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Greger, P

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STATUS OF THE FLORA AND FAUNA ON THE NEVADA TEST SITE, 1993

Results of Continuing Basic Environmental Monitoring January through December 1993

Compiled By
Richard B. Hunter

September 1994

Work Performed Under Contract No. DE-AC08-94NV11432

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

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EXECUTIVE SUMMARY

The following reports provide the results of monitoring of plants and animals on the Nevada Test Site during calendar year 1993. Monitoring was accomplished under the Department of Energy's Basic Environmental Compliance and Monitoring Program, initiated in 1987. The program looks at both baseline study areas, chosen to represent undisturbed conditions as much as possible, and areas disturbed by Department of Energy (DOE) activities or natural phenomena. DOE disturbances studied include areas blasted by above-ground nuclear tests before 1962, subsidence craters created by underground nuclear tests, road maintenance activities, areas cleared for drilling, and influences of man-made water sources. Natural phenomena studied include recovery from range fires, effects of introduced species, damage to plants by insect outbreaks, and effects of weather fluctuations. In 1993 disturbances examined included several burned areas and roadsides, a drill pad on Pahute Mesa, introduced grasses and shrub removal effects on ephemeral plants, and effects on pine trees of an infestation of pinyon needle scale insects.

Winter rainfall was high in 1993, with more than 200 mm falling between December 1992 and March 1993. Densities of ephemeral plants were high compared to 1992 in most valleys, but about equal to 1992 on the Mesas. Biomass produced was approximately equal to that of 1992, another high-rainfall winter. Ephemeral populations on burned areas and roadsides were similar to control populations. A study of roadsides failed to show any

Lizard numbers were high in 1993, appropriate for the second successive year of good rainfall. Areas with reduced shrub cover, such as burned areas and roadsides, had reduced lizard populations. Lizards were associated with the sparser but larger shrubs along roadsides.

Summer densities of rodents were high in 1993, and diversity was good. Little pocket mouse (*Perognathus longimembris*) numbers continued a decline begun after the 1989-1990 drought. Great Basin kangaroo rat (*Dipodomys microps*) numbers increased to make it the most abundant rodent in 1993. At higher altitudes deer mice (*Peromyscus maniculatus*) were particularly abundant.

Roughly 25 percent of deer mice trapped on Pahute and Rainier Mesas carried a hantavirus which caused a number of human fatalities in the Southwestern United States in 1993.

Among most mobile species, horse numbers declined from 65 to 62 adults, and foal mortality continued at a high rate. Six of eleven foals were known dead by December, and the other five were of uncertain status. Mule deer sighting rates were unchanged from 1992. Raven and raptor reproduction was good in 1993, with many sightings of hatchling-year birds. Two Swainson's hawks were

REPTILE POPULATIONS ON THE NEVADA TEST SITE IN 1993

by

Bruce Woodward

ACKNOWLEDGEMENTS

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ABSTRACT

Lizard populations were studied in relatively undisturbed baseline areas and disturbed study areas in 1993. This was a relatively wet year, and lizard numbers appeared high relative to historical norms. Correlations between number of side-blotched lizards and year of study were nonsignificant on undisturbed baseline areas, implying lizards have not been undergoing a long term decline on the Nevada Test Site. Inspection of the data suggests the nonsignificance of the relationship is an outcome of small sample sizes (few years of study) and large yearly fluctuations, and implies the overall trend is towards an increase in side-blotched lizard numbers at most study areas. Ancillary evidence suggests the fluctuations are likely a response to rainfall levels over the years of monitoring.

Study of disturbed areas and their associated controls revealed a different pattern. Areas disturbed by fire, roadside grading, or grading and other construction associated activities, all contained reduced lizard populations relative to nearby undisturbed areas. These effects appear to be the major consequence of DOE activities on lizards at the Nevada Test Site.

INTRODUCTION

Reptiles are a diverse group with approximately six thousand species worldwide. Southwestern U.S. deserts contain around 50 species, mostly snakes. Snakes are typically nocturnal and secretive and thus seldom seen (Pianka 1986). Lizards, on the other hand, are primarily diurnal, occur at high densities, and can be approached to within a few meters, making them relatively easy to study. In the Mojave and Great Basin deserts, 6 to 10 lizard species may be commonly encountered with *Uta stansburiana* (side-blotched lizards, or Uta) and *Cnemidophorous tigris* (western whiptails) typically the most abundant species (Bury 1982, Pianka 1986). Reptile physiology is well suited for desert life, both because of mechanisms to deal with desiccation or heat overload, and because of their ectothermic nature. As ectotherms, reptiles have lower energy demands relative to endotherms and are able to maintain large populations in desert systems in spite of large fluctuations in available resources (Pough 1980, Dunham 1980, Vitt 1991). Lizards are closely associated with vegetation, probably because plants offer refuge from predators and extreme temperatures, and support insects-their primary prey base. As a consequence, factors that influence vegetation commonly affect lizards (Dunham 1980, Pianka 1986).

Reptile studies on the Nevada Test Site (NTS) are largely restricted to lizards and the desert tortoise (*Gopherus agasizzi*), a federally listed species (Woodward 1994). The Basic Environmental Compliance and Monitoring Program (BECAMP) performs two types of studies. Long-term population trends

The following techniques were employed during all lizard transect studies unless otherwise noted below. On each transect three investigators walked abreast and recorded number of lizards seen per species per 50 m of 15 m wide transect (see Hunter and Medica 1989). Ten to 25 transect sections were examined at each location. Surveys were performed during the morning over temperature ranges favorable to the focal species. Counts/50 m were recorded for each species, and number of species and the total number of individual lizards seen per 50 m were calculated. Analysis of variance tests were performed to examine variation in these parameters across days, treatments, or years. On alternate days investigators started from opposite ends of transects in order to sample each transect both early and late during the sample period. In 1993, on any given day all transects in an area were walked and then the first transect sampled again. A one way ANOVA was used to contrast counts for the first transect examined each day in 1993 with its repeat collected later that day. This analysis allowed us to ask if lizard activity changed over the sampling period. Finally, a runs test was performed to determine if uta counts or total lizard counts (pooled across species) changed over each day of the sampling period. Nonparametric analyses were used when parametric assumptions could not be met.

Plots were studied via a mark-recapture program as discussed in Hunter and Medica (1989). Our plots are relatively small and thus contain few individuals of most species (whiptails, zebra-tails, horned lizards, leopard lizards). Side-blotched lizards have low vagilities and occur at high densities, and thus are well suited to plot studies. Lizards were marked short-term with paint and long term via toe clipping. A sizeable sampling effort (usually four or five days with three to five people) was spent at each study site (single or multiple plots). Investigators started from opposite ends of the plot(s) on alternate days so each area was sampled both early and late in the morning.

A mark-recapture estimation program (Seber 1982) was used to generate a mean ± 2 standard error estimate for lizard densities. Simulation studies (Menkens and Anderson 1988) suggest standard errors or confidence intervals for these estimators may be underestimates (too narrow). The mean estimate does appear to be quite close to the actual mean value in simulation studies. We take a conservative approach to data analysis, by reporting $\overline{x} \pm 2$ se, urging caution when interpreting the estimate of variation, and using mean values in analyses. We used estimated mean densities to test for correlations between year of sample and lizard density. This approach allowed us to test for

BASELINE STUDIES

Baseline studies were conducted in largely undisturbed areas, and were monitored for long term changes in lizard populations. The baseline lizard plots were 105 x 105 m (1.10 ha) and were walked twice each morning. Different people walked each area during the first and second passes. In 1993, baseline study areas were examined in Yucca Flat, Jackass Flats, Rainier Mesa, and Pahute Mesa.

Yucca Flat Study Area (YUF001)

Lizard transects were walked in 1989, 1992, and 1993. In each year, five 500 m transects were examined. Transects were walked for at least three days in each year. For this analysis, data were used from the first three survey days in each year. Lizard counts were compared across years and across days within years with a two-way ANOVA. The analysis across days within years allows examination of the repeatability of the sampling approach.

Plot sampling was performed for five days in spring from 14 to 22 April, and

Pahute Mesa (PAM001)

This plot was sampled for five days in summer from 30 August to 2 September.

DISTURBANCES

A burn and its associated control were studied in Yucca Flat near Mine Mountain Road, as were a roadside area and its control in Frenchman Flat. The burn and the nearby unburned area were studied to assess effects of a fire on the lizard fauna. The roadside and control area on Frenchman Flat were studied to examine effects of a road on lizards. A series of lizard studies were also performed in 1993 at the Device Assembly Facility (DAF) on Frenchman Flat. These studies are described in detail in the 1993 DAF report (Woodward et al. in press), and are merely summarized in this report. The DAF lizard studies were designed to assess effects of the main access road, examine effects of a drainage ditch, and look for broad patterns in species abundances and distributions in the general DAF area.

Yucca Flat Burn Area (YUF002) and Control (YUF003)

Lizard transects were walked in 1990 and on three successive days from 8 to 10 June 1993. Four transects crossed burned and unburned areas in which YUF002 and YUF003 are located. Four hundred meters of each line was in the burn, 100 m in an ecotonal area, and 400 m in the unburned area. Counts per species, total number of species, and total number of lizards were recorded per 50 m of transect in each habitat type, and compared with a two way ANOVA, with location and day as factors. Juvenile or adult status was also recorded and the relative ratio of these two age classes was compared across the three treatments with a chi square test.

Two (75 x 75 m) plots, one in the burned area, the other in a nearby unburned control area were searched twice each morning from 23 to 27 April and from 23 to 26 August. A chi square test was performed to test for differences in lizard densities across years and burn regimes.

Frenchman Flat Roadside (FRF003) and Control (FRF004)

Lizard transects were sampled along the control and roadside mammal lines on Frenchman Flat near the 5-05 road on four mornings from 6 to 12 July 1993. Each line was 1250 m long and consisted of twenty-five 50 m sections. Alternate mornings alternate transects were walked first. The roadside transect was parallel to the road and ran from approximately 12.5 to 27.5 m from the center of the road. Data collected were the same as for the other transects. Data analyses consisted of two way ANOVAs contrasting counts across treatments, or order treatments were searched (control first, or roadside first).

Ten (20 x 40 m) plots were arranged along the roadside on the 5-05 road with an additional 10 plots located 500 to 900 m away in an undisturbed control area. Roadside plots began at the center of the road, ran 20 m away from the center, with the 40 m axis running parallel to it. Because of the small size of plots, few individuals were seen per plot, and mark-recapture estimation was impossible to use. The total number of individual lizards seen per plot over the five day sample period, or the mean number seen per day were used as estimates of density. These numbers were compared across treatments with two way ANOVA's, with treatment and date as the two factors. Mean weight, mean snout-vent length (SVL), and the population proportion that was female were also computed per plot for uta and compared across treatments with analysis of variance tests. The female proportion of the population (the sex ratio) was arc sine transformed to facilitate parametric comparisons. Lizards were assigned to cohorts (this year's young = year 0, last year's young = year 1, young born prior to last year = year 2) based on relationships between SVL and age established on individuals of known ages in this area. A chi square test was used to compare the frequency of individuals in each cohort, to determine if the age structure differed across treatments. Number of recaptures from spring to summer surveys was compared between roadside and control areas with a chi square test to determine whether survival or dispersal off plot differs between these two areas.

Device Assembly Facility (DAF) Studies

Methods for DAF lizard studies are given in detail in the 1993 DAF report (Woodward et al. in press). Effects of the DAF access road on lizards were assessed by examining lizards in ten (800 m^2) plots along the road and ten (800 m^2) plots in a nearby control area in the spring and summer, and walking transects in the same area in the summer. Effects of a graded diversion ditch around the DAF buildings were examined in spring and summer by comparing lizard numbers in six (1000 m^2) plots in the ditch to six (1000 m^2) plots in undisturbed arroyo bottoms and six (1000 m^2) plots in undisturbed flat areas. Finally, a series of timed surveys (Campbell and Christman 1982) was performed in the disturbed area around the DAF, and in undisturbed areas around it to assess consequences of the disturbances and look for clinal patterns of lizard abundances in undisturbed areas.

Tortoise Studies

Desert tortoise work consisted of surveying tortoises in three 341 m diameter (9 ha) enclosures in Rock Valley, and opportunistic sightings of free-roaming tortoises. The Rock Valley enclosures were searched for 15.5 man hours on three days in the spring, and 23 hours in the autumn over four days. Captured tortoises were measured to assess growth (Hunter and Medica 1989), and increase in plastron length was compared between males and females with a one way ANOVA.

RESULTS

Yucca Flat Studies (YUF001)

Transect Studies

There was a highly significant difference in number of *Cnemidophorus* (whiptails) seen per 50 m of transect across years ($F_{2,445}$ = 60.7, P < 0.0001). Whiptails were approximately four times as abundant in 1992 ($\bar{x} \pm 2$ se, numbers expressed on a per hectare basis: 23.3 ± 2.8/ha) or 1993 (26.2 ± 3.1/ha) as they were in 1989 (6.91 ± 1.9/ha). There were significantly more *Gambelia* (leopard lizards) seen in 1993 (1.33 ± 0.8/ha) relative to 1992 (0.26 ± 0.3/ha), or 1989 (0.00 ± 0.00/ha, $F_{2,445}$ = 9.2, P = 0.00012). In contrast, *Uta* (side-blotched lizard) numbers in 1993 (2.53 ± 0.9/ha) and 1992 (0.98 ± 0.7/ha) were considerably lower than in 1989 (8.6 ± 2.0/ha, $F_{2,445}$ = 35,9, P < 0.0001). Numbers of *Phrynosoma* (horned lizards) or *Callisaurus* (zebra-tailed lizards) were too low in 1989, 1992, and 1993 to analyze. The average number of lizard species seen per 50 m differed across years ($F_{2,445}$ = 10.5, P < 0.0001) with 1993 (1.1 ± 0.11/ha) greater than in 1989 (0.8 ± 0.12/ha) but not differing from 1992 (1.0 ± 0.08/ha). The total number of lizards seen per 50 m of transect also varied across years ($F_{2,445}$ = 22.9, P < 0.0001). 1993 (30.4 ± 8.3/ha) appeared to be a good year for lizards relative to 1992 (25.0 ± 2.9/ha) and especially compared to 1989 (16.1 ± 2.7/ha). In contrast, counts rarely differed across days within a year. Uta counts differed across days ($F_{2,445}$ = 7.7, P = 0.00052, Day 1, 5.0 ± 1.6; Day 2, 5.2 ± 1.8; Day 3, 1.9 ± 0.8). Number of species seen also differed across days ($F_{2,445}$ = 3.23, P = 0.04, Day 1, 1.1 ± 0.1; Day 2, 0.9 ± 0.1; Day 3, 0.8 ± 0.1). Runs tests were nonsignificant for number of uta seen per 50 m of transect on all three days in 1993 (day 1 z = 0.7735, P = 0.4412; day 2 z = 1.0032, P = 0.3174; day 3 z = 1.2386, P = 0.2150). In a similar manner runs tests for total number of lizards (pooled across all species) were also nonsignificant on all three days (day 1 z = 0.6334, P = 0.5286; day 2 z = 0.5829, P = 0.5620; day 3 z = 0.5959, P = 0.5486).

Plot Studies

Number of side-blotched lizards present on this baseline plot has changed greatly over the last several years (Tables 1,2, Figures 1 - 4). However, correlations between year of study and estimates of number of hatchlings, number of adults, or number of hatchlings and number of adults were not significant (Figures 1 - 4) implying no consistent long term change in uta numbers over the last seven years. Annual rainfall also was not significantly correlated with number of hatchling plus number of adult side-blotched lizards present in the summer ($r = 0.525$, 5 d.f., $P = 0.285$, Figure 5).

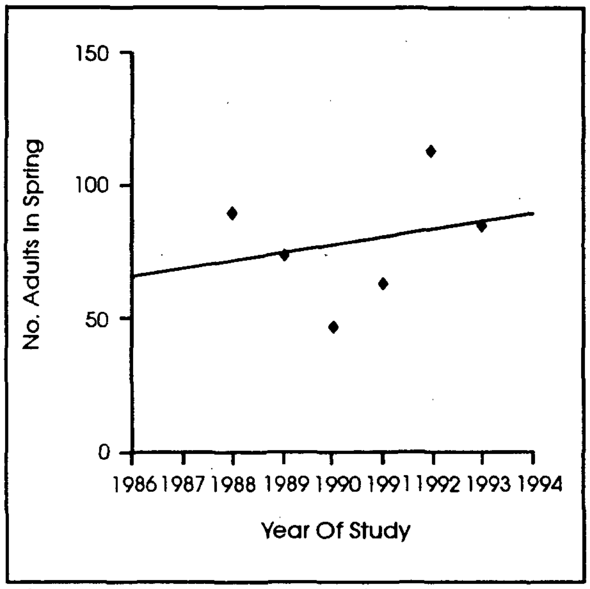

Figure 1 - Relationship between adult side-blotched lizard density estimate in spring and year of study on Yucca Flat. Year 1 = 1988.

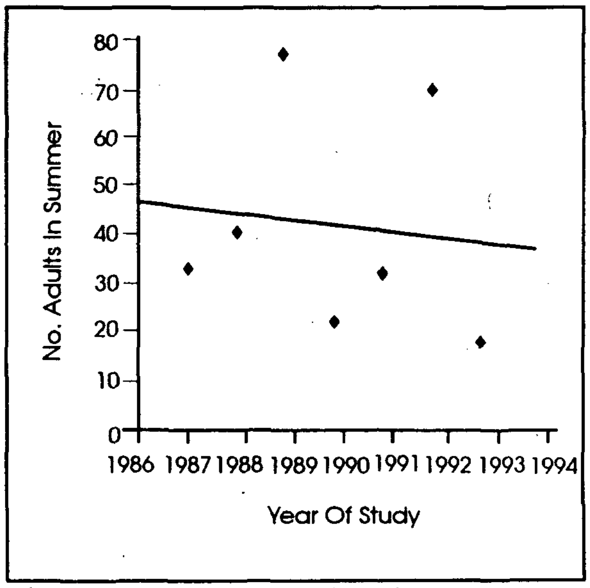

Figure 2 - Relationship between adult side-blotched lizard density estimate in summer and year of study on Yucca Flat. Year 1 = 1987.

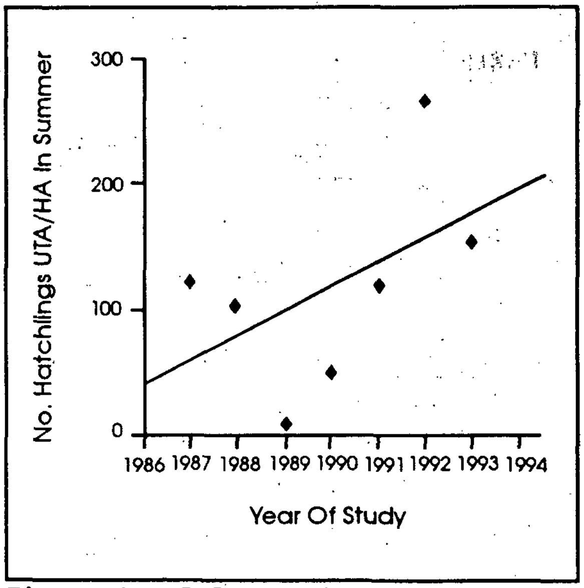

Figure 3 - Relationship between hatchling side-blotched lizard density estimate in summer and year of study on Yucca Flat. Year 1 = 1987.

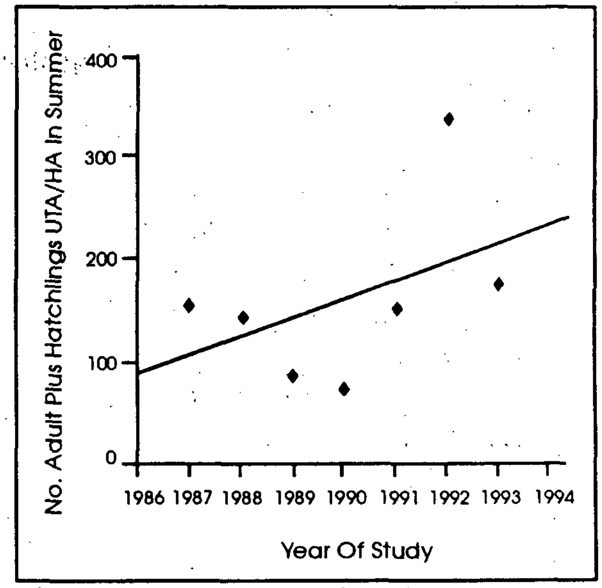

Figure 4 - Relationship between adult plus hatchling side-blotched lizard density estimate in summer and year of study on Yucca Flat. Year 1 = 1987.

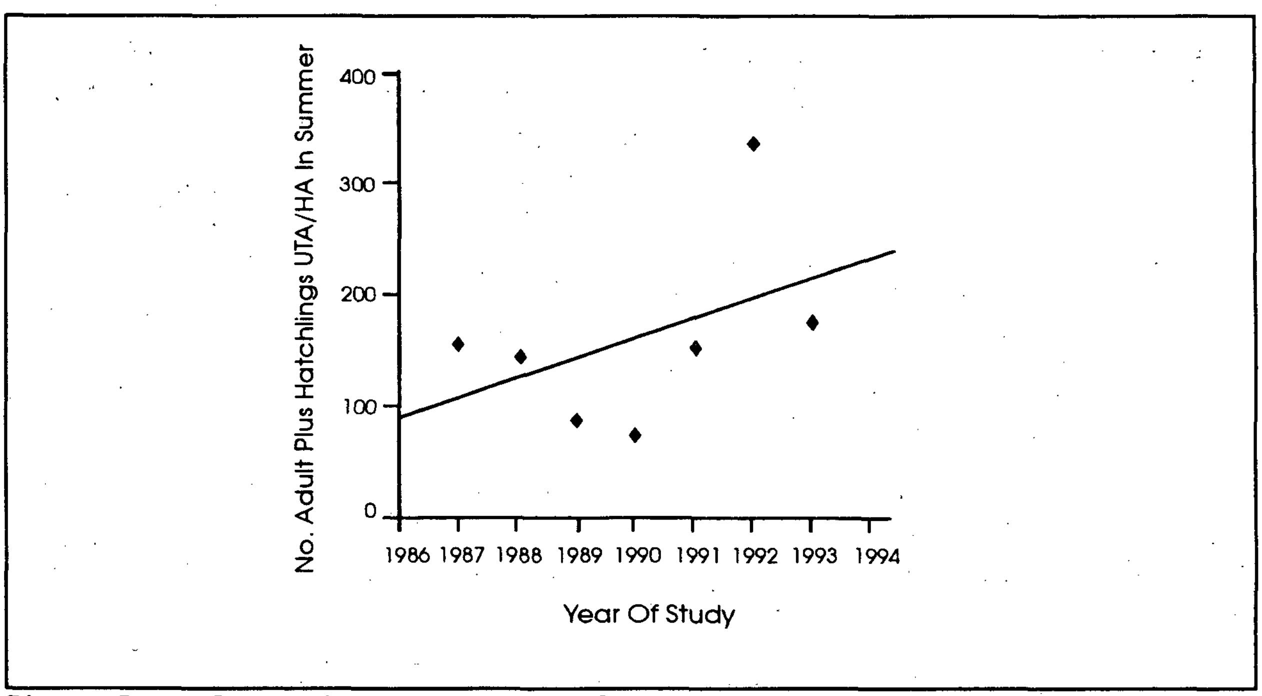

Figure 5 - Relationship between annual precipitation and estimated side-blotched lizard densities on Yucca Flat.

Table 1. Estimated spring densities (n/ha ± 2 se = standard error of the mean), and number of distinct uta captured on the YUF001 baseline plot on Yucca Flat.

	Adults				Hatchlings			
Year	Male	Female	Total	Density	Male	Female	Total	Density
1988	40	50	90	91 ± 10	--	--	--	--
1989	34	40	74	75 ± 10	--	--	--	--
1990	17	32	49	48 ± 6	--	--	--	--
1991	33	33	66	64 ± 6	--	--	--	--
1992	60	55	115	114 ± 9	--	--	--	--
1993	36	46	82	85 ± 11	--	--	--	--

Table 2. Estimated summer densities (n/ha ± 2 se = standard error of the mean), and number of distinct uta captured on the YUF001 baseline plot on Yucca Flat.

	Adults				Hatchlings			
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
1993	8	11	19	18 ± 3	74	63	137	154 ± 23

Jackass Flats (JAF001)

Transect Studies

Number of whiptails seen increased between 1990 (8.9 ± 0.8/ha, $\bar{x}$ ± 2 se) and 1993 (14.3 ± 1.3/ha, $F_{1,296}$ = 12.3, P < 0.001). Too few leopard lizards were seen to merit analysis. Side-blotched lizards were less common in 1990 (0.27 ± 0.13/ha) relative to 1993 (1.69 ± 0.80/ha, $F_{1,296}$ = 9.9, P = 0.002). Fewer lizard species were seen in 1990 (0.54 ± 0.08/50 m of transect) relative to 1993 (0.82 ± 0.10/50 m, $F_{1,296}$ = 17.6, P < 0.00001). None of the test parameters differed across days. Finally, number of individual lizards seen differed between 1990 (9.2 ± 1.6/ha) and 1993 (17.2 ± 2.7/ha, $F_{1,296}$ = 24.2, P < 0.0001). Runs tests were nonsignificant for number of Uta seen per 50 m of transect on all three days in 1993 (day 1 z = 0.65, P = 0.5156; day 2 z = 1.797, P = 0.073; day 3 z = 1.00, P = 0.1587). In a similar manner, runs tests for total number of lizards (pooled across species) were also nonsignificant on all three days (day 1 z = 0.766, P = 0.4412; day 2 z = 0.0124, P = 0.9920; day 3 z = 0.8298, P = 0.4066).

Plot Studies

Adult uta densities in spring 1993 were approximately twice those seen on this plot in spring 1990, although still much lower than the original spring estimate from 1988 (Table 3). Few adult side-blotched lizards remained by summer although many hatchlings were seen (Table 4). No estimate was possible for adult side-blotched lizards in summer so we used total number caught as the population estimate.

Correlations for summer data sets, between time since beginning of the study and number of adults (individuals born last year or earlier, r = -0.827, 2 d.f., P > 0.05), or number of hatchlings (individuals born this year, r = -0.368, 2 d.f., P > 0.05), or number of adults plus number of hatchlings (r = 0.271, 2 d.f., P > 0.50, Figure 6) were nonsignificant.

Table 3. Estimated spring densities (n/ha ± 2 se), and numbers of distinct uta captured on the JAF001 baseline plot on Jackass Flats.

	Adults				Hatchlings			
Year	Male	Female	Total	Density	Male	Female	Total	Density
1988	40	51	91	97 ± 15	-	-	-	-
1990	12	14	26	26 ± 5	-	-	-	-
1993	24	22	46	46 ± 7	-	-	-	-

Table 4. Estimated summer densities (n/ha ± 2 se), and numbers of distinct uta captured on the JAF001 baseline plot on Jackass Flats.

	Adults				Hatchlings			
Year	Male	Female	Total	Density	Male	Female	Total	Density
1987	7	4	11	19 ± 19	20	26	46	50 ± 12
1988	7	4	11	21 ± 18	25	30	55	135 ± 81
1990	2	4	6	6 ± 2	0	0	0	0
1993	5	2	7	---	48	56	104	154 ± 43

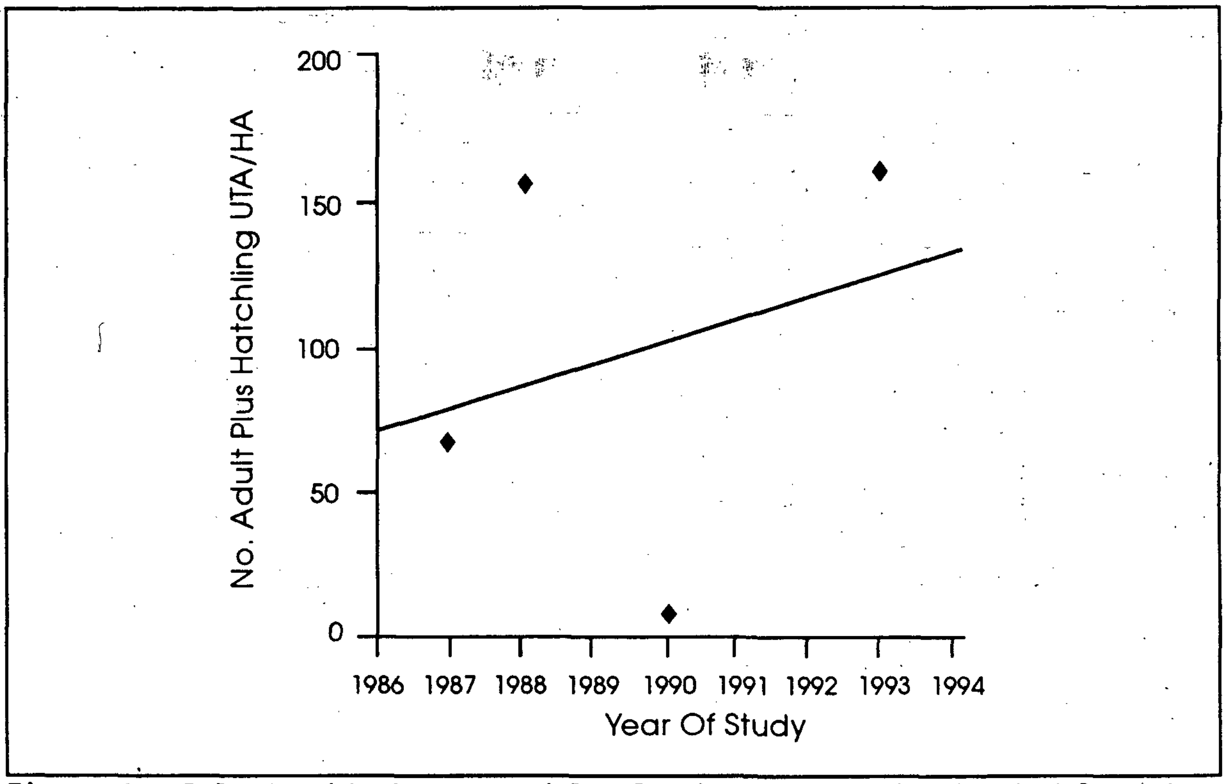

Figure 6 - Relationship between adult plus hatchling side-blotched lizard density estimate in summer and year of study on Jackass Flat.

RAM001 Plot

The Rainier Mesa plot (RAM001) was searched for lizards for the first time by BECAMP in 1993. The lizard fauna is quite different from lowland sites, in that *Sceloporus occidentalis* (western fence lizard) is the most abundant lizard, followed by side-blotched lizards, then *Eumeces skiltonianus* (western skink). No other lizard species were seen. Western fence lizards were present at densities of 13.6 ± 6.3/ha for adults and 7.0 ± 2.1 for prereproductive juveniles. Adult side-blotched lizards were present at densities of 14.3 ± 2.0/ha for adults. It was too early for hatchling uta to be present when samples were collected.

PAM001 Plot

The Pahute Mesa plot was searched for the sixth consecutive year during the summer. Significant correlations were lacking between year of study and estimated number of hatchlings/ha (r = -0.263, 4 d.f., P > 0.669) or estimated number of adults/ha ($r = -0.202$, 4 d.f., $P > 0.745$), or estimated number of adults plus hatchlings/ha ($r = -0.659$, 4 d.f., $p = 0.226$, Table 5, Figure 7) suggesting no overall long term trend.

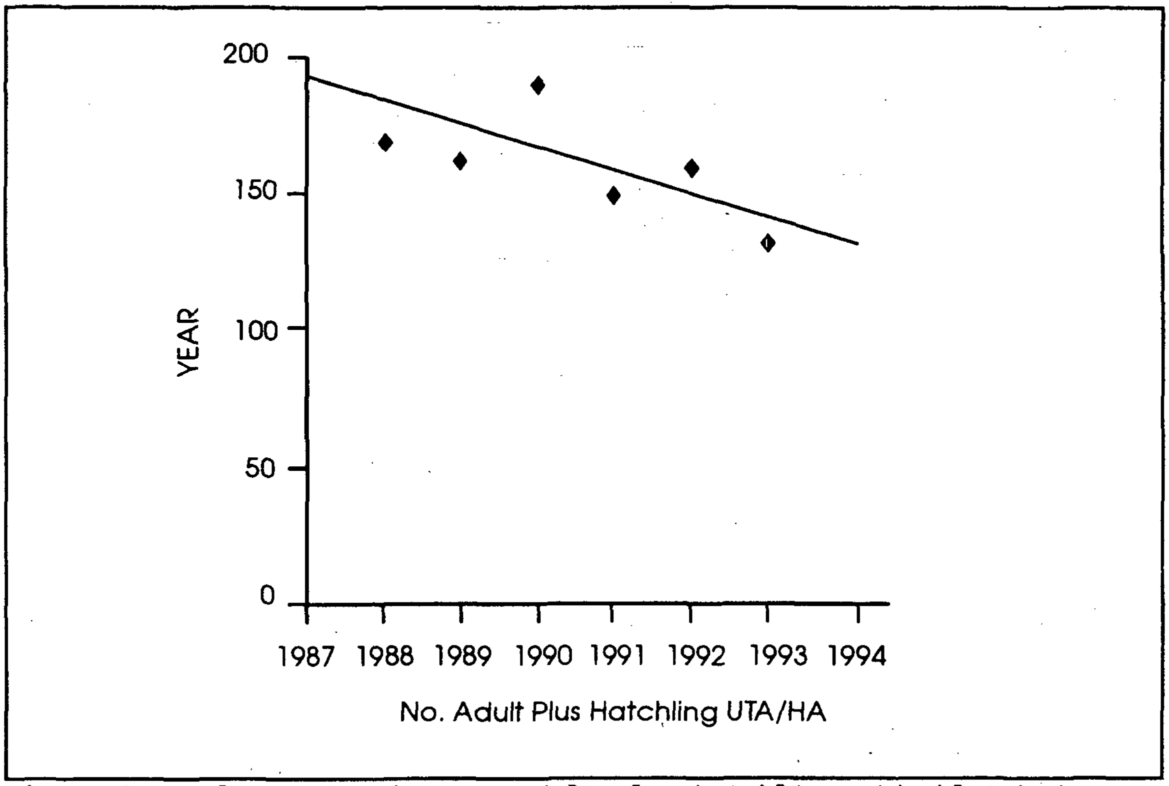

Figure 7 - Relationship between adult plus hatchling side-blotched lizard density estimate in summer and year of study on Pahute Mesa.

Table 5. Estimated summer densities (n/ha ± 2 se), and number of distinct uta captured on the PAM001 baseline plot on Pahute Mesa.

	Adults				Hatchlings			
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	19	34	38 ± 9	60	37	97	122 ± 27
1993	17	19	36	36 ± 7	37	39	76	96 ± 24

DISTURBANCES

Yucca Flat Burn (YUF002) and Control (YUF003)

Transect Studies

Whiptails and side-blotched lizards were abundant enough for analysis, horned lizards, leopard lizards, zebra-tailed lizards, *Crotalus* (Panamint rattlesnake), and *Masticophis* (red racer) were also seen, but too infrequently to merit analysis as separate species. The lizards were added to the total number of lizard individuals, and number of lizard species for analysis. Whiptail abundances differed across treatments ($F_{2,213} = 5.5$, $P < 0.005$), with the ecotone containing more lizards (28.3 ± 7.2/ha) relative to the unburned area (15.2 ± 3.0/ha), and as many as the burned area (18.2 ± 4.0/ha). Uta observations did not differ across the three treatments ($F_{2,213} = 1.62$, $P = 0.20$, ecotone 6.7 ± 3.2/ha, burn 4.2 ± 1.8/ha, unburned area 6.7 ± 3.2/ha). Number of lizard species differed across treatments ($F_{2,213} = 8.3$, $P = 0.00038$) with the ecotone (1.5 ± 0.3/50 m) containing more species than either the burned area (0.9 ± 0.1/50m), or the unburned area (1.1 ± 0.1/50 m). Number of individual lizards also differed across treatments ($F_{2,213} = 6.48$, $P = 0.002$) with the ecotone (38.3 ± 7.7/ha) containing more lizards relative to the burned (23.3 ± 4.6/ha), or unburned area (22.6 ± 3.5/ha). The two way ANOVA revealed similar patterns for all traits examined across treatments, and no differences across days. The proportion of juvenile whiptails did not differ across treatments ($X^2 = 0.13$, 2 d.f., $P > 0.937$) with juveniles accounting for approximately 13 percent of the population in all three treatments.

Plot Studies

The burn and associated control plots on Yucca Flat were examined in 1987, 1988, 1990, and 1993. Across this time period the unburned control area has contained more side-blotched lizards than the burned area (Tables 6 - 9). The burned area contained fewer adult uta in spring surveys relative to control areas ($X^2 = 19.11$, 2. d.f., $P < 0.001$, Tables 6 - 9). There were too few adult uta captured on the burned plot in the summer to meet the requirements of chi square analysis. There were fewer hatchling uta in summer on the burned area relative to its control ($X^2 = 29.15$, 3 d.f., $P < 0.001$, Tables 6 - 9). Similarly, number of hatchlings plus number of adult uta present in the summer was lower in the burned area relative to its control ($X^2 = 35.32$, 3 d.f., $P < 0.001$, Tables 6 - 9, Figure 8).

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Table 6. Estimated spring densities (n/ha ± 2 se), and numbers of distinct uta captured on the YUF002 burn plot on Yucca Flat.

	Adults				Hatchlings			
Year	Male	Female	Total	Density	Male	Female	Total	Density
1988	10	18	28	54 ± 7	-	-	-	-
1990	2	9	11	21 ± 3	-	-	-	-
1993	12	12	24	43 ± 0	-	-	-	-

Table 7. Estimated summer densities (n/ha ± 2 se), and numbers of distinct uta captured on the YUF002

Table 8. Estimated spring densities (n/ha ± 2 se), and numbers of distinct uta captured on the YUF003 unburned control plot on Yucca Flat.

	Adults				Hatchlings			
Year	Male	Female	Total	Density	Male	Female	Total	Density
1988	9	22	31	59 ± 9	-	-	-	-
1990	16	22	38	71 ± 9	-	-	-	-
1993	24	39	63	121 ± 13	-	-	-	-

Table 9. Estimated summer densities (n/ha ± 2 se), and numbers of distinct uta captured on the YUF003 unburned control plot on Yucca Flat.

	Adults				Hatchlings			
Year	Male	Female	Total	Density	Male	Female	Total	Density
1987	3	2	5	10 ± 4	19	14	33	75 ± 23
1988	2	9	11	30 ± 18	38	21	59	216 ± 98
1990	6	12	18	43 ± 14	20	16	36	129 ± 70
1993	4	11	15	50 ± 35	62	52	114	265 ± 45

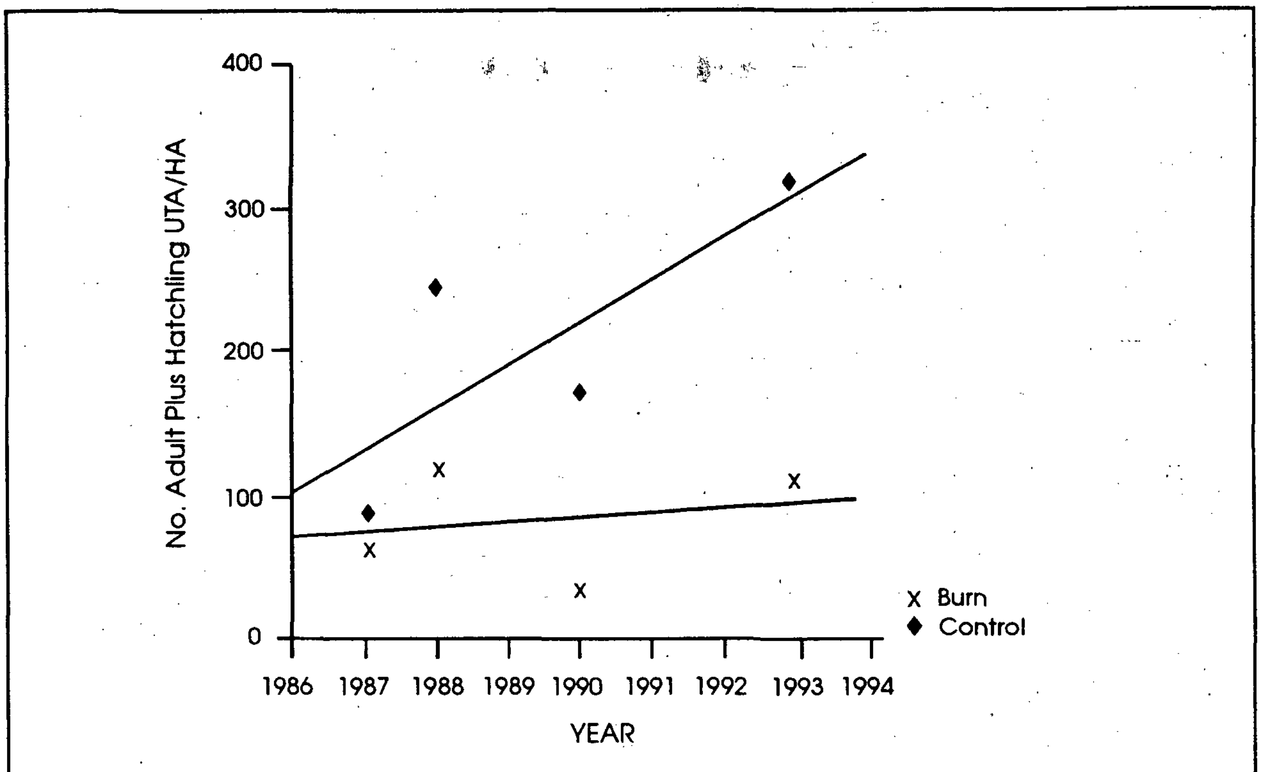

Figure 8 - Estimated number of hatchling plus adult side-blotched lizards/ha in a burned or unburned control area on Yucca Flat from 1987 to 1993.

Frenchman Flat Roadside (FRF003) and Control (FRF004)

<u>Transect Studies</u>

Number of side-blotched lizards, number of individual lizards seen, and number of lizard species seen were all greater on the roadside relative to the

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Table 10. Number of lizards/unit area on transects in the Frenchman Flat roadside and control areas. There are 1, 197 d.f., in all statistical comparisons. Statistics are for comparisons across treatments. R = roadside, C = control.

Comparison	Mean/ha	± 2 se/ha	Median/50m	Range/50m	F	P
Uta	R - 12.4 C - 1.9	2.6 1.3	1.0 0.0	0 - 4 0 - 2	73.9	< 0.0001
Cnemidoph -orous	R - 2.8 C - 3.5	1.3 1.3	0.0 0.0	0 - 2 0 - 2	0.50	0.48
Callisaurus	R - 0.4 C - 1.6	0.5 1.0	0.0 0.0	0 - 1 0 - 2	23.1	< 0.0001
All lizards	R - 15.9 C - 7.9	2.7 2.0	1.0 0.0	0 - 5 0 - 3	4.12	0.041
No. species	R - 0.86 C - 0.59	0.12 0.13	1.0 0.0	0 - 2 0 - 3	19.03	0.0001

Plot Studies

Average number of side-blotched lizards using plots each day was similar along the road (4.8 ± 1.9/ha) and the control area in spring (7.8 ± 4.5/ha, t = 1.29, 18 d.f., P = 0.213, Figure 9). Estimates of number of individuals using the plots over the five day sampling period also did not differ between the roadside (1.3 ± 0.4/plot) and the control areas (2.3 ± 0.4/plot, t = 1.79, 18 d.f., P = 0.0903). Snout-vent lengths of uta did not differ between roadside (47.2 ± 1.6 mm) and control areas (47.2 ± 0.8 mm, $F_{1,15}$ = 0.0, P = 0.99). Similarly, weight also did not differ between the roadside (3.30 ± 0.32 g) and control areas (3.05 ± 0.13 g, $F_{1,15}$ = 2.77, P = 0.117). Cohort composition (age classes) did not differ between roadside (1.7 ± 0.5) and control areas (1.4 ± 0.2, $F_{1,15}$ = 1.21, P = 0.289). The proportion of males and females in the population differed between roadside (30.8% female) and control areas (69.6% female, X^2 = 4.99, 1 d.f., P = 0.0255).

A closer look at uta distributions in spring reveals that only one lizard was seen in the area from 0 to 10 m from the center of the road. Average number of uta present per day differed across treatments with the area from 0 to 10 m from the road center containing only 0.5 ± 0.1/ha, considerably fewer than was present from 10 to 20 m from road center 7.5 ± 0.5/ha, or the control area 7.8 ± 0.2/ha, ($F_{2,27}$ = 4.29, P = 0.024, Figure 10). Number of individual side-blotched lizards using a plot over five sample days also was reduced near the road relative to the other two areas (0 - 10 m area 0.2 ± 0.4/plot, 10 - 20 m area 2.4 ± 1.7/plot, control 2.3 ± 0.8/plot, $F_{2,27}$ = 5.20, P = 0.012).

Average number of side-blotched lizards was similar along the road (14.8 ± 2.0/ha) and the undisturbed control area in the summer (15.1 ± 2.0/ha, t = 0.13, 18 d.f, P = 0.89, Figure 9). Number of individual uta using plots over the five day sample period also did not differ between the roadside (3.6 ± 0.7/plot) and control areas (4.6 ± 1.3/plot,18 d.f., t = 1.31, P = 0.21). In a similar manner, average SVL per plot did not differ between roadside (30.5 ± 2.0 mm) and control areas (33.4 ± 3.8 mm, t = 1.35, 18 d.f., P = 0.19). Mean weight did not differ between roadside (0.94 ± 0.2 g) and control plots (1.31 ± 0.48 g, t = 1.44, 18 d.f., P = 0.18). Finally, cohort distributions (ages) did not differ between roadside (0.03 ± 0.06) and control areas (0.18 ± 0.20, t = 1.40, 18 d.f., P = 0.178).

more in the berm area (29.0 ± 8.1/ha) and the control area (15.1 ± 2.0/ha, $F_{2,27}$ = 27.6, P < 0.0001, Figure 10). Number of individual uta seen per plot

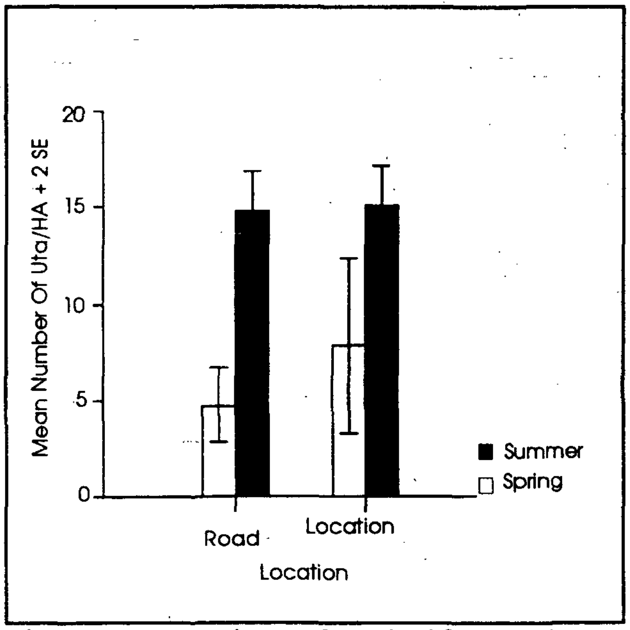

Figure 9 - Number of side-blotched lizards present in roadside and control areas along the 5-05 road in Frenchman Flat.

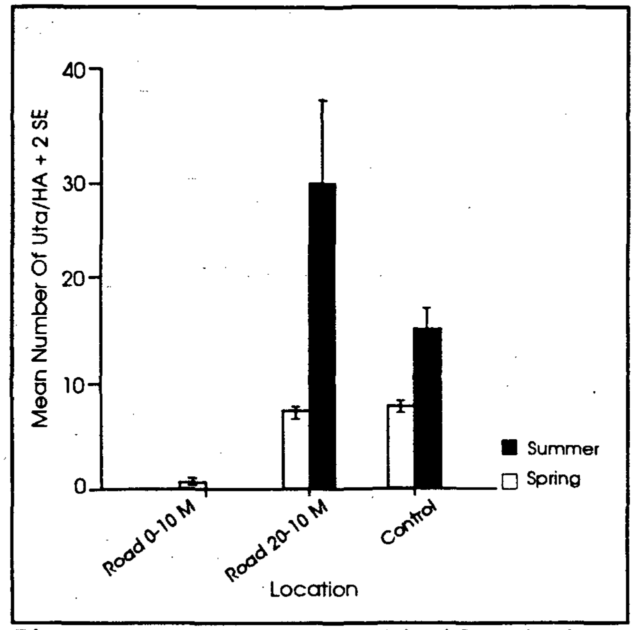

Figure 10 - Number of side-blotched lizards present from 0 - 10 m, 10 - 20 m from road center, or a control area along the 5-05 road in Frenchman Flat.

over five days also differed across these areas (roadside 0.0 ± 0.0/plot, berm area 3.6 ± 0.7/plot, control area 4.6 ± 1.3/plot, $F_{2,27}$ = 29.93, P < 0.0001).

DAF Studies

The results of DAF lizard studies are presented in detail in Woodward et al. (in press), here we briefly present the major findings. Side-blotched lizard densities in the DAF roadside area were approximately one half those in the nearby control area in the spring, however by summer densities in the two areas were similar (Figure 11). Subdividing the roadside area into the paved and graded area versus the berm area reveals a different pattern. In spring, no side-blotched lizards used the paved or graded areas near the road, and densities in the berm area could not be distinguished from the control plots (Figure 12). However, by summertime there were still no side-blotched lizards near the road, but the berm area contained twice as many side-blotched lizards as the control area (Figure 12).

The lizard fauna of the DAF diversion ditch was quite different from nearby control areas. The disturbed ditch had higher zebra-tailed lizard densities, but lower side-blotched lizard densities than the nearby undisturbed control areas (Figs. 13, 14). In spring whiptail lizards were more abundant in the control areas (13.3 ± 1.8/ha) relative to the disturbed ditch (0.3 ± 0.3, $F_{1,88}$ = 26.0, $P < 0.0001$). A similar pattern held in the summer (ditch 1.0 ± 1.1,

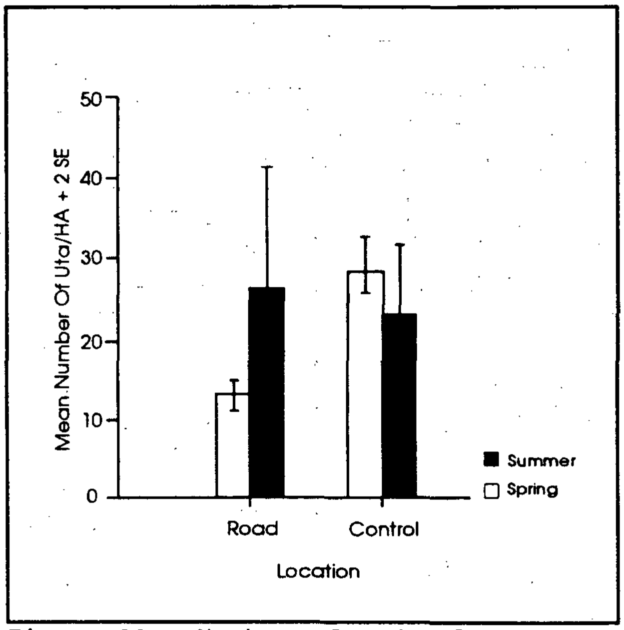

Figure 11 - Number of side-blotched lizards present in roadside and control areas along the DAF access road

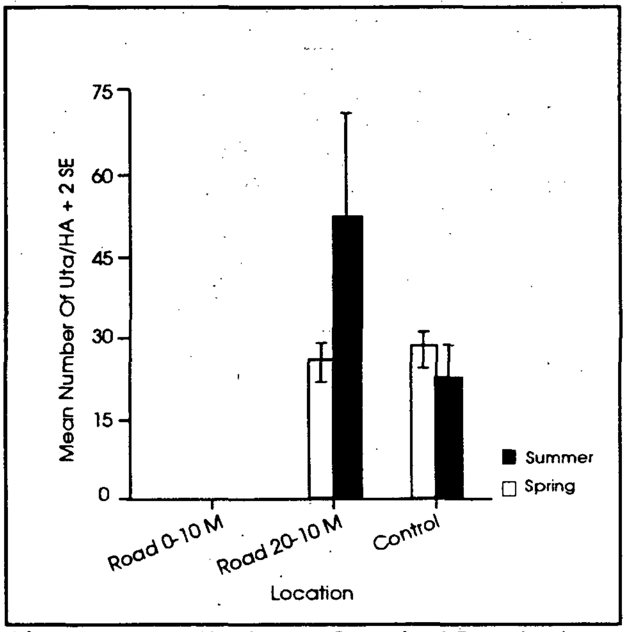

Figure 12 - Number of side-blotched lizards present from 0 - 10 m, 10 - 20 m from road center, or the control area long the DAF access road.

control 6.8 ± 3.5/ha, $F_{1,88}$ = 10.77, P = 0.00148). Timed searches in the area immediately south of the DAF, the disturbed area around the DAF buildings, immediately north of the DAF, > 1 km north of the DAF, and the foothills north and west of the DAF revealed differences in abundances for some species (Figures 15 - 17).

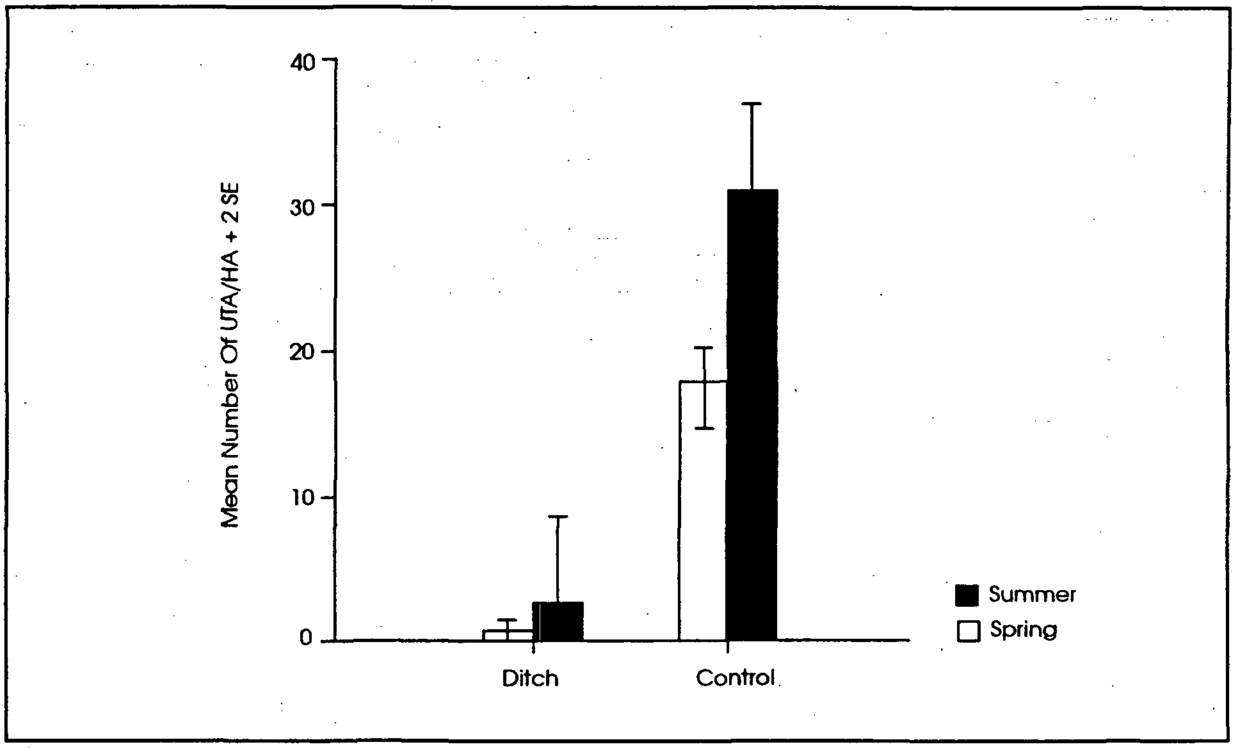

Figure 13 - Number of side-blotched lizards present on lizard plots in the DAF ditch or in nearby control areas.

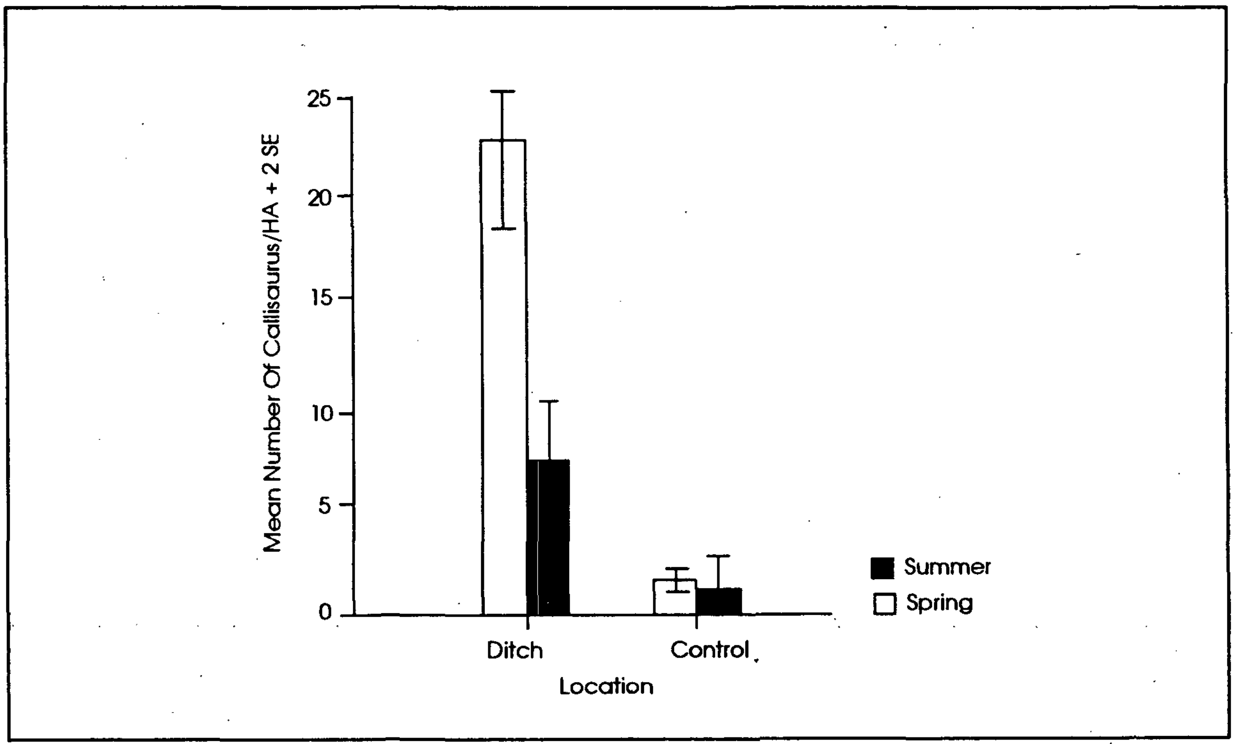

Figure 14 - Number of zebra-tailed lizards present in the DAF ditch and in nearby control areas.

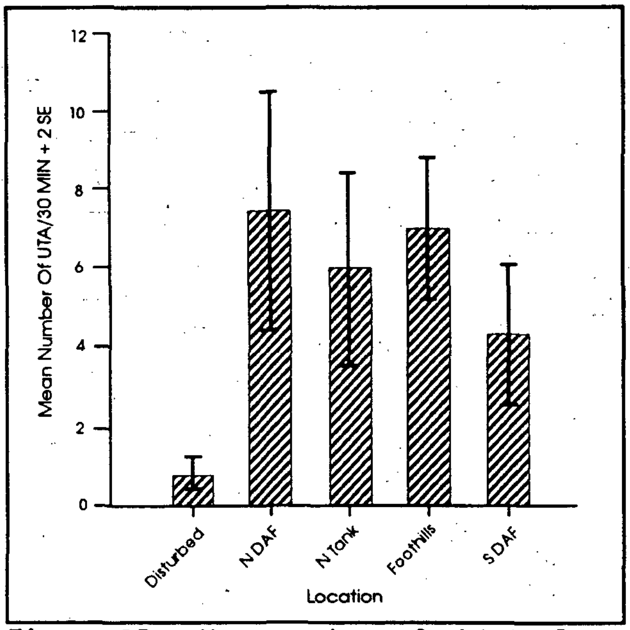

Figure 15 - Mean number of whiptail lizards seen per 30 minute search period in five areas near the DAF in summer 1993.

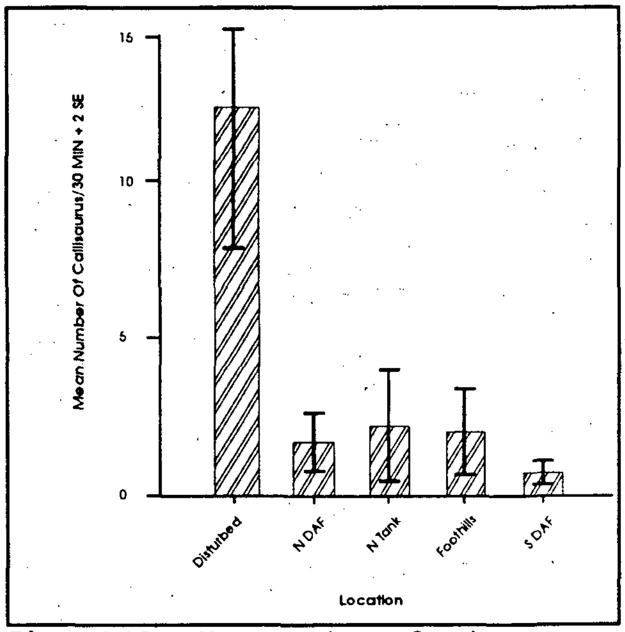

Figure 16 - Mean number of zebra-tailed lizards seen per 30 minute search period in five areas near the DAF in summer 1993.

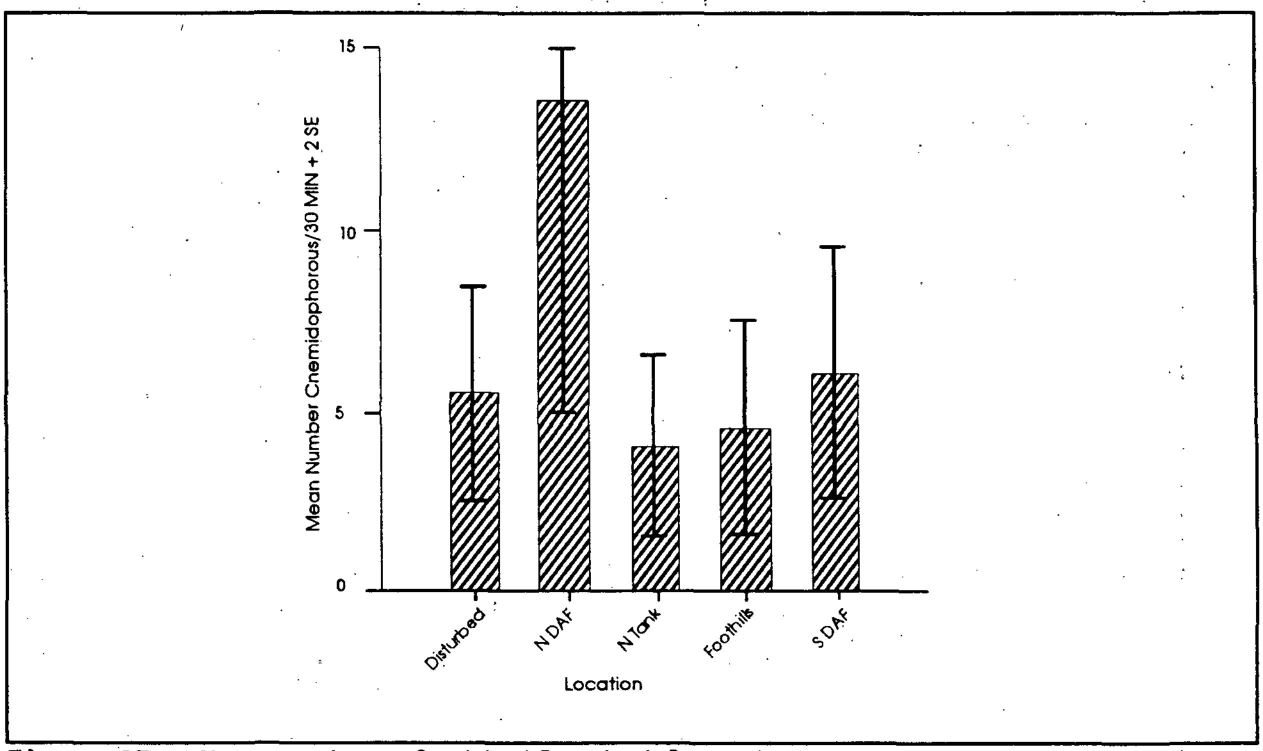

Figure 17 - Mean number of side-blotched lizards seen per 30 minute search period in five areas near the DAF in summer 1993.

Tortoise Studies

Fifteen of 19 marked tortoises in Rock Valley enclosures were observed in 1993, continuing the thirty-first year of measuring the fenced population. Growth (as estimated by plastron length) was significantly greater in males (range 1 - 10 mm) than in females (0 - 2 mm, $F_{1,10} = 9.6$, $P = 0.011$). No unmarked tortoises were observed. Only two tortoises were seen in opportunistic searches in 1993 (most likely because few searches were performed). Several old tortoise remains were seen near the DAF, and one live tortoise was sighted twice within 300 m of DAF-associated-disturbed-areas (Woodward et al. in press).

DISCUSSION

This was a relatively wet year, and lizards, like most other organisms did well. Lizard densities appeared to increase on almost all baseline plots. Correlation analyses revealed no evidence for a long term change in side-blotched lizard numbers on undisturbed baseline plots, suggesting human activities on the NTS have had minimal effects on areas not directly impacted by people. In fact, the nonsignificant trend appears to be a general increase on all plots except Pahute Mesa. The changes were coincident with a major drought, suggesting that drought had a major negative effect on uta populations early in this study, but populations increased subsequent to it (Woodward et al. in press). This is not surprising given the apparent severity of the drought effect on vegetation (Hunter 1994) and the strong relationship between vegetation and lizards (Dunham 1980). A correlation between annual precipitation and estimated side-blotched lizard densities was, however, nonsignificant. The lack of significance in all of these correlations appears to be largely due to the small sample sizes (i.e., few years of study). If trends continue, sample sizes will be sufficient to cm tall dirt ridge located at the edge of the shoulder along the 5-05 roadside, and the very large size of shrubs (200 to 250% of similar species located farther away from the road) in this area. Side-blotched lizards basked on the ridge and were tightly associated with the shrubs in this area. In contrast, the graded shoulder scrapings along the DAF roadside were laid down as a slight rise at the edge of the shoulder and the shrubs there are only 150% as tall as similar species located farther from the road. Shrub height differences may reflect the relative time elapsed since road construction.

Lizard faunas in both areas were dominated by side-blotched lizards and whiptails, although other species were present at low numbers. Patterns of lizard distributions and lizard characteristics were qualitatively similar across both roadsides suggesting these results may apply generally to paved roads (Table 11). Overall comparisons of the road effect were made by comparing the first 20 m from the center of the road, to a control area well removed from the road. The initial 20 m included the pavement, the graded shoulder, and the berm area with the tall vegetation. At the DAF site in spring, there were more side-blotched lizards in the control area than in the area within 20 m of the road center, however, by summer there was no difference between roadside and control areas (Table 11). The pattern was similar for the 5-05 road, although the spring estimates were not significantly different (density on controls were about 2x those on the roadside, however plot to plot variation was high). These results suggest that the net road effect can be negative for side-blotched lizards. Whiptails were approximately five times as abundant in the control areas relative to the roadside areas along the DAF road. Whiptail numbers were low and indistinguishable between roadside and control areas along the 5-05 road.

A closer examination of roadside plots revealed sizeable heterogeneity in lizard numbers. Along both roadsides, areas lacking perennial vegetation (the pavement and graded shoulder out to the berm) were essentially devoid of lizards, both in the spring and in the summer subsequent to reproduction. In spring, vegetated berm areas at the margin of roadside disturbance had similar densities to control areas (Table 11). By summer, side-blotched lizard densities in these areas were twice that of the nearby control areas along both roads (Table 11). In spring at the DAF site, the roadside berm contained 150% of control area females. In principle, the greater number of females present on the berm in spring could explain the increase in summer uta density at this area. At the 5-05 site the berm contained fewer females than the control, yet by summer the berm had twice the density of the control. Thus a disproportionate number of females along the berm cannot be the only possible explanation for the spring to summer increases in side-blotched lizard densities in berm areas. Differential movement into the berm in summer is an alternative explanation, as is a higher lizard carrying capacity due to increased insect densities on shrubs in this area (Lightfoot and Whitford 1991).

The spring to summer recapture rate on the control plots was higher relative to the roadside plots at the DAF, suggesting either survival was higher or dispersal off the plots reduced on control plots relative to roadside plots. The reduced number of perennial plants along the roadside could increase lizard mortality because of enhanced predation, or dispersal could be greater off roadside plots for this or some other factor. Either way, this result implies that seasonally the roadside is a poorer site for uta relative to the control area. There was not a significant difference in spring to summer recapture rate between roadside and control plots at the 5-05 roadside.

Side-blotched lizard distributions suggest the main consequence of road construction arises from vegetation removal due to paving, or grading the roadside. Shrub density estimates support this contention, as shrubs were considerably more abundant in control areas, or the second 10 m away from the road relative to the first 10 m away from the road (Woodward et al. in press). The pavement and graded shoulders of this two-laned road covered a 20 to 24 m wide area which was essentially devoid of lizards. This means the road removes 20 to 24 percent of the lizards in every hectare of desert it crosses. Further, the road apparently leads to seasonal shifts in density in the berm area (Table 11), another 20 percent of area in any hectare crossed. These seasonal shifts are not trivial, but are of the same magnitude as average densities in the control areas. Clearly, the road appears to have a major effect on the lizards. Lizards are a major insect predator (Polis and Yamashita 1991), and an important prey of other vertebrates. Roads, through effects on lizards, have the potential to strongly influence other taxa in desert systems.

Table 11. Characteristics ($\bar{x} \pm 2$ se) of *Uta* from two road sites in Frenchman Flat.

Lizard populations in the DAF ditch also differed a great deal from nearby controls (Figures 13, 14). Control areas were dominated by side-blotched lizards (10 to 15 times ditch densities), while the ditch was dominated by zebra-tailed lizards (6 to 15 times control densities). Whiptail lizards were also more abundant (7 to 39 times ditch densities) in the control area relative to the ditch. Pooling across species, control areas contained more lizards relative to the ditch. These differences are likely due to shrub removal and elimination of small mammal holes at the soil surface. Both of these activities remove cover for the lizards. Shrub removal also eliminates a resource base for insects, the lizards' primary prey base. Zebra-tailed lizards are known to favor open habitats (Pianka 1986), and thus have probably increased in the cleared ditch. Number of lizards per species, total number of lizard species, or total number of lizard individuals per plot differed between the DAF ditch and the control area. Another aspect of these analyses asked about differences in lizard faunas between arroyo bottoms and flat desert areas between arroyo bottoms in undisturbed habitat. None of the lizard species differed in abundance between these areas, implying these markedly different habitats supported similar faunas.

Five investigators of various experience levels, ages, and physical abilities performed timed searches in 5 areas near the DAF (disturbed areas near DAF, area out to 1 km S of DAF, N of DAF [about 1 km] to the water tank, water tank to foothills, 0.2 km into foothills). In spite of their differing abilities, counts/30 minutes did not vary across investigators, suggesting that investigators were largely interchangeable and that this variable had no effect on number estimates. In contrast, there were sizeable differences in lizard numbers across areas (Woodward et al. in press). Disturbed areas around the DAF buildings and road edges were largely devoid of lizards. In contrast, the DAF ditch appeared to contain high densities of zebra-tailed lizards. Superimposed on this pattern, the area to the north of the DAF contained more individual lizards, while the area south of the DAF contained few lizards relative to other areas near the DAF.

A 1985 fire in Yucca Flat removed most of the perennial vegetation from a sizeable area near plot YUF002. Comparisons of the burned area to a nearby unburned area or a partially burned ecotone between these areas, demonstrated sizeable effects on lizard populations. Transect results revealed more lizards in the ecotone relative to the other two areas. Plot studies of the burned and unburned areas revealed more uta present on the unburned area. These results suggest that fire, mostly likely through shrub removal, has negatively impacted lizard populations in this area.

All three types of disturbances examined in 1993 (fire, roads, grading associated with construction or ditches) had negative effects on lizards. Grading, associated with the road or construction activity, almost totally removed lizards. The effect appears to be due to shrub removal, and is not surprising given the strong connections between vegetation and lizards (Dunham 1980, Pianka 1986). Vegetation removal is likely the major detrimental human activity on the NTS, with important ramifications for many other taxa including lizards. These results suggest that steps should be taken to minimize vegetative disturbance, and that the interplay between the vegetation and other taxa should be more closely examined to determine what steps are necessary to restore each area to its undisturbed condition.

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TRENDS IN SMALL MAMMAL POPULATIONS ON THE NEVADA TEST SITE IN 1993

by

Mary B. Saethre

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ABSTRACT

The seventh year of monitoring small mammal populations on the Nevada Test Site was completed in 1993. The Basic Environmental Compliance and Monitoring Program (BECAMP) continued to focus on trends in heteromyid rodent populations at three baseline sites and included a bladed area and roadside disturbance generated by Department of Energy programs. Three sites disturbed by brush fires in 1985, 1986, and 1988 were also recensused in 1993.

The second consecutive year of above average rainfall occurred in 1993, after nearly three years of drought. Numbers of animals captured during the spring of 1993 on the baseline site in western Yucca Flat indicated kangaroo rat populations (*Dipodomys merriami* and *D. microps*) continued to rebound from drought conditions which prevailed in 1989 through 1990. *Dipodomys microps*, previously found as or less abundant than *D. merriami*, was the most abundant rodent in 1993. In 1992, the little pocket mouse (*Perognathus longimembris*) declined to the lowest density ever recorded, after being the most abundant rodent from 1987 through 1990. This plot has been trapped yearly since 1987 and has the most complete trapping record of any BECAMP site. Spring density of small mammals on this plot was positively correlated with winter rainfall.

Rodents on the baseline plot in western Jackass Flats also recovered since the last census in 1990. This area is more sandy than Yucca Flat and consists of Mojave Desert vegetation. The most common species in 1993 was *Dipodomys merriami*. *Perognathus longimembris* numbers on this plot, as on the Yucca Flat plot, were below pre-drought values. The baseline site on Rainier Mesa was first trapped in 1988 (pre-drought) and censused again in 1993 (post-drought). Nearly 10 times as many deer mice (*Peromyscus maniculatus*) were captured on this site in 1993 as in 1988, and three times as many chipmunks (*Tamias dorsalis*).

Murid rodents (*Peromyscus*, *Onychomys*, and *Neotoma*) were well represented at sites studied in 1993. *Neotoma lepida*, the desert woodrat, was captured at nearly every site trapped. An undisturbed area in Mid Valley had the highest species diversity for plots studied in 1993 at 0.9309 with eleven species captured.

INTRODUCTION

Description and History of the Area

The Nevada Test Site (NTS) is situated across the Transition Desert area between the Mojave (*Larrea-Ambrosia*) and Great Basin (*Artemisia*) desert "communities". The deserts vary in vegetation, soil type, and elevation. Typical habitats of both the Mojave and Great Basin deserts occur on the NTS, and aspects of each desert segue into the unique habitat mosaics of the Transition Desert. The vegetation communities on the NTS (Allred et al. 1963; Beatley 1974a; O'Farrell and Emery 1976) support rodent communities which typify each habitat, with a mixture occurring in transitional areas (Jorgensen and Hayward 1965).

Animal studies 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, 1963b; Jorgensen and Hayward 1965). Intensive studies were undertaken by the University of California Los Angeles (UCLA) in Rock Valley on the southern edge of the NTS, to determine animal abundance, home range, 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 in Rock Valley were part of the International Biological Program (IBP) during the 1970s (Chew 1975; Dingman 1975; Turner 1973, 1975; Turner and McBrayer 1974). 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; Bradley et al. 1977a, 1977b; Moor et al. 1976; Moor et al. 1977; O'Farrell and Sauls 1987).

BECAMP Study Sites

Small mammal monitoring under the auspices of the Basic Environmental Compliance and Monitoring Program (BECAMP) began in the summer of 1987. 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. Also studied were 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 thought to be denuded by gophers and an area burned by 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. The first three year cycle of NTS monitoring of disturbed sites was completed in 1990. That year, two additional blast areas were studied, along with the burned area studied in 1987 and extensive trapping was done at a roadside. The baseline site in Yucca Flat (YUF001) was chosen to be studied on a yearly basis, while the remaining four baseline sites and disturbance sites are to be sampled every three to four years (Saethre and Medica 1992).

Sites studied in 1993 included the baseline plots in Yucca Flat and Jackass Flats and on Rainier Mesa. The site on Rainier Mesa had not been sampled since it was first trapped in 1988. A roadside that was intensively trapped in 1990 (during the drought) was looked at again in 1993 (post-drought). It was decided that BECAMP would study similar plots in the same year, therefore, the two blast areas to be studied in 1993 would be studied in 1994. 1993 was to be a year to study areas disturbed by fire and roadsides. Locations of all plots studied in 1993 are shown in Figure 1. Latitudes, longitudes, and elevations are found in Appendix A.

Data from the baseline plots are 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 effects, if any, of the disturbance. Over time, recovery of a disturbed site may be followed. To date, seven years of small mammal population data are available for the Yucca Flat baseline site. Trends on this site are used to compare with what may be happening at other NTS sites during the years between censuses.

At present, 57 mammals occur on or near the NTS (Appendix B), the majority of which are rodents (Jorgensen and Hayward 1965; O'Farrell and Emery 1976; Medica 1990; EG&G/EM 1992, 1993; Saethre and Medica 1992; Saethre 1994a, 1994b). Two ungulates, elk (wapiti) and bighorn sheep, reside outside NTS boundaries and are rarely observed. Burros occasionally wander onto the NTS from a population off the extreme southwestern edge of the NTS.

Of the 23 rodent species inhabiting the NTS, the most ubiquitous are kangaroo rats and pocket mice. These heteromyids are well-adapted to xeric conditions and are the best known desert rodents (Reichman 1991). They are nocturnal, granivorous, and relatively easy to catch. The abundance of heteromyids and species diversity vary among the habitats present on the NTS, but, in general,

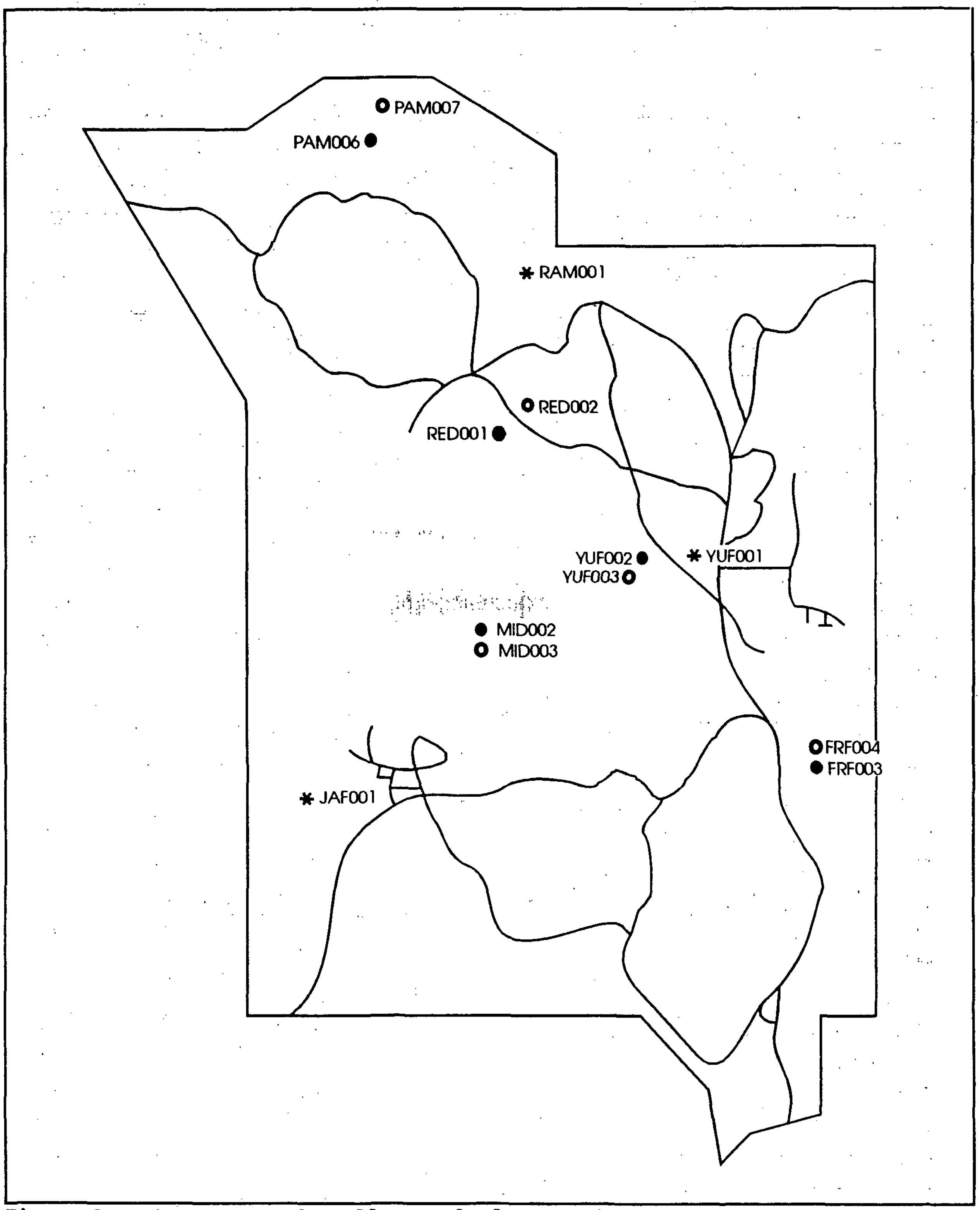


Figure 1 - Locations of small mammal plots studied by BECAMP in 1993.

Merriam's kangaroo rat (*Dipodomys merriami*) and the little pocket mouse (*Perognathus longimembris*) are most common in the southern two-thirds of the NTS (Mojave and Transitional areas). In the northern extremes (Transition and Great Basin Deserts) the chisel-toothed kangaroo rat (*D. microps*) and Great Basin pocket mouse (*P. parvus*) are more prevalent. However, various combinations of these four species occur throughout the NTS. Three other heteromyids, *D. deserti*, *D. ordii*, and *Microdipodops megacephalus* also occur on the NTS but are less widespread. In recent years the very small *P. longimembris* has been present at low densities while the long-tailed pocket mouse (*Chaetodipus formosus*), a medium-sized species typical of the intermountain sagebrush and Mojave Desert regions (Schmidley et al. 1993), has increased in virtually all areas of the NTS.

Several other seed-eating rodent species share habitat with heteromyids on the NTS, but most persist at low densities or are more difficult to capture. Nongranivorous squirrels are, for the most part, diurnal but often captured when traps are baited too early in the evening or left open later in the morning.

During the spring of 1993, a type of hantavirus carried by rodents (mainly the deer mouse, *Peromyscus maniculatus*) was linked to several deaths in the four corners area of the southwestern United States. The so-called Muerto Canyon virus is present in rodent urine or feces and is passed to humans when they breath aerosolized particles of infected excreta. After two confirmed cases of the so-called hantavirus disease (Adult Respiratory Distress Syndrome) in southern Nevada in mid-summer of 1993, DOE requested that BECAMP workers follow the Center for Disease Control and Prevention (CDC) guidelines for handling rodents.

METHODS

SMALL MAMMAL SAMPLING TECHNIQUES

Baseline Monitoring Sites

Small mammals were trapped on baseline monitoring sites for three consecutive nights. 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*). The permanent study plots (YUF001, JAF001, and RAM001) each 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 within the short trapping period. Traps were baited in the early evening (1800+ hours) with a mixture of rolled oats and birdseed. Half-cylinder shades made of sheetmetal were placed over traps to prevent hyperthermia from direct sunlight. Traps were checked shortly after sunrise and closed for the day. On the last day, all bait was removed from the traps and poured into plastic bags. No bait was left on the plots to avoid supplementing normal food sources.

Each rodent was permanently marked. Kangaroo rats (*Dipodomys* spp.) and the occasional lagomorph (*Lepus californicus* and *Sylvilagus* spp.) were ear tagged. 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 along with any pertinent notes (Hunter and Medica 1989). Any bait was removed from 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 (se) were calculated for each sex of two age classes (adult and juvenile) of the most common species captured.

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 1.69 ha) with the grid configuration depending on the shape of the disturbed area. In general, an 8 x 8 grid (1.10 ha) was used on disturbed sites while a similarly-sized grid in an adjacent undisturbed area served as a control. At the Mid Valley burned site a 5 x 15 grid (1.26 ha) was trapped, while at the Redrock burned site a 5 x 14 grid configuration (1.17 ha) was used. A roadside study area in Frenchman Flat consisted of two lines of 150 traps with 10-meter intervals between traps. One line was parallel and 20 m from the centerline of a paved road. The second line was located in moderately undisturbed habitat 500 m to the north. This set of plots was established in 1989 to assay what impact a moderately used road may have on the surrounding flora and fauna.

Density Estimation

The first night of the three nights of trapping was considered a preliminary trap night. The population size and a hypothetical standard error 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 (see Appendix C) 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 (N/ha) ± the standard error, N* and SE were both divided by the plot size in hectares, including a 7.5 m wide perimeter (adjusted grid size). 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.

Data used to estimate the population size and results of the Seber equations for all plots sampled in 1993 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 possible.

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),

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

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 t-test described by Zar (1984:146) was used to compare the species diversity at a disturbed site with its control in the same year 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.

Other Statistical Analyses

Mean weights were analyzed using twoway analysis of variance (F) for site (or year) and sex (ANOVA, RS/1, BBN Software Products Corp., Cambridge, MA). The weight for an individual was averaged if captured more than once. Weights on paired disturbance plots were compared by plot and sex for 1993. However, when comparing between years, a plot was only compared to itself by year and sex. Newman-Keuls Multiple Range Test (RS/1) was used for a multiple comparison test. 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. Degrees of freedom appear as subscripts following the test statistic (e.g.: $F_{2,238} = 2.110$). Results were significant when probability (P) was equal to or less than 0.05.

Bat Surveys

Mist nets (Avinet, Inc, Los Angeles, CA) were set for two nights along the edges of two water sources on the northern end of the NTS. Nets were black and 3' x 42', 2- or 3-shelf with no more than 1-1/2" mesh. All nets were low visibility, nylon strand either monofilament, 40 denier or two-ply, 30 denier. Two-ply teryulene (50 denier) was also used. Nets were strung on poles at various heights. Configurations of nets were changed after the first night.

The first site, well reservoir 19c, is a permanent, artificial water source located at an elevation of 2103 m in pinyon pine habitat in area 19 (see Greger this report for location). Surface area of the pond is approximately 2000 m^2 and the water depth is unknown but no more than 3 m. A berm surrounding the pond slopes approximately 45° and is about 3 m higher than the normal elevation. On the edges of the pond are thick stands of cattails. Due to size of the water area, nets were set only on the eastern end of the pond (Figure 2). Nets were set just before sunset on 20 and 21 July and removed at sunrise the following mornings.

The second site surveyed for bats was a manmade water catchment in Gold Meadows north of Rainier Mesa. The pond is less than 1-m deep and is generally dry by autumn. This site is located at 2028 m in a sagebrush-grass meadow. Stands of pinyon pine are located less than 250 m from the pond. Rock outcrops are also abundant adjacent to the pond. The water source itself was enlarged for use as a stock pond more than 40 years ago when the area was used for cattle ranching. The surface area was small compared to 19c - only about 300 m^2, and therefore nets could be placed around the entire pond (Figure 3). Nets at Gold Meadows sump were set at sunset on 3 and 4 August and struck at sunrise.

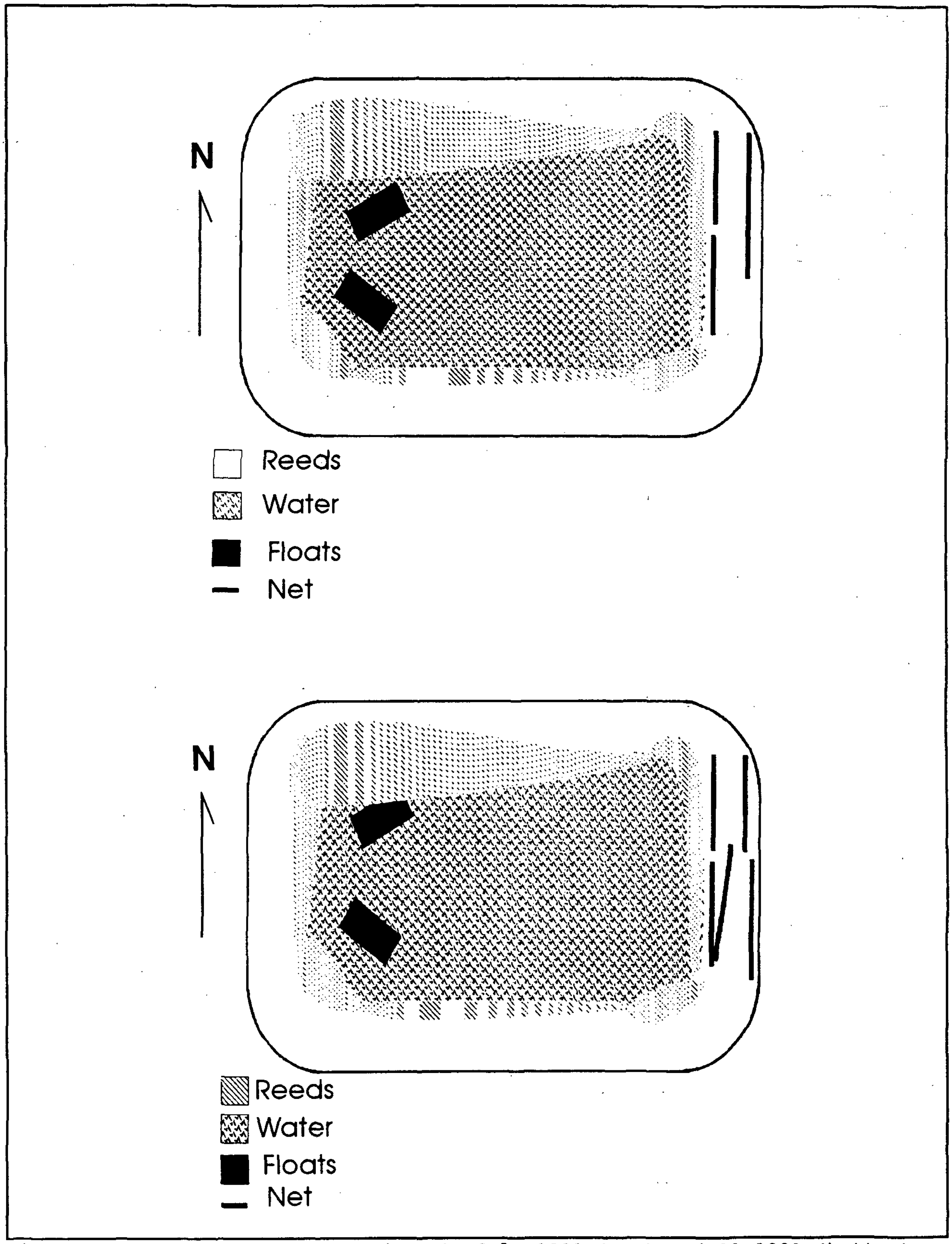


Figure 2 - Mist nets at 19c pond on 20 July 1993 (top) and 21 1993 (bottom).

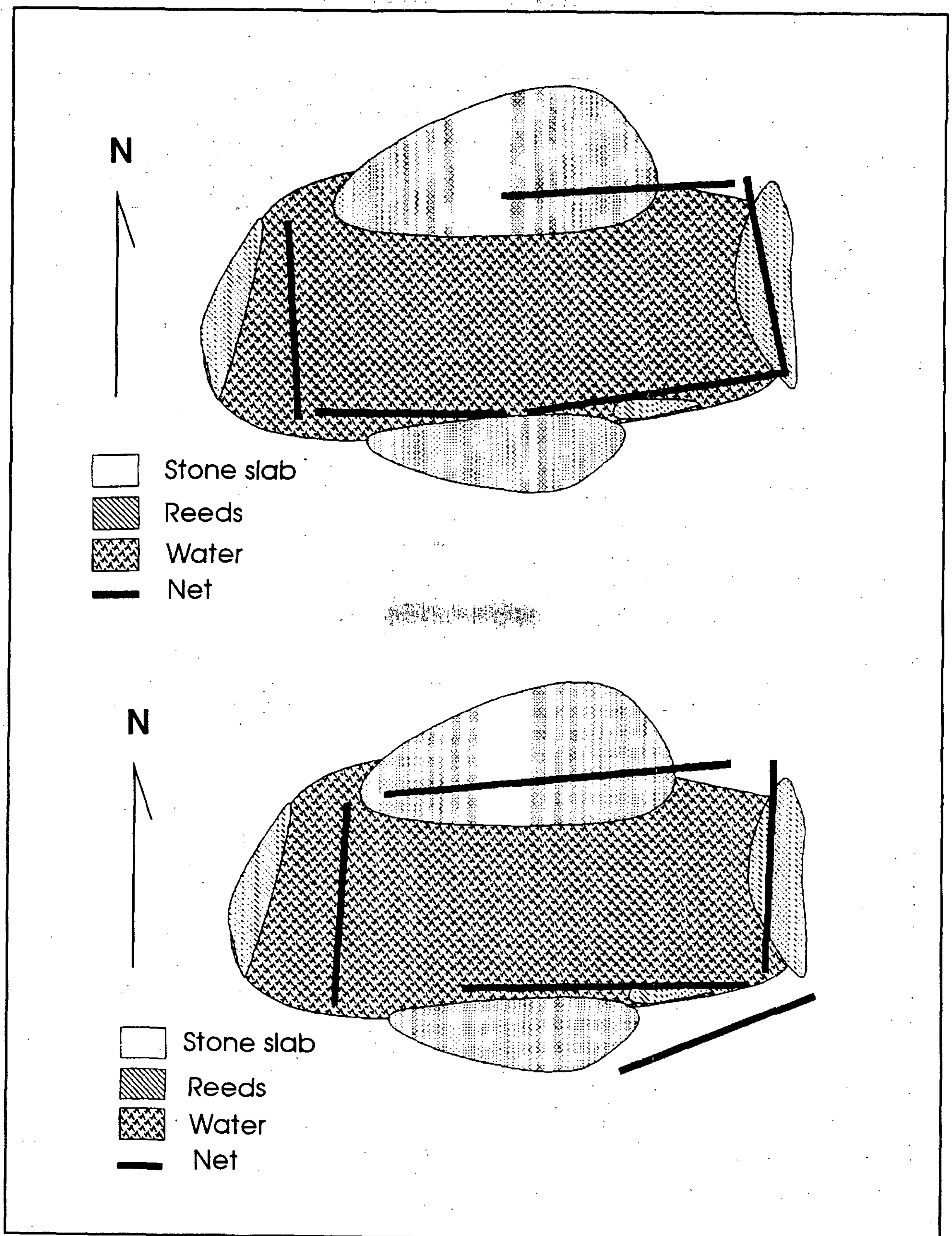


Figure 3 - Nets at Gold Meadows on 3 August (top) and 4 August 1993 (bottom).

Precautions Against Hantavirus

BECAMP implemented CDC guidelines after most of the trapping was concluded. These included wearing a half-face air-purifying respirator with filters, eye protection, disposable latex gloves under cloth gloves, and protective clothing. Dust masks were used when baiting. As an added precaution, BECAMP personnel had blood samples drawn and sent to the CDC for serological analysis. When traps were returned from the field bait was carefully poured into double plastic bags and discarded. Traps were disinfected with a mixture of bleach and water.

EG&G Energy Measurements, Inc (EG&G/EM) Environmental Safety and Health Division in conjunction with the CDC collected blood samples from rodents on 24-27 August 1993 at the Yucca Mountain Project (YMP) area north of the JAF001 baseline plot. BECAMP was invited to supply rodents from other sites on the NTS, preferably from areas with an abundance of *P. maniculatus*. Traps at two sites, one each on Pahute Mesa and Rainier Mesa, were set on the evening of 25 August and opened the next morning. Animals were captured in 7.5 x 8.0 x 26.0 cm mesh (0.1 x 1.0 cm) traps (Tripp-It, A Thru Z Consulting Company). Traps were placed randomly in lines of 10 traps approximately 10 m apart with 100 traps set on Pahute Mesa and 80 on Rainier Mesa.

Traps that contained animals were placed in doubled plastic bags and the outer bag was labeled with the mesa and approximate trap location. Animals were transported to YMP where the blood was drawn by CDC workers. Animals were returned to their trap and bag and released in the general area of capture later the same day. Blood analysis for hantavirus antibodies was conducted at the CDC in Atlanta, GA.

Abbreviations and Notations

Species names appear in the results tables as the abbreviations listed in Table 1. Scientific names follow that suggested by Wilson and Reeder (1993). Plot names are abbreviated with three letters designating the valley or mesa (e.g. YUF = Yucca Flat, PAM = Pahute Mesa) plus a unique three digit code for that area starting with 001 (YUF001 = Yucca Flat and PAM001 = Pahute Mesa baseline sites). An asterisk (*) in density tables indicates recapture data was insufficient to calculate a density.

Descriptions of the perennial and ephemeral plant compositions on plots studied by BECAMP in 1993 are discussed in the appropriate vegetation sections of this report (Hunter, this volume) and should be referred to for a more detailed account of the flora on these sites. Plants on the Redrock burned

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

Abbreviation	Scientific Name	Common Name
RODENTIA		
Sciuridae - Squirrels and chipmunks		
AMMLEU	*Ammospermophilus leucurus*	White-tailed antelope squirrel
SPETER	*Spermophilus tereticaudus*	Round-tailed ground squirrel
TAMDOR	*Tamias [=Eutamias] dorsalis*	Cliff chipmunk
[illegible]	[illegible]	[illegible]
CHAFOR	*Chaetodipus formosus*	Long-tailed pocket mouse
DIPDES	*Dipodomys deserti*	Desert kangaroo rat
DIPMER	*Dipodomys merriami*	Merriam's kangaroo rat
DIPMIC	*Dipodomys microps*	Chisel-toothed kangaroo rat
DIPORD	*Dipodomys ordii*	Ord's kangaroo rat
PERLON	*Perognathus longimembris*	Little pocket mouse
PERPAR	*Perognathus parvus*	Great Basin pocket mouse
Muridae - mice, rats and voles		
NEOLEP	*Neotoma lepida*	Desert woodrat
ONYTOR	*Onychomys torridus*	Southern grasshopper mouse
PERCRI	*Peromyscus crinitus*	Canyon mouse
PERERE	*Peromyscus eremicus*	Cactus mouse
PERMAN	*Peromyscus maniculatus*	Deer mouse
PERTRU	*Peromyscus truei*	Pinyon mouse
REIMEG	*Reithrodontomys megalotis*	Western harvest mouse
LAGOMORPHA		
Leporidae - rabbits and hares		
LEPCAL	*Lepus californicus*	Black-tailed jack rabbit
SYLAUD	*Sylvilagus audubonii*	Desert cottontail rabbit
SYLNUT	*Sylvilagus nuttallii*	Nuttall's cottontail rabbit
CARNIVORA		
Mustelidae - mustelids		
SPIPUT	*Spilogale putorius*	Western spotted skunk

area were not studied in 1993 but were in 1992 (Hunter, in press c, d). The vegetation on the Pahute Mesa drill pad was last measured in 1991 (Hunter 1994a, 1994b).

RESULTS

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 been trapped yearly from 1987 through spring 1993. During this time fluctuations in the small mammal population coincided with the local drought beginning in 1989 and recovery in 1991 (Figure 4, Table 2).

During summer trapping in 1987 (28-30 July), 143 individual rodents were captured 298 times for a trap success of 35%. After trapping on 26-28 April 1988, 97 animals were captured a total of 192 times, a significantly lower trap success of 22% (x^2 = 24.043, $P < 0.00001$). 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%. This was again significantly lower than the previous

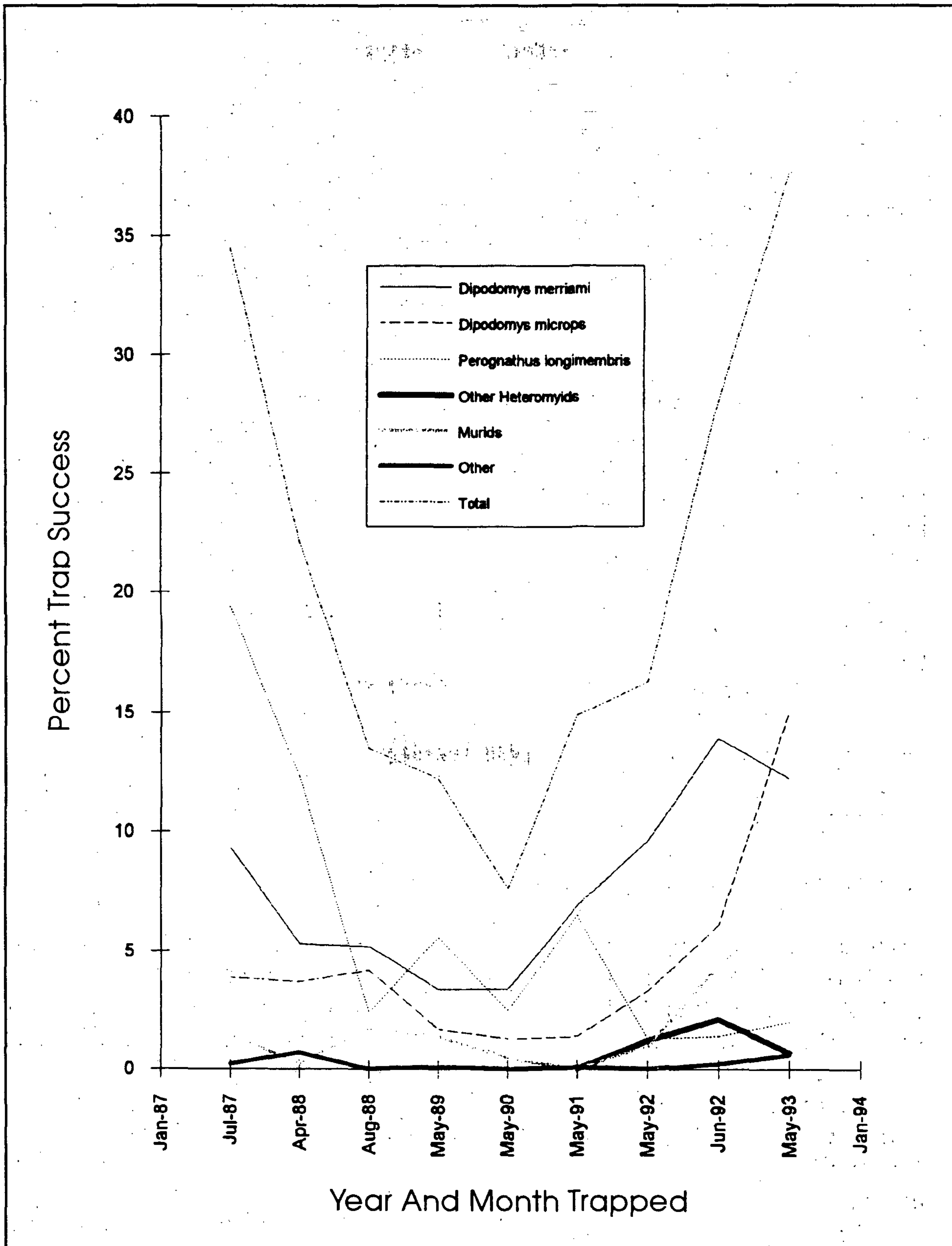
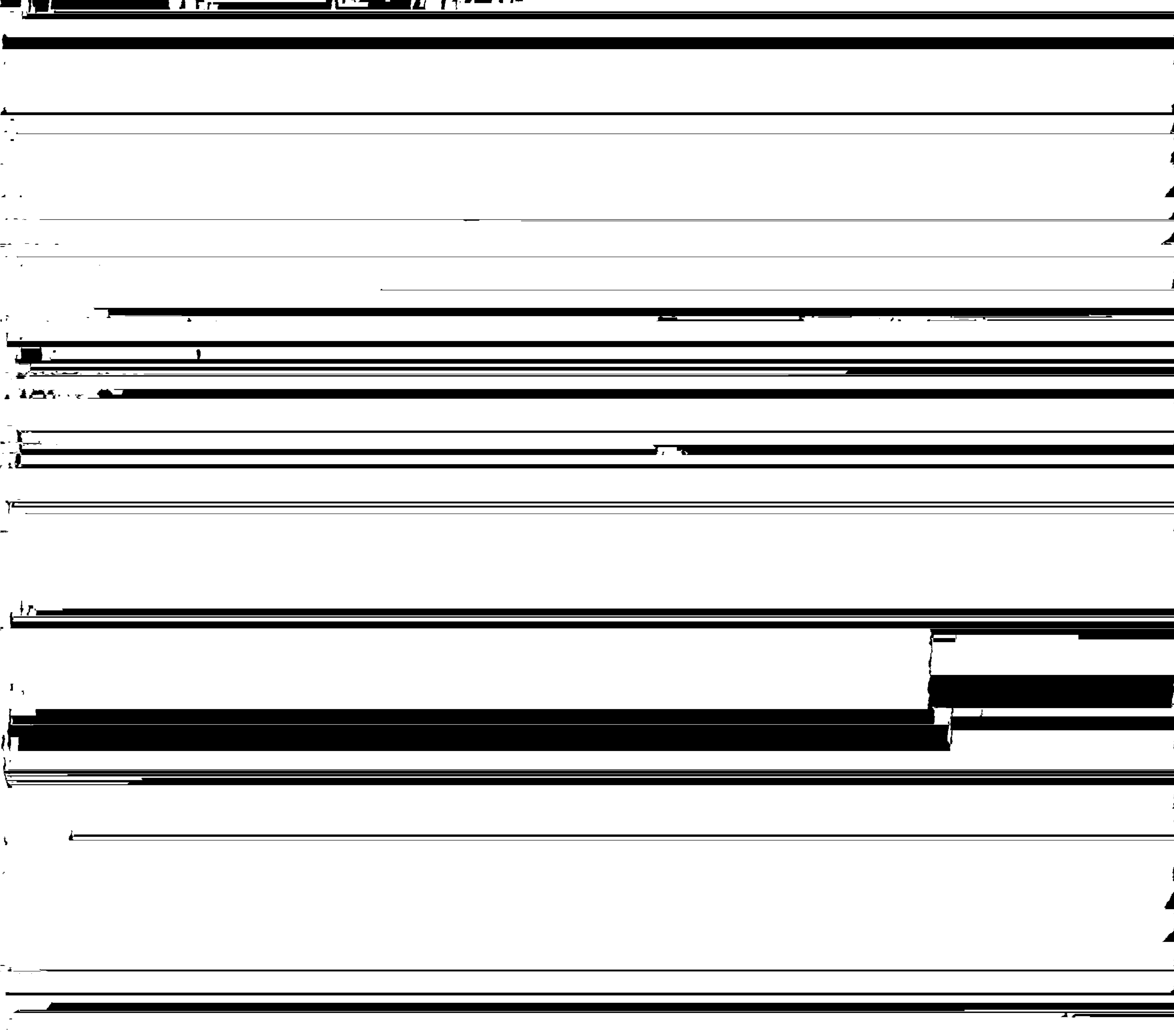


Figure 4 - Trap success at the Yucca Flat baseline site, 1987 through 1993.

Table 2. Estimated densities (N/ha ± 2 SE) and species diversity (H') on the Yucca Flat baseline plot (YUF001) 1987 through 1993. Numbers in parentheses are individuals.

	1987	1988	1989	1990	1991	1992	1993
CHAFOR	---	---	---	---	---	2.3±0.5 (7)	* (3)
DIPMER	9.8±0.3 (32)	5.2± 0 (17)	3.4± 0 (11)	5.0±1.3 (14)	7.4± 0 (24)	15.1±1.7 (45)	16.7±1.4 (51)
DIPMIC	5.0±0.7 (16)	5.2±0.8 (16)	2.7±0.7 (8)	2.3±1.0 (6)	1.2± 0 (4)	5.4±0.7 (17)	20.9±1.2 (65)
PERLON	27.8±2.4 (83)	19.0±1.8 (57)	* (7)	9.0±1.6 (26)	8.2±4.7 (16)	3.4±1.9 (8)	3.4±1.4 (9)
PERPAR	---	---	---	---	---	---	* (1)
ONYTOR	* (9)	* (2)	* (3)	* (3)	---	5.2±5.9 (7)	3.9±1.4 (11)
PERERE	---	---	---	---	---	* (1)	* (2)
PERMAN	* (1)	---	* (4)	---	---	---	4.4±0.4 (14)
REIMEG	---	---	---	---	---	---	2.5±1.5 (6)
AMMLEU	* (2)	* (4)	* (1)	---	---	---	* (1)
LEPCAL	---	---	---	---	---	---	* (2)
SYLAUD	---	* (1)	---	---	---	---	---
TOTALS	44.1 (143)	29.9 (97)	16.4 (53)	12.0 (39)	19.1 (62)	26.2 (85)	50.9 (165)
SPECIES	6	6	6	4	4	6	11
H'	0.5037	0.5097	0.6052	0.5292	0.4110	0.5840	0.7090

Estimates of spring density (number of animals per hectare ± two standard errors) for the most common rodents captured on YUF001 in 1988 through 1993 also indicated a continual reduction in the density until 1991, when densities appeared to increase for two species--*Dipodomys merriami* and *Perognathus*



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.

Although densities of *Dipodomys merriami* and *P. longimembris* increased from 1990 to 1991, the estimated density of *D. microps* continued to decline until 1992. In 1993, the number of *D. microps* captured was the highest ever at this site, surpassing *D. merriami* as the most commonly captured species. This precipitation and perennial plant growth were excellent and *D. microps* numbers responded by returning to pre-drought numbers or better.

The distribution of the total captured population among species for the seven years (Table 3) changed dramatically. In 1987 and 1988, 92 and 93% of the captured population of animals consisted of heteromyid rodents. *Perognathus longimembris* accounted 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 of *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, most of the small mammals captured were heteromyids (92% and 98% respectively).

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. In the summer, however, *D. merriami* was the most prevalent heteromyid species captured. In 1993, 78% of the individuals captured were heteromyids while murid rodents (*Onychomys*, *Peromyscus* spp, and *Reithrodontomys megalotis*) increased to 22%.

As a result of the change in species distribution, species diversity, H' (Table 2), decreased significantly in 1991 (t_{78} = 2.327, P = 0.0226). A significant increase in species diversity occurred in 1992 (t_{146} = 3.229, P = 0.00153).

Sex ratios (Table 4) for each species captured on YUF001 from 1987 to 1993 did not differ significantly from 1:1 (x^2, P > 0.05) except in 1990 when four times as many female as male *P. longimembris* were captured (x^2 = 6.25, P = 0.0124) and in 1993 when only males were captured (x^2 = 9.00, P = 0.00270). In May 1992, slightly more male *Dipodomys merriami* and significantly more male *Chaetodipus formosus* were captured (x^2 = 3.756, P = 0.0526 and x^2 = 7.00, P = 0.00815). This, however, was not the case in June 1992 nor in May 1993. Combining all species for each year, only in 1992 were significantly more males than females captured (x^2 = 8.576, P = 0.00341).

The mean weight of adult male *D. merriami* (Table 5) was significantly greater than that of adult female *D. merriami* in 1988 and 1989 (Saethre and Medica 1992; Saethre 1994a), but not in 1990, 1991, 1992, nor 1993 (P > 0.10).

test (Newman-Keuls multiple range test) showed adult mean weight in 1993 to be significantly heavier than those of 1988, 1990 and 1991 but not 1989 or 1992.

The mean weight of adult male *Perognathus longimembris* (Table 5) did not differ significantly from the mean weight of adult females in 1988, 1989, or 1990 (P > 0.10), but males were significantly heavier in 1991 (Saethre 1994a). In 1992, the three females were heavier than males (Table 5), and all were judged to be pregnant. No females were captured in 1993 for comparison.

Table 4. Sex ratio (♂/♀ = male/female) for small mammals captured on the YUF001 baseline plot from 1987 through 1993.

SPECIES	1987	1988	1989	1990	1991	1992	1993
CHAFOR	---	---	---	---	---	7/0	1/2
DIPMER	13/19	11/6	5/6	9/5	12/12	29/16	27/24
DIPMIC	9/7	9/7	6/2	4/2	2/2	12/5	33/32
PERLON	44/39	27/30	13/13	3/13	14/19	5/3	9/0
PERPAR	---	---	---	---	---	---	0/1
ONYTOR	2/7	2/0	2/1	2/1	---	2/5	7/4
PERERE	---	---	---	---	---	1/0	1/1
PERMAN	0/1	---	3/1	---	---	---	8/6
REIMEG	---	---	---	---	---	---	4/2
AMMLEU	0/2	2/2	0/1	---	1/0	---	[a]
LEPCAL	---	---	---	---	---	---	I[b]
SYLAUD	---	I[b]	---	---	---	---	---
TOTALS	68/75	51/45	29/24	18/21	29/33	56/29	90/72

[a]One animal of undetermined sex not included.
[b]Juveniles of indeterminate (I) sex captured.

Table 5. Spring mean weights (gms ± 2 se) by sex and age (adult or juvenile) of heteromyid rodents captured on the YUF001 baseline plot in 1988 through 1993. Numbers in parentheses are numbers of individuals.

SPECIES		ADULT		JUVENILE	
		MALE	FEMALE	MALE	FEMALE
CHAFOR	92	21.0±1.2 (7)	---	---	---
	93	21.5 (1)	21.7 (1)	---	15.0 (1)
PERLON	88	8.3±0.3 (27)	8.0±0.2 (30)	---	---
	89	7.6±0.5 (13)	7.6±0.3 (13)	---	---
	90	8.5±1.0 (3)	8.0±0.5 (13)	---	---
	91	8.4±0.3 (14)	7.7±0.3 (19)	---	---
	92	9.1±0.8 (5)	12.0±1.2 (3)	---	---
	93	8.6±0.4 (9)	---	---	---
DIPMER	88	42.5±0.9 (11)	39.6±2.0 (6)	---	---

rodents captured was still 25% less than in 1988.

The estimated density of *Dipodomys merriami* on this plot decreased by 56% from 1988 to 1990 (from 10.6 in 1988 to 4.6 in 1990) while the density of *Perognathus longimembris* dropped by 89% (Table 6). *Dipodomys merriami* density increased by 32% from 1988 to 1993 (20% from 1990 to 1993) while *P. longimembris* density decreased by 83% from 1988 to 1993 (but increased 50% from 1990 to 1993).

Although the average number of captures per animal remained relatively consistent among trapping periods (1.64 in 1987, 1.57 in 1988, 1.73 in 1990,

Table 6. Estimated density (N/ha ± 2 SE) and species diversity (H') of small mammals captured on the Jackass Flats baseline site (JAF001) in 1987, 1988, 1990, and 1993. Numbers in parentheses are individuals captured.

SPECIES	1987 4,5,6 AUG	1988 12,13,14 APR	1990 9,10,11 MAY	1993 11-13 May
DIPDES	* (1)	* (1)	---	---
DIPMER	13.4±1.7 (40)	10.6±0.8 (33)	4.6±0.8 (14)	14.0±0.4 (45)
PERLON	40.9±6.9 (101)	54.5±11.4 (67)	6.2±5.2 (10)	9.3±1.3 (28)
ONYTOR	---	---	* (1)	---
AMMLEU	* (1)	---	* (1)	* (2)
SPETER	* (1)	---	---	---
Totals	44.4 (144)	31.2 (101)	8.0 (26)	23.2 (75)
Species	5	3	4	3
H'	0.3075	0.2968	0.4132	0.3348

and 2.1 in 1993), the percent trap success changed considerably and appeared to fluctuate according to rainfall and annual plant availability (27, 18, 5, and 18% in 1987, 1988, 1990, and 1993, respectively).

At this site, two heteromyid rodents (*D. merriami* and *P. longimembris*, accounted for over 90% of the entire captured population (Table 7). Sex ratios of the two most commonly trapped rodents (Table 8) did not differ

Table 7. Percent of total captured population of small mammals captured on the JAF001 plot in 1987, 1988, 1990, and 1993.				
SPECIES	1987	1988	1990	1993
DIPDES	0.7	1.0	---	---
DIPMER	27.8	32.7	53.8	60.0
PERLON	70.1	66.3	38.5	37.3
ONYTOR	---	---	3.8	---
AMMLEU	0.7	---	3.8	2.67
SPETER	0.7	---	---	---
TOTALS	100.0	100.0	99.9	100.0

Table 8. Sex ratio (♂/♀) of small mammals captured on the JAF001 plot in 1987, 1988, 1990, and 1993.				
SPECIES	1987	1988	1990	1993
DIPDES	1/0	0/1	---	---
DIPMER	24/16	21/12	10/4	26/19
PERLON	55/46	30/37	4/6	19/9
ONYTOR	---	---	[a]	---
AMMLEU	0/1	---	0/1	1/1
SPETER	0/1	---	---	---
TOTALS	80/64	51/50	14/11	46/29

[a] One animal of undetermined sex not included.

significantly from 1:1. Species diversity (H') did not change significantly over the three years (Table 6). This area is considerably more sandy than the Yucca Flat baseline site and had lower plant density and fewer plant species

1993 than in 1990 ($F_{2,86}$ = 49.33, $P < 0.0001$) with no response for sex ($F_{1,86}$ = 3.18, $P = 0.078$). Both male and female *D. merriami* weights were significantly greater in 1988 and 1993 than 1990 (Male: $F_{2,32}$ = 16.21, $P < 0.001$; Female: $F_{2,89}$ = 48.71, $P < 0.001$). Female kangaroo rats showed no physical evidence of reproductive activity in 1990, while ~50% of the female kangaroo rats on this site in the springs of 1988 and 1993 showed such evidence. Males in both years were reproductively active.

Table 9. Spring mean weights (gms ± 2 se) by sex and age (adult or juvenile) of heteromyid rodents captured on the JAF001 baseline plot in 1988, 1990, and 1993. Numbers in parentheses are numbers of individuals.

SPECIES		ADULT		JUVENILE	
		MALE	FEMALE	MALE	FEMALE
PERLON	88	7.3±0.9 (31)	7.4±0.8 (36)	---	---
	90	7.2±0.4 (5)	6.8±0.8 (5)	---	---
	93	8.0±0.6 (19)	8.9±0.9 (9)	---	---
DIPMER	88	40.9±1.3 (21)	41.6±2.3 (12)	---	---
	90	34.1±1.0 (10)	30.9±1.0 (4)	---	---
	93	42.1±0.8 (26)	40.7±1.5 (19)	---	---

Rainier Mesa - RAM001

A baseline site on Rainier Mesa was established in 1988 to round out the different types of habitats studied on the NTS. This plot is located at approximately 2283 m on a slope with rocky areas interspersed. The vegetation consists of mainly *Pinus monophylla* (pinyon pine) and *Cowania mexicana* with some *Artemisia tridentata* and *Chrysothamnus nauseosus*. This site was trapped on 2-4 August 1988 and 3-5 August 1993.

Total captures, and percent trap success, was five times higher in 1993 (266, 31%) than in 1988 (57, 7%). This was due almost entirely to an explosion in the *Peromyscus maniculatus* population. Cliff chipmunks, *Tamias dorsalis*, also increased in the number of animals trapped from 1988 to 1993. Average number of captures per animal was similar for both years: 1.58 in 1988 and 1.52 in 1993. Species diversity (H') was significantly higher in 1988 (t_{134} = 8.262, $P < 0.0001$). This was most likely due to the nearly 10-fold increase in the most common rodent, *P. maniculatus*.

Table 10. Estimated density (N/ha ± 2 SE), percent of captured population (%T), and sex ratio (♂/♀) of small mammals captured on the Rainier Mesa baseline plot (RAM001) in 1988 and 1993. Numbers in parentheses are numbers of individuals.

SPECIES	2 - 4 August 1988			3 - 5 August 1993		
	N/HA (N)	%T	♂/♀	N/HA (N)	%T	♂/♀
PERPAR	* (1)	2.8	0/1	* (7)	4.0	3/4
PERTRU	1.5± 0 (5)	14.0	2/3	* (2)	1.1	1/1
PERSPP[a]	5.2±0.7 (16)	44.4	13/3	50.6±4.6 (142)	81.1	68/74
REIMEG	* (2)	5.6	1/1	---	---	---
TAMDOR	6.2±6.9 (8)	22.2	6/2	23.3±22.6 (23)	13.1	18/5
SYLNUT	* (4)	11.1	[b]	---	---	---
SPIPUT	---	---	---	* (1)	0.6	U[c]
TOTALS	11.1 (36)	100.1	22/10	54.0 (175)	99.9	90/84
SPECIES	6			5		
H'	0.6398			0.2803		

[a]*Peromyscus* species (except *P. truei*).

[b]Only juveniles of indeterminate sex were captured.

[c]Unknown, animal was not handled.

Table 11. Summer mean weights (gms ± 2 se) by sex and age (adult or juvenile) of rodents captured on the Rainier Mesa baseline plot in 1988 and 1993. Numbers in parentheses are numbers of individuals.

SPECIES		ADULT		JUVENILE	
		MALE	FEMALE	MALE	FEMALE
PERPAR	88	---	---	---	13.0 (1)
	93	---	---	14.3±3.5 (2)	13.0±1.4 (2)
PERSPP	88	17.5±2.9 (9)	21.0 (1)	13.5±2.5 (4)	12.5±4.2 (2)
PERMAN	93	19.3±0.9 (52)	20.5±1.0 (54)	15.1±0.7 (15)	14.6±0.8 (20)
PERTRU	88	---	26.5± 0 (2)	15.3±3.5 (2)	11.0 (1)
	93	---	18.0 (1)	13.0 (1)	---
TAMDOR	88	50.3±6.0 (6)	56.0 (1)	---	---
	93	51.9±1.4 (7)	57.8±8.3 (5)	46.2±1.2 (11)	---

BURNED AREAS

Two areas burned by lightning fires and one human-caused fire were studied in 1993.

Yucca Flat - YUF002

This study site on the southwestern edge of Yucca Flat is in the center of an area that was burned by a lightning-initiated fire on 24 June 1985. The area was first trapped for small mammals on 14-17 July 1987 on a 6 x 6 grid in the burned area and control and again on 22-24 July on four transect lines which extended 225 m into the burned area and continued for another 225 m into the unburned vegetation (Hunter and Medica 1989). In 1990, the 6 x 6 grid was enlarged to 8 x 8 to conform to the size of other BECAMP subsidiary study plots. This site was then trapped on 14-16 August 1990 and 7-9 July 1993, but only on the grids.

The estimated densities on the burned area and control decreased from 1987 to 1990, and species diversity decreased significantly on the control area (t_{49} = 4.445, $P < 0.0001$; Table 12). From 1990 to 1993 a significant increase in species diversity was found on both the burn (t_{53} = 3.077, $P = 0.00331$) and control (t_{49} = 6.014, $P < 0.001$).

Table 12. Estimated summer densities (N/Ha ± 2 SE) and species diversities (H') of small mammals captured on the Yucca Flat burn site and control in 1987, 1990, and 1993. Numbers in parentheses are individuals captured.

SPECIES	YUCCA FLAT BURN - YUF002			UNBURNED AREA - YUF003		
	1987[a]	1990	1993	1987[a]	1990	1993
CHAFOR	---	---	* (1)	* (2)	---	49.1±7.5 (61)
DIPMER	37.3±3.5 (52)	12.5± 0 (18)	52.2±6.0 (67)	14.7±2.8 (11)	10.6±2.1 (14)	36.6±3.7 (49)
DIPMIC	* (5)	---	10.4± 0 (15)	6.2±2.8 (5)	---	12.8±2.3 (17)
PERLON	37.7±22.1 (32)	6.3±4.4 (6)	* (5)	30.8±3.5 (24)	* (2)	* (6)
PERPAR	---	---	* (1)	---	---	* (1)
ONYTOR	* (2)	* (1)	18.8±16.4 (12)	* (2)	---	* (6)
PERMAN	---	---	---	---	---	* (1)
AMMLEU	---	---	* (7)	* (2)	---	* (6)
SYLAUD	---	---	---	* (1)	---	---
TOTALS	63.2 (91)	17.4 (25)	75.0 (108)	58.0 (47)	11.1 (16)	102.1 (147)
SPECIES	4	3	7	7	2	8
H'	0.4049	0.3074	0.5302	0.6108	0.1636	0.6255

[a]Density and number of individuals estimated for an 8x8 grid from data in Hunter and Medica 1989.

Although the density of *Dipodomys microps* was not initially high on the unburned area in 1987, this species was not captured at all in 1990 on either plot. In 1993, this species was again captured and in greater numbers than in 1987. This result was consistent with the decrease in number and even disappearance of this species from other plots on the NTS after 1988 and recovery in 1992.

In 1987, 98% of the captured population on the burned area consisted of three heteromyid species, while 89% of the control animals were heteromyid rodents (four species). The percent of the total captured population in 1990 was vastly different on the two sites when compared to 1987: 100% of the captured rodents on the control and 96% on the burn were only two species of heteromyids (Table 13). The most common species on the burned site in both years was *Dipodomys merriami*, which was also the most common species on the control in 1990. *Perognathus longimembris* was the most commonly captured species on the unburned in 1987, as it was in 1987 through 1991 on the Yucca Flat baseline site (Table 3). In 1993 the distribution of species on the control was similar to that in 1987 (91% from five heteromyid species). However, *Chaetodipus formosus* replaced *P. longimembris* as the most common species. The burned area in 1993 was still dominated by *D. merriami* although other species became established (82% from five heteromyid species). One additional species, *Peromyscus maniculatus*, was captured in 1987 on the transect line in the burned area (Hunter and Medica 1989) but was not captured in the undisturbed area either on the grid or the transect lines until 1993.

Sex ratios of the most common species did not differ significantly from 1:1 in any year (Table 14), except that five female and no male *D. microps* on the control in 1987 and six male and no female *P. longimembris* on the burned area in 1990 were captured. Mean weights were not significantly different between years, plot, or sex (Tables 15 a, b).

One note of interest: in 1990, the bait put into the traps in the evening at the control area was cleaned out of the traps during the night - by ants. The removal of the enticement to any rodents and the presence of ants in the traps might have affected trap success on the unburned area. An increase in *Onychomys torridus* numbers in 1993 might have been in response to the presence of large numbers of ants and other insects.

Table 13. Percent of total captured population of small mammals captured on the Yucca Flat burned site in 1987, 1990, and 1993.

SPECIES	BURNED AREA - YUF002			UNBURNED AREA - YUF003		
	1987	1990	1993	1987	1990	1993
CHAFOR	---	---	0.9	4.3	---	41.5
DIPMER	56.9	72.0	62.0	23.4	87.5	33.3
DIPMIC	5.9	---	13.9	10.6	---	11.6
PERLON	35.3	24.0	4.6	51.1	12.5	4.1
PERPAR	---	---	0.9	---	---	0.7
ONYTOR	2.0	4.0	11.1	4.3	---	4.1
PERMAN	---	---	---	---	---	0.7
AMMLEU	---	---	6.5	4.3	---	4.1
SYLAUD	---	---	---	2.1	---	---
TOTALS	100.1	100.0	99.9	100.0	100.0	100.1

Table 14. Sex ratio (♂/♀) of small mammals captured on the Yucca Flat burn plot and control in 1987, 1990, and 1993.

SPECIES	BURNED AREA - YUF002			UNBURNED AREA - YUF003		
	1987	1990	1993	1987	1990	1993
CHAFOR	---	---	0/1	2/0	---	36/25
DIPMER	17/12	7/11	27/40	8/3	7/7	28/21
DIPMIC	2/1	---	5/10	0/5	---	6/11
PERLON	10/8	6/0	3/2	14/10	0/2	1/5
PERPAR	---	---	0/1	---	---	0/1
ONYTOR	1/0	0/1	7/5	1/1	---	2/4
PERMAN	---	---	---	---	---	1/0
AMMLEU	---	---	3/3[a]	1/1	---	1/5
SYLAUD	---	---	---	[a]	---	---
TOTALS	30/21	13/12	45/62	26/20	7/9	75/62

[a]One animal of undetermined sex not included.

Table 15a. Summer mean weights (gms ± 2 se) by sex and age (adult or juvenile) of heteromyid rodents captured on the Yucca Flat burn plot in 1987, 1990, and 1993. Numbers in parentheses are numbers of individuals.

SPECIES		ADULT		JUVENILE	
		MALE	FEMALE	MALE	FEMALE
CHAFOR	93	---		---	15.0 (1)
PERLON	87	8.3±0.4 (10)	8.5±0.6 (8)	---	---
	90	8.6±0.5 (5)	---	6.0 (1)	---
	93	7.3±1.2 (3)	8.0 (1)	---	---
DIPMER	87	38.4±1.4 (13)	40.3±1.3 (9)	30.4±1.6 (4)	26.9±3.3 (3)
	90	40.4±1.4 (7)	37.5±2.0 (10)	---	32.0 (1)
	93	40.1±3.1 (9)	41.4±1.6 (19)	31.2±1.4 (18)	30.7±1.0 (21)
DIPMIC	87	61.0±14.0	---	---	46.0 (1)
	90	---	---	---	---
	93	53.3±4.5 (5)	54.7±5.9 (9)	---	47.0 (1)

Table 15b. Summer mean weights (gms ± 2 se) by sex and age (adult or juvenile) of heteromyid rodents captured on the Yucca Flat unburned plot in 1987, 1990, and 1993. Numbers in parentheses are numbers of individuals.

SPECIES		ADULT		JUVENILE	
		MALE	FEMALE	MALE	FEMALE
CHAFOR	93	20.2±0.6 (34)	19.4±0.7 (25)	14.5 (1)	---
PERLON	87	8.8±0.4 (14)	7.7±2.9 (10)	---	---
	90	---	8.0± 0 (2)	---	---
	93	8.0 (1)	7.4±2.3 (5)	---	---
DIPMER	87	40.7±4.3 (5)	39.0 (1)	30.6±1.1 (3)	27.3±3.5 (2)
	90	44.1±2.7 (5)	39.8±1.3 (7)	28.8±9.7 (2)	---
	93	41.5±1.7 (16)	40.0±2.1 (10)	31.4±1.2 (12)	30.7±1.4 (11)
DIPMIC	87	---	58.3±2.4 (3)	---	47.3±2.5 (2)
	90	---	---	---	---
	93	59.0±5.7 (6)	55.1±3.9 (9)	---	43.8±1.5 (2)

Mid Valley - MID002

A lightning-caused fire burned this area in Mid Valley on 20 July 1986. BECAMP set up small mammal study plots in this area in 1988, which consisted of a 15 x 5 grid extending into the burned area and a 15 x 5 grid extending into the unburned vegetation. This area was first trapped for small mammals on 3, 7, and 8 June 1988 and again on 4-6 June 1991 and 2-4 June 1993. Most of the species caught on the control site in 1988 were also captured on the burned area with the exception of a jackrabbit, *Lepus californicus* (one juvenile) and one western harvest mouse, *Reithrodontomys megalotis* (Table 16). In 1990, however, only two species were captured on the burned area and one species, *Perognathus parvus*, was captured for the first time on the control area. In 1993, rabbits and squirrels were trapped for the first time in the control, as was *Peromyscus eremicus*. *Neotoma lepida* was captured for the first time on both plots in 1993.

No one animal comprised more than 20% of the captured population on the unburned area in 1988, with the captured individuals evenly distributed between 5 species. In 1991 only heteromyids were captured on this plot. Only 4 species accounted for 93% of the captured individuals, with *D. microps* the most captured species (Table 17). One of the more common species in 1988, *P. maniculatus*, was not captured on either plot in 1991. In 1993 this site saw a near return to the 1988 species distribution.

On the burned area in 1988, 81% of the captured animals were *D. merriami* and *P. longimembris*, with no more than two individuals of any other species being captured. Most of the rodents in 1988 were captured in the traps closest to the undisturbed vegetation. In 1991, 100% of the captured rodents on the burned area were *D. merriami* and *P. longimembris*, and animals were captured throughout the entire grid. Only 55% of the animals captured in 1993 were the above two species, while five other species contributed to the remaining 45%.

Table 16. Estimated summer densities (N/ha ± 2 SE) and species diversities (H') of small mammals captured on the Mid Valley burn site and control in 1988, 1991, and 1993. Numbers in parentheses are individuals captured.

SPECIES	MID VALLEY BURN - MID002			UNBURNED AREA - MID003		
	1988	1991	1993	1988	1991	1993
CHAFOR	* (2)	---	---	* (3)	* (3)	---
DIPMER	8.0± 0 (15)	11.3±1.6 (18)	6.9±1.1 (11)	3.4±1.2 (5)	* (3)	* (4)
DIPMIC	* (1)	---	* (2)	3.6± 0 (6)	* (4)	9.4±3.3 (13)
PERLON	3.6± 0 (6)	* (1)	* (1)	3.6± 0 (6)	* (1)	4.9±2.1 (7)
PERPAR	---	---	* (3)	---	* (3)	4.1± 0 (7)
NEOLEP	---	---	* (2)	---	---	* (3)
ONYTOR	* (1)	---	* (2)	* (4)	---	* (4)
PERERE	---	---	---	---	---	3.0± 0 (5)
PERMAN	* (1)	---	* (1)	4.1±2.7 (5)	---	5.6±3.5 (8)
REIMEG	---	---	---	* (1)	---	* (1)
AMMLEU	---	---	---	---	---	* (1)
LEPCAL	---	---	---	* (1)	---	---
SYLAUD	---	---	---	---	---	* (1)
TOTALS	15.4 (26)	11.3 (19)	13.0 (22)	18.4 (31)	8.3 (14)	32.0 (54)
SPECIES	6	2	7	8	5	11
H'	0.5337	0.0895	0.6746	0.8408	0.6674	0.9309

Table 17. Percent of total captured population of small mammals captured on the Mid Valley burned site in 1988, 1991, and 1993.

SPECIES	BURNED AREA - MID002			UNBURNED AREA - MID003		
	1988	1991	1993	1988	1991	1993
CHAFOR	7.7	---	---	9.7	21.4	---
DIPMER	57.7	94.7	50.0	16.1	21.4	7.4
DIPMIC	3.8	---	9.1	19.4	28.6	24.1
PERLON	23.1	5.3	4.6	19.4	7.1	13.0
PERPAR	---	---	13.6	---	21.4	13.0
NEOLEP	---	---	9.1	---	---	5.6
ONYTOR	3.8	---	9.1	12.9	---	7.4
PERERE	---	---	---	---	---	9.3
PERMAN	3.8	---	4.6	16.1	---	14.8
REIMEG	---	---	---	3.2	---	1.9
AMMLEU	---	---	---	---	---	1.9
LEPCAL	---	---	---	3.2	---	---
SYLAUD	---	---	---	---	---	1.9
TOTALS	99.9	100.0	100.1	100.0	99.9	100.3

Species diversity (H', Table 16) decreased significantly on both plots between 1988 and 1991 (control: $t_{35} = 3.335$, $P = 0.00203$; burn: $t_{24} = 6.552$, $P < 0.0001$) and increased significantly from 1991 to 1993 (control: $t_{42} = 4.916$, $P < 0.0001$; burn: $t_{40} = 5.578$, $P < 0.0001$). H' on the control was significantly higher than on the burn in all three years (1988: $t_{52} = 7.454$, $P < 0.0001$; 1990: $t_{30} = 5.939$, $P < 0.0001$; 1993: $t_{31} = 2.820$, $P = 0.00830$). Species diversity on the undisturbed site was the highest of all sites studied in 1993.

Sex ratios (Table 18) did not differ significantly from 1:1 although nearly three times as many male as female *D. merriami* were captured in the burned area in 1988.

Table 18. Sex ratio (♂/♀) of small mammals captured on the Mid Valley burn plot and control in 1988, 1991, and 1993.

SPECIES	BURNED AREA - MID002			UNBURNED AREA - MID003		
	1988	1991	1993	1988	1991	1993
CHAFOR	1/1	---	---	2/1	2/1	---
DIPMER	4/11	12/6	6/5	3/2	1/2	2/2
DIPMIC	1/0	---	1/1	2/4	1/3	6/7
PERLON	3/3	0/1	0/1	3/3	1/0	4/3
PERPAR	---	---	2/1	---	3/0	5/2
NEOLEP	---	---	0/2	---	---	3/0
ONYTOR	0/1	---	1/1	1/3	---	2/2
PERERE	---	---	---	---	---	2/3
PERMAN	0/1	---	1/0	4/1	---	6/2
REIMEG	---	---	---	1/0	---	1/0
AMMLEU	---	---	---	---	---	0/1
LEPCAL	---	---	---	[a]	---	---
SYLAUD	---	---	---	---	---	[a]
TOTALS	9/17	12/7	11/11	16/14	8/6	31/22

[a]One animal of undetermined sex not included.

The percent trap successes on the two sites in 1988 were equal - 11%. In 1991, however, trap success on the burn (7%) was nearly twice that on the control plot (4%). Trap success did not increase appreciably on the burned area in 1993 (8%) but was nearly five times greater on the undisturbed area (19%). Individual animals were also captured a greater number of times on the burn than on the control in 1988 and 1991 (1.88 and 1.74 times on the burn and 1.55 and 1.21 times on the unburned area), but this was not the case in 1993 (1.55 on the burn and 1.57 on the control).

Mean weights were not significantly different between plots or years (Tables 19a and b).

Table 19a. Summer mean weights (gms ± 2 se) by sex and age (adult or juvenile) of heteromyid rodents captured on the Mid Valley burn plot in 1988 1991, and 1993. Numbers in parentheses are numbers of individuals.

SPECIES		ADULT		JUVENILE	
		MALE	FEMALE	MALE	FEMALE
CHAFOR	88	---	---	8.0 (1)	9.0 (1)
	91	---	---	---	---
	93	---	---	---	---
PERLON	88	8.2±2.0 (3)	10.0±3.1 (3)	---	---
	91	10.0 (1)	---	---	---
	93	---	10.0 (1)	---	---
PERPAR	88	---	---	---	---
	91	---	---	---	---
	93	22.0±11.3 (2)	20.0 (1)	---	---

Table 19b. Summer mean weights (gms ± 2 se) by sex and age (adult or juvenile) of heteromyid rodents captured on the Mid Valley unburned plot in 1988, 1991, and 1993. Numbers in parentheses are numbers of individuals.

SPECIES		ADULT		JUVENILE	
		MALE	FEMALE	MALE	FEMALE
CHAFOR	88	21.8±9.0 (2)	19.0 (1)	---	---
	91	19.0±8.5 (2)	17.0 (1)	---	---
	93	---	---	---	---
PERLON	88	8.3±0.7 (3)	9.5±1.0 (2)	---	6.0 (1)
	91	10.5 (1)	---	---	---
	93	9.0±0.8 (4)	9.4±0.6 (3)	---	---
PERPAR	88	---	---	---	---
	91	22.8±6.6 (3)	---	---	---
	93	23.3±3.0 (5)	20.3±7.3 (2)	---	---
DIPMER	88	41.0±2.0 (3)	38.7±6.7 (2)	---	---
	91	49.0 (1)	40.5±2.0 (2)	---	---
	93	46.0±4.0 (2)	43.0±2.0 (2)	---	---
DIPMIC	88	67.5 (1)	64.0 (1)	28.5 (1)	37.2±8.4 (3)
	91	79.0 (1)	74.7 (1)	---	44.5±1.0 (2)
	93	65.6±10.0 (5)	51.8±4.8 (3)	---	37.8±5.8 (4)

Redrock Valley - RED001

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), 24-25 August 1988 (one month after the fire), 25-27 October (3 months), 25-27 July 1989 (one year), 31 July - 2 August 1990 (two years), 14-16 July 1992 (four years), and 27-29 July 1993 (five years after the fire). With the exception of August 1988, all were 420 trap nights. 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 *Psorothamnus polydenius*, *Ephedra nevadensis*, and *Atriplex canescens*. After the fire, several *Atriplex canescens* and *Ephedra nevadensis* (perennial shrubs) survived in isolated patches, but the area was immediately invaded by *Salsola australis*. Indian rice grass, *Oryzopsis hymenoides*, crown-sprouted one year after the fire and was present on the burned area in 1992. 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 an unburned control area for 1988, 1989, 1990, 1992, and 1993 are given in Tables 20a (RED001) and 20b (RED002). 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 and 1993. 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, 1992, or 1993. 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 and on the burn in 1993). *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 grasshoppers and ants on this site (personal observation). An additional species, a gopher, *Thomomys bottae*, was captured on the burned area on 9 July 1992. *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_{45} = 3.115, P = 0.00320) and increased in 1992 (t_{42} = 1.504, P = 0.140) and 1993 (t_{208} = 0.823, P = 0.411). H' on the burned site in 1992 was significantly lower than H' in 1988 (t_{96} = 2.878, P = 0.00493). Although H'

Table 20a. Estimated density (N/ha ± 2 SE) and species diversity (H') of small mammals on the Redrock burned area (RED001) in 1988, 1989, 1990, 1992 and 1993. Numbers in parentheses are individuals captured.

SPECIES	1988 26-28 JUL	1988 24-25 AUG	1988 25-27 OCT	1989 25-27 JUL	1990 31 JUL-2 AUG	1992 14-16 JUL	1993 27-29 JUL
CHAFOR	* (2)	---	---	---	---	---	---
DIPMER	15.5±1.0 (24)	21.5±0.6 (34)	22.6±2.0 (34)	19.7±0.3 (31)	14.1±0.7 (22)	48.4±4.9 (69)	49.7±2.9 (75)
DIPMIC	* (3)	7.5±1.6 (11)	6.3± 0 (11)	6.8±3.5 (8)	* (1)	6.0±2.3 (8)	3.8± 0 (6)
DIPORD	---	* (4)	* (2)	4.8±0.9 (7)	* (3)	* (3)	6.8±3.5 (8)
PERLON	4.1±2.5 (5)	* (1)	---	* (1)	---	---	---
PERPAR	4.4± 0 (7)	6.8±3.5 (8)	---	* (3)	---	---	* (2)
ONYTOR	* (1)	* (1)	---	* (5)	---	7.0±3.1 (9)	* (1)
PERMAN	* (4)	* (2)	---	* (1)	* (1)	6.5±1.9 (9)	9.5± 0 (15)
AMMLEU	---	---	---	---	---	---	* (2)
SYLAUD	---	---	---	---	---	---	* (1)
TOTALS	29.2 (46)	38.7 (61)	29.2 (46)	35.6 (56)	17.1 (27)	62.2 (98)	69.8 (110)
SPECIES	7	7	3	6	4	5	8
H'	0.6415	0.5761	0.3003	0.6000	0.2845	0.4302	0.4835

Table 20b. Estimated density (N/ha ± 2 SE) and species diversity (H') of small mammals on the Redrock unburned area (RED002) in 1988, 1989, 1990, 1992 and 1993. Numbers in parentheses are individuals captured.

SPECIES	1988 26-28 JUL	1988 24-25 AUG	1988 25-27 OCT	1989 25-27 JUL	1990 31 JUL-2 AUG	1992 14-16 JUL	1993 27-29 JUL
CHAFOR	* (1)	---	* (1)	---	---	* (1)	---
DIPMER	20.7± 0 (31)	19.6±2.3 (29)	20.8±1.3 (32)	23.8±1.3 (36)	20.7±2.1 (31)	33.1±3.0 (49)	35.1±1.7 (54)
DIPMIC	8.3±6.1 (8)	5.9±0.8 (9)	12.2±0.6 (19)	10.4±0.8 (16)	5.7± 0 (9)	15.7±2.3 (23)	10.8± 0 (17)
DIPORD	---	---	---	---	---	* (2)	* (1)
PERLON	3.8± 0 (6)	* (1)	---	4.4±1.8 (6)	* (2)	---	* (4)
PERPAR	5.3±2.2 (7)	* (3)	---	3.2± 0 (5)	---	5.3±2.2 (7)	5.2±0.5 (8)
NEOLEP	---	---	---	---	---	* (1)	* (1)
ONYTOR	---	* (1)	* (3)	* (1)	* (3)	6.0±2.3 (8)	* (4)
PERMAN	* (3)	* (2)	* (3)	* (3)	* (1)	5.1± 0 (8)	10.8±5.4 (12)
REIMEG	---	---	* (1)	---	---	---	---
AMMLEU	---	---	---	---	---	* (1)	* (3)
SYLAUD	* (4)	---	* (1)	---	---	---	---
TOTALS	38.1 (60)	28.6 (45)	38.1 (60)	42.5 (67)	29.2 (46)	63.5 (100)	66.0 (104)
SPECIES	7	6	7	6	5	9	9
H'	0.6468	0.4747	0.5228	0.5591	0.4268	0.6487	0.6623

also decreased on the control from 1989 to 1990, it was not significant (t_{93} = 1.697, P = 0.0930). An increase on the control in 1992 was, however, significant (t_{92} = 2.985, P = 0.00363), but not in 1993 (t_{204} = 0.222, P > 0.50). Species diversity was significantly lower on the burned area in 1992 than on the undisturbed area (t_{197} = 3.584, P = 0.000427). In 1993 the same [illegible] (t[illegible] = 2.743, P = 0.00662).

The number of individuals captured on both plots was highest in 1993 and lowest in 1990. Trap success was higher on the burned area in 1992 (42%) and 1993 (50%) than on the undisturbed plot (43% in 1992 and 47% in 1993). Trap success was only 16% in 1990 on the burned plot and 23% on the control. Trap success on the control plot was equal or greater than on the burned area in all years and significantly greater in 1990 (x^2 = 5.824, P = 0.0158).

Dipodomys merriami comprised at least 50% of the total captured population on both sites in 1988, 1989, 1990, and 1992 (Table 21a and b). 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 22 a and b). 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, P = 0.00115). Only male *D. ordii* were captured in 1993 on the burn and control plots.

Comparing July mean weights for the five years studied, female adult *D. merriami* captured on the burned area were significantly heavier in 1992 than the other four years ($F_{4,57}$ = 10.00, P < 0.001), while males did not differ on the burn between years ($F_{4,66}$ = 0.15, P = 0.964). On the unburned area, adult females showed a significant difference between years ($F_{4,71}$ = 6.44, P < 0.001) with 1992 mean weight significantly heavier than 1989 and 1993 (Newman-Keuls multiple range test).

Female *D. merriami* captured on the burn plot in 1992 were significantly heavier than males (Table 23a), and appeared to be in the later stages of pregnancy (Saethre 1994a). Burn females were also significantly heavier than females on the undisturbed site. On the undisturbed area female and male weights were not significantly different in 1992. However, several neonates were discovered in the traps with females and a large number of juveniles were captured in 1992 (Tables 23a, 23b, and 24). This clearly indicated reproduction occurring at both plots in 1992, with possibly a slight lag on the burned area.

Table 21a. Percent of total captured population of small mammals captured on the Redrock Valley burned site in 1988, 1989, 1990, 1992, and 1993.

SPECIES	1988 26-28 JUL	1988 24-25 AUG	1988 25-27 OCT	1989 25-27 JUL	1990 31 JUL-2 AUG	1992 14-16 JUL	1993 27-29 JUL
CHAFOR	4.35	---	---	---	---	---	---
DIPMER	52.2	55.7	73.9	55.4	81.5	70.4	68.2
DIPMIC	6.5	18.0	21.8	14.3	3.7	8.2	5.5
DIPORD	---	6.6	4.4	12.5	11.1	3.1	7.3
PERLON	10.9	1.6	---	1.8	---	---	---
PERPAR	15.2	13.1	---	5.4	---	---	1.8
ONYTOR	2.2	1.6	---	8.9	---	9.2	0.9
PERMAN	8.7	3.3	---	1.8	3.7	9.2	13.6
AMMLEU	---	---	---	---	---	---	1.8
SYLAUD	---	---	---	---	---	---	0.9
TOTALS	100.1	99.9	100.1	100.1	100.0	100.1	100.0

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Table 21b. Percent of total captured population of small mammals captured on the Redrock Valley unburned site in 1988, 1989, 1990, 1992, and 1993.

	1988	1988	1988	1989	1990	1992	1993

Table 22a. Sex ratio (♂/♀) of small mammals captured on the Redrock Valley burned site in 1988, 1989, 1990, 1992, and 1993.

SPECIES	1988 26-28 JUL	1988 24-25 AUG	1988 25-28 OCT	1989 25-27 JUL	1990 31 JUL-2 AUG	1992 14-16 JUL	1993 27-29 JUL
CHAFOR	1/1	---	---	---	---	---	---
DIPMER	14/10	17/17	17/17	15/16	10/12	48/21	30/45
DIPMIC	2/1	5/6	6/4	2/6	0/1	5/3	5/1
DIPORD	---	2/2	0/2	4/2[a]	2/1	1/2	8/0
PERLON	3/2	0/1	---	0/1	---	---	---
PERPAR	2/4[a]	5/3	---	3/0	---	---	1/1
ONYTOR	[a]	1/0	---	1/4	---	3/6	0/1
PERMAN	3/1	2/0	---	1/0	0/1	6/3	10/5
AMMLEU	---	---	---	---	---	---	0/1[a]
SYLAUD	---	---	---	---	---	---	0/1
TOTALS	25/19	32/29	23/23	26/29	12/15	63/35	54/55

[a]One animal of undetermined sex not included.

Table 22b. Sex ratio (♂/♀) of small mammals captured on the Redrock Valley unburned site in 1988, 1989, 1990, 1992, and 1993.

SPECIES	1988 26-28 JUL	1988 24-25 AUG	1988 25-27 OCT	1989 25-27 JUL	1990 31 JUL-2 AUG	1992 14-16 JUL	1993 27-29 JUL
CHAFOR	0/1	---	0/1	---	---	1/0	---
DIPMER	18/13	15/14	18/14	17/19	14/17	22/27	26/28
DIPMIC	5/3	4/5	11/8	4/12	3/6	14/9	11/6
DIPORD	---	---	---	---	---	0/1[a]	1/0
PERLON	3/3	0/1	---	0/6	2/0	---	2/2
PERPAR	3/4	1/2	---	4/1	---	3/4	4/4
NEOLEP	---	---	---	---	---	1/0	1/0
ONYTOR	---	1/0	1/2	1/0	1/2	4/4	2/2
PERMAN	2/1	2/0	3/0	1/2	0/1	5/3	9/3
REIMEG	---	---	1/0	---	---	---	---
AMMLEU	---	---	---	---	---	0/1	3/0
SYLAUD	[b]	---	[b]	---	---	---	---
TOTALS	31/24	23/22	34/25	27/40	20/26	50/49	59/45

[a]One animal of undetermined sex no included.

[b]Only juveniles of indeterminate sex were captured.

In 1993, adult females were again significantly heavier on the burned area than the control ($F_{1,41}$ = 4.66, P = 0.037). There was no significant difference between mean weights of males on the two sites in 1993 ($F_{1,28}$ = 0.11, P = 0.746).

Table 23a. Summer mean weights (gms ± 2 se) by sex and age (adult or juvenile) of heteromyid rodents captured on the Redrock Valley burn plot in 1988, 1989, 1990, 1992, and 1993. Numbers in parentheses are individuals.

SPECIES		ADULT		JUVENILE	
		MALE	FEMALE	MALE	FEMALE
PERLON	88	8.0±1.2 (3)	6.5±1.0 (2)	---	---
	89	---	8.0 (1)	---	---
PERPAR	88	20.0±1.0 (2)	18.5 (1)	8.8±0.7 (2)	9.0 (1)
	89	20.7±2.2 (3)	---	---	---
	93	16.5 (1)	18.0 (1)	---	---

Male *D. merriami* captured on the burned area in 1989 were significantly heavier than females (Saethre 1994a). However, on the control plot 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 (ANOVA, P > 0.05).

Table 23b. Summer mean weights (gms ± 2 se) by sex and age (adult or juvenile) of heteromyid rodents captured on the Redrock Valley unburned plot in 1988, 1989, 1990, 1992, and 1993. Numbers in parentheses are numbers of individuals.

SPECIES		ADULT		JUVENILE	
		MALE	FEMALE	MALE	FEMALE
PERLON	88	7.0 (1)	8.0±1.2 (3)	6.5±1.0 (2)	---
	89	---	8.2±2.2 (6)	---	---
	93	7.5±1.4 (2)	8.0± 0 (2)	---	---
PERPAR	88	29.0 (1)	18.0±6.0 (3)	9.5 (1)	---
	89	20.1±4.6 (4)	15.0 (1)	---	---
	93	17.4±1.6 (4)	16.0±1.6 (4)	---	---
DIPMER	88	40.0±3.2 (11)	43.1±1.9 (10)	27.3±1.7 (7)	26.9±3.0 (3)
	89	40.8±2.4 (10)	38.9±1.1 (9)	31.2±7.8 (7)	29.7±8.8 (10)
	90	41.7±1.5 (12)	40.7±2.9 (13)	32.3±0.5 (2)	31.7±2.7 (4)
	92	43.9±2.2 (14)	44.8±3.7 (20)	28.8±2.3 (6)	24.1±2.5 (8)
	93	41.6±2.1 (13)	38.3±1.7 (18)	29.1±1.7 (13)	28.9±1.7 (10)
DIPMIC	88	58.4±8.2 (5)	54.3±9.3 (3)	---	---
	89	60.4±5.6 (4)	53.9±2.6 (11)	---	---
	90	61.0±4.4 (3)	57.3±5.2 (6)	---	---
	92	57.7±7.0 (8)	57.9±7.4 (5)	41.9±2.8 (6)	40.8±6.4 (3)
	93	62.2±4.4 (11)	60.4±4.4 (6)	---	---
DIPORD	92	---	44.0 (1)	---	----
	93	43.0 (1)	---	---	---
PERMAN	93	17.1±3.0 (4)	22.0 (1)	11.7±0.9 (5)	12.5±3.0 (2)

Table 24. Distribution of *Dipodomys merriami* on the Redrock plots by weight class.

		1988	1989	1990	1992	1993
BURNED AREA	<20	0	2	0	8	1
	20-<25	4	1	2	9	8
	25-<30	3	3	3	11	16
	30-<35	5	5	1	8	9
	35-<40	4	9	8	4	16
	40-<45	7	6	6	12	16
	≥45	1	5	2	17	9
UNBURNED	<20	0	0	0	1	0
	20-<25	3	2	0	3	3
	25-<30	6	3	1	5	11
	30-<35	4	11	6	7	12
	35-<40	2	10	11	7	16
	40-<45	12	7	12	8	8
	≥45	4	3	2	17	4

It appeared in 1992 and 1993 that reproduction on the undisturbed area was occurring later than on the burned area. This may be inferred from the lower mean weight of females on the control. A greater percentage of juveniles and immature animals were also captured on the burned area in both years (Tables 26a, 26b, and 27), which may also indicate a lag of growth from an earlier litter. No real conclusions should be made from trapping an area for such a short period of time and only once during the season.

BLADED AREA - PAM006

A rectangular area of approximately 2 hectares in the pinyon-juniper habitat of Pahute Mesa was cleared of all vegetation in 1979 or 1980 in preparation as a staging area for an underground test (U19ac). South of the scraped area is roped off as a potential crater area. An 8 x 8 plot in the scraped area was trapped for small mammals for the first time on 13-15 July 1993. Another 8 x 8 plot in undisturbed pinyon-juniper habitat approximately 400 m to the east of the bladed area was concurrently trapped. Elevation for this site is approximately 2134 m. Vegetation was first measured at these sites in 1991 (Hunter 1994a, 1994b). The perennial bunch grasses *Oryzopsis hymenoides* and *Stipa comata* were most prevalent on the drill pad, as was *Salsola australis*.

Dipodomys ordii continued to be associated with disturbed areas as it was captured only on the cleared area (Table 24). This species has only been captured in recent years on another bladed area of Pahute Mesa and the Redrock areas (Saethre and Medica 1992; Saethre 1994a, 1994b; Tables 20 a and b). The density of *Peromyscus maniculatus* on the undisturbed area was similar to that on Rainier Mesa in 1993 (Table 10, 50.6 $\pm$ 4.6). The Pahute Mesa area was not as rocky or as sloped as the Rainier Mesa site and junipers were more sparse on the Rainier Mesa plot. *Perognathus parvus* also appeared to fare well on the cleared area along with *P. maniculatus* and *D. ordii*. Consequently, species diversity on the clearing was higher than in the woods.

The capture of cliff chipmunks (*Tamias dorsalis*) at these sites extends the known range for this species on the NTS. Previously, chipmunks and rock squirrels (*Spermophilus variegatus*) were captured or observed only on Rainier Mesa. Several rock squirrels were observed on the road to PAM006 and PAM007 and a special effort was made to capture them. In nearly 200 trapnights, only three adult rock squirrels were captured (2 males and one female) confirming their presence on Pahute Mesa.

Table 24. Estimated density (N/ha ± 2 SE), percent of total captured population (%T), and sex ratio (♂/♀) of small mammals captured on the Pahute Mesa bladed area (PAM006) and undisturbed area (PAM007) 13-15 July, 1993. Numbers in parentheses are individuals captured.

SPECIES	BLADED AREA (PAM006)			UNDISTURBED AREA (PAM007)		
	N/HA (N)	%T	♂/♀	N/HA (N)	%T	♂/♀
DIPORD	24.3±12.7 (21)	29.6	12/9	---	---	---
PERPAR	10.2±2.5 (13)	18.3	8/5	6.3±0.5 (9)	11.7	4/5
PERMAN	26.8±5.2 (33)	46.5	14/19	53.8±10.2 (61)	79.2	31/30
REIMEG	* (1)	1.4	0/1	---	---	---
TAMDOR	* (3)	4.2	1/2	* (5)	6.5	1/4
SYLNUT	---	---	---	* (2)	2.6	1/1
TOTALS	49.3 (71)	100.0	35/36	53.5 (77)	100.0	37/40
SPECIES	5			4		
H'	0.5303			0.3074		

Table 25a. Summer mean weights (gms $\pm$ 2 se) by sex and age (adult or juvenile) of rodents captured on the Pahute Mesa bladed area in 1993. Numbers in parentheses are individuals weighed.

SPECIES		ADULT		JUVENILE	
		MALE	FEMALE	MALE	FEMALE
DIPORD	93	41.9$\pm$2.5 (12)	43.9$\pm$3.9 (8)	---	33.0 (1)
PERPAR	93	17.0$\pm$1.0 (6)	---	15.5$\pm$1.0 (2)	13.3$\pm$1.2 (5)
PERMAN	93	16.6$\pm$1.3 (4)	19.4$\pm$2.4 (9)	12.3$\pm$0.8 (10)	12.0$\pm$0.8 (10)

Table 25b. Summer mean weights (gms $\pm$ 2 se) by sex and age (adult or juvenile) of rodents captured on the Pahute Mesa undisturbed area in 1993. Numbers in parentheses are individuals weighed.

SPECIES		ADULT		JUVENILE	
		MALE	FEMALE	MALE	FEMALE
PERPAR	93	18.3$\pm$1.5 (2)	17.9$\pm$2.5 (3)	11.5$\pm$6.0 (20	11.2$\pm$6.3 (2)
PERMAN	93	16.9$\pm$1.1 (14)	19.2$\pm$1.3 (14)	12.2$\pm$0.9 (17)	11.7$\pm$0.9 (16)

Roadside Disturbance

Two roadside areas were studied in 1993: a moderately used, paved road in southern Frenchman Flat (5-05 road) and the paved access road to the Device Assembly Facility (DAF). The DAF was in pre-operational phase during 1993 with construction and support as the main vehicular traffic. Results from the DAF study are detailed in Woodward et al. (in press).

The 5-05 roadside study area was set up in 1989 to determine what effect a roadside might have on plant and animal populations. The traplines for monitoring small mammal populations outside of the Liquefied Gaseous Fuels Spill Test Facility (LGF) in southern Frenchman Flat were fortuitously trapped during the drought of 1989. At the control line next to the road it was found that most of the female kangaroo rats inhabiting the roadside area were pregnant or lactating (Hunter et al. 1991). Most other sites trapped in 1989, including a second control at the LGF away from any roads, showed a lack of reproductive females. Trap success was also quite high compared to the other LGF sites.

After one night of trapping in mid-July 1989, the 5-05 roadside line and control showed no difference in trap success, species composition, or reproductive status. It was thought that any reproductive activity may have been missed, therefore the lines were trapped monthly in 1990 from March through August. In 1993, this site was trapped 25-27 May, 15-17 June, 13-15 July and 10-12 August.

Heteromyids are relatively long-lived rodents and survival of adults through adverse conditions such as drought is favored over replacement by juveniles (Brown and Harney 1993; Zeng and Brown 1987b). Merriam's kangaroo rats are known for having an opportunistic reproductive ability and a rapid response to favorable environmental conditions (Kenagy and Bartholomew 1985; Zeng and Brown 1987a). As such, the roadside might represent a refugium from drought, possibly through the greater volume of vegetation next to the road as compared to distant from the road (Lightfoot and Whitford 1992).

In 1990 there were significantly more *D. merriami* captured on the roadside than the control 500 m away (Saethre 1994a). A significant increase in the mean weight of adult females was also found on the roadside between March and May, coincident with an increased percentage of females that were rated as pregnant. Females on the control showed little or no increase in mean weight during this same period. Juvenile *D. merriami* were captured two months earlier on the roadside and trap success was consistently higher on the roadside line (Saethre 1994a).

In 1993 it appeared that the roadside animals did not gain any benefit from location. Trap success was initially 4% higher on the control after trapping

Table 26. Species and number of individual rodents captured at the Frenchman Flat 5-05 roadside and control lines in 1993 (top) and corresponding month in 1990 (bottom).

	ROADSIDE (FRF003) 1993				CONTROL (FRF004) 1993			
SPECIES	MAY	JUNE	JULY	AUGUST	MAY	JUNE	JULY	AUGUST
CHAFOR	14	34	44	17	10	9	16	10
DIPMER	68	89	95	68	73	118	125	81
DIPMIC	---	---	---	---	1	2	---	---
PERLON	2	9	7	20	4	4	18	16
NEOLEP	1	1	2	---	1	5	2	---
ONYTOR	1	---	1	---	1	2	---	---
PERERE	---	1	1	---	---	---	---	---
PERMAN	---	---	---	---	1	---	---	---
AMMLEU	4	---	1	5	---	---	1	13
TOTAL	90	134	151	110	91	140	162	120
% SUCCESS	26.4	57.3	63.6	53.0	30.2	53.8	63.8	53.0
TRAP DAYS	450	450	450	372	450	450	450	372
	1990				1990			
CHAFOR	---	1	1	2	---	---	---	---
DIPDES	---	---	---	---	---	---	1	---
DIPMER	40	45	41	33	25	25	31	18
PERLON	17	28	12	11	25	24	16	18
ONYTOR	---	---	---	---	---	---	---	---
PERMAN	---	---	---	---	1	---	---	---
AMMLEU	1	---	--	---	1	---	---	---
SPETER	2	1	---	---	---	---	---	---
TOTAL	60	75	54	46	52	49	48	36
% SUCCESS	23.5	29.5	27.2	25.3	19.8	18.1	23.8	16.1
TRAP DAYS	404	404	202	372	404	404	202	372

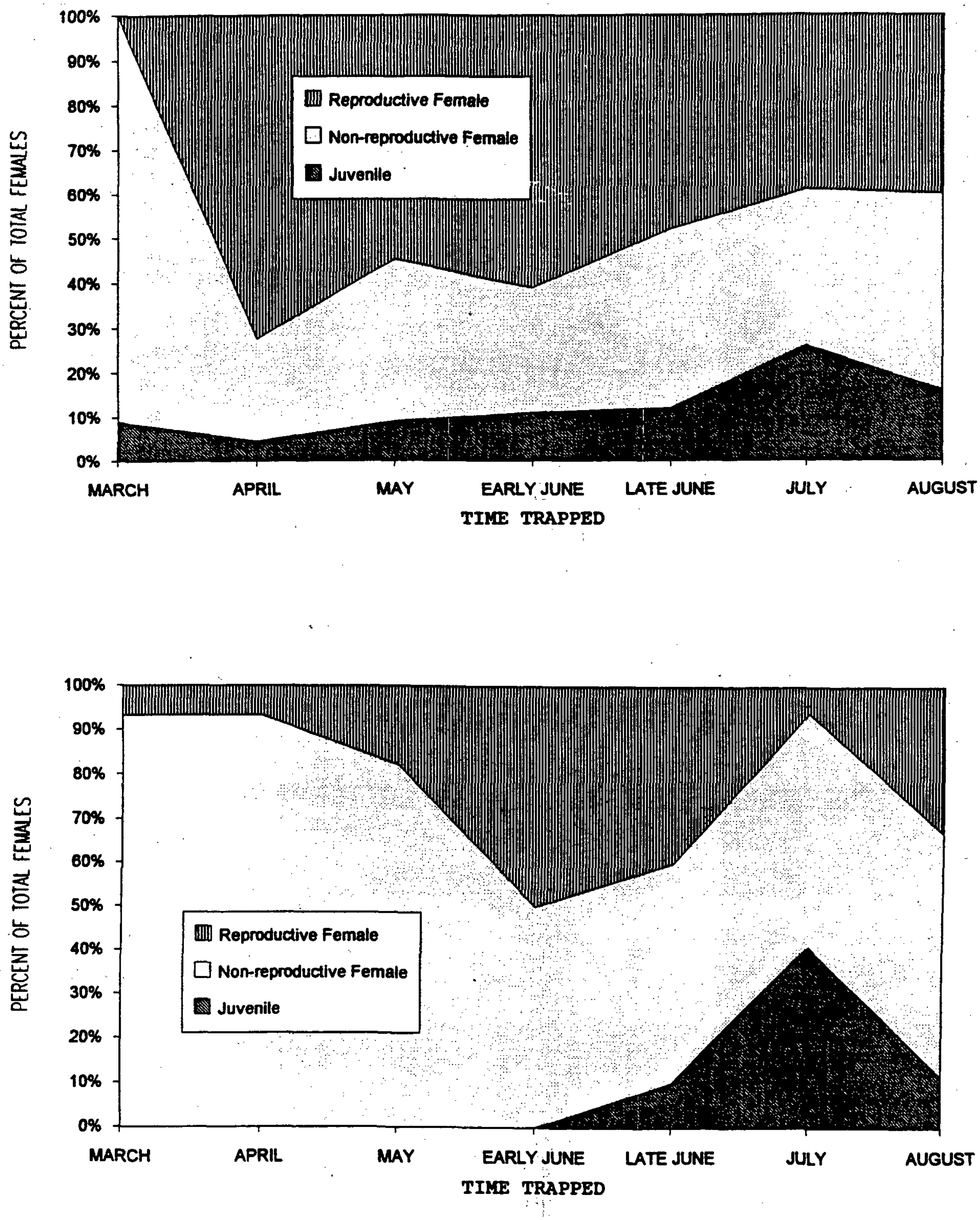

Figure 5 - Reproductive status of female *D. merriami* at the Frenchman Flat 5-05 roadside (top) and control (bottom) in 1990.

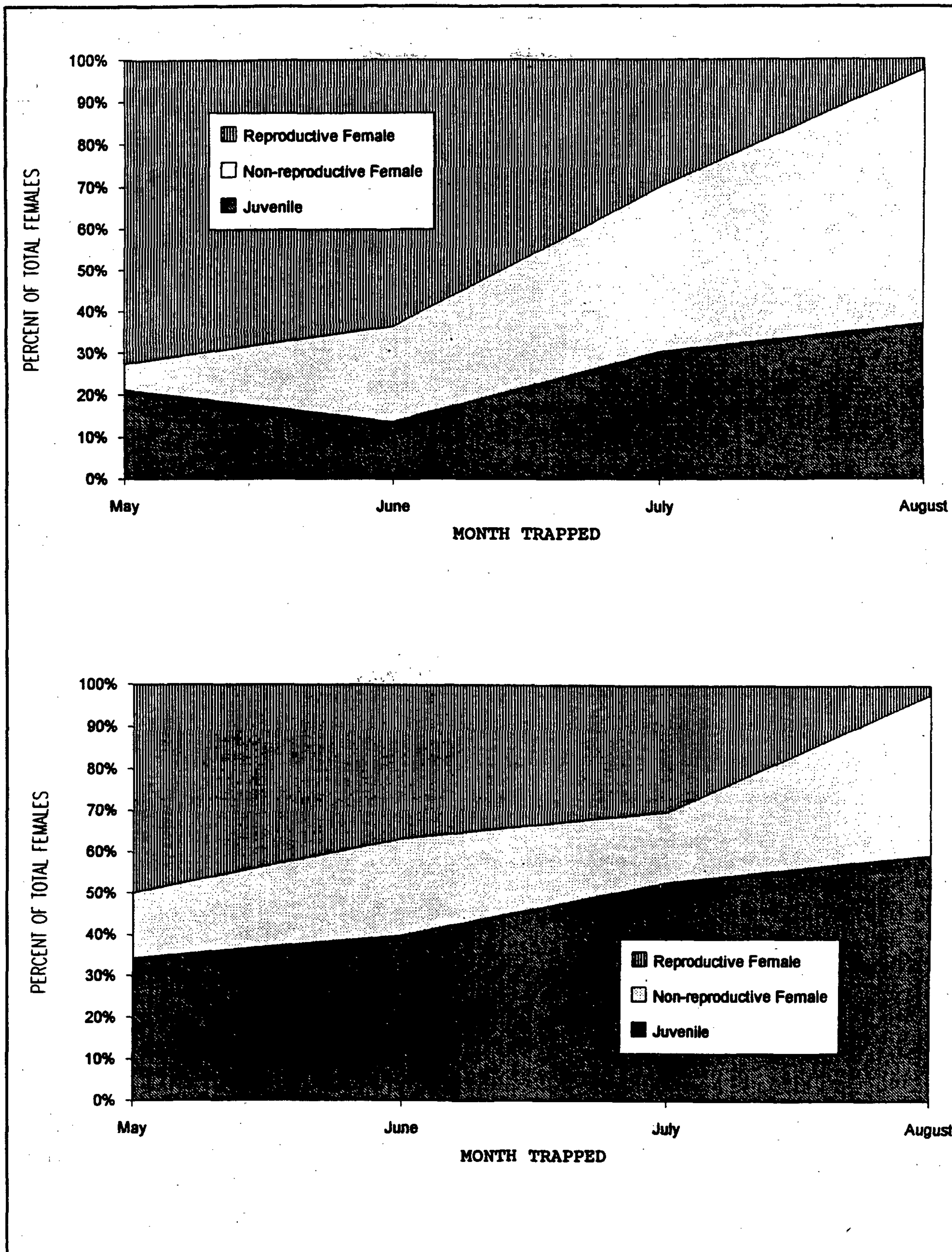

Figure 6 - Reproductive status of female *D. merriami* at the Frenchman Flat 5-05 roadside (top) and control (bottom) in 1993.

supply of food (see Hunter this report), which negated or overwhelmed any benefits derived from the roadside. To further support no difference in reproduction between the two sites in 1993, oneway analysis of variance on the weights of females captured at the two sites and four months were significantly different between months sampled ($F_{7,231} = 20.53$, $P < 0.0001$; Figure 7). Adult males showed the identical trend at the two sites.

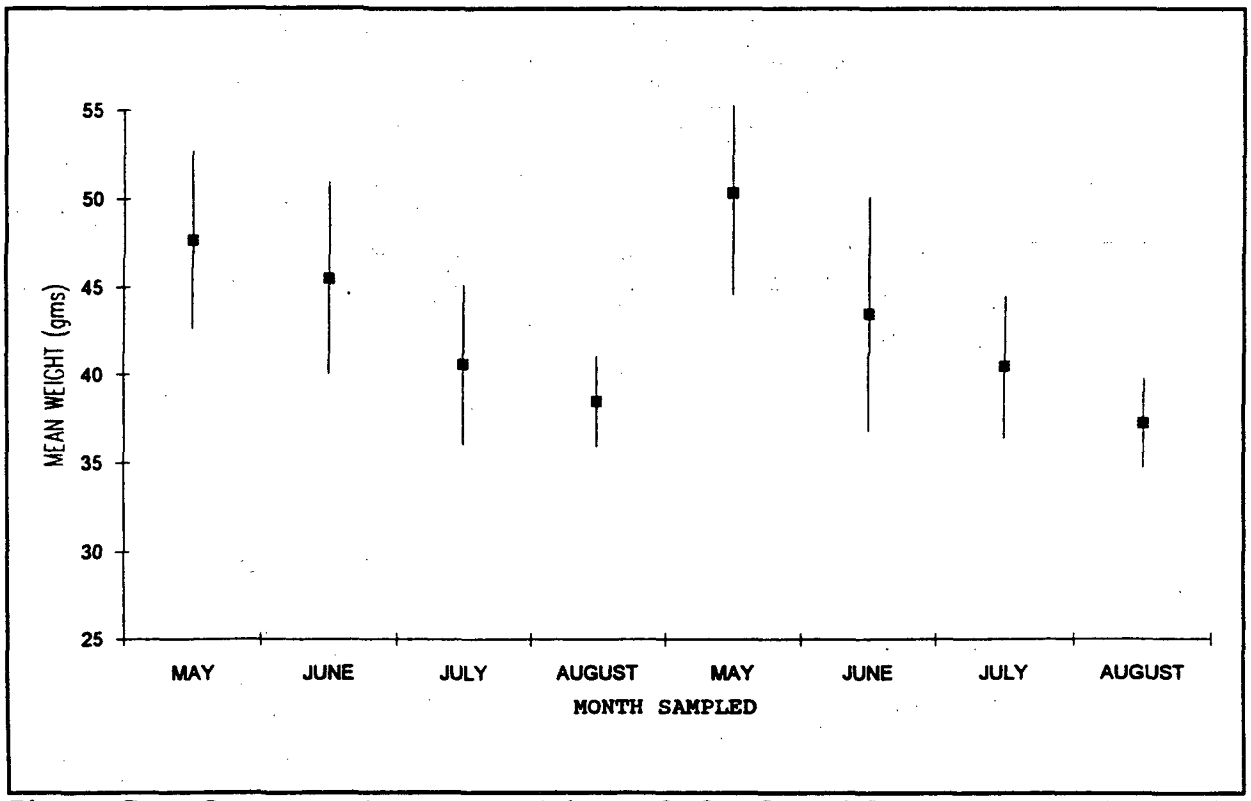

Figure 7 - Decrease in mean weights of female adult *D. merriami* at the Frenchman Flat 5-05 roadside and control.

Bat Surveys

Results from the two water sources are still preliminary as not all of the voucher specimens collected have been identified. Thirteen bats were captured in the nets on two nights at well 19c and 29 were captured at Gold Meadows sump. Wind was a factor in the low number of captures at 19c while intermittent rain showers affected net success at Gold Meadows. *Plecotus townsendii* and *Pipistrellus hesperus* were common to both sites, while *Antrozous pallidus* was captured only at Gold Meadows and *Eptesicus fuscus* was unique to 19c. At least three species of *Myotis* were captured at Gold Meadows and two at 19c. Three bats escaped before any identification could be made. No spotted bats (*Euderma maculatum*) were captured at either location although 19c is near a site where their vocalizations were recorded (EG&G/EM 1993).

Presence of Hantavirus

Eighteen rodents were captured on the Pahute Mesa site and 42 on Rainier Mesa. Seventeen of 18 animals on Pahute Mesa were *Peromyscus maniculatus*, of which four were seropositive for hantavirus antibodies. The other rodent, a *Perognathus parvus*, was seronegative. On Rainier Mesa, ten of the 40 *P. maniculatus* were seropositive. One *P. parvus* was negative. None of the 497 animals with sufficient blood from Yucca Mountain were positive. However, most animals captured at YMP were heteromyids - *Dipodomys*, *Perognathus*, and *Chaeotodipus* (EG&G/EM 1994) - which are not likely carriers of hantavirus.

These results indicate that where large numbers of *P. maniculatus* occur, approximately 25% can be expected to test positive for hantavirus. This species was most prevalent in 1993 on the mesas (27 to 54/ha) and Redrock Valley (10 to 11/ha) but very few were captured at other locations. Sites where NTS personnel are concentrated do not overlap with areas of high *P. maniculatus* densities.

DISCUSSION

Baseline Sites

It is clear that most sites have recovered from drought conditions in less than two years. However, results at the Yucca Flat baseline site suggest the little pocket mouse (*Perognathus longimembris*) continues to struggle to resume pre-drought densities. It is possible that the relatively long life-span of this species (French et al. 1967, 1974; Zeng and Brown 1987a), while contributing to its survival, was undermined by a lack of reproductive output or high dispersal from this site in 1989 and 1990. However, this species showed a decline on every site censused on the NTS, suggesting that the decline was due to a factor other than dispersal.

Lack of recruitment either from immigrants or juveniles is supported by the fact that no animals captured in 1990 or 1991 were recaptured at this site one and two years later (Figure 8). 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

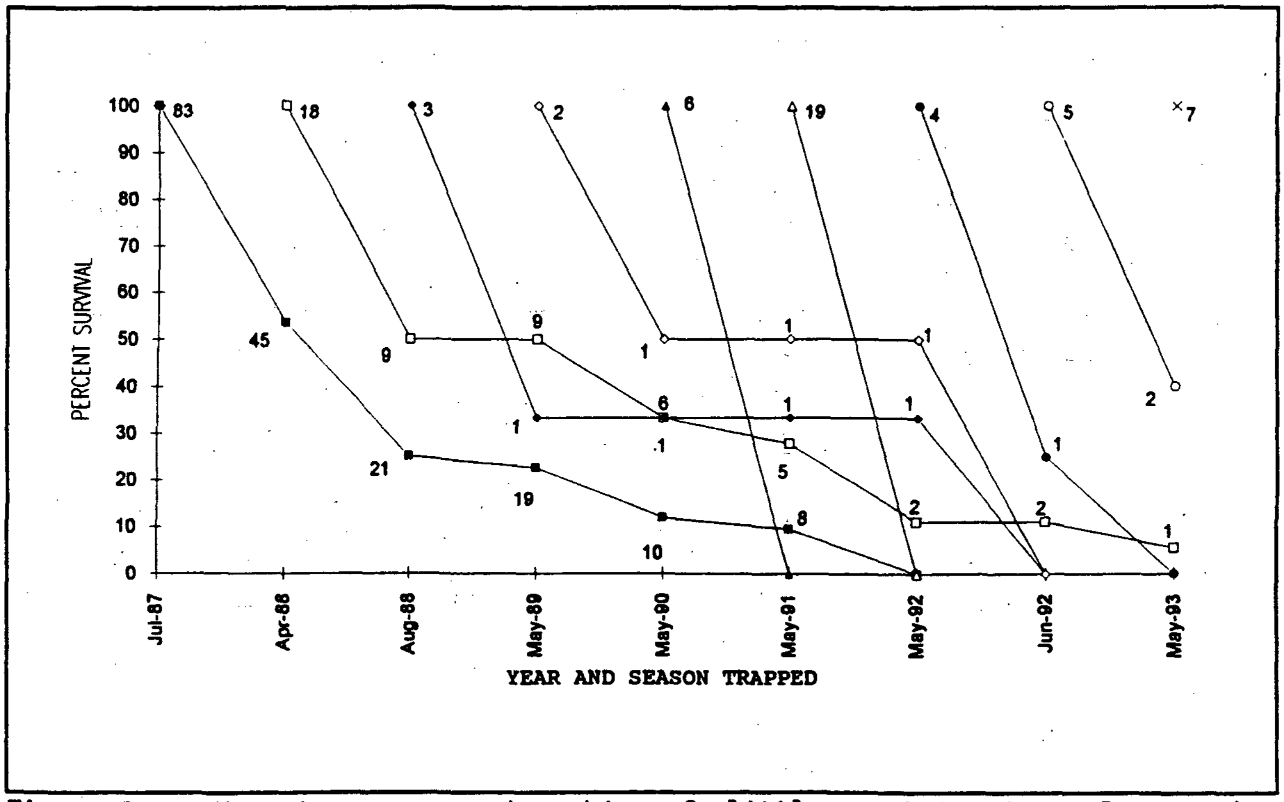

Figure 8 - Year-to-year survivorship of little pocket mice, *Perognathus longimembris*, as a percent of cohort size at the Yucca Flat baseline site in 1987 through 1993.

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.

Some degree of seasonal and annual periodicity has been demonstrated in heteromyid rodent populations in other deserts (Brown and Harney 1993). Food availability appears to determine the magnitude of population fluctuations, and plant productivity has been shown to be primarily determined by the amount and timing of precipitation (Rosenzweig 1968; Beatley 1974b). Most rodents (particularly heteromyids) 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). This, in turn, places precipitation, particularly that of winter, as the main control of population size (Beatley 1976). The trend on YUF001 clearly indicates a significant, positive correlation with rainfall (Figure 9).

That *D. microps* did not recover as fast as *D. merriami* may explained by the lack of facultative reproduction in *D. microps*. Where *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 season (Bradley and Mauer 1971; Kenagy 1973), *D. microps* is usually limited to only one reproductive bout per season and only then if there is adequate green perennial vegetation (Kenagy 1972).

In general, seed eaters make up half of the rodents inhabiting desert regions (Brown and Harney 1993). The granivory "guild" includes all heteromyids and several murid genera such as *Peromyscus* and *Reithrodontomys*. The nonrandom combinations in rodent assemblages vary temporally and spatially according to the abiotic and biotic factors available and how well these factors meet the requirements of the individual species (see Brown and Harney 1993 for a review). In general, climate and geological factors ultimately determine what species will be present at a site (Feldhammer 1979). Population size is also tempered by competition with coexisting rodents, vegetation availability, predation, parasitism, and disease.

Heteromyids fill available niches by exhibiting specific foraging microhabitat preferences and behavior which correlate with overall differences in morphology and size (Reichman and Price 1993). Interspecific competition for resources (primarily seeds) has a major influence on the organization of a rodent community, resulting in a regular pattern of body sizes in coexisting rodents (Bowers and Brown 1982; Price and Brown 1983; Brown and Harney 1993). It may be that while numbers of *Perognathus longimembris* were depressed, similar sized mice (*Peromyscus eremicus*, *P. maniculatus*, and *Chaetodipus formosus*) filled empty niche space and are competing for the same resource patches.

The year 1993 was another excellent year for murid species, particularly *Peromyscus maniculatus*. *Peromyscus eremicus* continued to be captured in small numbers at most sites as was *Neotoma lepida*. These results are similar to those of 1992 and are probably related to the high rainfall which both years experienced. Antelope ground squirrels (*Ammospermophilus leucurus*) were all too often an unwelcome sight in traps at most sites, even though traps were set as close to dusk as possible. Another unexpected capture was a spotted skunk (*Spilogale putorius*) on the Rainier Mesa baseline site, although only the tail-end was actually inside the trap.

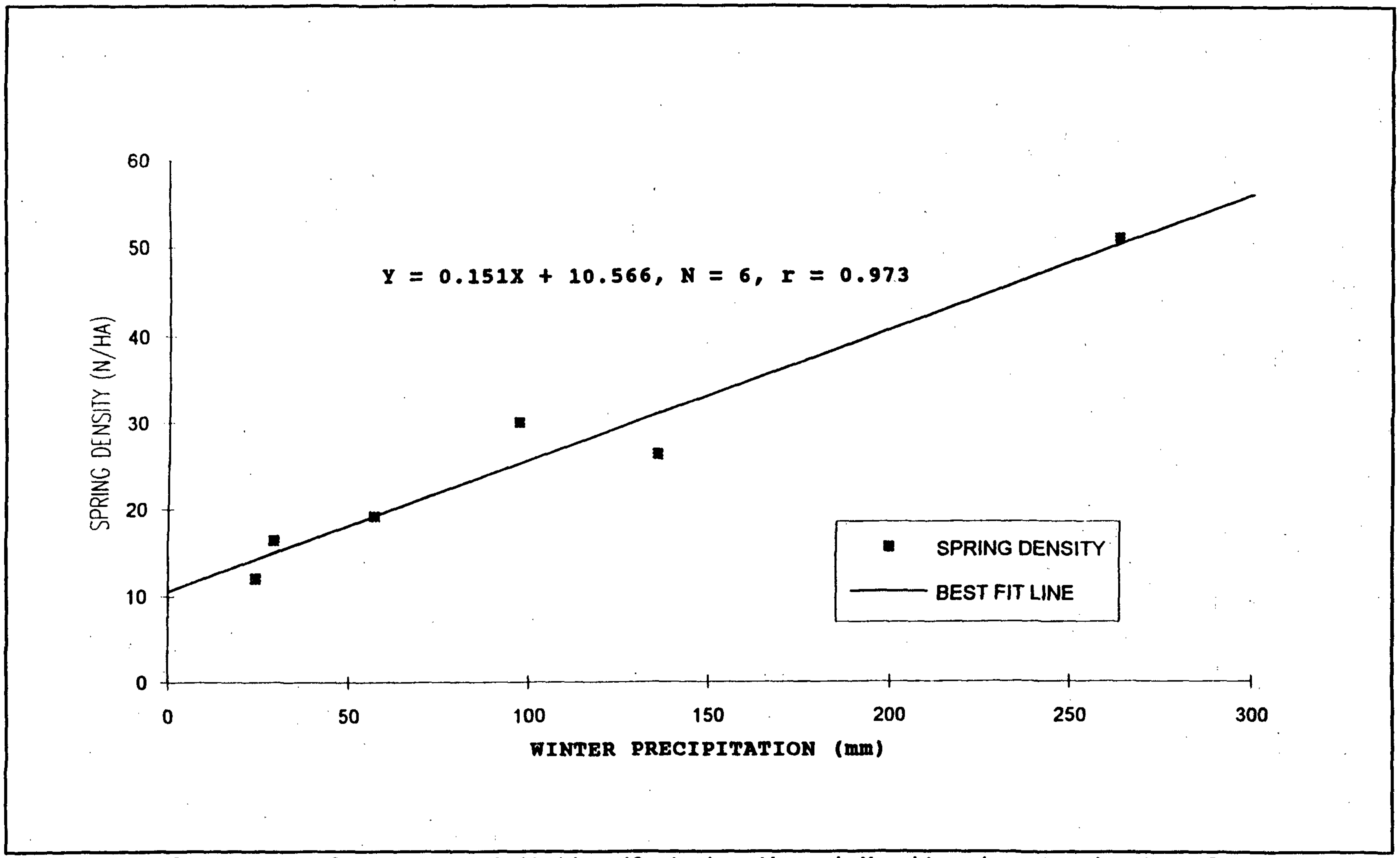

Figure 9 - Relationship of winter precipitation (September through March) and spring density of small mammals at the Yucca Flat baseline plot from 1988 through 1993.

Typically, the heteromyid/murid granivore compositions at undisturbed plots located on the NTS follow the usual nonrandom pattern of non-overlapping body size found at other sites, with the exception of Redrock Valley. Congeneric heteromyid species of similar body size (e.g. *D. merriami* and *D. ordii*) 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).

At the Redrock Valley burned area, *D. ordii* was captured at only 26 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 15 of the *D. ordii* capture sites (30 times out of a possible 2,380 trap nights). In 46 captures of *D. ordii* and 613 captures of *D. merriami*, only six times were these species captured on the same day in side-by-side traps and on three of those occasions, the same two animals were captured over three days. 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.

Disturbance Related Effects on Rodent Communities

The typical effect of disturbance on rodents appears to be indirect in that rodents disperse from areas that have had a decrease or loss in vegetation. Rodents spend most of the time in burrows well below the ground and are not likely to be killed by a fire. Loss of cover, however, will increase not only predation risk but also competition with other individuals for remaining resources. As expected, *Dipodomys merriami* was the dominant rodent on disturbed areas. Over the last seven years of monitoring, this species has consistently been the most prevalent rodent on disturbed areas of the NTS (Hunter and Medica 1989; Saethre and Medica 1992; Saethre 1994a, 1994b; Woodward et al. in press).

Pooling plots in Yucca Flat (the only area with more than two sites in any year) showed that species diversity remained greater on the undisturbed areas compared to the disturbed site (Yucca Flat burned area). Comparing the last seven years, 1993 had the highest average species diversity, number of species captured, and trap success.

CONCLUSIONS

Species diversity was the highest ever at BECAMP sites on the NTS since monitoring began in 1987. Although several species have not been captured in recent years (see Appendix B), the biotic community of the NTS appears to have prospered in spite of severe disturbances related to testing and maintenance activities. Recovery of small mammals from drought conditions appears to be complete except for the little pocket mouse. This species will continue to be monitored to determine if the phenomenon is long-term or only part of a cyclical life history.

Rodents have a large impact on the arid ecosystem on the NTS in that they comprise a major portion of the prey base for vertebrate predators. They also loosen soil, disperse seeds as well as compete with other seed-eating taxa (e.g., ants). Kangaroo rats have been termed a "keystone guild" in that removal of these rodents has resulted in less soil disruption, more litter accumulation, taller perennial and annual grasses, and decreased foraging by granivorous birds. In addition, rodents typical of grasslands colonized previously desert scrub habitat (Brown and Heske 1990; Brown and Harney 1993). That an important component of the desert has fared well on the NTS is indicative that the local area is relatively typical in ecological conditions.

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APPENDIX A

BECAMP PLOT LOCATIONS ON THE NEVADA TEST SITE

PLOT	LATITUDE LONGITUDE	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	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	945	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	938	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° 46' 15.6" N 116° 21' 19.0" 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)

PLOT	LATITUDE LONGITUDE	ELEVATION (M)	LOCATION
MID001	36° 53' 46.5" N 116° 11' 31.0" W	1448	Plant Transects, (N.End) E. side Saddle Rd.
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

PLOT	LATITUDE LONGITUDE	ELEVATION (M)	LOCATION
PAM006	37° 16' 32.4" N 116° 18' 7.8" W	2134	U19ac Drill Pad
PAM007	37° 17' 33.6" N 116° 17' 52.8" W	2134	U19ac Undisturbed Area
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)

PLOT	LATITUDE LONGITUDE	ELEVATION (M)	LOCATION
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
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° 00' 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

PLOT	LATITUDE LONGITUDE	ELEVATION (M)	LOCATION
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
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

PLOT	LATITUDE LONGITUDE	ELEVATION (M)	LOCATION
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
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	1204	Beatley Plot 60 (UCLA)

APPENDIX B[1]

MAMMALS OF THE NEVADA TEST SITE

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
Euderma maculatum[2]	Spotted bat
Lasionycteris noctivagans	Silver-haired bat
Lasiurus cinereus	Hoary bat
Myotis californicus	California myotis
Myotis evotis	Long-eared myotis
Myotis thysanodes	Fringed 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

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

[2]Vocalization evidence only (EG&G/EM 1993).

Family Mustelidae: Mustelids

Mustela frenata	Long-tailed weasel
Taxidea taxus	Badger
Spilogale putorius [=gracilis]	Western spotted skunk

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[3]	Wapiti (Elk)

Family Antilocapridae: Pronghorns

Antilocapra americana	Pronghorn

Family Bovidae: Bovids

Bos taurus	Cattle
Ovis canadensis[3]	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

[3]Resident populations outside boundaries of NTS.

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

APPENDIX C

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.
V = Estimated variance.
2 SE/HA = Two times the estimated standard error per hectare for N*/HA.

WHERE:

$$N* = \frac{[(n_1 + 1) * (n_2 + 1)]}{(m_2 + 1)} - 1$$

AND:

$$SE = \sqrt{\frac{(n_1 + 1) * (n_2 + 1) * (n_1 - m_2) * (n_2 - m_2)}{(m_2 + 1)^2 * (m_2 + 2)}}$$

JAF001 1993 SPRING DENSITY

		11-MAY-93	12-MAY-93	13-MAY-93
DIPMER				
	N1	0	31	41
	XB	31	10	4
	M2	0	25	37
	N2	31	35	41
	N*/HA		13.37	14.02
	V		3.79	0.50
	2*SE/HA		1.20	0.44
PERLON				
	N1	0	6	17
	XB	6	11	11
	M2	0	5	14
	N2	6	16	25
	N*/HA		5.81	9.32
	V		5.19	4.29
	2*SE/HA		1.41	1.28

MID002 1993 SUMMER DENSITY

		2-JULY-93	3-JULY-93	4-JULY-93
DIPMER				
	N1	0	6	7
	XB	6	1	4
	M2	0	4	6
	N2	6	5	10
	N*/HA		4.39	6.86
	V		0.56	0.90
	2*SE/HA		0.89	1.12

MID003 1993 SUMMER DENSITY

		2-JULY-93	3-JULY-93	4-JULY-93
DIPMIC				
	N1	0	4	6
	XB	4	2	7
	M2	0	3	4
	N2	4	5	11
	N^*/HA		3.85	9.36
	V		0,75	7.84
	2*SE/HA		1.03	3.31
PERLON				
	N1	0	2	3
	XB	2	1	4
	M2	0	2	2
	N2	2	3	6
	N^*/HA		1.78	4.94
	V		0	3.11
	2*SE/HA		0	2.09
PERPAR				
	N1	0	2	4
	XB	2	2	3
	M2	0	2	4
	N2	2	4	7
	N^*/HA		2.37	4.15
	V		0	0
	2*SE/HA		0	0
PERERE				
	N1	0	2	3
	XB	2	1	2
	M2	0	1	3
	N2	2	2	5
	N^*/HA		2.07	2.96
	V		0.75	0
	2*SE/HA		1.03	0

MID003 1993 SUMMER DENSITY, continued

		2-JULY-93	3-JULY-93	4-JULY-93
PERMAN				
	N1	0	4	6
	XB	4	2	1
	M2	0	2	1
	N2	4	4	2
	N*/HA		4.35	5.63
	V		2.78	8.75
	2*SE/HA		1.98	3.51

PAM006 1993 SUMMER DENSITY

		13-JULY-93	14-JULY-93	15-JULY-93
DIPORD				
	N1	0	10	14
	XB	10	4	7
	M2	0	2	4
	N2	10	6	11
	N*/HA		17.13	24.31
	V		68.44	84.00
	2*SE/HA		11.49	12.73
PERMAN				
	N1	0	15	26
	XB	15	11	7
	M2	0	11	14
	N2	15	22	21
	N*/HA		20.60	26.81
	V		8.65	13.86
	2*SE/HA		4.08	5.17

PAM007 1993 SUMMER DENSITY

		13-JULY-93	14-JULY-93	15-JULY-93
PERMAN				
	N1	0	25	40
	XB	25	15	21
	M2	0	18	22
	N2	25	33	43
	N^*/HA		31.62	53.77
	V		12.86	53.71
	2*SE/HA		4.98	10.18
PERPAR				
	N1	0	5	8
	XB	5	3	1
	M2	0	4	7
	N2	5	7	8
	N^*/HA		5.97	6.34
	V		0.96	0.14
	2*SE/HA		1.36	0.52

RAM001 1993 SUMMER DENSITY

		3-AUGUST-93	4-AUGUST-93	5-AUGUST-93
PERMAN				
	N1	0	55	117
	XB	55	62	25
	M2	0	26	62
	N2	55	88	87
	N^*/HA		56.66	50.56
	V		439.02	56.21
	2*SE/HA		12.93	4.63
PERPAR				
	N1	0	10	16
	XB	10	6	7
	M2	0	0	1
	N2	10	6	8
	N^*/HA		23.46	23.30
	V		2310.00	1338.75
	2*SE/HA		29.67	22.59

RED001 1993 SUMMER DENSITY

		27-JULY-93	28-JULY-93	29-JULY-93
DIPMER				
	N1	0	44	64
	XB	44	20	11
	M2	0	31	49
	N2	44	51	60
	N^*/HA		45.79	49.71
	V		18.00	5.13
	2*SE/HA		5.39	2.88
DIPMIC				
	N1			
	XB			
	M2			
	N2			
	N^*/HA			
	V			
	2*SE/HA			
DIPORD				
	N1			
	XB			
	M2			
	N2			
	N^*/HA			
	V			
	2*SE/HA			
PERMAN				
	N1	0	9	15
	XB	9	6	0
	M2	0	6	6
	N2	9	12	6
	N^*/HA		11.16	9.52
	V		5.97	0
	2*SE/HA		3.10	0

REDOO2 1993 SUMMER DENSITY

			27-JULY-93	28-JULY-93	29-JULY-1993
DIPMER					
	N1	0	38	50	
	XB	38	12	4	
	M2	0	21	38	
	N2	38	33	42	
	N^*/HA		37.63	35.07	
	V		24.30	1.73	
	2*SE/HA		6.26	1.67	
DIPMIC					
	N1	0	12	17	
	XB	12	5	0	
	M2	0	9	12	
	N2	12	14	12	
	N^*/HA		11.75	10.79	
	V		2.66	0	
	2*SE/HA		2.07	0	
PERPAR					
	N1				
	XB				
	M2				
	N2				
	N^*/HA				
	V				
	2*SE/HA				
PERMAN					
	N1	0	3	8	
	XB	3	5	4	
	M2	0	1	3	
	N2	3	6	7	
	N^*/HA		8.25	10.79	
	V		23.33	18.00	
	2*SE/HA		6.13	5.39	

YUF001 1993 SPRING DENSITY

		18-MAY-93	19-MAY-93	20-MAY-93
DIPMER				
	N1	0	32	39
	XB	32	7	12
	M2	0	23	31
	N2	32	30	43
	N*/HA		12.85	16.67
	V		4.48	5.00
	2*SE/HA		1.31	1.38
DIPMIC				
	N1	0	34	52
	XB	34	18	13
	M2	0	22	43
	N2	34	40	56
	N*/HA		18.95	20.88
	V		24.41	4.06
	2*SE/HA		3.05	1.24
PERLON				
	N1	0	4	5
	XB	4	1	4
	M2	0	4	3
	N2	4	5	7
	N*/HA		1.54	3.40
	V		0	4.80
	2*SE/HA		0	1.35
ONYTOR				
	N1	0	7	10
	XB	7	3	1
	M2	0	4	3
	N2	7	7	4
	N*/HA		3.64	3.94
	V		3.84	4.81
	2*SE/HA		1.21	1.35

YUF001 1993 SPRING DENSITY, Continued

		18-MAY-93	19-MAY-93	20-MAY-93
PERMAN				
	N1	0	8	13
	XB	8	5	1
	M2	0	8	10
	N2	8	13	11
	N^*/HA		4.01	4.41
	V		0	0.35
	2*SE/HA		0	0.36
REIMEG				
	N1	0	3	5
	XB	3	2	1
	M2	0	2	1
	N2	3	4	2
	N^*/HA		1.75	2.47
	V		1.11	6.00
	2*SE/HA		0.65	1.51

YUF002 1993 SUMMER DENSITY

		7-JULY-93	8-JULY-93	9-JULY-93
DIPMER				
	N1	0	40	57
	XB	40	17	10
	M2	0	22	31
	N2	40	39	41
	N^*/HA		48.82	52.17
	V		39.53	18.74
	2*SE/HA		8.73	6.01
DIPMIC				
	N1	0	9	15
	XB	9	6	0
	M2	0	7	8
	N2	9	13	8
	N^*/HA		11.46	10.42
	V		2.92	0
	2*SE/HA		2.37	0

YUF002 1993 SUMMER DENSITY, Continued

		7-JULY-93	8-JULY-93	9-JULY-93
ONYTOR				
	N1	0	6	7
	XB	6	1	5
	M2	0	2	1
	N2	6	3	6
	N*/HA		5.79	18.75
	V		3.11	140.00
	2*SE/HA		2.45	16.43

YUF003 1993 SUMMER DENSITY

		7-JULY-93	8-JULY-93	9-JULY-93
DIPMER				
	N1	0	28	42
	XB	28	14	7
	M2	0	12	27
	N2	28	26	34
	N*/HA		41.13	36.63
	V		74.13	6.95
	2*SE/HA		11.96	3.66
DIPMIC				
	N1	0	8	12
	XB	8	4	5
	M2	0	2	9
	N2	8	6	14
	N*/HA		13.89	12.85
	V		42.00	2.66
	2*SE/HA		9.00	2.26
CHAFOR				
	N1	0	35	54
	XB	35	19	7
	M2	0	21	22
	N2	35	40	29
	N*/HA		45.90	49.12
	V		35.27	29.11
	2*SE/HA		8.25	7.49

STATUS OF LARGE MAMMALS AND BIRDS ON THE NEVADA TEST SITE IN 1993

by

Paul Greger

ACKNOWLEDGEMENTS

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ABSTRACT

Primary monitoring efforts during 1993 involved surveys to assess trends of feral horses, mule deer, raptors, and ravens. Some additional work examined [illegible]

community. The feral horse population at the NTS is small, appears to be stable, unlike many other populations in the west which are expanding. Mule deer numbers appear to show no significant trends over the last five years. Raptor sighting rates showed differences with location and season during 1993. Raptor abundance was good during 1993, with many sightings of hatchling-year birds.

INTRODUCTION

This year's work completes six years of monitoring of large mammals and birds at the NTS. Work began in 1988, performed 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). Initial results included qualitative assessments of wildlife use at springs and well reservoirs and an investigation of the horse population (Romney and Greger 1992). Birds and large mammals were monitored through a drought (Greger and Romney 1994a,b), and during a post drought period (Greger and Romney 1994c). During 1993, monitoring of birds and large mammals were continued under BECAMP by Reynolds Electrical & Engineering Co. Inc.,(REECO).

Work included large mammals surveys, primarily for horses and deer, and bird monitoring including ravens and raptors. Work in 1993 concentrated on raptor observations with less emphasis on horses. In addition, a separate study (Woodward et al. 1994) investigated potential ecological effects of the Device Assembly Facility (DAF). This study emphasized in part, bird use of a newly constructed sewage pond and description of the local bird community.

Birds can be difficult to study because of their mobility and migratory nature. Birds are active endotherms, have high energy demands and maintain relatively high body temperatures at or near 40° C (Wiens 1991). Some bird species meet their energy demands by consuming seeds (mourning doves, Gambel's quail) while others eat more insects (black-throated sparrow). However, seeds contain far less preformed water than insects, so granivores may be more dependent on sources of free water than are insectivores (Wiens 1991). Birds generally need more energy per weight than other species, and thus may be more strongly effected by variation in rainfall and related food supplies from year to year. Mobility of birds in deserts is particularly important allowing individuals to find habitats with enough resources to survive and reproduce.

METHODS

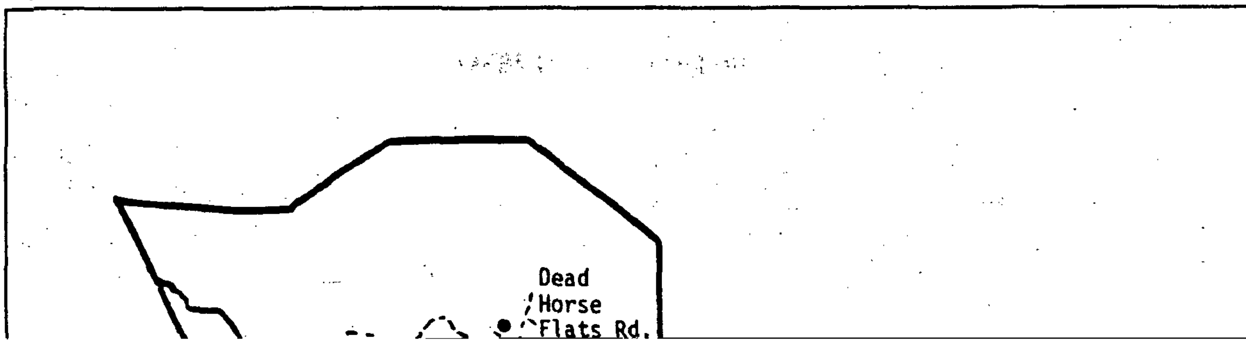
LARGE MAMMALS

Horse bands were located monthly from March-November to assess foal survival, check for missing horses, and describe movement patterns between winter-spring and summer-fall range. Surveys recorded individuals present and any changes in band structure. Approximate band locations were plotted on maps to illustrate range use. The consistency of range use by bands over years (1990-93) was examined using ANOVA comparing number of sightings recorded east or west of a reference line (Long. 116° 12 minutes) that bisects the Eleana Range. This benchmark was chosen to examine spatial relationships of bands because it followed a natural ridge approximately north to south through the Eleanas. This ridge is steep and impassable by horses in many locations and therefore may serve as a partial barrier to movements. Because road surveys were performed more often than surveys in remote areas (i.e. off-road areas), locations of bands recorded were partially biased towards roads.

Mule deer were monitored using spotlight counts along roads (Figure 1) on three nights in October in three regions: Pahute Mesa, Rainier Mesa, and in an area between mesas, Big Burn Valley. The overall sighting rate (deer/km), was regressed over years to examine recent trends in deer number. Two-way ANOVA examined overall effects between years and regions and *post-hoc* Tukey tests examined individual comparisons within regions. Counting deer at night depends heavily on eye tapetum reflections. Deer may avoid the light source in some cases, causing underestimates in total count (Cypher 1991). Therefore, for each deer group observed in 1993, deer number was counted before and after a whistle was blown. A paired t-test was used to determine if blowing the whistle influenced numbers of deer observed.

BIRD MONITORING

Road surveys for raptors were performed by driving 15-25 km/hour on a standard route 70-80 km long (Figure 2). Surveys were conducted between 0900 hrs and 1300 hrs, usually starting in Frenchman Flat followed by Yucca Flat. Sampling order was reversed on one occasion in fall when higher numbers were evident. There was no difference in patterns of abundance noted between locations. Normally sampling would be alternated throughout to compenste for time of day effects but was not done due to time limitations. Transects included roads with pole-lines and without pole-lines. Distances of each were measured with vehicle odometer and totaled by region. Once a raptor was sighted the vehicle was safely parked on the road shoulder. Raptors were counted, identified, with the use of 7x power binoculars or spotting scope (20x) and behavior was recorded. Counts were expressed per unit distance (number per 100km). Two-way ANOVA was used to examine overall effects of season and location on numbers observed from all road transects. To examine effects of pole-lines on numbers and species observed along the transect, raptor sightings were compiled in three groups; roads without poles, roads with poles, and all roads combined. The latter two groups were examined separately with respect to location and season with Kruskal-Wallis tests when parametric assumptions were not met. In addition, overall sighting rates (all locations and dates combined) from roads with poles were compared to roads without poles with Kruskal-Wallis test.


Dead
Horse
Flats Rd.

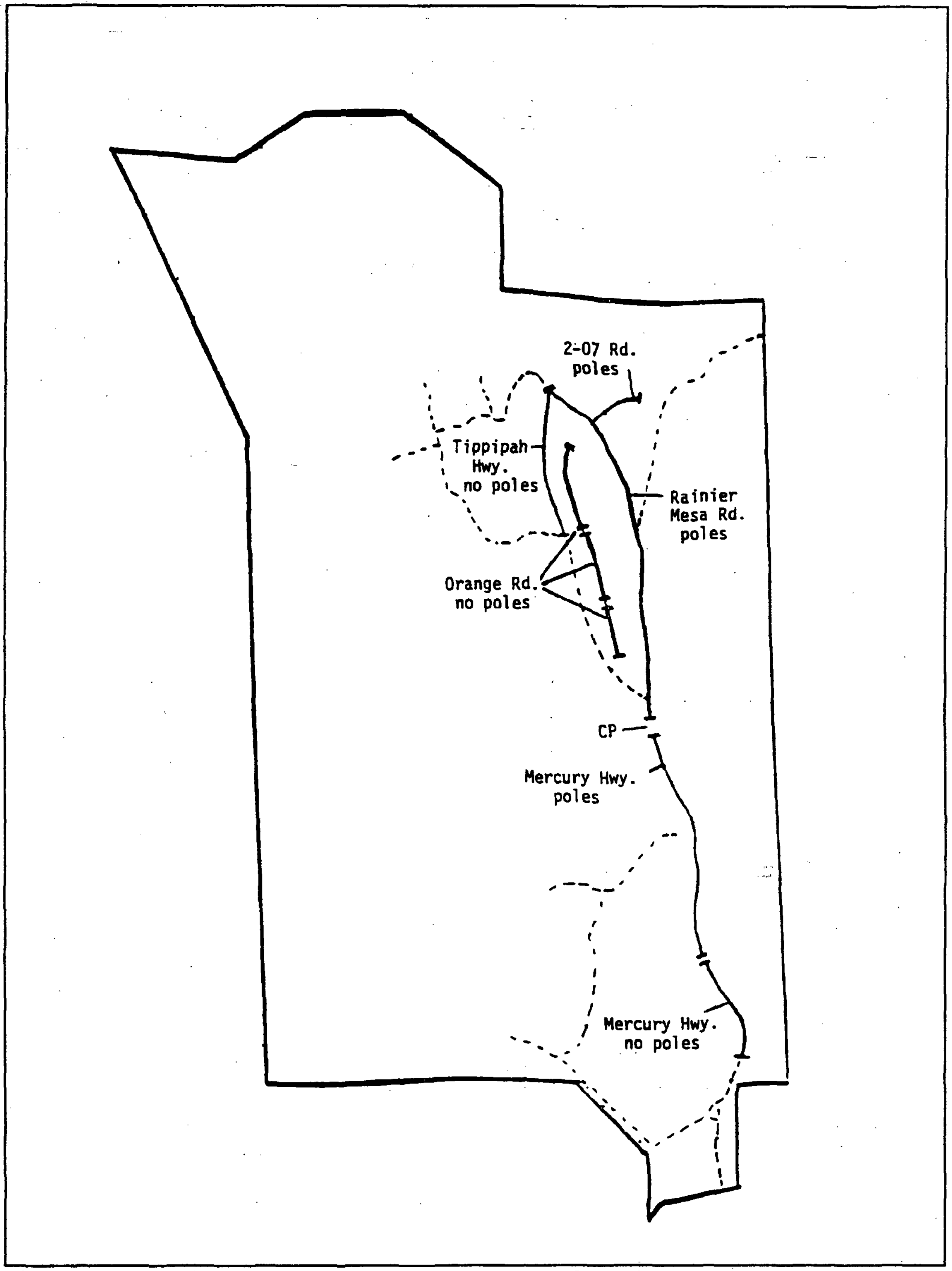


Figure 2 - Roads where raptor surveys were performed during 1993.

Relative abundance of common species were compared using two techniques; wildlife report card records (see Greger and Romney 1994a) versus standard road transects. The former includes opportunistic sightings of raptors from various habitats and regions of the NTS, and derive from numerous observers including BECAMP personnel and others with varying degrees of skill or interest. Conversely, standard road surveys include records from a road course driven repeatedly on Frenchman and Yucca flats by one investigator. Qualitative comparisons (%) between techniques were made as well as statistical comparison of relative abundance using Chi-square test.

Visits to selected springs and other higher elevation habitats on NTS were made to record evidence of breeding raptors. Known locations of active raven nests from previous years were checked for nestlings.

RESULTS

FERAL HORSES

During 1993, 62 of 65 individual horses were observed. The horse population may have declined by three or four individuals in 1993 (rate of increase = 0.94). Three horses (1 older male and two adult females) were not observed, and one adult female died on 6 July near area 2 camp apparently from natural causes. The remaining population could be as low as 61 animals two years or older. Eleven foals were observed during 1993, of which 6 were known to be missing and presumed dead. The remaining 5 were of uncertain status by December.

Some interesting band changes were observed during 1993. Nine out of 14 bands observed (64%) experienced member changes (loss or gain of one or more horses >2 yrs.). Two bands, A and R were broken up, and one new band (T) was formed. One band (E) that broke up in 1992 recombined in 1993 (the original stallion re-aquired the same 5 females). The total net exchange of females between bands estimated for the year was 14 of 34 (41%) including 11 adults, one 3 year old, and two 2 year olds. Two females (2 and 3 years old) remained in their natal bands. One male (2 year old) left his natal band in 1993. Of the 8 horses recruited to the NTS population since 1989, 6 (75%) were females. Although sample size is small, this suggests differential survival of females during the first three to five years of life.

Locations of eleven bands that persisted for several years are shown in Figures 3-5. Many bands intermix in a remote region of area 17 from February through May, and subsequently move to higher elevations by late May to early June. However, bands most often observed near Yucca flat (Figure 3), seem to

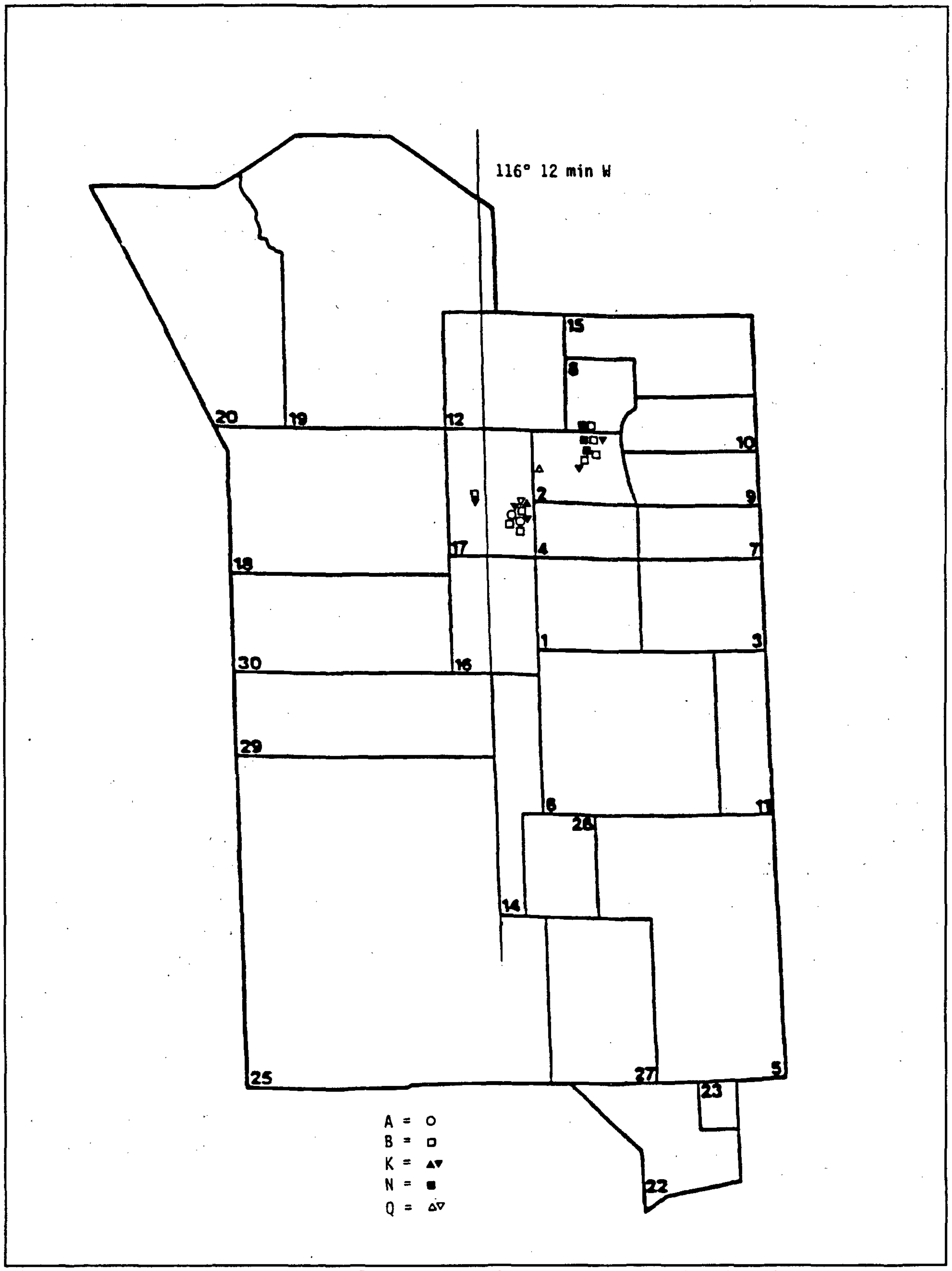


Figure 3 - Locations of feral horse bands (n = 21) at the NTS during 1993.

persist at much lower elevations throughout summer than do bands that occur predominantly west of the Eleanas (Figures 4,5). A few bands are able to do this by watering from well reservoir 2 outside Area 2 camp, while most other bands move to higher elevations west of the Eleanas during summer and are dependent on water from camp 17 pond.

Dispersal patterns of most bands were consistent across years and were pooled for analysis. Overall, band sightings across years (Figure 6) showed differences with respect to location ($F_{1,41} = 8.16$, $P = 0.007$), defined by (latitude 116° 12' W) east or west of the Eleanas.

Most bands showed a high degree of fidelity to a particular region on the NTS. For example bands A,B, and K were almost always observed east of the Eleanas range (Figure 6) as defined by an arbitrary benchmark (Figure 3). Similarly most other bands were found most often west of the Eleanas (Figures 4-6). Bands that appear to range over both sides the Eleanas include bands F and G. They may have larger home ranges than other bands on NTS.

Fresh horse feces were collected from three horses from the north central region of NTS during summer and examined for tritium content. Average tritium values from horse feces were very low ($\bar{x}$ = 1,508 picocuries/liter, range 121-

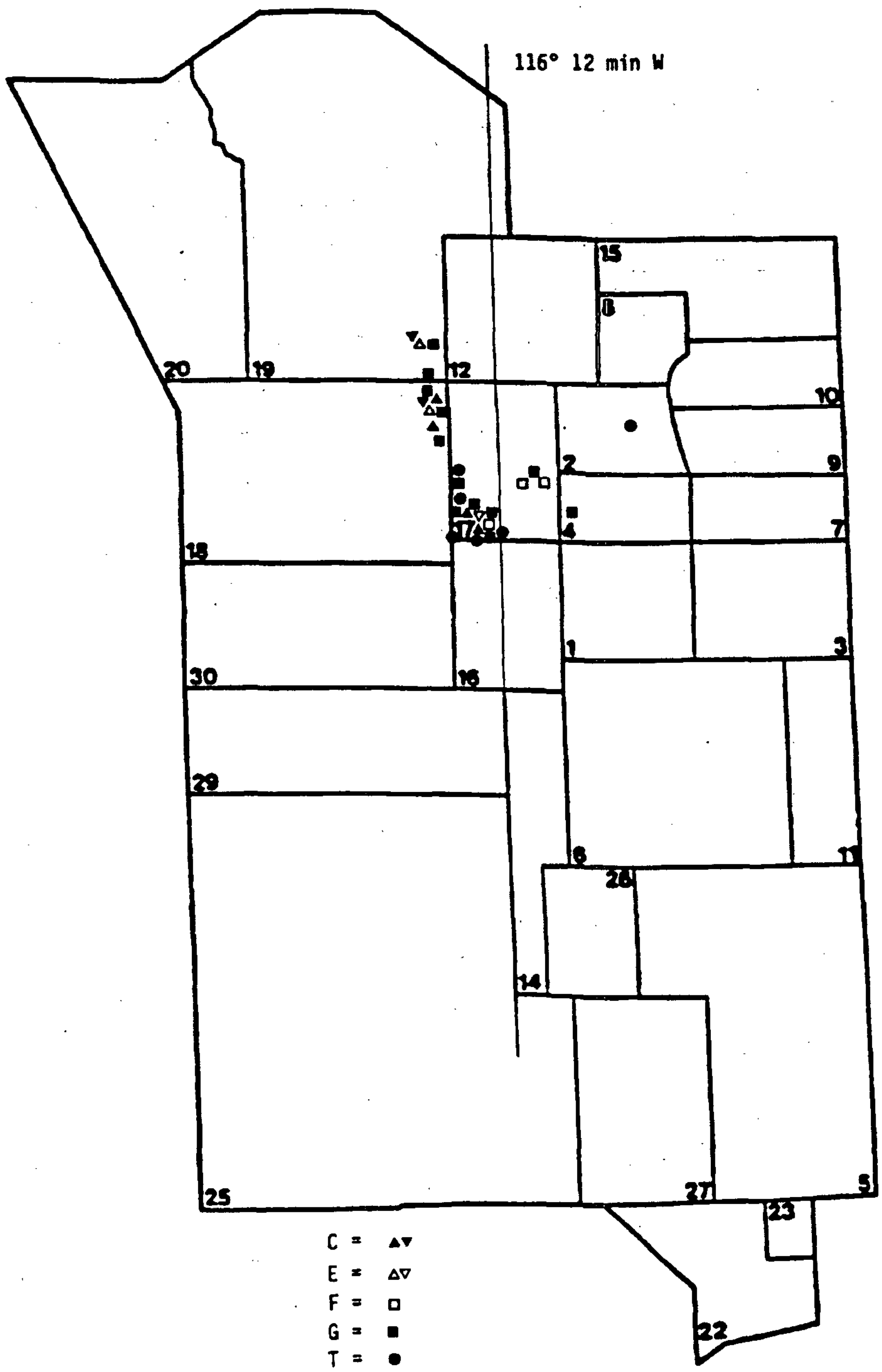


Figure 4 - Locations of feral horse bands (n = 33) at NTS during 1993.

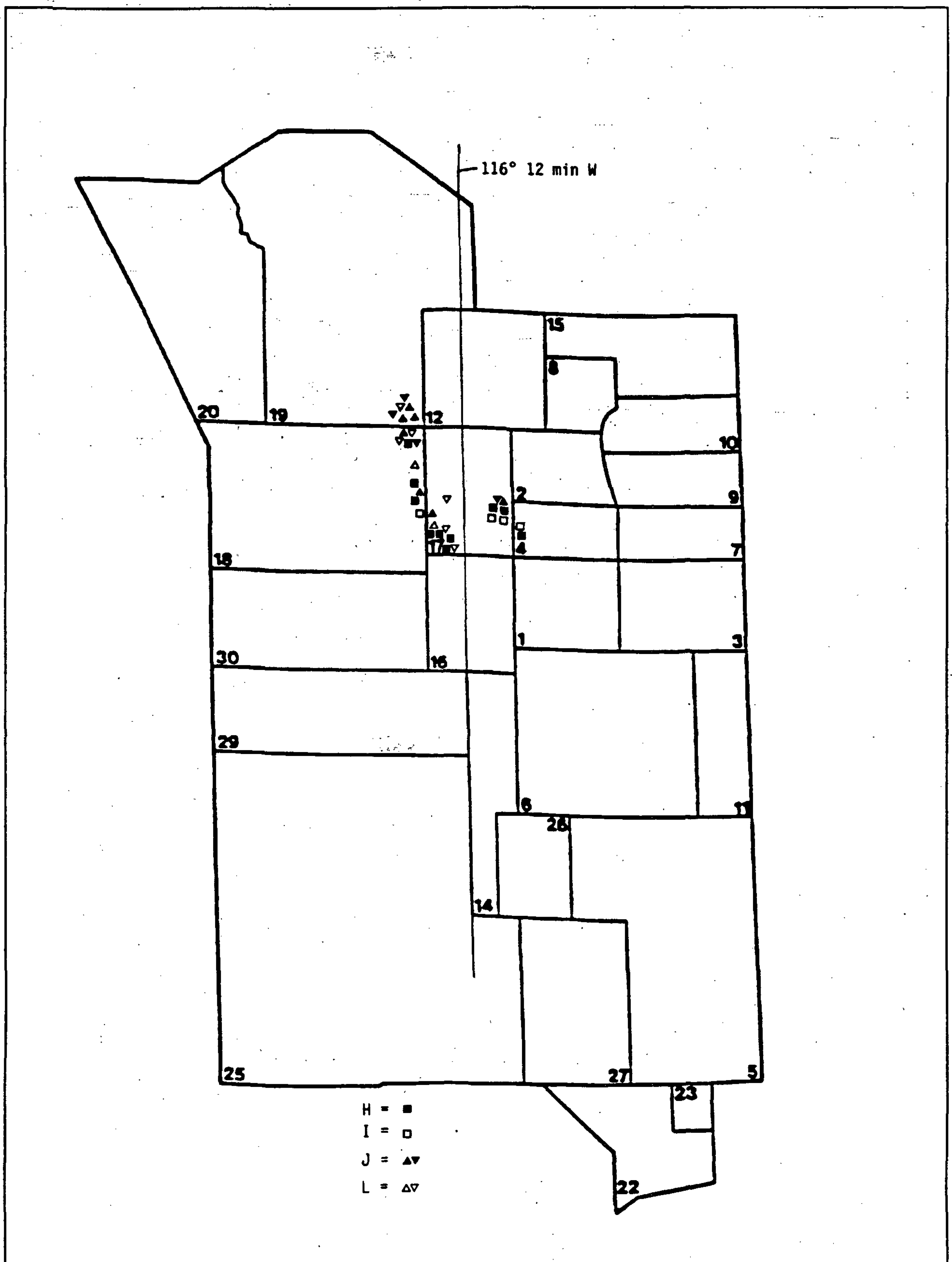


Figure 5 - Locations of feral horse bands (n = 30) at the NTS during 1993.

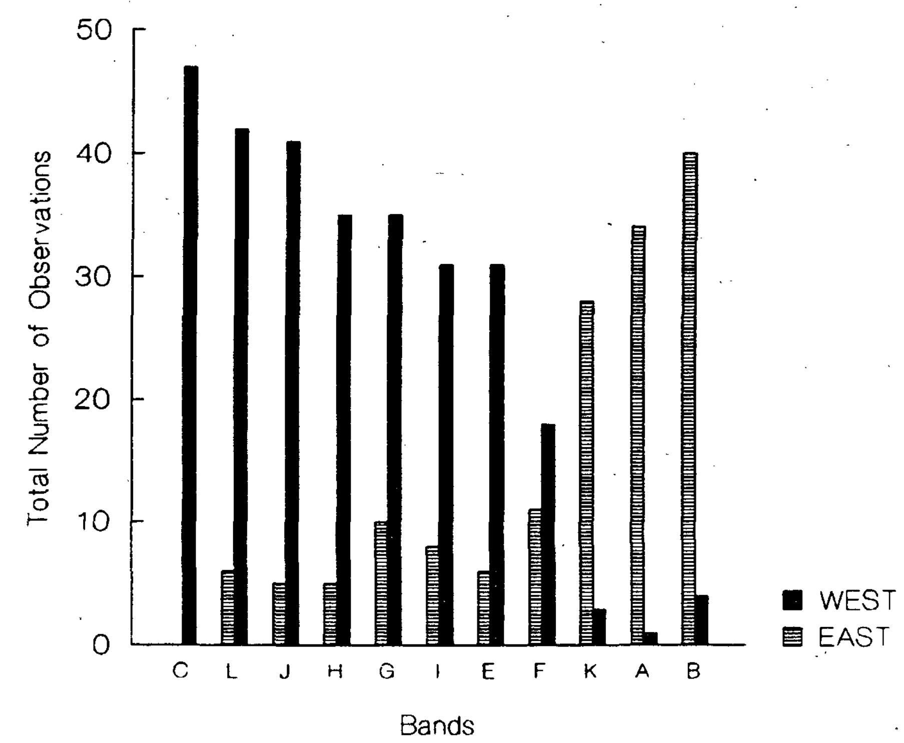
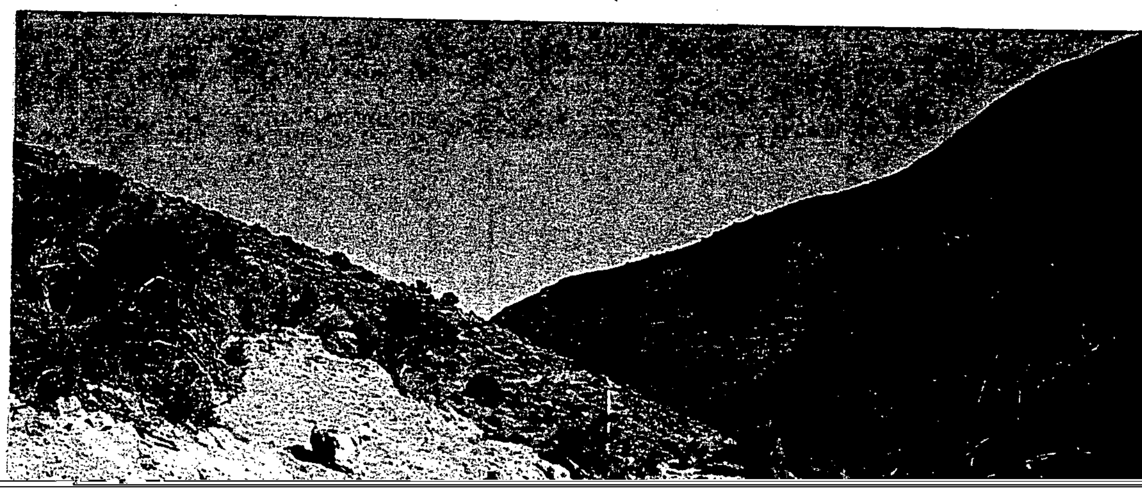


Figure 6 - Band sightings of horses east and west of the Eleanas Range 1990-93.

Horses normally consume fresh green grasses through spring and summer which are often abundant on burn areas such as Red Rock Valley. During drought horses may have a wider diet breath than during normal years because availability of preferred grases may vary. Horses consumed dry annuals such as *Eriogonum kearneyi*, during spring of 1990, a drought year, possibly because grasses were limited. Horses generally appear to eat small amounts of shrubs when consumed, although individual plants of *Tetradymia axillaris* appeared to be moderately grazed by horses in spring before the soft branch tips hardened into spines. These observations over several years suggest horses may eat numerous species of plants as conditions vary but rely primarily on grasses for the bulk of the diet.

Future work to assess impacts of horses may be examined by constucting exclosures from barbed wire of various sizes in areas of heavy use, and near water sources. Standard plant transects will be used to measure species composition, plant sizes, percent cover, and grazing impact within exclosures and outside protected areas.



MULE DEER

Mule deer numbers at the NTS appeared stable over the last five years (Figure 8). Slope of the regression line of sighting rate verses year was not significantly different from zero ($F_{1,3}$ = 0.004, P = 0.96) indicating no population trend.

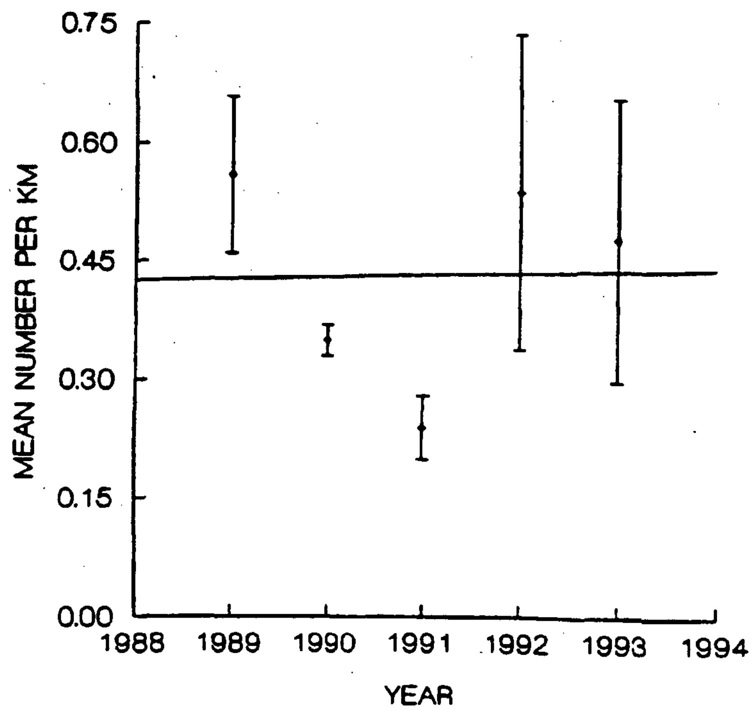


Figure 8 - Mean sighting rates of mule deer (number/km ± 2se) from roadsides on NTS during 1989-93.

During 1993 we evaluated a potential source of sighting bias by blowing a whistle stimulus during nighttime surveys. Number of deer per group was counted using spotlights before and after a whistle was blown. Use of the generally observed on Pahute Mesa than Rainier Mesa, however, significant differences were only shown for 1989 and 1990 (Table 1). This is in general agreement with population assessments by Giles and Cooper (1985), who found the Echo Peak herd (on Pahute Mesa) to be much larger than the Rainier Mesa component. Very few deer were seen from an 11 km stretch of Pahute Mesa road (from Camp 17 pond to 19 hill, Big Burn area): all deer in this area were observed near Camp 17 pond.

Table 1. Mule deer sighting rates (number/km) by region and year (± 2 se)

Table 2. Species composition for 1993 by location and season (n = 48) from standard road surveys. Percent composition by area in parentheses. Spr = March-May, Sum = June-August, Fall = September-November.

	Frenchman Flat				Yucca Flat			
Species	Spr	Sum	Fall	Total	Spr	Sum	Fall	Total
Red-tailed hawk	4	6	9	19(46)	8	23	26	57(45)
Swainson's hawk	1	0	0	1(2)	0	0	0	0(0)
Golden eagle	2	0	2	4(10)	1	0	6	7(5)
American kestrel	10	0	1	11(27)	6	7	19	32(25)
Prairie falcon	1	0	0	1(2)	1	5	8	14(11)
Turkey vulture	0	0	0	0(0)	1	0	0	1(<1)
Northern harrier	0	0	0	0(0)	0	1	4	5(4)
Barn owl	0	0	0	0(0)	1	0	0	1(<1)
Burrowing owl	0	0	0	0(0)	0	3	0	3(2)
Unid. buteo	3	0	2	5(12)	0	0	1	1(<1)
Unid. falcon	0	0	0	0(0)	0	0	5	5(4)
Unid. raptor	0	0	0	0(0)	0	0	1	1(<1)
Totals	21	6	14	41	18	39	70	127

Examination of raptor counts reported from wildlife cards compared to sightings from standard road transects (Table 3) revealed large differences in species (X^2 = 51.7, d.f. = 5, $P < 0.005$). Records from wildlife cards suggest American kestrels were recorded less often (possibly under-reported) while golden eagles and turkey vultures were recorded more often than expected from relative abundance comparisons from similar areas (Table 3). Relative abundance of red-tailed hawks and prairie falcons showed good general agreement between methods.

Table 3. Qualitative comparison (%) of the six most abundant raptor species reported by two techniques for 1993. N = number of sightings in region of Frenchman and Yucca flats combined. RT = Red-tailed hawk, AK = American kestrel, PF = Prairie falcon, GE = golden eagle, TV = turkey vulture, NH = northern harrier.

Method	RT	AK	PF	GE	TV	NH
Standard road survey N = 168	46	26	9	7	1	4
Opportunistic survey N = 152	51	3	6	18	11	4

Standard Road Surveys

Numbers of raptors observed (Table 4) differed greatly with location ($F_{1,42}$ = 44.8, $P < 0.0001$) and season ($F_{2,42}$ = 23.9, $P < 0.0001$) with a significant interation term ($F_{2,42}$ = 14.8, $P < 0.0001$). More raptors were observed on Yucca Flat than Frenchman Flat in summer and fall although not in spring (Tables 4,6). Numbers observed increased dramatically during the summer and fall on Yucca Flat.

Table 4. Mean sighting rates of raptors, number/100km ± 2 se by season for all roads (1765 km) driven during 1993. Number of surveys in parentheses. Kruskal-Wallis test result below compares Frenchman and Yucca flat locations, with value of P. Combined averages shown for comparison.

Location	Spring	Summer	Fall
Frenchman	4.2 ± 1.8 (14)	2.9 ± 2.2 (6)	7.6 ± 6.6 (6)
Yucca	5.2 ± 2.4 (10)	15.6 ± 5.4 (6)	32.8 ± 10.6 (6)
Areas combined	4.7 ± 1.6	9.7 ± 2.4	21.2 ± 8.2
Test Result	0.25, P = 0.62	8.4, P = 0.0004	7.4, P = 0.007

The proportion of roads sampled with pole-lines on Yucca Flat during surveys was greater than that on Frenchman Flat (Table 5). This represented a potential bias in the sighting rates because raptors are seen more frequently from areas with poles. Therefore, raptor sighting rates were recalculated in each region excluding distance and corresponding numbers observed from areas without poles (Table 6).

Table 5. Distribution of roads (km) with and without pole-lines surveyed for raptors on NTS. Total distance = 1765 km.

Region	Poles	%	Without poles	%
Frenchman Flat	500	56	394	44
Yucca Flat	669	77	202	23

Raptor sighting rates along roads with pole-lines (Table 6) were generally higher than all roads combined (Table 4). Sighting rates increased more for Frenchman Flat than Yucca Flat after excluding non-pole roads. The overall test results did not change, but probability of making an error due to chance increased for each comparison. This is consistent with the original source of bias from non-pole roads (Table 5) being greater on Frenchman (44%) than Yucca Flat (23%).

Table 6. Mean sighting rates of raptors, number/100km ± 2 se along roads with pole lines only during 1993. Kruskal-Wallis H values shown with levels of P, 1 d.f. for each comparison. (number of surveys).

Location	Spring	Summer	Fall
Frenchman	7.4 ± 3.6 (14)	5.3 ± 4.8 (6)	12.6 ± 11.0 (6)
Yucca	6.6 ± 3.0 (10)	15.7 ± 4.9 (6)	35.5 ± 10.7 (6)
Test result	0.12, P = 0.72	5.12, P = 0.024	5.04, P = 0.025

Overall, greater numbers of raptors (H = 32, d.f. = 1, P = 0.0001) were seen along roadsides with pole lines (12.2 ± 3.6 per 100km, n = 48) than along roads without poles (2.2 ± 2.2 per 100km, n = 38). During 1993, only 11 total raptors were observed from roads (596 km) without poles. Northern harriers do not perch on poles and were almost always seen in flight. They were observed only from roads lacking poles, but also were observed flying near well reservoirs.

RAVENS

Raven reproduction during 1993 appeared quite successful from the 9 active nests monitored. Six nests fledged young from Frenchman and Yucca flats combined. Four nests were located on man-made structures in desert tortoise habitat. Most nests produced 4 or 5 young with an average of 4.1 ± 0.35 birds per nest. Although actual number fledged was not observed, most nestlings

[redacted]

During 1993, bird use of a newly constructed sewage pond at the DAF indicated that bird use was significant during summer months. Peak estimated dove use of the pond exceeded 600 birds per hour. A wide variety of migratory species and native breeding birds used the pond during summer. Summer residents generally used the pond at greater rates than a nearby control location (Woodward et al. 1994). Relative summer bird density was estimated for the black-throated sparrow at about 1.8 birds per hectare, using the variable circular plot technique (Reynolds et al. 1980). The method appears to be horse 28, a female from band B died in July 1993 near Area 2 camp. It was observed the afternoon before it died and appeared to suffer from symptoms indicative of colic. Although many skeletal remains of horses have been found on NTS, it is a rare event to find a dying horse and assess cause of death. In this case predation was not involved.

Survival of foals on the NTS was low in 1993 as in previous years. Five or six foals were missing and another 6 were observed during summer but were not surveyed in the fall. Probable foal survival for 1993 is about 50% or less despite a moderate increase in total rainfall over the previous year. Analysis of fresh horse feces give preliminary results that tritium in horses is very low. It is recommended that more samples of scats be examined for tritium in the future. In addition, horse tissues should be examined for other radionuclides, either from dead horses or afterbirth remains as the opportunity permits.

DOE activities on the NTS are conferring a benefit to horses from use of several man-made water sources in summer. Because Gold Meadow sump often dries up in mid-summer, about 40 horses are presently dependant on Camp 17 pond for drinking. Horses would be forced to migrate in summer to survive if camp 17 pond was discontinued as a water source. If all reservoirs were discontinued on NTS, all horses may be forced to water at Captain Jack Spring possibly competing amongst themselves and with deer for limited suplies, unless they could find other springs that are not presently used. Potential negative impacts to horses from DOE activities are limited to road kills.

MULE DEER

Mule deer numbers appear stable on the NTS over the last five years (Figure 4) indicating no overall trend although effect of the drought and subsequent recovery are evident. Mean number observed per survey in 1993 (38 ± 14) decreased somewhat but not significantly over 1992 (44 ± 16). Total numbers in Michigan varied seasonally from 12-45% of the total (McCullough 1982). Numerous factors including limited visibility and difficult terrain on NTS made population estimates from spotlight surveys unobtainable. Surveys will falcon. Turkey vultures and northern harriers will not perch readily on poles. Surveys in open areas along roadsides with poles will bias counts against these species. To improve technique, transects without pole-lines should be included to account for non-perching species, and should be closely monitored to observe effects on counts. Other factors that vary along transects include vegetation and topography and level of disturbance. Disturbed habitat may be used differently than natural areas. Knight and Kawashima (1993) found that red-tailed hawks in the Mohave desert used transmission line corridors for nesting and perching at much greater rates than highways without powerlines. Effects of human disturbance on raptors such as vehicle activity or impacts from people on foot have not yet been examined. Flush responses to vehicles and people walking near perched raptors will be examined as a measure of human disturbance.

Comparison of standard road surveys against opportunistic sightings revealed some differences in relative abundance (Table 3), notably for golden eagles, turkey vultures, and American kestrels. This strongly suggests that opportunistic sightings can account for some large easily observed species, while other smaller inconspicuous species are under-reported. Both surveys appear to compliment each other. Opportunistic surveys are useful because they provide information on rarer species over a wider range of habitats. Standard road surveys however are more complete in species description but describe species use over a smaller region.

Raptor sighting rates showed two interesting patterns. Higher numbers observed in summer and fall and higher numbers on Yucca Flat compared to Frenchman Flat. The former is consistent with increased numbers of hatchling-year birds appearing on the NTS. These increased most dramatically in the fall, probably from migrational movements from areas north of the NTS. Accurate counts of juveniles were not made during surveys in 1993, however it was common to observe juveniles of three species including red-tail hawks, golden eagles and northern harriers. There was some evidence of raptor breeding on the NTS during 1993. For example, long-eared owls fledged from Cane Spring in June, and American kestrels with young were observed defending an area in Horse Wash (Area 17) during July. Burrowing owls also fledged from an area on Frenchman Flat near the DAF. However, most juveniles observed during fall of 1993 were probably migrants.

Higher numbers of raptors on Yucca Flat could be explained by more available food from somewhat higher densities of small mammals (Saethre in press), lower mean summer temperatures, more perches per area or more preferred perch types in both regions suggests a temperature effect. Other factors that may explain difference in numbers include level of habitat alteration, or possibly number of well reservoirs. Studies performed at the DAF in 1993 (Woodward et al. 1994) show water sources in summer attract high numbers of birds or other prey that raptors eat. The most abundant species, red-tail hawks, have also been observed drinking from ponds in mid summer. The second most abundant species observed, American kestrel, forages primarily on insects (e.g. grasshoppers) which may be more abundant on Yucca Flat during summer.

Finally, standard raptor surveys employed at NTS relied on making sightings while the vehicle was in motion. This may underestimate numbers because of limited visibility to observe birds in flight, compared to counts made from stationary points. Therefore stationary counts made at designated intervals of 2 miles along a transect may be made to compare to counts from a moving survey. Future work will examine some of these factors.

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STATUS OF EPHEMERAL PLANTS ON THE NEVADA TEST SITE IN 1993

by

Richard Hunter

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ABSTRACT

Ephemeral populations on the Nevada Test Site in 1993 increased in most places to thousands per square meter, a result of heavy rains in December 1992 and January - February 1993. Biomass did not generally increase proportionately, and in some locations density was constant from 1992 to 1993. Three burned areas were censused. There were few differences between the burned and control plots. Ephemerals continued to increase on a shrub-removal plot in Mercury, indicating shrubs inhibit ephemeral population growth. Plots sprayed with a grass-specific herbicide for a second year provided only weak evidence of competition between native species and the dominant introduced grasses. Roadside weeds were examined along Mercury Highway to find evidence for change in ephemeral populations near roads. Most of the weed species examined did not appear to be associated with roadside disturbance, and were as common 35 to 70 m from the road as at 5 and 15 m.

INTRODUCTION

1993 was the seventh consecutive year of ephemeral plant monitoring 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 1992 are reported in Hunter and Medica (1989), and Hunter (1992, 1994a, 1994b). The program examines ephemerals on both baseline and disturbed areas, with most sampled on a three year cycle.

In 1993 31 sites were sampled, including all five baseline sites and one historical monitoring plot. New plots were added around the Device Assembly Facility (DAF) which was being completed in northern Frenchman Flat. Those studies are reported in a separate report (Woodward et al. in press). Herbicide study plots associated with some of the baseline and disturbance plots were also resampled. Because many plot groups consisted of two or three plots there were only 14 independent locations.

Also in 1993 ephemeral densities were studied along two roadsides to try to determine the distance roadsides effect ephemeral populations by encouraging growth of weeds (Tyser and Worley 1992).

Rainfall in December 1992 through February 1993 was unusually heavy, the second consecutive year for good winter rains. Although conditions for good spring production of winter annual plants defined by Beatley (1974) were not quite met (she reported a requirement of an inch of rain falling in late September through early December), 1993 was the best year since 1973 for native wildflower displays, with the possible matching year of 1978, when January rains also were heavy. In most places numbers of ephemeral plants were greatly increased over 1992, probably reflecting the good seed production that year.

Efforts were divided to pursue several goals in 1993. Ongoing studies included monitoring the five BECAMP baseline sites, recensusing Beatley's plot 3 in Rock Valley (monitored 1963-1975 by Beatley, 1987-1993 by BECAMP), determining effects of roadsides on ephemerals, determining recovery of vegetation on two burned areas, and measuring effects on herbicide plots. Studies at new sites near the DAF, and technique modifications required for roadside studies also added to the complexity of 1993 studies.

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.

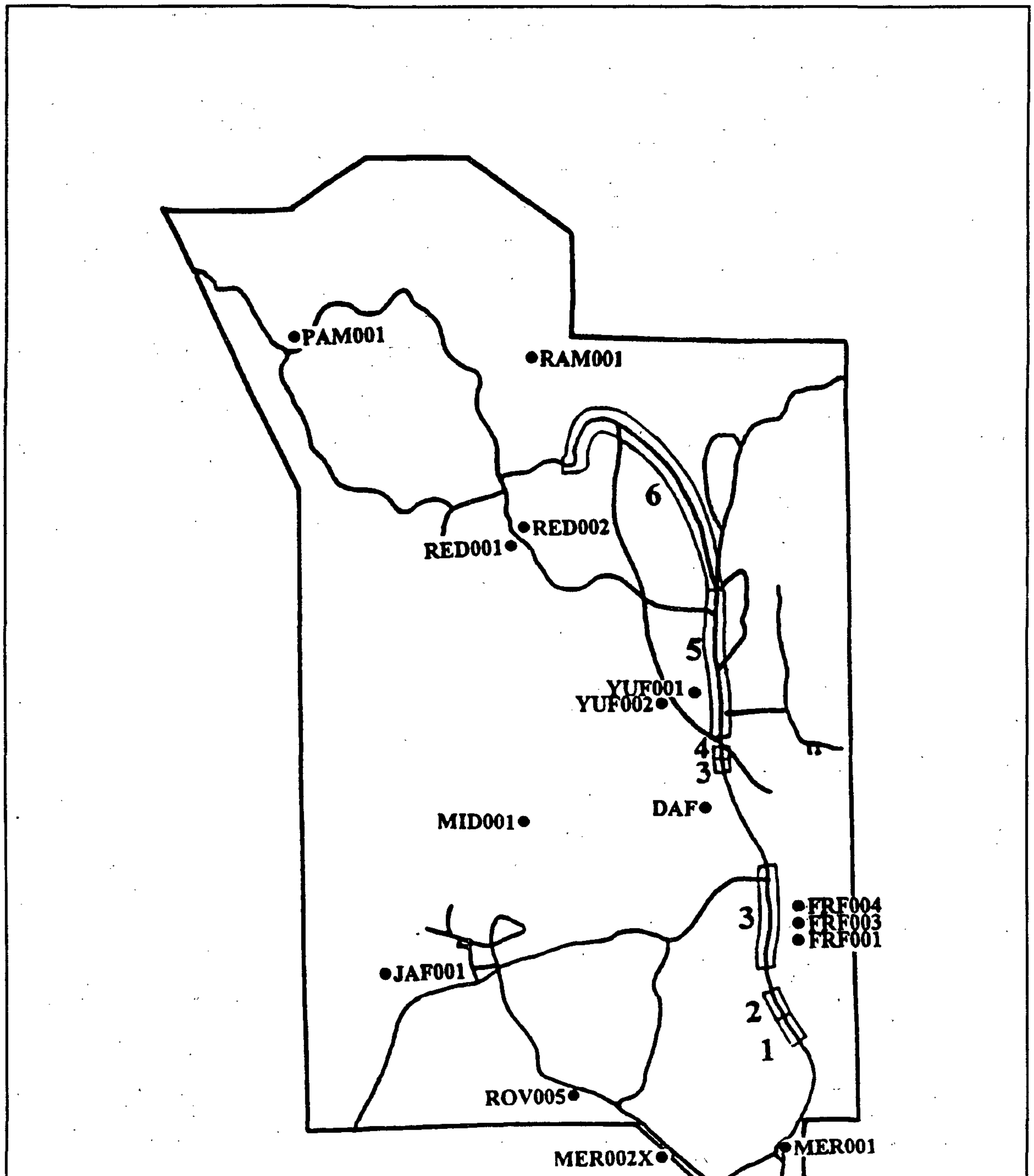
Table 1. Nevada Test Site plots sampled for ephemerals in 1993.			
Site designation	Location	Type	Elevation (meters)
FRF001XS	Frenchman Flat	herbicide, sprayed	965
FRF001XC	Frenchman Flat	herbicide, control	965
YUF001XS	Yucca Flat	herbicide, sprayed	1237
YUF001XC	Yucca Flat	herbicide, control	1237

Censusing methods were generally unchanged. The census technique involved harvesting 20 0.025 m^2 quadrats randomly placed along a 50 m tape. Nested areas of 100 m^2 and 1000 m^2 surrounding the tape were then searched for species not encountered in the smaller areas. Harvested specimens were dried and weighed to determine mean biomass by species. Species identifications were verified on the harvested specimens by comparison to herbarium specimens at the DOE/NTS herbarium in Mercury, Nevada. Voucher specimens of each species were deposited in the herbarium.

Ephemerals on the FRF003 roadside were censused along ten 15 m lines randomly selected along a 100 meter tape stretched along the edge of the asphalt pavement. Another tape was laid out perpendicular to the road, and 0.025 m^2 quadrats were sampled at two random meter-marks within 15 meters of the pavement at each of the ten points. The areas 1 m by 15 m along one side of the tape were then searched for species not in the quadrats (150 m^2). After sampling all ten lines, the whole area within 15 m of the pavement edge and the 100 m tape was searched (1500 m^2).

Standard errors were determined without checking for normal distributions, and are provided as an indicator of distribution. Actual plant distributions were quite patchy. No attempt was made to determine the actual shapes of distribution curves for the various species.

Herbicide plots were circular, 100 m^2 areas bounded by lawn edging. They were sampled with twenty randomly placed 0.025 m^2 quadrats, then the 100 m^2 area was searched for species outside the quadrats. Two plots were sprayed on March 22, 1993. Treatment was similar to that used in 1992 (Hunter 1994b), with spot application of Fusillade (Ornamec) primarily under shrubs. Plot FRF001 was visited the same day, and 20 *Bromus rubens* were hand pulled - all that were found. The MER002 plot was not weeded or sprayed in 1993, as it had low numbers in 1992 and it was expected to have too few *Bromus rubens* to warrant treatment.



PAM001
RAM001
6
RED002
RED001
5
YUF001
YUF002
4
3
DAF
MID001
3
FRF004
FRF003
FRF001
JAF001
2
1
ROV005
MER002X
MER001

[redacted]

To attempt to determine how far from the edge of a road weeds associated with the road edge affect ephemeral populations the whole length of Mercury Highway and Rainier Mesa Road from Mercury to the beginning of Stockade Wash Road was driven and weed species noted at each Rad-Safe Marker. (These roads traverse nearly the whole of the NTS from the southeast corner to the north-central border.) As a result of that survey the route was divided into six sections dominated by different species. The sections can be roughly described as the north-facing slopes, valley centers, and south facing slopes of Frenchman Flat and Yucca Flat where the highway passes through them (marked on Figure 1). Within each zone ten randomly selected Rad-Safe road markers were chosen and densities of eight common species were estimated within a 1 m^2 square quadrat. Density was estimated to the nearest power of two (i.e., 1,2,4,8,16,32, etc.) by two workers, and the two estimates averaged to calculate an approximate density. Density was estimated only for eight weedy species determined in the original census to be common along some sections. Quadrats were placed in the center of the road shoulder, the lowest point before the berm (a trough which often catches water), the raised berm created by scraping the roadsides, and at 5, 15, 35 and 70 meters from the peak of the berm. Where there were non-roadside disturbances affecting the 70 m area a new random location was picked. Utility lines following the course of Mercury Highway prevented sampling significant portions of the length of Mercury Highway (Figure 1).

Plant nomenclature followed Kartesz and Kartesz (1980), after identification following Munz (1974) or Welsh et al. (1987). *Salsola* is all referred to as *S. australis*, following Young (1991).

Descriptive statistics were done with the computer spreadsheet RS1 (BBN software). Student's t-tests were done by hand or with classical techniques in RS1, assuming equal variances. Error estimates in the text are 2 standard errors of the mean, unless otherwise noted.

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 megohm) was equal to the soil moisture when the sensor reading was greater than three megohms, 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 estimates. 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.

RESULTS

Winter rainfall fell primarily in December through February, and was relatively heavy on all but the Pahute Mesa area (Table 2). Germination (monitored on soil-moisture sites) occurred over several weeks from mid-January to mid-February, somewhat later at higher elevations. Germination was more marked under shrubs than in the open at the locations monitored.

Table 2. Fall and winter rainfall (mm) on the NTS, September 1992 through April 1993 (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	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OCT	17.8	14.7	18.5	18.8	20.6	18.3	16.3	29.2
NOV	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DEC	37.3	56.1	55.6	27.4	52.6	65.3	17.5	79.5
JAN	57.4	82.8	85.3	50.3	87.4	125.2	27.7	127.0

Table 2. Fall and winter rainfall (mm) on the NTS, September 1992 through April 1993 (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
FEB	74.9	92.5	84.6	68.1	84.6	140.7	39.9	108.5
MAR	13.0	12.7	24.1	14.0	17.8	14.5	22.9	27.9
APR	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0
TOTAL	201	259	268	179	263	364	124	372

Mercury soil moisture levels estimated for the top 30 cm reached 47.2 mm in late January (Table 3), surpassing the previous highest value of 27.1 mm in January 1988. Sparse germination occurred in Mercury in mid-November, but most plants germinated in late January and early February. Only insignificant rainfall fell in March and April, and ephemerals died in late April and early May.

Table 3. Soil water available to plants (mm, see methods) in the top 30 cm

Table 4. Species richness (#/1000 m^2), densities (n/m^2 ± 2 se) and total above-ground biomass (g/m^2 ± 2 se) of spring ephemerals in southwestern Yucca Flat, sampled in April, 1988-1993.						
	1988	1989	1990	1991	1992	1993
SEP-Apr rain, mm	120	30	29	57	135	263
Species	21	0	0	22	35	32
Density, n/m^2	1956±1114	0	0	78±70	172±133	1762±689
Biomass, g/m^2	21±5	0	0	0.5±0.5	26±26	18±9
Shrub live volume m^3	16.7	15.6	11.6	10.9	11.9	19.2
% *Bromus* (n/m^2)	97	-	-	82	62	50
% *Bromus* (g/m^2)	86	-	-	86	61	61

The Yucca Flat baseline site, sampled annually since 1988, is representative of much of the NTS. As elsewhere, winter ephemerals germinated there late January and early February in 1993, and persisted into early May. Even though rainfall was 95% greater, mean biomass in mid-April (18±9 g/m^2) was less than in late-April 1992, although the difference was not statistically significant (Table 4). Densities were 1762±689 (n/m^2) , up more than ten-fold from 1992, and approaching the record 1988 values (Table 4).

In 1993 overall numbers of plants were not different in quadrats with some shrub cover (n/m^2 = 1924 ± 977) compared with those in the open (1600 ± 1014; t_{18} = 0.29, P = 0.77). However, the numbers of *Bromus rubens* were significantly different (n/m^2 = 1448 ± 796 shrub, 320 ± 155 bare; t_{18} = 2.78, P = 0.012). *B. rubens* under shrubs increased 6.5 times, but in the open they increased 29 times. In neither case, however, did they surpass 1988 densities (3160/m^2 under shrub and 1052/m^2 in the open Table 5).

Weights per plant were higher for quadrats with some shrub cover. Average weight in the open was 6.5 ± 12 mg/plant, and under shrubs was/ 26 ± 18 (t_{18} = 2.17, P = 0.044). *Bromus rubens* weights were 6 ± 1 mg/plant in the open, and 15 ± 6 under shrubs. As a results, biomass under shrubs was significantly greater than in the open (30 ± 14 vs 7 ± 1 g/m^2;t_{18} = 3.28, P = 0.004).

Table 5. *Bromus rubens* densities n/.025m² in Yucca Flat with and without shade, 1988-1992.		
YEAR	COVER	DENSITY
1988	+	79±59
1988	-	26±18
1991	+	2.8±3.0
1991	-	0±0
1992	+	5.6±5.8
1992	-	0.3±0.3
1993	+	36±20
1993	-	8±4

Ephemeral production on other baseline sites varied considerably in 1993, as in 1992. In Jackass Flats both numbers and biomass produced were steady or declined, in spite of an increase in rainfall and a later sampling date (Table 6). In Frenchman Flat the opposite was true. In these two sandy valley sites the patchiness of ephemeral populations (indicated by the large error terms) prevented making definitive conclusions about trends in biomass, although numbers were more tractable. Rock Valley numbers and biomass increased considerably. Rock Valley has comparable soils and shrub populations to YUF001 (Table 4), but while numbers increased similarly on the two plots, biomass increased three-fold in Rock Valley (t_{38} = 2.30, P = 0.03, Table 6) but was stable in Yucca Flat (Table 4).

Ephemeral densities from 1991 through 1993 were unpredictable (Table 4, Table 6), and did not closely track total rainfall amounts. The correlation coefficient between rainfall and numbers for Yucca Flat 1988-1993 and the baseline sites 1991-1993 was 0.539, not significantly different from a zero slope ($F_{1,13}$ = 5.32, P = 0.038). Biomass was highly variable from point to point, indicated by large error terms on baseline plots in 1992 (Table 6). Error terms were generally proportionately smaller in years and places with high densities, such as 1988 and 1993.

Table 6. Sample dates, precipitation totals, densities, and mean biomass for BECAMP baseline sites, 1991 - 1993.

	JAF001	FRF001	ROV005	PAM001	RAM001
ELEVATION m	954	965	1036	1923	2283
SAMPLE DATE - 1991	MAY 7	APR 11	APR 3	-	-
SAMPLE DATE - 1992	APR 8	APR 8	APR 16	May 27	Jun 24
SAMPLE DATE - 1993	APR 28	MAY 3	APR 29	JUN 3	JUL 22
RAIN - 1991	98	57	83	-	-
RAIN - 1992	222	112	200	171	355

Table 6. Sample dates, precipitation totals, densities, and mean biomass for BECAMP baseline sites, 1991 - 1993.

	JAF001	FRF001	ROV005	PAM001	RAM001
RAIN - 1993	268	179	259	124	372
$n/m^2 \pm 2$ se - 1991	164±76	18±21	106±62	-	-
$n/m^2 \pm 2$ se - 1992	164±101	28±14	386±251	154±61	1.5±2.2

Table 7. Ephemeral plant population characteristics on burned and control areas in 1993. Averages are for 20 0.025 m^2 quadrats ± 2 se. Total species are for 1000 m^2 searched.					
PLOT	SPECIES	n/m^2	g/m^2	mg/plant	spp./quad.
RED002 CONTROL	24	904±404	28±13	50±18	3.4±0.8

The Yucca Flat burned area (YUF002)was sampled in 1987, two years after the fire. At that time *Bromus rubens* made up 93% of the numbers (1803 of 1938 $/m^2$) and 83% of the biomass (43 of 52 g/m^2) (Hunter and Medica 1989). Similarly, in 1988 when the Mid Valley site was first sampled (again two years after the fire), *Bromus tectorum* made up 94% of the ephemeral numbers and 97% of the biomass on the burned area. In 1993 that dominance by brome grasses was not evident (Table 8). They declined in proportions of the population on the previously sampled sites, more so on the burned areas than the controls. They were at very low densities on the Red Rock Valley burned site.

Table 8. *Bromus* species on NTS burned areas in 1993 as percent of the mean density and percent of mean biomass. Weights per plant are mg/l ± 2 se. + = present at low density.						
PLOT	*Bromus rubens*			*Bromus tectorum*		
	% n/m^2	% g/m^2	mg/plant	% n/m^2	% g/m^2	mg/plant
YUF002 burned	2	2	51 ± 36	+	+	-
YUF002 control	18	17	71 ± 36	+	+	-
MID001 burned	26	30	45 ± 18	25	36	61 ± 23
MID001 control	43	50	92 ± 51	4	7	135 ± 141
RED001 burned	+	+	-	+	+	-
RED002 control	2	6	98 ± 18	7	18	73 ± 37

Roadsides

5-05 Road: Random quadrats within 15 m of the pavement edge along 5-05 road in Frenchman Flat had similar numbers and biomass to quadrats 500 m away from the road (Plots FRF003 and FRF004 respectively; Table 9). Seven species were unique to the roadside, and 12 to the control area.

Table 9. Ephemeral plant densities, mean biomass, plant weights, and species richness (# per 1000 m^2) or mean number of species per 0.025 m^2 quadrat. ± 2 se.					
Plot	Species	n/m^2	g/m^2	mg/plant	spp./quadrat
FRF003 roadside	32	332 ± 195	25 ± 36	39 ± 21	2.7 ± 1.2
FRF004 control	36	340 ± 108	33 ± 31	95 ± 60	3.4 ± 0.9

Although overall means were very similar, the scraped shoulder of the roadside had a density of only 40 ± 53 plants per square meter, compared to 571 ± 280 in the undisturbed adjacent vegetation (t_{18} = 2.436, P = 0.026). Number of species per quadrat was lower on the scraped area (0.9 ± 1.1 versus 4.2 ± 1.4; t_{18} = 2.94, P = 0.009). This suggests that the unscraped area near the road had somewhat higher density and species richness than the average on the control to balance the lower density and richness on the scraped areas. However, the undisturbed roadside area density was not statistically different from the control area (t_{32} = 1.72, P = 0.095). The scraped shoulder differed dramatically in density from the control area (t_{24} = 52.8, P = 2 x 10^{-26}).

It is plausible the road enhanced ephemeral density outside the scraped area, an effect which might be associated with increased shrub cover or a more stable water environment. There was a greater density of ephemerals under shrubs near the road (800 ± 418 versus 360 ± 224), but the difference was not statistically significant (t_8 = 1.59, P = 0.15), perhaps because there were not enough quadrats under shrubs in the two areas (6 on the roadside and 4 on the control).

Of those species found only near the road, *Schismus arabicus*, *Eriogonum deflexum*, *Erodium cicutarium*, and *Anisocoma acaulis* (Figure 3) were probably present because they are adapted to disturbance and do not compete well in undisturbed areas. Unique species on the control area were mostly of low density, but the densest species on the control area, *Eriophyllum pringlei* (164 ± 99/m^2) was totally absent within fifteen meters of the road pavement.

Several species are associated with roadsides, but do not occur frequently enough to be found in small study areas. Some photographs of these are in Figure 4.

Mercury Highway Weed Study: Eight common weeds were examined along Mercury Highway to determine if their populations might be enhanced by existence of the road, and to gauge the distance roadside populations were spreading into undisturbed vegetation. Of the eight species, only *Erodium cicutarium* was more frequently found on the roadside. Three species were seen more often on the undisturbed areas (*Amsinckia tessellata*, *Bromus rubens* and *Bromus tectorum*), and the remaining four (*Descurainia sophia*, *Eriogonum deflexum*, *Halogeton glomeratus*, and *Sisymbrium altissimum*) were equally common on both roadside and undisturbed areas (Table 10).

Table 10. Properties of roadside weeds along Mercury Highway in Frenchman and Yucca Flats. Abbreviations are the first three letters of genus and species names.

Species	*Ams tes*	*Bro rub*	*Bro tec*	*Des sop*	*Eri def*	*Ero cic*	*Hal glo*	*Sis alt*
Introduced or Native?	N	I	I	I	N	I	I	I
More/less frequent on roadside? (t d.f. = 108 on all)	less t=5.0 $P=10^{-4}$	less t= 4.8 $P=10^{-4}$	less t=2.6 P=0.01	same t=1.5 P=0.15	same t=1.1 P=0.29	more t=4.1 $P=10^{-4}$	same t=1.4 P=0.17	same t=1.1 p=0.29
More/less dense nearer road? (t d.f. = 108)	same t=1.65 P=0.1	less t=2.40 P=0.02	same t=0.8 P=0.45	more t=3.9 $P=10^{-4}$	same t=1.5 P=0.13	same t=0.5 P=0.62	same t=1.0 P=0.32	same t=1.8 P=0.08
Percent of study sites occupied	60	98	84	78	73	71	22	38
Point of highest density	35 m	35 m	5 m	berm	75 m	15 m	berm	berm
Point of lowest density	scraped	scraped	scraped	scraped	scraped	berm	trough	75 m
Highest mean density $n/m^2 \pm 2$ se	5±4	28±15	22±28	20±10	18±17	17±19	5±4	0±1
Lowest mean density $n/m^2 \pm 2$ se	0.02 ± 0.04	2±2	0.9 ± 0.9	0.7 ± 0.6	1.1 ± 0.8	10±6	0.3 ± 0.6	0.02 ± 0.04
Varies along road? (ANOVA, P < 0.05)	yes	yes	yes	yes	yes	yes	no	yes

One species, *Descurainia sophia*, was most dense on the berm (Figure 3), and more dense at 5 and 15 meters from the berm than at 35 and 75 m. It was present primarily on the finer soils associated with the valley bottom, and was considerably less frequent on both north- and south-facing slopes. In favorable habitat it was associated with the soft disturbed soil on the road berm between the scraped and vegetated areas.

Contrary to appearances, the scraped roadside was usually the least dense area for the weeds studied. The one species which was more frequent on the scraped road shoulder (*Erodium cicutarium*) is normally an uncommon species on undisturbed areas. These results are unlike those of Tyser and Worley (1992) who found frequencies and species richness of introduced weeds were greatest in scraped/mowed shoulders along roads in Glacier National Park and decreased with distance from the road.

The frequency (proportion of total quadrats occupied by a given species) of seven of the eight species varied among the different sections of road (Table 11). Variations seen were concentration of *Descurainia sophia* in the valley bottoms, increase in *Amsinckia tessellata* towards the northern, higher altitude sections, and decreases in *Bromus rubens*, *B. tectorum*, and *Erodium cicutarium* towards the north.

Table 11. Mean percent of quadrats occupied by common weed species on roadside (R = shoulder, trough, and berm) areas and undisturbed areas (U = 5,15,35,70 m from berm) along Mercury Highway. Road sections are on Figure 1. Section 4 was not sampled because of excessive disturbance within 70 m of the berm. ANOVA tested whether all sections of road had similar densities (F,P values).

Section	AMS TES		BRO RUB		BRO TEC		DES SOP		ERI DEF		ERO CIC		SIS ALT	
	R	U	R	U	R	U	R	U	R	U	R	U	R	U
1	0±0	3±6	85±23	89±22	52±30	39±29	15±12	3±6	78±16	44±20	96±7	47±19	4±7	0±0
2	3±7	10±11	73±17	80±16	63±18	68±15	87±11	78±14	3±7	28±17	77±24	18±8	0±0	0±0
3	17±11	48±21	62±17	78±19	23±15	34±24	10±10	8±8	25±17	8±8	52±21	44±21	6±9	0±0
5	17±11	32±21	37±21	83±11	30±16	60±23	57±17	60±23	17±20	60±20	3±7	2±5	20±11	20±23
6	23±9	52±25	40±13	90±20	23±14	52±23	23±17	15±17	27±13	48±27	13±11	18±13	3±11	0±0
$F_{4,50}$ =	2.81	4.94	4.55	0.33	3.91	1.47	23.3	23.0	10.5	6.1	17.2	5.1	3.15	3.34
p =	0.035	0.002	0.003	0.85	0.008	0.22	0	0	10^{-5}	0.001	0	0.002	0.022	0.017

Table 12. Summary ephemeral population characteristics for a shrub removal plot (MER001W) and its adjacent control (MER001E) in Mercury, Nevada, 1986-1993. (In 1989 there were 0 ephemerals on either plot.) Error terms are ± 2 se.

YEAR →	1986	1987	1988	1990	1991	1992	1993
SEP-APR RAINFALL, mm	139	103	157	36	74	156	201
SAMPLE DATE	3/28	4/14	4/05	4/04-5	4/04	4/28-29	4/26-27
SHRUBS REMOVED							
n/m²	1099±577	616±401	3070±1044	8±7	269±151	594±178	5296±1439
g/m²	21±10	36±17	32±11	0.08±0.08	0.54±0.26	27±11	40±8
mg/plant (*Bromus*)	25±6	70±31	12±2	4	-	76	37±12
spp./0.6 m²	12	14	17	3	8	19	22
spp./plot	-	-	-	5	22	35	35
Bromus,% of n	72	74	62	25	0	0.5	0.7
CONTROL							
n/m²	358±191	395±249	581±306	0	22±16	58±24	868±345
g/m²	2.6±1.5	5±4	10±5	0	0.04±0.02	2.7±1.5	22±13
mg/plant (*Bromus*)	13±3	14±2	25±4	-	2.1±0.2	134	27±10
spp./0.6 m²	7	6	11	0	3	9	18
spp./plot	-	-	-	2	12	32	32
Bromus,% of n	47	89	76	-	43	3	8.5

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 12). Foot traffic has been minimized, and was virtually limited to censusing the ephemerals in spring of each year.

Several parameters on these two plots have diverged significantly since sampling began (Table 12). Total ephemeral numbers, total biomass, and numbers of species have been consistently greater on the plot with shrubs removed since sampling began (Hunter 1994b). In 1993 the same patterns held, with total numbers significantly greater (t_{48} = 6, P = 10^{-6}), total biomass significantly greater (t_{48} = 2.41, P = 0.02) and species per 0.025 m^2 quadrat significantly greater (bare = 9.0 ± 0.8, shrub = 4.6 ± 0.8;t_{48} = 8.8, P = 10^{-11}).

Between 1992 and 1993 numbers increased 9-fold on the bare plot, and 15-fold on the shrub plot. Biomass increased only 48% on the bare plot, but 815% on the shrub plot. Numbers of species were constant from 1992 to 1993, although a few low-density species were absent one or the other of the two years (see Appendix 1). In 1993 the most common species on the bare plot were *Schismus arabicus* (2040 ± 976/m^2) and *Vulpia octoflora* (1910 ± 717), two very similar diminutive annual grasses. *Schismus* is introduced and *Vulpia* is native. *V. octoflora* produced the most biomass on both plots (12 ± 4 and 8 ± 5 g/m^2 on bare and shrub plots, respectively), but *S. arabicus* was nearly absent from the shrub plot (24 ± 28/m^2; 0.3 ± 0.3 g/m^2). Among the top five species in terms of biomass only *V. octoflora* was common to both plots (detailed results are in Appendix E).

Herbicide Plots

Except for reducing the *Bromus* densities, herbicide had little apparent effect the first year sprayed (1992)(Hunter 1994b). There was no significant increase in native numbers, biomass, or individual size, within the measurement error limits. This was to be expected the first year, since germination occurred before spraying, and error limits were relatively large.

Bromus rubens was indeed lower on sprayed plots than on controls, but only if the plot were again sprayed or weeded. The herbicide plot in Mercury Valley was left unsprayed in the belief that the 13 ± 9 plants in 1992 couldn't produce enough seed to produce a significant *Bromus* population. It produced

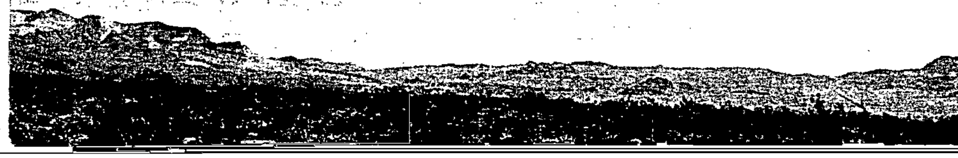
Table 13. *Bromus rubens* and native plant populations on plots sprayed with grass-specific herbicide in 1992 and 1993. *Plot MER002 was sprayed in 1992 but neither sprayed nor weeded in 1993.

	1992	1993

In 1993 samples of 10 large, medium, and small *Bromus rubens* plants were separated to determine seed production. Small plants averaged 24 mg dry weight and produced 9 seeds, medium plants weighed 46 mg and produced 28 seeds, and large ones weighed 130 mg and produced 55 seeds each. Thus increases of 12- to 15 fold on the sprayed plots was reasonable, but the increase on plot MER002 of 237-fold must have been accomplished by germination of large numbers of seed not produced by *Bromus* plants in 1992. They either were dormant through 1992 or blew in from surrounding populations. The more likely explanation is dormancy in the soft frequently disturbed soil on this "gopher" area plot. (However, Vollmer et al. [1982] found essentially all *B. rubens* germinated in Petri dishes without pretreatment, suggesting most seeds should have germinated in 1992.)

On sprayed plots numbers, weights, and weights per plant were not significantly different, although on the two plots sprayed in 1993 numbers and weights were somewhat higher on the sprayed plots. Native species which were most numerous on sprayed plots in 1993 did not appear to be particularly benefited by the reduction in *Bromus* numbers. Species which increased in density from 1992 to 1993 on sprayed plots, increased similarly on control plots. One species which might be significant was *Chaenactis stevioides*, which was the most numerous species on the YUF001 sprayed plot in 1993 ($310 \pm 157/m^2$), and increased from $4 \pm 3/m^2$ in 1992. But it went from merely present on the control plot in 1992 to $56 \pm 24/m^2$ in 1993, and also increased markedly on the MER001 shrub removal plot, suggesting it had a favorable year for germination.

On the Rock Valley sprayed plot a difference was noted in the number of *Rafinesquia neomexicana* plants. There were ten counted on the sprayed plot, and only one could be found on the control. On the YUF001 sprayed plot open flowers of *Malacothrix glabrata* were counted - there were 330 open on the sprayed plot, and only 38 on the control. Both these species are large-flowered and associated with shrubs (Figure 2), but are infrequently encountered in the 0.025 m^2 quadrats used for sampling.



Species Distributions

In 1993 133 species were identified on and near the 28 ephemeral plots, two less than seen on 29 plots in 1992 and for the three drought years 1989-1991 (Hunter 1994a, 1994b). Species seen, the plots they occurred on, densities to an order of magnitude, and range in elevation are in Appendix D. The 28 plots sampled, when corrected for controls and nearby sample points represented only 14 independent sites, and covered only 0.01% of the NTS. The species sampled therefore represented the most common ones, of approximately 300 occurring on the NTS (Beatley 1976).

The year 1993 was the third consecutive relatively productive year for ephemerals. *B. rubens* was again the most frequently encountered species (Table 14), occurring on 13 of the 14 possible sites. As in 1992 *Bromus rubens* had by far the highest median density of the ten most common species (Table 14). Only Rainier Mesa had none, although it was also very sparse on Pahute Mesa. The native species on the ten most frequent list changed little, though median densities increased somewhat. *Bromus rubens*' median density declined insignificantly, probably due to an increased proportion of study sites in Frenchman Flat, where its density is lower. Species new to the list in 1993 were *Chaenactis fremontii*, *Malacothrix glabrata*, and *Vulpia octoflora*, while those deleted were *Cryptantha pterocarya*, *Cryptantha gracilis*, and *Salsola australis*. The decline of *Salsola australis* from the second most-dense species in 1992 probably reflected cold temperatures during germination (January, February) in 1993.

Table 14. The ten most frequently encountered ephemeral species on the Nevada Test Site in 1993, with number of sites (of 14) occupied, ranges in elevation, and median densities on the sampled plots. Asterisks mark introduced species.

SPECIES	# of sites	RANGE (m)	median density
*Bromus rubens**	13	954-1923	74
Mentzelia albicaulis	13	954-2283	14
Cryptantha circumscissa	13	954-1923	6
*Bromus tectorum**	13	954-1923	>0.01
Descurainia pinnata	12	965-1923	9
Gilia transmontana	11	954-1923	4
Chaenactis fremontii	11	954-1923	3

Table 14. The ten most frequently encountered ephemeral species on the Nevada Test Site in 1993, with number of sites (of 14) occupied, ranges in elevation, and median densities on the sampled plots. Asterisks mark introduced species.

SPECIES	# of sites	RANGE (m)	median density
Malacothrix glabrata	11	954-1923	2
Vulpia octoflora	10	954-1448	12
Chaenactis stevioides	10	965-1448	5

There were a number of both deletions and additions to the list of species seen in 1993 (Appendix D). Most were related to the different sites sampled between the years, rather than a change in species composition across the NTS. many added species were seen in low density near the DAF or on plots RED001/RED002. The DAF was found to have a high species richness (Woodward et al. in press), and the Red Rock Valley plots are on a deep sand with a somewhat unusual species composition (*Abronia turbinata*, *Ambrosia acanthicarpa*, *Gilia nyensis*, *Tiquilia nuttallii* and *Machaeranthera arida*). Of interest near the DAF were occasional specimens of *Lotus humistratus*, *Eucrypta micrantha*, *Linanthus arenicola*, and *Phacelia parishii*. One specimen of a climbing snapdragon, *Antirrhinum filipes*, was seen near the DAF.

DISCUSSION

September to April rainfall in 1993 was greater than in any year since 1978 on many NTS locations. One would therefore expect increased density and biomass of ephemerals. Our expectations were often not met in 1993, which is probably attributable to the large number of variables affecting ephemeral populations. In general, rainfall and temperature control numbers of ephemerals through controls on germination, while biomass is controlled by growing conditions, which involve soil moisture availability during the later growing season, water use by shrubs, soil fertility, numbers germinated, and soil texture. In 1993 other variables appeared to be operating, and the invisible "seed bank" and possibly soil fertility and shrub-annual interactions also affected ephemeral populations.

Beatley (1974) summarized several years of observations of "winter annuals" on the NTS with a model that produced mass germination if either autumn rains of >25 mm or later rains of more than 25 mm combined with soil temperatures above 10°C. In 1993 rains fell after her critical period, and germination was therefore "late". Nevertheless, ephemeral plant densities often exceeded her range (0-975/m^2) and biomass in Rock Valley and the Mercury Valley herbicide plot exceeded her maximum value (62 g/m^2); B)eatley did not provide confidence or error limits). At the same time, in Jackass Flats numbers and biomass were unchanged from 1992 (Table 6). In Yucca Flat numbers increased 10-fold, while

rains in December and January should results in germination only at low altitudes, but numbers were quite high on the burned and control areas in Red Rock Valley and Mid Valley (1612 and 1448 m, respectively), among the higher elevations to produce significant ephemeral populations. Neither Pahute nor Rainier Mesa ephemeral populations were significant in 1993. Pahute Mesa had a poor rainfall year, and neither Pahute nor Rainier Mesa has had significant annual populations between 1988 and 1992, except on disturbed areas (Hunter be guessed from the numbers that actually germinate (Went and Westergaard 1949). The MER002 plot on which *Bromus rubens* densities went from 13 to $3080/m^2$ in one year has to be explained as an improvement in germination conditions between 1992 and 1993 for a sizable seed bank, rather than as seed production. In other areas, such as the Yucca Flat baseline plot, increases of 6 to 29-fold in density can be attributed to seed production by 1992 plants. In fact, the approximate ten-fold increases in densities on plots in Mercury Valley, Frenchman Flat, and Yucca Flat almost require a postulated increase in the seed pool over 1992, because rainfall in 1992 was too high to suggest germination was poor.

Absence of differences in densities between shrub and open areas in Yucca Flat might be due to uniformly good germination conditions in 1993, without regard to shrub cover. In other years the shade provided by shrubs may prevent rapid soil drying, and improve germination under shrubs. In 1993 the surface was wet from late December through approximately the third week of January, even in the open. This explanation is somewhat unsatisfying, as the shrub-bare difference was previously used to suggest seed survival was lower in the open due to high soil temperatures in summer (Hunter 1994b). This dichotomy between seed death and poor germination conditions cannot be answered in the absence of data on seed pools and more careful measurement of germination conditions.

One explanation for an absence of increased biomass production by ephemerals in 1993 is that shrub populations were utilizing the available water, either through rapid growth (YUF001), or a 1992 recovery from drought damage (JAF001; Hunter, perennials report, this volume). This, too, is somewhat unsatisfying, as the Mercury water balance studies (Table 3) suggested water was available

Randall equation predicted (Hunter 1994a, 1994b), but coarse precision of our ephemeral sampling procedure cannot distinguish the measured from predicted values.

Species numbers have been relatively constant at about 130 species since the first full year of sampling by BECAMP in 1988, with the exception of the severe drought years of 1989 and 1990. Indeed, Beatley (1969) reported 130 species on 68 plots scattered over the NTS for the early 1960's. Thus, the number of species found does not appear to fluctuate with rainfall. I believe this relates to the area sampled - BECAMP samples areas of 0.025 to 1000 m^2 on each plot to record species present. Although density may vary with rainfall, presence of a species appears to be fairly constant.

Department of Energy Effects

Many of the areas studied in 1993 were either control sites or locations of experimental (shrub-removal, herbicide) or natural (lightning fires, introduced species) disturbance. DOE and its contractors, however, are responsible for road maintenance and construction. In 1993 an attempt was made to both characterize ephemeral populations along roadsides and to estimate effects of roadside weeds on the surrounding vegetation.

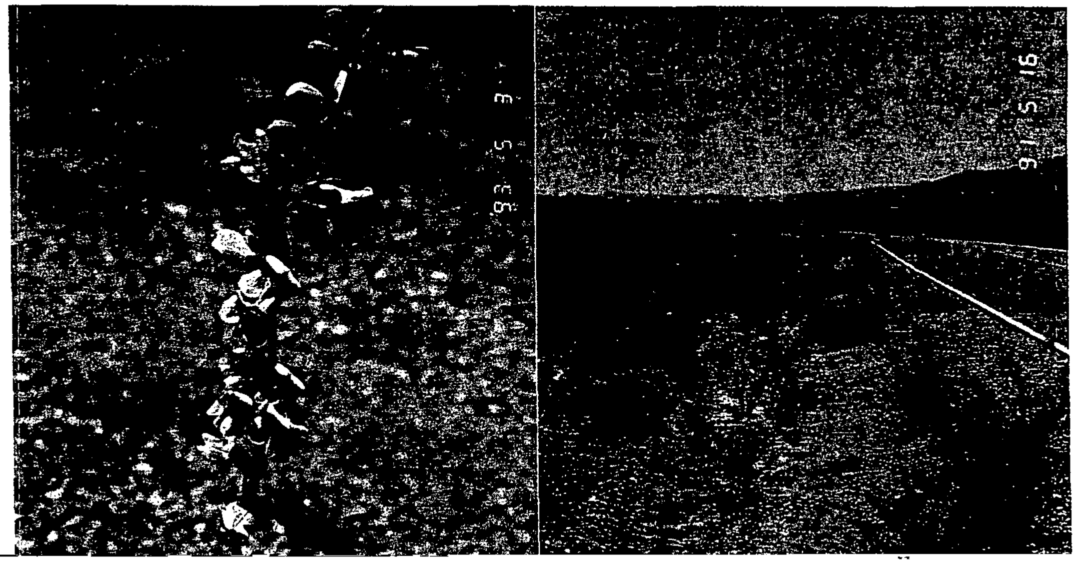
Definitive answers were not provided in either study, but it seems clear that, at least within the limits of the study technique, there was little overall effect of an active roadway through Frenchman Flat on ephemeral populations. This was true in spite of the obvious loss of habitat on the scraped road shoulder. For some relatively uncommon species roadways appeared to be a favorable habitat (Figure 4).

The roadside weed study did provide new information, and tended to negate the idea roads help to spread introduced weeds into new areas (Tyser and Worley 1992). However, the roadside weed study was not totally consistent with results of a similar study on the relatively new paved road to the DAF. Along the south side of that road *Schismus arabicus* was found along the roadside and out to 20 m from the pavement edge (Woodward et al., in press), and was absent from there to 50 m from the pavement edge. Mercury Highway, in existence since the early 1950's, may have already contributed to spread of some of the weeds studied to a distance beyond the 70 m examined. At that distance effects of the many NTS disturbances could overlap, and essentially the whole ecosystem could be thus affected by a general increased disturbance level. It would be difficult to find a large area on the NTS without some disturbance to use as a control. It might also be difficult off the NTS to find an area free for long periods from grazing, mining, dirt roads, campers and hikers, and other human disturbances.

Results for *Halogeton glomeratus* along Mercury Highway were also unsatisfying. In many places at least subjectively H. glomeratus appears associated with roadsides and other disturbances (Figure 3). The Mercury Highway study appeared inadequate to demonstrate that association (Table 10).

DOE controls fires on the NTS. In spite of this fire is a major cause of clearing of shrubs and creation of open areas (Hunter and Medica 1989). The ecological processes involved in recovery from fire are of interest and applicable to studies of recovery of vegetation on areas blasted free of vegetation by nuclear weapons testing in the 1950's and 1960's. Those areas

[illegible]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We are currently examining both different ways of sampling, and different methods of data analysis. Frequency data, as opposed to density data, may be a useful adjunct (Table 10).

As a one-time effort, it may be practical to determine ratios of seed production to above ground dry weight produced by various annual species. Those data could be used to estimate numbers of seeds produced each year. Over a period of years that might allow an estimation of seed reserves at sites sampled every year. For the Mercury shrub-removal plot and YUF001 such calculations could be carried back to 1986 and 1988, using data already collected. Some theoretical work on modeling of species with seed banks is appearing (e.g. Kalisz and McPeek 1992,1993), as are some measurements on actual seed banks (Gutterman and Ginnott 1994).

Cumulative effects of DOE activities have not been specifically addressed by the BECAMP program. In future years it may prove possible to allocate time to studying general NTS changes and comparing them to off-site ecosystem changes. Such studies may require cooperative agreements with other agencies, such as the Bureau of Land Management, U. S. Park Service, and U. S. Department of Defense.

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APPENDIX D

This table includes locations and rough densities of all annual and below-ground perennial species sampled on the Nevada Test Site in 1993. Entries after each species name are plot name (See Saethre, Status of Mammals on the Nevada Test Site, 1993, this report, for locations, altitudes, and descriptions). Letter code "X" indicates a *Bromus* exclusion plot sprayed with a grass-specific herbicide, "C" stands for control (i.e. untreated), and "S" for sprayed. A final "A" indicates it was present in quadrats, and information is available in Appendix 2 on its density, weight per plant and per square meter, and reproductive status. A final "B" indicates it was seen in the 100 m^2 search area, and a final "C" indicates it was only seen in the 1000 m^2 area. These codes give a rough idea of relative density for the rarer species.

Abronia turbinata RED001B
Allium nevadense FRF003C
Ambrosia acanthicarpa RED001A, RED002A
Amsinckia tessellata DAF, FRF001B, FRF001XCB, FRF001XSA, FRF003B, FRF004A, MER002XCA, MER002XSA, MID001A, MID001BURNA, RED002B, ROV005A, ROV005XCB, ROV005XSB, YUF001A, YUF001XSB, YUF002BURNA, YUF002CONTA
Anisocoma acaulis FRF001B, FRF003B
Antheropeas wallacei (= *Eriophyllum wallacei*) DAF, MID001BURNB
Antirrhinum filipes DAF
Astragalus acutirostris DAF
Astragalus nyensis MER001WA
Astragalus calycosus RAM001B
Astragalus didymocarpus JAF001B
Astragalus lentiginosus fremontii DAF, FRF004A, MER002XCB, MER002XSB, MID001BURNC, MID001C, PAM001B, RAM001C, YUF001A, YUF001XCA, YUF001XSA, YUF002BURNA, YUF002CONTA
Astragalus purshii MID001C
Astragalus tidestromii MER001WB, ROV005C, ROV005XSB
Baileya multiradiata MER001WB
Bromus rubens DAF, FRF001A, FRF001XCA, FRF003A, FRF004A, JAF001A, MER001CA, MER001WA, MER002XCA, MER002XSA, MID001A, MID001BURNA, PAM001B, RED001B, RED002A, ROV005A, ROV005XCA, ROV005XSA, YUF001A, YUF001XCA, YUF001XSA, YUF002BURNA, YUF002CONTA
Bromus tectorum DAF, FRF001XCB, FRF001XSB, FRF003B, FRF004B, JAF001C, MER001CB, MER001WB, MER002XCB, MER002XSA, MID001A, MID001BURNA, PAM001B, RED001C, RED002A, ROV005XCA, YUF001B, YUF001XCB, YUF001XSB, YUF002BURNB, YUF002CONTC

Bromus trinii MID001C, ROV005B, ROV005XCB
Calochortus flexuosus MID001BURNC, PAM001B
Calycoseris wrightii DAF, MID001B, ROV005B, ROV005XCB, JAF001C
Camissonia boothii DAF, YUF001B, YUF001XCA, YUF001XSA
Camissonia brevipes DAF, FRF001B, FRF001XCB
Camissonia claviformis DAF, FRF001XCA, FRF001XSA, FRF003A, MER001CB, MER001WA, RED001B, RED002B, ROV005A, ROV005XSA, YUF001B
Camissonia kernensis DAF, FRF001XSB, YUF002BURNA, YUF002CONTA
Camissonia pterosperma DAF
Camissonia pusilla PAM001A, RAM001C
Camissonia refracta DAF, FRF004B
Castilleja chromosa MID001BURNC, MID001C, PAM001B
Caulanthus cooperi DAF, MER001CB, MER001WB
Caulanthus lasiophyllus DAF, ROV005A, YUF002CONTA
Centrostegia thurberi (= *Chorizanthe thurberi*) DAF, FRF004B, MID001A, MID001BURNB, YUF002BURNC
Chaenactis carphoclinia DAF, MER001CA, MER001WA, MER002XSA, ROV005A, ROV005XCB, ROV005XSA
Chaenactis douglasii FRF003B, RAM001B
Chaenactis fremontii DAF, FRF001A, FRF001XCA, FRF001XSA, FRF003A, FRF004A, JAF001A, MER001CB, MID001B, PAM001B, RED002A, YUF001A, YUF002BURNA
Chaenactis macrantha DAF
Chaenactis stevioides DAF, FRF001B, FRF001XCB, FRF003B, FRF004A, MER001CA, MER001WA, MER002XCA, MER002XSA, MID001A, MID001BURNB, ROV005A, ROV005XSB, YUF001A, YUF001XCA, YUF001XSA, YUF002BURNA, YUF002CONTA
Chamaesyce albomarginata (= *Euphorbia albomarginata*) DAF, FRF003C, MER002XCA, MER002XSA, MID001A, MID001BURNC
Chenopodium fremontii RAM001C
Chenopodium incanum DAF
Chenopodium leptophyllum RAM001B, RED001C
Chenopodium species RED002A
Chorizanthe brevicornu DAF, MER001CA, MER002XCB, MID001B, PAM001C, ROV005A, ROV005XCA, ROV005XSA, YUF002CONTB
Chorizanthe rigida DAF, FRF001B, FRF001XCB, MER001CA, MER001WA, ROV005XSB, YUF001C
Chorizanthe watsonii FRF004B, MID001BURNA
Cryptantha circumscissa DAF, FRF001A, FRF001XCA, FRF001XSA, FRF003B, FRF004A, JAF001A, MER001WA, MER002XCA, MER002XSA, MID001B, PAM001B, RED001B, RED002A, ROV005C, ROV005XCB, ROV005XSA, YUF001A, YUF001XCA, YUF002BURNA, YUF002CONTA
Cryptantha dumetorum FRF003B, FRF004B
Cryptantha flavoculata RAM001B
Cryptantha gracilis PAM001B, RAM001C, YUF001A

Cryptantha maritima DAF
Cryptantha micrantha DAF, FRF001B, FRF001XCA, FRF001XSA, FRF003A, FRF004A, JAF001A, RED002A
Cryptantha nevadensis DAF, FRF001XCB, FRF001XSB, JAF001C, MER001CB, MER001WA, PAM001C, ROV005A, ROV005XCA, ROV005XSA, YUF001XCB, YUF001XSA
Cryptantha pterocarya DAF, FRF001A, FRF001XCB, FRF001XSB, FRF003A, FRF004A, JAF001B, MER001CB, MER001WB, MID001A, MID001BURNA, RED001A, RED002A, ROV005A, ROV005XCB, ROV005XSA, YUF001A, YUF001XCA, YUF001XSA
Cryptantha recurvata DAF, FRF001A, FRF001XCB, FRF004A, MER001CB, MER001WA, MER002XSB, ROV005A, ROV005XSA, YUF001B, YUF001XCA, YUF001XSA
Cryptantha species RED002A
Cryptantha virginensis MER001CB, MER001WB
Cuscuta nevadensis ROV005C, ROV005XSB
Cymopteris ripleyi FRF001C
Delphinium parishii DAF, MID001BURNB, MID001C, PAM001C, ROV005B
Descurainia pinnata DAF, FRF001A, FRF001XCB, FRF001XSB, FRF003A, FRF004A, MER001CA, MER001WA, MER002XCB, MER002XSB, MID001A, MID001BURNA, PAM001C, RED001B, RED002A, ROV005B, YUF001A, YUF001XCA, YUF001XSA, YUF002BURNA, YUF002CONTA
Descurainia sophia DAF, FRF001B, MER001CB, RED001B
Dichelostemma pulchellum MER002XCB, MER002XSA
Eriastrum eremicum FRF001XSA, FRF004A, JAF001B, MID001A, MID001BURNB, PAM001B
Erigeron pumilus PAM001A
Eriogonum deflexum DAF, FRF003A, MER001CA, MER001WA, RED001B, RED002B, ROV005C, YUF001A, YUF001XSB, YUF002CONTC
Eriogonum inflatum DAF, FRF004B, MER001CB, MER001WB, ROV005C, ROV005XSB
Eriogonum maculatum DAF, FRF001A, FRF001XCA, FRF001XSA, FRF003B, FRF004B, JAF001C, ROV005B, ROV005XSA, YUF001A, YUF001XCA, YUF002BURNA, YUF002CONTA
Eriogonum nidularium DAF, FRF004B, MID001A, MID001BURNA, PAM001B, RED001B, ROV005A, YUF001A, YUF001XCA, YUF001XSA, YUF002BURNA, YUF002CONTA
Eriogonum ovalifolium PAM001A, RAM001A
Eriogonum reniforme DAF, FRF001XSB, YUF002CONTB
Eriogonum trichopes DAF, MER001WA, ROV005B, ROV005XCA, ROV005XSA
Eriophyllum pringlei FRF001A, FRF001XCA, FRF001XSA, FRF004A, JAF001B, PAM001C, ROV005B, YUF001A, YUF001XCA, YUF001XSA
Erodium cicutarium DAF, FRF003B, MER001CA, MER001WA, MID001BURNA, ROV005C, ROV005XCB, YUF002BURNA, YUF002CONTA
Eschscholtzia glyptosperma DAF, FRF001A, FRF001XSB, MER002XCB, ROV005XSB
Eschscholtzia minutiflora DAF
Eucrypta micrantha DAF

Gilia latifolia ROV005C
Gilia nyensis RED001A, RED002A
Gilia sinuata DAF, FRF001A, FRF001XCA, FRF001XSA, FRF003A, FRF004A, JAF001B, MID001A, MID001BURNA, RED002C, YUF001A, YUF001XCA, YUF002BURNA
Gilia transmontana DAF, FRF001XCA, FRF001XSA, FRF004A, JAF001C, MER001CA, MER001WA, MER002XCA, MER002XSA, MID001A, MID001BURNA, PAM001A, ROV005B, ROV005XCA, ROV005XSA, YUF001A, YUF001XCA, YUF001XSA, YUF002BURNA, YUF002CONTA
Glyptopleura marginata FRF003A, FRF004B
Halogeton glomeratus DAF
Ipomopsis congesta RAM001B
Ipomopsis polycladon DAF, MER001CA, MER001WA, PAM001B, ROV005B, ROV005XSA, YUF001XCA, YUF001XSA
Langloisia schottii DAF, FRF003B, JAF001B, YUF001XSA
Langloisia setosissima DAF, FRF004B, MER001CA, MER001WA, ROV005A, YUF001XCA, YUF001XSA
Lepidium lasiocarpum DAF, FRF001C, FRF001XSB, MER001CB, MER001WB, MER002XSA, MID001A, ROV005A, YUF001A, YUF001XCA, YUF001XSA
Linanthus demissus DAF, FRF001XCA, FRF001XSA, MER001CA, MER001WB, ROV005B
Linanthus dichotomus DAF, MER002XCA, MER002XSA, MID001A, MID001BURNA, PAM001A
Linanthus jonesii DAF
Lomatium nevadense MID001BURNB
Lotus humistratus DAF, MER002XSA
Lupinus flavoculatus DAF, MID001A, MID001BURNB, YUF001B, YUF001XCA, YUF001XSB, YUF002BURNB, YUF002CONTA
Lupinus shockleyi DAF, FRF001B, FRF001XCB, FRF001XSB, FRF003B, FRF004B
Machaeranthera canescens DAF, MER002XCA, MER002XSA, MID001B, MID001BURNB, PAM001B, RED001A, RED002A, YUF001A, YUF001XCA, YUF001XSB
Malacothrix californica ssp *glabrata* DAF, FRF001A, FRF001XCA, FRF001XSA, FRF003A, FRF004A, JAF001A, MER001CB, MER001WB, MER002XSA, MID001B, MID001BURNB, ROV005XCB, ROV005XSA, ROV005XSB, YUF001A, YUF001XCB, YUF001XSA, YUF002BURNA, YUF002CONTA
Malacothrix sonchoides DAF, FRF001A, JAF001A, RED001C, RED002B
Mentzelia albicaulis DAF, FRF001A, FRF001XCA, FRF001XSA, FRF003A, FRF004A, JAF001A, MER001WB, MER002XCB, MER002XSA, MID001A, PAM001B, RAM001A, RED001A, RED002A, YUF001A, YUF001XCA, YUF001XSB, YUF002BURNA, YUF002CONTA
Mimulus bigelovii var. *cuspidatus* DAF
Mimulus rubellus DAF
Mirabilis bigelovii DAF
Monoptilon bellidiforme/bellioides DAF, FRF001A, FRF001XCA, FRF001XSA, FRF003A, FRF004A, JAF001B
Muilla coronata MER001WB

Nama aretioides DAF, RED001B, RED002B
Nama demissum DAF, FRF001B, FRF001XCA, FRF001XSA, FRF003A, FRF004A, JAF001B, MER001CB, MER001WB, MER002XCB, MER002XSB, ROV005C
Nama pusillum DAF
Nama species FRF004A
Nemacladus glanduliferus DAF, FRF001A, FRF001XCA, FRF001XSA, FRF003A, FRF004A, JAF001B, MER001CA, ROV005C, ROV005XSB, YUF001XCA
Orobanche fasciculata PAM001B
Oxytheca perfoliata DAF, FRF001B, ROV005B, YUF001B, YUF001XCA, YUF001XSA, YUF002BURNA, YUF002CONTA
Pectocarya heterocarpa DAF, MER001CA, MER001WA, ROV005A, ROV005XCA, ROV005XSA
Pectocarya platycarpa DAF, MER001CA, MER001WA, MER002XSB, ROV005XCA, ROV005XSA
Pectocarya setosa DAF, MID001B, MID001BURNA
Penstemon species RAM001C
Phacelia crenulata DAF
Phacelia fremontii DAF, MER001CA, MER001WA, MID001B, MID001BURNA, PAM001A, RED001B, RED002A, ROV005A, ROV005XCB, ROV005XSA, YUF001A, YUF001XCA, YUF001XSA, YUF002BURNA, YUF002CONTA
Phacelia rotundifolia DAF
Phacelia saxicola DAF, PAM001B
Phacelia vallis-mortae DAF, MID001A, MID001BURNB, RED002A, ROV005A, ROV005XCA, YUF001A, YUF001XCB, YUF001XSB, YUF002BURNC, YUF002CONTC
Phlox stansburyi MID001BURNA, PAM001B
Prenanthella exigua DAF, JAF001A, MER001CB, ROV005A, ROV005XSA, YUF001B, YUF001XSA
Rafinesquia neomexicana DAF, FRF001B, FRF001XSB, FRF003B, FRF004B, MID001B, ROV005XSB, YUF002CONTC
Salsola australis DAF, MER001WA, MID001BURNA, RED001A, RED002A, YUF001C, YUF001XCA, YUF001XSA, YUF002BURNA, YUF002CONTA
Schismus arabicus DAF, FRF003A, JAF001A, MER001CA
Sisymbrium altissimum DAF, MID001BURNC, YUF002BURNA, YUF002CONTB
Stephanomeria exigua DAF, MID001A, RED002A, YUF001A
Stephanomeria parryi YUF002BURNB, YUF002CONTB
Streptanthella longirostris DAF, FRF001A, FRF001XCB, FRF001XSB, FRF003A, FRF004B, JAF001B, MER001CB, MER001WB, MID001BURNB, ROV005C
Streptanthus cordatus RAM001C
Thysanocarpus curvipes MID001BURNB
Tiquilia nuttallii RED001A, RED002A
Tricardia watsonii MID001B
Unknowns MER001CA, MER001WA, MID001A
Viguiera multiflora MID001B, MID001BURNB

Vulpia microstachys MID001A, MID001BURNA

Vulpia octoflora DAF, FRF001C, FRF003A, FRF004A, JAF001A, MER001CA, MER001WA, MER002XCA, MER002XSA, MID001A, MID001BURNA, ROV005A, ROV005XCA, ROV005XSA, YUF001XCA, YUF001XSA

Total is 133 species (not counting unknowns). Taxonomy follows Kartesz and Kartesz except for *Salsola australis*.

APPENDIX E

The following tables include summary data for ephemerals harvested from 0.025 m^2 quadrats (usually 20) on the Nevada Test Site during 1993. Numbers are reported as means for the quadrats ($\bar{X}$), as densities (n/m^2), biomass ($grams/m^2$), and weights per plant (milligrams). Mean weight per plant and percent of a sample reproductive (having buds, flowers, or fruit) was averaged over the occupied quadrats, while total number per quadrat, total weight per quadrat, and mean weight per plant were averaged over all 20 quadrats. Error limits (± 2 se) 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 D. Results are presented in alphabetical order by plot name, as listed below.

	$\overline{x}$ ± 2 se	Species	n/m² ± 2 se	g/m² ± 2 se	wt/plant ± 2 se	%Repro ± 2 se
PLOT	FRF001	BRORUB	26 ± 26.8	1.180 ± 1.226	46 ± 9	100 ± 0
DATE	4/12/93	CHAFRE	88 ± 73.8	7.078 ± 6.981	95 ± 74	99 ± 2
%ROCK	42.8 ± 10.3	CRYCIR	2 ± 4	0.016 ± 0.032	8	100
%LITTER	4.3 ± 4.3	CRYPTE	4 ± 8	0.284 ± 0.568	71	100
%COVER	15.8 ± 16.3	CRYREC	2 ± 4	0.052 ± 0.104	26	0
%MOUND	20.5 ± 18.3	DESPIN	42 ± 56.1	1.006 ± 1.542	18 ± 9	99
PELLETS/M²	8 ± 7.3	ERIMAC	2 ± 4	0.014 ± 0.027	7	0
		ERIPRI	12 ± 20.2	0.076 ± 0.106	10 ± 11	50 ± 100
TOTAL N/M²	444 ± 219	ESCGLY	2 ± 4	0.040 ± 0.081	20	100
TOTAL G/M²	15.8 ± 13.7	GILSIN	4 ± 5.5	0.043 ± 0.061	11 ± 5	50 ± 100
AVG AVG WT	0.05 ± 0.04	MALGLA	22 ± 24.9	4.316 ± 5.129	339 ± 518	100 ± 0
AVG SPP/QU	2.85 ± 0.77	MALSON	2 ± 4.0	0.034 ± 0.068	17	100
		MENALB	32 ± 48.4	0.853 ± 1.180	36 ± 48	83 ± 33
		MONBEL	22 ± 16.9	0.206 ± 0.182	11 ± 10	95 ± 10
		NEMGLA	180 ± 134.8	0.336 ± 0.142	4 ± 1	66 ± 21
		STRLON	2 ± 4	0.222 ± 0.444	111	100

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	$\bar{x} \pm 2$ se	Species	n/m² ± 2 se	g/m² ± 2 se	wt/plant ± 2 se	%Repro ± 2 se
PLOT	FRF001XC	BRORUB	24 ± 44	0.120 ± 0.190	9 ± 10	100 ± 0
DATE	5/04/93	CAMCLA	4 ± 5.5	0.066 ± 0.120	17 ± 27	50 ± 100
%ROCK	41.5 ± 12.0	CHAFRE	30 ± 33.8	1.852 ± 1.864	107 ± 98	96 ± 7
%LITTER	2.2 ± 1.6	CRYCIR	6 ± 6.6	0.215 ± 0.399	36 ± 64	100 ± 0
%COVER	9.6 ± 9.4	CRYMIC	12 ± 13.1	0.119 ± 0.188	7 ± 6	100 ± 0
%MOUND	8.8 ± 11.1	ERIMAC	6 ± 8.8	0.054 ± 0.076	9 ± 3	100 ± 0
PELLETS/M²	4.0 ± 5.5	ERIPRI	38 ± 76	0.604 ± 1.208	16	100
		GILSIN	2 ± 4	0.034 ± 0.068	17	100
TOTAL N/M²	828 ± 242.6	GILTRA	2 ± 4	0.026 ± 0.052	13	0
TOTAL G/M²	7.84 ± 3.69	LINDEM	2 ± 4	0.012 ± 0.025	6	100
AVG AVG WT	0.02 ± 0.01	MALGLA	4 ± 5.5	0.268 ± 0.496	67 ± 114	100 ± 0
AVG SPP/QU	3.35 ± 0.70	MENALB	4 ± 8	0.828 ± 1.656	207	100
		MONBEL	62 ± 38.3	0.457 ± 0.271	8 ± 2	100 ± 0
		NAMDEM	572 ± 227	3.006 ± 1.089	7 ± 2	99 ± 3
		NEMGLA	60 ± 36.5	0.174 ± 0.129	3 ± 1	92 ± 15

	$\bar{x}$ ± 2 se	Species	n/m^2 ± 2 se	g/m^2 ± 2 se	wt/plant ± 2 se	%Repro ± 2 se
PLOT	FRF001XS	AMSTES	4 ± 5.5	10.408 ± 18.634	2602 ± 4106	100 ± 0
DATE	5/03/93	CAMCLA	2 ± 4	0.014 ± 0.028	7	100
%ROCK	35.3 ± 12.6	CHAFRE	14 ± 16.7	4.346 ± 8.32	152 ± 246	88 ± 25
%LITTER	3.9 ± 4.9	CRYCIR	4 ± 5.5	0.053 ± 0.079	13 ± 11	100 ± 0
%COVER	9.5 ± 10.3	CRYMIC	12 ± 10.2	0.077 ± 0.067	6 ± 2	100 ± 0
%MOUND	23.4 ± 18.6	ERIERE	2 ± 4	0.034 ± 0.068	17	100
PELLETS/M^2	2 ± 4	ERIMAC	4 ± 5.5	0.115 ± 0.212	29 ± 49	100 ± 0
		ERIPRI	2 ± 4	0.021 ± 0.042	10	100
TOTAL N/M^2	898 ± 279	GILSIN	6 ± 12	0.610 ± 1.22	102	100
TOTAL G/M^2	57.0 ± 99.4	GILTRA	6 ± 6.6	0.338 ± 0.414	56 ± 37	100 ± 0
AVG AVG WT	0.18 ± 0.20	LINDEM	4 ± 5.5	0.035 ± 0.050	9 ± 5	100 ± 0
AVG SPP/QU	3.15 ± 0.82	MALGLA	10 ± 16.3	34.924 ± 68.051	2345 ± 3826	100 ± 0
		MENALB	32 ± 31.6	0.174 ± 0.200	6 ± 3	76 ± 39
		MONBEL	22 ± 18.8	0.226 ± 0.316	7 ± 5	100 ± 0
		NAMDEM	750 ± 272.1	2.732 ± 0.832	5 ± 2	98 ± 2
		NEMGLA	24 ± 14.7	0.122 ± 0.122	5 ± 3	100 ± 0

	$\bar{x}$ ± 2 se	Species	n/m² ± 2 se	g/m² ± 2 se	wt/plant ± 2 se	%Repro ± 2 se
PLOT	FRF003	BRORUB	16 ± 16.8	0.870 ± 1.285	47 ± 44	100 ± 0
DATE	4/13/93	CAMCLA	2 ± 4.0	0.007 ± 0.013	3	0
%ROCK	19.1 ± 9.7	CHAFRE	26 ± 29.2	3.924 ± 5.715	129 ± 96	100 ± 0
%LITTER	5.2 ± 3.4	CRYMIC	8 ± 9.4	0.057 ± 0.081	9 ± 1	100 ± 0
%COVER	13.6 ± 12.0	CRYPTE	4 ± 5.5	0.376 ± 0.634	94 ± 126	100 ± 0
%MOUND	6.5 ± 10.3	DESPIN	14 ± 21.1	0.250 ± 0.407	27 ± 45	100 ± 0
PELLETS/M²	0.0 ± 0.0	ERIDEF	4 ± 5.5	0.070 ± 0.106	18 ± 15	0 ± 0
		GILSIN	6 ± 8.8	0.120 ± 0.220	16 ± 23	50 ± 100
TOTAL N/M²	332 ± 195	GLYMAR	2 ± 4.0	0.046 ± 0.092	23	0
TOTAL G/M²	25.4 ± 36.1	MALGLA	22 ± 36.0	8.684 ± 17.183	174 ± 304	67 ± 67
AVG AVG WT	0.04 ± 0.02	MENALB	20 ± 19.7	0.720 ± 0.915	27 ± 17	100 ± 0
AVG SPP/QU	2.70 ± 1.16	MONBEL	36 ± 55.9	0.169 ± 0.272	5 ± 3	84 ± 24
		NAMDEM	36 ± 52.5	0.407 ± 0.542	12 ± 8	100 ± 0
		NEMGLA	116 ± 85.7	0.283 ± 0.214	3 ± 2	83 ± 19
		SCHARA	8 ± 9.4	0.188 ± 0.312	18 ± 21	100 ± 0
		STRLON	6 ± 12.0	0.330 ± 0.660	55	67
		VULOCT	6 ± 12.0	0.124 ± 0.248	21	100

	$\bar{x} \pm 2$ se	Species	n/m² ± 2 se	g/m² ± 2 se	wt/plant ± 2 se	%Repro ± 2 se
PLOT	FRF004	AMSTES	4 ± 8.9	6.693 ± 13.387	1506	50
DATE	4/14/93	ASTLEN	4 ± 6.1	0.093 ± 0.128	21 ± 2	0 ± 0
%ROCK	37.5 ± 9.0	BRORUB	36 ± 62.0	12.413 ± 24.144	178 ± 211	100 ± 0
%LITTER	1.5 ± 1.2	CHAFRE	11 ± 8.7	1.956 ± 2.997	176 ± 252	100 ± 0
%COVER	18.8 ± 18.9	CHASTE	2 ± 4.4	0.084 ± 0.169	38	100
%MOUND	17.2 ± 18.7	CRYCIR	7 ± 9.7	0.092 ± 0.126	15 ± 9	100 ± 0
PELLETS/M²	22.5 ± 20.6	CRYMIC	13 ± 11.2	0.453 ± 0.524	36 ± 38	100 ± 0
		CRYPTE	2 ± 4.4	0.667 ± 1.333	300	100
TOTAL N/M²	340 ± 108.4	CRYREC	2 ± 4.4	0.000 ± 0.000		100
TOTAL G/M²	32.8 ± 31.1	DESPIN	29 ± 31.6	1.831 ± 2.530	56 ± 48	100 ± 0
AVG AVG WT	0.10 ± 0.06	ERIERE	7 ± 13.3	0.049 ± 0.098	7	0
AVG SPP/QU	3.44 ± 0.87	ERIPRI	164 ± 98.9	3.814 ± 3.051	55 ± 77	95 ± 5
		GILSIN	2 ± 4.4	0.076 ± 0.151	34	100
		GILTRA	2 ± 4.4	0.056 ± 0.111	25	0
		MALGLA	2 ± 4.4	0.038 ± 0.076	17	100
		MENALB	16 ± 11.5	3.674 ± 6.570	152 ± 238	83 ± 33
		MONBEL	2 ± 4.4	0.008 ± 0.016	4	100
		NAMDEM	16 ± 14.7	0.131 ± 0.175	8 ± 8	62 ± 48
		NAMsp	7 ± 9.7	0.251 ± 0.394	50 ± 72	75 ± 50
		NEMGLA	4 ± 6.1	0.169 ± 0.296	38 ± 57	100 ± 0
		VULOCT	7 ± 9.7	0.218 ± 0.302	38 ± 35	100 ± 0

	$\bar{x}$ ± 2 se	Species	n/m² ± 2 se	g/m² ± 2 se	wt/plant ± 2 se	%Repro ± 2 se
PLOT	JAF001	BRORUB	4 ± 5.5	0.322 ± 0.565	80 ± 121	100 ± 0
DATE	4/28/93	CHAFRE	26 ± 20.3	2.226 ± 1.763	88 ± 31	100 ± 0
%ROCK	11 ± 4.4	CRYCIR	6 ± 8.8	0.146 ± 0.250	21 ± 20	100 ± 0
%LITTER	5.9 ± 3.4	CRYMIC	74 ± 47.2	1.129 ± 0.635	22 ± 13	100 ± 0
%COVER	28.8 ± 16.0	MALGLA	2 ± 4.0	0.038 ± 0.076	19	100
%MOUND	24.3 ± 16.2	MALSON	4 ± 5.5	0.188 ± 0.265	47 ± 20	50 ± 100
PELLETS/M²	0.0 ± 0.0	MENALB	2 ± 4.0	0.004 ± 0.009	2	100
		PREEXI	2 ± 4.0	0.066 ± 0.132	33	0
TOTAL N/M²	140 ± 65.8	SCHARA	2 ± 4.0	0.014 ± 0.028	7	100
TOTAL G/M²	4.3 ± 2.2	VULOCT	18 ± 12.3	0.193 ± 0.181	10 ± 7	100 ± 0
AVG AVG WT	0.04 ± 0.01					
AVG SPP/QU	1.8 ± 0.61					

	$\bar{x}$ ± 2 se	Species	n/m² ± 2 se	g/m² ± 2 se	wt/plant ± 2 se	%Repro ± 2 se
PLOT	MER001C	BRORUB	74 ± 49.3	5.129 ± 5.335	52 ± 25	97 ± 6
DATE	4/27/93	CHACAR	12 ± 13.1	0.163 ± 0.156	16 ± 8	83 ± 33
%ROCK	48.8 ± 10.8	CHASTE	2 ± 4.0	0.044 ± 0.087	22	100
%LITTER	4.8 ± 2.6	CHOBRE	2 ± 4.0	0.063 ± 0.126	32	100
%COVER	19.8 ± 14.7	CHORIG	6 ± 12.0	0.061 ± 0.122	10	67
%MOUND	21.8 ± 16.4	DESPIN	126 ± 202.8	3.349 ± 3.971	89 ± 125	100 ± 0
PELLETS/M²	4 ± 5.5	ERIDEF	4 ± 5.5	0.031 ± 0.043	8 ± 2	0 ± 0
		EROCIC	6 ± 8.8	0.112 ± 0.177	17 ± 8	100 ± 0
TOTAL N/M²	868 ± 345	GILTRA	4 ± 5.5	0.086 ± 0.133	21 ± 21	100 ± 0
TOTAL G/M²	21.7 ± 12.6	IPOPOL	76 ± 41.0	1.292 ± 0.727	19 ± 6	52 ± 23
AVG AVG WT	0.03 ± 0.01	LANSET	34 ± 56.1	0.241 ± 0.374	9 ± 3	0 ± 0
AVG SPP/QU	4.6 ± 0.8	LINDEM	52 ± 63.6	0.636 ± 0.681	16 ± 8	100 ± 0
		NEMGLA	30 ± 29.5	0.112 ± 0.093	6 ± 4	100 ± 0
		PECHET	12 ± 14.3	0.131 ± 0.165	11 ± 7	100 ± 0
		PECPLA	8 ± 11.0	0.327 ± 0.467	41 ± 21	100 ± 0
		PHAFRE	24 ± 21.2	1.287 ± 2.148	38 ± 49	100 ± 0
		SCHARA	24 ± 28.1	0.275 ± 0.327	12 ± 8	83 ± 33
		UNKNWN	2 ± 4.0	0.014 ± 0.028	7	0
		VULOCT	370 ± 195.8	8.299 ± 5.063	20 ± 5	98 ± 4

	$\bar{x}$ ± 2 se	Species	n/m² ± 2 se	g/m² ± 2 se	wt/plant ± 2 se	%Repro ± 2 se
PLOT	MER001W	ASTNYE	2 ± 4.0	0.038 ± 0.076	19	100
DATE	4/26/93	BRORUB	36 ± 27.8	1.490 ± 1.339	37 ± 12	86 ± 22
%ROCK	35.8 ± 8.1	CAMCLA	2 ± 4.0	0.048 ± 0.096	24	0
%LITTER	4.0 ± 1.5	CHACAR	106 ± 79.6	0.640 ± 0.500	6 ± 3	17 ± 14
%COVER	0.2 ± 0.4	CHASTE	136 ± 66.0	5.054 ± 4.942	44 ± 42	27 ± 20
%MOUND	32.1 ± 21.8	CHORIG	22 ± 29.9	0.384 ± 0.617	15 ± 8	16 ± 19
PELLETS/M²	2.1 ± 4.2	CRYCIR	16 ± 13.5	0.095 ± 0.096	7 ± 6	94 ± 11
		CRYNEV	12 ± 20.2	0.068 ± 0.096	9 ± 9	100 ± 0
TOTAL N/M²	5296 ± 1439	CRYREC	2 ± 4.0	0.020 ± 0.040	10	100
TOTAL G/M²	39.6 ± 7.9	DESPIN	132 ± 51.3	0.974 ± 0.504	10 ± 5	94 ± 13
AVG AVG WT	0.02 ± 0.00	ERIDEF	248 ± 92.8	2.001 ± 0.925	9 ± 3	0 ± 0
AVG SPP/QU	9.0 ± 0.77	ERITRI	2 ± 4.0	0.016 ± 0.032	8	0
		EROCIC	316 ± 119.2	9.482 ± 3.288	37 ± 13	93 ± 9
		GILTRA	12 ± 8.4	0.174 ± 0.152	14 ± 8	50 ± 45
		IPOPOL	10 ± 9.8	0.097 ± 0.106	10 ± 7	75 ± 50
		LANSET	246 ± 108.5	1.068 ± 0.432	5 ± 1	0 ± 0
		PECHET	8 ± 12.4	0.124 ± 0.232	12 ± 15	100 ± 0
		PECPLA	20 ± 16.9	0.813 ± 0.744	44 ± 32	86 ± 29
		PHAFRE	12 ± 14.3	0.073 ± 0.083	7 ± 3	89 ± 22
		SALAUS	2 ± 4.0	0.020 ± 0.040	10	0
		SCHARA	2040 ± 976.3	5.278 ± 1.836	8 ± 9	92 ± 4
		UNKNWN	4 ± 5.5	0.035 ± 0.048	9 ± 3	0 ± 0
		VULOCT	1910 ± 717.3	11.562 ± 4.257	7 ± 2	100 ± 0

	$\bar{x}$ ± 2 se	Species	n/m^2 ± 2 se	g/m^2 ± 2 se	wt/plant ± 2 se	%Repro ± 2 se
PLOT	MER002XC	AMSTES	28 ± 39.6	39.616 ± 61.262	1612 ± 2499	100 ± 0
DATE	5/03/93	BRORUB	3104 ± 2638	82.787 ± 35.201	54 ± 33	100 ± 1
%ROCK	28.0 ± 13.6	CHASTE	1068 ± 437.5	22.819 ± 9.775	31 ± 17	95 ± 4
%LITTER	12.3 ± 9.5	CRYCIR	36 ± 72.0	0.340 ± 0.680	9	100
%COVER	15.5 ± 18.7	EUPALB	52 ± 59.7	1.596 ± 1.887	27 ± 13	39 ± 49
%MOUND	16.0 ± 22.2	GILTRA	100 ± 87.0	4.812 ± 4.922	68 ± 61	92 ± 13
PELLETS/M^2	40.0 ± 55.9	LINDIC	4 ± 8.0	0.148 ± 0.296	37	100
		MACCAN	48 ± 58.2	2.520 ± 4.943	36 ± 67	0 ± 0
TOTAL N/M^2	4796 ± 2921	VULOCT	356 ± 558.7	3.584 ± 5.341	15 ± 29	100 ± 0
TOTAL G/M^2	158.5 ± 65.1					
AVG AVG WT	0.24 ± 0.33					
AVG SPP/QU	4.7 ± 0.60					

	$\bar{x} \pm 2$ se	Species	$n/m^2 \pm 2$ se	$g/m^2 \pm 2$ se	wt/plant ± 2 se	%Repro ± 2 se
PLOT	MER002XS	AMSTES	48 ± 71.4	19.280 ± 26.130	475 ± 119	100 ± 0
DATE	5/03/93	BRORUB	3080 ± 3006.2	77.024 ± 59.863	30 ± 12	99 ± 1
%ROCK	20.0 ± 4.2	BROTEC	12 ± 17.1	0.343 ± 0.564	25 ± 20	100 ± 0
%LITTER	12.0 ± 7.5	CHACAR	24 ± 48.0	0.038 ± 0.075	2	100
%COVER	5.0 ± 10.0	CHASTE	476 ± 201.5	19.507 ± 11.925	42 ± 14	92 ± 14
%MOUND	8.0 ± 13.9	CRYCIR	4 ± 8.0	0.059 ± 0.117	15	100
PELLETS/M^2	4.0 ± 8.0	DICPUL	16 ± 32.0	0.190 ± 0.379	12	0
		EUPALB	84 ± 64.7	3.192 ± 2.438	57 ± 54	75 ± 34
TOTAL N/M^2	4888 ± 3175	GILTRA	28 ± 24.0	1.008 ± 1.178	33 ± 27	100 ± 0
TOTAL G/M^2	138.2 ± 66.6	LEPLAS	12 ± 17.1	0.127 ± 0.181	11 ± 0	100 ± 0
AVG AVG WT	0.07 ± 0.04	LINDIC	60 ± 79.3	0.456 ± 0.452	11 ± 5	100 ± 0
AVG SPP/QU	5.8 ± 1.29	LOTHUM	32 ± 64.0	0.295 ± 0.590	9	0
		MACCAN	20 ± 24.6	3.667 ± 7.186	303 ± 597	33 ± 67
		MALGLA	4 ± 8.0	0.066 ± 0.133	17	100
		MENALB	4 ± 8.0	0.182 ± 0.364	45	100
		VULOCT	984 ± 508.4	12.808 ± 7.597	16 ± 7	100 ± 0

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	$\bar{x}$ ± 2 se	Species	n/m² ± 2 se	g/m² ± 2 se	wt/plant ± 2 se	%Repro ± 2 se
PLOT	MID001	AMSTES	4 ± 5.5	0.308 ± 0.507	77 ± 96	50 ± 100
DATE	5/18/93	BRORUB	302 ± 119.6	19.747 ± 9.667	92 ± 51	98 ± 2
%ROC K	52.9 ± 16.7	BROTEC	28 ± 22.6	2.828 ± 2.497	135 ± 141	100 ± 0
%LITTER	30.4 ± 14.3	CHASTE	2 ± 4.0	0.016 ± 0.033	8	100
%COVER	33.7 ± 18.8	CHOTHU	46 ± 26.8	0.891 ± 0.711	20 ± 9	95 ± 9
%MOUND	15.0 ± 16.4	CRYPTE	20 ± 15.9	1.225 ± 1.563	83 ± 121	92 ± 17
PELLETS/M²	6.0 ± 6.6	DESPIN	4 ± 8.0	0.086 ± 0.172	21	100
		ERIERE	12 ± 11.8	0.103 ± 0.101	9 ± 5	100 ± 0
TOTAL N/M²	704 ± 188	ERINID	24 ± 35.0	0.315 ± 0.529	11 ± 10	100 ± 0
TOTAL G/M²	39.1 ± 15.4	EUPALB	2 ± 4.0	0.470 ± 0.940	235	100
AVG AVG WT	0.08 ± 0.03	GILSIN	16 ± 16.8	0.277 ± 0.318	25 ± 27	100 ± 0
AVG SPP/QU	4.8 ± 1.0	GILTRA	4 ± 8.0	0.108 ± 0.216	27	50
		LEPLAS	94 ± 61.2	1.118 ± 0.718	13 ± 3	90 ± 20
		LINDIC	12 ± 13.1	0.182 ± 0.222	14 ± 5	100 ± 0
		LUPFLA	2 ± 4.0	0.704 ± 1.408	352	100
		MENALB	2 ± 4.0	0.036 ± 0.072	18	100
		PHAVAL	12 ± 20.2	4.238 ± 8.326	226 ± 381	100 ± 0
		PHLSTA	24 ± 19.6	4.394 ± 5.09	262 ± 325	18 ± 28
		STEEXI	2 ± 4.0	0.170 ± 0.340	85	100
		UNKNWN	2 ± 4.0	0.013 ± 0.027	7	0
		VULMIC	66 ± 83.4	1.661 ± 1.796	35 ± 22	100 ± 0
		VULOCT	24 ± 28.1	0.247 ± 0.294	20 ± 28	100 ± 0

	$\overline{x}$ ± 2 se	Species	n/m² ± 2 se	g/m² ± 2 se	wt/plant ± 2 se	%Repro ± 2 se
PLOT	MID001B	AMSTES	4 ± 5.5	1.572 ± 2.645	393 ± 524	100 ± 0
DATE	5/18/93	BRORUB	348 ± 201.6	14.553 ± 7.774	45 ± 18	94 ± 13
%ROCK	54.0 ± 15.2	BROTEC	332 ± 168.4	17.598 ± 8.628	61 ± 23	100 ± 0
%LITTER	17.9 ± 9.7	CHOWAT	64 ± 66.5	0.399 ± 0.364	8 ± 4	100 ± 0
%COVER	2.5 ± 5.0	CRYPTE	52 ± 99.9	0.951 ± 1.716	32 ± 29	100 ± 0
%MOUND	5.0 ± 10.0	DESPIN	4 ± 5.5	0.023 ± 0.041	6 ± 9	100 ± 0
PELLETS/M²	18.0 ± 14.8	ERINID	52 ± 59.2	0.270 ± 0.329	8 ± 6	95 ± 10
		EROCIC	40 ± 46.1	1.296 ± 1.457	35 ± 12	100 ± 0
TOTAL N/M²	1348 ± 592	GILSIN	6 ± 8.8	0.051 ± 0.071	10 ± 10	100 ± 0
TOTAL G/M²	48.8 ± 20.6	GILTRA	26 ± 18.6	0.507 ± 0.511	30 ± 34	100 ± 0
AVG AVG WT	0.06 ± 0.02	LINDIC	2 ± 4.0	0.024 ± 0.048	12	100
AVG SPP/QU	4.35 ± 1.01	PECSET	40 ± 46.1	0.726 ± 0.749	25 ± 16	100 ± 0
		PHAFRE	6 ± 8.8	0.215 ± 0.400	29 ± 42	100 ± 0
		PHLSTA	18 ± 17.9	5.322 ± 5.186	335 ± 163	25 ± 32
		SALAUS	178 ± 282.3	1.036 ± 1.398	12 ± 12	0 ± 0
		VULMIC	146 ± 153.3	4.714 ± 5.317	24 ± 13	100 ± 0
		VULOCT	30 ± 48.9	0.492 ± 0.911	12 ± 13	100 ± 0

	$\overline{x} \pm 2$ se	Species	n/m² ± 2 se	g/m² ± 2 se	wt/plant ± 2 se	%Repro ± 2 se
PLOT	PAM001	CAMPUS	6 ± 8.8	0.061 ± 0.101	9 ± 7	50 ± 100
DATE	6/03/93	ERIOVA	2 ± 4.0	0.071 ± 0.141	35	0
%ROCK	49.9 ± 16.9	ERIPUM	2 ± 4.0	0.012 ± 0.025	6	0
%LITTER	20.8 ± 12.7	GILTRA	32 ± 31.0	0.651 ± 0.859	17 ± 9	96 ± 7
%COVER	49.3 ± 18.8	LINDIC	2 ± 4.0	0.024 ± 0.048	12	100
%MOUND	10.8 ± 9.5	PHAFRE	20 ± 36.0	0.342 ± 0.534	28 ± 28	67 ± 67
PELLETS/M²	18.0 ± 15.9					
TOTAL N/M²	64.0 ± 51.1					
TOTAL G/M²	1.16 ± 1.03					
AVG AVG WT	0.02 ± 0.01					
AVG SPP/QU	0.7 ± 0.33					

	$\bar{x} \pm 2$ se	Species	$n/m^2 \pm 2$ se	$g/m^2 \pm 2$ se	wt/plant ± 2 se	%Repro ± 2 se
PLOT	RAM001	ERIOVA	2 ± 4.0	0.023 ± 0.046	11	0
DATE	7/22/93	MENALB	4 ± 8.0	0.030 ± 0.060	8	100
%ROCK	16.2 ± 10.6					
%LITTER	53.3 ± 17.3					
%COVER	46.8 ± 20.4					
%MOUND	5.0 ± 10.0					
PELLETS/M^2	16.0 ± 13.5					
TOTAL N/M^2	6.0 ± 8.8					
TOTAL G/M^2	0.05 ± 0.07					
AVG AVG WT	0.01 ± 0.00					
AVG SPP/QU	0.1 ± 0.14					

	$\bar{x} \pm 2$ se	Species	n/m² ± 2 se	g/m² ± 2 se	wt/plant ± 2 se	%Repro ± 2 se
PLOT	RED001	AMBACA	2 ± 4.0	0.038 ± 0.075	19	0
DATE	5/25/93	CRYPTE	2 ± 4.0	0.096 ± 0.192	48	100
%ROCK	2.45 ± 2.2	GILNYE	10 ± 9.8	0.389 ± 0.449	43 ± 41	75 ± 50
%LITTER	23.8 ± 10.5	MACCAN	14 ± 16.7	0.505 ± 0.822	24 ± 19	0 ± 0
%COVER	3.25 ± 3.4	MENALB	16 ± 24.9	1.146 ± 1.617	85 ± 54	100 ± 0
%MOUND	10.0 ± 13.8	SALAUS	990 ± 682.0	9.389 ± 5.561	22 ± 16	0 ± 0
PELLETS/M²	24.0 ± 20.4	TIQNUT	6 ± 12.0	0.047 ± 0.093	8	0 ± 0

TOTAL N/M²	1040 ± 679
TOTAL G/M²	11.6 ± 5.8
AVG AVG WT	0.03 ± 0.01
AVG SPP/QU	1.35 ± 0.49

	$\bar{x} \pm 2$ se	Species	$n/m^2 \pm 2$ se	$g/m^2 \pm 2$ se	wt/plant ± 2 se	%Repro ± 2 se
PLOT	RED002	AMBACA	2 ± 4.0	0.048 ± 0.096	24	0
DATE	5/25/93	BRORUB	16 ± 18.7	1.562 ± 1.833	98 ± 18	100 ± 0
%ROCK	1.2 ± 0.6	BROTEC	64 ± 47.3	5.066 ± 4.051	73 ± 37	96 ± 8
%LITTER	24.4 ± 10.4	CHAFRE	10 ± 11.4	0.446 ± 0.604	61 ± 84	100 ± 0
%COVER	32.0 ± 20.2	CHEsp	2 ± 4.0	0.162 ± 0.324	81	0
%MOUND	14.8 ± 15.0	CRYCIR	34 ± 29.2	2.386 ± 3.281	57 ± 53	86 ± 29
PELLETS/M^2	14.0 ± 10.5	CRYMIC	18 ± 32.0	0.954 ± 1.838	37 ± 40	100 ± 0
		CRYPTE	20 ± 25.0	1.550 ± 1.966	78 ± 81	100 ± 0
TOTAL N/M^2	904 ± 404	CRYsp	2 ± 4.0	0.015 ± 0.031	8	0
TOTAL G/M^2	28.4 ± 12.7	DESPIN	2 ± 4.0	0.074 ± 0.148	37	0
AVG AVG WT	0.05 ± 0.02	GILNYE	10 ± 11.4	0.206 ± 0.250	21 ± 9	33 ± 67 0
AVG SPP/QU	3.35 ± 0.84	MACCAN	18 ± 16.9	0.245 ± 0.223	14 ± 6	0 ± 0
		MENALB	564 ± 399.7	10.437 ± 6.117	33 ± 14	96 ± 5
		PHAFRE	6 ± 6.6	0.062 ± 0.072	10 ± 5	33 ± 67
		PHAVAL	8 ± 16.0	4.082 ± 8.164	510	100
		SALAUS	16 ± 24.2	0.100 ± 0.14	7 ± 4	0 ± 0
		STEEXI	18 ± 28.7	0.574 ± 0.796	49 ± 62	50 ± 100
		TIQNUT	94 ± 141.6	0.386 ± 0.529	10 ± 13	0 ± 0

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	$\bar{x}$ ± 2 se	Species	n/m^2 ± 2 se	g/m^2 ± 2 se	wt/plant ± 2 se	%Repro ± 2 se
PLOT	ROV005	AMSTES	4 ± 8	0.326 ± 0.652	81	100
DATE	4/29/93	BRORUB	1964 ± 1027	68.5 ± 35.4	50 ± 20	97 ± 5
%ROCK	36 ± 15	CAMCLA	2 ± 4	0.032 ± 0.064	16	100
%LITTER	23 ± 17	CAULAS	2 ± 4	0.446 ± 0.892	223	1
%COVER	43 ± 22	CHACAR	6 ± 7	0.104 ± 0.115	17 ± 4	100 ± 0
% MOUND	32 ± 21	CHASTE	10 ± 13	0.484 ± 0.812	36 ± 33	100 ± 0
PELLETS/M^2	8 ± 12	CHOBRE	4 ± 6	0.028 ± 0.039	7 ± 2	100 ± 0
		CRYNEV	2 ± 4	0.024 ± 0.048	12	100
		CRYPTE	12 ± 14	0.330 ± 0.427	25 ± 18	67 ± 67
TOTAL N/M^2	2118 ± 1009	CRYREC	4 ± 6	0.048 ± 0.070	12 ± 18	100 ± 10
TOTAL G/M^2	72 ± 36	ERINID	2 ± 4	0.038 ± 0.076	19	100
AVG AVG WT	0.03 ± 0.01	LANSET	2 ± 4	0.040 ± 0.80	20	0
AVG SPP/QU	3.0 ± 0.7	LEPLAS	4 ± 6	0.050 ± 0.092	13 ± 21	100 ± 0
		PECHET	2 ± 4	0.038 ± 0.076	19	100
		PHAFRE	10 ± 14.1	0.098 ± 0.159	9 ± 8	75 ± 50
		PHAVAL	4 ± 5.5	0.164 ± 0.257	41 ± 42	100 ± 0
		PREEXI	10 ± 9.8	0.194 ± 0.215	19 ± 14	100 ± 0
		VULOCT	74 ± 53.0	1.066 ± 0.959	17 ± 11	100 ± 0

	$\bar{x} \pm 2$ se	Species	n/m^2 ± 2 se	g/m^2 ± 2 se	wt/plant ± 2 se	%Repro ± 2 se
PLOT	ROV005XC	BRORUB	4538 ± 1674	65.168 ± 21.226	17 ± 4	100 ± 0
DATE	4/29/93	BROTEC	2 ± 4.0	0.884 ± 1.768	442	100
%ROCK	55.1 ± 15.2	CHOBRE	8 ± 16.0	0.044 ± 0.088	5	100
%LITTER	31.1 ± 16.0	CRYNEV	10 ± 16.3	0.066 ± 0.104	7 ± 2	100 ± 0
%COVER	43.0 ± 19.1	ERITRI	10 ± 16.3	0.046 ± 0.063	7 ± 8	0 ± 0
%MOUND	30.3 ± 18.8	GILTRA	12 ± 24.0	0.040 ± 0.080	3	100
PELLETS/M^2	2.0 ± 4.0	PECHET	56 ± 103.9	0.225 ± 0.330	11 ± 15	62 ± 77
		PECPLA	18 ± 20.5	0.328 ± 0.509	16 ± 16	100 ± 0
TOTAL N/M^2	4933 ± 1600	PHAVAL	2 ± 4.0	0.029 ± 0.059	15	100
TOTAL G/M^2	68.0 ± 21.0	VULOCT	277 ± 215.0	1.140 ± 0.831	7 ± 5	99 ± 2
AVG AVG WT	0.02 ± 0.02					
AVG SPP/QU	2.2 ± 0.52					

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	$\bar{x}$ ± 2 se	Species	n/m² ± 2 se	g/m² ± 2 se	wt/plant ± 2 se	%Repro ± 2 se
PLOT	ROV005XS	BRORUB	672 ± 221.0	8.531 ± 2.711	15 ± 3	54 ± 16
DATE	5/03/93	CAMCLA	4 ± 8.0	0.083 ± 0.166	21	100
%ROCK	67.8 ± 12.6	CHACAR	8 ± 16.0	0.046 ± 0.092	6	100
%LITTER	3.4 ± 2.2	CHOBRE	6 ± 6.6	0.065 ± 0.073	11 ± 4	100 ± 0
%COVER	21.7 ± 18.1	CRYCIR	10 ± 12.8	0.102 ± 0.139	10 ± 2	100 ± 0
%MOUND	11.5 ± 13.1	CRYNEV	16 ± 28.1	0.235 ± 0.402	16 ± 3	93 ± 14
PELLETS/M²	6.0 ± 6.6	CRYPTE	68 ± 64.1	1.959 ± 2.834	17 ± 7	83 ± 21
		CRYREC	22 ± 18.8	0.162 ± 0.134	9 ± 6	100 ± 0
TOTAL N/M²	1204 ± 233	ERIMAC	2 ± 4.0	0.036 ± 0.071	18	100
TOTAL G/M²	16.5 ± 8.1	ERITRI	12 ± 16.5	0.051 ± 0.060	5 ± 2	0 ± 0
AVG AVG WT	0.01 ± 0.00	GILTRA	8 ± 12.4	0.086 ± 0.124	12 ± 6	100 ± 0
AVG SPP/OU	4.15 ± 0.64	IPOPOL	2 ± 4.0	0.014 ± 0.028	7	0
		MALGLA	2 ± 4.0	0.019 ± 0.038	10	100
		PECHET	38 ± 45.9	0.391 ± 0.426	13 ± 7	100 ± 0
		PECPLA	76 ± 80.8	0.914 ± 0.966	14 ± 9	94 ± 9
		PHAFRE	32 ± 26.3	0.338 ± 0.305	10 ± 3	100 ± 0
		PHAVAL	44 ± 88.0	2.176 ± 4.352	49	91
		PREEXI	4 ± 8.0	0.064 ± 0.128	16	100
		VULOCT	178 ± 96.0	1.193 ± 0.804	6 ± 2	97 ± 5

	$\bar{x}$ ± 2 se	Species	n/m² ± 2 se	g/m² ± 2 se	wt/plant ± 2 se	%Repro ± 2 se
PLOT	YUF001	AMSTES	2 ± 4.0	0.058 ± 0.116	29	0
DATE	4/15/93	ASTLEN	2 ± 4.0	0.014 ± 0.029	7	0
%ROCK	47.4 ± 12.0	BRORUB	884 ± 471.8	11.099 ± 6.364	11 ± 4	50 ± 16
%LITTER	18.4 ± 13.3	CHAFRE	2 ± 4.0	0.016 ± 0.032	8	0
%COVER	29.7 ± 17.6	CHASTE	290 ± 135.5	2.494 ± 1.648	9 ± 4	15 ± 13
%MOUND	17.5 ± 16.7	CRYCIR	12 ± 14.3	0.051 ± 0.060	4 ± 0	50 ± 58
PELLETS/M²	4.0 ± 5.5	CRYGRA	12 ± 13.1	0.435 ± 0.582	31 ± 21	92 ± 17
		CRYPTE	6 ± 12.0	0.027 ± 0.05	4	100
TOTAL N/M²	1762 ± 689	DESPIN	14 ± 13.3	0.831 ± 1.576	101 ± 196	88 ± 25
TOTAL G/M²	18.1 ± 8.6	ERIDEF	4 ± 5.5	0.062 ± 0.096	16 ± 15	0 ± 0
AVG AVG WT	0.02 ± 0.01	ERIMAC	6 ± 6.6	0.044 ± 0.056	7 ± 6	0 ± 0
AVG SPP/QU	5.05 ± 0.73	ERINID	34 ± 34.0	0.100 ± 0.103	3 ± 2	13 ± 25
		ERIPRI	290 ± 466.5	0.449 ± 0.499	5 ± 2	50 ± 29
		GILSIN	12 ± 24.0	0.074 ± 0.148	6	100
		GILTRA	20 ± 14.8	0.263 ± 0.245	11 ± 6	17 ± 33
		LEPLAS	86 ± 123.4	0.278 ± 0.293	6 ± 1	82 ± 28
		MACCAN	12 ± 13.1	0.069 ± 0.071	6 ± 1	0 ± 0
		MALGLA	6 ± 6.6	0.105 ± 0.130	17 ± 12	67 ± 67
		MENALB	24 ± 31.5	0.156 ± 0.199	7 ± 3	83 ± 33
		PHAFRE	38 ± 56.1	0.527 ± 0.810	12 ± 8	96 ± 7
		PHAVAL	2 ± 4.0	0.090 ± 0.180	45	100
		STEEXI	4 ± 8.0	0.898 ± 1.796	224	0

	$\bar{x}$ ± 2 se	Species	n/m² ± 2 se	g/m² ± 2 se	wt/plant ± 2 se	%Repro ± 2 se
PLOT	YUF001XC	ASTLEN	8 ± 7.3	0.446 ± 0.591	56 ± 60	0 ± 0
DATE	5/5/93	BRORUB	702 ± 467.7	25.908 ± 19.981	28 ± 8	100 ± 0
%ROCK	52.5 ± 14.6	CAMBOO	6 ± 8.8	0.034 ± 0.059	5 ± 5	100 ± 0
%LITTER	14.1 ± 10.6	CHASTE	56 ± 24.2	1.506 ± 0.912	34 ± 27	98 ± 4
%COVER	26.0 ± 17.5	CRYCIR	6 ± 12.0	0.047 ± 0.095	8	100
%MOUND	27.3 ± 18.0	CRYPTE	70 ± 116.5	1.694 ± 2.795	45 ± 56	100 ± 0
PELLETS/M²	10.0 ± 11.4	CRYREC	20 ± 20.5	0.494 ± 0.508	26 ± 7	88 ± 25
		DESPIN	40 ± 23.2	0.480 ± 0.384	17 ± 13	100 ± 0
TOTAL N/M²	1242 ± 516	ERIMAC	2 ± 4.0	0.045 ± 0.090	22	100
TOTAL G/M²	37.6 ± 22.4	ERINID	18 ± 24.3	0.148 ± 0.206	8 ± 3	50 ± 58
AVG AVG WT	0.03 ± 0.01	ERIPRI	48 ± 28.2	0.750 ± 0.486	16 ± 5	100 ± 0
AVG SPP/QU	6.0 ± 1.1	GILSIN	2 ± 4.0	0.034 ± 0.067	17	0
		GILTRA	10 ± 16.3	0.265 ± 0.458	24 ± 10	100 ± 0
		IPOPOL	34 ± 20.3	0.630 ± 0.449	21 ± 10	96 ± 7
		LANSET	96 ± 71.4	1.086 ± 0.760	18 ± 14	0 ± 0
		LEPLAS	24 ± 17.8	0.338 ± 0.402	12 ± 8	86 ± 29
		LUPFLA	4 ± 5.5	1.018 ± 1.551	254 ± 229	100 ± 0
		MACCAN	4 ± 5.5	0.037 ± 0.058	9 ± 8	0 ± 0
		MENALB	4 ± 8.0	0.060 ± 0.120	15	100
		NEMGLA	10 ± 16.3	0.068 ± 0.132	5 ± 7	50 ± 100
		OXYPER	4 ± 8.0	0.064 ± 0.128	16	100
		PHAFRE	28 ± 43.9	0.267 ± 0.483	7 ± 4	100 ± 0
		SALAUS	8 ± 9.4	0.049 ± 0.054	7 ± 2	0 ± 0
		VULOCT	38 ± 64.5	0.508 ± 0.963	10 ± 11	100 ± 0

	$\bar{x} \pm 2$ se	Species	n/m² ± 2 se	g/m² ± 2 se	wt/plant ± 2 se	%Repro ± 2 se
PLOT	YUF001XS	ASTLEN	2 ± 4.0	0.228 ± 0.456	114	100
DATE	5/05/93	BRORUB	94 ± 59.3	3.544 ± 4.268	28 ± 23	81 ± 21
%ROCK	38.5 ± 13.9	CAMBOO	8 ± 12.4	0.646 ± 1.090	71 ± 37	100 ± 0
%LITTER	14.7 ± 10.7	CHASTE	310 ± 156.6	10.847 ± 6.468	36 ± 15	98 ± 2
%COVER	25.0 ± 16.3	CRYNEV	2 ± 4.0	0.012 ± 0.024	6	100
%MOUND	23.8 ± 17.8	CRYPTE	10 ± 16.3	0.893 ± 1.698	64 ± 85	100 ± 0
PELLETS/M²	6.0 ± 6.6	CRYREC	44 ± 44.2	1.994 ± 2.359	64 ± 62	100 ± 0
		DESPIN	46 ± 83.8	0.258 ± 0.432	9 ± 12	100 ± 0
TOTAL N/M²	776 ± 232	ERINID	4 ± 8.0	0.052 ± 0.104	13	0
TOTAL G/M²	21.8 ± 11.7	ERIPRI	34 ± 45.8	0.299 ± 0.423	8 ± 2	100 ± 0
AVG AVG WT	0.03 ± 0.01	GILTRA	6 ± 8.8	0.150 ± 0.207	27 ± 15	100 ± 0
AVG SPP/QU	4.65 ± 0.81	IPOPOL	42 ± 31.0	0.695 ± 0.519	18 ± 8	70 ± 27
		LANSCH	26 ± 52.0	0.162 ± 0.324	6	0
		LANSET	8 ± 7.3	0.142 ± 0.155	18 ± 12	0 ± 0
		LEPLAS	94 ± 61.2	0.829 ± 0.540	10 ± 3	86 ± 12
		MALGLA	6 ± 8.8	0.184 ± 0.257	32 ± 11	100 ± 0
		OXYPER	8 ± 12.4	0.090 ± 0.133	12 ± 4	100 ± 0
		PHAFRE	8 ± 7.3	0.606 ± 0.993	76 ± 119	100 ± 0
		PREEXI	8 ± 9.4	0.037 ± 0.053	4 ± 2	33 ± 67
		SALAUS	14 ± 13.3	0.077 ± 0.071	6 ± 3	0 ± 0
		VULOCT	2 ± 4.0	0.012 ± 0.023	6	100

	$\bar{x}$ ± 2 se	Species	n/m² ± 2 se	g/m² ± 2 se	wt/plant ± 2 se	%Repro ± 2 se
PLOT	YUF002BURN	AMSTES	42 ± 23.3	11.337 ± 6.594	280 ± 105	92 ± 17
DATE	5/11/93	ASTLEN	3 ± 4.6	0.060 ± 0.084	18 ± 4	0 ± 0
%ROCK	35.5 ± 10.8	BRORUB	20 ± 25.0	1.021 ± 1.442	51 ± 36	100 ± 0
%LITTER	25.5 ± 11.6	CAMKER	3 ± 4.6	0.163 ± 0.300	49 ± 83	100 ± 0
%COVER	0.2 ± 0.4	CHAFRE	3 ± 6.7	0.064 ± 0.127	19	100
%MOUND	0.0 ± 0.0	CHASTE	73 ± 36.9	6.5 ± 5.7	121 ± 130	98 ± 5
PELLETS/M²	8.7 ± 7.0	CRYCIR	12 ± 10.2	0.92 ± 1.52	105 ± 177	100 ± 0
		DESPIN	22 ± 18	0.355 ± 0.415	16 ± 14	50 ± 37
TOTAL N/M²	1118 ± 374	ERIMAC	75 ± 130	0.502 ± 0.687	14 ± 13	100 ± 0
TOTAL G/M²	45.8 ± 12.5	ERINID	3 ± 7	0.027 ± 0.054	8	100
AVG AVG WT	0.07 ± 0.03	EROCIC	700 ± 294	20.3 ± 6.9	44 ± 12	100 ± 0
AVG SPP/QU	4.54 ± 0.83	GILSIN	5 ± 10	0.233 ± 0.467	47	100
		GILTRA	22 ± 17	0.904 ± 0.764	45	100 ± 0
		MALGLA	5 ± 6	0.107 ± 0.129	21 ± 12	100 ± 0
		MENALB	58 ± 34	2.3 ± 1.5	39 ± 13	100 ± 0
		OXYPER	2 ± 3	0.03 ± 0.06	18	100
		PHAFRE	50 ± 49	0.9 ± 1.5	18 ± 12	100 ± 0
		SALAUS	17 ± 17	0.18 ± 0.18	11 ± 2	0 ± 0
		SISALT	3 ± 5	0.03 ± 0.04	8 ± 7	0 ± 0

	$\bar{x} \pm 2$ se	Species	n/m^2 ± 2 se	g/m^2 ± 2 se	wt/plant ± 2 se	%Repro ± 2 se
PLOT	YUF002 CONTROL	AMSTES	22 ± 21.9	23.780 ± 21.619	1282 ± 959	95 ± 10
DATE	5/11/93	ASTLEN	8 ± 8.1	0.223 ± 0.248	30 ± 10	0 ± 0
%ROCK	36.3 ± 14.5	BRORUB	187 ± 172.6	11.135 ± 8.842	71 ± 36	100 ± 0
%LITTER	16.0 ± 7.6	CAMKER	40 ± 44.4	0.667 ± 0.717	20 ± 10	100 ± 0
%COVER	20.9 ± 18.7	CHASTE	77 ± 53.4	4.528 ± 3.247	85 ± 49	95 ± 7
%MOUND	12.5 ± 17.1	CRYCIR	50 ± 23.7	2.228 ± 1.711	54 ± 51	100 ± 0
PELLETS/M^2	12.5 ± 12.0	DESPIN	22 ± 25.3	0.117 ± 0.137	6 ± 6	100 ± 0
		ERIMAC	240 ± 356.1	1.281 ± 0.976	16 ± 9	100 ± 1
TOTAL N/M^2	1028 ± 429	ERINID	10 ± 20.0	0.067 ± 0.135	7	100
TOTAL G/M^2	64.7 ± 29.3	EROCIC	317 ± 172.0	16.244 ± 6.430	92 ± 56	96 ± 4
AVG AVG WT	0.14 ± 0.09	GILTRA	13 ± 14.1	1.105 ± 1.528	81 ± 67	100 ± 0
AVG SPP/QU	5.13 ± 0.81	LUPFLA	3 ± 5.0	1.830 ± 3.660	732	100
		MALGLA	15 ± 16.1	0.466 ± 0.583	31 ± 24	83 ± 33
		MENALB	8 ± 8.1	0.547 ± 0.799	73 ± 86	100 ± 0
		OXYPER	8 ± 10.9	0.235 ± 0.406	27 ± 27	100 ± 0
		PHAFRE	3 ± 5.0	0.171 ± 0.343	69	100
		SALAUS	3 ± 5.0	0.030 ± 0.059	12	0
		STRLON	3 ± 5.0	0.072 ± 0.145	29	100

STATUS OF PERENNIAL PLANTS ON THE NEVADA TEST SITE IN 1993

by

Richard Hunter

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ABSTRACT

Perennial plants were measured in 1993 on pristine areas, two burned sites, and two roadsides. Shrubs grew in most areas as a result of heavy winter rainfall. There was almost no germination of new plants, however. Growth was more rapid on burned areas and roadsides than on undisturbed areas. Total live volumes of perennial plants were at or above equilibrium values suggested by rainfall patterns at undisturbed sites.

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 Rickard 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). The year 1993 was the seventh year of data collection under the BECAMP program, and this report is largely restricted to documenting conditions of perennial plant populations in 1993 and changes since 1992. Results of 1987 through 1992 monitoring of vegetation are in Hunter and Medica 1989, and Hunter 1992, 1994a and 1994b.

Monitoring of perennial plants on the NTS is accomplished by repeatedly censusing shrubs, grasses and trees on permanently marked 100 m^2 belt transects scattered throughout the NTS. Baseline sites, areas of minimal or no disturbance, are sampled each year (since 1992) 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 censused at three year intervals.

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

METHODS

Study sites monitored in 1993 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).

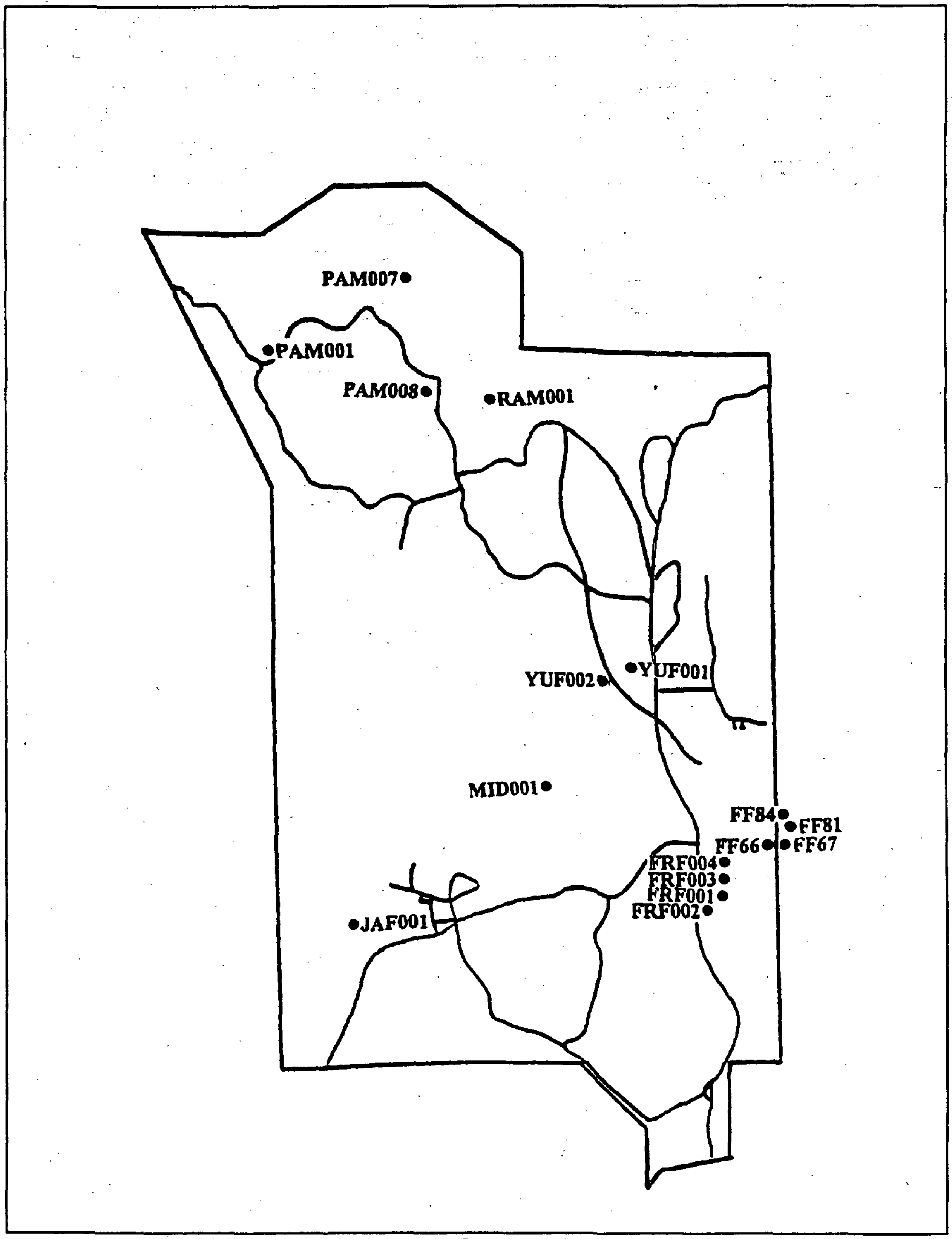


Figure 1 - Perennial plant study sites in 1993.

Table 1. Sites of perennial plant measurements in 1993.			
SITE	ELEVATION m	DOMINANT VEGETATION	LAST CENSUSED
FF66	940	Playa edge, *Atriplex confertifolia*	1992
FF67	940	Playa edge, *Atriplex canescens*	1992
FF81	945	*Atriplex canescens*	1992
FF84	945	*Larrea tridentata*	1992
JAF001	954	*Larrea tridentata*	1992
FRF001	965	*Larrea tridentata*	1992
FRF003	965	Roadside, *Larrea tridentata*	1990
FRF004	965	Roadside control, *Larrea tridentata*	1990
FRF002	977	Roadside, *Larrea tridentata*	1991
FRF002c	977	Roadside control, *Larrea tridentata*	1991
YUF001	1237	Baseline, *Atriplex canescens*	1992
YUF002	1288	Burned, *Lycium andersonii*	1990
YUF002c	1288	control, *Lycium andersonii*	1990
MID001	1448	Burned, *Artemisia tridentata*	1990
MID001c	1448	Control, *Artemisia tridentata*	1990
PAM008	1920	Marked pines, *Pinus monophylla*	1992
PAM001	1923	Baseline, *Artemisia nova*	1992

manufacturer. Sensors were placed at 1, 5, 10, 15, 30, 50, 75, 100, 125, and 150 cm depths. (The sensor at 1 cm on JAF001 failed in January.) Resistance sensor readings 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 and Medica 1989). 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 2, 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.

In 1993, the technique was slightly modified to attempt to get better reproducibility on measurements from the tape to the center of the base of a shrub. A wire was stretched over the transect on plots PAM001 and FRF002, at ground level. It was woven through shrub bases. Distance was measured from the wire instead of the tape. The primary advantage will relate to resampling plants whose bases lie near 1 meter from the tape - in some years they are measured, in others they are considered outside the transect.

On transect FRF002 several large clones of *Larrea tridentata* occurred. They were measured erratically because of difficulties determining the location of the "center of the base" and hence whether a given clone was inside or outside the transect. Locations were remeasured after the wire was laid out, and all data sets were modified and results recalculated in accordance with the 1993 locations.

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

Statistics were largely calculated with the programs RS1 (BBN software) and Minitab (Minitab, Inc.). Error terms are 2 standard errors of the mean (se) unless otherwise noted.

RESULTS

Weather

Total calendar year rainfall in 1992 was generally greater than that for eight of the last ten years. exceeded only in 1984 (Table 2). It ranged from 147 mm

Table 3. Shallowest (min) and deepest (max) soil depths wet (<900,000 Ohms on resistance sensors) at three baseline sites during 1993. There are no sensors below 150 cm.

FRF001			JAF001			YUF001		
Date	min	max	Date	min	max	Date	min	max
JAN 28	1	75	FEB 2	5	125	JAN 28	1	100
FEB 11	1	100	FEB 16	5	150	FEB 11	1	125
FEB 25	1	150	MAR 4	5	150	FEB 25	1	150
MAR 10	1	150	MAR 18	10	150	MAR 10	5	150
APR 2	1	150	APR 9	10	150	APR 2	5	150
APR 13	5	150	MAY 13	30	150	APR 13	5	150
MAY 10	30	150	MAY 26	30	150	MAY 20	15	150
JUN 2	50	150	JUN 8	5	150	JUN 2	30	150
JUN 16	75	150	JUN 24	15	150	JUN 16	75	150
JUN 29	75	150	JUL 7	30	150	JUN 29	75	150
JUL 12	75	150	JUL 22	50	150	JUL 12	100	150
JUL 27	75	150	AUG 8	100	150	JUL 27	100	150
AUG 11	75	150	AUG 17	100	150	AUG 11	100	150
SEP 08	100	125	SEP 6	125	150	SEP 6	100	150
SEP 27	-	-	SEP 27	-	-	SEP 27	125	150
OCT 14	100	100	OCT 14	10	150	OCT 14	5,100	150
NOV 2	-	-	NOV 2	10-15	150	NOV 2	100	150
NOV 15	100	100	NOV 16	5-10	-	NOV 15	100	150
DEC 1	100	100	DEC 1	5-15	150	DEC 1	5-10	75-150
DEC 16	100	100	DEC 14	5-15	150	DEC 16	5-15	100-150

BASELINE SITES

Numbers of perennial plant species on baseline sites generally changed little from 1992 to 1993 (Table 4). Most changes were a result of seedling establishment or death. On FRF001 in Frenchman Flat there was an increase in seedlings of *Oryzopsis hymenoides*, while the small changes in other species' numbers balanced to zero. On YUF001 in Yucca Flat the major changes were a decline of 19 in *Sphaeralcea ambigua*, due to the death of seedlings, and an increase of 14 *Artemisia spinescens*, seedlings which may have germinated deep

declined from 28 to 3, again due to death of 1992 seedlings. On Pahute Mesa (plot PAM001) the inclusion of 155 one-year-old *Artemisia nova* seedlings balanced out declines in the bunchgrasses *Sitanion jubatum* and *Stipa speciosa*. Similarly, on RAM001 on Rainier Mesa the death of many *Linanthus nuttallii* which germinated in 1992 balanced small changes in several other species.

Percent cover and total volume increased in most shrubs, but on plots with major dominant species (*Larrea tridentata*, *Artemisia nova*, or *Pinus monophylla*) the change was tempered by proportionately small changes in the dominant species. On the Frenchman Flat baseline plot (FRF001) a decrease in cover and volume by *L. tridentata* more than countered increases in the smaller shrub species, and total volume had a net decrease (Table 4).

Table 4. Density (n/m^2), cover (%), and total above ground volume ($m^3/100$ m^2) on the five BECAMP baseline plots. * = recalculated after data modification.

	JAF001	FRF001	YUF001	PAM001	RAM001

1993 censuses were attributed to 1992 germination. On plot PAM001 155 *Artemisia nova* seedlings which germinated and survived through 1992 were measured in 1993. They were too small and hidden in litter in 1992 to get a good count. Many new plants were *Oryzopsis hymenoides* plants which flowered and fruited in 1993. Even though those grasses grew well in 1993, it is very unlikely that they could both germinate and fruit in one season. It is more likely they germinated and died to below the surface in 1992, and were therefore missed in 1992, then flowered and fruited in 1993. *O. hymenoides* thought to be 1993 seedlings were very small, with only one tiller, and had no flowers or fruit.

Growth

Most of the change in perennial volumes since monitoring began has been through dieback and regrowth of the large plants which contribute a majority of the volume. 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)/years] is easily calculated for plants measured at two different times. The resulting "growth constant", k, requires some interpretation, however. A plant with $k > 0.7$ 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).

Growth constants for the period 1992 to 1993 on baseline plots generally averaged considerably less than one, the highest value being 0.75 ± 0.34 ($\bar{x} \pm$ 2 se) for *Acamptopappus shockleyi* on Yucca Flat (Table 5). Several species on the Yucca Flat baseline plot had $k > 0.6$, resulting in a rough doubling of live volumes on that plot (Table 4).

Mean growth rates on the five baseline plots differed significantly (ANOVA, $F_{4,1026} = 13.18$, $P < 10^{-9}$). A Tukey post-hoc comparison showed growth on YUF001 to be greater than on JAF001, RAM001, and PAM001, and JAF001 and PAM001 to also be lower than growth on FRF001 (Table 5). Average growth on the Pahute Mesa baseline plot (PAM001) was negative, meaning that 1993 sizes were somewhat smaller than 1992 sizes, although the growth constant was not significantly different from zero (no change in size).

Table 5. Mean growth constants (k = ln(V2/V1)/Δt; V = volume, t = years; $\bar{x}$ ± 2 se) for common shrub species on baseline plots for 1991-1992 and 1992-1993. () enclose numbers of plants matched at the two times.

SPECIES	YR	JAF001	FRF001	YUF001	PAM001
Acamptopappus shockleyi	92	1.8±0.2 (80)		2.4±0.9 (6)	
	93	0.2±0.2 (89)		0.8±0.3 (6)	
Ambrosia dumosa	92	1.3±0.1 (65)	2.2±0.6 (14)		
	93	-0.3±0.2 (68)	0.6±0.5 (16)		
Artemisia nova	92				0.5±0.1 (148)
	93				-0.1±0.1 (148)
Atriplex canescens	92			1.9±0.5 (30)	
	93			0.6±0.3 (30)	
Ceratoides lanata	92			2.0±0.6 (33)	
	93			0.7±0.4 (32)	
Ephedra nevadensis	92			0.4±0.5 (18)	-0.1±0.4 (28)
	93			0.6±0.2 (18)	0.6±0.4 (31)
Grayia spinosa	92			1.1±0.4 (32)	
	93			0.2±0.4 (32)	

Table 5. (Continued) Mean growth constants ($k = \ln(V2/V1)/\Delta t$; V = volume, t = years; $\bar{x} \pm 2$ se) for common shrub species on baseline plots for 1991-1992 and 1992-1993. () enclose numbers of plants matched at the two times.

SPECIES	YR	JAF001	FRF001	YUF001	PAM001
Larrea tridentata	92	-0.1±0.1 (7)	0.4±0.8 (6)		
	93	0.21±0.16 (7)	-0.3±0.7 (6)		
Lycium andersonii	92			-1.2±0.8 (13)	
	93			0.6±0.3 (11)	
Menodora spinescens	92	0.2±0.4 (20)			
	93	0.5±0.2 (20)			
Oryzopsis hymenoides	92				0.4±0.6 (11)
	93		0.6±0.6 (12)	0.2±2.2 (5)	-0.1±0.3 (12)
Sitanion jubatum	92				1.1±0.3 (88)
	93				-0.9±0.3 (68)

Table 5. (Continued) Mean growth constants ($k = \ln(V2/V1)/\Delta t$; V = volume, t = years; $\bar{x} \pm 2$ se) for common shrub species on baseline plots for 1991-1992 and 1992-1993. () enclose numbers of plants matched at the two times.

SPECIES	YR	JAF001	FRF001	YUF001	PAM001
Plot Means	92				
	93	0.0±0.1 (196)	0.4±0.3 (54)	0.6±0.1 (196)	-0.1±0.1 (358)

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 the years 1989 through 1991, and some herbaceous species died out completely (Table 6). Others, notably *Ephedra nevadensis*, *Atriplex canescens*, and *Grayia spinosa* declined only slightly. Recovery of drought-hardy shrubs in 1992 was not dramatic, but in 1993 growth was rapid and brought total volume to the greatest value since monitoring began in 1987. A few shrubs thought to be dead sprouted from the base in 1993, particularly *Grayia spinosa* and *Lycium andersonii*. Herbaceous species, which increased in number in 1992, declined in 1993, as many seedlings of *Erioneuron pulchellum* and *Sphaeralcea ambigua* were not found (Table 6).

Live volumes of shrubs on the YUF001 baseline plot declined during drought and recovered fully during 1993, although volumes and numbers followed somewhat different trends. Herbaceous perennials are small and contributed only 1.3% of total live volume, a 2.5 fold increase, but insignificant. Total live volume increased 61% in 1993, and was 104% of the 1987 volume. *Atriplex canescens* maintained the dominance it achieved after good growth in 1992, and contributed 32.5% of total volume. It contributed only 11% in 1987. In 1993 *A. canescens* fruited profusely, to the point where many stems died late in the season, and it can be expected to be smaller in 1994. *Ephedra nevadensis*, the next most-dominant species, increased 53% in volume in 1993 to reach 110% of its 1987 size. Over the seven years monitored, dominance has shifted from *Ephedra nevadensis*, a very drought-hardy long-lived species, to *A. canescens*, a shorter-lived species with lower drought tolerance, while other species have increased or decreased considerably (Table 7).

Table 6. Counts of live perennial plants by species, and dead shrubs and grasses on a 100 m^2 baseline plot in southwestern Yucca Flat, 1987 -

Table 6. (Continued) Counts of Live Perennial Plants by Species, and dead shrubs and grasses on a 100 m^2 Baseline Plot in Southwestern Yucca Flat, 1987 - 1993. * marks grasses.

Species	1987	1988	1989	1990	1991	1992	1993
Tetradymia axillaris	2	2	2	2	2	1	1
Totals	438	329	251	237	175	260	246
Dead grasses	-	-	8	32	44	33	18
Dead shrubs	-	-	55	167	449	230	189

Table 7. Estimated live volumes (liters per 100 m^2) of perennial plants on a baseline plot in southwestern Yucca Flat, 1987 - 1993. * marks grasses.

Species	1987	1988	1989	1990	1991	1992	1993
Acamptopappus shockleyi	592	344	381	16	41	93	304
Arabis pulchra	0	1	0	0	0	0	0
Artemisia spinescens	732	537	575	47	32	5	10
Atriplex canescens	2085	1535	1264	921	893	3802	6232
Ceratoides lanata	798	461	611	378	265	780	1119
Ephedra nevadensis	5007	5320	5015	4482	4130	3599	5513
*Erioneuron pulchellum**	1	2	0	0	0	0	0
Grayia spinosa	2948	3195	3015	1598	1392	2612	3648
Hymenoclea salsola	420	196	188	44	41	238	292
Lycium andersonii	4073	3511	2681	2521	2630	677	1672
Menodora spinescens	1	1	1	0	1	0	3
Mirabilis pudica	5	1	0	0	1	89	182
*Oryzopsis hymenoides**	41	10	2	0	0	3	3
*Sitanion jubatum**	11	2	0	0	0	0	1

Table 7. (Continued) Estimated live volumes (liters per 100 m^2) of perennial plants on a baseline plot in southwestern Yucca Flat, 1987 - 1993. * marks grasses.							
Species	1987	1988	1989	1990	1991	1992	1993
Sphaeralcea ambigua	34	20	0	0	0	11	65
*Stipa speciosa**	2	3	3	2	1	1	4
Tetradymia axillaris	1732	1583	1869	1636	1514	0	128
Totals	18482	16722	15604	11646	10941	11910	19176
Dead grasses	-	-	4	21	57	13	32
Dead shrubs	-	-	2429	3487	5184	5057	2947

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* associated with 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, when essentially all *Atriplex* plants died. On FF84 only *Larrea tridentata* survived in 1991. Total live volumes reflect the decline in numbers. In 1992, germination of *Atriplex* species and *Oryzopsis hymenoides* increased numbers considerably, and growth of those seedlings continued in 1993 (Table 8. The four transects differed considerably in the recovery patterns, generally in accordance with prior vegetation community characteristics. Plot FF66 was dominated before the drought by *Atriplex confertifolia* but also had some small *Kochia americana*. Germination after the drought included both those species, but in 1993 most of the *A. confertifolia* seedlings died. The *K.americana*, however, generally survived (29 of 32) and tripled in total volume. Mean k was 1.4 ± 0.5 (2 se).

Plot 67 was dominated originally by *Atriplex confertifolia*, but had a significant proportion of *Atriplex canescens*. Both species germinated in 1992 but numbers were predominantly *A. confertifolia* (285 to 19 by 1993). Live volume of *A. confertifolia* on this plot increased 121X between June 1992 and July 1993, from 3 to 426 liters. Growth of the four seedlings matched both years averaged 4.0 ± 0.8 (k ± 2 se), which would give a yearly increase of 48 fold per year. On FF67 there were also 12 new *Stanleya pinnata*, an herbaceous species, which grew from 0.5 to 106 l total volume, for a mean k = 4.4 ± 3.0 (2 se).

Plot FF81 is further from the playa. It was historically dominated by *Atriplex canescens* and *Oryzopsis hymenoides*, with three other species present. In 1993 82 *A. canescens* seedlings contributed 119 of 259 liters, *O. hymenoides* seedlings 20 liters, and *Mirabilis pudica* (an herbaceous perennial with below-ground dormancy) 118 liters.

Finally, plot FF84 was farthest from the playa, and was historically dominated by *Larrea tridentata*, with a few *Atriplex canescens* and *Oryzopsis hymenoides*. The *L. tridentata* did not die, but declined to a minimum volume in 1992 and regrew only slightly in 1993. Growth was not significantly different from zero (k = 0.4 ± 0.7). At the same time, seedlings of *Atriplex canescens* grew from 10 to 426 l (k = 3.1 ± 0.8) and *Oryzopsis* seedlings went from 1 to 3.5 l (k = 0.4 ± 0.3).

Table 8. 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	1993
Numbers									
FF66	113	117	145	137	111	10	26	85	48
FF67	87	53	66	72	48	15	1	721	317
FF81	83	117	---	55	46	5	0	451	431
FF84	16	19	---	---	10	8	5	133	111
Live volumes m^3									
FF66	3.8	10.6	11.3	12.3	7.0	0.2	0.05	0.09	0.17
FF67	2.4	4.4	5.6	5.2	2.6	0.7	0.06	0.05	0.69
FF81	3.1	5.6	---	3.7	3.7	0.5	0.00	0.02	0.26
FF84	13.3	12.8	---	---	12.0	11.3	9.10	5.53	6.25

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).

Of 26 *Yucca brevifolia* censused in 1992 one died before the 1993 census. It was grazed to ground level. The remaining 25 included two large plants (approximately 5 m tall), neither of which fruited in 1993. The mean change in height of the remaining 23 plants was 1.2 ± 2.6 cm (± 2 se; no significant change). Thus in the four years of monitoring the only year when this cohort of seedlings grew was 1992 (Hunter 1994b). Mean height of this cohort of young plants was 32 ± 4 cm ($n = 31$; $\bar{X} \pm 2$ se).

Cacti on plot YUF001 were of three species, *Opuntia basilaris* (beavertail), *O. echinocarpa* (golden cholla), and *O. ramosissima* (pencil cactus). Of 14 beavertail cactus measured in 1992, five were dead and one missing in 1993, and the remaining eight all shrank ($k = -2.3 \pm 0.9$; $\bar{X} \pm 2$ se). They did not appear to be significantly grazed, but died as if from disease or drought. In contrast, all 11 golden cholla survived, of which 7 grew ($k = +0.34 \pm 0.32$; $\bar{X} \pm 2$ se). The difference in growth between the two species was significant ($t = 6.24$, $P = 0.0001$). There was one pencil cactus, which increased ten-fold in volume ($k = +2.2$).

Eighteen *Juniperus osteosperma* were remeasured on the Pahute Mesa baseline plot, PAM001. Of 17 plants censused both years, mean change in height was +4.1 ± 3.5 cm ($\bar{X}$ ± 95% confidence limits), indicating there was slight growth for the year. In four previous censuses there was no net growth (Hunter 1994b). Mean height of 16 plants measured every year was 104 ± 28 cm in 1993, compared to 100 ± 26, 99 ± 28, and 100 ± 28 cm ($\bar{X} \pm 1$ se) in 1992, 1991 and 1989, respectively.

There were three marked populations of pinyon pine trees (*Pinus monophylla)*, of which only two were censused in 1992. On plot PAM008, infested with pinyon needle scale (*Matsucoccus acalyptus*), eight more trees died in 1993, leaving 39 of the original 50. The pinyon leaf scale was not present in significant numbers in 1993, so death should be attributed to the weakened condition of many of the trees. Mean height of the remaining trees on this plot was 137 ± 37 cm compared to 157 ± 36 cm in 1992 ($\bar{X} \pm 2$ se). For trees present both years mean change in height was +0.8 ± 3.5 cm ($\bar{X} \pm 2$ se). Trees on plot

PAM007, considered an unaffected control plot, grew an average of 10.0 ± 3.1 cm, which was significantly different from the PAM008 trees ($t = 3.27$, $P = .0015$).

Pinyon trees on the third plot (RAM001) were censused after a two year hiatus in 1993. The 50 trees grew an average of 5.9 ± 6.7 cm ($\bar{X} \pm 2$ se) over two years. None died, but several were very young seedlings in the shade of adults and should not be expected to survive long.

DISTURBED SITES

Disturbed sites monitored in 1993 included two burned areas and associated controls, and two roadsides.

BURNED SITES

Yucca Flat

Two burned areas were first sampled in 1987, the first year of the BECAMP program. One transect 200 m long by 2 m wide was measured in Yucca Flat at the site of a June, 1985 fire initiated by lightning (plot YUF002). The transect started 50 m into undisturbed vegetation, with the edge of the bladed firebreak considered the edge of disturbance. The first 90 m of the transect were not burned, but a bladed firebreak occupied meters 50 to 55. The transect was placed crossing the edge of the burned area in order to determine if vegetation recovery was more rapid near the undisturbed vegetation than far into the burned area.

In six years of monitoring the number of plants on the burned portion of transect YUF002 has steadily declined (Table 9). Initially the vegetation was totally dominated by species which crown-sprouted from below ground following the fire (*Ephedra nevadensis*, *Lycium andersonii* and *Stipa speciosa*). Although these crown-sprouts were small, numbers were comparable to those on the control site. Loss of numbers on both the burned and control sections was due to death of the bunchgrasses *Stipa speciosa*, *Oryzopsis hymenoides*, and *Sitanion jubatum*. Small changes in numbers of shrubs were normally explainable as errors in measurement, usually in determining whether a particular plant was alive or dead when censused. However, new plants of *Ericameria cooperi* germinated between 1987 and 1990, and were recognizably seedlings.

Table 9. Numbers of plants, by species, on burned and control portions of a transect in Yucca Flat (plot YUF002) sampled in 1987, 1990, and 1993. The first 90 m were not burned, and 90 - 200 m were cleared by fire in June 1985. Values are adjusted to 100 m^2 for each section. * values between 0 and 1 were rounded to 1.

	Burned			Unburned		
Species	1987	1990	1993	1987	1990	1993

andersonii (k = 0.49 ± 0.21), both of which grew faster on the burned area (t = 2.97, P = 0.01 and t = 4.52, P = 0.0001, respectively) than on the unburned area.

Table 10. Volumes (liters) of plants, by species, on burned and control portions of a transect in Yucca Flat (plot YUF002) sampled in 1987, 1990, and 1993. The first 90 m were not burned, and 90 - 200 m were cleared by fire in June 1985. Values are adjusted to 100 m^2 for each section.

	Burned			Unburned		
Species	1987	1990	1993	1987	1990	1993
Ambrosia X Hymenoclea	0	0	0	0	1	4
Artemisia spinescens	0	0	0	0	0	0
Ceratoides lanata	0	0	0	173	-	0
Coleogyne ramosissima	0	0	0	1048	1060	1268
Ephedra nevadensis	125	162	1184	3192	2163	3383
Ericameria cooperi	0	0	19	348	83	251
Grayia spinosa	0	0	77	4348	1860	1786
Hymenoclea salsola	9	12	639	268	259	1917
Lycium andersonii	61	75	340	2222	3192	2315
Oryzopsis hymenoides	0	0	1	0	1	0
Sitanion jubatum	0	0	0	1	0	0
Stipa speciosa	52	21	34	419	12	13
Unknown	0	0	0	30	0	0
Yucca brevifolia	33	40	51	0	0	0
Totals	281	335	2345	12,605	8630	10,937
Dead shrubs and grasses	-	1220	1080	-	4882	3778

Mid Valley

A 350 m transect was set up in 1987 on another burned area in Mid Valley (1445 m, plot MID001). The first 100 m was in undisturbed vegetation, and the next 250 m was on an area burned by a lightning fire in July 1986.

Numbers of perennial plants increased at each census on the Mid Valley burned area, and declined at each census on the control area (Table 11).

Table 11. Numbers of perennial plants per 100 m^2 on a burned area (500 m^2 of transect) and adjacent control area (200 m^2) in southern Mid Valley (MID001). The fire occurred in June 1986.

	BURNED			CONTROL		
Species	1987	1990	1993	1987	1990	1993
ART TRI	0	1.4	1.4	46.0	51.5	46.5
ATR CAN	0.4	1.0	1.0	0	0	0.5
CHR TER	0.4	1.4	1.0	3.0	5.0	5.0
CHR VIS	1.2	0	0.2	19.5	24.0	23.0
COL RAM	0	0.8	1.0	30.0	38.0	37.5
EPH NEV	6.4	6.6	7.6	30.5	53.5	27.5
ERI CAE	0	0.2	0.2	0	0	0
ERI COO	0	0	0	4.0	5.5	6.0
ERI PUL	0	0	0.0	0	0	0
GRA SPI	0	0	0	1.0	0.5	0.5
LYC AND	0.6	1.0	1.0	0	0	0
MEN SPI	0	0.4	0.8	0	0	0
OPU ECH	0	1.0	1.0	0	0	0
OPU ERI	0	0	0	0.5	0.5	0.5
ORY HYM	45.4	1.8	16.0	69.5	0.5	0.5
PHL STA	9.0	2.2	105.8	6.5	0.5	0.0
SIT JUB	-	-	89.2	-	-	1.5
SPH AMB	0	37.6	36.0	0	4.0	3.5
STI SPE	-	40.6	15.6	-	18.5	1.0
UNKNOWN	0	1.6	2.1	0	1.5	0.0

Table 11. (Continued) Numbers of perennial plants per 100 m² on a burned area (500 m² of transect) and adjacent control area (200 m²) in southern Mid Valley (MID001). The fire occurred in June 1986.

	BURNED			CONTROL		
YUC BRE	1.0	1.2	1.2	1.0	1.5	1.0
TOTALS	66.4	99.2	281.2	212	207.5	157.5
DEAD GRASS	-	77.4	22.0	-	169	116.5
DEAD SHRUBS	-	80.4	49.4	-	35	34.5

Changes in numbers of plants were concentrated among the herbaceous perennial species, especially the three bunch grasses (*Oryzopsis hymenoides*, *Sitanion jubatum* and *Stipa speciosa*), the herbaceous shrub *Sphaeralcea ambigua*, and the rhizomatous herb *Phlox stansburyi*. (The grass species were not well-differentiated in 1987 and 1990, when they did not flower, so actual proportions of the three species are not exact in Table 11.) Most of the grasses died during the 1898-90 drought, and in 1993 most were new, rather than surviving from earlier years. On the control area most of the decline in numbers was attributable to death of the bunchgrasses, but there was some fluctuation in *Ephedra nevadensis* shoots.

In the control area *Ephedra* grew as short, independent rhizomatous shoots, which is its habit on the baseline plot on Pahute Mesa (Hunter 1992). On the burned area it was growing as multiple shoots coalesced into a small area of overlapping canopies, more closely resembling its form in the Mojave Desert sections of the NTS.

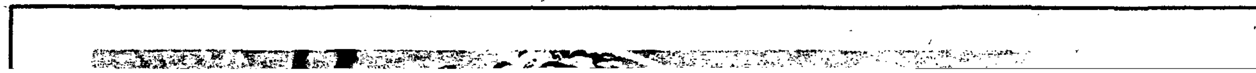
Plant live volumes in Mid Valley were dominated by shrubs (Table 12). Total live volume increased 481% on the burned area since 1990, and only 21% on the control area. On the burned area *Atriplex canescens*, *Sphaeralcea ambigua* and *Ephedra nevadensis* increased greatly, while on the control area growth was primarily by *Ephedra nevadensis* and *Coleogyne ramosissima*.

Table 12. Volumes (liters per 100 m²) on burned and control sections of a transect in Mid Valley (MID001).

	BURNED			CONTROL		
Species	1987	1990	1993	1987	1990	1993
ART TRI	0	4.6	163	12004	8480	8568

Table 12. (Continued) Volumes (liters per 100 m^2) on burned and control sections of a transect in Mid Valley (MID001).ontiCnued)

	BURNED			CONTROL		
ATR CAN	15	149	615	0	0	0
CHR TER	5.9	29.7	145	372	500	556
CHR VIS	32.6	-	30	3636	962	2762
COL RAM	0	7	24	4192	4587	7279
EPH NEV	424	402	1258	1220	3855	2941
ERI CAE	0	0.0	0	0	0	0
ERI COO	0	0	0	178	170	168
ERI PUL	0	0	0	0	0	0
GRA SPI	0	0	0	48	46	132
LYC AND	10.8	6.7	26	0	0	0
MEN SPI	0	0.4	13	0	0	0
OPU ECH	0	1.2	0.3	1.4	2.4	<1
OPU ERI	0	0	0	13.8	18.6	57
ORY HYM	19.6	0.2	23	99	0.2	0.3
PHL STA	116.4	1.4	3.7	-	0.0	0
SIT JUB	-	-	32	0	1.0	<1
SPH AMB	0	12.8	675	0	1.0	12
STI SPE	-	10.1	19	-	5.8	2
UNKNOWN	26.4	3.1	0	0	0.1	0
YUC BRE	18.3	13.6	26	16.6	8.7	17
TOTALS	668.6	641.6	3087	21780	18638	22496
DEAD GRASS	-	3.0	3.3	-	47.4	22.0
DEAD SHRUBS	-	576	393	-	4998	4021



Growth on the burned area was significantly faster than on the control ($\bar{k}$ = 0.75 ± 0.09 burn, 0.30 ± 0.06 control; t = 8.44, P = 0.0001). Mean growth was greater on the burn for each species which occurred on both burned and control areas.

Mid Valley *Yucca brevifolia*

On the Mid Valley burned area 100 Joshua trees (*Yucca brevifolia*) were marked when studies began in 1987. The tops of most were killed by fire, but basal sprouts were produced by many, and in 1990 52% of the 64 on the burned area still survived. By 1993 only 20 remained alive (31%; Table 13).

Table 13. Characteristics of *Yucca brevifolia* on and off a burned area in Mid Valley in 1987, 1990, and 1993. Error terms are ± 2 se.

	Burned			Unburned		
	1987	1990	1993	1987	1990	1993
# marked	64	64	64	36	36	36
# with live trunks	-	5	1	36	36	35
# with live sprouts	31	30	19	3	7	8
Mean # of live sprouts	5.7 ± 1.6	3.1 ± 0.6	2.9 ± 0.8	1.0 ± 0.0	1.3 ± 0.6	1.8 ± 0.6
# fruiting	-	1	0	-	13	1
Mean trunk height, cm	-	34 ± 9	29	189 ± 36	192 ± 36	223 ± 35

The primary cause of death in both the remaining live plants and the basal sprouts was falling of the trunk (caudex). Roots damaged or killed by death of most of the photosynthetic portions of the plant evidently were not strong enough to support the large burned trunks. Toppling of the trunk killed both the remaining live meristems on the trunk and the sprouts at the base. (The basal sprouts nearly always occurred on a widened flange of the trunk, but rarely apparently from roots.) The one surviving main trunk on the burned area was a small plant which was missed by the fire. The average height of the tallest sprouts for each sprouting plant on the burned area (35 ± 6 cm) exceeded the height of the lone surviving original shoot.

Size of adult played a role in survival of crown sprouts. Plants with trunks of moderate size, 1 to 2 m tall, tended to remain standing and the sprouts generated at their bases were still surviving (Figure 2). Very tall plants had fewer sprouts (Hunter and Medica 1989) and also had a greater tendency to blow down.

Roadsides

Perennials were monitored along two roadsides in Frenchman Flat. Objectives were both to characterize the obvious differences in vegetation along the roadsides, and to determine differences in growth rates between roadsides and control areas.

5-03 Road

The plants on the shoulder of abandoned 5-03 road were measured in 1988, 1991, and 1993 on a transect parallel to the pavement and two meters from its edge. A control transect was placed about 100 m from the road in undisturbed vegetation. The layout of the transect only allows study of the shoulder and control (Hunter 1994a), but monitoring continues primarily to measure differences in growth rates between the two sites.

Since 1988 perennial plants increased in number and size on the 5-03 roadside, but decreased on the control (Table 14). Total live volume in 1993 increased to 4535 liters per 100 m^2 on the roadside, which was 41% of control live volume, an increase from 28% in 1988. Dominant species on the roadside were *Ephedra nevadensis* and *Ambrosia dumosa* with significant contributions by *Psorothamnus fremontii* and *Larrea tridentata*. On the control *L. tridentata* was dominant, contributing 79% of total volume in 1993. *Ambrosia dumosa* was the only other significant species on the control, contributing 9%. *A. dumosa* was the most numerous species on both plots, making up 77 and 73% of numbers on roadside and control, respectively.

Table 14. Perennial plant numbers and total live volumes (liters) on roadside transect FRF002 and its control, sampled in 1988, 1991, and 1993. All values are for 100 m^2.

	Numbers			Volumes		
	Roadside					
Species	1988	1991	1993	1988	1991	1993
Ambrosia dumosa	33	40	41	1076	512	1406

Table 14. (Continued) Perennial plant numbers and total live volumes (liters) on roadside transect FRF002 and its control, sampled in 1988, 1991, and 1993. All values are for 100 m².						
	Numbers			Volumes		
Ephedra nevadensis	2	3	2	2282	2117	1813
Erioneuron pulchellum	1	0	0	0	0	0
Larrea tridentata	2	2	2	67	111	343
Opuntia basilaris	0	1	1	0	0	1
Oryzopsis hymenoides	4	2	4	4	0	1
Psorothamnus fremontii	2	3	3	322	198	971
Totals	44	51	53	3750	2939	4535
Dead plants	0	6	3	0	15	9
	Control					
Species	1988	1991	1993	1988	1991	1993
Ambrosia dumosa	41	36	36	1028	155	1028
Ephedra nevadensis	8	7	5	1830	859	1045
Grayia spinosa	3	2	1	506	49	37
Larrea tridentata	4	4	4	9613	8136	8701
Lycium andersonii	1	1	1	139	69	159
Psorothamnus fremontii	0	0	2	0	0	15
Stipa speciosa	1	0	0	64	0	0
Totals	58	50	49	13,181	9,268	10,986
Dead plants	9	28	15	265	1084	700

From 1991 to 1993 growth was slight in *Larrea tridentata* on the control transect. As a result volume change was slight on the control (it increased from 9268 to 10986 l on 100 m²). On the roadside, live volume increased from 2939 to 4535 l, due largely to growth in three *Psorothamnus fremontii* (from 198 to 971 l) and *Ambrosia dumosa* (white bursage) (from 512 to 1406 l).

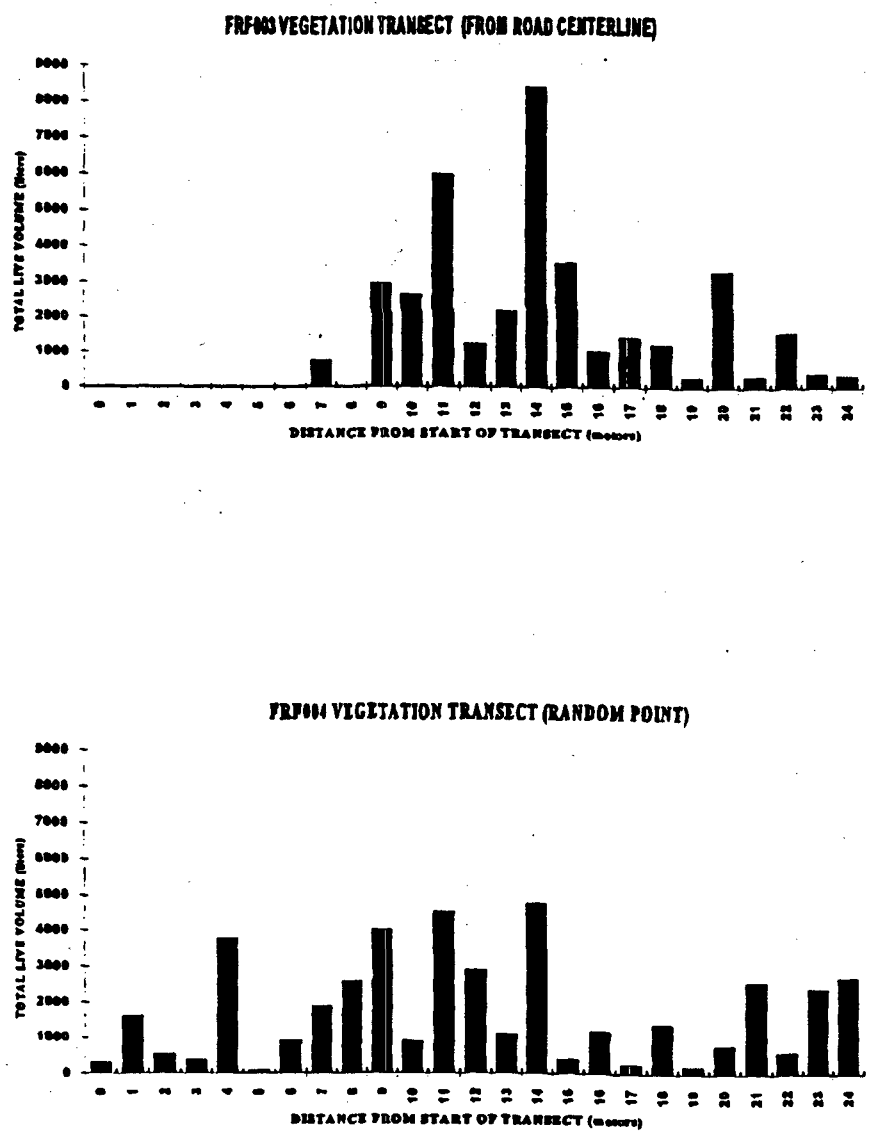


Figure 3 - Total plant volumes (1) as a function of distance from road center (top) or a random point (bottom). Each bar represents 16 m^2.

Average growth rates were dominated by the most numerous species, *Ambrosia dumosa*. Mean growth rates were significantly higher on the control transect ($t = 2.15$, 94 d.f., $P = 0.03$), where *A. dumosa* increased seven-fold in size as it recovered to its pre-drought volume ($k = 1.02 \pm 0.18$). The roadside *A. dumosa* did not shrink so much during drought (Table 14) and only grew three-fold in volume from 1991 through 1993 ($k = 0.66 \pm 0.15$). Total live volume of *A. dumosa* on the roadside increased 31% from 1988 (1406 versus 1076 l), while on the control it was unchanged (1028 l both years).

5-05 Road

A site in the center of 5-05 road, which goes from Well 5b in central Frenchman Flat to Mercury highway, was studied in 1990 and 1993. Eight transects of 25 m were oriented perpendicular to the road, and eight control transects were in undisturbed desert 500 m to the northwest.

The 5-05 road at the study area is oriented approximately East-West. The 25 m of transect consists of about 3-4 m of asphalt from the centerline to the pavement edge, 4 m of scraped shoulder to the bottom of the trough, 2 m of the sloped road side of the berm, and approximately 1 m of loose soil on the back side of the berm. The peak of the berm occurred between 9.4 and 10.5 m from the centerline. The road shoulder was scraped in spring of 1993 to the bottom of the trough (about 4 to 8 m from the centerline). The shoulder and back side of the berm sloped down facing north, and the road side of the berm sloped down toward the south. Thus, about 35 to 40% of the 25 m transects was periodically scraped.

As might be expected, the numbers of perennial plants were lower on the roadside than on the control. Numbers per 50 m^2 averaged 35 ± 7 on the roadside, and 57 ± 15 on control transects ($t = 2.85$, d.f. = 14, $P = 0.022$). Excluding *Oryzopsis hymenoides*, which had a total of 116 on the eight roadside transects and 193 on the controls the difference was marginally non-significant ($t = 1.78$, 14 d.f., $P = 0.095$). The *O. hymenoides* germinated in 1992 and 1993, and was reduced in density on the roadside plots ($\overline{x} = 9 \pm 6$ vs 24 ± 11; $t = 2.43$, 14 d.f., $P = 0.03$).

Total live volumes on the roadside and control plots were not significantly live plant volume at the edge of the scraped area (Figure 3). If we break the data at 15 m, the point where the last *Hymenoclea* was found on the roadside in 1990, then the vegetated area close to the road (9 to 15 m) averaged significantly greater live volumes per meter than the area from 16 to 25 meters from the road (t = 3.05, d.f. = 14, P = 0.009). Between the berm peak and 15 m live volume averaged 3859 ± 1888 liters per meter, compared to 1107 ± 646 l/m^2 from 16 to 25 m.

On the control transect the same areas (9 to 15 and 16 to 25 m) did not differ significantly (t = 1.83, 14 d.f., P = 0.09; means 2673 ± 1404 vs 1357 ± 61). In both locations, however, there was considerable fluctuation in live volumes among meter-lengths of pooled transect (Figure 3). On the roadside there was some suggestion of a minimum value one or two meters behind the larger peak on and just behind the berm. It seems plausible that competition from those large plants prevented growth of nearby shrubs, leading to an oscillation of volumes with distance from the road.

Growth rates of live shrubs near the road were significantly higher than those on the control plots ($\bar{k}$ = 0.46 ± 0.10 versus 0.31 ± 0.10; t = 2.10, 247 d.f., P = 0.037). The fastest growing species on the roadside, *Hymenoclea salsola*, ($\bar{k}$ = 0.82 ± 0.34) was not found on the control transects, and without that species growth on the roadside did not differ significantly from the control ($\bar{k}$ = 0.41 vs 0.31; t = 1.28, 229 d.f., P = 0.20).

Linear correlation coefficient between growth rates and distance from the road center was -0.51 (r^2 = 0.26), indicating growth was significantly faster closer to the road ($F_{1,18}$ = 6.45, P = 0.021). On control transects the correlation coefficient between distance along a transect and k was +0.21 (r^2 = 0.04), indicating change in growth rates with distance was not significantly different from 0.

DISCUSSION

There are enough similarities in the results from various areas and years on the NTS to propose some mechanisms of response of the perennial plant communities to disturbance. The majority of observations can be explained by reference to water availability at various locations and times, while ancillary factors modify overall patterns.

Seven years of plant data are now available from the Yucca Flat baseline plot, YUF001. Over that time period there were two consecutive years of severe drought followed by several years of normal to above-normal precipitation. Perennial plant live volumes and species compositions fluctuated considerably over that time span. Perennial plant total live volume can be correlated with annual precipitation (Table 2). Yearly precipitation does not correlate significantly ($r = +0.4559$, $n = 7$, $P = 0.30$), but two-year, three year, and four year running means do. The best fit is the four-year running mean, where $r = 0.940$, $r^2 = 0.883$ ($F_{1,5} = 37.6$, $P = 0.002$), indicating 88% of variation in live volume can be explained by variation in rainfall (Figure 4). The linear regression line for this relationship was

$$TLV = 2338 + 96.7P \quad \textit{equation } 1$$

where TLV is total live perennial volume in liters and P is mean annual precipitation (mm) for the four years ending in the year of measurement at the location studied. Application of this equation to the other baseline sites suggests it holds relatively well at lower altitudes, but not for Pahute and Rainier Mesas (Table 15).

Table 15. Total live volumes of perennial plants at BECAMP baseline sites predicted by equation 1 and compared to actual 1993 measured values.

Site	Mean Precipitation (mm)	Predicted Volume (m^3)	Actual Volume (m^3)
JAF001	117	13.7	13.9
FRF001	191	20.8	22.9
YUF001	156	17.4	19.2
PAM001	180	19.7	14.2
RAM001	332	34.4	65.1

Turner and Randall (1989) analyzed data from Rock Valley to produce an equation relating precipitation to annual net production by shrubs. Such estimates required measuring leaf, flower, and fruit production on numerous species, and related to ecological questions of how undisturbed desert ecosystems work. Although BECAMP data could be used to roughly estimate annual net production, they are more related to how the ecosystems respond to and recover from disturbance.

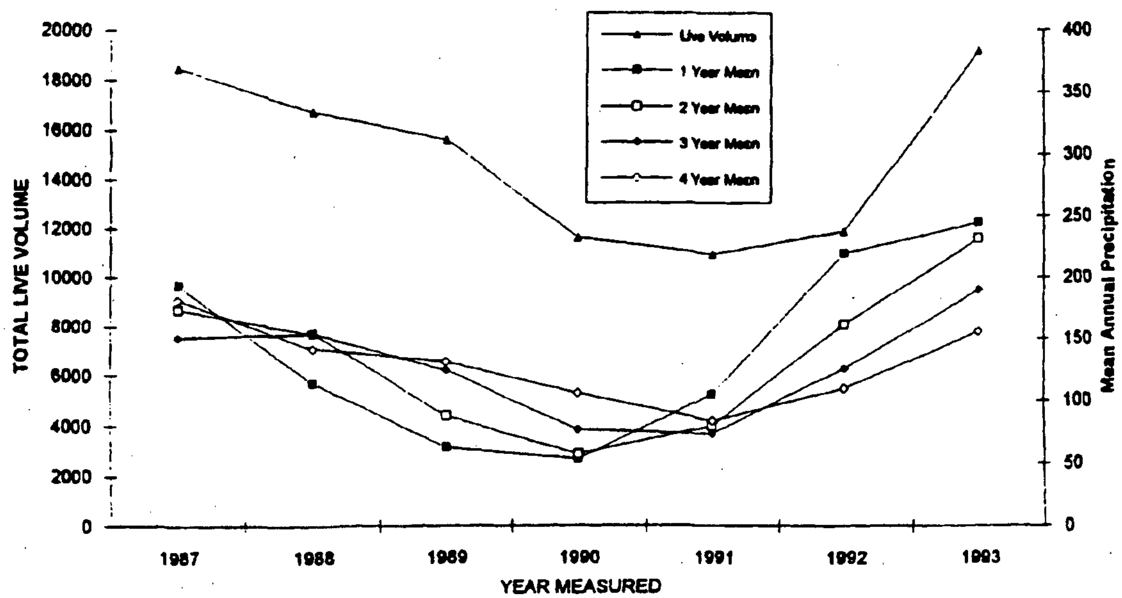


Figure 4 - Live volume of perennial plants versus 1-, 2-, 3-, and 4-year running mean rainfall for plot YUF001.

There are other factors which will affect perennial populations, including the following:

- seasonality of soil moisture availability, which can interact with species composition and phenologies to modify growth parameters.
- species composition, which can limit total growth depending on size limits of different species.
- soil types, which affect water and nutrient extraction, root penetration and rooting depths.
- altitude, which affects temperature and thus evaporation rates and phenologies of plants present.
- germination events, which depend on different conditions than growth, but which can have major effects on species composition (Ackerman 1979, Hunter 1989).
- extremes of weather - frost, drought, high temperatures can eliminate some species (Beatley 1974, 1975).
- age of a seedling cohort can affect growth rates, as young plants grow more rapidly than older, larger plants.

Most of the information necessary to mathematically use these observations to judge the health or predict the responses of the NTS perennial vegetation is not readily available. Nevertheless, the BECAMP data are relevant and help to explain the responses of vegetation on the areas studied.

Both amount and seasonality of precipitation were unusual in 1993. Precipitation was largely restricted to the period between December 1992 and February 1993, when shrubs were dormant and temperatures cold. The cold temperatures allowed maximum infiltration of rainwater, which for the first time in this writer's experience wet soils below 150 cm. During emplacement of soil sensors in 1989 roots were examined in Frenchman Flat (FRF001) and Yucca Flat (YUF001). Roots were absent or very sparse below 117 cm in the deep sands of Frenchman Flat, and absent from soils deeper than about 80 cm in the cemented alluvium on YUF001. Thus, in 1993 water penetrated below the root zone, and was not fully extracted before the end of the year (Table 3). Although water was less available late in 1993, there was never a time of severe stress that might have led to dieback of spring growth.

Differences in increases in live volume can be explained by differences in rainfall and whether the vegetative community was already fully developed. For example, the small increase in live volume on JAF001 can be explained by the already high volume in 1992, wile the large increase in volume on YUF001 was appropriate for the reduced total live volume the previous year. Similarly, the slight shrinkage in Frenchman Flat did not reduce live volume below that predicted by equation 1, suggesting the amount of vegetation was appropriate for the rainfall conditions prevailing there. Pahute Mesa volume is below that predicted by the equation, which is attributable to its position on top of a rocky knoll. Soil on plot PAM001 is very shallow and the vegetation consists primarily of *Artemisia nova*, a naturally short species.

Most water was available in cool weather, and shrubs able to grow in cool weather (*Acamptopappus shockleyi*, *Ceratoides lanata*, *Ephedra nevadensis*, *Grayia spinosa*, *Lycium andersonii*, *Atriplex canescens*, and *Oryzopsis hymenoides*)(Ackerman and Bamberg 1974) should therefore have been favored over those growing preferentially in hot weather (*Ambrosia dumosa*, *Larrea tridentata*, *Krameria parvifolia*). This may explain why *Atriplex canescens* grew so much better than *L. tridentata* on the LGF plot 84 (Table 8), where the two occurred together. Two years when rain fell primarily during winter (1992 and 1993) may also partially explain why *Atriplex canescens* became the dominant species on plot YUF001 (Table 7).

Germination temperature is another important factor affecting species composition on NTS plots. Germination of some species apparently only occurs in warm weather (*Larrea tridentata* and *Ambrosia dumosa*) and others only in cool weather (*Atriplex confertifolia*, *Ceratoides lanata*, *Ephedra nevadensis*, *Grayia spinosa)* (Ackerman 1979). Although published data are not available for *Oryzopsis hymenoides* and *Sphaeralcea ambigua*, their germination on the NTS in 1992 and 1993 argues for those being species which germinate preferentially in cool weather.

We can therefore explain the significant growth in volume on some baseline plots as responses primarily to the good rainfall in 1993, the reduced live volume from years of drought, and cool weather when water was most available.

Differences in growth rates between *Larrea tridentata* and *Atriplex canescens*, as on transect FF84, can be explained as due to the maturity of the *L. tridentata*, the young age of the *A. canescens*, and the seasonality of precipitation, which favored the *A. canescens*.

Disturbed sites

Burned areas and roadsides were examined in 1993. In general the plants on the disturbed areas grew significantly faster than those on the control areas. This follows a pattern noted over many years in which plants on disturbed areas are healthier and more susceptible to grazing by jackrabbits (Hunter 1987). The effect is attributable to the live volume on the disturbed sites being reduced, leaving excess water for growth of the few plants present. The only exception seen in this report was growth of *Ambrosia dumosa* on the FRF002 roadside, which was slower on a relative basis (k was lower) than on the control. This was explained as due to the more severe size reduction on the control than on the roadside during recent drought years.

If growth is faster on disturbed areas, why do Mojave Desert sites take so long to recover? Burned areas in Mid Valley studied in previous years had not recovered since 1959, ground zeroes have only partially recovered since the mid-1950's, and subsidence craters created in the 1960's are in the early stages of recovery. The answers lie apparently in some of the subsidiary factors mentioned above.

One of the most significant problems with natural revegetation on the NTS lies in the absence of germination events. In undisturbed desert germination is rare, and establishment very rare. Ackerman (1979) studied permanent study quadrats in Rock Valley totalling 76 m^2 from 1971 through 1977. On that area only 201 shrub seedlings germinated and only 1 survived to the end of the study (0.5%). In 1983, however, numerous *Ambrosia dumosa* germinated in Jackass Flats at densities up to 535 per m^2 in response to heavy summer rains (Hunter 1989). There was some germination of *Ephedra nevadensis* in 1976 in Mercury. Scattered germination of other species occurred in 1992, primarily *Oryzopsis hymenoides* and *Atriplex canescens* (Hunter 1994a). *Artemisia nova* and *A. tridentata* germinated in large numbers on Pahute Mesa in 1992. Romney et al. (1981)referred to a "pulse hypothesis" with respect to recovery of a radiation-damaged area of Pahute Mesa which suggested germination occurred primarily in three high-rainfall years between radiation damage in 1965 and examination of the plants in 1976.

Grazing is another reason disturbed areas recover slowly. Hunter (1987) found jackrabbits preferred vegetation growing on disturbed areas, and killed many seedlings on a roadside borrow-pit (unpublished observations). A small herd of cattle present on the NTS in 1990 preferentially grazed plants on the MID001 burned area (Hunter 1994a), and grazing by feral horses was seen on bunchgrasses present on the Red Rock Valley burned area studied in 1992 (Hunter 1994b).

In spite of such problems total live volume slowly increases on disturbed areas. The Mid Valley burned area went from 3.1% of control volume in 1987 to 3.4% in the drought year of 1990, to 13.7% in 1993. Species present on such areas are often grazing tolerant, such as the bunchgrasses (*Oryzopsis hymenoides*, *Stipa speciosa*) and herbaceous perennials (*Sphaeralcea ambigua*, *Stephanomeria pauciflora*, *Stanleya pinnata*). Germination of dominant perennials has been rare on such areas, though *Hymenoclea salsola* apparently germinated on the ground zeroes in Yucca Flat between 1983 and 1986 (Hunter 1994a).

Numbers of plants on the 5-05 roadside were reduced from those on the control. Much of this effect could be attributed to the absence of *Oryzopsis* seedlings on the 40% of each transect covered by pavement or scraped free of vegetation during maintenance. Total live volumes were not significantly different, though the roadside transects averaged only 87% of control transect volumes. The increased growth rate near the road and the high volumes of vegetation near the berm suggest the vegetation has nearly compensated for the loss of the road areas in the approximately 35 years since construction of 5-05 road.

Vegetation on the abandoned road 5-03 has grown on the scraped shoulder, in 1993 to 41% of control volume. Since there are essentially no plants growing on the paved portion, we expect that strip on the shoulder to eventually surpass the control transect in total live volume, as it will technically be inhabiting the area excluded by the pavement as well as the sampled area.

Future sampling

Over the seven years of BECAMP monitoring considerable progress has been made in understanding the response of the NTS perennial vegetation to varying disturbances, primarily involving removal of shrub cover by blast, fire, or construction equipment. Recovery modes are becoming predictable, which is gratifying. Some of the factors that delay recovery are beginning to be seen, but are not sufficiently documented at the present time. More details of seed production and dispersal and germination conditions might give valuable insights into recovery processes on disturbed areas. Certainly monitoring of both pristine and disturbed areas should be continued with techniques which allow comparison of future and past conditions.

In 1993 two samples of horse feces showed low contamination by tritium (Greger, this report). The uptake of radionuclides by plants growing on contaminated areas, and movement of contaminants through animals to uncontaminated areas, is a significant question that has been studied in the past (e.g. Romney et al. 1970; Romney et al. 1973), but is not currently being monitored.

At the same time there are ongoing disturbances which are not being monitored. Road, camp, and building construction and maintenance, installation and operation of utility lines, creation of new pits or drainage channels, clearing of contaminated areas for "restoration" work, and drilling of deep wells are some recent DOE activities that are not currently being monitored. Natural disturbances such as grazing by feral horses and deer, invasion of new species along roadsides and water sources, spread of insects and plant pathogens, and population changes in migratory birds all affect NTS ecosystems.

The absence of cattle grazing, mining, lumber harvest, and recreational offroad vehicle use on the NTS distinguishes it from many other natural areas in the western US. The NTS may have value as a control area for some of those disturbances.

A better understanding of water use by perennial plants would be useful in estimating effects of disturbance on the hydrology of the NTS. For example, disturbed areas may allow water penetration below the root zone, and eventually some percolation of water through contaminated soils to groundwater. New techniques to measure soil moisture content, plant transpiration, and depths at which plants withdraw water are available and should be used to determine the role of vegetation in NTS water balances.

Current monitoring techniques determine for particular sites the vegetative cover, volume, species composition, appearance of seedlings, and crude

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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
Arabis pulchra M.E. Jones ex S. Wats.	ARA PUL
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	CH 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
Ericameria nana (= *Haplopappus nanus*) (Nutt.) D. C. Eaton	ERI NAN
Eriogonum caespitosum Nutt.	ERI CAE
Eriogonum microthecum Nutt.	ERI MIC
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
Hymenoclea salsola Torr. & Gray ex Gray	HYM SAL
Juniperus osteosperma (Torr.) Little	JUN OST
Kochia americana Benth.	KOC AME
Krameria parvifolia Benth.	KRA PAR
Larrea tridentata (Sesse & Moc. ex DC.) Coville	LAR TRI

SPECIES AND AUTHORITY	ABBREVIATION
Linanthus nuttallii (Gray) Greene ex Milliken	LIN NUT
Lycium andersonii Gray	LYC AND
Menodora spinescens Gray	MEN SPI
Mirabilis pudica Barneby	MIR PUD
Opuntia basillaris Engelm. & Bigelow	OPU BAS
Opuntia echinocarpa Engelm. & Bigelow	OPU ECH
Opuntia erinacea var. ursina (A. Weber) Parish	OPU ERI
Opuntia ramosissima Engelm.	OPU RAM
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
Quercus gambellii Nutt.	QUE GAM
Sitanion jubatum J.G. Sm.	SIT JUB
Sphaeralcea ambigua Gray	SPH AMB
Stanleya pinnata (Pursh) Britt.	STA PIN
Stephanomeria pauciflora (Torr.) Nutt.	STE PAU
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
Yucca brevifolia Engelm.	YUC BRE

APPENDIX G

The following tables summarize the perennial plant population parameters on belt transects censused on the Nevada Test Site in 1993 and the last previous year they were measured. Transects were normally 50 m long by 2 m wide (100 m^2), but some on burned areas were longer, and On Pahute and Rainier Mesas they were 25 X 2 m (50 m^2). Tables are in alphabetical order by plot name. Information in the top line of each table gives plot name, sample dates (higher lines are the earlier dates for a given species), and elevations, and total plot area. Values are not adjusted, so for transects other than 100 m^2 plant cover does not equal percent cover. Locations of the plots are in the text map (Figure 1), and exact locations are given in appendix A of the small mammal report (Saethre, this report).

PLOT	LOCATION	DISTURBANCE	TABLE
FF66	Frenchman Flat	LGF monitoring	1
FF67	Frenchman Flat	LGF monitoring	2
FF81	Frenchman Flat	LGF monitoring	3
FF84	Frenchman Flat	LGF monitoring	4
FRF001	Frenchman Flat	Baseline	5
FRF002R	Frenchman Flat	Roadside	6
FRF002C	Frenchman Flat	Control for FRF001	7
FRF003	Frenchman Flat	Roadside (5-05)	8
FRF004	Frenchman Flat	Control for FRF003	9
JAF001	Jackass Flats	Baseline	10
MID001B	Mid Valley	Burned (1986)	11
MID001c	Mid Valley	Control for MID001B	12
PAM001	Pahute Mesa	Baseline	13
RAM001	Rainier Mesa	Baseline	14

PLOT	LOCATION	DISTURBANCE	TABLE
YUF001	Yucca Flat	Baseline	15
YUF002B	Yucca Flat	Burned (1985)	16
YUF002C	Yucca Flat	Control for YUF002B	17

Table 1. FF66; SAMPLED 9 June 1992, 17 June 1993; ELEVATION 940m; 100 m^2.

SPECIES	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOL l	TOT VOL l	AVG BIO g	TOT BIO Kg
ATR CON	53	3±1	3±1	2±1	0.25±0.17	0.13	0.71±0.49	37.78	3.35±2.29	0.18
ATR CON	19	7±2	4±2	3±1	0.25±0.17	0.05	0.65±0.57	12.32	3.05±2.68	0.06
KOC AME	32	16±1	10±1	8±1	0.81±0.17	0.26	1.77±0.50	56.74	5.50±1.56	0.18
KOC AME	29	22±1	17±2	12±1	2.00±0.43	0.58	5.36±1.52	155.34	16.61±4.72	0.48
DEAD SHR	116	31±1	49±3	41±3	22.3±2.5	25.86	100±14	11566		
DEAD SHR	113	32±1	49±3	39±3	21.7±2.6	24.56	100±15	11305		
TOTALS	85					0.39		94.53		0.35
TOTALS	48					0.63		167.66		0.54

Table 2. FF67; SAMPLED 4 June 1992, 21 July 1993; ELEVATION 940 m; 100 m^2.

SPECIES	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOL l	TOT VOL l	AVG BIO g	TOT BIO Kg
ATR CAN	31	5±2	3±1	2±1	0.31±0.29	0.10	1.46±1.46	46	3.8±3.8	0.11
ATR CAN	19	12±3	11±3	7±3	1.69±1.31	0.32	8.44±8.08	160	22±21	0.42
ATR CON	684	2±0	2±0	1±0	0.02±0.00	0.12	0.005±0.001	3	0.02±0.00	0.02
ATR CON	285	11±0	11±0	9±0	1.01±0.06	2.90	1.50±0.11	426	7.0±0.5	2.00
SPH AMB	0									
SPH AMB	1	3	2	2	0.03	0.00	0.01	0.01	0.00	0.00
STA PIN	6	6±1	4±1	4±1	0.128±0.03	0.01	0.1±0.0	0.55	0.04±0.02	0.00
STA PIN	12	33±7	14±2	12±2	1.8±0.5	0.22	8.8±3.0	106	3.8±1.3	0.05
DEAD SHR	77	30±1	44±2	34±2	14.6±1.5	11.27	53±6	4083		
DEAD SHR	85	28±2	38±3	29±2	12.4±1.5	10.50	48±7	4112		

Table 3. FF81; SAMPLED 9 June 1992, 21 July 93; ELEVATION 945 m. 100 m².

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	TOT BIO Kg
ATR CAN	1488	5±0	3±0	2±0	0±0.01	0.09	0.03±0.01	5.15	0.09±0.01	0.01
ATR CAN	822	17±1	9±1	6±1	0.66±0.11	0.54	1.46±0.30	119	3.79±0.77	0.31
ATR CON	1	1	1	1	0.01	0.00	0.00	0.00	0.00	0.00
ATR CON	0									
MIR PUD	33	17±3	20±3	15±2	2.34±0.26	0.07	4.16±1.34	12.48	1.79±0.58	0.01
MIR PUD	111	22±2	25±3	17±3	3.94±0.71	0.44	10.75±3.20	118	4.62±1.37	0.05
ORY HYM	2944	13±0	1±0	1±0	0.01±0.00	0.03	0.01±0.00	3.59	0.01±0.00	0.00
ORY HYM	349	15±0	3±0	2±0	0.04±0.0	0.14	0.06±0.0	20.95	0.07±0.0	0.02
SPH AMB	55	2±0	3±1	2±1	0.07±0.03	0.00	0.02±0.01	0.08	0.01±0.00	0.00
SPH AMB	88	6±1	5±1	4±1	0.21±0.08	0.02	0.15±0.09	1.21	0.07±0.04	0.00
DEAD GRS	288	3±1	9±1	7±1	0.55±0.09	0.14	0.23±0.08	6.02		
DEAD GRS	199	4±0	9±1	7±1	0.62±0.12	0.12	0.26±0.07	4.87		
DEAD SHR	677	26±2	43±4	37±4	19.2±3.2	12.50	80±16	5217		
DEAD SHR	511	31±2	49±4	42±5	23.3±4.3	11.87	107±23	5442		
TOTALS	451					0.19		21		0.02
TOTALS	450					1.14		260		0.38

Table 4. FF84; SAMPLED 10 June 1992, 28 July 1993; ELEVATION 945 m; 100 m².										
SPECIES	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOL l	TOT VOL l	AVG BIO g	TOT BIO Kg
ATR CAN	50	8±0	5±0	4±0	0.20±0.03	0.10	0.20±0.04	10	0.52±0.10	0.03
ATR CAN	37	20±2	21±2	17±2	4.0±0.8	1.47	12±3	426	30±8	1.11
LAR TRI	5	87±21	117±26	96±19	102±30	5.09	1104±391	5519	1434±508	7.17
LAR TRI	5	90±15	134±25	94±17	111±30	5.55	1165±378	5827	1515±492	7.57
ORY HYM	78	17±0	1±0	1±0.0	0.01±0.00	0.01	0.01±0.00	1.09	0.02±0.00	0.00
ORY HYM	69	18±1	2±0	2±0	0.04±0.01	0.03	0.05±0.02	3.60	0.06±0.02	0.00
DEAD GRS	1	10	24	13	2.5	0.02	2.5	2.45		
DEAD GRS	1	5	14	11	1.2	0.01	0.6	0.60		
DEAD SHR	8	37±5	57±8	55±9	28±7	2.26	117±30	932		
DEAD SHR	8	41±7	61±9	54±9	30±8	2.42	146±46	1169		
TOTALS	133					5.20		5530		7.20
TOTALS	111					7.04		6256		8.69

Table 5. FRF001; SAMPLED 27 May 1992, 2 June 1993; ELEVATION 965 m; 100 m^2.

SPECIES	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOL l	TOT VOL l	AVG BIO g	TOT BIO Kg
ACA SHO	3	19±3	20±5	16±5	2.83±1.43	0.08	6.22±3.65	18.65	19.3±11.3	0.06
ACA SHO	4	18±5	22±6	17±6	3.90±1.82	0.16	9.12±4.56	36.50	28.3±14.1	0.11
AMB DUM	16	28±3	28±3	26±4	7.04±1.62	1.13	25±7	22	62±18	0.99
AMB DUM	16	32±3	38±5	30±5	12.10±4.01	1.94	54±23	861	135±59	2.15
CER LAN	9	40±5	30±4	22±3	5.64±0.96	0.51	25±5	227	81±16	0.73
CER LAN	9	42±4	31±3	24±3	6.31±1.13	0.57	29±6	258	92±19	0.83
EPH NEV	1	47	41	45	14.49	0.14	68.11	68.11	95.35	0.10
EPH NEV	1	58	53	36	14.99	0.15	86.92	86.92	122	0.12
GRA SPI	2	65±6	55±1	50±9	21.3±3.3	0.43	141±34	281	323±78	0.65
GRA SPI	3	68±1	67±3	53±5	28.3±3.7	0.85	191±24	573	439±55	1.32
HYM SAL	4	23±7	18±4	15±4	2.35±1.02	0.09	8±5	30.17	24±15	0.10
HYM SAL	2	40±5	40±4	26±6	8.53±2.87	0.17	33±7	65.36	105±23	0.21
LAR TRI	6	100±15	161±32	119±20	173±7	10.40	2186±12	13117	2842±64	17.05
LAR TRI	6	97±17	146±35	117±21	161±65	9.65	1983±1071	11898	2578±1393	15.47
LYC AND	3	44±8	48±18	38±12	17.57±10.09	0.53	87±50	260	191±111	0.57
LYC AND	3	43±8	42±9	30±5	10.39±3.37	0.31	49±20	148	109±44	0.33

Table 5. (Continued) FRF001; SAMPLED 27 May 1992, 2 June 1993; ELEVATION 965 m; 100 m^2.

SPECIES	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOL l	TOT VOL l	AVG BIO g	TOT BIO Kg
ORY HYM	19	14±1	2±1	2±0	0.06±0.04	0.01	0.10±0.09	1.97	0.11±0.09	0.00
ORY HYM	38	11±1	1±0	1±0	0.01±0.00	0.00	0.01±0.00	0.49	0.02±0.00	0.00
PSO FRE	1	7	8	6	0.38	0.00	0.26	0.26	0.66	0.00
PSO FRE	1	33	41	20	6.44	0.06	21.25	21.25	53.13	0.05
DEADGRS	7	8±2	6±1	5±1	0.32±0.12	0.02	0.27±0.15	1.87		
DEADGRS	10	5±1	8±2	7±2	0.61±0.22	0.05	0.52±0.26	4.12		
DEADSHR	102	19±1	26±2	20±2	6.88±1.15	7.02	27±7	2730		
DEADSHR	110	20±2	26±2	17±2	6.52±1.07	6.91	27±6	2851		
TOTALS	64					13.32		14399		20.24
TOTALS	83					13.86		13949		20.59

Table 6. FRF002R; SAMPLED 13 June 1991, 25 August 1993; ELEVATION 977 m; 100 m².

SPECIES	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm²	TOT COV m²	AVG VOL l	TOT VOL l	AVG BIO g	TOT BIO Kg
AMB DUM	40	17±1	27±2	22±2	5.89±0.95	2.36	12.81±2.66	512	32±7	1.28
AMB DUM	41	26±1	41±2	34±2	12.18±1.32	5.00	34.3±4.9	1406	86±12	3.51
EPH NEV	3	52±23	94±40	91±43	93±49	2.80	706±395	2117	988±553	2.96
EPH NEV	2	79±5	122±5	120±6	115±11	2.30	907±149	1814	1270±208	2.54
LAR TRI	2	33±9	45±13	38±12	14±8	0.29	55±40	111	72±52	0.14
LAR TRI	2	46±23	66±22	49±18	28±18	0.56	171±148	343	223±193	0.45
OPU BAS	1	4	8	5	0.31	0.00	0.13	0.13		
OPU BAS	1	5	12	12	1.13	0.01	0.57	0.57		
ORY HYM	2	13±0	2±1	2±1	0.04±0.03	0.00	0.05±0.04	0.10	0.06±0.05	0.00
ORY HYM	5	9±3	4±1	3±1	0.15±0.07	0.01	0.18±0.12	0.73	0.20±0.13	0.00
PSO FRE	3	17±6	51±25	41±23	26±19	0.77	66±55	198	165±138	0.50
PSO FRE	3	32±12	86±31	79±38	71±44	2.12	324±239	971	810±599	2.43
DEADGRS	3	11±4	11±6	12±8	1.80±1.61	0.05	3.14±2.95	9.43		
DEADGRS	2	10±6	16±11	13±8	2.31±2.15	0.05	3.59±3.54	7.17		

Table 6. (Continued) FRF002R; SAMPLED 13 June 1991, 25 August 1993; ELEVATION 977 m; 100 m^2.

SPECIES	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOL l	TOT VOL l	AVG BIO g	TOT BIO Kg
DEADSHR	3	16±3	14±2	9±1	1.07±0.23	0.03	1.78±0.59	5.34		
DEADSHR	1	16	14	11	1.21	0.01	1.94	1.94		
TOTALS	51					6.22		2939		4.88
TOTALS	53					10.00		4535		8.93

Table 7. FRF002C; SAMPLED 13 June 1991, 25 August 1993; ELEVATION 977 m; 100 m².

SPECIES	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm²	TOT COV m²	AVG VOL l	TOT VOL l	AVG BIO g	TOT BIO Kg
AMB DUM	36	14±1	17±2	13±1	2.29±0.46	0.82	4.31±1.06	155	10.8±2.6	0.39
AMB DUM	36	28±1	35±2	29±2	9.26±1.27	3.33	28.6±4.5	1028	71.4±11.3	2.57
EPH NEV	7	31±6	50±18	39±14	27.1±14.9	1.90	123±71	859	172±100	1.20
EPH NEV	5	46±4	69±19	60±16	42.1±19.8	2.10	209±102	1045	292±142	1.46
GRA SPI	2	36±9	31±10	21±10	5.82±4.17	0.12	24.6±20.3	49.21	56.6±46.7	0.11
GRA SPI	1	55	31	28	6.82	0.07	37.5	37.49	86.24	0.09
LAR TRI	4	103±16	156±36	146±25	200±74	7.99	2034±625	8136	2644±813	10.6
LAR TRI	4	103±12	158±28	158±34	218±80	8.72	2175±657	8701	2828±854	11.3
LYC AND	1	35	52	48	19.60	0.20	68.61	68.61	151	0.15
LYC AND	1	48	67	63	33.15	0.33	159	159	350	0.35
PSO FRE	0									
PSO FRE	2	17±2	23±10	18±10	3.99±3.27	0.08	7.43±6.36	14.86	18.6±15.9	0.04
DEADGRS	1	49	36	18	5.09	0.05	24.94	24.94		
DEADGRS	1	35	27	14	2.97	0.03	10.39	10.39		

Table 7. (Continued) FRF002C; SAMPLED 13 June 1991, 25 August 1993; ELEVATION 977 m; 100 m².

SPECIES	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm²	TOT COV m²	AVG VOL l	TOT VOL l	AVG BIO g	TOT BIO Kg
DEADSHR	27	17±3	25±5	19±4	8.37±3.09	2.26		1059		
DEADSHR	14	20±6	28±7	23±7	9.62±4.05	1.35		690		
TOTALS	50					11.03		9265		12.43
TOTALS	49					14.64		10986		15.82

Table 8. FRF003; SAMPLED 23 August 1990, 23 June 1993; ELEVEVATION 965 m; 400 m^2. (sum of eight 50 m^2 transects).

SPECIES	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOL	TOT VOL	AVG BIO	TOT BIO
		cm	cm	cm	dm^2	m^2	l	l	g	Kg
ACA SHO	2	16±2	20±2	16±8	2.44±0.95	0.05	3.88±1.21	7.76	12.0±3.7	0.02
ACA SHO	9	27±3	35±3	22±2	6.30±1.16	0.57	18.0±5.0	209	55.8±15.6	0.50
AMB DUM	83	20±1	23±2	19±2	5.83±1.14	4.37	16.9±3.5	1268	42.3±8.8	3.19
AMB DUM	100	29±1	40±2	31±2	11.7±1.1	11.7	40.1±5.5	4010	100±14	10.0
ART SPI	5	28±2	30±3	23±2	5.61±1.06	0.22	16.1±3.8	64.6	66.2±15.4	0.26
ART SPI	4	19±10	11±9	10±8	2.58±2.52	0.10	12.0±11.9	47.8	49.0±48.8	0.20
CER LAN	3	23±6	18±3	22±2	3.23±0.70	0.10	7.21±1.87	21.6	23.1±6.0	0.07
CER LAN	2	37±7	31±4	22±1	5.49±0.83	0.11	20.9±6.9	41.8	66.9±22.1	0.13
EPH NEV	5	29±7	27±9	31±12	9.76±5.02	0.49	39.0±21.3	195	54.6±29.8	0.27
EPH NEV	5	44±9	40±2	33±3	10.6±1.3	0.53	49.0±13.1	245	68.7±18.4	0.34
GRA SPI	14	53±4	55±4	45±5	20.9±3.12	2.71	122±24	1584	280±56	3.64
GRA SPI	10	67±4	64±5	51±7	28.1±5.1	2.80	191±38	1914	440±87	4.40
HYM SAL	30	26±4	27±6	21±5	10.6±4.8	2.98	59.4±28.9	1663	190±93	5.32
HYM SAL	26	48±4	62±5	52±5	29.2±4.5	7.60	167±35	4349	535±113	13.9
LAR TRI	19	90±9	110±18	95±13	109±24	20.6	1244±323	23628	1617±421	30.7

Table 8. (Continued) FRF003; SAMPLED 23 August 1990, 23 June 1993; ELEVEVATION 965 m; 400 m^2. (sum of eight 50 m^2 transects).

SPECIES	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOL l	TOT VOL l	AVG BIO g	TOT BIO Kg
LAR TRI	20	88±9	105±14	84±13	93.4±19.9	18.7	1090±276	21799	1417±359	28.3
LYC AND	8	47±5	69±11	69±16	42.6±13.8	2.13	218±87	1088	478±191	2.39
LYC AND	8	34±5	52±6	34±4	14.5±2.6	1.16	50.1±11.1	401	110±24	0.88
MIR PUD	0									
MIR PUD	1	17	25	24	4.71	0.05	8.01	8.01	3.44	0.00
ORY HYM	0									
ORY HYM	116	13±1	2±0	2±0	0.03±0.00	0.04	0.05±0.01	5.38	0.05±0.01	0.01
PSO FRE	8	34±14	58±27	50±24	59.5±40.1	4.76	597±450	4779	1494±1124	11.9
PSO FRE	9	40±11	77±21	57±15	54.8±30.2	4.94	464±325	4174	1159±812	10.4
TET AXI	2	84	21	132	21.77	0.22	183	183	494	0.49
TET AXI	1	78	71	62	34.57	0.35	270	270	728	0.73
DEADGRS	8	13±2	9±2	7±1	0.57±0.17	0.05	0.95±0.33	7.58		
DEADGRS	7	10±5	16±8	13±7	4.28±3.68	0.30	13.7±13.1	95.8		
DEADSHR	259	22±1	27±1	23±1	8.63±0.87	22.2	33.5±4.8	8609		
DEADSHR	200	22±1	26±2	20±1	7.91±1.28	15.8	36.1±9.7	7224		
TOTALS	179					38.6		34481		58.3
TOTALS	311					48.6		37426		69.9

Table 9. FRF004; SAMPLED 14 September 1990, 23 June 1993; ELEVATION 965 m; 400 m^2 (sum of eight 50 m^2 transects).

SPECIES	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOL l	TOT VOL l	AVG BIO g	TOT BIO Kg
ACA SHO	8	20±2	31±7	28±6	9.03±3.73	0.72	22.2±10.6	177	68.7±32.8	0.55
ACA SHO	20	28±1	41±4	34±3	12.7±2.5	2.55	40.7±10.3	813	126±32	2.52
AMB DUM	75	16±1	20±2	14±2	3.96±0.97	2.66	11.2±3.7	749	28.0±9.2	1.87
AMB DUM	129	25±1	34±1	27±1	7.88±0.46	10.2	21.4±1.7	2764	53.6±4.1	6.91
ATR CAN	1	20	25	15	2.95	0.03	5.89	5.89	15.32	0.02
ATR CAN	0									
CER LAN	14	32±3	22±3	18±3	3.89±1.04	0.55	15.5±5.4	216	49.5±17.4	0.69
CER LAN	20	47±3	40±4	31±3	11.3±1.8	2.3	59.3±10.9	1186	190±35	3.79
EPH NEV	30	27±2	39±5	30±4	13.2±3.2	3.96	47.7±12.9	1432	66.8±18.1	2.00
EPH NEV	13	33±4	43±5	31±4	11.9±2.3	1.54	43.6±11.1	567	61.1±15.5	0.79
GRA SPI	4	52±7	33±10	33±9	10.6±4.3	0.42	51.3±21.1	205	118±48	0.47
GRA SPI	5	61±4	65±7	53±8	28.9±7.1	1.45	179±48	896	412±111	2.06
KRA PAR	1	6	9	5	0.35	0.00	0.21	0.21	0.42	0.00
KRA PAR	1	5	12	11	1.04	0.01	0.52	0.52	1.04	0.00
LAR TRI	37	82±5	110±11	89±9	98.5±18.0	36.4	1030±229	38125	1340±298	49.6

Table 9. (Continued) FRF004; SAMPLED 14 September 1990, 23 June 1993; ELEVATION 965 m; 400 m^2 (sum of eight 50 m^2 transects).

SPECIES	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOL l	TOT VOL l	AVG BIO g	TOT BIO Kg
LAR TRI	34	80±5	109±11	87±9	96.3±17.1	32.7	979±208	33292	1273±270	43.3
LYC AND	17	47±3	82±6	57±5	39.7±5.8	6.74	200±35	3398	440±77	7.48
LYC AND	22	40±2	73±6	58±6	38.2±6.1	8.4	168±30.9	3689	369±68	8.12
MIR PUD	0									
MIR PUD	1	30	41	22	7.08	0.07	21.3	21.3	9.14	0.01
ORY HYM	0									
ORY HYM	193	11±0	2±0	1±0	0.02±0.01	0.01	0.03±0.01	6.10	0.03±0.01	0.01
PSO FRE	2	42±3	63±16	60±6	30.0±10.9	0.60	129±55	259	324±137	0.65
PSO FRE	1	43	86	71	48.0	0.48	206	206	516	0.52
DEADGRS	29	21±1	7±1	6±1	0.46±0.10	0.13	1.07±0.29	31.0		
DEADGRS	27	12±1	13±1	10±1	1.20±0.24	0.33	1.66±0.42	44.7		
DEADSHR	357	23±1	34±1	28±1	10.4±0.8	37.1	36.4±4.10	12975		
DEADSHR	278	22±1	33±1	26±1	10.0±0.91	27.9	35.5±4.5	9882		
TOTALS	189					52.1		44568		63.3
TOTALS	439					59.7		43441		68.0

Table 10. JAF001; SAMPLED 19 May 1992, 26 July 1993; ELEVATION 954 m; 100 m².

SPECIES	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOL l	TOTVOL l	AVG BIO g	TOT BIO Kg
ACA SHO	88	27±1	34±1	26±1	7.88±0.63	6.93	22.1±2.04	1945	68.5±6.31	6.03
ACA SHO	92	28±1	35±2	27±1	8.92±0.74	8.20	27.2±2.7	2499	84.2±8.3	7.75
AMB DUM	71	32±1	50±2	41±2	17.8±1.3	12.6	62.9±6.2	4462	157±15	11.2
AMB DUM	68	27±1	45±2	38±3	15.6±2.2	10.6	51.1±11.2	3474	128±28	8.68
CER LAN	5	38±3	38±2	31±1	9.29±0.71	0.46	35.0±1.4	175	112±4	0.56
CER LAN	5	39±5	36±3	26±3	7.70±1.32	0.39	27.4±2.9	137	87.6±9.3	0.44
LAR TRI	7	84±12	151±26	115±19	158±46	11.0	1631±628	11418	2120±816	14.8
LAR TRI	7	91±10	166±31	129±26	203±66	14.2	2158±790	15108	2806±1027	19.6
MEN SPI	20	19±1	51±7	44±6	23.2±6.0	4.65	48.7±13.2	975	405±110	8.09
MEN SPI	20	24±2	62±7	48±6	29.6±6.2	5.91	85.7±20.7	1714	711±172	14.2
ORY HYM	36	10±2	2±0	1±0	0.05±0.04	0.02	0.18±0.16	6.58	0.20±0.17	0.01
ORY HYM	30	13±2	2±0	1±0	0.02±0.00	0.01	0.03±0.01	1.04	0.04±0.01	0.00
DEADGRS	49	10±1	9±1	7±1	0.77±0.24	0.38	0.87±0.27	42.5		
DEADGRS	47	11±1	12±1	9±1	1.27±0.30	0.59	1.67±0.44	78.7		
DEADSHR	87	16±1	27±1	22±1	5.47±0.49	4.76	11.4±1.5	991		
DEADSHR	82	17±1	29±2	22±1	6.21±0.57	5.09	13.4±1.8	1102		

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Table 10. (Continued) JAF001; SAMPLED 19 May 1992, 26 July 1993; ELEVATION 954 m; 100 m^2.

SPECIES	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOL l	TOTVOL l	AVG BIO g	TOT BIO Kg
TOTALS	227					35.7		18982		40.7
TOTALS	222					39.3		22933		50.7

Table 11. MID001B; SAMPLED 7 August 1990, 21 June 1993; ELEVATION 1452 m; 250 m^2.

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	TOT BIO Kg
ART TRI	7	14±5	11±3	10±3	1.18±0.66	0.08	3.32±2.53	23.2	5.97±4.56	0.04
ART TRI	7	52±7	54±7	42±5	19.2±5.1	1.35	116±44	814	210±79	1.47
ATR CAN	5	35±11	48±18	40±15	23.4±15.9	1.17	149±120	745	387±312	1.94
ATR CAN	5	57±11	87±27	80±22	74.0±42.9	3.70	615±452	3076	1600±1176	8.00
BUNCHGRS	0									
BUNCHGRS	6	13±1	1±0	1±0	0.01±0.00	0.00	0.01±0.00	0.06	0.01±0.00	0.00
CACTUS	1	3	3	2	0.05	0.00	0.01	0.01		
CACTUS	0									
CHR TER	7	19±5	26±10	16±7	6.16±3.92	0.43	21.2±16.1	149	53.1±40.1	0.37
CHR TER	5	31±3	43±7	37±7	14.1±5.6	0.70	49.7±25.6	248	124±64	0.62
CHR VIS	0									
CHR VIS	1	44	76	57	34.0	0.34	150	150	374	0.37
COL RAM	4	25±4	22±3	18±3	3.13±0.86	0.13	8.76±3.68	35.1	45.6±19.2	0.18
COL RAM	5	29±3	34±4	27±3	7.70±1.89	0.39	23.6±7.3	118	123±38	0.61
EPH NEV	33	29±2	53±5	38±3	18.8±3.0	6.15	60.9±10.1	2008	85±14	2.81
EPH NEV	38	45±2	65±5	54±4	31.7±4.2	12.1	166±28	6289	232±40	8.81

Table 11. (Continued) MID001B; SAMPLED 7 August 1990, 21 June 1993; ELEVATION 1452 m; 250 m².										
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
ERI CAE	1	4	6	4	0.19	0.00	0.08	0.08		
ERI CAE	1	3	13	7	0.71	0.01	0.21	0.21		
ERI PUL	1	1	2	1	0.02	0.00	0.00	0.00	0.00	0.00
ERI PUL	0									
LYC AND	5	27±6	40±2	28±4	8.92±1.62	0.45	26.0±7.5	130	57±17	0.29
LYC AND	5	18±2	25±5	18±3	3.52±0.76	0.18	6.72±2.21	33.6	14.8±4.9	0.07
MEN SPI	4	21±3	34±5	26±4	7.44±1.87	0.30	16.8±5.8	67.1	139±48	0.567
MEN SPI	2	10±1	12±5	10±1	0.97±0.42	0.02	1.08±0.58	2.15	8.94±4.83	0.02
OPU ECH	5	11±3	9±3	7±3	0.79±0.48	0.04	1.23±0.90	6.13		
OPU ECH	5	9±2	6±2	4±1	0.25±0.17	0.01	0.34±0.29	1.71		
ORY HYM	9	8±1	5±1	4±0	0.18±0.04	0.02	0.14±0.03	1.23	0.15±0.03	0.00
ORY HYM	80	27±1	7±1	6±0	0.45±0.07	0.36	1.46±0.27	117	1.61±0.30	0.13
PHL STA	11	7±1	9±1	7±1	0.67±0.15	0.07	0.63±0.16	6.97	0.27±0.07	0.00
PHL STA	529	8±0	8±0	6±0	0.42±0.01	2.23	0.35±0.01	184	0.15±0.01	0.08

Table 11. (Continued) MID001B; SAMPLED 7 August 1990, 21 June 1993; ELEVATION 1452 m; 250 m^2.

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	TOT BIO Kg
SIT JUB	0									
SIT JUB	446	17±0	5±0	4±0	0.19±0.01	0.85	0.36±0.02	161	0.40±0.03	0.18
SPH AMB	182	5±0	8±0	6±0	0.48±0.04	0.87	0.35±0.07	64.0	0.15±0.03	0.028
SPH AMB	180	26±1	22±1	15±1	4.21±0.59	7.57	18.7±4.0	3373	8.06±1.70	1.45
STI SPE	203	8±0	6±0	5±0	0.29±0.02	0.59	0.25±0.02	50.5	0.27±0.02	0.06
STI SPE	78	19±1	8±1	6±0	0.53±0.08	0.41	1.24±0.20	97.0	1.37±0.22	0.11
UNKNOWN	8	8±2	11±4	7±3	1.37±0.8	0.11	1.89±1.24	15.1		
UNKNOWN	5	34±9	45±16	34±12	18.1±10.8	0.90	95.4±67.4	477		
YUC BRE	6	12±2	21±9	19±11	7.07±4.35	0.42	11.3±7.0	68.0		
YUC BRE	6	24±7	22±8	19±6	5.13±2.72	0.31	21.4±12.7	128		
DEADGRS	378	4±0	5±0	4±0	0.21±0.01	0.50	0.06±0.01	15.0		
DEADGRS	110	3±0	8±0	6±0	0.44±0.05	0.49	0.15±0.04	16.8		
DEADSHR	401	14±1	21±1	14±1	4.36±0.57	11.8	10.7±2.2	2877		
DEADSHR	247	14±1	19±1	13±1	3.59±0.53	8.86	7.96±1.31	1967		
TOTALS	493					10.3		3208		5.52
TOTALS	1406					31.9		15433		22.66

Table 12. MID001C; SAMPLED 7 August 1990, 21 June 1993. ELEVATION 1445 m; 200 m^2.

SPECIES	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOL l	TOT VOL l	AVG BIO g	TOT BIO Kg
ART TRI	103	41±2	54±4	40±3	26±4	26.57	165±28	16960	296±50	30.53
ART TRI	93	54±2	57±4	42±3	26±4	24.09	186±35	17135	335±64	30.84
CACTUS	2	4±1	4±2	4±2	0.17±0.16	0.00	0.08±0.08	0.17		
CACTUS	0									
CHR TER	10	37±7	46±10	36±8	19±5	1.87	100±32	1001	250±80	2.50
CHR TER	1	46	83	39	25	0.25	117	117	292	0.29
CHR VIS	48	27±2	36±3	30±3	11±2	5.66	40±7	1923	100±17	4.81
CHR VIS	46	43±2	58±4	48±3	25±3	11.69	120±17	5525	300±42	13.81
COL RAM	76	41±2	53±4	44±3	24±3	18.34	121±17	9174	628±90	47.71
COL RAM	75	43±1	57±4	54±11	35±11	26.23	197±73	14558	1023±380	75.70
EPH NEV	107	25±1	45±5	30±3	21±4	22.90	72±19	7710	101±26	10.79
EPH NEV	55	36±2	49±5	34±4	20±5	11	107±39	5882	150±55	8.24
ERI COO	11	24±3	35±6	26±6	9.7±3.4	1.07	30±12	340	77±31	0.85
ERI COO	12	26±2	38±6	24±5	9.6±3.5	1.15	28±11	337	70±27	0.84
GRA SPI	1	45	51	51	20	0.20	92	92	211	0.21
GRA SPI	1	52	90	72	51	0.51	265	265	609	0.61

Table 12. (Continued) MID001C; SAMPLED 7 August 1990, 21 June 1993. ELEVATION 1445 m; 200 m^2.

SPECIES	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOL l	TOT VOL l	AVG BIO g	TOT BIO Kg
OPU ECH	1	24	17	15	2.0	0.02	4.8	4.8		
OPU ECH	1	3	6	6	0.3	0.00	0.08	0.08		
OPU ERI	4	22±5	20±11	12±6	3.3±2.5	0.13	9.3±7.1	37		
OPU ERI	4	34±8	31±11	17±7	6.0±3.3	0.24	29±18	114		
ORY HYM	1	8	8	7	0.44	0.00	0.4	0.4	0.3	0.00
ORY HYM	1	21	10	4	0.31	0.00	0.7	0.7	0.7	0.00
PHL STA	1	3	5	2	0.08	0.00	0.02	0.02	0.01	0.00
PHL STA	0									
SIT JUB	0									
SIT JUB	3	24±6	3±1	2±1	0.06±0.03	0.00	0.2±0.1	0.51	0.19±0.11	0.00
SPH AMB	8	4±1	6±2	4±1	0.28±0.14	0.02	0.3±0.2	2.10	0.11±0.09	0.00
SPH AMB	7	16±4	14±4	8±3	1.4±0.7	0.10	3.4±1.8	24	1.5±0.8	0.01
STI SPE	37	16±1	5±1	4±0	0.19±0.03	0.07	0.32±0.06	12	0.36±0.07	0.01
STI SPE	5	26±3	6±1	5±1	0.30±0.08	0.01	0.84±0.22	4	0.92±0.24	0.00

Table 12. (Continued) MID001C; SAMPLED 7 August 1990, 21 June 1993. ELEVATION 1445 m; 200 m².

SPECIES	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm²	TOT COV m²	AVG VOL l	TOT VOL l	AVG BIO g	TOT BIO Kg
YUC BRE	3	20±6	17±4	14±6	2.2±1.1	0.07	5.8±3.2	17		
YUC BRE	2	32±14	26±2	24±2	4.9±0.8	0.10	17±9	34		
UNKNOWN	2	2±2	2±0	2±0	0.02±0.01	0.00	0.01±0.01	0.01		
UNKNOWN	9	39±6	55±11	39±8	22±7	1.97	111±38	995		
DEAD GRS	338	16±1	6±1	5±1	0.7±0.4	0.46	1.5±1.0	95		
DEAD GRS	233	6±0	6±0	5±0	0.29±0.02	0.66	0.19±0.02	44		
DEAD SHR	70	30±2	72±5	56±5	43±6	29.71	145±27	9996		
DEAD SHR	65	29±3	71±5	50±4	37±5	23.48	126±25	8041		
TOTALS	415					76.94		37275		97.42
TOTALS	315					77.38		44991		130.35

Table 13. PAM001; SAMPLED 8 August 1992, 30 August 1993; ELEVATION 1923 m; 50 m².

SPECIES	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm²	TOT COV m²	AVG VOL l	TOT VOL l	AVG BIO g	TOT BIO Kg
ART NOV	299	18±1	24±1	19±1	6.65±0.53	19.9	24.1±2.4	7206	60.3±6.1	18.0
ART NOV	338	15±1	22±1	17±1	6.00±0.48	20.3	20.1±2.0	6783	50.2±5.0	17.0
AST PUR	3	2±1	2±0	1±0	0.01±0.00	0.00	0.00±0.00	0.01		
AST PUR	4	5±0	4±1	3±1	0.13±0.05	0.01	0.06±0.03	0.26		
BUNCHGRASS	8	11±1	3±1	2±0	0.06±0.02	0.00	0.07±0.02	0.54	0.07±0.03	0.00
BUNCHGRASS	13	8±1	2±1	1±0	0.04±0.03	0.01	0.07±0.06	0.90	0.08±0.07	0.00
CER LAN	0									
CER LAN	1	18	23	16	2.89	0.03	5.20	5.20	16.6	0.02
CHR VIS	1	40	46	28	10.1	0.10	40.5	40.5	101	0.10
CHR VIS	2	32±13	30±15	28±17	8.56±7.35	0.17	36.9±34.7	73.7	92.2±86.7	0.18
CHRVIPU	1	20	20	17	2.67	0.03	5.34	5.34		
CHRVIPU	0									
EPH NEV	34	22±1	14±1	10±1	1.32±0.20	0.45	3.34±0.61	114	4.70±0.86	0.16
EPH NEV	33	26±2	17±2	14±2	2.24±0.43	0.74	6.93±1.70	229	9.70±2.38	0.32
ERI CAE	1	2	9	8	0.57	0.01	0.11	0.11		
ERI CAE	1	2	9	9	0.64	0.01	0.13	0.13		

Table 13. (Continued) PAM001; SAMPLED 8 August 1992, 30 August 1993; ELEVATION 1923 m; 50 m^2.

SPECIES	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOL l	TOT VOL l	AVG BIO g	TOT BIO Kg
ORY HYM	13	20±1	7±1	6±1	0.42±0.13	0.05	0.90±0.29	11.7	0.99±0.32	0.01
ORY HYM	13	18±1	7±1	5±1	0.33±0.10	0.04	0.65±0.21	8.43	0.71±0.23	0.01
SIT JUB	111	15±0	5±0	4±0	0.20±0.01	0.23	0.33±0.03	36.7	0.36±0.03	0.04
SIT JUB	79	11±1	5±0	4±0	0.20±0.02	0.16	0.21±0.03	16.2	0.26±0.03	0.02
STI COM	1	22	5	5	0.20	0.00	0.43	0.43		
STI COM	2	20±2	5±0	5±0	0.20±0.00	0.00	0.38±0.05	0.77		
STI SPE	12	21±2	9±2	4±0	0.28±0.07	0.03	0.76±0.24	9.17	0.84±0.26	0.01
STI SPE	2	17±8	3±0	3±0	0.05±0.02	0.00	0.07±0.01	0.14	0.07±0.01	0.00
DEADGRS	22	5±1	6±1	4±0	0.23±0.05	0.05	0.13±0.05	2.75		
DEADGRS	43	12±1	5±0	4±0	0.17±0.03	0.07	0.21±0.05	9.02		
DEADSHR	25	16±2	28±5	19±3	6.64±2.09	1.66	10.5±2.9	263		
DEADSHR	27	16±1	24±4	15±2	4.77±1.64	1.29	7.95±2.39	215		
TOTALS	484					20.8		7425		18.3
TOTALS	488					21.5		7118		17.5

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Table 14. RAM001; SAMPLED 28 July 1992, 5 August 1993; ELEVATION 2283 m; 50 m².

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOL	TOT VOL	AVG BIO	TOT BIO
			cm	cm	cm	dm²	m²	l	l	Kg
ARE CON	1	5	10	8	0.63	0.01	0.31	0.31	0.14	0.00
ARE CON	1									
ART NOV	12	12	20	17	2.67	0.03	3.20	3.20	8.01	0.01
ART NOV	14									
ART TRI	52	27±2	35±3	30±4	11.9±2.2	6.19	51±13	2649	92±24	4.77
ART TRI	57	26±2	41±4	30±3	13.5±2.2	6.76	56±14	2797	101±25	5.03
BUNCHGRASS	21	17±1	3±0	2±0	0.06±0.01	0.01	0.11±0.03	2.25	0.12±0.03	0.00
BUNCHGRASS	49	11±2	3±1	2±0	0.08±0.04	0.01	0.09±0.05	1.08	0.10±0.06	0.00

Table 14. (Continued) RAM001; SAMPLED 28 July 1992, 5 August 1993; ELEVATION 2283 m; 50 m^2.

Species	n	HT	MAXWID cm	PERWID cm	AVG COVER cm	TOT COV dm^2	AVG VOL m^2	TOT VOL l	AVG BIO l	TOT BIO Kg
COW MEX	12	78±7	136±15	107±15	131±30	15.7	1133±298	13599	2833±746	34.0
COW MEX	14	66±11	131±21	102±19	140±36	16.8	1152±323	13824	2880±808	34.6
ERI CAE						0				
ERI CAE	6	5±1	11±3	7±2	0.81±0.46	0.04	0.55±0.39	2.73		
ERI UMB	12	12±3	13±4	10±2	1.69±0.74	0.20	4.03±2.16	48.4	1.73±0.93	0.02
ERI UMB	13	14±3	12±3	7±1	0.79±0.24	0.06	1.10±0.33	8.83	0.47±0.14	0.00
FEN UTA	4	5±1	8±1	6±0	0.36±0.03	0.01	0.16±0.03	0.66		
FEN UTA	0									
HAP NAN	7	25±6	15±4	13±5	1.86±0.86	0.13	7.76±5.05	54	19.4±12.6	0.14
HAP NAN	10	17±6	18±6	11±4	3.33±2.60	0.33	18.4±17.2	184	46.0±43.1	0.46
LIN NUT	107	5±1	5±1	4±1	0.56±0.16	0.60	1.01±0.36	108	2.53±0.89	0.27
LIN NUT	146	8±1	8±1	6±1	1.01±0.24	0.93	1.94±0.57	178	4.85±1.42	0.44
OPU ERI	3	12±2	20±5	14±6	2.63±1.21	0.08	3.65±1.79	11.0		
OPU ERI	3	17	33	29	7.52	0.08	12.8	12.8		
ORY HYM	9	11±2	5±1	4±1	0.19±0.06	0.02	0.28±0.12	2.50	0.31±0.14	0.003

Table 14. (Continued) RAM001; SAMPLED 28 July 1992, 5 August 1993; ELEVATION 2283 m; 50 m^2.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOL	TOT VOL	AVG BIO	TOT BIO
			cm	cm	cm	dm^2	m^2	l	l	Kg
ORY HYM	5	5	1	1	0.01	0.0	0.00	0.00	0.00	0.00
PEN SPE	3	5±1	5±1	6±3	0.28±0.19	0.01	0.16±0.12	0.47	0.07±0.05	0.00
PEN SPE	5	10±3	9±1	6±1	0.48±0.12	0.02	0.53±0.23	2.63	0.23±0.10	0.00
PIN MON	9	76±33	70±28	60±26	77.1±38.1	6.94	1565±1040	14086		
PIN MON	16	49±21	47±20	39±17	51.1±27.0	7.67	1013±680	15195		
POA SAN	50	19±1	6±1	4±0	0.26±0.04	0.13	0.55±0.12	27.6	0.61±0.13	0.03
POA SAN	41	15±2	7±1	5±1	0.43±0.13	0.14	0.73±0.34	24.1	0.80±0.37	0.03
QUE GAM	7	24±4	22±4	21±3	4.05±1.14	0.28	11.38±3.83	79.6	28.4±9.6	0.20
QUE GAM	6	32±4	31±5	19±6	5.21±2.16	0.26	17.57±7.35	87.8	43.9±18.4	0.22
SIT JUB	5	26±2	8±3	4±1	0.44±0.29	0.02	1.13±0.68	5.67	1.25±0.75	0.006
SIT JUB	9	18±3	4±1	2±0	0.11±0.05	0.01	0.20±0.07	1.58	0.22±0.08	0.002
STI SPE	18	20±1	7±1	6±1	0.42±0.10	0.08	0.74±0.16	13.3	0.81±0.17	0.01
STI SPE	20	13±2	7±2	5±1	0.44±0.15	0.08	0.32±0.11	5.46	0.35±0.12	0.01
STR COR	16	20±4	5±1	4±0	0.15±0.04	0.02	0.41±0.16	6.63	0.18±0.07	0.00
STR COR	22	4±0	3±0	3±0	0.07±0.02	0.01	0.03±0.01	0.42	0.01±0.00	0.00
DEAD GRS	2	20±3	5±0	4±0	0.14±0.02	0.00	0.28±0.08	0.56		
DEAD GRS	16	7±1	7±1	5±0	0.29±0.04	0.04	0.23±0.06	3.40		

Table 15. YUF001; SAMPLED 6 July 1992, 29 July 1993; ELEVATION 1237 m; 100 m^2.

SPECIES	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOL l	TOT VOL l	AVG BIO g	TOT BIO Kg
ACA SHO	9	20±3	25±3	20±3	4.13±1.10	0.37	10.3±3.9	92.7	31.9±12.0	0.29
ACA SHO	10	25±3	32±5	28±5	8.68±3.02	0.87	30.4±15.3	304	94.3±47.6	0.94
ART SPI	2	14±1	14±3	14±3	1.57±0.70	0.03	2.26±1.14	4.53	9.28±4.68	0.02
ART SPI	16	8±1	7±2	5±1	0.52±0.20	0.08	0.62±0.27	9.89	2.53±1.09	0.04
ATR CAN	32	50±2	52±3	46±3	21.0±2.5	6.73	119±19	3802	309±48	9.89
ATR CAN	34	52±3	61±5	50±4	29.1±4.1	9.88	183±32	6232	477±83	16.2
BUNCHGRASS	1	14	1	1	0.01	0.00	0.01	0.01	0.01	0.00
BUNCHGRASS	0									
CER LAN	35	37±2	26±2	19±2	4.82±0.76	1.69	22.3±4.52	780	71.3±14.5	2.50
CER LAN	36	39±2	33±2	25±2	7.06±0.79	2.54	31.1±4.4	1119	99.5±14.0	3.58
EPH NEV	18	39±5	60±10	50±9	34.4±9.8	6.19	200±66	3599	280±92	5.04
EPH NEV	18	42±5	78±13	58±9	49.0±12.8	8.83	306±96	5513	429±134	7.72
ERI PUL	28	1±0	4±1	2±0	0.12±0.07	0.03	0.07±0.06	1.85	0.07±0.07	0.00
ERI PUL	3	1±0	2±0	2±0	0.03±0.00	0.00	0.00±0.00	0.01	0.00±0	0.00
GRA SPI	35	51±1	45±2	38±2	14.2±1.2	4.97	74.6±7.4	2612	172±17	6.01
GRA SPI	38	50±2	49±3	38±3	17.3±2.0	6.57	96.0±13.4	3648	221±31	8.39

Table 15. (Continued) YUF001; SAMPLED 6 July 1992, 29 July 1993; ELEVATION 1237 m; 100 m^2.

SPECIES	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOL l	TOT VOL l	AVG BIO g	TOT BIO Kg
HYM SAL	5	34±7	41±8	30±7	11.3±4.5	0.57	47.7±25.1	238	153±80	0.76
HYM SAL	4	41±4	51±8	40±9	17.4±5.3	0.70	73.2±24.3	293	234±78	0.94
LYC AND	13	44±4	46±8	27±3	11.1±2.6	1.45	52.1±12.9	677	115±28	1.49
LYC AND	19	41±3	52±6	38±4	18.9±3.66	3.60	88.0±19.0	1672	194±42	3.68
MEN SPI	0									
MEN SPI	1	10	19	17	2.54	0.03	2.54	2.54	21.1	0.02
MIR PUD	11	22±3	22±3	17±3	3.49±0.75	0.38	8.07±1.72	88.8	3.47±0.74	
MIR PUD	11	21±3	32±5	21±3	6.35±1.33	0.70	16.6±4.67	182	7.13±2.01	
ORY HYM	4	31±11	4±2	3±2	0.15±0.12	0.01	0.76±0.67	3.06	0.84±0.73	0.00
ORY HYM	8	10±2	4±2	3±1	0.22±0.15	0.02	0.40±0.32	3.16	0.43±0.35	0.00
SIT JUB	4	20±2	2±1	2±1	0.05±0.02	0.00	0.09±0.04	0.36	0.10±0.05	0.00
SIT JUB	4	20±1	3±1	3±1	0.10±0.04	0.00	0.18±0.07	0.71	0.20±0.08	0.00
SPH AMB	60	4±0	4±0	3±0	0.19±0.06	0.11	0.19±0.12	11.4	0.08±0.05	0.00
SPH AMB	41	11±1	7±1	4±1	0.53±0.25	0.22	1.58±0.96	64.8	0.68±0.41	0.03
STI SPE	3	28±3	4±1	3±1	0.09±0.04	0.00	0.29±0.15	0.87	0.32±0.17	0.00
STI SPE	2	22±11	9±4	8±2	0.61±0.41	0.01	1.78±1.59	3.57	1.96±1.75	0.00
TET AXI	0									
TET AXI	1	72	55	41	17.7	0.18	128	128	344	0.34
DEADGRS	33	10±1	6±1	5±0	0.28±0.05	0.09	0.40±0.11	13.09		
DEADGRS	18	11±2	10±2	9±1	1.00±0.31	0.18	1.80±0.77	32.4		

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Table 15. (Continued) YUF001; SAMPLED 6 July 1992, 29 July 1993; ELEVATION 1237 m; 100 m^2.

Table 16. YUF002B; SAMPLED 16 July 1990, 16 August 1993; ELEVATION 1288m; 220 m^2.

SPECIES	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOL l	TOT VOL l	AVG BIO g	TOT BIO Kg
EPH NEV	5	31±7	51±11	39±9	18±6	0.92	71±24	356	100±34	0.50
EPH NEV	5	62±10	95±18	81±19	71±23	3.54	521±194	2605	730±271	3.65
ERI COO	2	7±0	6±0	6±2	0.26±0.07	0.01	0.18±0.05	0.4	0.5±0.1	0.00
ERI COO	2	32±11	30±2	26±0	6.3±0.4	0.13	21±8	41	52±21	0.10
GRA SPI	1	56	45	28	9.9	0.10	55	55	127	0.13
GRA SPI	1	63	57	60	27	0.27	169	169	389	0.39
HYM SAL	2	26±6	26±2	20±2	4±0	0.08	10±2	21	33±8	0.07
HYM SAL	4	52±6	89±22	77±20	66±25	2.55	351±155	1406	1125±497	4.50
LYC AND	29	15±2	22±4	14±2	3.2±0.8	0.83	6.3±1.6	165	14±3	0.36
LYC AND	32	22±1	36±3	27±2	8.9±1.5	2.86	23±5	747	51±11	1.64
ORY HYM	0									
ORY HYM	1	31	11	10	0.86	0.01	2.7	2.7	2.9	0.00
STI SPE	92	7±0	6±1	5±0	0.42±0.07	0.39	0.5±0.1	46	0.6±0.1	0.05
STI SPE	58	17±1	8±1	6.1±0.6	0.6±0.1	0.33	1.3±0.3	75	1.4±0.3	0.08
YUC BRE	1	66	43	39	13.1	0.13	87	87		
YUC BRE	1	89	42	38	12.5	0.13	112	112		

Table 16. (Continued) YUF002B; SAMPLED 16 July 1990, 16 August 1993; ELEVATION 1288m; 220 m^2.										
SPECIES	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm^2	TOT COV m^2	AVG VOL l	TOT VOL l	AVG BIO g	TOT BIO Kg
DEAD GRS	101	6±1	7±1	6±0	0.48±0.07	0.49	0.4±0.1	44		
DEAD GRS	35	4±1	11±1	9±1	0.9±0.2	0.33	0.5±0.1	16		
DEAD SHR	138	15±2	23±2	15±1	5±1	7.28	19±4	2639		
DEAD SHR	87	15±2	29±4	18±2	8±2	6.79	27±9	2359		
TOTALS	131					2.45		730		1.11
TOTALS	103					9.81		5158		10.37

Table 17. YUF002C; SAMPLED 16 July 1990, 16 August 1993; ELEVATION 1288 m; 180 m².

SPECIES	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm²	TOT COV m²	AVG VOL l	TOT VOL l	AVG BIO g	TOT BIO Kg
AMB x HYM	1	8	4	3	0.09	0.00	0.08	0.08	0.19	0.00
AMB x HYM	1	25	21	18	3.0	0.03	7.4	7.4	19	0.019
CER LAN	2									
CER LAN	0									
COL RAM	7	55±10	62±14	60±17	39±12	2.70	273±97	1908	1417±504	9.92
COL RAM	8	62±9	71±11	55±12	37±11	2.97	285±111	2283	1484±576	11.87
EPH NEV	13	48±6	72±11	64±11	46±12	6.02	299±89	3893	419±125	5.45
EPH NEV	14	52±6	79±12	74±13	60±16	8.44	435±141	6089	609±197	8.52
ERI COO	6	22±8	22±8	19±8	6±3	0.35	25±17	149	62±43	0.37
ERI COO	6	28±4	46±11	44±12	21±11	1.26	75±44	452	188±111	1.13
GRA SPI	14	61±6	63±9	52±9	33±9	4.27	258±86	3348	592±199	7.70
GRA SPI	10	66±6	82±8	65±7	45±8	4.48	322±66	3215	739±153	7.39
HYM SAL	8	28±9	20±11	23±13	10±9	0.72	67±60	466	213±192	1.49
HYM SAL	11	59±4	83±7	66±7	47±10	5.21	314±88	3451	1004±280	11.04
LYC AND	21	45±4	74±10	60±10	49±12	9.81	287±78	5746	632±171	12.64
LYC AND	26	37±3	66±7	48±6	33±7	8.48	160±46	4166	353±102	9.17

Table 17. (Continued) YUF002C; SAMPLED 16 July 1990, 16 August 1993; ELEVATION 1288 m; 180 m².										
SPECIES	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm²	TOT COV m²	AVG VOL l	TOT VOL l	AVG BIO g	TOT BIO Kg
ORY HYM	1	11	13	11	1.1	0.01	1.2	1.2	1.4	0.00
ORY HYM	4	18±4	3±1	2±0	0.05±0.01	0.00	0.09±0.03	0.36	0.10±0.03	0.00
STI SPE	20	13±1	9±1	8±1	0.8±0.2	0.15	1.1±0.3	22	1.2±0.3	0.02
STI SPE	18	18±1	8±2	6±1	0.6±0.2	0.11	1.3±0.6	24	1.5±0.6	0.03
DEAD GRS	79	30±1	11±1	9±1	0.9±0.1	0.73	3.4±0.5	258		
DEAD GRS	59	16±1	13±1	10.5±0.7	1.3±0.1	0.74	2.3±0.3	136		
DEAD SHR	88	31±2	46±3	37±3	20±32	17.69	97±15	8531		
DEAD SHR	57	32±3	53±5	42±4	25±4	14.40	117±21	6664		
TOTALS	93					24.03		15534		37.60
TOTALS	98					30.99		19777		49.17

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