEPTEMBER - OCTOBER) WEIGHT (g)	NET GROWTH (mm)
A	4	30	♀	221	227	2325		NS		
	5	?	♂	242	274	3650		NS		
	11	?	♂	239	248	2725		NS		
	88	?	I	110	122	400		NS		
	89	?	I	138	142	575		NS		
B	1	30	♂	250	280	3950		NS		
	2	32	♂	253	272	3850	257	272	3275	+4
	3	31	♂		NS		207	222	1800	+2[2]
	4	31	♀		NS		247	261	3950	+6[2]
C	1	30	♂	234	247	2475		NS		
	2	?	♀	212	221	2375		NS		
	3	29	♂	257	265	3700	272	271	3075	+15
	4	?	♂	228	255	2950	233	255	2550	+5
	5	29	♀	226	232	2375				
	6	30	♀	221	227	2325		NS		
	8	29	♂	221	238	2350		NS		
	9	29	I	162	174	1050	166	175	1175	+4
	10	31	♀	219	233	2350		NS		
C	11	30	♀	215	230	2475		NS		

[1]? = Cannot age to ± 1 year.

[2]Growth based on change in plastron length from October 1991.

Incidental Sightings

Several dozen recently transformed bullfrogs, (*Rana catesbeiana*), were seen in the Area 3 Mudplant pond (37 2' 50.8" N, 116 1' 48.6" W, NAD83) on 16 April 1992. Two were captured and placed in the BECAMP collection as voucher specimens.

DISCUSSION

Site And Precipitation

The number of adult and juvenile *Uta* fluctuated greatly over years and from place to place on the NTS, a pattern not atypical for lizards (Vitt 1991). In general there appears to be more *Uta* on the Pahute Mesa site than on the Yucca Flat site. Interestingly, adult and juveniles appear to experience drought differently. Drought tended to increase adult *Uta* densities (especially on Pahute Mesa) while it lowered juvenile densities. This difference may in part reflect a generational lag, as the success of this years's juvenile cohort largely determines the size of the adult population next year. Thus the number of adults in the first year of drought, may largely reflect the number of juveniles that overwintered from the previous (normal precipitation) year, and to a lesser degree drought conditions in this year. The significant interaction between site and drought period implies that adults in these two *Uta* populations experienced the drought in different ways. The Pahute Mesa population began at low numbers, shot up four-fold during the drought period, and then receded to about twice the predrought densities (Fig. 2). On the other hand the adult population on Yucca Flat was essentially unchanged over the three drought periods (Fig. 2). Vitt et al. (1978) report decreased reproduction in drought years in a desert lizard, and Dunham (1980) reports decreased insect abundance in drought years. These findings hint at potential causes of the observed results.

Adult SVLs varied across both sites and years, although the variation was only about 1 percent across drought periods, and about 4 percent higher on Pahute Mesa. The effects on weight were pronounced, with Pahute Mesa lizards weighing 20 percent more than *Uta* on Yucca Flat (Fig. 9). *Uta* weight during the drought period did not differ from the predrought period, but *Uta* during the postdrought period appear to be about 15 percent heavier (Fig. 9). There were fairly sizeable differences in adult weight/SVL between sites and between

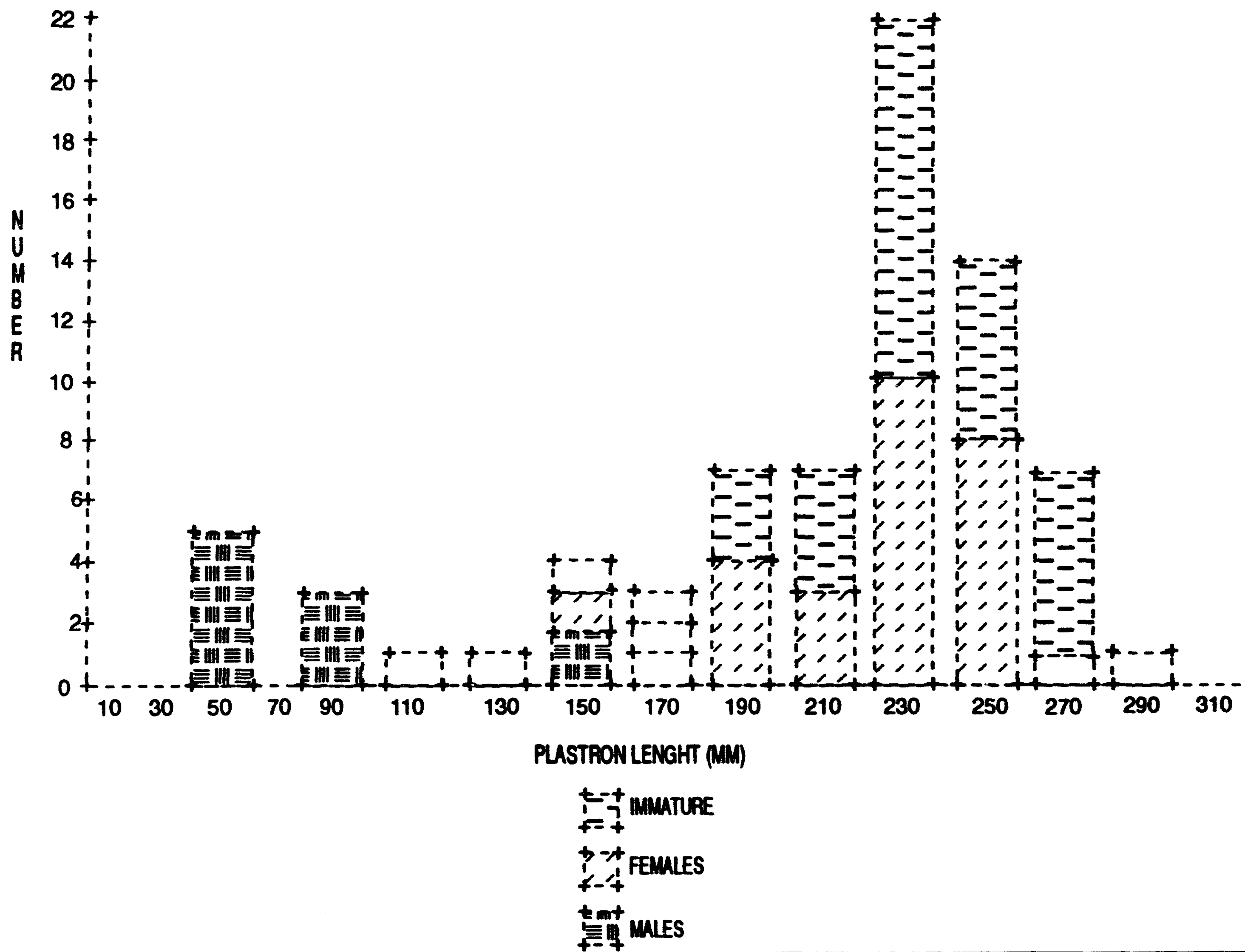

Figure 22 - Size distribution of desert tortoises marked and released by BECAMP on the NTS through 1992.

predrought and drought conditions and postdrought conditions. Reduced insect abundances during drought years (Dunham 1980, Wisdom 1991) is a likely cause.

Juvenile *Uta* were approximately 5 percent shorter during the drought, and approximately 14 percent shorter on Yucca Flat relative to Pahute Mesa. Weight patterns were similar, although the magnitudes of differences were greater. Juveniles on Pahute Mesa were 40 percent heavier than their counterparts on Yucca Flat. Juvenile weights before and after the drought were approximately equal, however, juveniles during the drought weighed 22 percent less. Weight/SVL (an estimator of leanness) was 30 percent greater for Pahute Mesa juveniles relative to Yucca Flat juveniles. Juveniles during the drought period were 8 percent leaner than during the pre- or postdrought periods. Neither adult nor juvenile ages differed across sites or drought periods. This is not surprising as with our sampling protocol and the current analysis we are basically measuring differences in overwinter survival (i.e.,differences in ages between plots will occur only when there are large differences in overwinter survival between plots).

Differences in *Uta* traits were pronounced across our two study sites with Pahute Mesa lizards being larger. Differences between plots are not surprising as the two sites differ in elevation, dominant vegetation and a host of other factors which are likely to influence lizard natural history (Dunhan 1980, Pianka 1986). These comparisons suggest that *Uta* at the two sites would bring different suites of characters to bear should a perturbation such as a test event impact them. One type of perturbation, a drought, did impact the lizards over our study period. Differences in responses (e.g., increased adult densities on Pahute Mesa and no change on the Yucca Flat site) as indicated by significant interaction terms, demonstrate lizards at the two sites respond differently to a perturbation. This has important ramifications for sampling designs in a monitoring program as it suggests perturbations may have widely differing effects on different sites. This implies that it is imperative to sample widely, so that we can speak with confidence about the ramifications of test events.

Subsidence Craters

The subsidence crater data set covers the drought year of 1989 and the normal precipitation year of 1992. In 1989, sample sizes were quite small, as a consequence, the subsidence crater analysis should be interpreted cautiously. There were seasonal differences for most *Uta* traits reflecting the introduction of new hatchlings from the spring to summer season. The summer population had higher densities, and is biased towards younger and smaller individuals. These differences suggest perturbations in different seasons may have different effects on *Uta* because the population experiencing the perturbation will be quite different in the spring and summer months.

Several lizard traits also differed across years. Adult SVL differed across years with *Uta* in 1989 being significantly smaller than those in 1992. This effect was not consistent across treatments with larger effects in the craters relative to the control plots. Adult weight also differed with 1989 *Uta* again smaller than 1992 *Uta*. Effects on weight were more pronounced in craters relative to control plots, probably because of the reduced vegetation in craters (Hunter 1992), and the presumably low insect abundances associated with the reduced vegetation (Wisdom 1992). Finally, adults in 1989 were leaner than those observed in 1992. Juvenile weight and juvenile leanness also exhibited similar patterns across years. Differences between 1989 and 1992 are qualitatively similar to those observed on the baseline plots - adults and juveniles tended to be smaller during the drought relative to years following the drought.

There is some evidence that living in a subsidence crater influences *Uta* traits. Adults in craters were about 10 percent lighter than adults in the corresponding control plots (a difference just shy of statistical significance). There also were fewer juveniles in craters as opposed to their controls (although this was again marginally nonsignificant). Adults in the craters were almost 15 percent leaner than their counterparts on control plots, implying that life in the craters was harsher.

The subsidence crater results are best regarded as suggestive because of the very small sample sizes in 1989, especially in crater U10af and its control. These results are informative however, especially when we look across the four main factors. The craters appear to negatively effect adult leanness. This effect is smaller than differences between the spring and summer season, and about the same size as that observed between a drought and a normal precipitation year. Location effects tended to be smaller than the treatment effects. These differences put the statistical difference in adult leanness into biological perspective. Said differently, crater formation had as great an effect on adult leanness as drought did. This suggests that to study the effects of crater formation on *Uta* one needs to be aware of seasonal, weather induced, and site specific factors that effect *Uta* populations.

Transect Studies

Transect studies again revealed that the lizard faunas of Pahute Mesa and Yucca Flat differ. Pahute Mesa transects contained *Sceloporus occidentalis* which has been lacking on Yucca Flat transects, while *Cnemidophorus tigris* was present on Yucca Flat transects, but absent on Pahute Mesa transects. *Cnemidophorous* numbers appeared to be higher in 1992 than in prior years.

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TRENDS IN SMALL MAMMAL POPULATIONS ON THE NEVADA TEST SITE, 1992

Mary B. Saethre

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ABSTRACT

The sixth year of monitoring selected small mammal populations on the Nevada Test Site was completed in 1992. Monitoring, which began in 1987, continued to focus on trends in heteromyid rodent populations at two baseline sites and included subsidence craters and drill pads generated by the Department of Energy nuclear testing program. A site disturbed by a brush fire in 1988 was also recensused in 1992.

Numbers of animals captured on the baseline site in western Yucca Flat indicated that the kangaroo rat population (*Dipodomys merriami* and *D. microps*) continued to rebound from drought conditions which prevailed from 1989 through 1990. The little pocket mouse (*Perognathus longimembris*) declined to the lowest density ever recorded at this site, after being the most abundant rodent from 1987 through 1991.

Densities were the highest ever recorded at a human-caused burn area, mostly due to increases in the kangaroo rat populations. Murid rodents (*Peromyscus*, *Onychomys*, and *Neotoma*) also did particularly well at the sites studied in 1992. *Peromyscus maniculatus* was the most common rodent at the Pahute Mesa baseline site in 1992, replacing *Perognathus parvus*.

Of the three crater sites, last studied in 1989, two (U10af and U7au) showed increases in the number of individual animals captured, while one (U3cn) experienced a decline. The decline was apparently due to a pair of ravens which repeatedly used the bottom of the crater as a nesting site and the surrounding area for foraging territory. Most other plots sampled during the drought years (1989 and 1990) showed increases in animal abundance after the drought (1991, 1992 and 1993).

INTRODUCTION

History

The Nevada Test Site (NTS) is located across the transition zone between the Mojave (*Larrea-Ambrosia*) and Great Basin (*Artemisia*) desert communities. Available habitat, therefore, varies in vegetation, soil type, and elevation. While typical habitats of both deserts occur on the NTS, aspects of each are present in the transition zone, yielding complex and unique habitats. These various vegetation communities on the NTS (Allred et al. 1963; Beatley 1974a; O'Farrell and Emery 1976) support rodent communities which typify each habitat, with intergradation occurring in the transitional areas (Jorgensen and Hayward 1965).

Ecological studies of animals on the NTS were initiated in 1959 when Brigham Young University (BYU) set out to catalog the flora and fauna of the NTS (Allred and Beck 1963a; Jorgensen and Hayward 1965). Intensive studies were undertaken in Rock Valley on the southern edge of the NTS by the University of California Los Angeles (UCLA), with several projects undertaken to determine animal abundance, home range, the effects of chronic radiation, and life spans of a population of desert rodents (French 1964; French et al. 1966, 1967; French et al. 1974; French et al. 1968; Maza et al. 1973; Gibson 1993). Additional small mammal studies were also done in Rock Valley as part of the International Biological Program (IBP) during the 1970s (Chew 1975; Dingman 1975; Turner 1973, 1974, 1975). During the late 1970s and early 1980s, the Nevada Applied Ecology Group (NAEG) studied rodent populations at several contaminated sites on the NTS (Moor and Bradley 1974, 1987; Bradley and Moor 1975, 1976, 1978; Moor et al. 1976; Bradley et al. 1977a, 1977b; Moor et al. 1977; O'Farrell and Sauls 1987).

At the present time, 54 mammals occur on or near the NTS (Appendix A), the majority of which are rodents (Jorgensen and Hayward 1965; O'Farrell and Emery 1976; Medica 1990). Three bat species, *Lasionycteris noctivagans* (silver-haired bat), *Eptesicus fuscus* (big brown bat), and *Tadarida brasiliensis* (Mexican free-tail bat) were overlooked in earlier species accounts, although three specimens from 1963, 1964, and 1978 exist. Two other species, *Lasiurus cinereus* (hoary bat) and *Myotis volans* (long-legged bat), were first recorded on the NTS in 1992 (EG&G/EM 1992). Two ungulates, the elk (wapiti) and bighorn sheep, are resident outside the NTS boundaries and are rarely observed.

Of the 23 species of rodents inhabiting the NTS, the most ubiquitous are the heteromyid kangaroo rats and pocket mice. The abundance of rodents and species diversity vary among the habitats present on the NTS, but, in general, the kangaroo rat *Dipodomys merriami* and pocket mouse *Perognathus longimembris* are most common in the southern half of the NTS (Mojave desert) and *Dipodomys microps* and *Perognathus parvus* are more prevalent in the northern extremes (Great Basin Desert). Most of the rodents are herbivores or granivores and therefore depend on adequate quantities of plant biomass, most importantly from annual plants, for reproduction and growth (Kenagy 1972, 1973; Van de Graaff and Balda 1973; Reichman and Van de Graaff 1973, 1975; Kenagy and Bartholomew 1981). In turn, available ephemeral plant material is dependent on adequate amounts of winter rainfall for germination and spring rain for growth (Beatley 1974b, 1976).

Becamp Study Sites

Small mammal monitoring under the auspices of the Basic Environmental Compliance and Monitoring Program (BECAMP) began in the summer of 1987. At that time, permanent baseline study sites were established in the three major valleys of the NTS (Hunter and Medica 1989). An area burned by a lightning fire in 1985 and an undisturbed control area were also studied in 1987. In 1988, monitoring continued on the three baseline sites, moving the census to spring. Two new baseline sites on the tops of mesas were also added. Sites were studied at eight disturbance areas, concentrating on areas disturbed by nuclear testing (e.g. blast areas from aboveground tests and overburden from a cratering test). An area denuded by gophers and an area burned by a human caused fire were added and also sampled in 1988 (Saethre and Medica 1992).

In 1989 three crater bottoms, two areas scraped of all vegetation, and an alpha radiation contaminated site were studied. 1990 completed the first three year cycle of NTS monitoring of disturbed sites. That year, two additional blast areas were studied, along with the burned area studied in 1987. The baseline site in Yucca Flat (YUF001) was chosen to be studied on a yearly basis, while the remaining four sites are to be sampled every four years (Saethre, in press).

In 1992, the three craters studied in 1989 (YUF019, YUF021, and YUF023) and adjacent controls (YUF020, YUF022, and YUF024) were resampled. Two scraped areas and controls (MID004, MID005, PAM002, and PAM003) were also studied again after a three year lapse. A plot in an area disturbed by a man-caused range fire in Redrock Valley (RED001 and control RED002), censused in 1988, 1989, and 1990, was recensused in 1992. The baseline site on Pahute Mesa (PAM001) was resampled again after two years, while yearly monitoring continued on YUF001. Locations of all plots studied in 1992 are shown in Figure 1. Latitudes, longitudes, and elevations are found in Appendix B.

Information from the Yucca Flat and Pahute Mesa baseline plots is used to provide information on species composition, relative densities of the most common species and sex distributions of populations at relatively "pristine" sites. Disturbed sites and controls yield information on the effect, if any, of the disturbance, and, over time, information on succession at a site. To date, six years of small mammal population data are available for the Yucca Flat baseline site. Trends on this site are used to indicate what may be happening at other NTS sites during the years between censuses.

METHODS

SMALL MAMMAL SAMPLING TECHNIQUES

Baseline Monitoring Sites

Small mammals were trapped on the baseline monitoring sites for three consecutive nights each. Small nocturnal mammals were captured in Sherman live traps (8 x 9 x 30 cm) which were set to capture animals over 5 g (approximately the weight of a juvenile *Perognathus longimembris*). Each of the permanent study plots (YUF001 and PAM001) consisted of a 12 x 12 staked grid (144 stations) with 15 m between stakes (2.72 ha) and two traps set at each station (288 total traps). Two traps were used to provide more opportunities for animals to be captured in the short trapping period. Traps were baited in the early evening (1730+ hours) with a mixture of rolled oats and birdseed and placed under a metal (half-cylinder) cover to prevent hyperthermia from direct sunlight. Traps were checked shortly after sunrise and closed for the day.

Each rodent was permanently marked. An occasional lagomorph (*Lepus californicus* and *Sylvilagus* spp.) was given an individually numbered ear tag. All other rodents, including squirrels, were toe-clipped with no more than one toe amputated per foot. Species, capture status (new or recapture), animal number, sex, reproductive condition, and grid location were recorded on field data sheets (Hunter and Medica 1989, Figure 15). Any bait was removed from

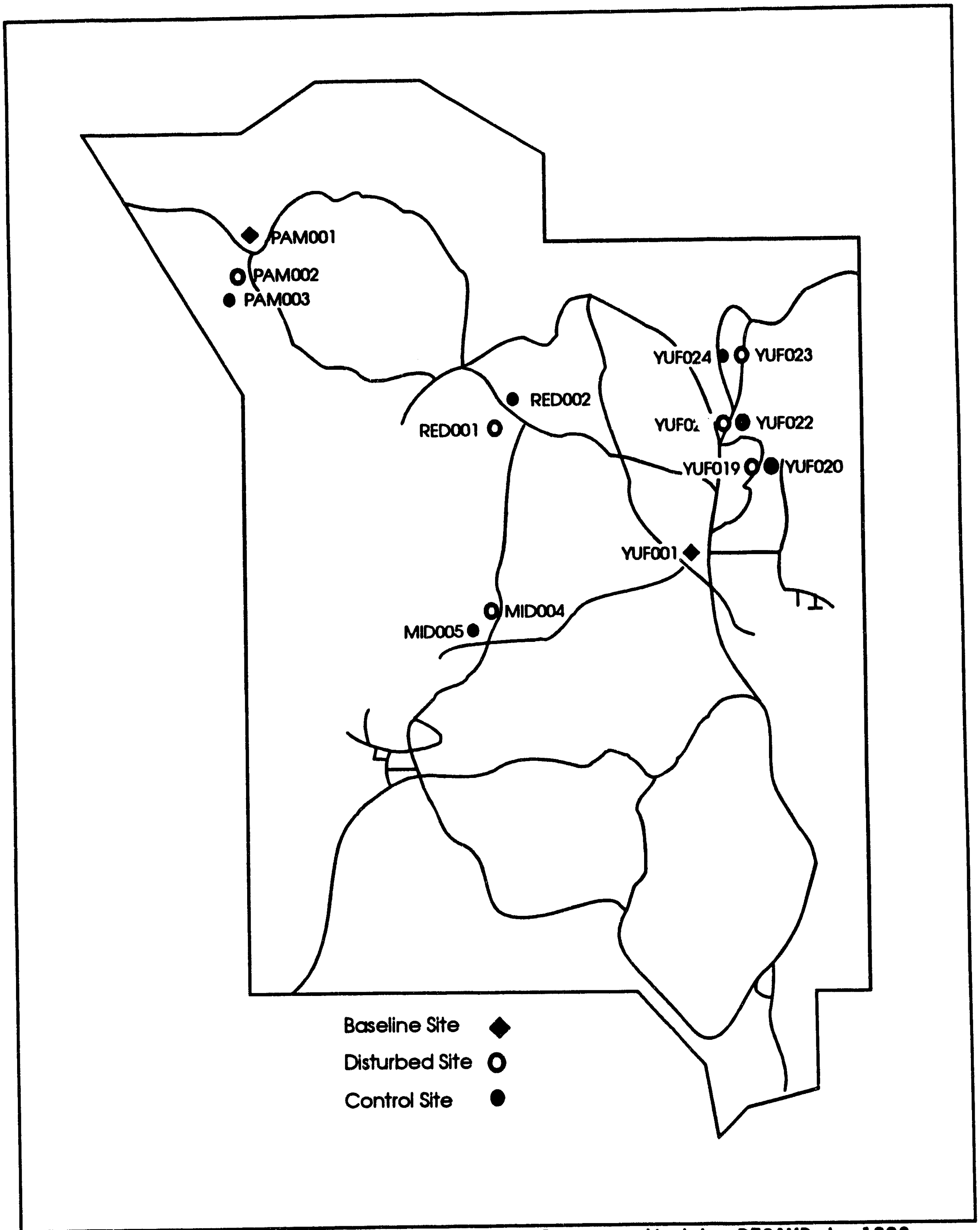


Figure 1 - Locations of small mammal plots studied by BECAMP in 1992.

cheek pouches and each animal was weighed to the nearest gram and released at the point of capture. A mean weight and standard error of the mean (sem) were calculated for each sex of two age classes (adult and juvenile) of the most common species captured. Mean weights were analyzed using analysis of variance (ANOVA, RS/1, BBN Software Products Corp., Cambridge, MA), while sex ratios and trap successes were compared by analyzing contingency tables with the chi-square (x^2) statistic. Unless otherwise indicated, degrees of freedom, df, equal one.

Disturbed Sites

Procedures on disturbed plots did not differ from the baseline monitoring procedure except for plot size. Each subsidiary plot was smaller (1.08 to 1.17 ha) with the grid configuration depending on the shape of the disturbed area. In general, 8 x 8 grid (1.10 ha) plots were used on disturbed sites while similarly-sized grids in adjacent undisturbed areas served as controls. At the U7au crater site, 7 x 9 grid configurations (1.08 ha) were used and on the Redrock areas, 14 x 5 grid were used (1.17 ha).

Density Estimation

The first night of the three nights of trapping was considered a preliminary trap night. The population size (N*) and a hypothetical variance (V) and standard error (SE) of the most commonly trapped species were estimated following Seber (1982:138) with data from the second and third nights of trapping. Calculations using the Seber formulas gave an estimate of population in number per plot (N*) plus or minus the standard error (SE). To estimate density in number of animals per hectare ± the standard error, N* and SE were both divided by the plot size in hectares, including a 7.5 m wide perimeter. Estimated standard errors of zero resulted when all of the animals captured on the last day were previously marked (no new animals), or when all of the previously marked animals were captured on the last day along with unmarked animals, if any.

Data used to estimate the population size and results of the Seber equations for all plots sampled in 1992 are listed in Appendix C. Because the variances are hypothetical and no degrees of freedom could be assigned, statistical tests for differences between estimated densities were not appropriate.

An overall "naive density" (number per hectare) was estimated for all animals captured on a site by dividing the total number of individuals captured by the adjusted grid size.

Species Diversity Index

The numbers of individuals in each species captured at a site were used to calculate a Shannon's species diversity index (H'). The Shannon formula (Zar 1984:33),

$$H' = \frac{n \times \log_{10}(n) - \Sigma[f_i \times \log_{10}(f_i)]}{n}$$

was used as an index of the species diversity at each site, where n is the total number of individuals captured at a site and f_i is the number of individuals of the ith species. A high value for H' indicates that a relatively large number of common species are residing at a location and a high diversity exists.

This index is useful in comparing a disturbed area on the NTS with a relatively undisturbed site, or even changes over time at the same site. A two-tailed t-test described by Zar (1984:146) was used to compare the species diversity at a disturbed site with its control or to compare the same site between different years. Any differences between two sites or changes over time in the species diversity may indicate a loss of diversity (a decrease in H') or an increase in maturity due to succession (increase in H') at a site.

LAGOMORPH CENSUS - TRANSECT LINES

Censuses for hares (*Lepus californicus*) and rabbits (*Sylvilagus* spp.) on the NTS were performed concurrently with the line transects for enumeration of lizards (see Woodward, this volume). Transects on the two baseline sites consisted of five parallel lines, 500 m long and 100 m apart. Each line was walked simultaneously by three observers, 7.5 m apart. When a rabbit or hare was observed, the flushing distance was estimated and recorded along with time of observation.

To obtain the density (D) in number per hectare, the following formula was used (Whitford 1973):

L = Total distance walked in the transect in meters

N = Number of flushes
r = Mean flushing distance in meters.

$$D = \frac{N}{2*r*L} * 10{,}000 \frac{m^2}{ha}$$

Estimated densities of a species were averaged for all days transects were walked (usually 5), and the standard error was calculated.

Species names appear in the results tables as the abbreviations listed in Table 1. Descriptions of the perennial and ephemeral plant compositions on

Table 1. Abbreviations, scientific, and common names of small mammals named in this report.

Abbreviation	Scientific Name	Common Name
RODENTIA		
Sciuridae		
AMM LEU	*Ammospermophilus leucurus*	White-tailed antelope squirrel
Heteromyidae		
CHA FOR	*Chaetodipus formosus*	Long-tailed pocket mouse
DIP MER	*Dipodomys merriami*	Merriam's kangaroo rat
DIP MIC	*Dipodomys microps*	Chisel-toothed kangaroo rat
DIP ORD	*Dipodomys ordii*	Ord's kangaroo rat
MIC MEG	*Microdipodops megacephalus*	Dark kangaroo mouse
PER LON	*Perognathus longimembris*	Little pocket mouse
PER PAR	*Perognathus parvus*	Great Basin pocket mouse
Muridae		
NEO LEP	*Neotoma lepida*	Desert woodrat
ONY TOR	*Onychomys torridus*	Southern grasshopper mouse
PER CRI	*Peromyscus crinitus*	Canyon mouse
PER ERE	*Peromyscus eremicus*	Cactus mouse
PER MAN	*Peromyscus maniculatus*	Deer mouse
PER TRU	*Peromyscus truei*	Pinyon mouse
REI MEG	*Reithrodontomys megalotis*	Western harvest mouse
LAGOMORPHA		
Leporidae		
LEP CAL	*Lepus californicus*	Black-tailed jack rabbit
SYL AUD	*Sylvilagus audubonii*	Desert cottontail rabbit
SYL NUT	*Sylvilagus nuttallii*	Nuttall's cottontail rabbit

all plots studied by BECAMP in 1992 are discussed in the ephemeral and perennial vegetation sections (Hunter, this volume) and should be referred to for a more detailed account of the flora on these sites.

RESULTS

Rodent populations in 1992 continued to recover from severe drought conditions during 1989 and 1990, when little or no ephemeral plants germinated and perennial plants were either dormant or dead. 1992 was a year of above average spring rainfall and hence abundant ephemeral vegetation was available and rodent populations of several species were the highest recorded since monitoring began in 1987. Results from sites studied in 1992 are summarized below according to plot type or disturbance.

BASELINE MONITORING SITES

Yucca Flat - YUF001

This site is on the western side of Yucca Flat at an elevation of 1237 m. It has a large number and diverse selection of plant species present, but is dominated by *Lycium andersonii* and *Grayia spinosa* (Beatley 1979). The soil surface at this site is predominantly desert pavement. YUF001 has the most complete trapping record from 1987 through 1992. During this time a trend in the small mammal population emerged which coincided with the local drought beginning in 1989 and recovery in 1991 (Figure 2).

During summer trapping in 1987 (28-30 July), 143 individual rodents were captured 283 times for a trap success of 32.8%. After trapping on 26-28 April 1988, 97 animals were captured a total of 192 times, a significantly lower trap success of 22.2% (x^2=24.043, 0<0.001). Trapping in April occurred before any juveniles were present in the population. In 1989, 53 different animals were captured on 9, 10, and 12 May a total of 105 times for a trap success of only 12.2%. This was again significantly lower than the previous year (x^2=30.773, $p<0.001$). On 16-18 May 1990, the trap success further decreased to a low of 7.6% (39 captured 66 times), which was significantly lower than 1989 (x^2=9.872, $0.001<p<0.005$). A significant increase (x^2=22.943, $p<0.001$) to 14.9% in trap success was seen in 1991 (62 captured 129 times) and another increase to 16.0% (85 individuals captured 184 times) in May 1992 (x^2=0.408, $0.50<p<0.75$).

While overall trap success increased in 1991 and 1992, only in 1991 did the individual trap success increase for the little pocket mouse, *Perognathus longimembris*. In 1992 this species fell into another decline (Figure 2, Table 2), with only eight individuals captured. Four of those were recaptures from 1988 and 1989. All of the *P. longimembris* captured at this site in May 1992 were captured within the southeast quarter of the plot. This site was trapped again on 24-25 June 1992 to determine whether or not the decrease in this species was real or was due to inactivity. Again, only eight animals were captured, with three of those being recaptures. However, the new animals were captured throughout the entire plot and two were juveniles.

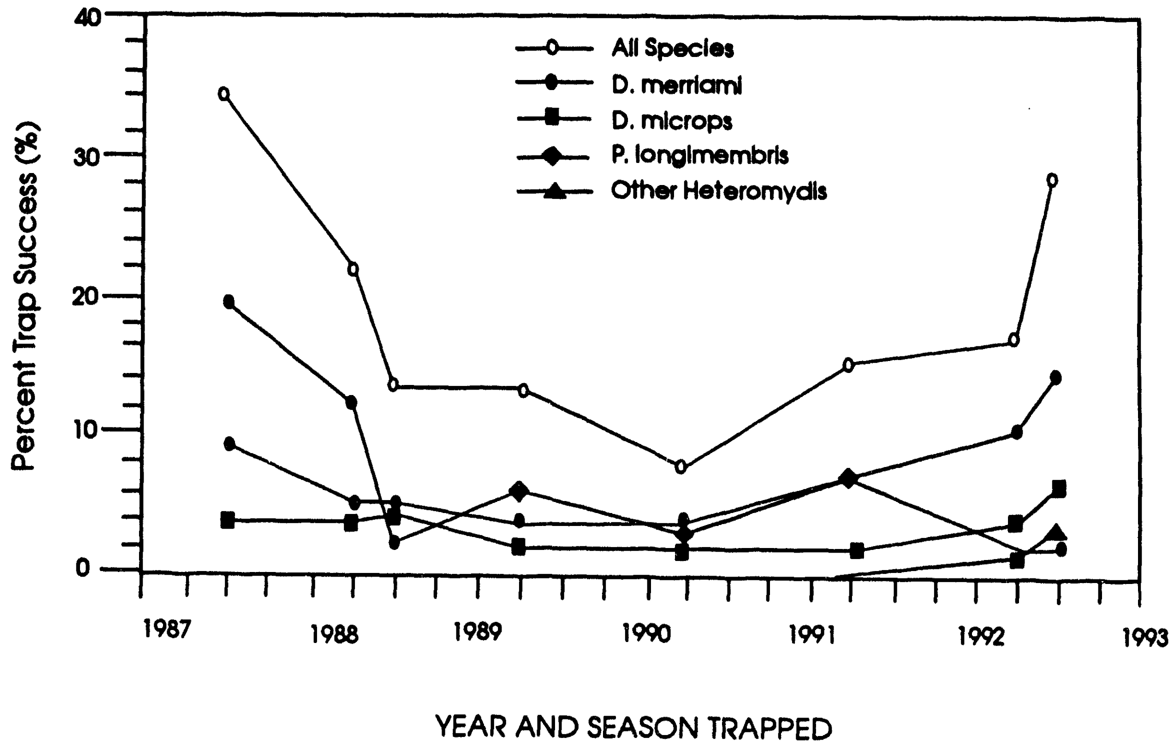
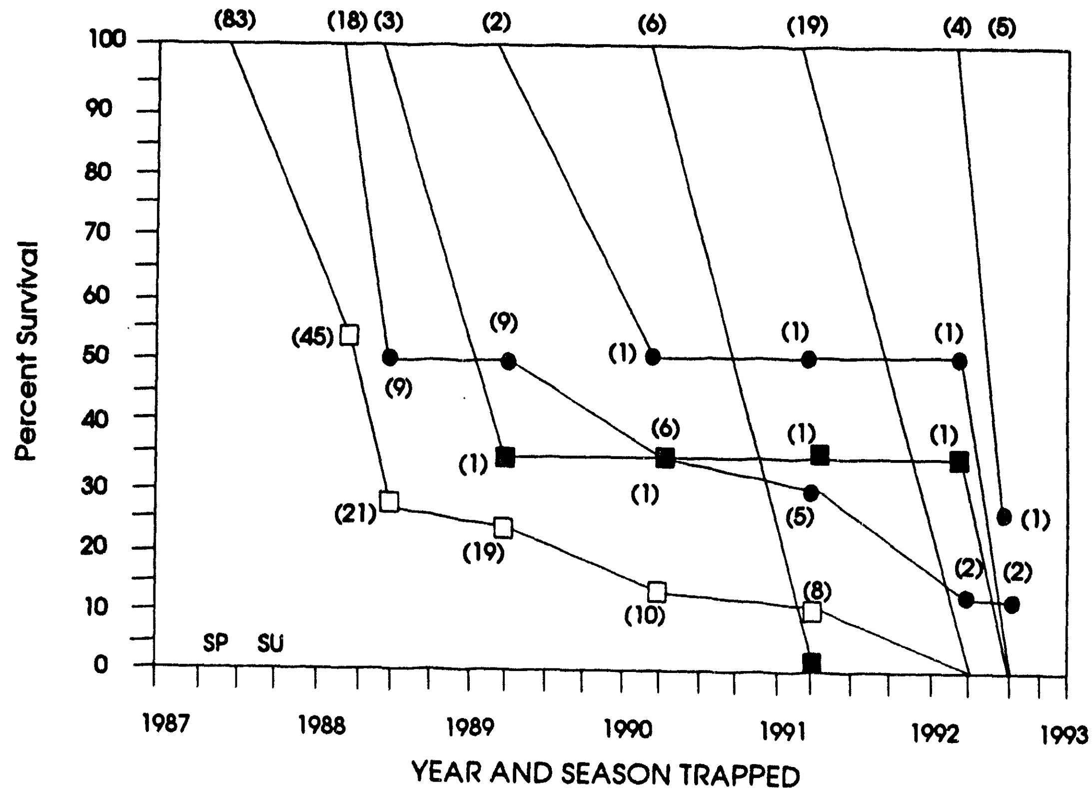


Figure 2 - Change in percent trap success at the Yucca Flat baseline site, YUF001, from 1987 through 1992. SP = Spring, SU = Summer.

It is possible that the relatively long life-span of this species, while contributing to the survival of this species at this site, was undermined by a lack of reproductive output or high dispersal from this site. This is supported by the fact that no animals captured in 1990 or 1992 were recaptured at this site one and two years later (Figure 3). Only two new *P. longimembris* individuals were captured at this site in 1989 and only 6 new in 1990. However, the number of *P. longimembris* recaptured in 1989 and 1990 were undercounted: in 1991 animals first captured in 1987 and 1988, but not captured in 1989 or 1990, were recaptured. An additional five animals were known to be alive in 1989 and another eight in 1990. However, this was within the density estimate 95% confidence interval for both years.



Note: Numbers in () are minimum known alive and may not equal individuals captured.

Figure 3 - Year-to-year survivorship of little pocket mice, *Perognathus longimembris*, as a percent of cohort size at the Yucca Flat baseline site in 1987 through 1992.

Estimates of spring density (number of animals per hectare ± two standard errors) for the most common rodents captured on YUF001 in 1988 through 1992 also indicated a continual reduction in the density at this site until 1991, when densities increased on this plot for two species--*Dipodomys merriami* and *Perognathus longimembris* (Table 2). Most noticeable was the 53% decrease in density of *P. longimembris* in 1989, and followed by a decrease of 9% in 1990, and a 61% increase in 1991. These results coincided with low rainfall in 1989 and 1990 and higher rainfall in 1988 and 1991.

While the densities of *D. merriami* and *P. longimembris* increased from 1990 to 1991, the estimated density of *Dipodomys microps* continued to decline until 1992, when the number of *D. microps* captured was the highest ever at this site. This species rarely has more than one reproductive cycle per year and uses green perennial vegetation for reproductive energy (Beatley 1969; Kenagy 1973). Sufficient late winter/early spring precipitation caused an adequate amount of annual plant germination in the spring of 1991 (Hunter in press) and 1992, however the standing live perennial biomass in 1991 might not have been sufficient for a successful reproductive season in *D. microps*. *D. merriami* and *P. longimembris* are able to gain water and food resources for reproduction from green material of annual plants, and may successfully reproduce for most of the active year (Bradley and Mauer 1971; Kenagy 1973).

The distribution of the total captured population among species for the six years (Table 3) changed dramatically. In 1987 and 1988, 92 and 93% of the captured population of animals consisted of the heteromyid rodents, *Dipodomys* spp. and *Perognathus longimembris*, with *P. longimembris* accounting for more than half of the total number of heteromyids captured. In 1989, the percentage of heteromyids captured decreased slightly to 85%, mainly due to a 50% decrease in the number individual *D. microps* and a 55% decrease in *P. longimembris* captures, while the number of murid rodents (*Onychomys torridus* and *Peromyscus maniculatus*) increased to 13% of the captured population. Furthermore, *D. merriami* decreased 35% in numbers of individuals captured from 1988 to 1989 (Table 2). In 1990 and 1991, almost all of the small mammals captured were heteromyids (92.3% and 98.4% respectively). However, in 1992, less than 10% were *P. longimembris*.

In 1992 heteromyids (including *Chaetodipus formosus*) accounted for 90.6% of the captured population in the spring and decreased to 79.8% during two days of summer trapping. At this time, however, *D. merriami* was the most prevalent heteromyid species captured. As a result of the change in species

Table 2. Estimated densities and species diversities (H') of small mammals on the BECAMP baseline plot in Yucca Flat from 1987 to 1992. Numbers in parentheses are individuals captured.

SPECIES	1987 28,29,30 JULY	1988 26,27,28 APRIL	1988 11 AUGUST	1989 9,10,12 MAY	1990 16,17,18 MAY	1991 7,8,9 MAY	1992 13,14,15,16 May	1992 24,25 JUNE
CHA FOR	---	---	---	---	---	---	2.3±0.5 (7)	3.5±1.4 (9)
DIP MER	9.8±0.3 (32)	5.2± 0 (17)	* (15)	3.4± 0 (11)	5.0±1.3 (14)	7.4± 0 (24)	15.1±1.7 (45)	15.2±0.9 (48)
DIP MIC	5.0±0.7 (16)	5.2±0.8 (16)	* (12)	2.7±0.7 (8)	2.3±1.0 (6)	1.2± 0 (4)	5.4±0.7 (17)	7.1±0.8 (22)
PER LON	27.8±2.4 (83)	19.0±1.8 (57)	* (7)	9.0±1.6 (26)	8.2±4.7 (16)	13.2±3.5 (33)	3.4±1.9 (8)	7.1±8.3 (8)
NEO LEP	---	---	---	---	---	---	---	* (1)
ONY TOR	* (9)	* (2)	* (4)	* (3)	* (3)	---	5.2±5.9 (7)	7.7±3.6 (17)
PER ERE	---	---	---	---	---	---	* (1)	* (2)
PER MAN	* (1)	---	---	* (4)	---	---	---	* (1)
REI MEG	---	---	* (1)	---	---	---	---	---
AMM LEU	* (2)	* (4)	---	* (1)	---	* (1)	---	* (1)
SYL AUD	---	* (1)	---	---	---	---	---	---
Totals	44.1 (143)	29.9 (97)	12.0 (39)	16.4 (53)	12.0 (39)	19.1 (62)	26.2 (85)	33.3 (109)
Species	6	6	5	6	4	4	6	9
H'	0.5057	0.5097	0.5932	0.6052	0.5292	0.4110	0.5840	0.6836

*Species present but data insufficient to estimate density.

distribution, species diversity, H′ (Table 2), decreased significantly in 1991 ($t=2.327$, $df=78$, $0.02<p<0.05$). A significant increase in species diversity occurred in 1992 ($t=3.229$, $df=146$, $0.001<p<0.002$).

Sex ratios (Table 3) for each species captured on YUF001 from 1987 to 1991 did not differ significantly from 1:1 (x^2, $p>0.05$) except in 1990 when 4 times as many female as male *P. longimembris* were captured ($x^2=6.25$, $0.01<p<0.025$). In May 1992, slightly more male *Dipodomys merriami* and significantly more male *Chaetodipus formosus* were captured ($x^2=3.756$, $0.05<p<0.10$ and $x^2=7.00$, $0.005<p<0.01$). This, however, was not the case in June 1992. Combining all species for each year, only in 1992 were significantly more males than females captured ($x^2=8.576$, $0.001<p<0.005$).

The mean weight of adult male *D. merriami* (Table 4) was significantly greater than that of adult female *D. merriami* in 1988 and 1989 (Saethre and Medica 1992; Saethre in press), but not in 1990, 1991, nor 1992 (ANOVA, $p>0.10$). The mean weight of adult male *Perognathus longimembris* (Table 4) did not differ significantly from the mean weight of adult females in 1988, 1989, or 1990, but males were significantly greater in 1991 (Saethre, 1994). In 1992, the three females were heavier than males (Table 4), and all were judged to be pregnant.

Pahute Mesa - PAM001

A baseline site on Pahute Mesa was first established in 1988. Small mammals were enumerated on 24, 28, 29 June and 19 August 1988, 20, 22, and 23 June 1990, and 30 June to 2 July 1992. This site is located at an elevation of 1923 m in sagebrush with young juniper trees (< 1 m) interspersed. The east end of this plot goes through a long sandy wash with older (>2 m) junipers, otherwise the surface is hard volcanic rock.

In 1988, a new species for this area was recorded (Medica 1990; Saethre and Medica 1992) when one dark kangaroo mouse, *Microdipodops megacephalus*, was captured near the wash (Table 5). This species was previously only captured off the NE edge of the NTS (Moor and Bradley 1974). Also in 1988, due to inexperience, no distinction could be made as to which species of *Peromyscus* were captured. In 1990 it was determined that the species were *P. crinitus*, the canyon mouse, *P. maniculatus*, the deer mouse, and *P. truei*, the pinyon mouse. One additional species, the cactus mouse, *P. eremicus*, was captured in

Table 3. Percent of total captured population (%T) and sex ratio (♂/♀ = male/female) of small mammals on the baseline plot, YUF001, 1987 to 1992.

SPECIES	JULY 1987 %T	JULY 1987 ♂/♀	APRIL 1988 %T	APRIL 1988 ♂/♀	AUGUST 1988 %T	AUGUST 1988 ♂/♀	MAY 1989 %T	MAY 1989 ♂/♀	MAY 1990 %T	MAY 1990 ♂/♀	MAY 1991 %T	MAY 1991 ♂/♀	MAY 1992 %T	MAY 1992 ♂/♀	JUNE 1992 %T	JUNE 1992 ♂/♀
CHA FOR	---	---	---	---	---	---	---	---	---	---	---	---	8.2	7/0	8.3	7/2
DIP MER	22.4	13/19	17.5	11/6	38.5	7/8	20.7	5/6	35.9	9/5	38.7	12/12	52.9	29/16	44.0	25/23
DIP MIC	11.2	9/7	16.5	9/7	30.8	5/6[a]	15.1	6/2	15.4	4/2	6.5	2/2	20.0	12/5	20.2	10/12
PER LON	58.0	44/39	58.8	27/30	18.0	3/4	49.1	13/13	41.0	3/13	53.2	14/19	9.4	5/3	7.3	7/1
NEO LEP	---	---	---	---	---	---	---	---	---	---	---	---	---	---	0.9	1/0
ONY TOR	6.3	2/7	2.1	2/0	10.3	2/2	5.7	2/1	7.7	2/1	---	---	8.2	2/5	15.6	6/11
PER ERE	---	---	---	---	---	---	---	---	---	---	---	---	1.2	1/0	1.8	1/1
PER MAN	0.7	0/1	---	---	---	---	7.5	3/1	---	---	---	---	---	---	0.9	0/1
REI MEG	---	---	---	---	2.6	1/0	---	---	---	---	---	---	---	---	---	---
AMM LEU	1.4	0/2	4.1	2/2	---	---	1.9	0/1	---	---	1.6	1/0	---	---	0.9[a]	
SYL AUD	---	---	1.0	I[b]	---	---	---	---	---	---	---	---	---	---	---	---
TOTALS	100.0	68/75	100.0	51/45	100.2	18/20	100.0	29/24	100.0	18/21	100.0	29/33	99.9	56/29	99.9	57/51

[a]One individual of unknown sex not included.
[b]One juvenile of indeterminate (I) sex was captured.

Table 4. Spring mean weights (grams ± 2 sem) by sex and age of heteromyid rodents captured on the Yucca Flat baseline plot in 1988 through 1992.

SPECIES	SEX	AGE	1988 N	1988 WEIGHT	1989 N	1989 WEIGHT	1990 N	1990 WEIGHT	1991 N	1991 WEIGHT	1992 N	1992 WEIGHT
CHA FOR	♂	A	0		0		0		0		7	21.0±1.2
PER LON	♂	A	27	8.3±0.3	13	7.6±0.5	3	8.5±1.0	14	8.4±0.3	5	9.1±0.8
	♀	A	30	8.0±0.2	13	7.6±0.3	13	8.0±0.5	19	7.7±0.3	3	12.0±1.2
DIP MER	♂	A	11	42.5±0.9	4	42.6±2.1	8	40.8±1.7	12	39.7±2.2	28	43.3±1.1
	♀	A	6	39.6±2.0	5	38.2±2.6	4	37.6±3.0	10	40.4±2.1	13	44.9±2.9
	♂	J	0		1	22.0	1	22.5	0		1	23.5
	♀	J	0		1	20.5	1	30.0	2	22.3±1.3	3	26.8±6.2
DIP MIC	♂	A	5	63.2±4.2	4	58.9±3.3	4	62.9±4.6	1	69.3	10	61.5±9.0
	♀	A	5	58.8±5.2	0		0		2	55.8±8.3	4	61.0±9.9
	♂	J	4	36.7±2.7	2	36.0±4.0	0		1	45.0	2	26.8±2.5
	♀	J	1	47.0	2	31.5±3.0	2	44.8±6.3	0		1	46.2

Table 5. Estimated density (N/ha ± 2 SE) and species diversity (H') of small mammals on the baseline site on Pahute Mesa in 1988, 1990, and 1992. N = individuals captured.

	June 1988		June 1990		June-July 1992	
SPECIES	DENSITY	N	DENSITY	N	DENSITY	N
DIP MIC	*	2	*	2	*	2
MIC MEG	*	1	*	3	---	
PER PAR	10.9±0.9	34	4.4±0.4	14	7.9±1.0	24
NEO LEP	*	2	*	1	2.3±1.0	6
PER CRI	---		*	1	*	1
PER ERE	---		---		3.6±0.6	11
PER MAN	---		1.7±0.7	5	12.4±1.2	38
PER TRU	---		*	1	*	2
PER SPP[a]	4.3±0.8	13	2.8±1.4	7	17.4±1.8	52
REI MEG	---		---		*	3
AMM LEU	*	1	---		---	
SYL NUT	*	1	---		---	
Totals	16.4	54	8.3	27	26.9	87
Species	7+		7		8	
H'	0.4828		0.6323		0.6531	

* Species present but data insufficient to estimate density.
[a]*Peromyscus* species combined.

1992. *Perognathus parvus* and *Peromyscus* spp. were the most commonly captured species in 1988 and 1990 (Table 6). In 1992, *Peromyscus* species appeared to be the most common with over twice as many individuals as *P. parvus*. Species diversity (H', Table 5) did not change significantly from 1988 to 1992 ($t=0.460$, $df=90$, $p>0.50$).

P. parvus is most often encountered in association with *P. maniculatus*, *Reithrodontomys*, and, in northern regions, *Onychomys leucogaster* (Verts and Kirkland, Jr. 1988). *P. parvus* and *P. maniculatus* are also most abundant in *Artemisia* (sagebrush) habitats of the Great Basin region (Kritzman 1974), although in *Artemisia/Atriplex* habitats of northeastern Nevada, *P. parvus* and *Dipodomys microps* are the ecologically widespread and abundant species (O'Farrell and Clark 1986). On the Pahute Mesa region of the NTS, it appears that the *Perognathus/Peromyscus* association is the most common. It is also noteworthy that while *P. parvus* is known to dominate and even attack *Microdipodops megacephalus* (Blaustein 1972), these two species were captured at the same trap location (but not the same trap) in 1988 and 1990.

Table 6. Percent of total captured population (%T) and sex ratio (♂/♀) of small mammals captured on the baseline site on Pahute Mesa (PAM001) in 1988, 1990 and 1992.

	1988		1990		1992	
SPECIES	%T	♂/♀	%T	♂/♀	%T	♂/♀
DIP MIC	3.7	1/1	7.4	1/1	2.3	1/1
MIC MEG	1.9	1/0	11.1	1/2	---	---
PER PAR	63.0	20/14	51.9	7/7	27.6	14/10
NEO LEP	3.7	2/0	3.7	1/0	6.9	5/1
PER CRI	---	---	3.7	0/1	1.1	0/1
PER ERE	---	---	---	---	12.6	5/6
PER MAN	---	---	18.5	2/3	43.7	23/15
PER TRU	---	---	3.7	1/0	2.3	0/2
PER SPP[a]	24.1	9/4	25.9	3/4	59.8	28/24
REI MEG	---	---	---	---	3.4	2/1
AMM LEU	1.8	1/0	---	---	---	---
SYL NUT	1.8	I[b]	---	---	---	---
Total	100.0	34/19	100.0	16/18	99.9	78/60

[a]*Peromyscus* species not differentiated.
[b]One juvenile of indeterminate sex (I) was captured.

Overall, as on the rest of the NTS, the number of animals captured on PAM001 declined from 1988 to 1990 and increased in 1992 (Table 5). The most common species captured in 1988, *Perognathus parvus*, was present in 1990 at less than half of the 1988 estimated density but rebounded in 1992 to 72% of the 1988 density (Table 5). Trap success was significantly lower in 1990 (x^2=17.123, p<0.001) and at 5.6% (48 captures) was also only 50% of the 1988 success (11%, 98 captures). The 19.2% trap success of 1992 (165 captures) was 1.7 times greater than in 1988 (x^2=17.068, p<0.001). Average captures per animal remained approximately equal between 1988 (1.85 times), 1990 (1.77 times), and 1992 (1.90 times).

While the total number of individuals captured decreased from 1988 to 1990 on PAM001, it appears that the decrease occurred over all of the species, with two of those, *Sylvilagus nuttallii* and *Ammospermophilus leucurus*, not even captured in 1990 or 1992. That the ground squirrel, *A. leucurus*, was not captured did not mean a disappearance of this species - it is diurnal and not regularly captured during night trapping on NTS. Capturing rabbits in the Sherman-type traps used is also rare. No rabbits were observed while walking transects at this site in 1990, but one was observed in 1992 (see Table 28).

In 1992, increases occurred over all species, with the exception of *Microdipodops megacephalus*, which was not captured in 1992.

Sex ratios (Table 6) of the most commonly captured species did not differ significantly from 1:1 (x^2, p>0.05), although the combined species sex ratio was significantly greater than 1:1 in 1988 (x^2=4.245, 0.025<p<0.05). Mean weights of the animals captured on the Pahute Mesa site were not significantly different between the three years (Table 7), although females of *P. maniculatus* and *Peromyscus* species overall were heavier in 1992 and were more noticeably reproductive (enlarged mammae).

Table 7. Summer mean weights (grams ± 2 sem) by sex and age of the common rodent species on the Pahute Mesa baseline site in 1988, 1990, and 1992.

			1988		1990		1992	
SPECIES	SEX	AGE	N	WEIGHT	N	WEIGHT	N	WEIGHT
PER PAR	♂	A	9	20.0±1.5	4	18.5±3.0	9	19.0±1.6
	♀	A	6	19.8±1.7	2	17.8±3.5	3	19.7±4.8
	♂	J	11	12.7±0.9	3	14.0±1.2	5	13.8±1.2
	♀	J	8	11.5±1.3	5	12.6±0.9	7	12.3±1.2
DIP MIC	♂	A	1	50.0	1	47.0	0	
	♀	A	0		1	46.0	0	
	♂	J	0		0		1	42.0
	♀	J	1	32.0	0		1	25.3
PER SPP[a]	♂	A	6	18.3±2.1	3	16.5±2.1	7	16.8±0.5
	♀	A	2	17.0±2.0	3	18.8±0.3	9	23.3±2.9
	♂	J	3	12.5±1.0	0		21	12.6±0.9
	♀	J	2	13.0±1.0	1	12.0	14	12.7±0.7
PER CRI	♀	A			1	19.0	1	31.0
PER ERE	♂	A			0		1	16.0
	♀	A			0		3	21.3±1.7
	♂	J			0		4	12.0±1.0
	♀	J			0		3	11.3±0.7
PER MAN	♂	A			2	15.8±2.5	6	16.9±0.5
	♀	A			2	18.8±0.5	4	21.3±1.7
	♂	J			0		17	12.7±1.0
	♀	J			1	12.0	10	12.8+0.7

Table 7, continued.

			1988		1990		1992	
SPECIES	SEX	AGE	N	WEIGHT	N	WEIGHT	N	WEIGHT
PER TRU	♂	A			1	18.0	0	
	♀	J			0		1	30.0
	♂	J			0		0	
	♀	J			0		1	15.7

DISTURBED AREAS

Subsidence Craters

Three subsidence craters in Yucca Flat were first studied in 1989 and again in 1992. Trapping grids inside the craters were constructed as close as possible to the center of each crater with the outer perimeter trap lines usually ending up on one slope of the craters. Corresponding control plots in relatively undisturbed habitat outside of and adjacent to the crater area were trapped at the same time. The three craters were of varying depth and diameter with distinctive vegetational differences between south and north facing slopes. However, the bottoms of all three craters resembled a small playa and had little vegetation, with the exception of a few small ephemeral plants, most noticeably *Salsola* spp. Depths, diameters, and test dates for the three craters are given in Table 8. Vegetation characteristics for the crater plots and controls are found in the Perennials, and Ephemerals reports. All three craters are on the northeastern side of Yucca Flat (Figure 1). However, plant communities (including species richness and cover) of the three control plots were dissimilar.

Table 8. Date of test and maximum depth and width of the three craters sampled by BECAMP in 1989.

CRATER (ID CODE)	DATE OF TEST	MAXIMUM DEPTH (m)	MAXIMUM WIDTH (m)
U3cn (YUF019)	13 Sept. 1963	25.0	393.2

Table 8, continued.

CRATER (ID CODE)	DATE OF TEST	MAXIMUM DEPTH (m)	MAXIMUM WIDTH (m)
U7au (YUF021)	27 Sept. 1978	15.7	398.4
U10af (YUF023)	7 Sept. 1967	22.7	347.5

U3cn crater - YUF019

U3cn (Bilby) crater was the southernmost crater studied by BECAMP. A road exists to the bottom of crater U3cn so that the 8 x 8 plot grid (1.10 ha) was actually on the southeast of the crater bottom (YUF019). A plot of equal size (YUF020) was located outside and to the east of the crater (Figure 4). At the bottom of U3cn is a ~1.5-m-diameter and 3-m-high casing pipe that has been repeatedly used as a nesting site by ravens, *Corvus corax*.

The most abundant species captured on the U3cn plots, *Dipodomys merriami*, decreased slightly in the crater and increased on the control from 1989 to 1992 (Table 9). Species diversity on the crater plot also decreased significantly in 1992 ($t=2.097$, $df=36$, $0.02<p<0.05$). There was essentially no change in H′ on the control ($t=1.150$, $df=35$, $0.20<p<0.50$). No clear trend emerged in animal abundance or species composition (Table 10) which might distinguish a crater from undisturbed habitat.

Percent trap success did not differ significantly between the U3cn crater plot 13%, 40 captures, and 6%, 23 captures) and its control (12%, 44 captures, and 9%, 36 captures) in 1989 or 1992 (1989: $x^2=0.269$, $0.50<p>0.75$ and 1992:$x^2=2.864$, $0.05<p<0.10$). This was surprising as the crater habitat was considerably less hospitable with less available cover (mostly dead shrubs, dead grasses, and *Atriplex canescens*) and hard-packed soil. Outside of the crater area the soil was sandy and plant volume was nearly 5 times that in the center of the crater (Hunter, this volume). Trap success decreased on both plots from 1989 to 1992, although significantly so only in the crater ($x^2=9.389$, $0.001<p<0.005$). This was unusual, as populations in most other areas studied in 1989 appeared to be depressed druing the drought and then

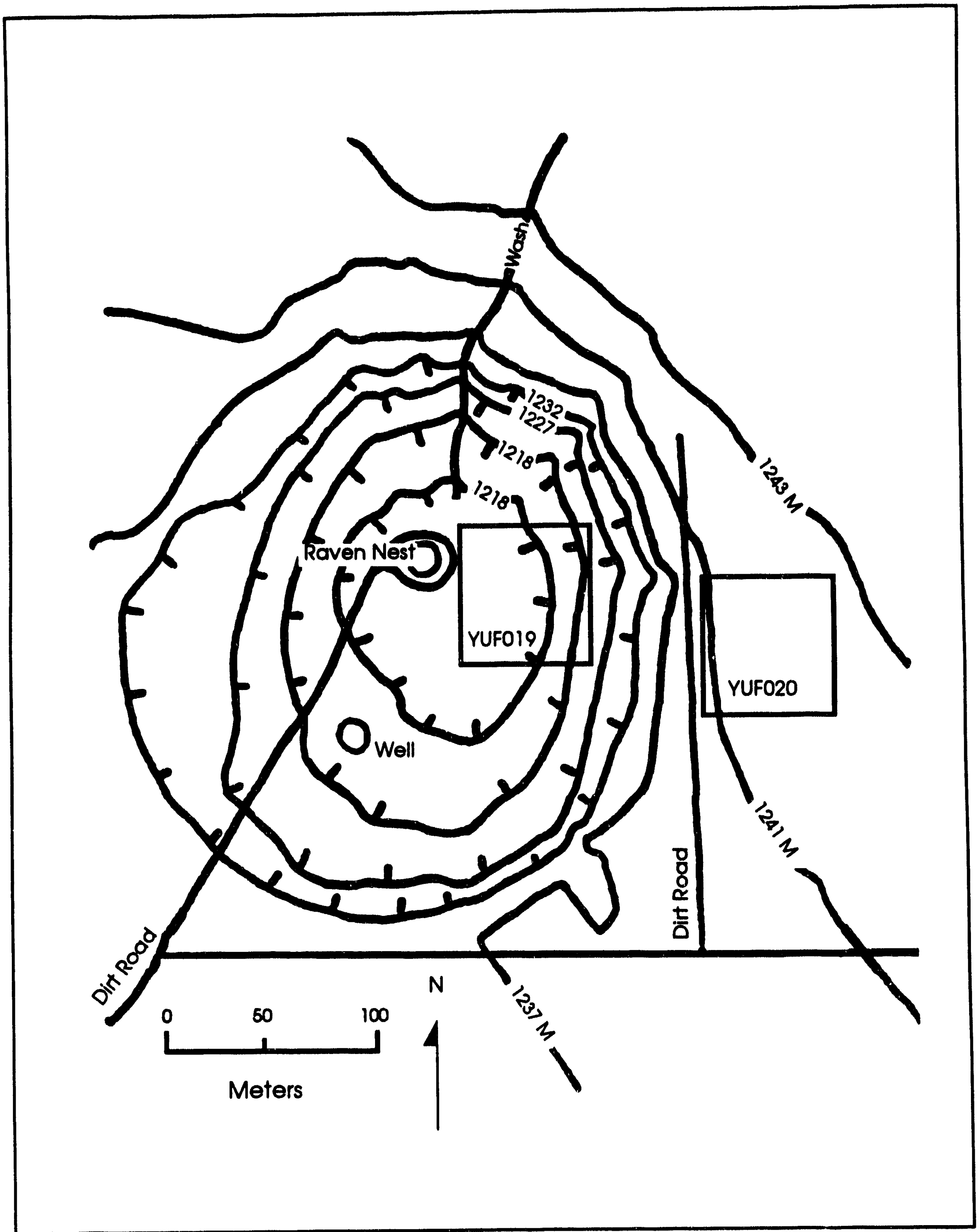


Figure 4 - Crater U3cn diagram.

Table 9. Estimated spring densities and species diversity (H') of small mammals on the U3cn crater area (YUF019) and control (YUF020) plots in 1989 AND 1992. N = individual animals captured.

	U3cn CRATER AREA - YUF019				UNDISTURBED AREA - YUF020			
	17-19 MAY 1989		19-21 MAY 1992		17-19 MAY 1989		19-21 MAY 1992	
SPECIES	DENSITY	N	DENSITY	N	DENSITY	N	DENSITY	N
DIP MER	12.0±0.8	17	9.7±1.8	13	9.3±1.0	13	13.9±2.7	18
DIP MIC	*	4	---		---		*	1
PER LON	---		---		6.0±1.4	8	*	3
ONY TOR	---		*	1	---		---	
PER MAN	*	1	---		*	1	---	
AMM LEU	*	1	---		---		---	
Totals	19.0	23	9.7	14	15.3	22	15.3	22
Species	4		2		3		3	
H'	0.3476		0.1129		0.2923		0.3076	

* Species present but data insufficient to estimate density.

increased in 1992 when conditions were more favorable. It was felt that the ravens nesting in the crater had an adverse effect on the rodent population in the crater and in the immediate vicinity. Regurgitated pellets collected at the base of the nest indicated that the majority of the ravens' diet was small vertebrates (Greger and Romney, 1994).

Heteromyid rodents comprised 95.5% of the total captured population on the control plot in 1989 (Table 10). Nearly all of the rodents captured on the crater plot were in edge traps located closest to relict stands of perennial vegetation that were growing on the slopes of the crater. Crater U3cn differed from the other craters in that large clumps of dead shrubs were sparsely distributed over 75% of the plot. Also present were several *Tamarix* (Salt ceder) trees growing in an extinct runoff channel from an old well. Although some vegetation is present at this site, the soil is hard-packed and therefore few rodent burrows are present on the crater bottom.

While males were captured more frequently than females, the ratios of males to females for the most abundant species (Table 10) in each year were not significantly different from 1:1 (x^2, p>0.05). Overall, significantly more males of all species were captured on the control plot in 1992 (x^2=6.545, 0.01<p<0.025). Although in 1992 *D. merriami* females on both plots were usually heavier than males (Table 11), there were no significant differences between mean weights of males and females on the U3cn plots between the crater and its control or between years (ANOVA, p>0.05).

Table 10. Percent of total captured population (%T) and sex ratio (♂/♀) of small mammals on the BECAMP U3cn crater site and control in Yucca Flat in 1989 and 1992.

	U3cn CRATER AREA - YUF019				UNDISTURBED AREA - YUF020			
	1989		1992		1989		1992	
SPECIES	%T	♂/♀	%T	♂/♀	%T	♂/♀	%T	♂/♀
DIP MER	73.9	12/5	92.9	8/5	59.1	10/3	81.8	13/5
DIP MIC	17.4	2/2	---	---	---	---	4.5	1/0
PER LON	---	---	---	---	36.4	4/4	13.6	3/0
ONY TOR	---	---	7.1	1/0	---	---	---	---
PER MAN	4.4	1/0	---	---	4.5	0/1	---	---
AMM LEU	4.3	0/1	---	---	---	---	---	---
TOTALS	100.0	15/8	100.0	9/5	100.0	14/8	99.9	17/5

Table 11. Spring mean weights (grams ± 2 sem) by sex and age of the heteromyid rodents captured at the U3cn crater site and control in Yucca Flat in 1989 and 1992.

			U3cn CRATER AREA - YUF019				UNDISTURBED AREA - YUF020			
			1989		1992		1989		1992	
SPECIES	SEX	AGE	N	WEIGHT	N	WEIGHT	N	WEIGHT	N	WEIGHT
PER LON	♂	A	0		0		3	8.0±0	3	10.7±0.7
	♀	A	0		0		1	7.0	0	
	♂	J	0		0		1	6.7	0	
	♀	J	0		0		3	6.0±0	0	
DIP MER	♂	A	10	42.2±3.0	8	43.0±2.5	8	41.8±2.1	13	44.1±1.8
	♀	A	4	42.2±3.0	5	48.9±8.8	3	40.3±3.5	4	45.5±6.8
	♂	J	2	30.2±1.0	0		2	21.0±2.0	0	
	♀	J	1	20.0	0		0		1	23.0
DIP MIC	♂	A	2	72.5±5.0	0		0		1	69.0
	♀	A	0		0		0		0	
	♂	J	0		0		0		0	
	♀	J	2	41.5±7.0	0		0		0	

U7au crater - YUF021

The crater U7au is relatively younger and shallower than the other two craters studied by BECAMP. This crater also contains a playa-like bottom, which regularly becomes a pond after rainshowers. The north and south slopes of this crater do not have as distinct differences in plants present as was found in the other craters studied. The north (south facing) slope also had many of the same species as were measured outside of the crater impact area (*Grayia spinosa*, *Lycium andersonii*, *Atriplex canescens*, *Artemisia spinescens*, and *Ceratoides lanata*). On all sides of this crater the slopes were steep, and a distinct break between relict habitat and disturbed area was evident.

Due to the shape of the available undisturbed habitat in the area studied a 9 x 7 (1.08 ha) grid was used instead of the usual 8 x 8 grid (Figure 5). This area was first trapped 25-27 April 1989 and again on 27-29 May 1992. The plots were trapped later in 1992 because it was thought that the low trap success in 1989 (2% on both plots) may have been due to low morning temperatures: a reading of 7° was common on the three mornings between 0630 and 0730 hours, while temperatures of 13 to 17° were more common at the other crater sites in 1989, trapped later in May.

While numbers of animals captured at U7au (YUF021) and its control (YUF022) in 1989 were too low to calculate densities in 1989, both sites showed increases in 1992 in both number of animals and number of species captured (Table 12). Animals in both years on the crater plot were captured on the edge rows of the plot, closest to relict plants. The majority of this plot was covered with

Table 12. Estimated densities (N/ha ± 2 SE) and species diversity (H') at the U7au crater site in 1989 and 1992. N = individuals captured.

	U7au CRATER AREA - YUF019				UNDISTURBED AREA - YUF020			
	APRIL 1989		MAY 1992		APRIL 1989		MAY 1992	
SPECIES	DENSITY	N	DENSITY	N	DENSITY	N	DENSITY	N
DIP MER	*	3	12.0±2.0	16	*	3	8.7±0.9	12
DIP MIC	---		---		*	1	*	1
NEO LEP	---		---		---		*	1
ONY TOR	---		*	2	*	2	*	1
PER ERE	---		---		---		*	1
PER MAN	*	2	*	1	---		---	
AMM LEU	---		*	1	*	1	---	
Totals	3.5	5	14.1	20	4.9	7	11.3	16
Species	2		4		4		5	
H'	0.2923		0.3076		0.5446		0.3947	

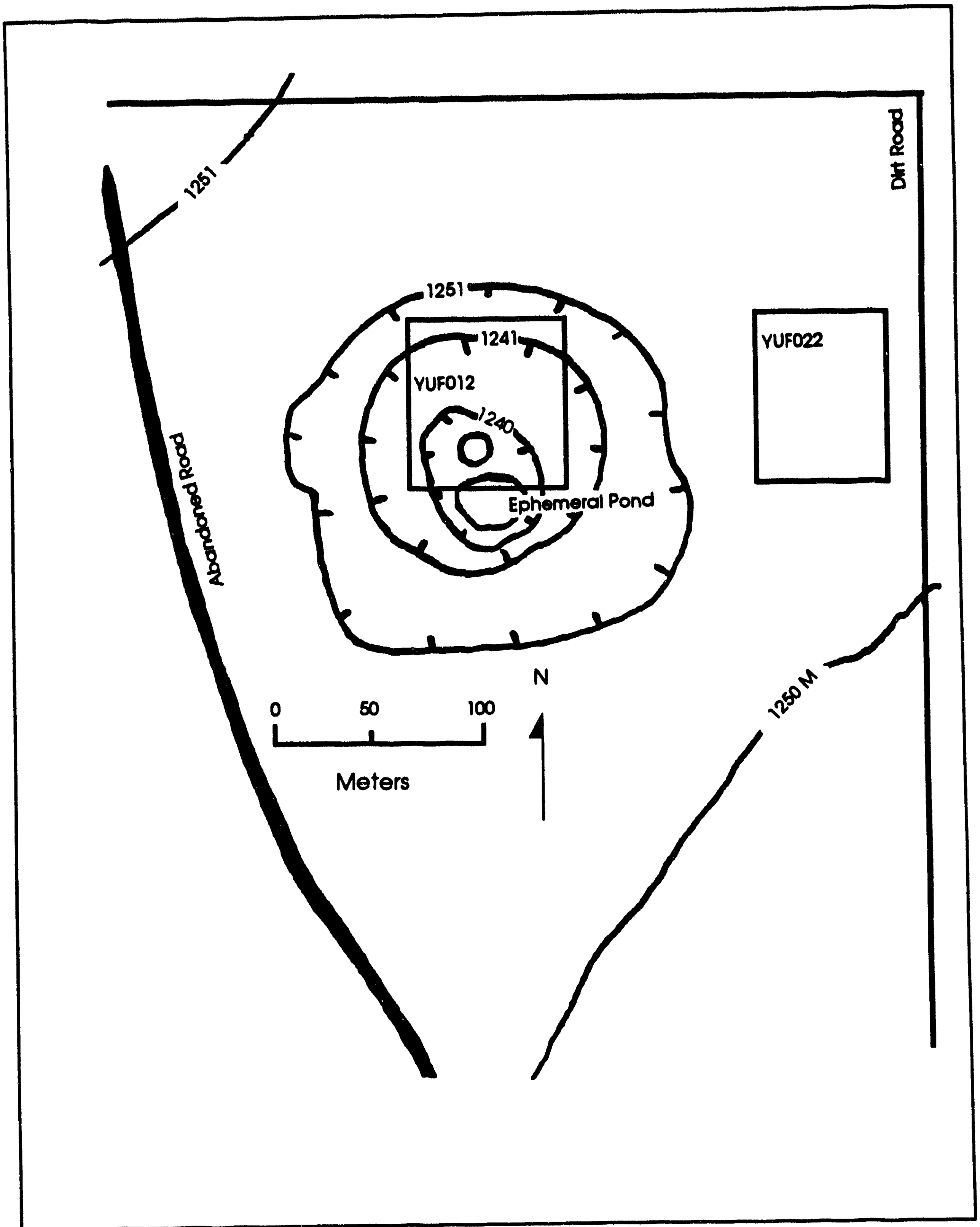


Figure 5 - Crater U7au site.

small annual plants, which provided almost no cover. Again, the surface in the center of the crater was hard and no rodent burrows were present.

Although the number of species captured in both plots increased, the species diversity on the undisturbed area actually decreased, but not significantly ($t=0.149$, $df=24$, $p>0.50$). This was because 75% of the animals captured in 1992 at this site were *Dipodomys merriami* (Table 13). Species diversity was significantly higher on the undisturbed plot in 1989 ($t=3.112$, $df=10$, $0.02<p<0.05$), but there was no significant difference between the two sites in 1992 ($t=1.292$, $df=33$, $0.20<p<0.50$).

Table 13. Percent of total captured population (%T) and sex ratio (♂/♀) of small mammals on the U7au crater site and undisturbed area in 1989 and 1992.

	U7au CRATER AREA - YUF021				UNDISTURBED AREA - YUF022			
	1989		1992		1989		1992	
SPECIES	%T	♂/♀	%T	♂/♀	%T	♂/♀	%T	♂/♀
DIP MER	60.0	2/1	80.0	11/5	42.9	3/0	75.0	9/3
DIP MIC	---	---	---	---	14.3	1/0	6.2	0/1
NEO LEP	---	---	---	---	---	---	6.2	0/1
ONY TOR	---	---	10.0	1/1	28.5	0/2	6.2	1/0
PER ERE	---	---	---	---	---	---	6.2	0/1
PER MAN	40.0	1/1	5.0	1/0	---	---	---	---
AMM LEU	---	---	5.0	0/1	14.3	0/1	---	---
TOTALS	100.0	3/2	100.0	13/7	100.0	4/3	99.8	10/6

Numbers of individuals captured were too small for statistical analysis of sex ratios (Table 13) and mean weight (Table 14) in 1989. In 1992, although slightly more males than females were captured at both sites, this was not significant (YUF021: $x^2=1.80$, $0.10<p<0.25$ and YUF022: $x^2=1.00$, $0.25<p<0.50$). Females captured in 1992 on both sites were also heavier than males captured in that year (Table 14). Trap success, while not significantly different between the crater and control in each year, increased significantly on both plots from 1989 to 1992 (YUF021: $x^2=12.737$, $0<0.001$ and YUF022: $x^2=9.757$, $0.001<p<0.005$).

Table 14. Spring mean weights (grams ± 2 sem) by sex and age of the heteromyid rodents captured at the U7au crater site and control in Yucca Flat in 1989 and 1992.

			U7au CRATER AREA - YUF021				UNDISTURBED AREA - YUF022			
			1989		1992		1989		1992	
SPECIES	SEX	AGE	N	WEIGHT	N	WEIGHT	N	WEIGHT	N	WEIGHT
DIP MER	♂	A	1	41.0	11	43.3±2.1	3	42.0±4.6	7	43.3±2.3
	♀	A	1	44.0	5	49.8±1.9	0		3	47.5±15.4
	♂	J	1	33.0	0		0		1	26.0
	♀	J	0		0		0		0	
DIP MIC	♂	A					1	59.3	0	
	♀	A					0		1	71.0
	♂	J					0		0	
	♀	J					0		0	

U10af crater - YUF023

The U10af crater was the northernmost crater studied and is approximately 100 m from a sanitary landfill. This dump was frequented by numerous ravens until burial procedures were improved in 1990. Since then, the number of ravens has decreased (Greger and Romney, 1994). The majority of the 8 x 8 grid lies on the bottom of the crater, with only the outer rows extending up the slope (Figure 6). Between 1989 and 1992, approximately 10 cm of soil was washed into the bottom of the crater, burying trap covers and moving stakes. While iron casing pipes are still present in the bottom of U3cn and U7au, none is apparent in U10af. The center of the crater had a thick cover of dead *Salsola* where rodents were rarely captured. The control for this plot, although located outside of the crater impact area, appeared to have been disturbed in the distant past. Shrub cover on the plot is low compared to other sites in Yucca Flat (R. B. Hunter, personal communication).

The crater plot (YUF023) and control (YUF024) had the highest densities of all crater plots in 1989, and this was also the case in 1992 (Table 15). The densities of kangaroo rats on the control did not change from 1989 to 1992. In the crater, however, density nearly doubled for *D. merriami*. Species diversity decreased significantly inside the crater ($t=2.554$, $df=60$, $0.01<p<0.02$) but showed no significant change on the control ($t=0.980$, $df=53$, $0.20<p<0.50$), although H' did decrease on this plot as well (Table 15).

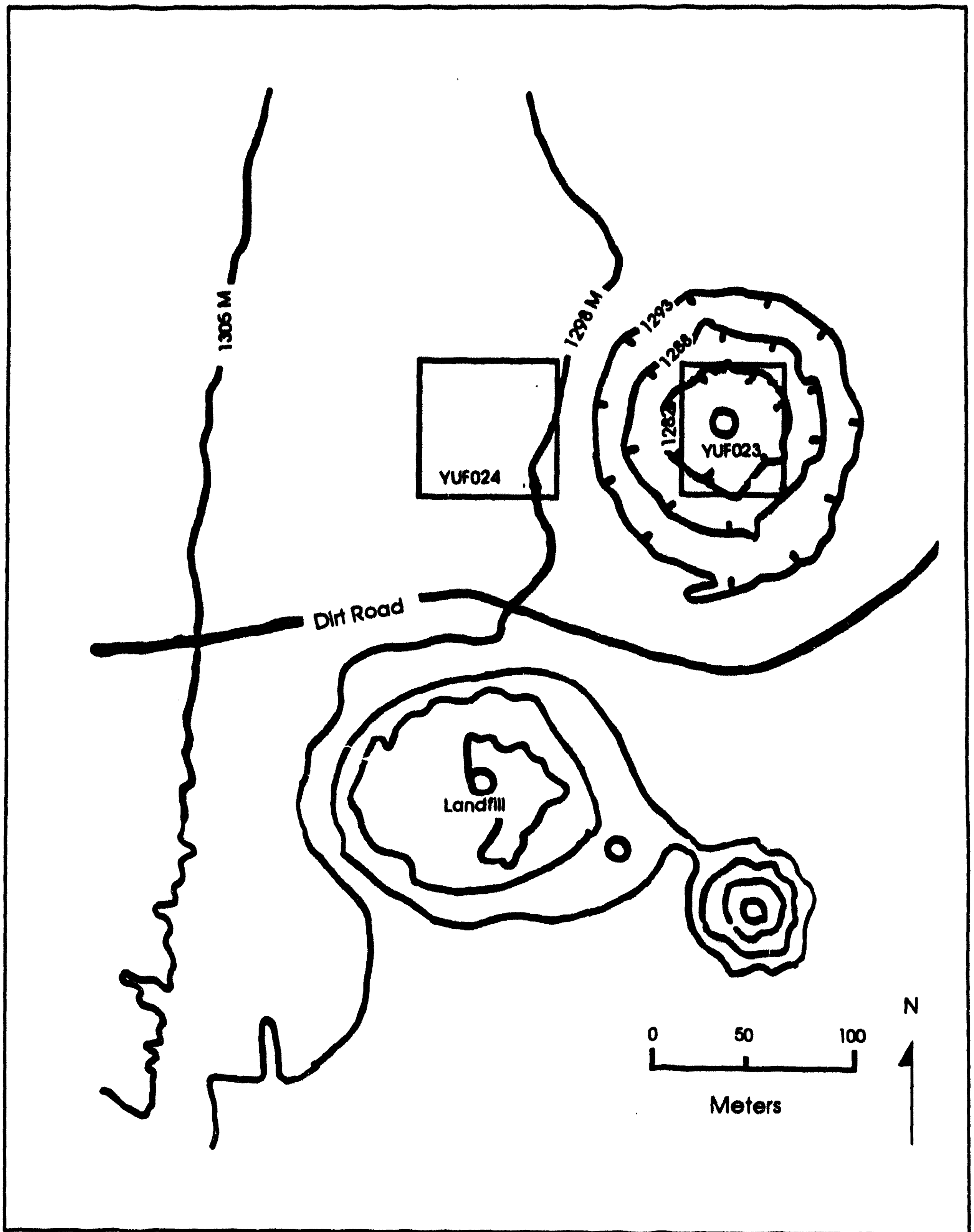


Figure 6 - Crater U10af site.

Table 15. Estimated spring densities and species diversity (H') of small mammals on the U10af crater area (YUF023) and control (YUF024) in 1989 and 1992. N = individuals captured.

	U10af CRATER AREA - YUF023				UNDISTURBED AREA - YUF024			
	23,31 MAY 1 JUNE 1989		2-4 JUNE 1992		23,31 MAY 1 JUNE 1989		2-4 JUNE 1992	
SPECIES	DENSITY	N	DENSITY	N	DENSITY	N	DENSITY	N
DIP MER	11.8± 0	17	21.3±1.3	30	24.3±5.0	31	25.2±0.8	36
DIP MIC	*	4	*	2	7.1±0.8	10	7.1±0.8	10
PER LON	*	1	---		*	1	---	
ONY TOR	---		---		*	1	*	2
PER MAN	*	4	*	1	*	3	---	
AMM LEU	*	1	*	1	---	---	*	1
Totals	18.8	27	23.6	34	31.9	46	34.0	49
Species	5		4		5		4	
H'	0.4783		0.2104		0.4092		0.3304	

*Species present but data insufficient to calculate density.

The majority of the animals captured on these two sites continued to be heteromyids. However, only kangaroo rats were caught - pocket mice were not captured at either site in 1992, while one animal was captured at each site in 1989 (Tables 15 and 16).

Table 16. Percent of total captured population (%T) and sex ratio (♂/♀) of small mammals on the U10af crater site and control in 1989 and 1992.

	U10af CRATER AREA - YUF023				UNDISTURBED AREA - YUF024			
	1989		1992		1989		1992	
SPECIES	%T	♂/♀	%T	♂/♀	%T	♂/♀	%T	♂/♀
DIP MER	63.0	11/6	88.2	13/17	67.4	18/13	73.5	20/16
DIP MIC	14.8	2/2	5.9	1/1	21.7	5/5	20.4	7/3
PER LON	3.7	1/0	---	---	2.2	0/1	---	---
ONY TOR	---	---	---	---	2.2	0/1	4.1	2/0
PER MAN	14.8	1/2[a]	2.9	1/0	6.5	2/1	---	---
AMM LEU	3.7	1/0	2.9	1/0	---	---	2.0	0/1
TOTALS	100.0	16/10	99.9	16/18	100.0	25/21	100.0	29/20

[a]One animal of undetermined sex not included.

As on the other crater sites in 1992, more males than females were captured at the U10af control (Table 17). However, this was not statistically significant x^2=1.653, 0.10<p<0.25). Adult mean weights of the most common species captured, *Dipodomys merriami*, were not significantly different between plots or years (ANOVA, p>0.05). However, more juveniles were captured in the crater in 1992 than in 1989.

Table 17. Spring mean weights (grams ± 2 sem) by sex and age of the heteromyid rodents captured at the U10af crater (YUF023) and undisturbed area (YUF024) in 1989 and 1992.

			U10af CRATER AREA - YUF023				UNDISTURBED AREA - YUF024			
			1989		1992		1989		1992	
SPECIES	SEX	AGE	N	WEIGHT	N	WEIGHT	N	WEIGHT	N	WEIGHT
DIP MER	♂	A	10	42.8±1.9	12	43.4±1.4	13	39.1±1.9	19	42.8±1.9
	♀	A	6	39.8±3.4	11	40.1±2.8	11	40.0±2.5	12	43.1±3.1
	♂	J	1	32.5	1	17.0	4	24.7±2.6	1	22.5
	♀	J	0		6	20.5±5.3	2	26.7±6.7	4	20.8±4.6
DIP MIC	♂	A	1	65.0	1	52.3	3	53.8±3.7	5	59.9±7.0
	♀	A	1	55.3	1	No weight	5	49.2±7.2	3	58.1±7.2

Trap success was significantly higher on the control in both years (1989: x^2=16.609, p<0.001 and 1992: x^2=6.968, 0.005<p<0.01). Number of individuals captured increased from 90 in 1989 to 111 in 1992 on the control (x^2=2.194, 0.10<p<0.25) and significantly on the crater from 43 to 75 (x^2=8.678, 0.001<p<0.005).

BLADED AREAS

Two areas scraped of all vegetation were studied in 1989 and again in 1992. One area in Mid Valley, MID004, was trapped for small mammals on 6-8 June 1989 and 9-11 June 1992. This was a bladed area of approximately 40 ha that was cleared in the early 1980s and abandoned in 1984. The other site, PAM002, was adjacent to a drill pad for an underground test in 1985, U20ao, on Pahute Mesa. For this test, an area of approximately 17 ha was cleared in the early 1980s for support trailers. This cleared area was sampled 8-10 August 1989 and 21-23 July 1992. The soil surfaces on both sites were scraped and hence all vegetation removed before the commencement of testing activity. A control plot for each bladed area was constructed in nearby undisturbed vegetation.

The two control areas were vastly different habitats, and therefore had different species of animals present. The Mid Valley site is located at an elevation of 1439 m. The soil in this area is rocky and vegetation consists primarily of *Coleogyne ramosissima*. The plant community near the Pahute Mesa bladed area is almost entirely *Artemisia tridentata* and is located at an elevation of approximately 1910 m.

Mid Valley

In 1989, the scraped area at this site contained almost no vegetational cover. In the summer of 1992, however, this site was covered with *Sisymbrium altissimum* (an annual) which although dead, was 45 to 50 cm high. The exception to this cover was on the eastern side of the plot, where a hard packed area from an old road (or dragline) exists and remained bare of vegetation. Evidence of erosion at this site was present and several stakes were located over 45 m from their proper location, either due to wind or water movement. The hard-packed soil made stake placement difficult, although several rodent burrows were present.

Peromyscus maniculatus, was the most common species captured at the Mid Valley bladed area in 1989 with three individuals (Table 18), or 37% of the total captured population (Table 19). In 1992, it appeared that *P. maniculatus* and *Dipodomys merriami* were co-dominants at this site. *Chaetodipus formosus* (17 animals) was the most abundant rodent in the undisturbed area in Mid Valley in both 1989 and 1992 (Table 18). Species diversity was not significantly greater on the Mid Valley control site (MID005) than on the bladed site in 1989 or 1992, but H′ did increase significantly on the bladed area ($t=3.136$, $df=10$, $0.01<p<0.02$).

Individual animals captured on the cleared area more than tripled in 1992 (from 8 to 28), while fewer were caught on the undisturbed site in 1992 (from 47 down to 38). One *P. maniculatus* moved from the undisturbed area to the bladed area in 1992, approximately 100 m away. Percent trap successes were

Table 18. Estimated densities and species diversity of small mammals captured on the Mid Valley bladed (MID004) and undisturbed (MID005) plots in 1989 and 1992. N = number of individuals captured.

	BLADED AREA (MID004)				UNDISTURBED (MID005)			
	1989		1992		1989		1992	
SPECIES	DENSITY	N	DENSITY	N	DENSITY	N	DENSITY	N
CHA FOR	---		*	1	12.9±2.3	17	14.8±4.8	17
DIP MER	*	1	5.6± 0	8	6.4±0.6	9	*	1
DIP MIC	*	1	3.0±0.9	4	6.1±1.6	8	*	2
PER PAR	*	2	3.0±0.9	4	---		*	3
NEO LEP	---		---		---		*	1
ONY TOR	---		*	2	*	1	*	4
PER ERE	---		*	2	---		*	3
PER MAN	*	3	6.3±3.1	7	4.3±0.7	7	5.6±3.4	6
PER TRU	*	1	---		3.9+1.5	5	---	
REI MEG	---		---		---		*	1
Totals	5.6	8	19.4	28	32.7	47	26.4	38
Species	5		7		6		9	
H'	0.6489		0.9526		0.6904		0.7519	

*Species present but data insufficient to estimate density.

Table 19. Percent of total captured population and sex ratio of small mammals captured on the BECAMP monitoring plot on a scraped area (MID004) and control (MID005) in Mid Valley in 1989 and 1992.

	MID VALLEY BLADED AREA - MID004				UNDISTURBED AREA - MID005			
	1989		1992		1989		1992	
SPECIES	%T	♂/♀	%T	♂/♀	%T	♂/♀	%T	♂/♀
CHA FOR	---	---	3.6	0/1	36.2	13/4	44.7	12/5
DIP MER	12.5	0/1	28.6	7/1	19.2	6/3	2.6	1/0
DIP MIC	12.5	1/0	14.3	1/2*	17.0	5/3	5.3	2/0
PER PAR	25.0	1/1	14.3	4/0	---	---	7.9	1/1*
NEO LEP	---	---	---	---	---	---	2.6	0/1
ONY TOR	---	---	7.1	1/1	2.1	0/1	10.5	1/2*
PER ERE	---	---	7.1	1/1	---	---	7.9	2/1
PER MAN	37.5	1/2	25.0	3/4	14.9	4/3	15.8	4/2
PER TRU	12.5	1/0	---	---	10.6	2/2*	---	---
REI MEG	---	---	---	---	---	---	2.6	0/1
TOTALS	100.0	4/4	100.0	17/10	100.0	30/16	99.9	23/13

*One animal of undetermined sex not included.

3.7%, 14 captures, and 24.7%, 95 captures, on the Mid Valley bladed and control area respectively in 1989 (x^2=60.193, p<0.001) and increased significantly on the bladed area in 1992 to 12.0%, 46 captures (x^2=17.067, p<0.001) but decreased on the control to 14.8%, 57 captures (x^2=9.500, 0.005<p<0.001). Trap success was not significantly higher on the undisturbed than on the bladed area in 1992 (x^2=1.175, 0.25<p<0.50).

After analyzing sex ratios for the most commonly captured species on the bladed plots and controls (Table 20), the only species which differed significantly from a 1:1 ratio in 1989 was the long-tailed pocket mouse, *Chaetodipus formosus*: on the Mid Valley control plot, over three times as many males were captured than females (x^2= 4.765, 0.025<p<0.05). In 1992, the number of male *Dipodomys merriami* captured on the bladed area was significantly greater than the number of females (x^2= 4.500, 0.025<p<0.05).

Table 20. Mean weights (grams ± 2 sem) by sex and age of the most common rodents captured on the Mid Valley bladed area and control in 1989 and 1992.

			MID VALLEY BLADED - MID004				UNDISTURBED AREA - MID005			
			1989		1992		1989		1992	
SPECIES	SEX	AGE	N	WEIGHT	N	WEIGHT	N	WEIGHT	N	WEIGHT
CHA FOR	♂	A	0		0		11	19.0±1.0	8	17.0±2.2
	♀	A	0		0		3	18.9±1.6	3	17.0±5.0
	♂	J	0		0		2	8± 0	4	14.11.3
	♀	J	0		1	14.0	1	10.0	2	13.0± 0
DIP MER	♂	A	0		7	44.9±3.4	4	39.4±7.3	1	50.0
	♀	A	1	36.7	1	60.0	3	41.7±5.9	0	
	♂	J	0		0		2	25.7±0.7	0	
	♀	J	0		0		0		0	
DIP MIC	♂	A	1	59.0	1	71.3	3	62.7±6.8	1	61.3
	♀	A	0		1	43.5	1	56.5	0	
	♂	J	0		0		2	47.5±5.0	1	35.3
	♀	J	0		1	34.0	2	44.0±4.0	0	
PER PAR	♂	A	1	19.0	4	20.1±0.2	0		1	19.0
	♀	A	1	15.3	0		0		1	20.5
PER MAN	♂	A	0		2	19.5±1.0	0		3	19.6±3.7
	♀	A	1	18.0	3	21.8±0.2	1	18.0	2	18.0±10.0
	♂	J	1	10.0	1	15.0	4	13.4±2.7	1	11.0
	♀	J	1	15.5			2	12.8±2.4	0	

Pahute Mesa

Vegetation on the scraped area at PAM002 consisted primarily of a sparse cover of the annual species *Salsola australis* and *Halogeton glomeratus*. Several pieces of remaining construction material (wooden boards and pipes) showed evidence of utilization by rodents (burrowing under and tracks). Estimated densities of the most commonly captured rodents and presence of other species on this site increased dramatically from 1989 to 1992 (Table 21). The most abundant species on the Pahute Mesa bladed area in both years was Ord's kangaroo rat, *Dipodomys ordii*. It was also captured on the control, PAM003, but in low numbers. It was not captured on the Pahute Mesa baseline plot approximately 1 km to the north, studied in 1988, 1990, and 1992 (Saethre and Medica 1992; Saethre, 1994; this report, Table 5).

Table 21. Estimated density and species diversity (H') of small mammals on the BECAMP subsidiary plots on a bladed site and control on Pahute Mesa in 1989 and 1992. N = individuals captured.

	BLADED AREA (PAM002)				UNDISTURBED (PAM003)			
	1989		1992		1989		1992	
SPECIES	DENSITY	N	DENSITY	N	DENSITY	N	DENSITY	N
DIP MER	---		---		---		*	3
DIP MIC	---		*	1	*	1	2.8± 0	4
DIP ORD	9.5±1.4	13	14.1±0.7	20	*	2	*	1
PER PAR	---		---		4.2±0	6	8.6±2.2	11
NEO LEP	---		---		---		*	1
ONY TOR	---		---		---		*	2
PER ERE	---		*	1	---		7.3±1.3	10
PER MAN	*	2	*	3	9.7±1.7	12	27.8±4.0	36
AMM LEU	---		---		---		*	1
SYL AUD	---		---		---		*	2
Totals	10.4	15	16.7	25	14.6	21	49.3	71
Species	2		4		4		10	
H'	0.1705		0.2999		0.4567		0.8298	

*Species present but data insufficient to estimate density.

The most abundant species captured on the control plot on Pahute Mesa was *Peromyscus maniculatus*, which comprised 57% of the total captured population in 1989 and 51% in 1992 (Table 22). As on the PAM001 site, this species was present at slightly higher numbers than were *P. parvus* and *P. eremicus*. The control site on Pahute Mesa had a significantly greater species diversity than the bladed area in both years ($t=2.897$, $df=36$, $p<0.01$ in 1989 and $t=4.742$, df=72, p<0.001 in 1992). Species diversity also increased significantly on the control area from 1989 to 1992 (t=3.701, df=70, p>0.001).

Table 22. Percent of total captured population (%T) and sex ratios (♂/♀) of small mammals captured on the Pahute Mesa bladed area and control in 1989 and 1992.

	BLADED AREA - PAM002				UNDISTURBED AREA -PAM003			
	1989		1992		1989		1992	
SPECIES	%T	♂/♀	%T	♂/♀	%T	♂/♀	%T	♂/♀
DIP MER	---	---	---	---	---	---	4.2	1/2
DIP MIC	---	---	4.0	1/0	4.8	1/0	5.6	1/3
DIP ORD	86.7	6/7	80.0	11/9	9.5	1/1	1.4	1/0
PER PAR	---	---	---	---	28.6	3/3	15.5	4/7
NEO LEP	---	---	---	---	---	---	1.4	1/0
ONY TOR	---	---	---	---	---	---	2.8	0/2
PER ERE	---	---	4.0	1/0	---	---	14.1	5/5
PER MAN	13.3	0/2	12.0	1/2	57.1	5/7	50.7	21/15
AMM LEU	---	---	---	---	---	---	1.4	0/1
SYL AUD	---	---	---	---	---	---	2.8	*
TOTALS	100.0	6/9	100.0	14/11	100.0	10/11	99.9	44/35

*Juveniles of undetermined sex.

Fifteen animals were captured 30 times on the Pahute Mesa drill pad plot in 1989 (7.8% trap success). This increased to 25 individuals captured 54 times in 1992 (14.1%). Twenty-one animals were captured 44 times on the control in 1989 (11.5%) and this number more than tripled in 1992 to 72 individuals captured 137 times (35.2% trap success). Trap success on the bladed plot nearly doubled from 1989 to 1992 (x^2=6.857, 0.005<p<0.01) and tripled on the control x^2=46.263, p<0.001). Trap success was higher on the undisturbed area in both years, but only significantly in 1992 (x^2=34.714, p<0.001).

Mean weights for the most common species captured (Table 23) indicated a sharp increase in the juveniles of all species at both sites. Numbers of animals were too few for any statistical analysis.

Table 23. Mean weights (grams ± 2 sem) by sex and age of heteromyid rodents captured on the Pahute Mesa bladed area (PAM002) and control (PAM003) on the NTS in 1989 and 1992.

			BLADED - PAM002				UNDISTURBED AREA - PAM003			
			1989		1992		1989		1992	
SPECIES	SEX	AGE	N	WEIGHT	N	WEIGHT	N	WEIGHT	N	WEIGHT
DIP MER	♂	A	0		0		0		0	
	♀	A	0		0		0		1	32.0
	♂	J	0		0		0		1	30.0
	♀	J	0		0		0		1	19.0
DIP MIC	♂	A	0		0		1	60.0	1	65.0
	♀	A	0		0		0		3	63.2±2.8
	♂	J	0		1	36.3	0		0	
	♀	J	0		0		0		0	
DIP ORD	♂	A	6	47.8±2.7	6	45.3±2.1	0		1	64.0
	♀	A	4	45.9±2.7	7	43.5±1.5	0		0	
	♂	J	0		5	34.6±2.8	1	39.0	0	
	♀	J	1	35.0	2	34.8±6.5	1	32.0	0	
PER PAR	♂	A	0		0		3	19.7±2.1	3	18.0±1.2
	♀	A	0		0		1	16.7	4	19.4±0.5
	♂	J	0		0		0		1	15.0
	♀	J	0		0		2	15.7±0.7	3	15.3±1.1
PER ERE	♂	A	0		0		0		1	17.3
	♀	A	0		0		0		2	18.3±2.5
	♂	J	0		1	10.0	0		4	9.5±1.4
	♀	J	0		0		0		3	7.7±0.3
PER MAN	♂	A	0		0		3	17.1±2.5	5	16.1±2.6
	♀	A	2	18.5±4.2	2		4	14.1±1.5	6	18.4±0.8
	♂	J	0		1	12.0	1	13.0	16	13.4±0.6
	♀	J	0		0		3	13.7±7.2	8	12.9±1.3

BURNED AREAS

Redrock Valley

Small mammals on the burned area in Redrock Valley (RED001) and its control (RED002) were trapped on 26-28 July 1988 (six days after a brush fire), 25-27 July 1989 (one year after the fire), 31 July - 2 August 1990 (two years after the fire) and 14-16 July 1992 (four years after fire) for a total of 420 trap nights each year. This sandy site is located in a narrow valley at an elevation of 1612 m and slopes gently to the south. The dominant vegetation at the undisturbed site (and presumably before the fire) was *Atriplex canescens*. After the fire, several *Atriplex* and *Ephedra nevadensis* shrubs remained in isolated patches, but the area was immediately invaded by *Salsola*. Indian rice grass, *Oryzopsis hymenoides*, was also present on the burned area in 1992, and the area was extensively utilized by feral horses as a summer foraging area in 1992.

Estimated summer densities and species present on the plot in the burned area and a control in an unburned area for 1988, 1989, 1990, and 1992 are given in Table 24. The number of kangaroo rats (*Dipodomys* spp.) increased on both plots from 1988 to 1989 but decreased from 1989 to 1990 then increased again in 1992. The estimated density of pocket mice (*Perognathus* spp.) decreased from 1988 to 1989 on both plots and none were captured on the burned site in 1990 or 1992. Two species captured in 1988 but not in 1989 and 1990 were *Chaetodipus formosus* (found on both plots in 1988) and *Sylvilagus audubonii* (found on the control plot in 1988). *P. parvus* was not captured on either plot in 1990, and *Onychomys torridus* was not captured in 1990 on the burned area, despite an abundance of ants on this site. An additional species, a gopher, *Thomomys bottae*, was captured on the burned area on 9 July 1993. *Dipodomys ordii* was not captured during July in 1988 but was captured in the burned area during August (four animals) and October (two animals) of that year (Saethre and Medica 1992). This species was captured for the first time on the control in 1992.

Species diversity (H′) decreased significantly on the burned site from 1989 to 1990 ($t=3.115$, $df=45$, $p<0.001$) and increased in 1992, but not significantly ($t=1.504$, $df=42$, $0.10<p<0.20$). H′ on the burned site in 1992 was significantly lower than H′ in 1988 ($t=2.878$, $df=96$, $0.002<p<0.005$). Although H′ also decreased on the control from 1989 to 1990, it was not significant ($t=1.697$, $df=93$, $0.05<p<0.10$). An increase on the control in 1992 was, however, significant ($t=2.985$, $df=92$, $0.002<p<0.005$). Species diversity was significantly lower on the burned area in 1992 than on the undisturbed area ($t=3.584$, $df=197$, $p<0.001$).

The number of individuals captured on both plots was highest in 1992 and lowest in 1990. Trap success was significantly higher in 1992 - 42% on the burned area and 43% on the undisturbed plot. Trap success was only 16% in 1990 on the burned plot and 23% on the control. The trap success on the

Table 24. Estimated July density and species diversity of small mammals on the burned area and undisturbed site in Redrock Valley during 1988, 1989, 1990, and 1992. Numbers in parentheses are individuals captured.

	REDROCK VALLEY BURN - RED001				UNDISTURBED - RED002			
SPECIES	1988	1989	1990	1992	1988	1989	1990	1992
CHA FOR	* (2)	---	---	---	* (1)	---	---	* (1)
DIP MER	15.4±1.6 (24)	19.7±0.3 (31)	14.1±0.7 (22)	48.4±4.9 (69)	21.0±2.4 (31)	23.8±1.9 (36)	20.7±2.1 (31)	33.1±3.6 (49)
DIP MIC	* (3)	6.8±3.5 (8)	* (1)	6.0±2.3 (8)	8.2±6.1 (8)	10.4±0.8 (16)	5.7± 0 (9)	15.7±2.3 (23)
DIP ORD	---	4.8±0.9 (7)	* (3)	* (3)	---	---	---	* (2)
PER LON	4.1±2.5 (5)	* (1)	---	---	5.7±4.0 (6)	4.4±1.8 (6)	* (2)	---
PER PAR	5.1±3.1 (7)	* (3)	---	---	5.3±2.2 (7)	3.2± 0 (5)	---	5.3±2.2 (7)
NEO LEP	---	---	---	---	---	---	---	* (1)
ONY TOR	* (1)	* (5)	---	7.0±3.1 (9)	---	* (1)	* (3)	6.0±2.3 (8)
PER MAN	* (4)	* (1)	* (1)	6.5±1.9 (9)	* (3)	* (3)	* (1)	5.1± 0 (8)
SYL AUD	---	---	---	---	* (4)	---	---	---
Totals	29.2 (46)	35.6 (56)	17.1 (27)	62.2 (98)	38.1 (60)	42.5 (67)	29.2 (46)	63.5 (100)
Species	7	7	4	5	7	6	5	9
H′	0.6415	0.6000	0.2845	0.4302	0.6468	0.5591	0.4268	0.6487

*Species present but data insufficient to estimate density.

control plot was equal to or greater than on the burned area in all years and significantly greater in 1990 (x^2=5.824, 0.01<p<0.025).

Dipodomys merriami comprised at least 50% of the total captured population on both sites in 1988, 1989, 1990, (Table 25.) Sex ratios of the most common rodents were not significantly different from 1:1 (x^2, p.0.05) in 1988, 1989, or 1990 (Table 25). The number of male *D. merriami* captured on the burned area in 1992 was significantly greater than the number of females in that year (x^2=10.565, 0.001,p,0.005). The females captured on this plot in 1992 were significantly heavier than males (Table 26; ANOVA, F=12.52, df=1.36, p=0.001), and appeared to be in the later stages of pregnancy. Females on the burned area in 1992 were also significantly heavier than females on that area in 1990 (ANOVA, F=11.84, df=1,20, p=0.003). On the undisturbed area, the sex ratio did not differ significantly from 1:1 and females were not significanlty heavier in 1992. However, several neonates were discovered in the traps with females and a large number of juveniles were captured in 1992 (Tabel 27).

Male *D. merriami* captured on the burned area in 1989 were significantly heavier than females (Saethre, 1994). However, on the control plot in that year, there were no significant differences between mean weights of male and female *D. merriami*, nor did mean weights differ significantly between males on the two plots or females on the two plots (Saethre, 1994).

It appeared in 1992 that reproduction on the undisturbed area was occurring later than on the burned area. This may be inferred from the greater percentage of juveniles captured on the burned area (Table 27). Females on the burned area were also generally heavier and more often noted as pregnant on the data sheets than were control females. However, no real conclusions can be made from trapping an area for such a short period of time and only once during the season.

In general, congeneric heteromyid species of similar body size have mostly non-overlapping geographic ranges. Occasionally, they may occupy niches segregated on a smaller scale (microallopatric) by unique soil or vegetational habitats at the same location (Bowers and Brown 1982; Price et al. 1991). The latter association has been shown to occur between *Dipodomys merriami* and *D. ordii* (Schroder 1987; Schroder and Rosenzweig 1975).

The heteromyid compositions at plots located on the NTS follow the usual pattern of non-overlapping body size found at other sites, with the exception

Table 25. Percent of total captured population (%T) and sex ratio (♂/♀) of small mammals on the BECAMP plots on NTS in Redrock Valley in July 1988, 1989, 1990, and 1992.

	BURNED AREA - RED001								UNDISTURBED AREA - RED002							
	1988		1989		1990		1992		1988		1989		1990		1992	
SPECIES	%T	♂/♀	%T	♂/♀	%T	♂/♀	%T	♂/♀	%T	♂/♀	%T	♂/♀	%T	♂/♀	%T	♂/♀
CHA FOR	4.3	1/1	---	---	---	---	---	---	1.7	0/1	---	---	---	---	1.0	1/0
DIP MER	52.2	14/10	55.3	15/16	81.5	10/12	70.4	48/21	51.7	18/13	53.7	17/19	67.4	15/16	49.0	22/27
DIP MIC	6.5	2/1	14.3	2/6	3.7	0/1	8.2	5/3	13.3	5/3	23.9	4/12	19.6	3/6	23.0	14/9
DIP ORD	---	---	12.5	4/2[a]	11.1	2/1	3.1	1/2	---	---	---	---	---	---	2.0	0/1
PER LON	11.0	3/2	1.8	0/1	---	---	---	---	10.0	3/3	9.0	0/6	4.3	2/0	---	---
PER PAR	15.2	4/2[a]	5.4	3/0	---	---	---	---	11.7	3/4	7.5	4/1	---	---	7.0	3/4
NEO LEP	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1.0	1/0
ONY TOR	2.2	[a]	8.9	1/4	---	---	9.2	3/6	---	---	1.6	1/0	6.5	1/2	8.0	4/4
PER MAN	8.7	3/1	1.8	1/0	3.7	0/1	9.2	6/3	5.0	2/1	4.5	1/2	2.2	0/1	8.0	5/3
AMM LEU	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1.0	0/1
SYL AUD	---	---	---	---	---	---	---	---	6.7	I	---	---	---	---	---	---
TOTALS	100.1	27/17	100.0	26/29	100.0	12/15	100.1	63/35	100.1	31/25	100.2	27/40	100.0	20/26	100.0	50/49

[a]One animal of undetermined sex not included.
In the case of *Sylvilagus audubonii*, only juveniles of indeterminate (I) sex were captured.

Table 26. Mean weights (grams ± 2 sem) by sex and age of the heteromyid rodents captured on the Redrock Valley burned area and control in 1988, 1989, 1990, and 1992.

			1988		1989		1990		1992	
			BURNED AREA - RED001							
SPECIES	SEX	AGE	N	WEIGHT	N	WEIGHT	N	WEIGHT	N	WEIGHT
PER LON	♂	A	3	8.0±1.2	0		0		0	
	♀	A	2	6.5±1.0	1	8.0	0		0	
	♂	J	0		0		0		0	
	♀	J	0		0		0		0	
PER PAR	♂	A	2	20.0±1.0	3	20.7±2.2	0		0	
	♀	A	1	18.5	0		0		0	
	♂	J	2	8.8±0.7	0		0		0	
	♀	J	1	9.0	0		0		0	
DIP MER	♂	A	8	41.3±3.3	10	43.3±1.9	9	41.0±1.6	24	41.3±2.3
	♀	A	5	39.9±3.2	11	38.9±1.8	8	38.5±2.9	14	49.1±4.3
	♂	J	6	29.2±3.0	5	30.3±3.2	1	27.0	24	24.4±2.2
	♀	J	5	26.3±7.4	5	22.6±5.5	4	25.8±2.5	7	23.1±3.3
DIP MIC	♂	A	2	52.2±5.0	2	65.5±4.2	0		4	59.9±6.6
	♀	A	1	51.3	5	57.3±5.8	1	49.0	1	62.0
	♂	J	0		0		0		1	42.0
	♀	J	0		1	47.5	0		2	40.5±9.0
DIP ORD	♂	A	0		3	47.1±1.8	2	50.1±2.8	1	53.0
	♀	A	0		2	43.2±1.7	1	43.3	2	40.5±1.4
	♂	J	0		1	16.0	0		0	
	♀	J	0		0		0		0	
			UNBURNED AREA - RED002							
PER LON	♂	A	1	7.0	0		2	7.8±0.5	0	
	♀	A	3	8.0±1.2	6	8.2±2.2	0		0	
	♂	J	2	6.5±1.0	0		0		0	
	♀	J	0		0		0		0	
PER PAR	♂	A	1	29.0	4	20.1±4.6	0		2	17.7±1.3
	♀	A	3	18.0±6.0	1	15.0	0		3	18.1±1.2
	♂	J	1	9.5	0		0		1	7.0
	♀	J	0		0		0		1	5.0
DIP MER	♂	A	11	40.0±3.2	10	40.8±2.4	12	41.7±1.5	14	43.9±2.2
	♀	A	10	43.1±1.9	9	38.9±1.1	13	40.7±2.9	20	44.8±3.7
	♂	J	7	27.3±1.7	7	31.2±7.8	2	32.3±0.5	6	28.8±2.3
	♀	J	3	26.9±3.0	10	29.7±8.8	4	31.7±2.7	8	24.1±2.5
DIP MIC	♂	A	5	58.4±8.2	4	60.4±5.6	3	61.0±4.4	8	57.7±7.0
	♀	A	3	54.3±9.3	11	53.9±2.6	6	57.3±5.2	5	57.9±7.4
	♂	J	0		0		0		6	41.9±2.8
	♀	J	0		0		0		3	40.8±6.4
DIP ORD	♂	A	0		0		0		0	
	♀	A	0		0		0		1	44.0
	♂	J	0		0		0		0	
	♀	J	0		0		0		0	

Table 27. Distribution of *Dipodomys merriami* weights in Redrock Valley during July in 1988, 1989, 1990, and 1992.

	1988	1989	1990	1992
Burned area				
<20	0	2	0	8
20-<25	4	1	2	9
25-<30	3	3	3	11
30-<35	5	5	1	8
35-<40	4	9	8	4
40-<45	7	6	6	12
≥45	1	5	2	17
Undisturbed area				
<20	0	0	0	1
20-<25	3	2	0	3
25-<30	6	3	1	5
30-<35	4	11	6	7
35-<40	2	10	11	7
40-<45	12	7	12	8
≥45	4	3	2	17

of Redrock Valley. At the Redrock Valley burned area, *D. ordii* was captured at only 21 of the 70 trap locations during the entire trap history at this site. *D. ordii* were regularly caught on the highest (north) end of the plot and near shrub clumps. *D. merriami* was captured at 10 of the *D. ordii* capture sites (25 times out of a possible 1,190 opportunities). However, in 34 captures of *D. ordii* and 459 captures of *D. merriami*, only once were these species captured on the same day in side-by-side traps. This suggests that although these rodents are inhabiting the same area and may potentially compete for the same resources, niche separation is occurring on a small scale, facilitating the coexistence of these two similarly sized species. A more precise characterization of the available habitat at RED001 is needed for conclusions to be made on community partitioning between these two species.

RABBIT AND HARE SURVEYS

Transects were performed only on the Yucca Flat and Pahute Mesa baseline sites in 1992. Although no animals were observed on the Yucca Flat site (YUF001) during transects in early June, both jackrabbits (*Lepus californicus*) and cottontail rabbits (*Sylvilagus audubonii*) were observed at this site later in July. This indicated that *Sylvilagus* was present at this site after a three year absence (Table 28). The animals counted in late June 1992 on the Pahute

Mesa baseline site (PAM001) were all located on the southern edge of the site in a sandy wash. This portion of the area also had the greatest vegetational cover, with an abundance of tall sagebrush and juniper trees.

The method used here to estimate abundance is crude at best, but time and personnel constraints preclude adequate surveys. BECAMP workers generally note any rabbits found dead on the roads and NTS personnel regularly return wildlife observation cards which often include roadkills. The relative number of roadkills observed appeared to be greater in 1992, which may be a better way of censusing these species.

Table 28. Summary of lagomorph densities (N/ha ±1 sem) at two NTS sites, 1988 through 1992. Numbers in parentheses are mean flushing distance in m±1 sem).

YUF001	1988	1989	1990	1991	1992
Sylvilagus	0.14±0.11 (11±5)	0	0	0	0*
Lepus	0.01±0.01 (27)	0.43±0.20 (17±6)	0.04±0.04 (10)	0.06±0.05 (7)	0*
PAM001					
Sylvilagus	1.00±0.19 (5±1)	ND	ND	0	0.82±0.32 (7±3)
Lepus	0.53±0.25 (10±4)	ND	ND	0	1.60±0.24 (2±1)

*Observed at this site in July.
ND = not done this year.

DISTRIBUTION OF *Perognathus parvus*

A special effort was made in 1992 to trap for *Perognathus parvus* on the NTS in order to determine its geographic distribution and to investigate techniques to determine geographic distributions of small mammals in general. Fourteen sites were trapped in habitat that looked suitable for this species, concentrating effort north and west of Yucca Flat. Forty traps were used at each site and sites were trapped one or two nights, depending on success. Jorgensen and Hayward (1965) reported capture locations for 27 species of rodents, including *P. parvus*, on the NTS during 1959 to 1965. In addition, historical locations for rodent species were reported in Allred and Beck (1963a), Allred et al. (1964), Hatch et al. (1970), Moor and Bradley (1974; 1987), and O'Farrell and Sauls (1987).

Of the fourteen sites, *Perognathus parvus* was captured at five sites. This species was captured at seven of the 14 regular BECAMP plots in 1992. Historic and present capture locations for this species are shown in Figure 7.

On the NTS, *P. parvus* appeared to be strongly associated with *Coleogyne*, *Artemisia*, and Pinyon-Juniper habitats at elevations over 1300 m where soil was sandy to slightly gravelly and the native bunch grass *Oryzopsis hymenoides* was present (Table 29). Occasionally, this species was encountered at elevations as low as 1200 m. It was captured in a heavily forested site on Rainier Mesa (2283 m) where the soil was mostly rocky, but not on rocky slopes. It was encountered for the first time on the Yucca Flat baseline plot in July of 1992 when this species was captured in a can trap used to census lizards.

Elsewhere, this species is found in a wide variety of habitats including sandy ground where *Artemisia tridentata* is dominant (Verts and Kirkland 1988). It is known to inhabit desert and grassland habitats and is usually excluded from heavily forested areas. On occasion it has been captured in dry grasslands of eastern Washington and was infrequently captured in Pinyon-Juniper in southern Nevada (Deacon et al. 1964). It is abundant locally in rocky areas and on slopes and flats of sagebrush (*Artemisia*), Pinyon-Juniper, saltbush (*Atriplex*) and greasewood (*Sarcobatus*) in eastern California, Oregon, and Washington. It has been found on shrub-steppe with light (sic) textured soils but more abundant in lower elevations dominated by annuals (O'Farrell 1975) and in semi-desert and grassland habitats in eastern Washington and northern Idaho (Rickard 1960).

It appears that *P. parvus* is precluded from inhabiting areas with coarse textured soils which may inhibit burrowing. Presence of this species has been positively correlated with percent sand and negatively with percent clay in SE Oregon where distribution is restricted to sage and greasewood habitat (Feldhammer 1979). It was also three times more abundant on an unburned than on a burned area in a bitterbrush and sage habitat (Gano and Rickard 1982).

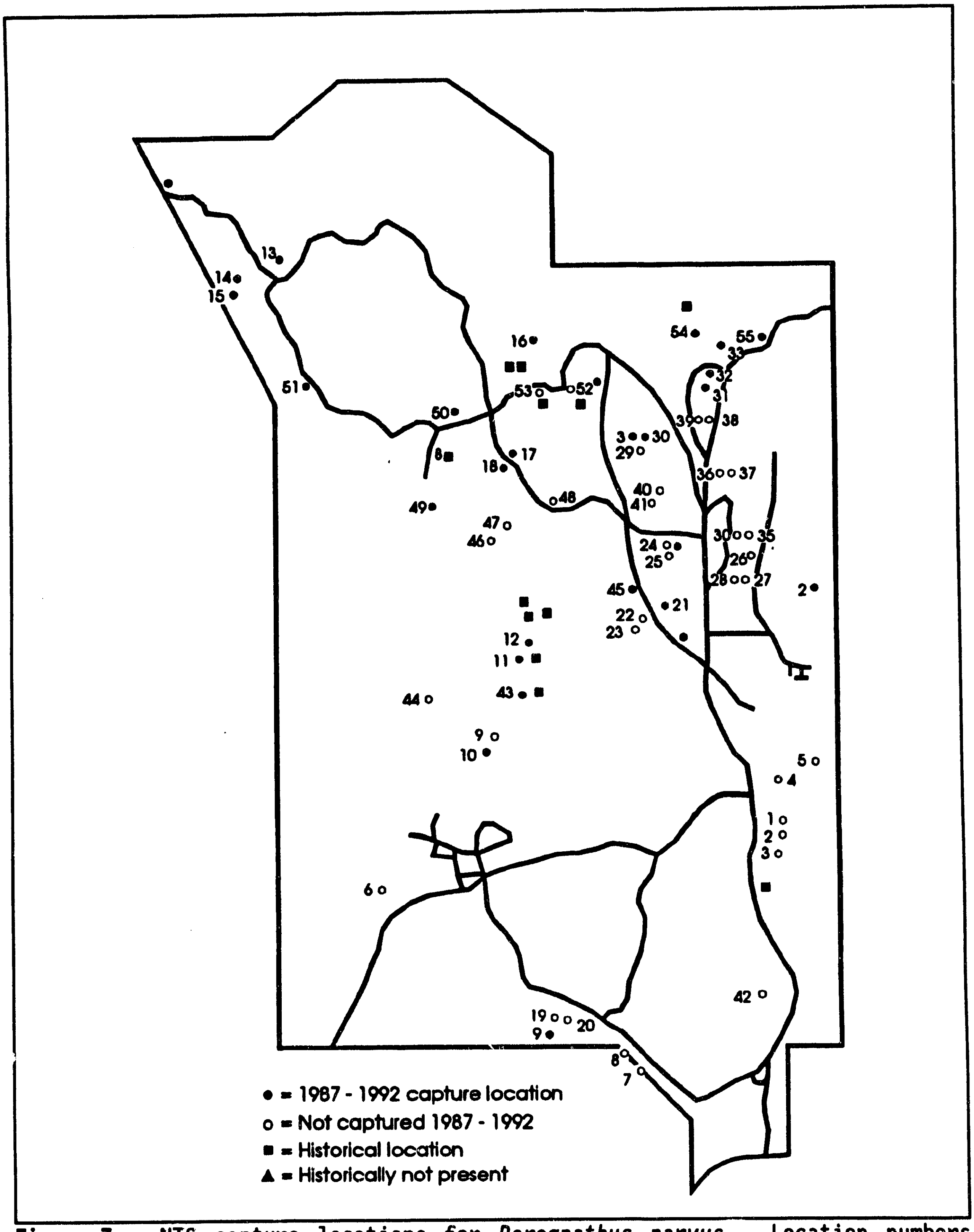


Figure 7 - NTS capture locations for *Perognathus parvus*. Location numbers correspond to Table 29.

Table 29. Characterization of capture locations of *Perognathus parvus*.

BECAMP Locations - 1987 through 1992:

NUMBER	NAME	FIGURE 7 KEY	ELEVATION (m)	SOIL TYPE[a]	PLANT COMMUNITY[b]	OTHER
1	FRF001	○	965	SG	LA-AM	
2	FRF003	○	965	SG	LA-AM	Roadside
3	FRF004	○	965	SG	LA-AM	
4	FRF005	○	963	G	LA-AM-AT	
5	FRF006	○	963	G	LA-AM	alpha-contaminated
6	JAF001	○	954	S	LA-AM	
7	MER002	○	1076	S	ST	gopher
8	MER003	○	1103	DP	LA-AM	
9	MID002	○	1445	G	O-SS	burn
10	MID003	●	1452	R	CO-AR-O	
11	MID004	●	1439	H	E-CO	bladed
12	MID005	●	1445	R	CO	
13	PAM001	●	1923	R	AR	
14	PAM002	●	1911	H	O-SS	bladed
15	PAM003	●	1910	R	AR	
16	RAM001	●	2283	R	P-J	
17	RED001	●	1612	S	O-E	burn
18	RED002	●	1612	S	AT-E-O	
19	ROV007	○	1030	DP	LA-AM	
20	ROV008	○	1039	DP	LA-AM	fenced plot
21	YUF001	●	1237	DP	G-LY	
22	YUF002	○	1288	S	SS	burn
23	YUF003	○	1301	G	G-LY	
24	YUF009	○	1279	S	O	blast, aboveground
25	YUF010	○	1267	DP	AT-CH	
26	YUF011	○	1242	S	AT	revegetated site
27	YUF012	○	1239	SG	AC-AT-CE-E	
28	YUF013	○	1236	S	O	blast, aboveground
29	YUF014	○	1371	S	AT	blast, aboveground
30	YUF015	○	1338	SG	H-CE	
31	YUF016	○	1318	S	O-SS	blast ejecta
32	YUF017	○	1327	S	O-H	blast ejecta
33	YUF018	○	1335	G	CO-O	
34	YUF019	○	1213	H	OR	crater bottom
35	YUF020	○	1241	S	CH-AT	
36	YUF021	○	1234	H	O	crater bottom
37	YUF022	○	1251	SG	G-LY	
38	YUF023	○	1277	H	O	crater bottom
39	YUF024	○	1300	G	CE-O	
40	YUF025	○	1317	S	SP-SS	blast, aboveground
41	YUF026	○	1320	DP	G-LY	
42	BURCSF	○	1036	DP	LA-AM	S. Frenchman Flat
43	MIDCSF	●	1440	S	E	old burn, Mid Valley
44	SHOCSF	○	1768	R	CO-AR,P-J	SE slope, Shoshone Mt

Table 29, Capture locations, continued.

BECAMP Locations - 1987 through 1992:

NUMBER	NAME	FIGURE 7 KEY	ELEVATION (m)	SOIL TYPE[a]	PLANT COMMUNITY[b]	OTHER
45	YUFCSF	●	1310	DP	CO-AR	W Yucca Flat
46	TP1CSF	○	1615	SG	AR	Tippipah spring
47	TP2CSF	○	1615	G	AP	Tippipah spring
48	16PCSF	○	1494	G	CO	ridge
49	18aCSF	●	1524	GR	AR	horse activity
50	BBWCSF	○	1554	SG	CO-AR	wash, horse use
51	BMRCSF	●	1707	R	CO-AR	slope, Buckboard Mesa
52	CJSCSF	○	1951	R	CO-AR,P-J	Capt. Jack Spring
53	RAMCSF	○	2012	GR	CO-AR,P-J	slope, Rainier Mesa
54	EPACSF	●	1402	SG	CO	N Yucca Flat
55	GRMCSF	○	1414	R	CO-AR	NW Yucca Flat

Historical Locations:

NUMBER	NAME	FIGURE 7 KEY	ELEVATION (m)	REFERENCE
1	GMX	▲	963	Moor & Bradley 1974
2	Pu Valley	▲	1274	Moor & Bradley 1974
3	T2	■	1335	O'Farrell & Sauls 1987
4	Sedan	■	1315-1340	Allred et al. 1964
5	Sedan	■	1315	O'Farrell & Sauls 1987
6	Area 13	■	1387	Moor & Bradley 1974
7	Palanquin	■	2000	O'Farrell & Sauls 1987
8	Little Feller II	■	1585	Moor & Bradley 1987
9	Rock Valley	▲	1032-1049	Turner 1973, 1974, 1975 French et al. 1966, 1967
NONE	Various locations	■		Jorgensen & Hayward 1965

[a]Soil type key:
- DP=desert pavement
- H=hard packed
- S=Sandy
- G=gravel
- R=rocky

[b]Plant key:
- AC=*Acamptopappus*
- AR=*Artemisia*
- CE=*Ceratoides*
- CO=*Coleogyne*
- G=*Grayia*
- J=*Juniperus*
- LY=*Lycium*
- P=*Pinus*
- SS=*Stipa*
- AM=*Ambrosia*
- AT=*Atriplex*
- CH=*Chrysothamnus*
- E=*Ephedra*
- H=*Hymenoclea*
- LA=*Larrea*
- O=*Oryzopsis*
- SP=*Sphaeralcea*
- ST=*Stanleya*

Apparently the distribution of this species on the NTS is dynamic and cannot be elucidated in only one year or sporadic years of sampling. It is possible that during less favorable years *Perognathus parvus* distribution is restricted to the higher elevation sagebrush and blackbrush (*Coleogyne*) habitats more typical of the Great Basin, but extends its range to the lower, transitional habitats when population sizes are larger and dispersion is more favorable. Other factors involved in capturing this species appear to be moonlight and inclement weather, which have strongly negative effects (Verts and Kirkland 1988). Numbers of animals also show a strong positive correlation with winter rainfall (Dunigan et al. 1980). An area where this species was noticeably absent in recent years was the Sedan crater impact area. This species was present before the 1962 cratering test out to 2134 m NNE of ground zero (GZ) and out to 1500 m post-test (Allred et al. 1964). One animal was captured at 915 m SE in 1982-1983 (O'Farrell and Sauls 1987) but none out to 1600 m NNE in 1988 or 1991 (Saethre, 1994). Winter rainfall in 1982-83 was above average, as was 1988. One *Perognathus parvus* individual was captured in 1992 approximately 2900 m N (plot EPACSF), a year of above average winter rainfall.

DISCUSSION AND CONCLUSIONS

As in the five previous years, for 1992 the most common rodents captured on BECAMP plots at lower elevations were kangaroo rats and, to a lesser extent, pocket mice. *Dipodomys merriami* increased in density in 1992 from previous years. *D. microps*, a species severely reduced in number during and just after drought, appeared to have finally rebounded after a low in 1991 at the Yucca Flat baseline site (YUF001). *Perognathus longimembris*, the little pocket mouse, however, decreased in density to a five year low on the YUF001 plot, where this species was regularly the most abundant rodent. The decrease in *P. longimembris* was not a local phenomenon as numbers decreased on other NTS sites as well.

The Great Basin pocket mouse, *P. parvus*, fared better at higher elevation plots such as PAM001 (1923 m) where it increased from 14 animals in 1990 to 24 in 1992, and PAM003 (1910 m) where twice as many animals were captured in 1992 as in 1989. In Mid Valley (1440 m) it increased from 1989 numbers on both an undisturbed plot and a bladed area. In Redrock Valley (1612 m), numbers increased back to 1988 levels on the undisturbed area after being absent in 1990.

1992 was an excellent year for *Peromyscus* species with the deer mouse, *P. maniculatus*, being the most abundant rodent at two undisturbed sites on Pahute Mesa. *P. eremicus*, the cactus mouse, was captured for the first time on BECAMP plots since monitoring began in 1987 and was caught on 7 of the 14 plots trapped in 1992. Both of these species are normally present at low densities and apparently became more active or abundant in 1992 due to the increased rainfall.

Combining plots trapped in Yucca Flat over the last six years, several trends in disturbed versus undisturbed plots have emerged (Table 30). Overall, mean species diversity (F=24.04, df=1,40, p=0.0001) and number of species (F=13.95, df=1,40, p=0.001) were significantly greater on the undisturbed sites. Average number of captures per animal, percent trap success and total density did not differ significantly between the two types of plots, although mean trap success and density were greater on the undisturbed areas. Average number of captures per animal also tended to be higher on the disturbed areas, but animals were usually caught at both sites on two of the three nights (range 1.79 to 2.15).

Over the last six years, number of species (F=4.50, df=5,16, p=0.009), trap success (F=5.51, df=5,16, p=0.004), and total density (F=6.96, df=5,16, p=0.001) were significantly different between years for all undisturbed plots in Yucca Flat. Mean number of species captured was significantly greater in 1987 and 1988 than in 1990 and 1991 (Newman-Keuls Multiple Range Test). However, for trap success, only 1987 was significantly different from all other years except 1992. If the 1987 data are eliminated (it was trapped later in the summer than other sites in later years) there is no significant difference in mean trap success between the remaining five years (ANOVA, $p > 0.10$), although the same trend over the six years occurred with lowest values in 1989, 1990, and 1991.

Overall, significantly more male (207) than female (141) rodents were captured in Yucca Flat in 1992 (x^2=12.52, $p < 0.001$). However, as the trapping season progressed, disparities between sex ratios became less significant, indicating a seasonal shift in the activity pattern rather than an actual difference in the number of rodents by sex present at a site. Trapping a site only one week every three years (at best two years) cannot elicit conclusive answers to questions of rodent ecology. However, following several plots in Yucca Flat may help explain a phenomenon as part of a normal pattern rather than erroneously assume an anomalous situation.

Table 30. Mean plot parameters of Yucca Flat plots studied in 1987 through 1992. Error terms are 1 sem.

YEAR	NUMBER SURVEYED	MEAN H'	NUMBER OF SPECIES	AVERAGE CAPTURE	PERCENT SUCCESS	MEAN DENSITY
1987						
ALL	3	0.5071±0.0594	5.67±0.88	1.90±0.06	39.02±3.63	55.04±5.63
UNDISTURBED	2	0.5583±0.0526	6.50±0.50	1.88±0.10	35.85±3.05	51.08±6.94
DISTURBED	1	0.4049	4	1.92	45.37	62.96
1988						
ALL	9	0.4237±0.0651	4.78±0.49	2.12±0.08	18.16±2.19	25.72±4.10
UNDISTURBED	4	0.5954±0.0381	6.00± 0	1.88±0.04	22.40±1.38	34.84±4.71
DISTURBED	5	0.2863±0.0614	3.80±0.58	2.30±0.06	14.77±3.10	18.42±4.17
1989						
ALL	7	0.4347±0.0437	4.14±0.51	1.79±0.11	10.79±2.73	15.25±3.57
UNDISTURBED	4	0.4812±0.0589	4.50±0.65	1.81±0.17	12.37±4.31	17.13±5.57
DISTURBED	3	0.3027±0.0551	3.67±0.88	1.77±0.18	8.69±3.32	12.75±4.68
1990						
ALL	7	0.2929±0.0664	3.14±0.51	2.01±0.10	10.27±1.89	13.43±2.25
UNDISTURBED	4	0.3463±0.0833	3.75±0.63	1.91±0.13	11.08±2.90	14.99±3.34
DISTURBED	3	0.2218±0.0112	2.33±0.67	2.15±0.15	9.20±2.69	11.34±3.03
1991						
ALL	9	0.2660±0.0613	2.78±0.36	2.07±0.13	11.39±2.00	14.74±2.58
UNDISTURBED	4	0.4316±0.0394	3.50±0.29	2.14±0.16	11.76±1.58	15.21±2.68
DISTURBED	5	0.1336±0.0520	2.20±0.49	2.02±0.21	11.09±3.59	14.36±4.43
1992						
ALL	7	0.3128±0.0567	4.00±0.49	1.88±0.12	13.59±3.17	19.18±3.39
UNDISTURBED	4	0.3899±0.0711	4.50±0.65	1.96±0.15	15.42±4.86	21.71±5.18
DISTURBED	3	0.2101±0.0564	3.33±0.67	1.78±0.22	11.15±4.23	15.81±4.10
TOTAL MEAN						
ALL	42	0.3574±0.0271	3.90±0.24	1.98±0.05	14.89±1.49	20.58±2.13
UNDISTURBED	22	0.4273±0.0338	4.57±0.29	1.96±0.05	16.90±1.93	23.75±2.85
DISTURBED	20	0.2729±0.0358	3.11±0.30	2.01±0.08	12.46±2.26	16.75±3.05

An alternative method of censusing lagomorphs should be considered. Spotlighting at night appears to be the most time- and cost-efficient method if combined with other evening projects. During night surveys for deer (see Greger this volume) and while returning at dusk from setting small mammal traps, numerous jackrabbits were regularly observed crossing the roads. In this case, relative numbers of lagomorphs may then be estimated over a regularly driven route of known length.

Concerning the sympatric relationship of *Dipodomys ordii* and *D. merriami* at the Redrock burn site, Schroder (1987) found that *D. ordii* was not common in undisturbed habitat and was a transient member of the rodent community. Schroder also noted that *D. ordii* was trapped more often on grassier sites, and preferred to forage in the open between grass clumps in shrubby habitat. *D. merriami*, however, was trapped at sites associated with the dominant shrub and showed no preference to either open or shrubby habitat.

At the Redrock site, *D. ordii* showed a clear preference for the burned area (grassy), while *P. longimembris*, *P. parvus*, and *D. microps* preferred the unburned habitat (shrubby). *D. merriami* showed no clear preference until 1992. A more detailed analysis is needed before any further conclusions may be made, which, at present, is beyond the scope of the current monitoring program.

Analysis of demographic parameters from the YUF001 plot will continue in the future as an attempt to account for annual fluctuations that may occur in the region due to abiotic (weather) factors. The relatively long-lived little pocket mouse (*Perognathus longimembris*) will continue to be monitored on the YUF001 plot to assess the far-reaching effects of the low density and survivorship in 1992.

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APPENDIX C

MAMMALS OF THE NEVADA TEST SITE[1]

Order INSECTIVORA: Insectivores

Family Soricidae: Shrews	
Notiosorex crawfordii	Desert shrew
Sorex merriami	Merriam's shrew
Sorex tenellus	Inyo shrew

Order CHIROPTERA: Bats

Family Vespertilionidae: Vespertilionid bats	
Antrozous pallidus	Pallid bat
Eptesicus fuscus	Big brown bat
Lasionycteris noctivagans	Silver-haired bat
Lasiurus cinereus	Hoary bat
Myotis californicus	California myotis
Myotis volans	Long-legged myotis
Pipistrellus hesperus	Western pipistrelle
Plecotus townsendii	Townsend's big-eared bat
Family Molossidae: Free-tailed bats	
Tadarida brasiliensis	Mexican free-tail bat

Order CARNIVORA: Carnivores

Family Canidae: Coyotes and foxes	
Canis latrans	Coyote
Urocyon cinereoargenteus	Gray fox
Vulpes velox [=macrotis]	Kit fox
Family Procyonidae: Procyonids	
Bassariscus astutus	Ringtail
Family Mustelidae: Mustelids	
Mustela frenata	Long-tailed weasel
Taxidea taxus	Badger
Spilogale putorius [=gracilis]	Western spotted skunk

3 of 4

Family Felidae: Cats

Felis concolor	Cougar
Lynx rufus	Bobcat

Order **PERISSODACTYLA:** Odd-toed ungulates

Family Equidae: Horses

Equus asinus	Burro
Equus caballus	Horse

Order **ARTIODACTYLA:** **Even-toed ungulates**

Family Cervidae: Deer and Elk

Odocoileus hemionus	Mule deer
Cervus elaphus[2]	Wapiti (Elk)

Family Bovidae: Bovids

Antilocapra americana	Pronghorn
Bos taurus	Cattle
Ovis canadensis[2]	Bighorn sheep

Order **RODENTIA:** **Rodents**

Family Sciuridae: Squirrels

Ammospermophilus leucurus	White-tailed antelope squirrel
Spermophilus tereticaudus	Round-tailed ground squirrel
Spermophilus townsendii	Townsend's ground squirrel
Spermophilus variegatus	Rock Squirrel
Tamias [=Eutamias] dorsalis	Cliff chipmunk

Family Geomyidae: Pocket gophers

Thomomys bottae	Botta's pocket gopher

Family Heteromyidae: Heteromyid rodents

Chaetodipus [=Perognathus] formosus	Long-tailed pocket mouse
Dipodomys deserti	Desert kangaroo rat
Dipodomys merriami	Merriam's kangaroo rat
Dipodomys microps	Chisel-toothed kangaroo rat
Dipodomys ordii	Ord's kangaroo rat
Microdipodops megacephalus	Dark kangaroo mouse
Perognathus longimembris	Little pocket mouse
Perognathus parvus	Great Basin pocket mouse

Family Muridae: Rats, mice, and voles

Lemmiscus [=Lagurus] curtatus	Sagebrush vole
Neotoma lepida	Desert woodrat
Onychomys torridus	Southern grasshopper mouse
Peromyscus crinitus	Canyon mouse
Peromyscus eremicus	Cactus mouse
Peromyscus maniculatus	Deer mouse
Peromyscus truei	Pinyon mouse
Reithrodontomys megalotis	Western harvest mouse

Family Erethizontidae: New World porcupines

Erethizon dorsatum	Porcupine

Order **LAGOMORPHA**: Lagomorphs

Family Leporidae: Hares and rabbits

Lepus californicus	Black-tailed jackrabbit
Sylvilagus audubonii	Desert cottontail
Sylvilagus nuttallii	Nuttall's cottontail

[1]Nomenclature follows Wilson and Reeder 1993. List is from O'Farrell and Emery 1976, Jorgensen and Hayward 1965, Medica 1990, and EG&G/EM 1992.

[2]Resident populations outside boundaries of NTS.

APPENDIX D

BECAMP/ECOLOGY PLOT LOCATIONS ON THE NEVADA TEST SITE
(AS OF MARCH 25, 1992)

PLOT	LATITUDE LONGITUDE (NAD 1983)	ELEVATION (M)	LOCATION
FF66	36° 49' 12.3" N 115° 55' 57.8" W	948	LGF 3 km line Frenchman Flat
FF67	36° 49' 8.5" N 115° 55' 32.7" W	947	LGF 3 km line Frenchman Flat
FF81	36° 49' 45.0" N 115° 55' 7.4" W	951	LGF 5 km line Frenchman Flat
FF84	36° 50' 5.3" N 115° 55' 6.3" W	957	LGF 5 km line Frenchman Flat
FOR001	37° 8' 7.8" N 116° 15' 23.4" W	1756	Beatley Plot 61 (UCLA)
FOR002	37° 8' 27.5" N 116° 15' 25.9" W	1750	Beatley Plot 62 (UCLA)
FOR003	37° 8' 48.8" N 116° 15' 21.6" W	1554	Jct. Stockade Wash and Pahute Mesa Roads
FRF001	36° 48' 48.0" N 115° 59' 12.0" W	965	Frenchman Flat
FRF002	36° 48' 25.9" N 116° 0' 23.3" W	977	Frenchman Flat (Roadside)
FRF003	36° 48' 45.8" N 115° 58' 48.2" W	965	Frenchman Flat (Roadside 5-05 Road E. End)
FRF004	36° 49' 9.0" N 115° 58' 42.5" W	965	Frenchman Flat Control (N. Power Line Rd. E. End)

PLOT	LATITUDE LONGITUDE (NAD 1983)	ELEVATION (M)	LOCATION
FRF005	36° 50' 38.0" N 115° 56' 8.0" W	963	GMX GZ
FRF006	36° 50' 45.6" N 115° 56' 28.7" W	963	GMX Control
FRF007	36° 49' 2.9" N 115° 57' 56.9" W	960	Tritium Well, Atriplex Site
GOL001	37° 13' 42.2" N 116° 13' 2.3" W	2060	Gold Meadows
JAF001	36° 46' 10.9" N 116° 22' 37.0" W	954	Jackass Flats
JAF002	36° 45' 11.0" N 116° 22' 35.5" W	937	Beatley Plot 8 (UCLA)
JAF003	36° 46' 16.1" N 116° 21' 14.1" W	963	Gopher Area (E. of Beatley Plot 7)
JAF004	36° 45' 11.0" N 116° 22' 35.5" W	963	Beatley Plot 7 (UCLA)
MER001	36° 39' 59.6" N 115° 59' 52.0" W	1161	Mercury Water Balance Plots
MER002	36° 39' 8.7" N 116° 7' 9.3" W	1076	Gopher Denuded Area
MER003	36° 39' 26.8" N 116° 7' 8.1" W	1103	Undisturbed Area N. of MER002
MER004	36° 40' 18.2" N 116° 7' 53.9" W	1088	Beatley Plot 2 (UCLA)
MID001	36° 53' 46.5" N 116° 11' 31.0" W	1448	Plant Transects, (N.End) E. side Saddle Rd.

PLOT	LATITUDE LONGITUDE (NAD 1983)	ELEVATION (M)	LOCATION
MID002	36° 53' 52.1" N 116° 11' 59.0" W	1445	Burn, July 1986 W. side Saddle Rd.
MID003	36° 53' 45.9" N 116° 12' 4.8" W	1452	Unburned, W. Side Saddle Rd.
MID004	36° 58' 28.3" N 116° 10' 46.3" W	1439	Mid Valley Bladed Area
MID005	36° 58' 28.3" N 116° 10' 57.9" W	1445	Mid Valley Undisturbed Area
MID006	36° 57' 36.2" N 116° 11' 1.8" W	1445	Beatley Plot 42, SE Corner (UCLA)
MID007	36° 57' 38.3" N 116° 11' 1.0" W	1445	Beatley Plot 41, SE Corner (UCLA)
PAM001	37° 15' 11.2" N 116° 26' 54.8" W	1923	Pahute Mesa
PAM002	37° 14' 49.4" N 116° 28' 13.1" W	1911	U20ao Drill Pad
PAM003	37° 14' 44.9" N 116° 28' 26.0" W	1910	U20ao Undisturbed Area
PAM004	37° 17' 28.7" N 116° 19' 38.5" W	2103	U19e Drill Pad
PAM005	37° 17' 25.8" N 116° 19' 42.2" W	2103	U19e Undisturbed Area
PAM006	37° 16' 29.1" N 116° 8' 37.8" W	2134	U19ac Drill Pad
PAM007	37° 17' 1.7" N 116° 18' 2.1" W	2134	U19ac Undisturbed Area,

PLOT	LATITUDE LONGITUDE (NAD 1983)	ELEVATION (M)	LOCATION
PAM008	37° 11' 46.1" N 116° 16' 45.8" W	1920	Pinyon Scale Plot
RAM001	37° 11' 20.9" N 116° 13' 0.9" W	2283	Rainier Mesa
RAM002	37° 11' 51.8" N 116° 12' 35.1" W	2263	Beatley Plot 64 (UCLA)
RED001	37° 4' 51.5" N 116° 13, 29.0" W	1612	Burned Area, July 1988 Redrock Valley
RED002	37° 4' 47.8" N 116° 13' 3.5" W	1612	Unburned Area Redrock Valley
ROV001	36° 41' 17.5" N 116° 11' 31.1" W	1032	Rock Valley UCLA Plot A
ROV002	36° 41' 26.8" N 116° 11' 9.8" W	1049	Rock Valley UCLA Plot B
ROV003	36° 41' 11.1" N 116° 11' 41.6" W	1033	Rock Valley UCLA Plot C
ROV004	36° 41' 29.0" N 116° 11' 24.5" W	1033	Rock Valley UCLA Plot D
ROV005	36° 41' 9.1" N 116° 11' 19.4" W	1036	Beatley Plot 3, SE Corner (UCLA)
ROV006	36° 41' 59.5" N 116° 10' 24.5" W	1049	Beatley Plot 4, SE Corner (UCLA)
ROV007	36° 41' 29.6" N 116° 11' 29.9" W	1030	Rock Valley IBP Plot 16
ROV008	36° 41' 10.0" N 116° 11' 16.6" W	1039	Rock Valley, Plot B W. 1/4 Mammal Grid

PLOT	LATITUDE LONGITUDE (NAD 1983)	ELEVATION (M)	LOCATION
WAH001	36° 48' 48.0" N 116° 9' 47.2" W	1311	Beatley Plots 66 & 67 (UCLA)
YUF001	37° 0' 26.0" N 116° 4' 58.1" W	1237	Yucca Flat
YUF002	37° 0' 0.9" N 116° 6' 10.5" W	1288	Yucca Flat Burn (June 1985)
YUF003	36° 59' 49.8" N 116° 6' 15.8" W	1301	Yucca Flat Unburned
YUF004	37° 3' 6.0" N 116° 6' 19.0" W	1295	T1 Plots Romney UCLA #1
YUF005	37° 3' 8.0" N 116° 6' 29.0" W	1301	T1 Plots Romney UCLA #2
YUF006	37° 3' 12.0" N 116° 6' 39.0" W	1306	T1 Plots Romney UCLA #3
YUF007	37° 3' 13.0" N 116° 6' 51.0" W	1282	T1 Plots Romney UCLA #4
YUF008	37° 3' 16.0" N 116° 7' 0.0" W	1326	T1 Plots Romney UCLA #5
YUF009	37° 2' 50.8" N 116° 5' 45.0" W	1279	T1 Blast Area 960 m SE, GZ
YUF010	37° 2' 29.6" N 116° 5' 18.8" W	1267	T1 Undisturbed 1760 m SE, GZ
YUF011	37° 2' 52.0" N 116° 0' 23.0" W	1242	3B Consolidation Site
YUF012	37° 2' 57.8" N 116° 0' 8.9" W	1239	3B Undisturbed Area

PLOT	LATITUDE LONGITUDE (NAD 1983)	ELEVATION (M)	LOCATION
YUF013	37° 3' 1.4" N 116° 0' 30.0" W	1236	T3 Blast Area ESE of GZ
YUF014	37° 8' 13.5" N 116° 6' 50.9" W	1371	T2 Blast Area
YUF015	37° 8' 46.0" N 116° 5' 54.0" W	1338	T2 Undisturbed Area
YUF016	37° 10' 44.6" N 116° 2' 25.9" W	1318	Sedan, 457 m NE GZ, 16A Line
YUF017	37° 10' 54.5" N 116° 2' 6.6" W	1327	Sedan, 1067 m NE GZ, 16A Line
YUF018	37° 11' 0.4" N 116° 1' 31.0" W	1335	Sedan, 1600 m NE GZ, 16A Line
YUF019	37° 3' 46.1" N 116° 1' 2.2" W	1213	U3cn Crater
YUF020	37° 3' 30.0" N 116° 1' 7.4" W	1241	U3cn undisturbed
YUF021	37° 4' 48.3" N 116° 3' 7.7" W	1234	U7au Crater
YUF022	37° 4' 48.7" N 116° 2' 57.7" W	1251	U7au undisturbed
YUF023	37° 9' 10.8" N 116° 3' 12.9" W	1277	U10af Crater
YUF024	37° 9' 10.6" N 116° 3' 24.8" W	1300	U10af undisturbed
YUF025	37° 5' 35.1" N 116° 6' 4.5" W	1317	T-4 Blast Area

PLOT	LATITUDE LONGITUDE (NAD 1983)	ELEVATION (M)	LOCATION
YUF026	37° 5' 19.8" N 116° 6' 28.4" W	1320	T-4 Undisturbed
YUF027	37° 0' 32.3" N 116° 4' 55.2" W	1227	Beatley Plot 46 (UCLA)
YUF028	37° 2' 33.4" N 115° 59' 30.4" W	1268	Beatley Plot 57 (UCLA)
YUF029	37° 2' 42.4" N 116° 5' 30.1" W	1305	T-1 Transition Zone
YUF030	37° 10' 48.8" N 116° 8' 23.4" W	1509	Beatley Plot 51 (UCLA)
YUF031	36° 57' 44.3" N 115° 59' 28.4" W	2104	Beatley Plot 60 (UCLA)

APPENDIX E

RESULTS OF DENSITY AND STANDARD ERROR CALCULATIONS USING SEBER (1982:138)

Legend

N1 = Total individuals marked before present trap night.
XB = New individuals marked during present trap night.
N2 = Total individuals captured during present trap night.
M2 = Number in N2 which were recaptures.
N*/HA = Estimated number of animals per hectare.
V̂ = Estimated variance.
2 SE/HA = Two times the estimated standard error per hectare for N*/HA.

MID004 1992 SPRING DENSITY

	9-JUN-92	10-JUN-92	11-JUN-92
DIP MER			
N1	0	5	8
XB	5	3	0
M2	0	3	4
N2	5	6	4
N*/HA		6.60	5.56
V̂		3.15	0
2*SE/HA		2.47	0
DIP MIC			
N1	0	3	3
XB	3	0	1
M2	0	2	2
N2	3	2	3
N*/HA		2.08	3.01
V		0	0.44
2*SE/HA		0	0.93
PER PAR			
N1	0	1	3
XB	1	2	1
M2	0	1	2
N2	1	3	3
N*/HA		2.08	3.01
V		0	0.44
2*SE/HA		0	0.93
PER MAN			
N1	0	2	5
XB	2	3	2
M2	0	2	2
N2	2	5	4
N*/HA		3.47	6.25
V		0	5.00
2*SE/HA		0	3.11

MIDO05 1992 Spring Density

	9-JUN-92	10-JUN-92	11-JUN-92
CHA FOR			
N1	0	7	12
XB	7	5	5
M2	0	4	6
N2	7	9	11
N*/HA		10.42	14.78
V		8.00	11.94
2*SE/HA		3.92	4.80
PER MAN			
N1	0	5	5
XB	5	0	1
M2	0	2	1
N2	5	2	1
N*/HA		3.47	5.56
V		0	6.00
2*SE/HA		0	3.40

PAM001 1992 Spring Density

	30-JUN-92	1-JUL-92	2-JUL-92
PER PAR			
N1	0	11	19
XB	11	8	5
M2	0	10	14
N2	11	8	19
N*/HA		6.09	7.92
V		1.26	2.78
2*SE/HA		0.69	1.03
NEO LEP			
N1	0	4	4
XB	4	0	2
M2	0	3	2
N2	4	3	4
N*/HA		1.23	2.26
V		0	2.78
2*SE/HA		0	1.03
PER ERE			
N1	0	1	7
XB	1	6	4
M2	0	1	6
N2	1	7	10
N*/HA		2.16	3.57
V		0	0.90
2*SE/HA		0	0.58

PAM001 1992 SUMMER DENSITY

	9-JUN-92	10-JUN-92	11-JUN-92
PER MAN			
N	0	20	35
XB	20	15	3
M2	0	14	20

PAM001 1992 SUMMER DENSITY, continued.

	9-JUN-92	10-JUN-92	11-JUN-92
N2	20	29	23
N*/HA		12.65	12.39
V		15.75	4.01
2*SE/HA		2.45	1.24
PER SPP			
N1	0	23	45
XB	23	22	7
M2	0	16	27
N2	23	38	34
N*/HA		16.69	17.44
V		27.71	8.92
2*SE/HA		3.25	1.84

PAM002 1992 SUMMER DENSITY

	21-JUL-92	22-JUL-92	23-JUL-92
DIP ORD			
N1	0	16	18
XB	16	2	2
M2	0	10	16
N2	16	12	18
N*/HA		13.26	14.05
V		1.83	0.28
2*SE/HA		1.88	0.73

PAM003 1992 SUMMER DENSITY

	21-JUL-92	22-JUL-92	23-JUL-92
DIP MIC			
N1	0	1	4
XB	1	3	0
M2	0	1	3
N2	1	4	3
N*/HA		2.78	2.80
V		0	0
2*SE/HA		0	0
PER PAR			
N1	0	6	7
XB	6	1	4
M2	0	5	5
N2	6	6	9
N*/HA		4.98	8.56
V		0.19	2.54
2*SE/HA		0.61	2.21
PER ERE			
N1	0	7	8
XB	7	1	2
M2	0	5	6
N2	7	6	8
N*/HA		5.79	7.34
V		0.44	0.83
2*SE/HA		0.93	1.26

PAM003 1992 SUMMER DENSITY, continued.

	21-JUL-92	22-JUL-92	23-JUL-92
PER MAN			
N1	0	22	29
XB	22	7	7
M2	0	18	18
N2	22	25	25
N*/HA		21.16	27.81
V		2.32	8.32
2*SE/HA		2.12	4.01

RED001 1992 SUMMER DENSITY

	14-JUL-92	15-JUL-92	16-JUL-92
DIP MER			
N1	0	33	51
XB	33	18	18
M2	0	26	36
N2	33	44	54
N*/HA		35.34	48.44
V		9.44	14.84
2*SE/HA		3.90	4.89
DIP MIC			
N1	0	4	5
XB	4	1	3
M2	0	1	3
N2	4	2	6
N*/HA		4.13	6.03
V		3.75	3.15
2*SE/HA		2.46	2.25
ONY TOR			
N1	0	7	8
XB	7	1	1
M2	0	3	2
N2	7	4	3
N*/HA		5.71	6.98
V		2.00	6.00
2*SE/HA		1.80	3.11
PER MAN			
N1	0	4	6
XB	4	2	3
M2	0	4	4
N2	4	6	7
N*/HA		3.81	6.48
V		0	2.24
2*SE/HA		0	1.90

RED002 1992 SUMMER DENSITY

	14-JUL-92	15-JUL-92	16-JUL-92
DIP MER			
N1	0	27	41
XB	27	14	8
M2	0	16	29

RED002 1992 SUMMER DENSITY, continued.

	14-JUL-92	15-JUL-92	16-JUL-92
N2	27	30	37
N*/HA		31.78	33.14
V		25.70	5.49
2*SE/HA		6.44	2.98
DIP MIC			
N1	0	16	21
XB	16	5	2
M2	0	9	11
N2	16	14	13
N*/HA		15.56	15.66
V		8.11	3.29
2*SE/HA		3.62	2.30
PER PAR			
N1	0	3	3
XB	3	0	4
M2	0	2	2
N2	3	2	6
N*/HA		1.90	5.29
V		0	3.11
2*SE/HA		0	2.24
ONY TOR			
N1	0	2	5
XB	2	3	3
M2	0	1	3
N2	2	4	6
N*/HA		4.13	6.03
V		3.75	3.15
2*SE/HA		2.46	2.25
PER MAN			
N1	0	5	8
XB	5	3	0
M2	0	4	5
N2	5	7	5
N*/HA		5.46	5.08
V		0.96	0
2*SE/HA		1.24	0

YUF001 1992 SPRING DENSITY

	12-MAY-92	13-MAY-92	14-MAY-92	15-MAY-92
CHA FOR				
N1	0	4	6	6
XB	4	2	0	1
M2	0	1	1	4
N2	4	3	1	5
N*/HA		2.78	1.85	2.28
V		10.00	0	0.56
2*SE/HA		1.95	0	0.46
DIP MER				
N1	0	22	34	39
XB	22	12	5	6

YUFOO1 1992 SPRING DENSITY, continued.

	12-MAY-92	13-MAY-92	14-MAY-92	15-MAY-92
M2	0	16	24	23
N2	22	28	29	29
N*/HA		11.80	12.65	15.12
V		9.23	3.23	8.00
2*SE/HA		1.88	1.11	1.75
DIP MIC				
N1	0	5	10	10
XB	5	5	0	7
M2	0	5	5	9
N2	5	10	5	16
N*/HA		3.09	3.09	5.46
V		0	0	1.19
2*SE/HA		0	0	0.67
PER LON				
N1	0	3	5	5
XB	3	2	0	3
M2	0	2	3	2
N2	3	4	3	5
N*/HA		1.75	1.54	3.40
V		1.11	0	9.06
2*SE/HA		0.65	0	1.85
ONY TOR				
N1	0	3	5	
XB	3	2	2	
M2	0	0	0	
N2	3	2	2	
N*/HA		3.40	5.25	
V		36.00	90.00	
2*SE/HA		3.70	5.86	

YUFOO1 1992 SUMMER DENSITY

	24-JUN-92	25-JUN-92
CHA FOR		
N1	0	6
XB	6	3
M2	0	3
N2	6	6
N*/HA		3.47
V		3.51
2*SE/HA		1.45
DIP MER		
N1	0	34
XB	34	14
M2	0	31
N2	34	45
N*/HA		15.22
V		2.00
2*SE/HA		0.87

YUF001 1992 SUMMER DENSITY, continued.

	24-JUN-92	25-JUN-92
DIP MIC		
N1	0	15
XB	15	7
M2	0	13
N2	15	20
N*/HA		7.10
V		1.60
2*SE/HA		0.78
PER LON		
N1	0	5
XB	5	3
M2	0	0
N2	5	3
N*/HA		7.10
V		180.00
2*SE/HA		8.28
ONY TOR		
N1	0	9
XB	9	8
M2	0	4
N2	9	12
N*/HA		7.72
V		34.67
2*SE/HA		3.63

YUF019 1992 SPRING DENSITY

	19-MAY-92	20-MAY-92	21-MAY-92
DIP MER			
N1	0	4	11
XB	4	7	2
M2	0	2	7
N2	4	9	9
N*/HA		10.88	9.72
V		19.44	1.67
2*SE/HA		6.12	1.79

YUF020 1992 SPRING DENSITY

	19-MAY-92	20-MAY-92	21-MAY-92
DIP MER			
N1	0	6	13
XB	6	7	5
M2	0	4	9
N2	6	11	14
N*/HA		10.97	13.89
V		7.84	3.82
2*SE/HA		3.89	2.71

YUF021 1992 SPRING DENSITY

	27-MAY-92	28-MAY-92	29-MAY-92
DIP MER			
N1	0	1	8
XB	1	7	8
M2	0	1	7
N2	1	8	15
N˚/HA		5.64	11.99
V		0	2.00
2*SE/HA		0	2.00

YUF022 1992 SPRING DENSITY

	27-MAY-92	28-MAY-92	29-MAY-92
DIP MER			
N1	0	3	9
XB	3	6	3
M2	0	3	8
N2	3	9	11
N˚/HA		6.35	8.70
V		0	0.44
2*SE/HA		0	0.94

YUF023 1992 SPRING DENSITY

	02-JUN-92	03-JUN-92	04-JUN-92
DIP MER			
N1	0	20	28
XB	20	8	2
M2	0	16	21
N2	20	24	23
N˚/HA		20.75	21.28
V		3.23	0.88
2*SE/HA		2.50	1.30

YUF024 1992 SPRING DENSITY

	02-JUN-92	03-JUN-92	04-JUN-92
DIP MER			
N1	0	22	29
XB	22	7	7
M2	0	22	28
N2	22	29	35
N˚/HA		20.14	25.17
V		0	0.30
2*SE/HA		0	0.76
DIP MIC			
N1	0	8	9
XB	8	1	1
M2	0	4	7
N2	8	5	8
N˚/HA		6.81	7.12
V		1.44	0.31
2*SE/HA		1.67	0.78

STATUS OF LARGE MAMMALS AND BIRDS AT NEVADA TEST SITE, 1992

Paul Greger and Evan Romney

ACKNOWLEDGEMENTS

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ABSTRACT

Wildlife monitoring during 1992 included work on the feral horse population at the Nevada Test Site as well as observations on raptors and other migratory birds. The number of adults in the horse population (3 years and older) stayed nearly constant at fifty nine horses. The drought eased in 1992, resulting in an increased number of foals produced (seventeen), but foal losses increased to 100%. Mountain lion predation on foals was postulated to be controlling growth rate of the herd. A maximum population size of 80 horses for the NTS is recommended to minimize habitat disturbance. Increased frequencies of sightings of deer, raptors and other birds occurred during 1992 over 1991 suggesting a population response to the increased moisture availability.

INTRODUCTION

Monitoring of feral horses *Equus caballus* at the NTS began in 1989 by the University of California at Los Angeles (UCLA) under the U.S. Department of Energy's (DOE) Basic Environmental Compliance and Monitoring Program (BECAMP). The objective was to address concerns by estimating population size and monitoring the long-term trends in the horse population. The NTS, located approximately 100 km northwest of Las Vegas, Nevada, was commissioned in 1950 for nuclear weapons testing. Cattle and other livestock grazed by local ranchers were removed from the NTS prior to the commencement of testing in January of 1951. A small herd of feral horses was known to occupy this region after removals although a census was never performed. Since then, with the exception of some experimental cattle grazing, the 3500 km^2 of the NTS has been protected from livestock grazing.

Monitoring of wildlife trends of large mammals and birds continued at the NTS during 1992 with horses and raptors receiving the most emphasis. Feral horses were placed under federal protection, with the Wild and Free-Roaming Horse and Burro Act of 1971, and much interest has focused on populations in the western United States. Recent estimates of feral horse numbers in the western United States exceed 40,000, with the largest component, about 28,000 occurring in Nevada (Berger 1986). There has also been concern about recent increases in horse populations in central Nevada bordering the northern NTS boundary.

METHODS

Large Mammals

During 1992 all horses were easily recognized as individuals from color patterns. Horses of known age from previous years were observed for survival. All bands that persisted for at least three months or longer were described and given a letter designation (A,B,C etc). Associations of bachelor males were also recorded. Most bands were located monthly in the peak foaling season (March-June) and again in the fall (October-November) to assess foal survival and to describe movement patterns between winter and summer range. Additional data recorded were changes in band structure, presence or absence of foals, and health status of individuals. Approximate locations of bands were plotted on maps to illustrate usage of the available range between years. Because road surveys were performed much more often than field surveys in remote areas (i.e. off-road areas), the locations of bands recorded were biased towards roads.

Foal survival was calculated by dividing number alive at the end of the biological year (following April) by the initial cohort observed. Foaling rate was estimated by dividing total foals observed in each year by the number of females judged to be three years of age or older. The finite rate of increase λ, defined as the change in population size per unit time (final number divided by initial number), was determined for horses (yearling and older) surviving through April of each year. Well reservoirs were visited to record presence of horses, mountain lions and deer.

Mule deer were also monitored using spotlight counts on three nights in September on Pahute and Rainier mesas. The sighting rate, expressed as deer per kilometer of road driven, was used as a relative trend indicator.

Bird Monitoring

Opportunistic sightings of raptors were recorded in 1992 as in previous years, combining sightings from all months. Additional road surveys for raptors were implemented in the fall of 1992 to illustrate a technique which is more quantitative than previous methods. With this method raptors were counted and expressed per unit of field time (raptors/hour). Visits to springs were continued to record breeding activity of raptors and other species of birds. Known locations of active raven nests from previous years were checked for nestlings and new ravens nests were also recorded when located.

Repeated visits were made in recent years to selected springs and well reservoirs to record species of migratory birds. The locations (degree, minute, second) and elevations (m) of these sites are listed in Tables 1 and 2. The present bird monitoring effort is directed at updating the bird species list for the NTS, as well as recording new records of breeding birds. Springs and ponds on the NTS offer special habitats where many species of birds can be located. Details of field methods for wildlife monitoring at water sources can be found in Greger and Romney (1991a).

Table 1. Approximate elevations and locations of natural springs on the Nevada Test Site monitored for wildlife utilization in 1992.

Water source	Elevation m	Area	Latitude	Longitude Coordinates
Cane spring	1237	5	36 47 56 N	116 05 42 W
Tippipah spring	1585	16	37 02 35 N	116 12 13 W
Topopah spring	1774	29	36 56 20 N	116 16 07 W
Reitman seep	1402	7	37 05 38 N	115 58 23 W
White Rock spring	1539	12	37 12 06 N	116 07 43 W
Captain Jack spring	1792	12	37 10 07 N	116 10 08 W
Oak spring	1783	15	37 14 45 N	116 04 23 W
Tub spring	1594	15	37 14 28 N	116 02 33 W
Gold Meadow sump	2048	12	37 13 47 N	116 12 22 W

Table 2. Approximate elevations and locations of well reservoirs on the Nevada Test Site monitored for wildlife utilization.

Reservoir	Elevation m	Area	Latitude	Longitude Coordinates
Mercury sewage	1103	23	36 39 22 N	116 00 46 W
Well J11 pond	1048	25	36 47 06 N	116 17 07 W
Well J12 pond	954	25	36 45 53 N	116 23 27 W
Well J13 pond	1000	25	36 48 45 N	116 23 48 W
Nuwax pond	932	25	36 44 30 N	116 23 22 W
Well 5B pond	943	5	36 48 05 N	115 58 05 W
Well Ue5c pond	978	5	36 50 11 N	115 58 47 W
Cambric-ditch	954	5	36 49 20 N	115 58 03 W
Well C1 pond	1195	6	36 55 11 N	116 00 35 W
Decon pond	1195	6	36 56 15 N	116 02 10 W
CP sewage pond	1228	6	36 55 55 N	116 02 60 W
Well 3 pond	1210	6	36 59 45 N	116 03 30 W
Mud Plant pond	1227	3	37 02 51 N	116 01 46 W
Well 16D pond	1426	16	37 04 11 N	116 09 49 W
Well 2 pond	1365	2	37 09 58 N	116 05 11 W
Mud Plant pond	1372	2	37 09 47 N	116 05 41 W
Sewage pond	1554	12	37 12 03 N	116 08 50 W
N Tunnel ponds	1753	12	37 11 49 N	116 10 57 W
Camp 17 pond	1756	18	37 09 49 N	116 15 33 W
Well 8 pond	1737	18	37 09 50 N	116 17 31 W
19C Lower pond	2036	19	37 16 00 N	116 19 23 W

RESULTS

FERAL HORSE POPULATION

The Study Region

Horses resided on the Eleana Range and peripheral areas within a 325 km^2 region of transition zone between the Mohave and Great Basin deserts (Figure 1). Horses occupied habitats between 1300 and 2000 m elevation and made seasonal altitudinal adjustments within this range. The habitat was dominated by desert shrubs, largely blackbrush (*Coleogyne ramosissima*) and sagebrush (*Artemisia tridentata* and *A. nova*), with intermixed grasses such as galleta (*Hilaria jamesii*), ricegrass (*Oryzopsis hymenoides*), and needlegrass (*Stipa speciosa*). Mean rainfall (1976-91) measured at Tippipah Spring weather station (elevation 1519 m; N Lat. 37-03-12, W Long. 116-11-30) was 240 mm. Winters were mild with limited snowfall.

Water Usage

Only six of the approximately 30 water sources available for wildlife usage were utilized by feral horses from 1992 (Figure 2). These included Gold Meadow sump, Captain Jack Spring, reservoir 2-Area 2, N tunnel ponds, Camp 17 pond and well reservoir U19c (lower). Water sources in the higher elevations such as reservoir U19c were less frequently by horses than water sources at mid to lower elevations. Horse activity around water sources was concentrated at elevations of 1500-1800 m in the Eleana Range, and centered around two water sources, Camp 17 pond and Captain Jack Spring. About 40 horses (yearlings and older) were primarily dependent on Camp 17 pond as a summer water source. Gold Meadow sump was used during summer but it was not a dependable summer-fall water source. It dried up by early October of 1992. By contrast, Captain Jack Spring, while small in storage volume (<1.0 m^3) was more dependable as a summer water source. About 23 horses foraging on the east side of the Eleana Range utilized Captain Jack Spring as a summer water source. The Area 2 pond and N Tunnel ponds were also used as water sources during the summer and fall of 1992 but probably less frequently than Captain Jack Spring. T tunnel ponds were not known to be used by horses at any time since the study began.

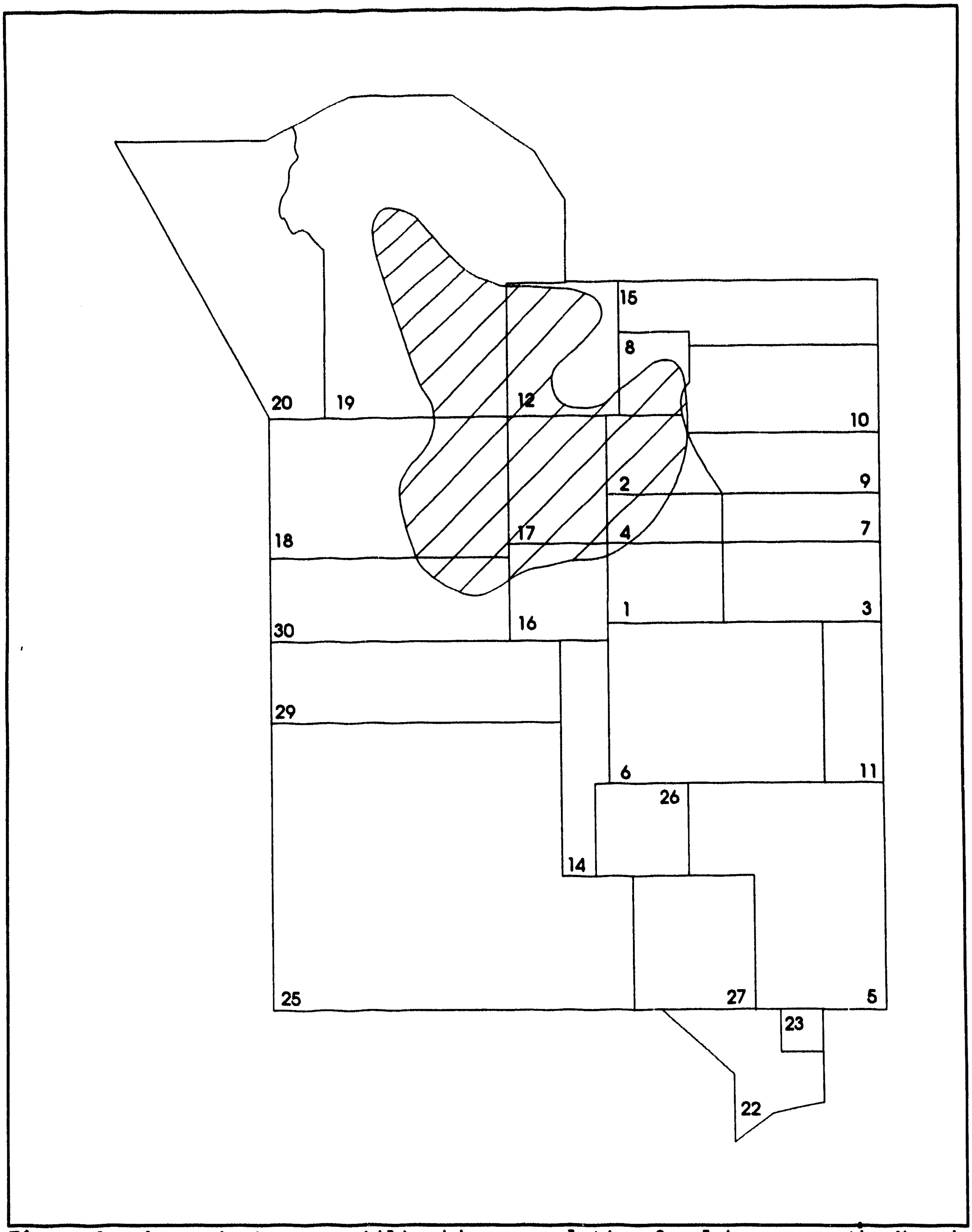

Figure 1 - Approximate area utilized by a population feral horses on the Nevada Test Site from 1989-1992.

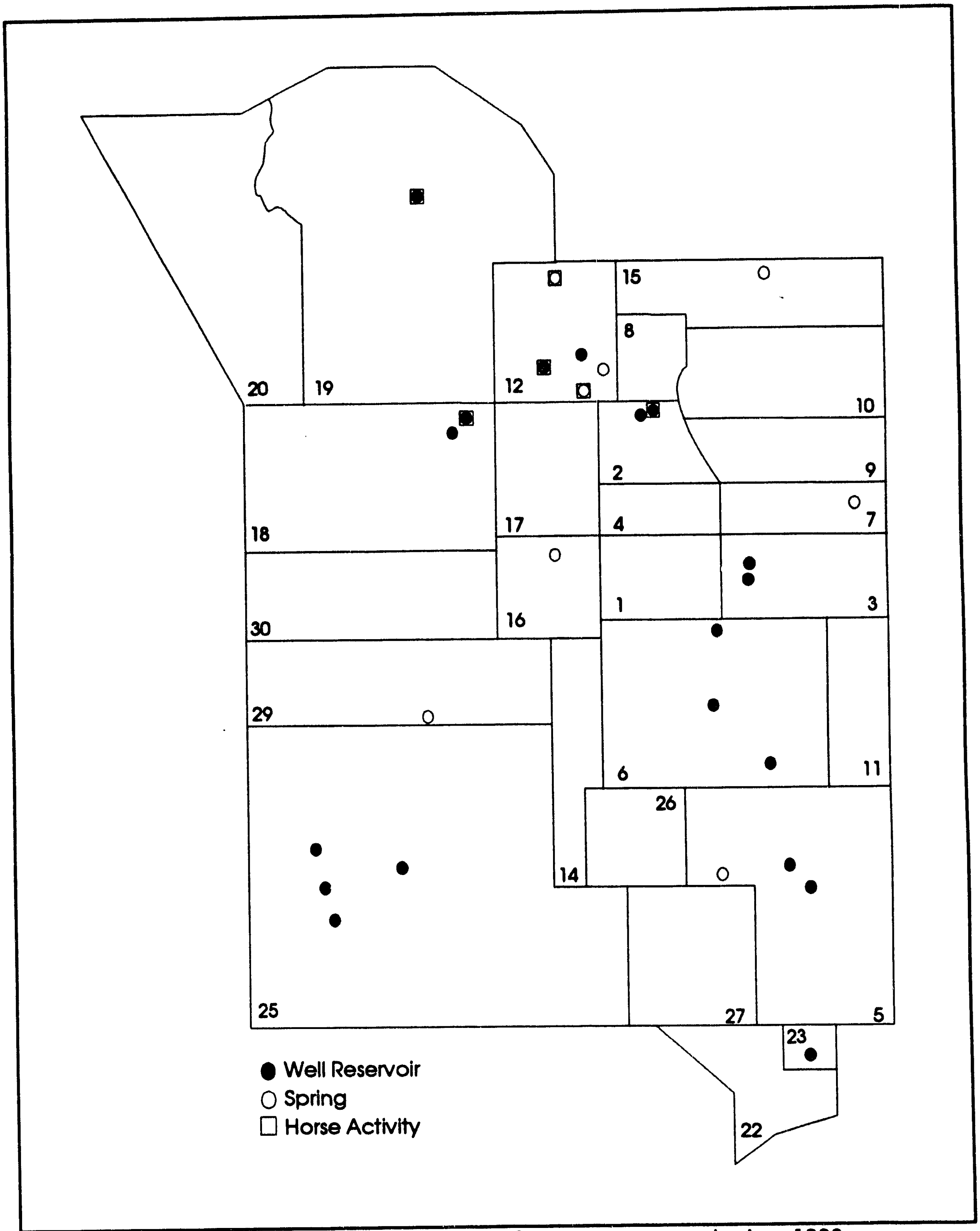

Figure 2 - Feral horse usage of water sources during 1992.

Status of Horse Bands

At the end of 1992 there were thirteen active horse bands, and eleven individual bachelor males (Table 3). The NTS horse population, like most other ones from the western United States has less males than females (male\female sex ratio = 0.84:1.0 : 59 adults, 3 years or older). Mean band size and harem size during 1992 was 3.8±0.4 and 2.1± 0.3 respectively and changed little over the past three years. A band is a social unit of horses ranging in size from 2 to 20 or more individuals, and is generally defined by one stallion and one or more adult females and their offspring. A band with more than one adult male is called a multimale band. Bands can be short lived (several months) or persist for years. Stable bands are those which normally do not incur a stallion change within a period of a year. Groups of bachelor males (those not associated with harems) also form associations which may last only days or weeks. During 1992 most bands maintained as distinct social units. Exceptions were band R, newly formed in 1992 and band E which broke up in mid-summer of 92; all six females from band E were temporarily acquired by the stallion from band C, who consorted with them until late fall, after which they changed bands a second time.

Table 3. Feral horse associations at the NTS 1992.

Band	Horse Identification Numbers
A	Bays 8,9,<u>11</u>,12,59
B	Blacks 26,<u>27</u>,30,69, Bay <u>20</u>,
C	Bays 1,21,22,7, Buckskin 39, Gray <u>46</u>
E	Bays <u>13</u>,16,17,18, Grays 35,37
F	Bays <u>4</u>,52,53,62,31
G	Bays <u>50</u>,51, Sorrel 47,
H	Bays <u>2</u>,58,60,
I	Bays 6,<u>15</u>,24,67, Gray 38
J	Bays <u>3</u>, <u>57</u>, Gray 56,<u>66</u>
K	Bay <u>19</u>, Sorrel <u>40</u>, Blacks 29,63
L	Sorrel <u>54</u>, Bay 64, Black 61
N	Bay <u>48</u>, Palomino 32
Q	Bays <u>65</u>, 34
R	Bay <u>44</u>, Grey 55
Bachelor males	Bays 10,13,14,23,25,42,43,49,Black 28,Sorrel 45, Grey 36

All males in bands are underlined. Bands D,M,O and P disbanded in previous years. Band E broke up in 1992.

Reproductive Status and Age

During 1992, 31 females gave birth to at least 17 foals (foaling rate = 55 %). This rate is conservative because one or more mares were pregnant but were never observed with foals (Table 4). Observations indicate that foal births commenced in late March and continued through June. The last foal sighting was on July 30. Comparing previous years records to 1992, indicates that some mares (7) showed a pattern of foaling in consecutive years while others in alternate years. Reproductive capability or foaling rates in horses increases with age. Normally, horses begin foaling at age three or older, although rare cases have been reported where two year-old mares gave birth (Berger 1986).

Table 4. Mare reproductive summary and status of foals during 1992. N = the number of sightings. Final date is the day a given foal was last seen.

Mare	Band	Dates of Foals initial	final	N	Foaling[a] frequency	Status	Color
Bay	51 G	3-30-92	5-26-92	5	f	missing	bay
Bay	52 F	4-01-92	4-20-92	4	2c	missing	bay
Gray	35 E	4-13-92	4-22-92	4	a	missing	bay
Bay	18 E	4-13-92	4-16-92	2	3c	missing	bay
Gray	38 I	4-22-92	-------	1	f	missing	bay
Black	29 K	4-22-92	-------	1	a	missing	sorrel
Bay	1 C	5-04-92	6-29-92	6	f	missing	bay
Bay	21 C	5-04-92	7-30-92	10	2c	missing	bay
Bay	22 C	5-04-92	6-17-92	5	a	missing	bay
Gray	37 E	5-18-92	5-21-92	2		missing	bay
Bay	64 L	5-19-92	7-07-92	7	2c	missing	bay
Bay	8 A	5-22-92	-------	1	a	missing	bay
Bay	58 H	5-26-92	-------	1	3c	missing	bay
Gray	24 I	6-02-92	6-04-92	2	2c	missing	bay
Sorrel	47 G	6-04-92	6-17-92	3	f	missing	bay
Bay	62 F	5-22-92	6-02-92	3	3c	missing	bay
Black	61 H	6-17-92	7-01-92	2	f	found dead	bay
Grey	56 J					Pregnant[b]	

[a] a= mare produced foals in alternate years.
c = number of consecutive years that a mare produced a foal.
f = first time mare was recorded with a foal.
[b] mare was pregnant in the final trimester but the foal was never observed.

Horses aged between about 5 and 12 years are generally the most fecund. Berger (1986) reported that foaling rates for horses (five years and older) from numerous populations varied from about 50 to 70 % or greater. Although detailed knowledge of age structure for the NTS population is not yet known, most of the 31 monitored females were believed to be more than three years old in 1992. One three year-old female (born in 1989) has not yet been observed with a foal.

Minimum ages were inferred from relative body size and dated photographs of individual horses. For example, one individual, number 61, foaled in 1992 (possibly her first) and was age estimated from photographs to be at least 5 years old. Similarly, number 51, observed with a foal, was believed to be 7 years old in 1992. Presently, known ages exist for only eight horses on the NTS (Table 6). Additional age data will be developed yearly as new horses are recruited to the population.

Seasonal Movements

Records of band sightings suggest that the range is spatially partitioned by season and bands showed a moderate to high degree of fidelity to regions inhabited between years. During spring of 1992, all bands except C spent time intermixing in a remote region of area 17 (Figs. 3-5). In mid-May, as air temperatures rose, most bands began their movements to higher elevations. Spatial partitioning of the available range by different bands became apparent at this time. For example, bands A,B,K,and N occupied the east slope of the Eleana Range and areas of Yucca Flat (Fig. 3). Conversely, most other bands (C,E,F,G,H,I,J,L) showed consistent summer and fall habitat usage on the west slope of the Eleana Range (Figs. 4-5). These patterns have been observed regularly between years with some variation.

Foal Mortality and Population Stability

Bands were monitored for foal births and status over a twenty week period. Losses of foals was highest in late May through June (Table 5). No foals survived past the month of August. Foals were missing at an average rate of about one or two a week and their disappearance was usually sudden (several days to a week). In addition foals normally appeared healthy with no obvious physical problems.

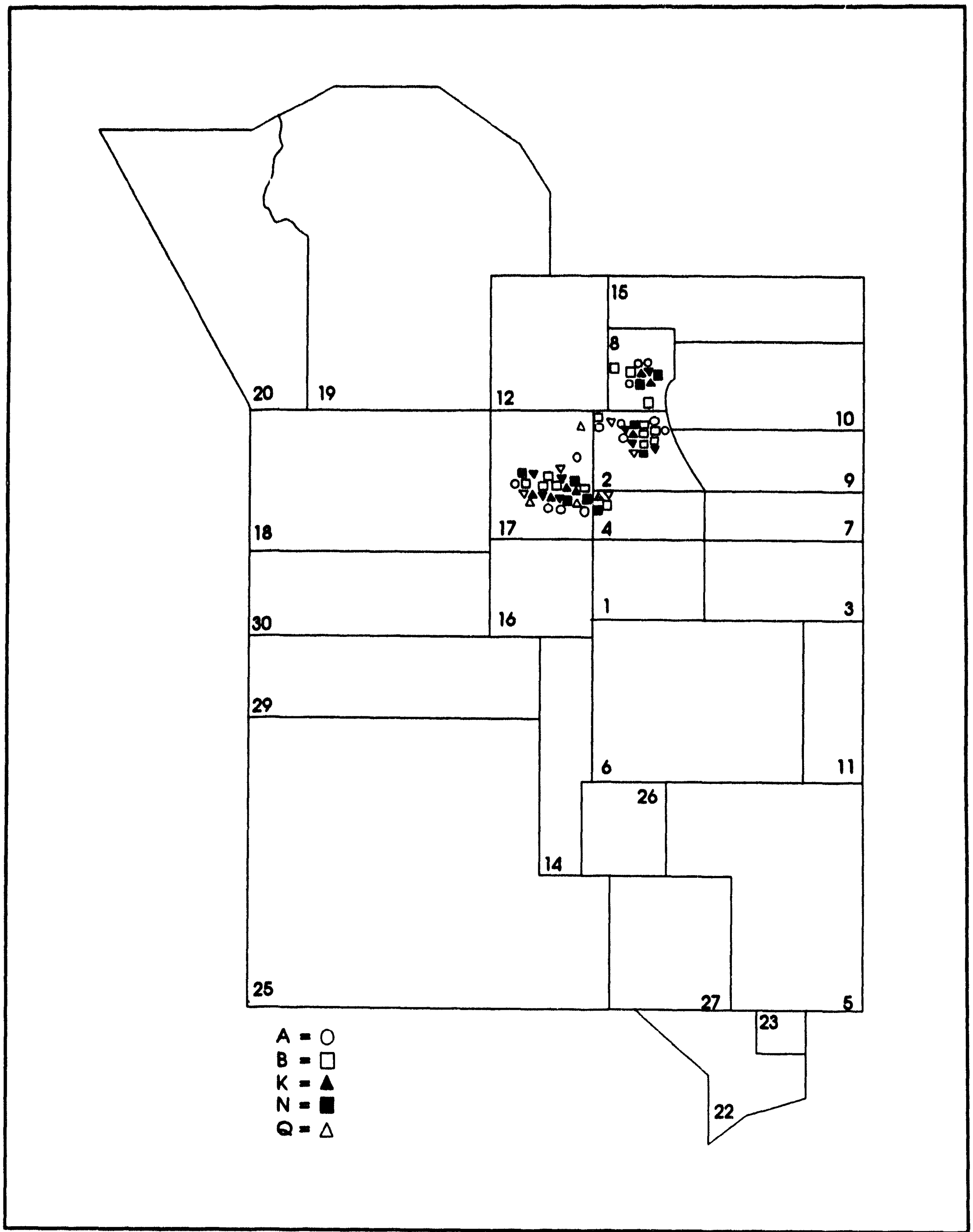

Figure 3 - Locations of feral horse bands during 1992.

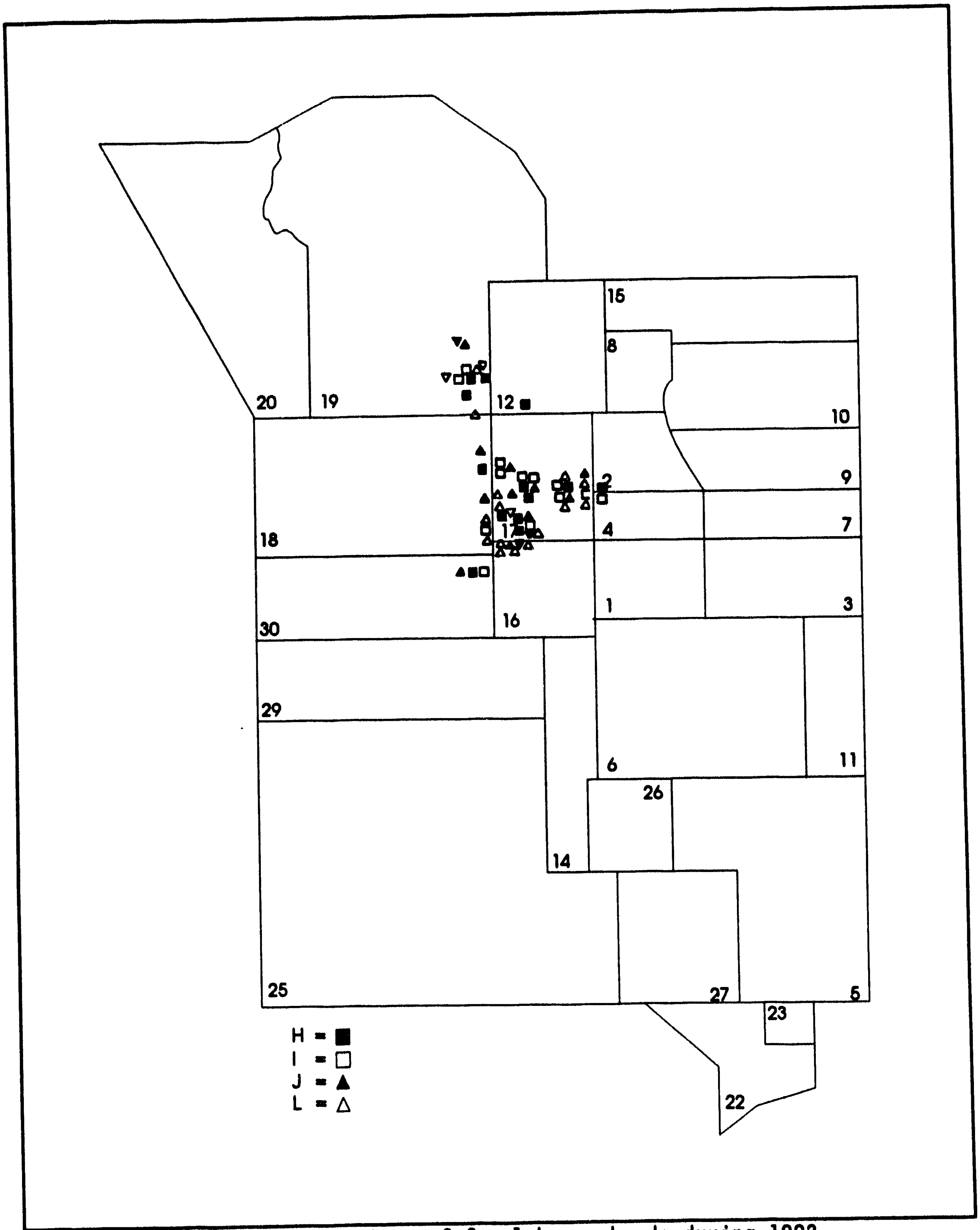

Figure 4 - Locations of feral horse bands during 1992.

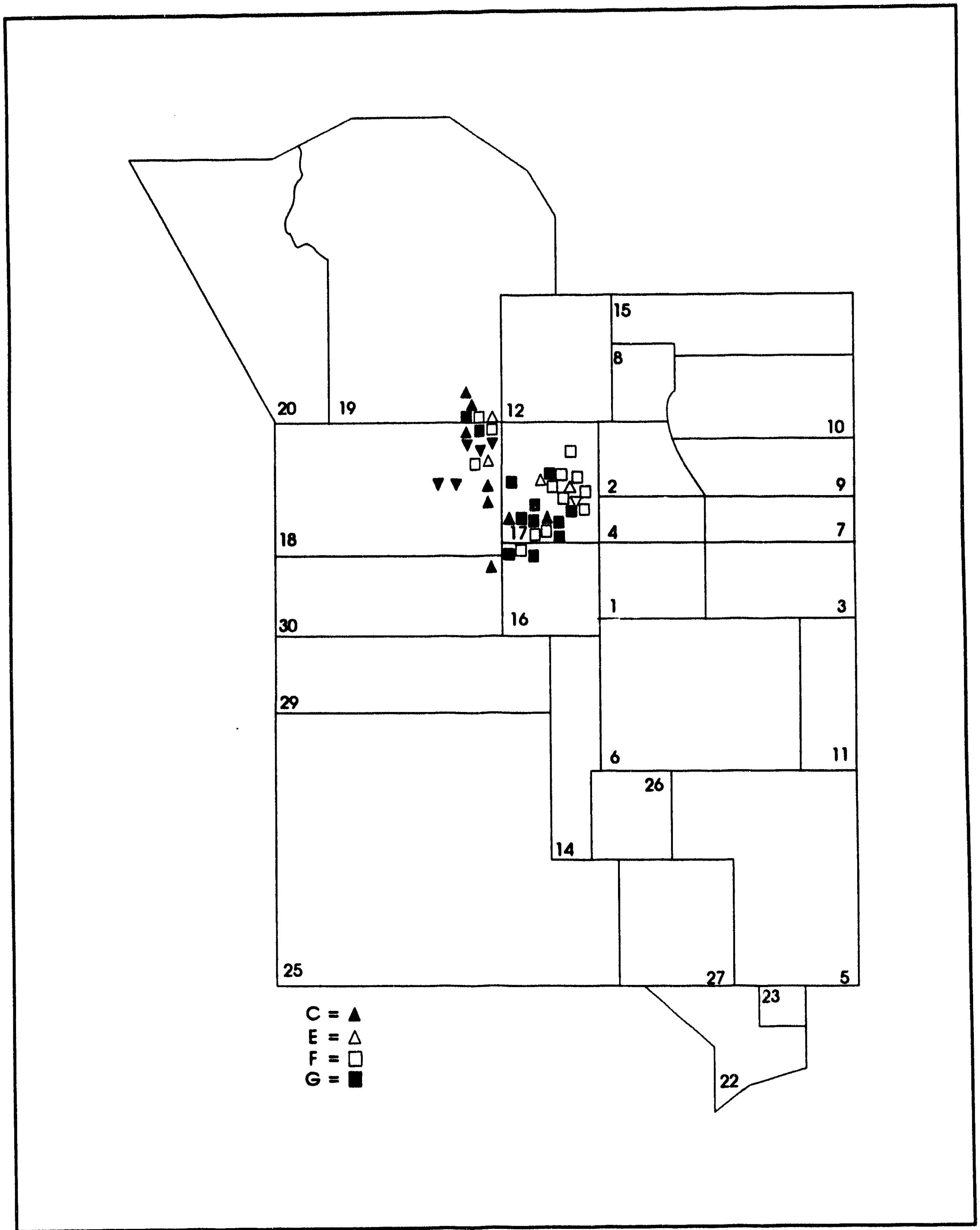

Figure 5 - Locations of feral horse bands during 1992.

Table 5. Foal losses and Incremental Foal Survival rates at the NTS during Spring and Summer 1992.

	Periods		
	3-30 to 5-22	5-25 to 7-3	7-6 to 8-1
Total Number[a]	13	12	2
Foals remaining	8	2	0
% Survival[b]	61.5	16.7	0

[a] = Total number alive during each period.
[b] = Live foals at the end of each period/total number.

Cumulative adult survival of horses at the NTS over a three year period was high (97 %). Annual rates of increase (Table 6) over the same period were low (0 to 7%) in comparison to more recent rates reported (15-30%) for feral horses in the Great Basin (Eberhardt et al. 1982, Berger 1986, Wolfe 1986, Garrott et al. 1991). The horse population at the NTS appears to be stable primarily because of low recruitment. Locating missing foals has proved to be difficult. Only one foal has ever been located shortly after death. One colt was observed with a large wound (presumably from a predator) on his hindquarters in mid June 1992, and was found dead about two weeks later. This foal appeared to die from complications related to the wound.

Table 6. Total population number of feral horses at the NTS from 1990-92. Foals excluded.

Age Class	1989	1990	1991	1992
Adults[a]	59	58	57	57
Three Year olds		0	0	2
Two Year olds		0	2	2
Yearlings	1	2	2	4
Total	60	60	61	65
Rate of increase		1.00	1.02	1.07

[a] = Horses were estimated to be at least three years old in 1989 based on relative body size and photographic records available.

Mule Deer Census

Road counts of mule deer/km on the NTS suggested that the population was reduced during years of drought (Table 7). Counts from 1992 imply that numbers were rebounding to near pre-drought levels. The variation in the nightly counts has generally been low in past years with the exception of 1992. This was attributed to changing weather patterns (primarily high winds and low temperature) observed on the last count night coincident with fewer deer observed.

Table 7. Mean (± 2sem) number of deer seen per kilometer of road travelled on three nights at sites on Pahute and Rainier Mesas, 1989-1992.

Year	N/Km
1989	0.56 ± 0.10
1990	0.35 ± 0.02
1991	0.24 ± 0.04
1992	0.54 ± 0.20

Raptor Observations

During 1992 we continued to record opportunistic sightings of raptors, however intensive monitoring was not performed. Combining counts from all years, percent composition indicated the six most abundant species observed were turkey vulture, red-tailed hawk, golden eagle, american kestrel, burrowing owl and prairie falcon. Relative numbers of raptors recorded increased during 1992 (Table 8), probably reflective of an increase in numbers of migrants moving through the region. Notable records in 1992 include a peregrine falcon, sighted near a well reservoir on Frenchman flat in the fall, and several sightings of northern goshawks near Gold Meadows sump and above Rainier Mesa in summer. Most sightings reflect effort at the lower elevations of the NTS, because we normally record raptors when we are performing other tasks. Because our field time was concentrated on the lower shrub communities, sightings are generally biased against raptors that inhabit the forested mesas (i.e. accipiters). Cooper's and Sharp-shinned hawks were two common NTS species under-represented in our counts. Number of field days indicate (Table 9) that effort varied about 7 to 27% over all years. From 1989 through 1990 although field effort increased, the number of raptor sightings decreased dramatically. This change may have been reflective of regional population declines of raptors during the ongoing drought. Total numbers of raptors recorded between 1991 and 1992 increased by about 82 percent (χ^2 = 83.5, P<.001, 14 df), while estimated field effort increased by only about 7 percent. In this case, increasing numbers of sightings were consistent with population increases as a response to waning drought conditions.

Table 8. Opportunistic sightings of raptors on the NTS, 1989-92. Percent composition calculated by combining counts from all years.

Species	1989	1990	1991	1992	91-92[b]	% composition
Turkey vulture	48	24	70	90	28.6	27.6
Golden eagle	37	14	22	28	27.3	12.0
Red-tailed hawk	69	35	44	70	59.1	25.9
Rough-legged hawk	9	0	2	7		2.1
Northern harrier	3	2	1	15		2.5
Osprey	1	1	2	3		0.8
Prairie falcon	18	6	7	14	100.0	5.4
Peregrine falcon	0	0	0	1		0.1
American kestrel	18	25	19	36	89.5	11.7
Northern goshawk	0	0	0	2		0.2
Accipiters	3	21	2	13		2.3
Long-eared owl[a]	0	2	2	4		0.9
Burrowing owl[a]	1	7	9	38	322.0	7.3
Great horned owl	1	1	1	5		0.9
Barn owl	0	0	0	1		0.1
Totals	214	118	181	317		
Estimated field days	104	132	114	122		

[a]= Sightings in 1992 include reproductive pairs and fledglings.
[b]= Percent increase in counts from 1991 to 1992 by the most common species

During the fall of 1992, raptors were counted per unit effort in the field (raptors observed\hour) as an illustration of the more quantitative technique (Table 9). Raptor sighting rates varied greatly between surveys, depending on weather and wind. The range in sighting rates in fall 1992 varied between a low of 0.4/hour (a cold day), to a maximum of 5 raptors/hr. This method if used more regularly may be the most cost effective technique for measuring yearly trends.

Table 9. Fall raptors recorded on field surveys on Yucca and Frenchman flats (N=12) per time effort.

Date	time(hr)	Number	Hawks\hr
10-15-92	3.00	4	1.33
10-16-92	6.75	4	0.59
10-21-92	5.25	4	0.76
10-22-92	5.75	4	0.70
10-23-92	2.00	2	1.00
10-26-92	5.50	3	0.54
10-28-92	4.00	6	1.50
11-02-92	2.00	1	0.50
11-03-92	5.00	2	0.40
11-04-92	5.50	10	1.81
11-05-92	5.50	8	1.45
12-10-92	3.00	15	5.00
Totals	53.25	63	1.30±0.36

Observations of Ravens

Sixteen active raven nests were located with young during field surveys in 1992, compared to only eight in 1991. The numbers of nestlings per nest was 1 to 6, compared to 1 to 3 for nests located in 1991. Although the number of fledged birds was not counted during 1992, the above evidence suggests an increase in reproductive effort for 1992. This pattern is consistent with increased water and food availability in 1992 over 1991. Six of eight nests that were active in 1991 were also producing young in 1992. As in 1991, most raven nests (13 of 16) were on man-made structures. The only nests on natural structures included two cliff nests and one on a Joshua tree.

On October 30, 1992 near a roadside in Mercury we observed three ravens in the immediate vicinity of a covey of chukars of which three were freshly killed. The ravens were feeding on the fresh remains and were apparently responsible for the kills. This is our first recorded evidence for raven predation on such a large granivorous bird. Ravens were also observed eating mourning doves at Cane spring in 1992. Ravens commonly exploited afterbirth remains of horses as a food resource in area 12 and 17.

Migratory Birds at Water Sources

During 1992, bird observations were not as extensive as was accomplished in 1990-91, however forty eight visits to water sources were performed for the examination of wildlife usage. Bird lists for well reservoirs were summarized by geographic area of the NTS (Tables 10-13). The data compiled from sightings imply a general increase in bird abundance both in relative numbers and species from 1991 to 1992. Higher numbers of juveniles (e.g. black-throated sparrows, chipping sparrows) were observed during 1992 than in 1991 implying increased reproductive activity. Birds sighted at well reservoirs consistently included migratory shorebirds and ducks, while springs continue to lack these species. Higher numbers of species were observed at high elevation water sources such as Gold meadows and Captain Jack spring verses springs at lower elevations such as Tippipah or Cane spring. Birds per visit was highest at Cane and Tippipah spring (Table 12), with mourning doves contributing the majority of numbers observed. The counts while only partially quantitative, indicate that mourning doves appeared to be more numerous in 1992 compared to 1991. For example, total numbers of birds (1sem) were sighted at Tippipah spring at a rate of 36 ± 22\visit in 1991 verses 119 ± 13\visit in 1992. At Captain Jack spring, sightings were 52 ± 27\visit in 1991 and 72 ± 17 in 1992.

Large granivorous species such as chukar, quail, and doves have rebounded well from recent increases in rainfall. Gambel's quail were observed in the vicinity of Captain Jack spring and at Well J11 in Jackass Flats in 1992, the first numerous sightings (>100) of this species since 1989. We have also observed Chukar with young in many locations throughout the NTS while in past years these sightings were few. High numbers of mourning doves at Cane spring in 1992 provided enough food such that long-eared owls were able to nest and fledge young. Mourning doves feed primarily on seeds of annuals (Best and Smartt 1986), and increases of rainfall at the NTS have resulted in increased annual production (see Hunter 1992 Ephemerals, this report). Higher annual production will likely produce a more abundant seed crop. Increased numbers of doves, chukar and quail observed with juveniles is consistent with increases in the food resource.

Table 10. Counts of migratory birds recorded at well reservoirs on Jackass Flats during 1992. N is the number of visits to each site. [a]=Juveniles abundant.

Species	N=6 Well J11	N=2 Well J13
Red-tailed hawk	1	
Cooper's hawk	1	1
American kestrel	1	
Great blue heron	3	
American bittern		1
Gambel's quail	40	
Mourning dove	16	>30
Road runner		1
Barn owl	1	
Great horned owl	3	
Red-naped sapsucker	1	
Say's phoebe		1
Western kingbird	2	2
Horned lark	5	26
N. rough-winged swallow	1	1
Common raven	4	
American robin	1	
Varied thrush	1	
Northern mockingbird	1	
American pipit	4	
Loggerhead shrike	2	2
European starling	3	
Yellow-rumped warbler	12	
Yellow warbler		2
Savannah sparrow	5	
Brewer's sparrow	2	1
White-crowned sparrow	10	>20
Black-throated sparrow[a]	>70	>6
Sage sparrow	6	>30
Western meadowlark	4	
Red-winged blackbird	3	
Brown-headed cowbird	15	
Lesser goldfinch	1	
House finch		>6
Teal (unid.)	1	
Sandpiper (unid.)		1
Number of species	29	16
Total Number of sightings	219	131
Mean Birds per visit	37±11	66±14
Total Number of species = 32		

Table 11. Counts of migratory birds at well reservoirs on Yucca Flat and northern regions of the NTS. N = the total number of visits to each site.

Species	N=1 Area 6 Well 3	N=2 Area 2 Well 2	N=1 Area 2 Mud	N=4 Area 3 Mud	N=2 Area 12 N Tunnel	N=7 Area 18 Camp 17
American bittern				1		
B. c. night heron				1		
Northern pintail				1		
American widgeon						10
Green-winged teal			11			
Cinnamon teal						1
Blue-winged teal						2
Redhead			2			
American coot			2	5		
Teal (unid.)			1			
Ducks (unid.)			10			
Turkey vulture					3	
Osprey						1
Cooper's hawk						1
Accipiter (unid.)						1
Red-tail hawk		1				
Northern harrier		2		1		
Killdeer					3	
Long-billed dowitcher	1					
Long-billed curlew	1					
Common snipe					1	
Solitary sandpiper						1
Spotted sandpiper						1
Gull (unid.)				1		
Mourning dove	>30	70				178
Belted kingfisher				1		
Northern flicker					2	
Say's phoebe						3
Western kingbird	3					
Horned lark	6	21				
Violet-green swallow						2

Table 11, continued. Migratory birds at well reservoirs.

Species		Area 6 Well 3	Area 2 Well 2	Area 2 Mud	Area 3 Mud	Area 12 N Tunnel	Area 18 Camp 17
Common raven	2	4		25			
Pinyon jay			60	54			
N. mockingbird	1						
Sage thrasher		1					
Cedar waxwing					1		
Loggerhead shrike					2		
Western tanager					1		
Sage sparrow		>10			>50		
Black-throated sparrow			1			5	
Brewer's sparrow					21		
Chipping sparrow					1		
White-crowned sparrow			>8		15		
Red-winged blackbird						6	
Brown-headed cowbird					15		2
Brewer's blackbird							3
Great-tailed grackle					1		
Pine siskin						25	
House finch		6					>30
Total birds observed		50	118	13	38	140	370
Species per site		8	9	2	11	9	21
Mean Birds per visit		50	59±16	13	11±5	70±64	62±41

Total Number of species = 46

Table 12. Migratory bird counts at springs on the NTS throughout the year. N=total number of visits per site.

Species	N=2 Cane spring	N=1 White Rock	N=2 Reitman Seep	N=5 Gold Meadow	N=7 Captain Jack	N=2 Tippipah spring	N=1 Topopah spring
Turkey vulture			13	5			
Northern goshawk			1				
Sharp-shinned hawk			1	1			
Cooper's hawk				1			
Accipiters (unid.)			1	4			
Red-tailed hawk			2	1	1		
Northern harrier			1				
Chukar				35			
Gambel's quail				69			
Mourning dove	200	50	20	73	260	200	50
Long-eared owl	4						
W. throated swift					2		
Say's phoebe	1	3				2	
Cassin's kingbird				1			
V. green swallow				2			
Common raven	1	1		42	4		
Pinyon jay				2	50		
Bushtit					2		
Rock wren				1	11	1	
B. g. gnatcatcher					2		
Western bluebird				8			
Amercian robin				1			
N. mockingbird					1	1	
Phainopepla	1						
Starling	1						
Lazuli bunting	1						
Rose-breasted grosbeak				1			
Black-headed grosbeak			2				
B. throated sparrow	5				>10	4	
Lark sparrow				2			
Vesper sparrow				5			
Brewer's sparrow				4		2	
Chipping sparrow				71			
Dark-eyed junco			1		15		
B. headed cowbird				13		8	1
Pine siskin					25		

Table 12, continued. Migratory bird counts at springs.

Species	N=2 Cane spring	N=1 White Rock	N=2 Reitman Seep	N=5 Gold Meadow	N=7 Captain Jack	N=2 Tippipah spring	N=1 Topopah spring
Lesser goldfinch				4			
American goldfinch				3			
House finch	>40			35		20	
Cassin's finch				20			
Unid. sandpiper				1			
Total number	254	54	21	309	499	239	51
Birds per visit	129±10	108	10±9	63±10	72±17	119±13	51
Species per site	9	3	2	24	18	9	2

Total number of species = 40

Table 13. Counts of migratory birds on Frenchman Flat reservoirs and at Mercury sewage ponds.

Species	N= 1 Mercury Sewage	N=1 Well 5b	N=3 Ue5c
Peregrine falcon			1[a]
Killdeer	11		
Greater yellowlegs	1		
American coot		1	
Common snipe			1
Bonaparte's gull[b]	2		
American pipit	>1		
Loggerhead shrike			1
Horned lark		1	8
Marsh wren		1	
Yellow-rumped warbler			2
Sage sparrow		>20	>20
White crowned sparrow			1
Brown-headed cowbird		1	
House finch		>6	>40

Total species = 15

[a] = First recent sighting since reported by O'Farrell and Emery (1976)

[b] = First recent sighting since recorded by Castetter (unpubl. field notes 1975-77).

DISCUSSION

Feral Horses and other Large Mammals

The migration of different components of the herd in the summer and fall appears related to several factors such as the location of water sources, rising air temperatures, increasing water needs, forage availability and loss of ephemeral water sources. It is not known why some bands move to the Camp 17 region for summer water and why others move to Captain Jack Spring region at the same time. However the patterns have been consistent over three years of study. Horses that water around Captain Jack Spring in the summer have never been observed near Camp 17 pond during any season. Similarly most bands (except F) that habitually use summer water at Camp 17 pond, have not been seen near Captain Jack spring. Certain bachelor males seem to be more flexible than regular bands and appear in both regions from year to year (see Greger and Romney 1991b). Therefore, bands occupy " home ranges" which include all the resources horses need to survive. Formation of home ranges by bands undoubtedly involves a "learning component" developed through conditioned responses and past experiences. However, the flexibility of such responses towards a changing environment is not known. Therefore, if the availability of a "man-made" water source was discontinued during a critical period (i.e.summer), it is not known if feral horses could respond by locating another.

A total of 59 adult horses were identified in the population during the first year of study (1989-90). Since then, no new adult horses were identified (i.e. possible immigrants) from 1990 through 1992, suggesting that the population was insular. This finding is noteworthy, considering that the Nellis Air Force Range located directly north of the NTS currently harbors an expanding population between 4000 and 5000 horses. However, sightings of large groups of horses (>80 individuals) were made in 1992 near the northern boundary of the NTS in Kawich Valley. It is likely that rugged terrain and narrow canyons in this region are restricting direct horse movement into more southern regions of the NTS. Playas are also known to be barriers to horse dispersal (Berger 1986).

Cause of Foal Losses

Growth of the NTS horse population in 1992 appeared limited by predation pressure. Mountain lion predation appears to be the most reasonable explanation for the sudden disappearance of healthy foals. Missing foals have been noted in each year of study since 1990, with seventeen missing in 1992 alone. Disappearance of foals with no observable deficiencies over very short time intervals (several days to a week), suggests losses due to predation. Furthermore it is not probable that losses of 100 percent could be the result of inbreeding mortality alone. Similarly, migration of foals away from bands by themselves to other regions is not reasonable. Other known causes of death for horses on the NTS include vehicle collisions on highways (one yearling was killed in spring of 1992). Numerous old skeletal remains (>15) including several foals have been located on the NTS over the last four years indicating that horses complete their life spans here. Foal survival rates previously reported in North America ranged from 67 to 93% (Berger 1986, Siniff et al. 1986, Wolfe 1986). Estimated foal survival at the NTS over three years was lower (6 of 38 foals or 16 %) than any studies reported in the U.S. Most recently, mountain lion predation on feral horses in the Montgomery Pass Wild Horse Territory limited annual foal survival to about 27 percent over four years (Turner et al. 1991).

Although foaling rate increased appreciably in 1992 over 1991, all foals perished by the end of summer. Total rainfall (X) received during three years was significantly correlated with foal production ($r=.99$; $Y = .04 X + 4.178$) and foaling rate ($r=.99$; $Y = .0014 X + 0.109$) (Table 14). Similarly spring rainfall (during the final trimester of gestation) was significantly correlated with number of foals produced ($r=.98$) and foaling rate ($r= .97$). Foal survival was negatively correlated with rainfall ($r= -.84$) suggesting some other factor is crucial. Improved forage conditions were observed in 1992 and foals should benefit from this, however benefit was not reflected in increased survival (Table 14). Finding direct evidence for the sudden disappearances of healthy foals on the NTS in recent years has proved to be difficult. The difficulties arise because of the large areas that need to be searched. Because the period of heaviest predation appears to be June (Table 5) search effort should be concentrated at this time.

Deer numbers may lag behind other mammals as they respond to easing drought conditions. However, if deer numbers are increasing as surveys suggest, then predation by mountain lions could shift away from horses back to deer, their usually abundant prey. It is also feasible that the total foal losses could be explained by predation from several selective lions alone. Foals have were lost at a rate of about one or at most two individuals a week, well within the capability of two mountain lions. Two options can be considered to answer the question of predation; First is to put transmitters on mountain lions captured in the NTS, and track their movements to foaling areas, observing evidence of predation. The second is to attach transmitters with mortality sensors to foals, and monitor kills as they occur, recording cause of death.

Table 14. Estimated foaling rates and foal survival compared to rainfall (mm) measured at the Tippipah Spring weather station (Eleana Range) from 1987-1992.

	1987	1988	1989	1990	1991	1992
Jan-May rainfall	191	127	39	67	98	194
Total rainfall	350	204	60	123	192	322
Total foals			4*	9	12	17
Foaling rate				0.27	0.39	0.55
Foal survival				0.22	0.33	0.00

*=incomplete survey

Concluding Remarks on Feral Horses

Low values for foaling rate and foal survival may infer energetic constraints for this population during drought conditions. Because the population is small, predation may regulate recruitment and population growth. Although data are limited to three years, the NTS population has remained nearly stable over the period. The NTS population has increased in size from only about 60 to 65 individuals over three years, an average growth rate of about 2 or 3 % each year. Assuming an annual rate of increase of 2 % and average rainfall, it is conceivable that the NTS herd would grow to 80 or more individuals in ten years.

Monitoring of feral horses should be continued on a yearly basis to compare drought years to normal or above normal rainfall years. Future work should emphasize accurate measurements of foaling rate and foal survival, which reflect the well-being of the population. Also, predation as a natural mechanism of population control could be more closely examined. The construction of grazing exclosures with vegetative monitoring is recommended to measure potential impacts that horses may have on the habitat or on sensitive plant species. Extensive horse trails and moderate trampling of vegetation near water sources and springs (in particular Captain Jack) has been observed and photographed over several years time. Heavily to moderately grazed habitats by horses on the NTS total about 80 mi^2. Considering a subjective density of one horse per square mile to limit impacts on heavily used areas, we recommend a maximum population size of 80 horses. Should horse numbers increase over the limit allowed, the excess numbers could be considered for removal. The NTS is ecologically valuable because a large proportion of the land area (90%) is still undisturbed. Historically, very few areas in the west have received any protection from overgrazing. The NTS, by contrast, has not been impacted severely by grazing of livestock and therefore has ecological and scientific as well as cultural value. Growth of the feral horse herd, if left unregulated, is a threat to this value and should be managed with concern for maintaining the ecosystem within reasonable limits.

Bird Observations

Birds, especially raptors are believed to be sensitive indicators of the environment (Newton 1979). Passerine species as well have been used as indicators of the environment for impacts such as grazing (Bock and Webb 1984, Medin and Clary 1990). Trend analysis of resident breeding birds can pose problems because losses can occur on winter ranges of species, and be misinterpreted as local impacts (Rotenbury and Wiens 1980). A recent ten year analysis of christmas bird count data, offers some promise for analyzing bird trends, because it accounts for species abundance on winter range (Root 1988).

Over the last four years, relative changes in bird abundance have been observed at the NTS, although effort dedicated to bird monitoring has been low. The changes noted are qualitative but consistent with species responses to drought which limits water and may modify the food base. Smith (1982) documented a reduction in breeding numbers and some structural community changes in a resident population of passerine birds during a drought in northern Utah. Migratory birds such as ducks and loons (etc.) dependant on water have also been shown to be negatively affected by drought (Evrard et al. 1978, Rohwer et al. 1979, Sykes 1979, Derksen and Eldridge 1980)

Three basic methods exist for monitoring raptors. These include nest site studies, road surveys and observations from a fixed point (e.g. a mountaintop). On the NTS, we have implemented work on the first two methods with moderate success. Because effort expended in raptor monitoring has been minimal (resulting in low counts), the data have been combined across seasons and then by years. The data generated to date are useful in describing a species list as well as relative abundance of the more common species. The most frequently sighted raptor (also the most easily observable) was the turkey vulture. Counts of this species increased each year since 1990 suggesting an upward trend with easing of drought conditions (Table 10). These data agree with the increased counts of turkey vultures in 1992 recorded from the Goshute Mountains in northern Nevada (Hoffman 1992). At the NTS, increased sightings were noted for over eight species of raptors in 1992 with red-tails increasing by about 59%. Overall, the data probably indicate an increased regional abundance of raptors. Increased abundance is most likely due to increased reproductive success region-wide. Turkey vultures which are strict carrion feeders may be increasing their residence time on the NTS influenced by the abundance of road kill animals or increased foal production of horses (afterbirth remains), which represent a significant food resource. Some evidence for increased total numbers of recorded roadkills (large mammals, small mammals and snakes) in 1992 (110) over 1991 (63) was apparent. Future raptor work on the NTS should concentrate on improved quantification because of observer bias as well as methods bias. Road surveys are arguably the best method (cost effective) to monitor trends at the NTS, because they are generally effective in measuring raptor responses to different land use patterns in various habitats.

Raven monitoring in 1992, indicated a trend in increased reproductive effort, suggested by additional active nests located and increased numbers of nestlings observed. Future plans are to census all active nests in 1993 for nestlings and reproductive success and to search areas in desert tortoise habitat near active raven nests for remains of desert tortoises.

Observations of migratory birds at water sources in 1992 provided some evidence that larger flocks of passerine birds were common including large groupings of juvenile birds. Presence of these flocks in mid-summer at water sources provided indirect evidence of reproductive success on the NTS. A new species record included a Rose-breasted grosbeak, an uncommon vagrant from the mid-west. Several Bonaparte's gulls and a solitary sandpiper (both uncommon migrants) were observed at well reservoirs, the first species sightings since observations commenced in 1989.

Counting birds accurately when observed in large flocks at some of the spring habitats has proved to be difficult. A new method will be employed in future surveys which will quantify number of bird visits to a water source per hour as a quantitative measure instead of trying to estimate total numbers. Some habitats exist (e.g. Captain Jack spring area) where birds occupy extended canyons and washes with ephemeral water where counting accurately is impossible, allowing only crude relative estimates of numbers.

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STATUS OF PERENNIAL PLANTS ON THE NEVADA TEST SITE, 1992

Richard Hunter

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ABSTRACT

Measurement of perennial plants on the Nevada Test Site in 1992 revealed some recovery from drought damage incurred from 1988 through 1991. Rainfall was better than any year since 1984, but growth was limited by seasonality of the precipitation and the severely reduced sizes of most shrubs. Germination of new perennial plants was sparse, but the bunchgrass *Oryzopsis hymenoides* and the shrub *Atriplex canescens* had widespread but scattered germination, and herbaceous sub-shrubs like *Sphaeralcea ambigua* and *Mirabilis pudica* increased in size and numbers. On Pahute Mesa sagebrush species (*Artemisia nova* and *A. tridentata*) germinated in large numbers. Pinyon pine (*Pinus monophylla*) trees near 17 Camp were damaged by scale insects (*Matsucoccus acalyptus*), but the infestation ended in 1992. Vegetation was monitored in three subsidence craters. Changes in the craters were complex, mediated by drought, disturbance, and the aspects of the different slopes. At middle elevations (1400 to 1600 m) there was little change over three years in the shrub populations of a scraped area in Mid Valley or a burned site in Red Rock Valley. *Oryzopsis hymenoides* increased in density on the burned site, which was moderately grazed by feral horses.

INTRODUCTION

Perennial plants on the Nevada Test Site (NTS) have been studied since the end of above-ground nuclear weapons testing in the late 1950s (Shields and Richard 1961; Beatley 1979). Since 1987 the Department of Energy has monitored the status of the vegetation and animals on the NTS through its Basic Environmental Compliance and Monitoring Program (BECAMP). 1992 was the sixth year of data collection under the BECAMP program, and this report is largely restricted to documenting conditions of perennial plant populations in 1992 and changes since 1991. Results of 1987 through 1991 monitoring of vegetation are in Hunter and Medica 1989, Hunter 1992, and Hunter et al., in press.

Monitoring of perennial plants on the NTS is accomplished by repeatedly censuring shrubs and trees on permanently marked 100 m^2 belt transects scattered throughout the NTS. Baseline sites, areas of minimal or no disturbance, are sampled every year with one transect each in Jackass Flats, Frenchman Flat, Yucca Flat, Pahute Mesa, and Rainier Mesa. Disturbed sites, including above-ground blast zones, subsidence craters, drill pads, burned areas, and rodent-denuded areas are censured at three year intervals. In 1992, three subsidence craters, one burned site, and one scraped and compacted area were censured.

Although many publications on various aspects of NTS vegetation have been produced in the decades of testing, the only study comparable to the BECAMP monitoring effort was work of J. C. Beatley (1979), who reported the status of perennial plants for 1963 and 1975 on a set of 63 plots scattered over the NTS. She found small increases over that period in cover, mean height, and number of plants per site, as measured by line intercept transects, but did not provide statistical confidence limits for those observations. Because of technique differences, and certain biases related to technique, her data are only grossly comparable to the BECAMP data (Hunter in press).

Data covering 1981 through 1992 taken to monitor the vegetation downwind of the Liquified Gaseous Fuels Spill Test Facility (Hunter et al. 1991) on Frenchman Lake (a dry playa) provide the longest period of data taken with comparable techniques. Those transects continue to be censured yearly under the BECAMP program.

METHODS

Study sites monitored in 1992 ranged from elevations of 954 to 2283 m (3130 to 7490 feet), covered the range from playa-edge to mountain top, and monitored vegetation varying from Mojave Desert scrub to pinyon-juniper woodland (Table 1, Figure 1).

Table 1. Sites of perennial plant measurements in 1992.

SITE	ELEVATION m	DOMINANT VEGETATION	LAST CENSURED
FF66	940	Playa edge, *Atriplex confertifolia*	1991
FF67	940	Playa edge, *Atriplex canescens*	1991
FF81	945	*Atriplex canescens*	1991
FF84	945	*Larrea tridentata*	1991
JAF001	954	*Larrea tridentata*	1991
FRF001	965	*Larrea tridentata*	1991
YUF019	1213	Crater U3cn, *Atriplex canescens*	1989
YUF020	1241	U3cn control, *Atriplex canescens*	1989
YUF021	1234	Crater U7au, *Atriplex canescens*	1989
YUF022	1251	U7au control, *Tetradymia axillaris*	1989
YUF001	1237	Baseline, *Atriplex canescens*	1991
YUF023	1277	Crater U10af, *Atriplex canescens*	1989
YUF024	1300	U10af control, *Ceratoides lanata*	1989
MID004	1439	Scraped, *Ephedra nevadensis*	1989
MID005	1445	Control, *Coleogyne ramosissima*	1989
RED001	1612	Burned, *Ephedra nevadensis*	1989
RED002	1612	Control, *Ephedra nevadensis*	1989
PAM003	1910	Drill pad control, *Artemisia*	1989
PAM008	1920	Marked pines, *Pinus monophylla*	1991
PAM001	1923	Baseline, *Artemisia nova*	1991
PAM007	2134	Marked pines, *Pinus monophylla*	1991
RAM001	2283	Baseline, *Pinus monophylla*	1991

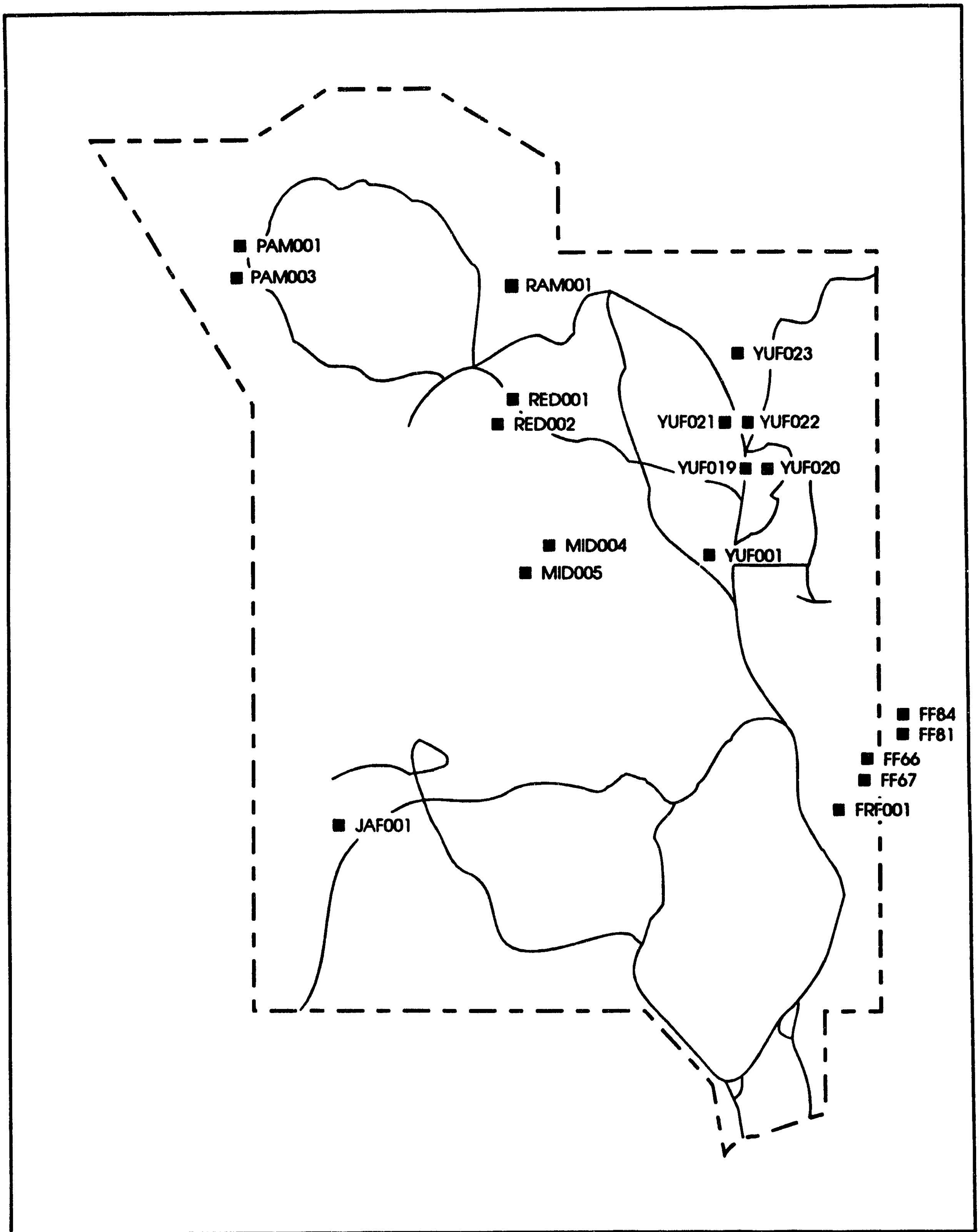

Figure 1 - Sample sites for perennial plants on the Nevada Test Site in 1992.

Precipitation data are from the National Oceanic and Atmospheric Association, U. S. Weather Bureau Nuclear Support Office, which monitors a set of stations around the NTS.

Soil moisture was measured at three baseline sites (FRF001, JAF001, YUF001) using fiberglass resistance sensors (Colman blocks, Soil Test Inc, Peoria, Ill). Readings were temperature-corrected following a graph supplied by the manufacturer. Sensors were placed at 1, 5, 10, 15, 30, 50, 75, 100, 125, and 150 cm depths. Resistance sensor reading below 900,000 Ohms were considered to indicate soil moisture available to plants.

The basic techniques of perennial plant measurements did not change from previous years (Hunter in press). A 50 m fiberglass tape marked in cm was stretched between two permanent metal fenceposts. All perennial plants within 1 m of either side of the tape were measured (maximum height, maximum width, and width perpendicular to the maximum), and notes were taken on their reproductive state, percent of canopy dead, and grazing damage. Mean heights and widths, cover, and volume were calculated from the size measurements, and biomass (dry weight) was estimated from the volume data using regression lines reported in Hunter and Medica 1989. Summary data are reported here as Appendix G, and the raw data are available through Reynold's Electrical and Engineering Co., Inc.'s Coordination and Information Center. Note that cover was not corrected for overlapping canopies, and the estimates are therefore somewhat higher than the percent of total area covered by shrubs.

Some important species are monitored by marking individuals on particular sites, then returning to measure those individuals periodically. The same data are taken for those plants as for those measured on transects.

RESULTS

Weather

Total rainfall in 1992 was generally greater than that for seven or eight of the last ten years (Table 2). It ranged from 141 mm in Frenchman Flat (Well 5B - 939 m) to 434 mm on Rainier Mesa (2283 m). Total rainfall was not strictly related to altitude, and Jackass Flats (1042 m) received considerably more than Frenchman Flat (940 m) and Yucca Flat (1195 m), as has been true for several years (Table 2).

Table 2. Precipitation (mm) on the various NTS landforms as reported by NOAA. > indicates some data are missing.

YEAR	JACKASS FLATS	FRENCHMAN FLAT	YUCCA FLAT	PAHUTE MESA	RAINIER MESA
1983	303	222	350	>350	682
1984	258	225	276	197	>348
1985	83	83	106	88	>205
1986	171	152	154	>160	302
1987	>209	163	194	>272	389
1988	132	111	114	>164	263
1989	104	29	63	83	140
1990	108	80	54	169	188
1991	137	79	105	198	359
1992	254	141	220	206	434

The three baseline sites where soil moisture was monitored were somewhat wet from January through mid-July, although amounts in soil were minimal after mid-June (Table 3). Soil drying at this time followed a normal pattern related to seasonal temperature patterns and shrub phenologies, caused by rapid shrub water use in late spring.

Table 3. Shallowest (min) and deepest (max) soil depths (cm)wet (<900,000 Ohms on resistance sensors) at three baseline sites during 1992.

	FRF001			JAF001			YUF001	
Date	min	max	Date	min	max	Date	min	max
JAN 16	1	30	JAN 2	1	15	JAN 16	1	30
JAN 31	5	30	JAN 21	5	30	JAN 31	5	30
FEB 14	1	-	FEB 14	1	-	FEB 14	1	-
FEB 27	1	50	FEB 28	1	100	FEB 27	1	50
MAR 12	1	50	MAR 16	5	125	MAR 12	1	75
APR 8	5	50	APR 8	5	125	MAR 30	1	-
MAY 26	30	75	APR 29	10	150	APR 17	5	75
JUN 8	75	75	MAY 19	30	150	APR 29	10	75
JUN 22	75	75	JUN 1	30	150	MAY 12	10	75
JUL 9	75	75	JUN 5	50	150	JUN 1	5	75

Table 3, continued.

FRF001			JAF001			YUF001		
Date	min	max	Date	min	max	Date	min	max
JUL 20	DRY	DRY	JUN 29	75	150	JUN 8	10	75
			JUL 13	100	100	JUN 22	30	30
SEP 14	DRY	DRY				JUL 9	30	30
OCT 9	DRY	DRY	OCT 9	DRY	DRY	JUL 20	30	30
NOV 4	5	15	NOV 6	10	10			
NOV 24	15	30	NOV 25	DRY	DRY	SEP 14	DRY	DRY
DEC 22	1	50	DEC 10	5	75	OCT 20	DRY	DRY
						NOV 4	5	10
						NOV 24	10	10
						DEC 22	1	50

BASELINE SITES

Numbers of perennial plant species on all baseline sites generally increased from 1991 to 1992 (Table 4), as a result of seedling germination during the spring of 1992. Cover and total volume also increased, as the more mature shrubs and trees increased in size following several drought years.

Table 4. Density (n/m^2), cover (%), and total above ground volume ($m^3/100m^2$) on the five BECAMP baseline plots. Data for RAM001 are 1988-1992, for the rest 1991-92.

	JAF001		FRF001		YUF001		PAM001		RAM001	
DATE	AUG 91	MAY 92	JUN 91	MAY 92	JUL 91	JUN 92	SEP 91	AUG 92	AUG 88	JUL 92
n/m^2	179	227	40	64	173	259	812	720	892	1040
cover %	27	36	11	13	19	23	39	42	64	70
m^3	16.3	19.0	12.9	14.4	9.7	11.9	12.0	14.8	99.2	161.2

Seedlings

Seedlings were of relatively few species, and germinated only in communities where the species already occurred. The most common species which germinated were *Atriplex canescens* and *Oryzopsis hymenoides*. Both germinated in many places at elevations of 945 to 1600 m. *Atriplex canescens* germinated near Frenchman Lake, where it was dominant over large areas before the drought, and on scattered disturbed areas elsewhere. New *Atriplex* seedlings were not seen on control and baseline plots dominated by *Larrea tridentata*, *Lycium andersonii-Grayia spinosa*, or *Coleogyne ramosissima*. *Oryzopsis hymenoides* seedlings were found on both disturbed and baseline sites, except where soils were fine-textured or compacted (Mid Valley, near Frenchman Lake). Several dominant species germinated only on the undisturbed areas where their populations were dense, including *Artemisia nova* (PAM001), *Artemisia tridentata* (PAM003), and *Coleogyne ramosissima*. Other species which germinated were seen only rarely, at one or a few sites. They were generally herbaceous perennials, such as bunchgrasses, *Sphaeralcea ambigua*, and *Erioneuron pulchellum*. Some rhizomatous perennials also increased in number, including *Polygala subspinosa* (YUF020), *Kochia americana* (FF66) and *Ephedra nevadensis* (MID005, RED001), and *Mirabilis pudica* may have increased both by seed germination and rhizomatous spread. On Rainier Mesa a number of new *Linanthus nutallii* probably germinated in 1992, although the four years between censuses and the large size of some new ones suggests germination may also have occurred earlier there.

Growth

Most of the change in perennial volumes since monitoring began has been through dieback of the large plants which contribute a majority of the volume. Much of the recovery evident in 1992 was a result not of germination, but of regrowth. A convenient way of expressing plant growth that removes some of the size bias between small and large plants is to use a logarithmic formula for change in size (Erickson 1976). The formula k = [ln(size 2/size 1)/elapsed time] is easily calculated for plants measured at two different times. The resulting "growth constant", k, requires some interpretation, however. A plant with k>1 will double in size in less than a year. *Ambrosia dumosa* in Jackass Flats has had k > 8 over a one year period (Hunter 1989). Ephemeral plants sometimes have k > 10, and can double in size in less than two weeks (Hunter, unpublished data) (Table 6).

Growth constants for several species exceeded 2 for the period 1991-1992 (Table 7). *Ambrosia dumosa*on the Frenchman Flat baseline plot and *Acamptopappus shockleyi* and *Ceratoides lanata* on Yucca Flat grew that rapidly. In Jackass Flats growth approached those rates in *Acamptopappus shockleyi* and

Table 5. Seedlings of perennial plants found on BECAMP plots in 1992.

PLOT	ART NOV	ART TRI	ATR CAN	ATR CON	COL RAM	MIR PUD	ORY HYM	SIT JUB	SPH AMB	STI SPE
FF66				50						
FF67			31	626			9			
FF81			147	1		3	294		5	
FF84			50				78			
JAF001							34			
FRF001							18			
YUF019N			1			26	1009			
YUF019S						23	488			
YUF020						1	185			
YUF021N							182			
YUF021S						2				
YUF022						3				
YUF001						10	4	4	60	
YUF023N			12				38		2	
YUF023S							24			
YUF024							51		1	
MID004								1		
MID005					15					
RED001			2				186			
RED002							34			3
PAM003		10000						8		12
PAM001	102							1		
RAM001								4		

Table 6. Time required to double in volume for different growth coefficietns.

k	time
0.1	6,9 years
0.2	3,46 years
0.4	1.73 years
0.7	361 days
1.0	253 days
2.0	126 days
3.0	84 days
4.0	63 days
5.0	51 days
7.0	36 days
9.0	28 days

and *Ambrosia dumosa*. Other species like the dominant *Larrea tridentata* and *Lycium andersonii* had negative and zero growth constants for the same period. These two extremes represent differing growth/dieback strategies in the several species.

Table 7. Growth constants (k = ln(V2/?t; V = volume, t = years) for common shrub species on baseline plots for 1991-1992. Error terms ate ± 2 standard errors of the mean (sem), () enclose numbers of plants matched at the two times.

SPECIES	JAF001	FRF001	YUF001	PAM001
Acamptopappus	+1.8±0.2 (80)		+2.4±0.9 (6)	
Ambrosia dumosa	+1.3±0.1 (65)	+2.2±0.6 (14)		
Artemisia nova				+0.5±0.1 (148)
Atriplex canescens			+1.9±0.5 (30)	
Ceratoides lanata			+2.0±0.6 (33)	

Table 7, continued.

Species	JAF001	FRF001	YUF001	PAM001
Ephedra nevadensis			*+0.4±0.5 (18)*	*-0.1+0.4 (28)*
Grayia spinosa			*+1.14+0.4 (32)*	
Larrea tridentata	-0.1±0.1 (7)	+0.4±0.8 (6)		
Lycium andersonii			1.15±0.8 (13)	
Menodora spinescens	+0.2±0.4 (20)			
Oryzopsis hymenoides				+0.4±0.6 (11)
Sitanion jubatum				+1.1±0.3 (88)
Dead Grass	-0.5±0.3 (48)		-1.2±0.4 (33)	
Dead Shrub	-0.6±0.2 (86)	-0.0±0.2 (100)	+0.2±0.2 (224)	+0.5±0.9 (10)

Long-Term Trends

The baseline site in Yucca Flat has been sampled each year since 1987. Perennial population shifts due to drought were a major influence on that and many other NTS sites sampled less frequently. Many species declined significantly in numbers over that period, and some herbaceous species died out completely (Table 8). Others, notably Ephedra nevadensis, Atriplex canescens, and *Grayia spinosa* declined only slightly. Recovery of drought-hardy shrubs in 1992 was not dramatic. Some shrubs badly damaged by drought continued to die. Those species which increased in numbers in 1992 were largely herbaceous species, especially *Sphaeralcea ambigua*, *Mirabilis pudica*, and the perennial grasses.

Live volumes of shrubs showed similar trends, but were weighted by size of the different species (Table 9). Because herbaceous perennials are small, they contributed little to total live volume (<1%). Total live volume on YUF001 increased only 9% in 1992, and was only 64% of the 1987 estimated volume. *Atriplex canescens* increased dramatically, to become the dominant species in terms of 1992 volumes. *Grayia spinosa* doubled in total volume, approaching its peak volume (1988). Two species, *Lycium andersonii* and *Ephedra nevadensis* continued to shrink in total volume, but at the same time put out new branches. These species, which sat through the drought in a dormant condition, tended to lose old branches when new ones sprouted from the center, resulting in both new growth and overall shrinkage. In terms of total live volumes, *Atriplex canescens* during this period went from fourth to first place. It has a shorter life-span (several decades) than *Ephedra nevadensis*, *Grayia spinosa*, and *Lycium andersonii*, and will probably not remain dominant at this location.

Table 8. Counts of Live Perennial Plants by Species, and dead shrubs and grasses on a 100 m^2 Baseline Plot in Southwestern Yucca Flat, 1987 - 1992. *marks grasses.

Species	1987	1988	1989	1990	1991	1992
Acamptopappus shockleyi	44	34	26	13	11	9
Arabis pulchra	0	1	0	0	0	0
Artemisia spinescens	49	47	38	21	6	2
Atriplex canescens	36	38	38	41	31	32
Ceratoides lanata	65	58	53	54	42	35
Ephedra nevadensis	22	18	21	21	21	18
Erioneuron	28	17	0	2	0	27
Grayia spinosa	40	35	34	44	33	35
Hymenoclea salsola	11	9	8	10	8	5
Lycium andersonii	20	15	18	20	14	13
Menodora spinescens	1	1	1	1	1	0
Mirabilis pudica	7	4	0	0	1	11
Oryzopsis	8	6	5	0	0	4
*Sitanion jubatum**	28	8	0	0	0	4
Sphaeralcea ambigua	71	26	2	0	1	60
*Stipa speciosa**	6	10	5	8	3	3

Table 8. continued.

Species	1987	1988	1989	1990	1991	1992
Tetradymia axillaris	2	2	2	2	2	0
Totals	438	329	251	237	175	258
Dead grasses	-	-	8	32	44	33
Dead shrubs	-	-	55	167	449	230

Table 9. Estimated live volumes (liters per 100 m^2) of perennial plants on a baseline plot in southwestern Yucca Flat, 1987-1992. *marks grasses.

Species	1987	1988	1989	1990	1991	1992
Acamptopappus shockleyi	592	344	381	16	41	93
Arabis pulchra	0	1	0	0	0	0
Artemisia spinescens	732	537	575	47	32	5
Atriplex canescens	2085	1535	1264	921	893	3802
Ceratoides lanata	798	461	611	378	265	780
Ephedra nevadensis	5007	5320	5015	4482	4130	3599
*Erioneuron pulchellum**	1	2	0	0	0	0
Grayia spinosa	2948	3195	3015	1598	1392	2612
Hymenoclea salsola	420	196	188	44	41	238
Lycium andersonii	4073	3511	2681	2521	2630	677
Menodora spinescens	1	1	1	0	1	0
Mirabilis pudica	5	1	0	0	1	89
*Oryzopsis hymenoides**	41	10	2	0	0	3
*Sitanion jubatum**	11	2	0	0	0	0
Sphaeralcea ambigua	34	20	0	0	0	11
*Stipa speciosa**	2	3	3	2	1	1
Tetradymia axillaris	1732	1583	1869	1636	1514	0
Totals	18,482	16,722	15,604	11,646	10,941	11,910
Dead grasses	-	-	4	21	57	13
Dead shrubs	-	-	2429	3487	5184	5057

Fuel Spill Transects

The longest running span of perennial plant data currently available is for several transects set up in 1981 to monitor the region downwind of the Liquified Gaseous Fuels (LGF) Spill Test Facility on Frenchman Lake. They were resampled in 1986 and some have been censused every year since. The area is dominated by monocultures of *Atriplex canescens*, *Atriplex confertifolia*, and *Larrea tridentata* in different soil types. Of the four transects monitored since 1987 two (FF67 and FF81) are dominated by *Atriplex canescens*, one (FF66) by *Atriplex confertifolia*, and one by *Larrea tridentata* (FF84). Numbers of live plants declined precipitously during the 1989-91 drought. Essentially all *Atriplex* plants died. On FF84 only *Larrea tridentata* survived in 1991. Total live volumes reflect the decline in numbers. In 1992 the rebound in numbers was due to germination of *Atriplex* species and some herbaceous perennials (Table 6), but sizes were insignificant in comparison to previous years. On these transects there appeared to be an approximate doubling of *Atriplex* volumes from 1981 to 1986 (Table 10), which would be reasonable given the two wet summers of 1983 and 1984 (Table 1).

Table 10. Perennial plant numbers and total live volumes (m^3) on four 100 m^2 transects northeast of Frenchman Lake.

Transect	1981	1986	1987	1988	1989	1990	1991	1992
Numbers								
FF66	113	117	145	137	111	10	26	85
FF67	87	53	66	72	48	15	1	721
FF81	83	117	---	55	46	5	0	451
FF84	16	19	---	---	10	8	5	133
Live volumes m^3								
FF66	3.8	10.6	11.3	12.3	7.0	0.2	0.05	0.09
FF67	2.4	4.4	5.6	5.2	2.6	0.7	0.06	0.05
FF81	3.1	5.6	---	3.7	3.7	0.5	0.00	0.02
FF84	13.3	12.8	---	---	12.0	11.3	9.10	5.53

Individuals

Individuals of *Yucca brevifolia* (YUF001), *Juniperus osteosperma* (PAM001), *Pinus monophylla* (RAM001) and cacti (YUF001)have been marked on baseline plots. In addition, a healthy *Pinus monophylla* population has been marked on PAM007, the control plot for a drill pad on Dead Horse Flats road, and a diseased population was marked where Pinyon needle scale was visibly defoliating trees north of 17 Camp, in Big Burn Valley (PAM008) (Figure 2).

In contrast to the years 1989 through 1991, there were no deaths in censused *Yucca brevifolia* individuals in 1992 (only 63 of 88 locations were examined, which included 25 of 31 live plants, due to lack of time). Excluding two mature trees, growth in height averaged 5.2 ± 1.6 cm ($\bar{X}$ ± 2 sem), bringing mean height of 23 young plants to 29 ± 4 cm from 24 ± 3 ($\bar{X}$ ± 2 sem). This was the first year of significant growth ($t = 6.7$, d.f. = 22, $p = 10^{-6}$) since this population was marked in 1989.

Seventeen *Juniperus osteosperma* were remeasured for the fourth year in 1992 on the Pahute Mesa baseline plot, PAM001. Of 15 plants censused both years, mean change in height was +2 ± 4 cm ($\bar{X}$ ± 2 sem), thus there was no growth for the year, as in the two previous time periods (Hunter, in press). Mean height was 100 ± 26 cm, compared to 99 ± 28 cm in 1991 and 100 ± 28 in 1989 ($\bar{X}$ ± 1 sem).

Of three marked populations of pinyon pine trees, two were recensused in 1992. On plot PAM008, infested with pinyon needle scale (*Matsucoccus acalyptus*), three of the 50 trees died. Mean height on this plot was 157 ± 18 cm both years ($\bar{X}$ ± 1 sem)(Table 11). Trees on plot PAM007, considered an unaffected control plot, grew significantly, ($t = 3.2$, d.f. = 49, $p = 0.001$; Table 11).

The damage caused by pinyon needle scale is primarily defoliation. Pine needles are generally long-lived, and growth of a branch results in a length of branch with needles. The average lengths of needle-covered branch tips were estimated on the trees in both populations, and were much greater on the uninfected plot (Table 11; $t = 3.17$, d.f. = 49, $p < 0.025$). However, in fall 1992 there was no evidence of the scale insects on the PAM008 plot, in marked contrast to the previous year, and we expect most of the marked trees to recover in subsequent years.

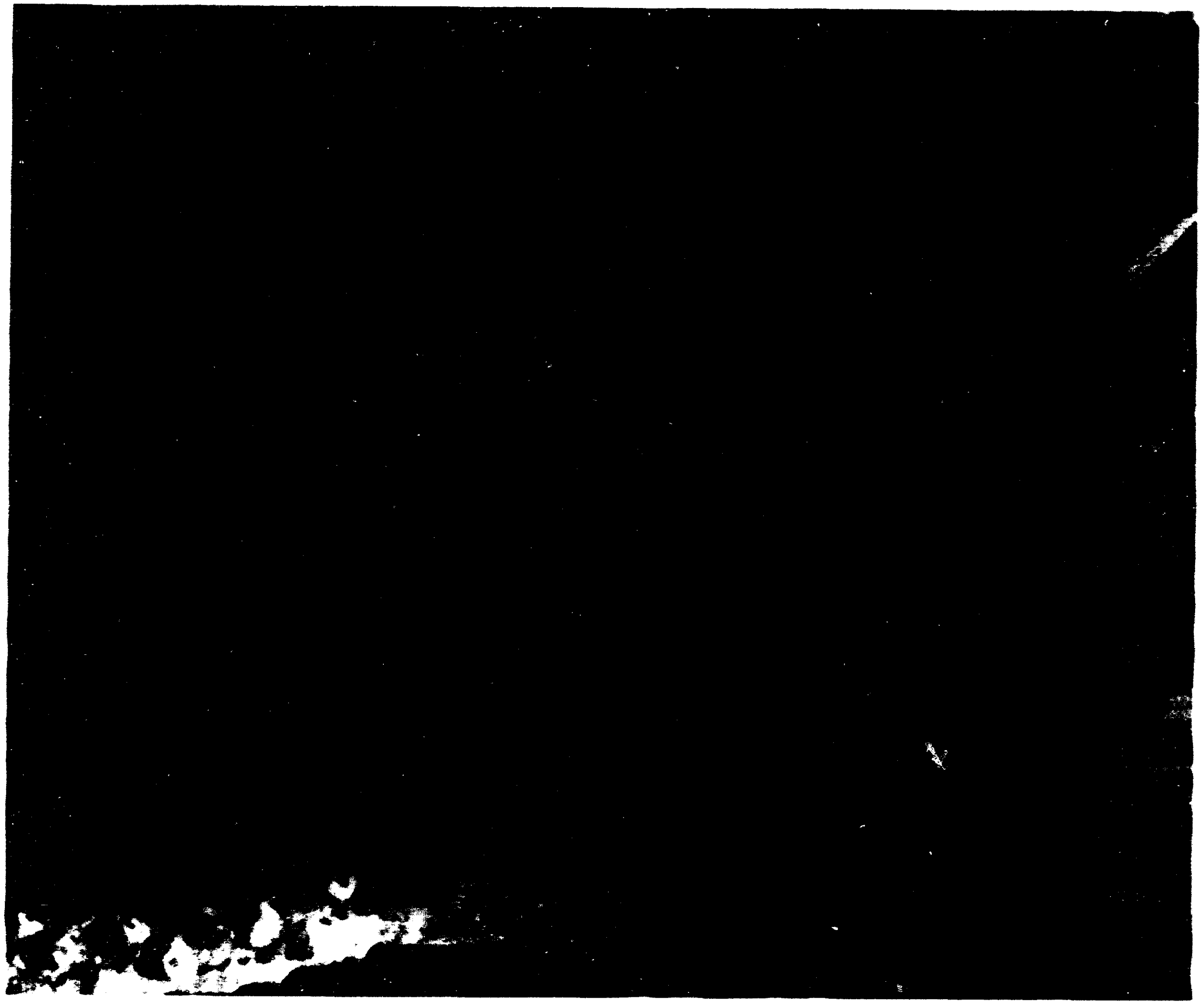

Figure 2 - Pinyon needles scale (*Matsucoccus acalyptus*) on damaged pine needles from plot PAM008 in Big Burn Valley.

Table 11. Mean height, change in height, and needle cover per branch on *Pinus monophylla* trees on two Pahute Mesa plots in 1992. Error terms are + 1 sem.

	PAM008		PAM007		RAM001
	1991	1992	1991	1992	1991
n	50	47	50	50	50
height, cm	157 ± 18	157 ± 18	196 ± 11	200 ± 11	224 ± 26
mean Δ ht, cm	-	-3.6 ± 2.3	-	+3.8 ± 1.2	-
needles, cm/branch	9 ± 1	8 ± 1	22 ± 1	26 ± 1	22 ± 1

Another significant infestation of pinyon needle scale was seen in 1992 near drill hole U19j, at an approximate location of Latitude 37° 20' 7" N, Longitude 116° 18' 57" W. Pinyon needle scale are commonly seen in other areas, but at low densities they are insignificant to the health of the host trees.

DISTURBED SITES

Disturbed sites monitored in 1992 included three subsidence craters, one scraped/compacted site (and the control for another), and one burned site.

Craters

The subsidence craters have proven to be complex environments. The north and south slopes are visibly different. Shrubs and grasses are more visible on north-facing slopes and bare soil and scattered shrubs, and litter-filled erosion channels mark the south-facing slopes (Hunter - in press). The centers of the craters have silty playa-like deposits that are generally devoid of vegetation, as on the playas on the NTS (Figure 3). In addition, there is much disturbance of the surface vegetation from drilling and staging activities prior to the test that created the crater. Some areas are scraped, some scraped and graveled, and there is usually a collapsed "mud pond" with a different soil type. On large craters these disturbances do not extend to the outer edge, but are concentrated near the centers. There are no rims or throwout mounds, but slopes start gradually at normal surface level and steepen near the center, levelling off only in the region of water deposits,

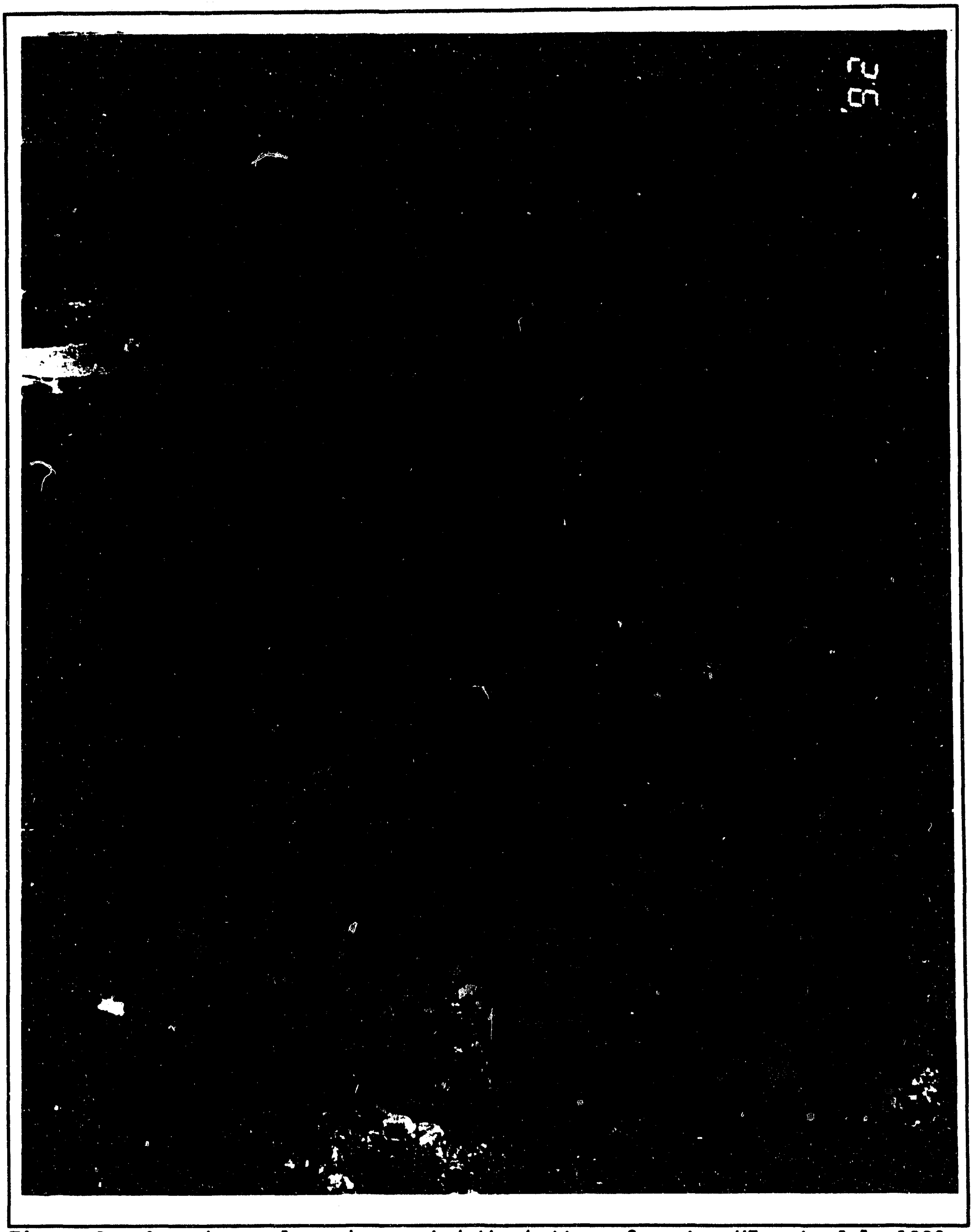

Figure 3 - An ephemeral pond occupied the bottom of crater U7au in July 1992.

which apparently increases in depth and area with time. Some craters are in the areas blasted free of vegetation by atmospheric tests during the 1950s. The surface of northeast Yucca Flat slopes gently towards the south. There are scraped dirt roads leading to the crater and others passing nearby. One of the studied craters, U7au, has a section of paved road collapsed within its circumference. The craters thus provide complex environments for the plants inhabiting them.

Species composition is probably the best indicator of disturbance on most of the crater transects. *Atriplex canescens*, *Oryzopsis hymenoides*, *Sphaeralcea ambigua*, and *Mirabilis pudica* can invade disturbed areas, but are relatively short-lived (decades). *Ceratoides lanata*, *Grayia spinosa*, *Polygala subspinosa*, *and Chrysothamnus viscidiflorus* are not common on areas cleared of shrubs, and are long-lived. The species composition of the various crater study sites suggests the shrubs were cleared in the past on all but the control plots for U3cn and U7au, the south-facing slope of U7au, and possibly the north-facing slope of U10af. The number of species and total shrub volumes (Table 12) are confirming indicators, as more species and greater total volumes are found on these uncleared transects (Table 12). The control plot for U10af was incorrectly chosen in a previously cleared area. The new plants did not differ in size between the north- and south- facing slopes. However,in U3cn and U7au there were significantly more *Oryzopsis* seedlings on the north-facing slope than on the south-facing slope (U3cn $t = 3.33$, d.f. = 9, $p = 0.004$; U7au $t = 2.94$, d.f = 9, $p = 0.009$) and in U10af numbers were greater but not significantly ($t = 1.605$, d.f. = 9, $p = 0.126$). This could be due to better germination conditions on the north-facing (shadier) slope, to fewer seed-producing plants inhabiting the south-facing slope, or to greater erosion, and therefore greater removal of seed from the south-facing slopes.

Oryzopsis hymenoides seedlings dominated the plant numbers, but on disturbed areas *Atriplex canescens* dominated the perennial volumes. Their numbers were too few and their sizes confounded by disturbance, so it was not possible to compare effects of aspect on *Atriplex* sizes. In general numbers of *Atriplex canescens* decreased from 1989 to 1992 in the craters, except where a few seedlings were found (Table 5). Total volumes were erratic - some fell due to drought, others increased as established plants on the disturbed sites grew. The undisturbed control areas for U3cn and U7au declined significantly in total volumes (Table 12).

Table 12. Total live perennial plant volumes ($m^3/100m^2$), total cover (%), numbers of plants, and numbers of species on north- and south-facing slopes of three subsidence craters and their associated controls in Yucca Flat. Sampled 1989 and 1992.

	U3cn				U7au			U10af			
	NORTH	MID	SOUTH	CON	NORTH	SOUTH	CON	NORTH	MID	SOUTH	CON
TOTAL m^3, 1989	1884	79	42	4956	1786	2251	8011	1063	0.7	373	405
TOTAL m^3, 1992	2081	349	567	961	822	452	1902	880	4.4	509	454
TOTAL COVER, 1989	4.6	0.2	1.4	15	2.7	6.0	20.4	3.6	0.1	0.8	2.0
TOTAL COVER, 1992	4.6	0.5	2.4	2.7	1.2	1.5	4.7	2.3	0.0	0.9	1.0
TOTAL n, 1989	143	2	133	342	29	78	203	95	3	18	103
TOTAL n, 1992	1180	23	728	691	202	32	66	137	122	43	60
# OF SPECIES, 1992	4	2	4	10	5	9	12	6	2	4	4

Scraped Sites

The scraped area in the center of Mid Valley (MID004) showed very slight recovery from the previous census in 1989 (Table 13). There was 1 more plant on the 100 m^2 area, a bunchgrass, *Sitanion jubatum*. The size of the *S. jubatum* suggested it germinated earlier than 1992. The two small *Ephedra nevadensis* plants grew a slight amount from 1989 to 1992.

Table 13. Summary values for perennial vegetation on the Mid Valley scraped area and its adjacent control plot, 1989 and 1992.

	SCRAPED/COMPACTED		CONTROL	
	1989	1992	1989	1992
TOTAL VOLUME, $m^3/100\ m^2$	0.017	0.028	28.3	25.4
TOTAL COVER, %	0.1	0.1	54	52
TOTAL NUMBER/100 m^2	2	3	181	189

The control plot (MID005) also showed very little change. In 1992 there were 15 *Coleogyne ramosissima* seedlings in 100 m^2, germinated from three animal caches. The bunchgrasses, *Oryzopsis hymenoides* and *Stipa speciosa*, died out completely on this transect, and there was no evidence of their germination in 1992. There were three young cacti (*Opuntia echinocarpa* - golden cholla) whose sizes again suggested germination prior to 1992. Although there were some dead *Artemisia tridentata* plants on the transect, there were no live ones, and there were just a few large scattered ones nearby. The transect was dominated by *Coleogyne ramosissima* (88 % of volume), but some *Ephedra nevadensis* plants were mixed with the *Coleogyne*, apparently reproducing largely vegetatively.

A second scraped area, drill pad U20ao near the junction of Pahute Mesa and Buckboard Mesa Roads, was examined in 1992 (Plot PAM002). The perennial plant transect on the drill pad could not be located, and the season ended before it could be replaced. During the census for ephemeral plants (see the ephemeral section of this report) a *Stipa* species was noted to occur within the 1000 m^2 search area, but not within 100 m^2.

The control transect for the drill pad, plot PAM003, had a monoculture of *Artemisia tridentata*. There was very little change on that transect from 1989 to 1992 (Table 14). *Artemisia* seedlings, presumed *A. tridentata* because they were under those plants, were censused on only 1 m^2 of the transect, where 104 were found. They contributed virtually nothing to cover or volume, and are not included in the summary results (Table 13, Appendix G). *Artemisia tridentata* made up 99.97% of the total volume and 99.92% of total cover on this transect. Of 136 *A. tridentata* plants measured in 1989, 113 were alive and recensused in 1992. Mean height increased from 45 ± 3 to 56 ± 3 (cm ± 2 sem), probably due to flower stalk production in 1992. (In 1989 5 of 136 *A. tridentata* had buds or flowers, in 1992 118 of 126 did.)

Burned Site RED001

One burned area, where perennials were first censused in 1989, was reexamined in 1992. This site burned in July 1988, probably ignited by a cigarette. Since 1989 two small *Atriplex canescens* and numerous *Oryzopsis hymenoides* appeared on the transect, greatly increasing perennial plant numbers (Table 15, Appendix G). Volume and cover were dominated by crown-sprouts of *Ephedra nevadensis*, which did not change significantly from 1989 to 1992. (The increased number of *Ephedra* [Appendix G] was due to new rhizomatous shoots produced outside the canopy edge of the previous crown sprouts.)

Table 14. Perennial plant summary for transect PAM003, the control for drill pad U20ao.

	1989	1992
TOTAL VOLUME, $m^3/100M^2$	22.2	23.5
TOTAL COVER, %	38.5	36.4
n/100 m^2	168	142

Table 15. Perennial plant summary for burned site RED001 and its control RED002.

	BURNED, RED001		CONTROL, RED002	
	1989	1992	1989	1992
TOTAL VOLUME, $m^3/100m^2$	1.2	1.1	25.9	20.2
TOTAL COVER, %	2.9	2.3	30.4	27.9
n/100m^2	98	288	50	83
SPECIES	3	3	4	4

On both the burned and control areas *Oryzopsis hymenoides* numbers increased from 1989 to 1992. The burned site was grazed by horses during the summer, and many of the *Oryzopsis* were damaged. In 1992, 52 of 135 plants were grazed, an average of about 41 ± 5 % of the canopy volume being missing on grazed plants. The mean size was larger (basal width = 5 ± 1 cm ± 2 sem) on grazed than ungrazed plants (3.0 ± 0.8 cm ± 2 sem)(t_1 = 2.55, d.f. = 133, p = 0.01)(t_1 is defined in the Ephemerals chapter), indicating horses were selecting the larger plants, and evidently not killing them. On the control plot only 2 of 28 were grazed, and the size of grazed plants (6.5 ± 1.0 cm) was not significantly different from (t = 1.09, d.f. = 26, p = 0.29) the ungrazed plants (3.8 ± 1.4 cm).

In 1992, *Salsola australis* grew well on RED001, but was absent from the control transect. Assuming 1 g/m^3 of canopy, it produced approximately 64 ± 32 $kg/100m^2$ on the burned area, an order of magnitude greater than the biomass of shrubs on the site (Figure 4).

DISCUSSION

Considering 1992 was the wettest year since 1984 on the NTS, the woody perennial plants grew surprisingly little. Shrub seedlings were relatively sparse. The germination of the woody species was largely restricted to areas where they were already dominant, and seedling numbers were not great. In contrast, in 1983 hundreds of *Ambrosia dumosa* germinated per square meter in Jackass Flats following over 99 mm of rain over 11 days in August (Hunter 1989). Only on Pahute Mesa, where *Artemisia* seedling germination approached that value, was 1992 comparable.

The seasonality of the rain was the most likely cause of poor germination, as the large storms occurred in February and March, and not in warmer weather when shrubs are active. The same could be said for growth of the established shrubs. Because 66 % of the season's precipitation fell in January through March (BJY station), when shrubs are dormant from cold, growth was not unusually great, even though shrub sizes were depressed by drought and competition was reduced.

The perennial data can be explained by several interacting factors. There was a general tendency for areas with low shrub cover to increase both cover and total live volumes. This is reasonable given the absence of severe competition from established shrubs on such areas, which are represented in

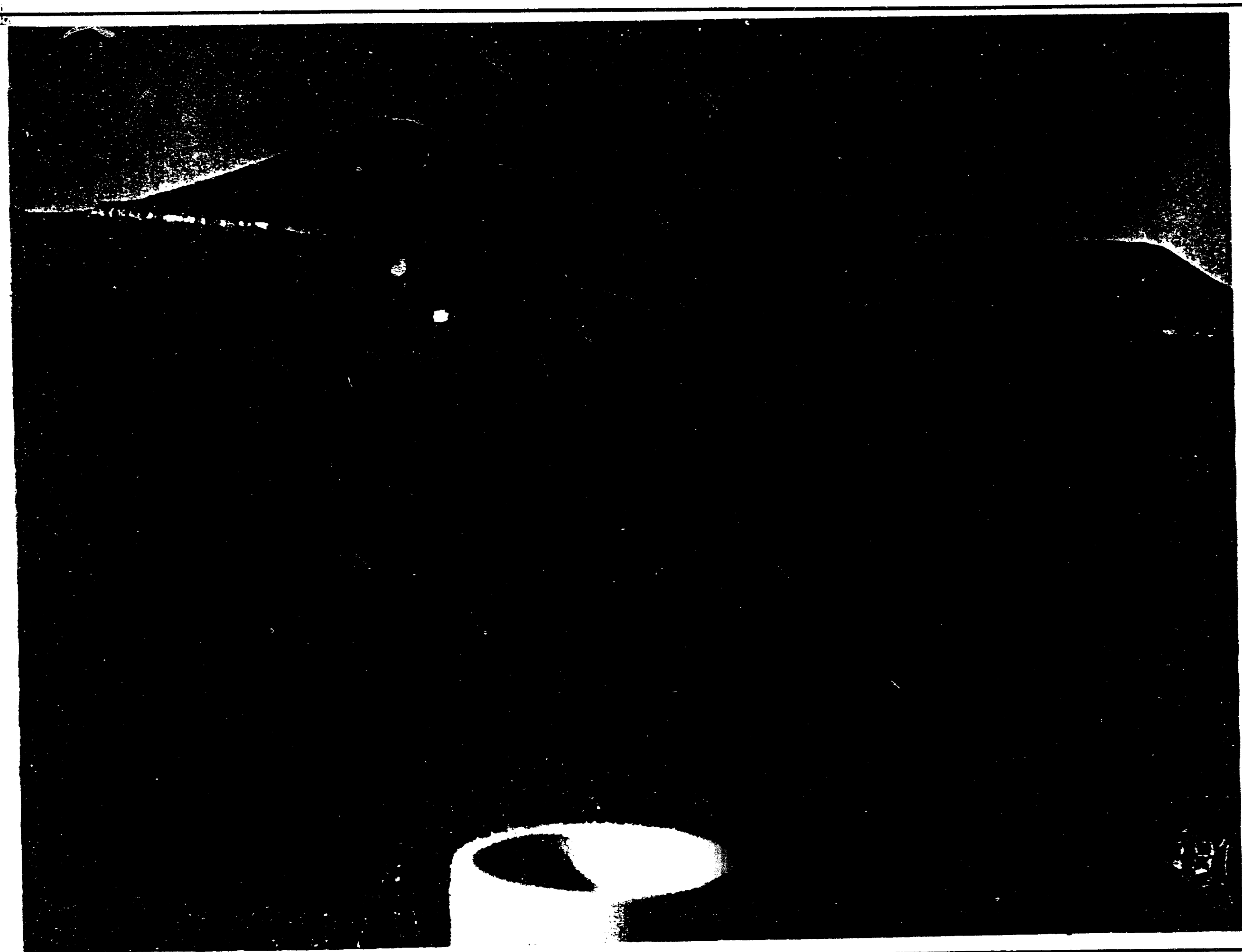

Figure 4 - Four years after a range fire vegetation onplot RED001 was dominated by Russian thistle (*Salsola australis*).

these data by some of the crater transects and the burned and scraped sites, as well as some of the drought damaged populations in Frenchman Flat.

The effects of the drought must be considered as well. Even on cleared areas there was a general die-off of grasses and many shrubs between 1989 and 1991 (Hunter,in press). On undisturbed areas with a relatively full shrub cover, such as control transects (Tables 10,12,14) and the Yucca Flat baseline plot (Table 9) there was considerable dieback over three-year periods, and small increases in cover and live volume from 1991 to 1992 (eg. Table 9).

Altitude was a significant variable. Drought did not kill many shrubs or trees above about 1400 m, so that in Mid Valley, Red Rock Valley, Pahute Mesa and Rainier Mesa plants showed only small variations in cover and total live volume. The biggest changes at higher altitudes were due to flowering in *Artemisia* species, and the inclusion of more pine trees on Rainier Mesa. The latter was an artifact of more rigorous transect measurement techniques instituted after the last census in 1988.

Finally, variations in rainfall were somewhat significant. Jackass Flats was not so severely affected by drought, and shrubs recovered there partially in 1991, and grew well again in 1992. In Jackass Flats, at nearly the lowest altitude on the NTS, and not in a closed basin, the temperature in March and April may have allowed shrubs to make better use of rainfall than in Frenchman Flat, where temperature inversions affect plant populations (Beatley 1975).

Effects of DOE Operations

There were no major effects of 1992 DOE operations seen on perennial plants. The monitored disturbed areas are mostly old, and still adjusting to previous disturbances. Baseline sites were recovering from drought. Continuing activities involve ongoing disturbances such as road maintenance, water use and disposal, creation of new subsidence craters, and clearing of vegetation for construction, drilling, or environmental restoration. These activities create long-term adjustments in the flora and fauna on the NTS, and it is largely the long-term consequences the BECAMP program is monitoring.

Threats to Perennial Plant Populations

As can be seen for 1992 in this report, and from the previous reports, vegetation on the NTS is in flux. From 1981 to 1986 shrub live volumes approximately doubled (Table 10), and from 1988 through 1991 they declined 30 to 100 % (Tables 9,10). This might be considered normal variation, and appeared to represent adjustment of shrub populations to short-term trends in precipitation. Given these fluctuations, what new factors are present that might represent threats to the perennial populations?

One relatively new factor is fire. About 4% of the NTS burned between 1978 and 1988 (Hunter 1992). Man both causes fires and fights them, and some are caused by lightning. Certain areas of the NTS are prone to fire, generally in the transition zone between the Mojave Desert vegetation at lower altitudes and the Pinyon-Juniper forests at higher elevations. Vegetation in the Mojave Desert is too sparse to carry fire. On the NTS the pinyon juniper community is probably too broken up to carry extensive fires. Communities on the NTS prone to brush fires recover slowly (Hunter in press), and increased fire frequency may represent a threat. At the present time, however, fires are controlled on the NTS, and they do not represent a major threat for that reason. Increased fire frequency associated with introduced grass species is a problem in some communities (Whisenant 1990; Updike et al. 1990), and the NTS has the introduced grasses (Hunter 1990, 1991), but drought has limited their populations since 1988 (Hunter, ephemerals section).

Introduced species are another new factor. There are many introduced species of annual plant on the NTS (Beatley 1976), but except for the fire danger, they do not threaten perennial populations. *Tamarix ramosissima* (Tamarisk) spreads naturally to spring sites and any permanent water ponds and wells, and may threaten a few aquatic species, but native aquatic/wetlands species are essentially absent from the NTS. It is likely that the few natural small seeps and springs are not permanent, and species occurring there are temporary occupants.

Radiation levels currently found on the NTS are too low to affect plants (Kaaz et al. 1971; Rhoads et al. 1969; Vollmer and Bamberg 1975; Wallace and Romney 1972; Shields and Rickard 1961). Neither short-term nor long-term effects of existing radiation levels would be expected, and radiation levels are expected to decrease as "environmental restoration" proceeds. (The restoration activities are more a threat to the vegetation than the radiation.)

There is evidence, currently undocumented, that some species are spreading outside their normal ranges along roadsides. For example, in the 1980s *Chrysothamnus nauseosus* became quite prominent on roadsides and disturbances throughout the NTS. Because the roadsides are moister environments, these species can persist there, but can't invade undisturbed desert. At least at the present time road construction and maintenance do not seem a threat except to the adjacent vegetation.

Fluctuations in precipitation have had considerable effect on the NTS vegetation in the past six years. Some species like *Artemisia spinescens* in Yucca Flat were seriously depleted by drought (Table 9). There is evidence in Mid Valley that *Artemisia tridentata* recently died among the dominant *Coleogyne ramosissima*, and in northern Frenchman Flat *Coleogyne* died but *Larrea tridentata* survived. Big Burn Valley, where the infestation of pinyon needle scale was severe, is at the lower altitudinal limit of *Pinus monophylla*. Such changes at the boundaries between vegetative communities might be expected to result from climate change, and such changes have been documented in the Mojave during recent centuries using packrat midden analyses (Hunter 1991). The short-term fluctuations which have affected the NTS vegetation over the last decade suggest that long-term changes in precipitation regime might result in significant changes in the plant communities.

Beatley believed the *Atriplex* species were Great Basin Desert representatives, and thus considered the communities around Frenchman and Yucca Lakes to be islands of Great Basin Desert within Mojave and transition desert vegetation (Beatley 1975, 1976). Her view is supported by the death of those communities during the severe drought of 1989-91. It is also supported by the germination in 1992 during late winter of the *Atriplex* species and *Oryzopsis hymenoides*. These events may be contractions and expansions of these desert communities associated with these short-term climate fluctuations. The NTS, situated at the Great Basin Mojave transition, may thus be ideally situated to monitor effects of climate change on vegetation.

Monitoring Techniques

Changes in monitoring techniques over the past six years have had some positive effects. In particular the technique of monitoring individuals of the rarer species is beginning to show its usefulness. The population of *Yucca brevifolia* plants in Yucca Flat has demonstrated the importance of grazing by jackrabbits (*Lepus californica*) and protection by shrub canopies during drought. The plants marked to follow pinyon needle scale have demonstrated differences in growth and needle longevity (Table 11). The absence of growth by *Juniperus osteosperma* on the Pahute Mesa baseline plot since 1989 is also revealing.

Monitoring of individual plants has advantages, but also some disadvantages. It does not allow correlation of a monitored species' attributes with those of other species around it. For example, dieback of pines may help junipers in Big Burn Valley, but no data are available on the junipers there.

In 1992, in order to measure all five baseline transects, only one transect was measured on each. I believe this provides adequate data on the general trend in vegetation at each site, but it reduces the sample size of certain less common but still important species. The result can be seen in Table 7, where some species like *Larrea tridentata* are represented by fewer than 10 individuals. In that situation, it may be advantageous to mark extra individuals around a transect and follow them separately. In 1988, a technique was tried where certain species like *Larrea* were sampled on larger areas centered on the transect, but the result was to make calculation of densities and means more complicated without sufficiently increasing the sample size. Species which might in the future be censused with marked individuals include *Larrea tridentata*, *Ephedra nevadensis*, *Menodora spinescens*, and *Tetradymia axillaris*. Each can be large, long-lived, and relatively sparse on 100 m^2 areas.

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APPENDIX F

SPECIES NAMES AND ABBREVIATIONS USED IN THIS REPORT.

Appendix F. Perennial plant species names, authorities, and the abbreviations used in the tables for this report.

SPECIES AND AUTHORITY	ABBREVIATION
Acamptopappus shockleyi Gray	ACA SHO
Ambrosia dumosa (Gray) Payne	AMB DUM
Arenaria congesta Nutt. ex Torr. & Gray	ARE CON
Artemisia nova A. Nels.	ART NOV
Artemisia spinescens D.C. Eat.	ART SPI
Artemisia tridentata Nutt.	ART TRI
Astragalus purshii Doug. ex Hook.	AST PUR
Atriplex canescens (Pursh) Nutt.	ATR CAN
Atriplex confertifolia (Torr. & Frem.) S. Watts	ATR CON
Perennial bunchgrass (not identified)	BUNCHGR
Cactus (unidentified to species)	CACTUS
Ceratoides lanata (Pursh) J.T. Howell	CER LAN
Chrysothamnus parryi (Gray) Petrak	CHR PAR
Chrysothamnus viscidiflorus (Hook.) Nutt.	CHR VIS
Chrysothamnus viscidiflorus ssp. puberulus (D. C. Eat.) Hall & Clements	H VI p
Coleogyne ramosissima Torr.	COL RAM
Cowania mexicana D. Don	COW MEX
Cryptantha flavoculata (A. Nels.) Payson	CRY FLA
Ephedra nevadensis S. Wats.	EPH NEV
Eriogonum caespitosum Nutt.	ERI CAE
Eriogonum umbellatum Torr.	ERI UMB
Erioneuron pulchellum (H.B.K.) Tateoka	ERI PUL
Fendlerella utahensis (S. wats.) Heller	FEN UTA
Grayia spinosa (Hook.) Moq.	GRA SPI
Haplopappus nanus (= *Ericameria nana*) (Nutt.) D. C. Eaton	HAP NAN
Hymenoclea salsola Torr. & Gray ex Gray	HYM SAL
Juniperus osteosperma (Torr.) Little	JUN OST
Kochia americana Benth.	KOC AME
Larrea tridentata (Sesse & Moc. ex DC.) Coville	LAR TRI
Linanthus nuttallii (Gray) Greene ex Milliken	LIN NUT
Lycium andersonii Gray	LYC AND
Menodora spinescens Gray	MEN SPI

Appendix F, continued.

SPECIES AND AUTHORITY	ABBREVIATION
Mirabilis pudica Barneby	MIR PUD
Opuntia echinocarpa Engelm. & Bigelow	OPU ECH
Opuntia erinacea var. ursina (A. Weber) Parish	OPU ERI
Oryzopsis hymenoides (Roemer & Schultes) Ricker	ORY HYM
Penstemon species (not identified)	PEN sp
Phlox stansburyi (Torr.) Heller	PHL STA
Pinus monophylla Torr. & Frem.	PIN MON
Poa sandbergii Vasey	POA SAN
Polygala subspinosa S. Wats.	POL SUB
Psorothamnus fremontii (Torr. ex Gray) Barneby	PSO FRE
Psorothamnus polydenius (Torr. ex S. Wats.) Rydb.	PSO POL
Quercus gambellii Nutt.	QUE GAM
Sitanion jubatum J.G. Sm.	SIT JUB
Sphaeralcea ambigua Gray	SPH AMB
Stanleya pinnata (Pursh) Britt.	STA PIN
Stipa comata Trin. & Rupr.	STI COM
Stipa speciosa Trin. & Rupr.	STI SPE
Streptanthus cordatus Nutt. ex Torr. & Gray	STR COR
Tetradymia axillaris A. Nels.	TET AXI
Tetradymia glabrata Torr. & Gray	TET GLA
Yucca brevifolia Engelm.	YUC BRE
Yucca schidigera Roezl ex Ortgies	YUC SCH

APPENDIX G

The following tables summarize the perennial plant population parameters determined on belt transects censused on the Nevada Test Site in 1992 and one previous year. Results for some plots are for the 1991-1992 period, and for others 1989-1992, or 1988 - 1992. The transects were normally 50 meters long and 2 meters wide, but two (Pahute Mesa plot Pam001 and Rainier Mesa plot RAM001) were 25 X 2 m, because of the high densities of plants. The tables are ordered by landform, generally from lowest altitude to highest altitude.

Table 1. Population characteristics of perennial plants on plot JAF001, transect V1, sampled August 12, 1991 (top line) and May 19, 1992 (second line). Elevation 954 m.

Species	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOLUME l	TOT VOL l	AVG BIO g	TOTAL BIO Kg
ACA SHO	80	19±1	23±2	16±2	4.0±1.0	2.82	8±2	606	23± 7	1.88
ACA SHO	88	27±1	34±3	26±2	8.0±1.0	6.93	22±4	1946	69±13	6.03
AMB DUM	67	25±1	35±3	29±3	9.0±1.0	5.97	24± 4	1596	60±11	3.99
AMB DUM	71	32±2	50±4	41±4	18.0±3.0	12.61	63±12	4462	157±31	11.16
CER LAN	5	28±5	22±8	18±4	3.0±1.0	0.15	8±1	38	24±4	0.12
CER LAN	5	38±5	38±5	31±2	9.3±1.4	0.46	35±3	175	112±9	0.56
LAR TRI	7	84±19	161±59	117±46	180±120	12.52	1813±1435	12690	570±204	16.50
LAR TRI	7	84±24	151±51	115±38	157± 92	11.04	1631±1255	11418	405±110	14.84
MEN SPI	20	19±3	52±16	44±14	27±16	5.30	69±49	1373	570±407	11.39
MEN SPI	20	19±2	51±13	44±12	23±12	4.65	49±26	975	405±219	8.09
ORY HYM	0									
ORY HYM	36	11±4	2±1	1±1	0.05±0.08	0.02	0.2±0.3	6.6	0.2±0.3	0.01
DEAD GR	49	13±2	9±2	7±2	0.9±0.6	0.42	1.1±0.9	54.2		
DEAD GR	49	10±2	9±2	7±2	0.8±0.5	0.38	0.9±0.5	42.5		
DEAD SH	96	18±2	31±3	23±3	7.0±1.0	6.85	16.0±4.0	1518		
DEAD SH	87	16±2	27±3	22±2	5.0±1.0	4.76	11.0±3.0	991		
TOTALS	179					26.8		16303		33.9
TOTALS	227					35.7		18982		40.7

Table 2. Population characteristics of perennial plants on plot FF66 on the north edge of Frenchmen Lake, sampled on May 21, 1991 (top line) and June 9, 1992 (second line). Elevation 940 m.

Species	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOLUME l	TOT VOL l	AVG BIO g	TOTAL BIO Kg
ATR CON	3	27±12	31±17	17±9	4.7±4.6	0.14	15±20	46.3	72±95	0.22
ATR CON	53	3±2	3±2	2±1	0.3±0.3	0.13	0.7±1.0	37.8	3.4±4.6	0.18
KOC AME	23	7±2	3±1	3±1	0.13±0.14	0.03	0.19±0.25	4.3	0.58±0.78	0.01
KOC AME	32	16±3	10±2	8±2	0.8±0.3	0.26	1.7±1.0	56.7	5.5±3.1	0.18
DEAD SH	126	32±3	49±6	41±5	24±5	29.86	111±29	14034		
DEAD SH	116	31±3	49±6	41±5	22±5	25.86	100±28	11566		
TOTALS	26					0.17		50.6		0.23
TOTALS	85					0.39		94.5		0.35

Table 3. Population characteristics of perennial plants on plot FF67 on the north edge of Frenchmen Lake, sampled June 3,1991 (top line) and June 4, 1992 (second line). Elevation 940 m.

Species	n cm	HT cm	MAXWID cm	PERWID dm^2	AVG COVER m^2	TOT COV l	AVG VOLUME l	TOT VOL g	AVG BIO Kg	TOTAL BIO
ATR CAN	1	49	41	36	11.6	0.12	57	57	148	0.15
ATR CAN	31	5±2	3±1	2±1	0.31±0.29	0.10	1.47±1.46	45.51	3.82±3.79	0.12
ATR CON	0									
ATR CON	675	2±0	2±0	1±0	0.02±0.00	0.12	0.005±0.001	3.48	0.024±0.003	0.02
ORY HYM	0									
ORY HYM	9	1±0	1±0	1±0	0.01±0.00	0.00	0.001±0	0.01	0.001±0	0.00
STA PIN	0									
STA PIN	6	6±1	4±1	4±1	0.12±0.03	0.01	0.092±0.037	0.55	0.040±0.016	0.00
DEAD SHR	78	32±1	46±2	37±2	16.2±1.7	12.6	62±8	4847		
DEAD SHR	77	30±1	44±2	34±2	14.6±1.5	11.3	53±6	4083		
TOTALS	1					0.12		56.8		0.15
TOTALS	721					0.23		49.6		0.13

Table 4. Population characteristics of perennial plants on plot FF81, northeast of Frenchmen Lake, sampled June 3, 1991 (top line) and June 9, 1992 (second line). Elevation 945 m.

Species	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOLUME l	TOT VOL l	AVG BIO g	TOTAL BIO Kg
ATR CAN	0									
ATR CAN	148	5±1	3±0	2±0	0.06±0.02	0.09	0.03±0.02	5.1	0.09±0.06	0.01
ATR CON	0									
ATR CON	1	1	1	1	0.01	0.00	0.00	0.0	0.00	0.00
MIR PUD	0									
MIR PUD	3	17±10	20±12	15±7	2.3±1.7	0.07	4.2±5.4	12.5	1.8±2.3	0.01
ORY HYM	0									
ORY HYM	294	13±1	1±0	1±0	0.01±0.00	0.03	0.01±0.00	3.6	0.01±0.00	0.00
SPH AMB	0									
SPH AMB	5	2±1	3±2	2±2	0.07±0.11	0.00	0.02±0.03	0.1	0.01±0.01	0.00
DEAD GR	23	7±4	9±3	8±3	0.6±0.5	0.15	0.5±0.8	11.7		
DEAD GR	28	4±2	9±3	7±2	0.6±0.4	0.14	0.2±0.3	6.0		
DEAD SH	68	30±7	48±15	39±14	21±13	13.86	87±66	5769.5		
DEAD SH	67	26±8	43±15	37±15	19±13	12.50	80±64	5216.6		
TOTALS	0					0.00		0		0.00
TOTALS	451					0.19		21		0.02

Table 5. Population characteristics of perennial plants on plot FF84, northeast of Frenchmen Lake, sampled June 10, 1992. Elevation 945 m.

Species	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOLUME l	TOT VOL l	AVG BIO g	TOTAL BIO Kg
ATR CAN	0									
ATR CAN	50	8±1	5±1	4±1	0.20±0.05	0.10	0.20±0.08	10.0	0.5±0.2	0.03
LAR TRI	5	96±35	147±59	114±56	157±115	7.83	1800±1500	9100	2366±998	11.83
LAR TRI	5	87±41	117±53	96±37	102± 59	5.09	1100± 780	5519	1435±508	7.17
ORY HYM	0									
ORY HYM	78	17±0	1±0	1±0	0.01±0.00	0.01	0.01±0.00	1.1	0.02±0.00	0.00
DEAD GR	1	13	32	23	5.8	0.06	7.5	7.5		
DEAD GR	1	10	24	13	2.5	0.02	2.5	2.5		
DEAD SH	8	40±10	68±20	54±17	32±16	2.59	147±89	1177.3		
DEAD SH	8	37±10	57±16	55±19	28±14	2.26	117±61	932.4		
TOTALS	5					7.83		9100		11.8
TOTALS	133					5.20		5530		7.2

Table 6. Population characteristics of perennial plants on plot FRF001, transect V1, sampled June 4, 1991 (top line) and May 27, 1992 (second line). Elevation 965 m.

Species	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOLUME l	TOT VOL l	AVG BIO g	TOTAL BIO Kg
ACA SHO	3	13±4	11± 8	8± 9	1.0±1.5	0.03	1.5±2.6	4.5	4.6±8.0	0.01
ACA SHO	3	19±5	20±11	16±10	2.8±2.9	0.08	6.2±7.3	18.6	19±23	0.06
AMB DUM	15	14±3	19±7	12±4	2.5±1.6	0.37	4.0±3.0	64.5	11±8	0.16
AMB DUM	16	28±6	28±6	26±8	7.0±3.0	1.13	25±15	395.4	60±40	0.99
CER LAN	8	34± 8	16±3	15±5	2.0±1.0	0.17	8.0±6.0	64.8	26±19	0.21
CER LAN	9	40±10	30±9	22±6	6.0±2.0	0.51	25±10	227.1	81±32	0.73
EPH NEV	1	52	52	39	16	0.16	83	82.8	120	0.12
EPH NEV	1	47	41	45	14	0.14	68	68.1	95	0.10
GRA SPI	3	42± 6	28±18	32±29	8.0±9.0	0.25	36±36	107.3	83±84	0.25
GRA SPI	2	65±12	55± 2	50±17	21.0±7.0	0.43	140±70	281.0	320±160	0.65
HYM SAL	2	20±20	10±1	9±3	0.6±0.2	0.01	1.2±0.9	2.4	4±3	0.01
HYM SAL	4	23±14	18±8	15±8	2.4±2.0	0.09	7.5±9.6	30.2	24±31	0.10
LAR TRI	6	100±38	143±63	112±49	154±131	9.27	2059±2455	12357	2677±1596	16.06
LAR TRI	6	100±30	161±64	119±39	173±143	10.40	2186±2527	13117	2842±1643	17.05
LYC AND	2	55±5	59±51	44±17	22±25	0.43	115±127	230.1	253±279	0.51
LYC AND	3	44±15	48±36	38±25	16±20	0.53	87±101	260.1	191±221	0.57
ORY HYM	0									
ORY HYM	19	14±3	2±1	2±1	0.06±0.09	0.01	0.10±0.20	2.0	0.1±0.2	0.00

Table 7. FRF001, V1, continued.

Species	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOLUME l	TOT VOL l	AVG BIO g	TOTAL BIO Kg
PSO FRE	0									
PSO FRE	1	7	8	6	0.38	0.00	0.26	0.3	0.66	0.00
DEAD GR	5	9±4	10±4	8±3	0.7±0.6	0.03	0.7±0.9	3.6		
DEAD GR	7	8±3	6±3	5±3	0.3±0.2	0.02	0.3±0.3	1.9		
DEAD SH	106	21±3	27±5	22±4	9.0±3.0	9.28	36±17	3861		
DEAD SH	102	19±3	26±4	20±4	6.9±2.3	7.02	27±14	2730		
TOTALS	40					10.7		12913		16.8
TOTALS	64					13.3		14399		20.2

Table 8. Population characteristics of perennial plants on baseline plot YUF001 in southwestern Yucca Flat, transect v2, sampled July 29, 1991 (top line) and July 6, 1992 (second line). Elevation 1237 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm^2	m^2	l	l	g	Kg
ACA SHO	11	13±3	16±7	12±6	2.2±1.8	0.24	3.7±3.5	40	11±11	0.13
ACA SHO	9	20±6	25±5	20±6	4.1±2.2	0.37	10±8	93	32±24	0.29
ART SPI	6	20±7	20±7	14±4	2.4±1.2	0.14	5.4±4.5	32.3	22±18	0.13
ART SPI	2	14±2	14±6	14±7	1.6±1.4	0.03	2.3±2.3	4.5	9± 9	0.02
ATR CAN	31	33±5	32±6	23±5	7.1±2.4	2.19	29±14	893	75±36	2.32
ATR CAN	32	50±5	52±7	46±7	21±5	6.73	119±37	3802	309±96	9.89
BUNCHGR	0									
BUNCHGR	1	14	1	1	0.01	0.00	0.01	0.0	0.01	0.00
CER LAN	42	22±3	16±3	11±3	2.0±1.1	0.83	6±4	265	20±14	0.85
CER LAN	35	37±5	26±5	19±4	4.8±1.5	1.69	22±9	780	71±29	2.50
EPH NEV	21	31±10	56±22	43±18	34±20	7.17	197±136	4130	275±190	5.78
EPH NEV	18	39±10	60±20	50±18	34±20	6.19	200±131	3599	280±184	5.04
ERI PUL	0									
ERI PUL	27	1±0	3±0	2±0	0.00±0.00	0.01	0.01±0.00	0.2	0.01±0.00	0.00
GRA SPI	33	39±4	37±6	26±5	9±3	3.04	42±15	1392	97±35	3.20
GRA SPI	35	51±3	45±4	38±4	14±2	4.97	75±15	2612	172±34	6.01
HYM SAL	8	20± 4	19± 7	12± 5	2.3±1.6	0.18	5± 4	41	16± 14	0.13
HYM SAL	5	34±14	41±17	30±13	11±9	0.57	48±50	238	153±161	0.76

Table 9. YUF001 baseline plot, continued.

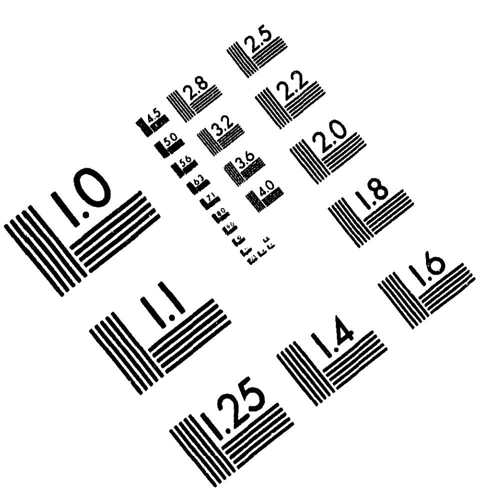
Species	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOLUME l	TOT VOL l	AVG BIO g	TOTAL BIO Kg
LYC AND	14	47±6	60±22	47±21	33±28	4.68	188±175	2631	413±385	5.79
LYC AND	13	44±8	46±15	27± 7	11± 5	1.45	52± 26	677	115± 57	1.49
MEN SPI	1	10	10	9	0.71	0.01	0.71	0.7	5.9	0.01
MEN SPI	0									
MIR PUD	1	10	12	6	0.57	0.01	0.57	0.6	0.24	0.00
MIR PUD	11	22±5	22±6	17±5	3.5±1.5	0.38	8±3	88.8	3.5±1.5	0.04
ORY HYM	0									
ORY HYM	4	31±22	4±3	4±3	0.15±0.24	0.01	0.8±1.3	3.1	0.8±1.5	0.00
SIT JUB	0									
SIT JUB	4	20±4	2±2	2±1	0.05±0.04	0.00	0.09±0.09	0.4	0.10±0.09	0.00
SPH AMB	1	2	2	2	0.03	0.00	0.01	0.0	0.00±0	0.00
SPH AMB	60	4±1	4±1	3±1	0.2±0.1	0.11	0.19±0.23	11.4	0.08±0.10	0.00
STI SPE	3	16±9	5±3	4±3	0.2±0.2	0.01	0.3±0.3	1.0	0.4±0.3	0.00
STI SPE	3	28±7	4±3	3±2	0.09±0.09	0.00	0.3±0.3	0.9	0.3±0.3	0.00
TET AXI	1	74	72	70	39.6	0.40	293	293	791	0.79
TET AXI	0									

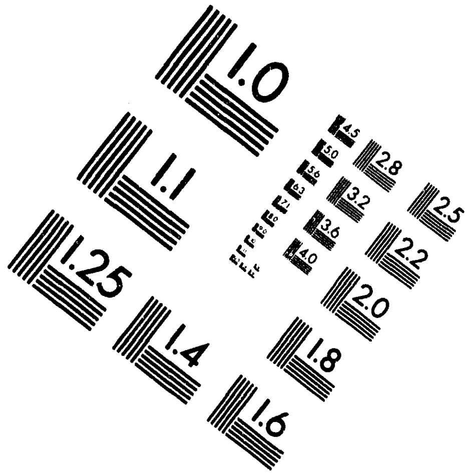
Table 10. YUF001 baseline plot, continued.

Species	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOLUME l	TOT VOL l	AVG BIO g	TOTAL BIO Kg
DEAD GR	44	12±2	9±2	7±2	0.72±0.36	0.32	1.3±0.9	57.0		
DEAD GR	33	10±2	6±1	5±1	0.28±0.09	0.09	0.40±0.21	13.1		
DEAD SH	230	22±2	30±2	22±2	7.1±1.5	16.34	23±7	5184		
DEAD SH	230	22±2	29±2	23±2	7.1±1.3	16.29	22±6	5057		
TOTALS	173					18.9		9719		19.13
TOTALS	259					22.5		11910		26.04

Table 11. Population characteristics of perennial plants on the north-facing slope of U3cn crater (YUF019), sampled July 20, 1989 (top line) and June 24, 1992 (second line). Elevation 1213 m.

Species	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOLUME l	TOT VOL l	AVG BIO g	TOTAL BIO Kg
ATR CAN	21	40±8	36±13	30±9	13±10	2.67	80±73	1671	2070±189	4.34
ATR CAN	22	39±7	38±10	29±9	12± 7	2.63	66±52	1442	170±134	3.75
MIR PUD	3	5±4	1±0	1±0	0.01±0.00	0.00	0.00±0.00	0	0.00±0.00	0.00
MIR PUD	29	28±3	32±7	22±4	6.7±2.2	1.94	22±8	626	9±4	0.27
ORY HYM	118	7±1	13±2	12±1	1.7±0.4	1.97	1.8±1.3	213	2.0±1.4	0.23
ORY HYM	1129	15±0	1±0	1±0	0.01±0.00	0.09	0.01±0.00	13	0.01±0.00	0.01
SPH AMB	1	3	3	3	0.07	0.00	0.02	0	0.01	0.00
SPH AMB	0									
DEAD GR	163	10±1	14±1	11±1	1.6±0.3	2.59	2.0±0.4	318		
DEAD GR	283	8±1	9±1	8±0	0.7±0.1	1.94	0.7±0.1	184		
DEAD SH	16	44±11	70±20	58±18	41±20	6.56	226±131	3615		
DEAD SH	19	40±10	74±17	63±16	46±17	8.74	238±117	4510		
TOTALS	143					4.63		1884		4.58
TOTALS	1180					4.66		2081		4.03





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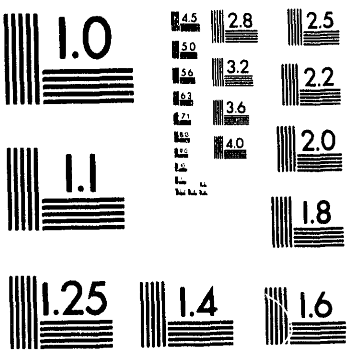

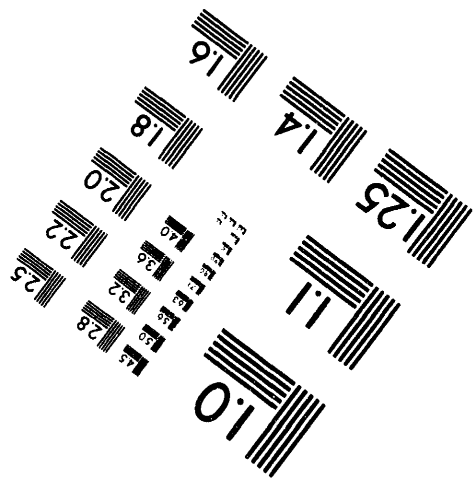

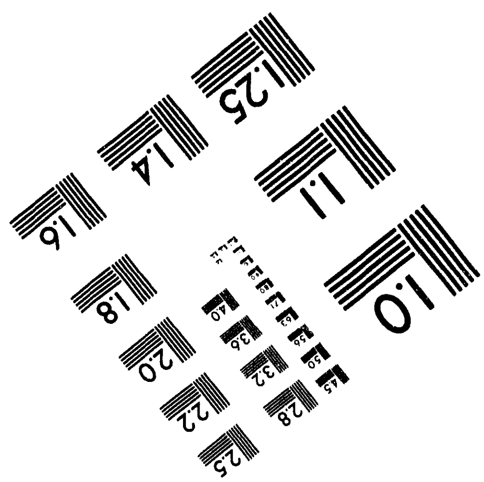

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Table 12. Population characteristics of perennial plants on plot YUF019M, the center of U3cn crater, sampled July 20, 1989 (top line) and June 22, 1992 (second line). Elevation 1213 m.

Species	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOLUME l	TOT VOL l	AVG BIO g	TOTAL BIO Kg
ATR CAN	2	37±2	42±3	34±21	11±6	0.22	40±20	79	103±52	0.21
ATR CAN	1	74	79	76	47	0.47	349	349	907	0.91
ORY HYM	0									
ORY HYM	22	10±1	1±0	1±0	0.01±0.00	0.00	0.01±0.00	0.18	0.01±0.00	0.00
DEAD GS	0									
DEAD GS	2	2±2	5±4	4±5	0.2±0.3	0.00	0.03±0.02	0.05		
DEAD SH	1	39	55	49	21	0.21	83	83		
DEAD SH	2	48±34	60±13	51±13	24±6	0.49	126±137	253		
TOTALS	2					0.22		79		0.21
TOTALS	23					0.47		349		0.91

Table 13. Population characteristics of perennial plants on the south-facing slope of U3cn crater (YUF019), sampled July 20, 1989 (top line) and June 17, 1992 (second line). Elevation 1213 m.

Species	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOLUME l	TOT VOL l	AVG BIO g	TOTAL BIO Kg
MIR PUD	3	4±2	6±7	3±2	0.2±0.2	0.00	0.06±0.10	0.2	0.03±0.04	0.00
MIR PUD	26	23±2	30±6	22±5	6.7±3.0	1.74	18±10	477.8	7.9±4.5	0.21
ORY HYM	125	4±1	9±1	9±2	1.1±0.4	1.35	0.3±0.1	35.9	0.3±0.1	0.04
ORY HYM	613	18±0	1±0	1±0	0.01±0.00	0.06	0.02±0.00	10.8	0.02±0.00	0.01
SPH AMB	1	6	8	10	0.63	0.01	0.38	0.4	0.16	0.00
SPH AMB	0									
DEAD GR	4	6±6	11±7	11±9	1.3±1.4	0.05	1.3±1.5	5.2		
DEAD GR	87	7±1	8±1	7±1	0.6±0.1	0.50	0.6±0.2	52.5		
DEAD SH	0									
DEAD SH	2	23±35	17±31	14±25	3.2±6.5	0.07	13±26	26.1		
TOTALS	133					1.41		42		8.48
TOTALS	728					2.36		567		0.22

Table 14. Population characteristics of perennial plants on U3cn crater control (YUF020), sampled July 24, 1989 (top line) and June 11, 1992 (second line). Elevation 1241 m.

Species	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOLUME l	TOT VOL l	AVG BIO g	TOTAL BIO Kg
ATR CAN	20	28±5	26± 9	22±7	6.8±4.2	1.35	27±19	525	68±49	1.37
ATR CAN	15	30±6	31±10	26±8	8.3±4.6	1.24	30±20	456	79±53	1.19
CER LAN	19	26±5	24±6	25±7	5.7±2.3	1.09	18± 9	346	58±28	1.11
CER LAN	10	31±10	28±10	18±8	5.4±4.3	0.54	22±23	224	72±73	0.72
CHR VIS	54	30±3	36±7	32±6	13±6	6.98	52±30	2822	131±75	7.05
CHR VIS	11	30±3	25±10	18±5	4±2	0.47	19±10	153	35±24	0.38
GRA SPI	1	35	24	26	4.90	0.05	17.15	7	39.45	0.04
GRA SPI	0									
MIR PUD	0									
MIR PUD	1	33	35	19	5.22	0.05	17.24	17	7.41	0.01
POL SUB	51	1±0	1±0	1±0	0.01±0.00	0.00	0.00±0.00	0		
POL SUB	277*	9±0	58±3	47±2	24±2	65.15	24±3	*		
LYC AND	1	43	60	35	16	0.16	71	71	156	0.16
LYC AND	1	37	55	34	15	0.15	54	54	120	0.12
ORY HYM	191	12±1	15±1	14±1	2.0±0.3	3.87	2.4±0.5	466	2.7±0.6	0.51
ORY HYM	376	16±0	1±0	1±0	0.08±0.08	0.31	0.15±0.14	56	0.2±0.2	0.06
SPH AMB	1	9	12	10	0.94	0.01	0.85	1	0.36	0.00
SPH AMB	0									

* Number and sizes do not correspond - numbers include crowns, sizes measure multiple crowns.

Table 15. U3cn control, continued.

Species	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOLUME l	TOT VOL l	AVG BIO g	TOTAL BIO Kg
TET GLA	4	42±14	64±31	62±28	36±28	1.42	177±165	708	478±445	1.91
TET GLA	0									
DEAD GR	66	10±1	12±2	11±2	1.3±0.4	0.87	1.4±0.4	93		
DEAD GR	287	9±1	16±1	12±1	1.9±0.3	5.55	2.4±0.5	677		
DEAD SH	238	2±1	2±1	2±1	0.5±0.4	1.18	1.9±1.6	444		
DEAD SH	74	27±3	38±5	31±4	12±3	9.05	46±15	3387		
TOTALS	342					14.94		4956		12.1
TOTALS	691					2.75*		961*		2.5*

* Totals do not include *Polygala subspinosa*.

Table 16. Population characteristics of perennial plants on the north-facing slope of crater U7au (YUF021), sampled July 26, 1989 (top line) and July 13, 1992 (second line). Elevation 1234 m.

Species	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOLUME l	TOT VOL l	AVG BIO g	TOTAL BIO Kg
ART SPI	1	15	29	32	7.29	0.07	10.93	10.9	44.82	0.04
ART SPI	0									
ATR CAN	2	65±25	122±81	119±62	124±135	2.49	887±1184	1773.3	2305±1539	4.61
ATR CAN	1	72	126	115	114	1.14	819	819.4	2130	2.13
ORY HYM	19	1±1	7±1	7±1	0.47±0.12	0.09	0.07±0.04	1.3	0.07±0.05	0.00
ORY HYM	201	8±0	1±0	1±0	0.01±0.00	0.03	0.01±0.00	2.6	0.01±0.01	0.00
SIT JUB	6	1±0	6±2	5±2	0.28±0.18	0.02	0.03±0.02	0.2	0.03±0.02	0.00
SIT JUB	0									
STI SPE	1	1	3	4	0.09	0.00	0.01	0.0	0.01	0.00
STI SPE	0									
DEAD GR	35	1±0	9±1	9±1	0.7±0.1	0.23	0.07±0.01	2.3		
DEAD GR	74	11±1	8±1	6±1	0.5±0.1	0.38	0.7±0.2	47.9		
DEAD SH	2	21±22	30±24	25± 4	6± 6	0.12	16± 25	31.8		
DEAD SH	4	22±21	47±35	39±35	21±33	0.85	98±182	390.8		
TOTALS	29					2.67		1786		4.66
TOTALS	202					1.16		822		2.13

Table 17. Population characteristics of perennial plants on the south-facing slope of crater U7au (YUF021), sampled July 26, 1989 (top line) and July 15, 1992 (second line). Elevation 1234 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
	cm	cm	cm	dm^2	m^2	l	l	g	Kg	
ART SPI	14	17±3	24± 5	21± 4	4±2	0.63	8.2±3.3	114.3	33±14	0.47
ART SPI	3	15±5	15±12	16±13	2±4	0.07	4.1±6.4	12.2	17±26	0.05
ATR CAN	20	37±6	35± 7	29±7	10±4	1.92	44±21	874.8	114±55	2.27
ATR CAN	5	37±5	39±13	27±8	8±3	0.41	32±16	160.0	83±42	0.42
CER LAN	13	28±5	26±5	25±6	6±2	0.71	17±7	217.0	53±24	0.69
CER LAN	4	30±6	27±6	19±8	4±2	0.17	13±7	50.6	41±21	0.16
GRA SPI	10	38±6	45±10	36±9	14±6	1.42	57±28	568.3	131±63	1.31
GRA SPI	0									
LYC AND	7	30±5	37±10	37±8	11±5	0.80	35±16	242.1	76±36	0.53
LYC AND	9	26±4	34±10	28±8	8±4	0.72	23±12	203.0	50±27	0.45
MIR PUD	0									
MIR PUD	2	21±9	32±14	30±20	8±8	0.16	18±24	36.9	8±10	0.02
ORY HYM	11	2±1	11±3	9±2	0.9±0.4	0.10	0.18±0.19	1.9	0.2±0.2	0.00
ORY HYM	9	8±2	1±0	1±0	0.01±0.00	0.00	0.01±0.00	0.1	0.01±0.00	0.00
SPH AMB	2	6±5	7±10	4±4	0.30±0.53	0.01	0.23±0.44	0.5	0.1±0.2	0.00
SPH AMB	0									

Table 18. U7au south-facing, continued.

Species	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOLUME l	TOT VOL l	AVG BIO g	TOTAL BIO Kg
TET AXI	1	57	85	61	41	0.41	232	232.1	627	0.63
TET AXI	0									
DEAD GR	16	8±1	13±3	12±2	1.4±0.6	0.22	1.2±0.7	19.2		
DEAD GR	28	7±2	10±2	8±1	0.7±0.3	0.21	0.5±0.2	13.7		
DEAD SH	24	41±7	43±8	43±10	17±6	4.19	91±43	2193.4		
DEAD SH	88	31±3	43±5	32±4	14±3	11.87	57±17	5038.9		
TOTALS	78					5.98		2251		5.90
TOTALS	32					1.53		453		1.09

Table 19. Population characteristics of perennial plants on the control for crater U7au (YUF022), sampled July 26, 1989 (top line) and July 13, 1992 (second line). Elevation 1251 m.

Species	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOLUME l	TOT VOL l	AVG BIO g	TOTAL BIO Kg
ART SPI	53	20±2	32±4	26±4	8±2	4.08	18±5	940	73±20	3.85
ART SPI	4	15±3	15±2	14±2	1.7±0.3	0.07	2.6±1.0	10	11±4	0.04
ATR CAN	44	34±3	33±5	28±4	8.7±2.5	3.82	34±12	1474	87±32	3.83
ATR CAN	13	14±7	9±7	8±8	2.0±2.6	0.26	8±11	103	21±28	0.27
CACTUS	1	14	23	21	3.79	0.04	5±5			
CACTUS	0									
CER LAN	55	33±3	32±4	30±4	8.7±2.1	4.78	32±10	1751	102±32	5.60
CER LAN	33	39±4	31±3	25±3	6.5±1.4	2.15	27± 8	906	88±24	2.90
CHR VIS	1	12	18	5	0.71	0.01	0.85	1	2.12	0.00
CHR VIS	0									
EPH NEV	1	14	37	30	8.72	0.09	12.2	12	17	0.02
EPH NEV	1	15	31	24	5.84	0.06	8.7	9	12	0.01
GRA SPI	21	47±5	56±11	47±8	23±7	4.82	117±46	2455	269±107	5.65
GRA SPI	2	42±6	48±15	38±4	14±3	0.28	59±21	119	137±48	0.27
LYC AND	13	40±8	45±17	44±17	21±14	2.74	105±74	1371	232±164	3.02
LYC AND	8	37±8	54±25	39±15	21±13	1.68	89±59	710	195±130	1.56
MIR PUD	0									
MIR PUD	3	26±9	30±9	22±6	5.3±2.6	0.16	15±9	44	6±4	0.02

Table 20. U7au control, continued.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
	cm	cm	cm	dm^2	m^2	l	l	g	Kg	
ORY HYM	6	5±4	6±3	6±2	0.34±0.23	0.02	0.2±0.2	1	0.2±0.2	0.00
ORY HYM	2	27±23	7±3	6±3	0.30±0.28	0.01	1.0±1.4	2	1.0±1.6	0.00
SPH AMB	1	4	9	7	0.49	0.00	0.20	0.2	0.09	0.00
SPH AMB	0									
SIT JUB	7	1±0	8±2	7±2	0.4±0.2	0.03	0.04±0.02	0.3	0.05±0.02	0.00
SIT JUB	0									
DEAD GR	0									
DEAD GR	9	7±2	6±1	4±1	0.2±0.1	0.02	0.2±0.1	1.4		
DEAD SH	22	38±9	47±11	42±10	19±7	4.19	95±52	2085.6		
DEAD SH	182	33±2	43± 3	35± 3	15±2	27.32	67±14	12117.6		
TOTALS	203					20.42		8011		22.0
TOTALS	66					4.66		1902		5.1

Table 21. Population characteristics of perennial plants on the north-facing slope of U10af crater (YUF023), sampled August 1, 1989 (top line) and July 9, 1992 (second line). Elevation 1277 m.

Species	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOLUME l	TOT VOL l	AVG BIO g	TOTAL BIO Kg
ATR CAN	14	36±7	37±10	29±8	10±4	1.42	42±18	584.4	109±47	1.52
ATR CAN	20	27±4	24± 7	20±6	5±3	1.04	17±11	346.5	45±28	0.90
CER LAN	5	37± 8	36±14	28±8	8± 5	0.42	34±24	169.8	109± 77	0.54
CER LAN	2	49±17	59±28	52±3	24±10	0.47	119±88	238.3	381±283	0.76
CHR VIS	1	29	40	28	8.80	0.09	25.51	25.5	63.77	0.06
CHR VIS	0									
LYC AND	2	47± 0	54±17	48±38	21±22	0.43	101±105	201.5	222±231	0.44
LYC AND	2	43±10	78±38	47±29	31±32	0.61	124±105	247.8	273±232	0.55
ORY HYM	72	5±1	15±1	13±1	1.7±0.3	1.25	1.1±0.6	80.8	1.2±0.6	0.09
ORY HYM	110	14±2	3±1	2±1	0.16±0.08	0.18	0.4±0.2	46.9	0.47±0.27	0.05
SPH AMB	1	13	10	9	0.71	0.01	0.92	0.9	0.40	0.00
SPH AMB	3	5±2	5±4	1±0	0.04±0.03	0.00	0.02±0.02	0.1	0.01±0.01	0.00
DEAD GR	74	10±1	15±1	13±1	1.7±0.3	1.26	1.9±0.4	137.3		
DEAD GR	124	7±1	11±1	8±1	0.8±0.1	1.03	0.7±0.2	83.5		
DEAD SH	5	32±23	44±39	36±36	23±30	1.16	95±108	477.0		
DEAD SH	18	35± 7	54±16	49±15	28±13	4.98	114± 59	2057.2		
TOTALS	95					3.61		1063		2.66
TOTALS	137					2.31		880		2.26

Table 22. Population characteristics of perennial plants in the center of U10af crater, plot YUF023, sampled August 1, 1989 (top line) and July 9, 1992 (second line). Elevation 1277 m.

Species	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOLUME l	TOT VOL l	AVG BIO g	TOTAL BIO Kg
ATR CAN	0									
ATR CAN	1	11	17	12	1.60	0.02	1.76	1.8	4.58	0.00
ORY HYM	3	1±0	14±22	10±14	2.3±4.5	0.07	0.23±0.44	0.7	0.26±0.49	0.00
ORY HYM	121	13±2	1±0	1±0	0.01±0.00	0.01	0.02±0.01	2.6	0.02±0.01	0.00
DEAD GR	5	6±4	5±2	4±1	0.19±0.10	0.01	0.13±0.14	0.6		
DEAD GR	1	1	1	1	0.01	0.00	0.00	0.0		
DEAD SH	2	7±7	23±28	21±28	5±10	0.11	1.8±2.6	3.5		
DEAD SH	1	43	1	1	0.01	0.00	0.03	0.0		
TOTALS	3					0.07		0.7		0.00
TOTALS	122					0.03		4.4		0.01

Table 23. Population characteristics of perennial plants on the south-facing slope of crater U10af (YUF023), sampled August 1, 1989 (top) and July 1, 1992 (second). Elevation 1277 m.

Species	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOLUME l	TOT VOL l	AVG BIO g	TOTAL BIO Kg
ATR CAN	0									
ATR CAN	1	28	60	28	13.2	0.13	37.0	37.0	96	0.10
CER LAN	1	35	31	53	12.9	0.13	45.2	45.2	145	0.14
CER LAN	1	43	59	57	26.4	0.26	113.6	113.6	363	0.36
GRA SPI	1	64	89	73	51.0	0.51	327	326.6	751	0.75
GRA SPI	1	71	70	90	49.5	0.49	351	351.3	808	0.81
ORY HYM	16	4±2	10±3	7±2	0.7±0.3	0.11	0.10±0.03	1.6	0.11±0.04	0.00
ORY HYM	40	12±2	2±0	2±0	0.03±0.02	0.01	0.04±0.04	1.7	0.05±0.04	0.00
DEAD GR	30	10±3	14±4	11±2	1.8±1.0	0.54	3±3	99.7		
DEAD GR	46	7±1	10±2	7±1	0.7±0.3	0.34	0.8±0.4	34.4		
DEAD SH	2	25±42	41±46	33±46	15±27	0.30	65±129	130.0		
DEAD SH	3	33±33	48±42	42±37	22±24	0.65	111±160	333.4		
TOTALS	18					0.75		373		0.90
TOTALS	43					0.90		509		1.29

Table 24. Population characteristics of perennial plants on U10af control (YUF024), sampled August 2, 1989 (top line) and July 21, 1992 (second line). Elevation 1300 m.

Species	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOLUME l	TOT VOL l	AVG BIO g	TOTAL BIO Kg
CER LAN	6	32±12	40±19	40±20	16±11	0.95	66±51	393.4	210±164	1.26
CER LAN	3	47± 6	65±17	58±15	30±16	0.91	148±89	443.3	473±286	1.42
ORY HYM	96	1±0	12±1	10±1	1.1±0.2	1.03	0.11±0.02	10.7	0.12±0.02	0.01
ORY HYM	56	15±2	2±0	1±0	0.04±0.03	0.02	0.09±0.08	4.8	0.09±0.09	0.01
SPH AMB	0									
SPH AMB	1	24	18	18	2.54	0.03	6.11	6.1	2.63	0.00
STI SPE	1	18	9	10	0.71	0.01	1.27	1.3	1.40	0.00
STI SPE	0									
DEAD GR	25	6±1	9±2	7±1	0.6±0.3	0.15	0.4±0.2	9.2		
DEAD GR	98	6±1	9±1	7±1	0.6±0.1	0.58	0.4±0.1	43.5		
DEAD SH	2	3±1	7± 1	7± 4	0.4±0.3	0.01	0.1±0.1	0.2		
DEAD SH	7	8±7	23±14	16±15	5.1±7.5	0.36	11±21	78.0		
TOTALS	103					1.99		405		1.27
TOTALS	60					0.96		454		1.43

Table 25. Population characteristics of perennial plants on plot MID004, a bladed area in Mid Valley, sampled July 28,1989 (top line) and July 16, 1992 (second line). Elevation 1439 m.

Species	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOLUME l	TOT VOL l	AVG BIO g	TOTAL BIO Kg
EPH NEV	2	32±21	22±20	18±15	3.6±5.3	0.07	8.6±9.2	17.2	12±13	0.02
EPH NEV	2	30±21	26± 5	20±10	4.0±2.8	0.08	14±17	27.1	19±24	0.04
SIT JUB	0									
SIT JUB	1	14	7	5	0.27	0.00	0.38	0.4	0.42	0.00
TOTALS	2					0.07		17.2		0.02
TOTALS	3					0.08		22.5		0.04

Table 26. Population characteristics of perennial plants on plot MID005, an undisturbed area adjacent to MID004 in Mid Valley, sampled July 31, 1989 (top line) and July 20, 1992 (second line). Elevation 1445 m.

Species	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOLUME l	TOT VOL l	AVG BIO g	TOTAL BIO Kg
COL RAM	163	46±2	59±4	53±4	28±3	46.16	145±22	23570	752±114	122.57
COL RAM	179	41±2	56±4	47±4	26±3	45.96	124±20	22218	645±102	115.54
EPH NEV	5	59±11	133±55	120±51	147±91	7.33	943±601	4716	1320±841	6.60
EPH NEV	7	47±12	103±51	74±44	83±67	5.80	449±360	3143	629±504	4.40
OPU ECH	0									
OPU ECH	3	22±3	10±4	6±1	0.5±0.3	0.01	1.1±0.6	3.2		
ORY HYM	1	1	26	17	3.5	0.03	0.35	0.3	0.38	0.00
ORY HYM	0									
STI SPE	12	2±1	9±3	9±4	0.9±0.6	0.11	0.17±0.16	2.0	0.2±0.2	0.00
STI SPE	0									
DEAD GR	2	38±1	12±5	9±3	0.8±0.6	0.02	3.0±2.0	5.9		
DEAD GR	15	20±7	8±3	6±2	0.5±0.3	0.08	1.20±0.80	17.4		
DEAD SH	4	20±15	83±32	57±24	42±33	1.65	110±128	439.7		
DEAD SH	15	24± 6	41±11	29±10	12± 9	1.84	31±22	457.8		
TOTALS	181					53.6		28288		129
TOTALS	189					51.8		25364		119

Table 27. Population characteristics of perennial plants on plot RED001, a site in Red Rock Valley which burned in July 1988, sampled July 12, 1989 (top line) and July 22, 1992 (second line). Elevation 1612 m.

Species	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOLUME l	TOT VOL l	AVG BIO g	TOTAL BIO Kg
ATR CAN	0									
ATR CAN	2	42±12	10±5	7±1	0.5±0.3	0.01	2.2±2.0	4.4	6±5	0.01
EPH NEV	3	39±12	130±51	85±34	94±61	2.81	400±318	1201	561±445	1.68
EPH NEV	5	46±11	90±29	58± 9	42±15	2.08	205±113	1027	288±158	1.44
ORY HYM	94	12±1	3±0	3±0	0.09±0.03	0.08	0.11±0.04	10.4	0.12±0.05	0.01
ORY HYM	281	16±1	3±0	2±0	0.09±0.03	0.25	0.16±0.05	44.2	0.17±0.05	0.05
PSO POL	1	2	2	1	0.02	0.00	0.00	0.0	0.01	0.00
PSO POL	0									
UNKNOWN	7	25±14	7±5	7±6	0.8±1.1	0.06	4±6	28.4		
UNKNOWN	0									
DEAD GR	-									
DEAD GR	15	2±1	9±3	7±1	0.5±0.2	0.08	0.10±0.08	1.5		
DEAD SH	-									
DEAD SH	36	25±5	36±13	28±12	16±12	5.91	58±47	2098		
TOTALS	98					2.89		1212		1.69
TOTALS	288					2.35		1077		1.50

Table 28. Population characteristics of perennial plants on plot RED002, an unburned site across Pahute Mesa Road from burned plot RED001, sampled July 12, 1989 (top line) and July 21, 1992 (second line).

Species	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOLUME l	TOT VOL l	AVG BIO g	TOTAL BIO Kg
ATR CAN	9	64±13	68±23	53±24	35±24	3.16	280±250	2518	727±649	6.55
ATR CAN	7	52±18	43±30	35±24	20±20	1.42	147±162	1026	381±422	2.67
EPH NEV	3	64±64	122±186	106±170	225±438	6.76	2826±5594	8479	3957±7832	11.87
EPH NEV	3	60±52	126±178	112±170	231±444	6.92	2500±4932	7499	3500±6902	10.50
ORY HYM	6	8±4	7±4	4±2	0.28±0.26	0.02	0.3±0.3	1.9	0.35±0.38	0.00
ORY HYM	40	20±4	3±2	3±1	0.12±0.04	0.05	0.5±0.4	18.0	0.49±0.34	0.02
STI SPE	0									
STI SPE	1	28	4	4	0.13	0.00	0.35	0.4	0.39	0.00
PSO POL	31	62±6	94±16	75±12	66±22	20.44	480±196	14893	1201±492	37.23
PSO POL	32	53±5	91±14	72±12	61±18	19.51	364±140	11652	910±174	29.13
DEAD GR	0									
DEAD GR	9	6±3	13±2	9±2	0.93±0.40	0.08	0.5±0.3	4.5		
DEAD SH	19	46±9	80±22	64±18	54±26	10.24	320±193	6081		
DEAD SH	29	47±9	86±18	77±17	67±26	19.40	417±209	12100		
TOTALS	50					30.4		25892		55.6
TOTALS	83					27.9		20196		42.3

Table 29. Population characteristics of perennial plants on plot PAM001, an undisturbed area on Pahute Mesa. sampled September 9, 1991 (top line) and August 8, 1992 (second line). Elevation 1923 m.

Species	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOLUME l	TOT VOL l	AVG BIO g	TOTAL BIO Kg
ART NOV	197	24±2	37±2	27±2	9.6±1.2	18.92	29±5	5776	73±13	14.44
ART NOV	299	18±2	24±3	19±2	6.7±1.1	19.88	24±5	7206	60±12	18.02
AST PUR	6	3±2	4±2	3±2	0.13±0.13	0.01	0.07±0.11	0.4		
AST PUR	3	2±2	2±1	1±0	0.01±0.01	0.00	0.00±0.00	0.0		
BUNCHGR	33	11±2	1±0	1±0	0.01±0.00	0.00	0.01±0.01	0.5	0.02±0.01	0.00
BUNCHGR	8	11±2	3±1	2±1	0.06±0.03	0.00	0.07±0.05	0.5	0.07±0.05	0.00
CER LAN	1	36	41	37	11.9	0.12	42.9	42.9	137	0.14
CER LAN	0									
CHR VIS	2	21±9	25±20	22±15	5±6	0.10	11±17	22.6	28±43	0.06
CHR VIS	1	40	46	28	10.1	0.10	40.5	40.5	101	0.10
CH VI p	0									
CH VI p	1	20	20	17	2.7	0.03	5.3	5.3		
EPH NEV	40	21+3	12+2	10+2	1.1+0.4	0.45	3.0±1.5	121.3	4.2+2.1	0.17
EPH NEV	34	22+2	14+2	10+2	1.3+0.4	0.45	3.4±1.2	114.2	4.7+1.7	0.16
ERI CAE	1	1	9	8	0.57	0.01	0.06	0.1		
ERI CAE	1	2	9	8	0.57	0.01	0.11	0.1		
ORY HYM	14	18±2	7±2	5±2	0.3±0.2	0.04	0.6±0.5	8.8	0.7±0.5	0.01
ORY HYM	13	20±3	7±2	6±2	0.4±0.3	0.05	0.9±0.6	11.7	1.0±0.6	0.01

Table 30. Table IX, continued.

Species	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOLUME l	TOT VOL l	AVG BIO g	TOTAL BIO Kg
SIT JUB	110	16±1	3±0	2±0	0.07±0.02	0.07	0.12±0.03	12.9	0.13±0.04	0.01
SIT JUB	111	15±1	5±0	4±0	0.20±0.03	0.23	0.33±0.05	36.7	0.36±0.06	0.04
STI COM	2	15±4	4±1	3±1	0.07±0.01	0.00	0.10±0.04	0.2		
STI COM	1	22	5	5	0.20	0.00	0.43	0.4		
STI SPE	0									
STI SPE	12	21±5	9±4	4±1	0.3±0.1	0.03	0.8±0.5	9.2	0.8±0.5	0.01
DEAD GR	26	7±2	5±2	4±2	0.24±0.24	0.03	0.22±0.27	2.7		
DEAD GR	22	5±2	6±1	4±1	0.23±0.11	0.05	0.13±0.09	2.8		
DEAD SH	43	13±2	21±5	14±4	4.0±2.7	1.71	6±4	278		
DEAD SH	25	16±3	28±10	19±6	6.6±4.2	1.66	10±6	263		
TOTALS	406					19.7		5986		14.8
TOTALS	484					20.8		7425		18.3

Table 31. Population characteristics of perennial plants on plot PAM003 an undisturbed area adjacent to drill pad u20ao, sampled August 8, 1989 (top line) and July 23, 1992 (second line). Elevation 1910 m.

Species	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOLUME l	TOT VOL l	AVG BIO g	TOTAL BIO Kg
ART TRI	136	45±3	61±5	47±5	28±5	38.47	163±43	22212	294±78	39.98
ART TRI	126	56±3	65±5	48±5	29±4	36.39	186±34	23476	336±61	42.26
BUNCHGR	28	3±1	5±1	4±1	0.22±0.11	0.06	0.03±0.01	0.8	0.03±0.01	0.00
BUNCHGR	1	3	2	2	0.03	0.00	0.01	0.0	0.01	0.00
CACTUS	0									
CACTUS	1	5	5	5	0.20	0.00	0.10		0.1	
ORY HYM	0									
ORY HYM	1	15	9	7	0.49	0.00	0.74	0.7	0.82	0.00
SIT JUB	1									
SIT JUB	9	24±6	11±15	3±2	0.25±0.27	0.02	0.5±0.6	4.8	0.6±0.6	0.01
STI SPE	1									
STI SPE	4	20±11	4±1	4±1	0.10±0.03	0.00	0.20±0.12	0.8	0.22±0.13	0.00
DEAD GR	110	7±1	7±1	6±1	0.45±0.10	0.49	0.42±0.13	46.5		
DEAD GR	97	5±1	6±0	6±2	0.3±0.1	0.27	0.14±0.05	14.0		
DEAD SH	41	17±6	38±14	28±10	18±11	7.44	69±51	2841		
DEAD SH	136	11±3	21± 5	16± 4	7± 3	9.44	28±17	3772		
TOTALS	168					38.5		22213		40.0
TOTALS	142					36.4		23483		42.3

Table 32. Population characteristics of perennial plants on plot RAM001 sampled August 19-23, 1988 and July 28-29, 1992. Elevation 2263 m. This transect was 2 X 27 m in 1988, 2 X 25 in 1992.

Species	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOLUME l	TOT VOL l	AVG BIO g	TOTAL BIO Kg
ARE CON	5	3±1	8±2	4±0	0.3±0.1	0.01	0.08±0.06	0.4	0.04±0.02	0.00
ARE CON	1	5	10	8	0.63	0.01	0.31	0.3	0.14	0.00
ART NOV	2	28±32	30±17	30±28	8±10	0.16	30± 55	61	76±137	0.15
ART NOV	2	39±53	33±26	33±31	10±15	0.20	58±110	116	145±274	0.29
ART TRI	56	24±4	36±6	30±5	11±4	6.37	40±19	2228	72±35	4.01
ART TRI	52	27±5	35±7	30±7	12±5	6.19	51±26	2649	92±47	4.77
BUNCHGR	15	14±4	3±1	2±1	0.06±0.05	0.01	0.08±0.07	1	0.09±0.08	0.00
BUNCHGR	53	18±2	2±0	2±0	0.04±0.01	0.02	0.07±0.02	4	0.08±0.03	0.00
CHR PAR	13	32± 9	29±14	27±12	10±8	1.25	47±47	607		
CHR PAR	12	27±10	28±13	22±11	8±7	0.94	33±36	398		
COW MEX	16	67±17	106±34	95±33	109±57	17.45	930±518	14883	2325±647	37.21
COW MEX	13	76±13	129±30	104±28	123±57	15.98	1056±570	13729	2640±713	34.32
CRY FLA	8	6±2	7±2	7±2	0.4±0.2	0.03	0.3±0.2	2	0.11±0.08	0.00
CRY FLA	15	6±2	7±3	5±2	0.4±0.3	0.07	0.4±0.3	5	0.15±0.12	0.00
ERI UMB	25	7±1	9±3	8±2	0.8±0.4	0.19	0.7±0.5	17	0.3±0.2	0.01
ERI UMB	14	10±5	12±7	9±4	1.5±1.3	0.21	3.5±3.8	48	1.5±1.6	0.02
FEN UTA	0									
FEN UTA	4	5±1	8±1	6±1	0.4±0.1	0.01	0.2±0.1	1		
HAP NAN	6	26±17	12±5	10±6	1.2±1.2	0.07	5± 8	29	12±19	0.07
HAP NAN	7	25±12	15±8	13±9	1.9±1.7	0.13	8±10	54	19±25	0.14

Table 33. RAM001, continued.

Species	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOLUME l	TOT VOL l	AVG BIO g	TOTAL BIO Kg
LIN NUT	63	12±2	12±2	9±2	1.4±0.5	0.88	3±1	162	6±3	0.41
LIN NUT	110	6±1	5±2	4±1	0.6±0.3	0.64	1.1±0.7	118	3±2	0.29
MIR PUD	1	27	4	2	0.06	0.00	0.17	0.2	0.07	0.00
MIR PUD	0									
OPU ERI	1	6	4	2	0.06	0.00	0.04		0.0	
OPU ERI	3	12±5	20±10	14±11	2.6±2.4	0.08	4±4	11		
ORY HYM	38	15±1	4±1	3±1	0.2±0.1	0.07	0.3±0.2	11	0.3±0.2	0.01
ORY HYM	9	11±4	5±2	4±1	0.2±0.1	0.02	0.3±0.2	2	0.3±0.3	0.00
PEN sp	5	4±1	5±2	4±2	0.2±0.2	0.01	0.09±0.10	0.4	0.04±0.04	0.00
PEN sp	3	5±1	5±2	6±6	0.3±0.4	0.01	0.2±0.2	0.5		
PIN MON	12	41±40	39±38	36±38	41±52	4.91	726±1128	8714	657	9.86
PIN MON	10	96±71	86±59	73±51	102±84	10.19	2302±2374	23020	2661±1214	26.61
POA SAN	131	19±1	3±0	2±0	0.09±0.03	0.12	0.2±0.1	26	0.2±0.1	0.03
POA SAN	50	19±2	6±1	4±1	0.3±0.1	0.13	0.6±0.2	28	0.6±0.3	0.03

Table 34. RAM001, continued.

Species	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOLUME l	TOT VOL l	AVG BIO g	TOTAL BIO Kg
QUE GAM	5	21±6	15±6	14±8	1.9±1.7	0.10	5±5	24	12±12	0.06
QUE GAM	7	24±8	22±9	21±6	4±2	0.28	11±8	80	28±19	0.20
SIT JUB	1	17	1	1	0.01	0.00	0.01	0	0.01	0.00
SIT JUB	5	26±4	8±7	5±3	0.4±0.6	0.02	1.1±1.4	6	1.3±1.5	0.01
STI SPE	18	21±2	5±2	4±2	0.3±0.2	0.05	0.5±0.3	9	0.6±0.4	0.01
STI SPE	19	20±3	7±2	6±2	0.4±0.2	0.08	0.7±0.3	13	0.8±0.3	0.01
STR COR	25	9±3	4±2	3±0	0.08±0.03	0.02	0.08±0.03	2	0.03±0.01	0.00
STR COR	21	15±6	4±1	4±1	0.14±0.07	0.03	0.3±0.2	7	0.1±0.1	0.00
UNKNOWN	1	11	6	8	0.38	0.00	0.41	0		
UNKNOWN	0									
DEAD GR	0									
DEAD GR	3	20±3	5±0	3±1	0.13±0.03	0.00	0.3±0.1	1		
DEAD SH	10	15±10	32±13	29±14	10±8	1.02	24±25	237		
DEAD SH	19	13± 5	26±10	23± 9	8±5	1.48	17±15	320		
TOTALS	447					31.7		26778		53.7
TOTALS	410					35.2		40290		66.7
TOTALS	894					63.4		53555		107.3
TOTALS	820					70.5		80579		137.2

Table 35. RAM001, continued.

Species	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOLUME l	TOT VOL l	AVG BIO g	TOTAL BIO Kg
TOTALS	410					35.23		40289.6		
TOTALS	410					31.70		26777.7		

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