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STATUS OF THE FLORA AND FAUNA ON THE NEVADA TEST SITE, 1989-91

**Results of Continuing Basic Environmental Monitoring
January through December 1989-1991**

**Compiled By
Richard B. Hunter**

March 1994

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**Prepared by
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TABLE OF CONTENTS

<u>Section</u>	<u>Chapter And Page</u>
EXECUTIVE SUMMARY	VII
TRENDS IN REPTILE POPULATIONS ON THE NEVADA TEST SITE	1
ACKNOWLEDGEMENTS	2
ABSTRACT	3
INTRODUCTION	4
METHODS	5
Sampling Locations And Dates	5
Reptile Sampling Techniques	8
Adult Uta	8
Hatchling Uta	9
Line Transect Monitoring	9
Desert tortoise Monitoring	10
RESULTS	10
Uta Populations, Baseline Plots	10
Yucca Flats	10
Pahute Mesa	11
Jackass Flats	12
Frenchman Flat	13
Uta Populations, Disturbance Plots	14
Subsidence Crater	14
Burned Study Area (Yucca Flat)	18
Tower (T) Blast Sites	20
Roadside Plots	23
Bladed dump	24
Gopher Plot	24
Sedan Plots	25
Other Species, Transect Results	26
Desert Tortoise	31
DISCUSSION	40
Effects Of Disturbance	40
Effects Of Drought	42
METHODS	45
REFERENCES	47
APPENDIX - A	A-1
APPENDIX - B	B-1
APPENDIX - C	C-1
APPENDIX - D	D-1
APPENDIX - C	E-1
APPENDIX - D	D-1

Section**Chapter And Page**

APPENDIX - E	E-1
APPENDIX - F	F-1
TRENDS IN SMALL MAMMAL POPULATIONS ON THE NEVADA TEST SITE	50
ACKNOWLEDGEMENTS	51
ABSTRACT	52
INTRODUCTION	53
BECAMP STUDY SITES	54
METHODS	57
Small Mammal Sampling Techniques	57
Baseline Monitoring Sites	57
Disturbed Sites	57
Density Estimation	58
Lagomorph Census - Transect Lines	59
RESULTS	60
Baseline Monitoring Sites	60
Yucca Flat - YUF001	60
Jackass Flats - JAF001	65
Frenchman Flat - FRF001	67
Pahute Mesa - PAM001	69
Disturbed Areas	71
Subsidence Craters	71
T-Sites	76
T1	76
T4	79
T2	80
T3	84
Sedan	86
Bladed Areas	95
Mid Valley and Pahute Mesa	95
Revegetation Site - YUF011	98
Alpha-Contaminated Area - GMX	100
Rock Valley - ROV007 and ROV008	103
Burned Areas	109
Redrock Valley	109
Yucca Flat	114
Mid Valley	117
Gopher Denuded Area - Mercury Valley	120
Roadside Study	122
Rabbit And Hare Surveys	129
DISCUSSION: TRENDS IN SMALL MAMMAL POPULATIONS IN YUCCA FLAT	131
CONCLUSIONS	133

Section**Chapter And Page**

REFERENCES	136
APPENDIX G	G-1
FERAL HORSE MONITORING AT THE NEVADA TEST SITE FROM 1989-91	141
ACKNOWLEDGEMENTS	142
ABSTRACT	143
INTRODUCTION	144
METHODS	144
RESULTS AND DISCUSSION	145
REFERENCES	169
TRENDS IN WILDLIFE UTILIZATION OF WATER SOURCES AND ADJACENT HABITATS AT THE NEVADA TEST SITE 1989-91	170
ACKNOWLEDGEMENTS	171
ABSTRACT	172
INTRODUCTION	173
METHODS	173
RESULTS AND DISCUSSION	179
Springs and Well Reservoirs	179
Migratory Birds	187
Passerine Species	203
Common Raven Census	205
Raptor Observations	208
Revision Of The NTS Bird Species List	217
Resident Bird Communities On The NTS	218
Mule Deer Utilization	219
Mountain Lion And Bobcat Records	226
Wildlife Report Card Summary	229
REFERENCES	233
Appendix - H	H-1
TRENDS IN PERENNIAL PLANT POPULATIONS ON THE NEVADA TEST SITE 1989-1991	236
ACKNOWLEDGEMENTS	237
ABSTRACT	238
INTRODUCTION	240
STUDY SITES	241
METHODS	243
TRANSECT STUDY METHODS	243
Location	243
Species	247
Size Measurements	247
Numbers of Plants	248
Crowns	249

<u>Section</u>	<u>Chapter And Page</u>
Dead	249
Reproductive States	249
Grazing Damage	250
Sources of Error	250
Individuals Study Methods	253
Taxonomic Methods	253
Soil Moisture Methods	253
Analytical Methods	253
RESULTS	254
Precipitation	254
Soil Moisture	254
Baseline Plot Transects	257
Jackass Flats	257
Frenchman Flat	258
Yucca Flat	260
Pahute Mesa	263
DISTURBED AREAS	266
Ground Zeroes	266
T1 Ground Zero	266
T3	269
T2 and T4	270
Sedan	271
Subsidence Craters	274
Burned Areas	277
Beatley 41, 42 - Mid Valley	278
Mid Valley - 1986 Fire	280
Yucca Flat - 1985 Fire	283
Red Rock Valley - 1988 Fire	284
Drill Pads	285
Drill Pad U20ao	286
Drill Pad U19ac	286
Scraped Areas	287
3B Consolidation Site	287
Mid Valley Bladed Area	289
Roadsides	290
Abandoned Roadside - 5-03	290
Active Roadside - 5-05 Road	291
Radiation Exclusion Area - GMX	296
Gopher-Denuded Areas	297
Mercury	297
HISTORICAL PLOTS	299

SectionChapter And Page

Beatley Plots	299
LGF Plots	304
Individuals	305
<i>Yucca brevifolia</i>	305
<i>Juniperus osteosperma</i>	307
<i>Pinus monophylla</i>	307
<i>Yucca schidigera</i>	309
DISCUSSION	309
Radioactive Contamination	309
Ground Zeroes And Scraped Areas	310
Burned Areas	313
Subsidence Craters	314
Roadsides	317
Revegetated Sites	319
Drought	320
The Future	325
REFERENCES	327
APPENDIX I	I-1
APPENDIX J	J-1
TRENDS IN EPHEMERAL PLANT POPULATIONS ON THE NEVADA TEST SITE, 1989-1991	334
ACKNOWLEDGEMENTS	335
ABSTRACT	336
INTRODUCTION	337
METHODS:	339
RESULTS	341
Soil Moisture	341
1989	344
1990	345
1991	347
Species Distributions	349
DISCUSSION	358
INTRODUCED SPECIES	358
Brome Grasses	358
Other Introduced Species	361
DISTURBANCE	364
Productivity	364
Species Distribution	365
MISCELLANEOUS INFLUENCES	368
Drought	369
Nitrogen	378

Section

Chapter And Page

Interactions With Shrubs	370
Interactions With Animals	371
Fire Frequency	372
REFERENCES	374
APPENDIX - K	K-1

EXECUTIVE SUMMARY

These volumes include six reports of monitoring work to determine the status of and trends in flora and fauna populations on the Nevada Test Site (NTS) from 1989 through 1991. The Nevada Operations Office of the U. S. Department of Energy supported monitoring under its Basic Environmental Compliance and Monitoring Program (BECAMP) since 1987. Under this program several undisturbed "baseline" plots, and numerous plots in disturbed areas, are sampled on annual or three-year cycles. Perennial plant populations, ephemeral plants, small mammals, reptiles, birds, and large mammals were monitored.

Monitoring results are reported for five baseline sites, one from each major landform on the NTS (Jackass Flats, Frenchman Flat, Yucca Flat, Pahute Mesa, and Rainier Mesa), and for areas cleared of vegetation by fires, atmospheric nuclear weapons tests, construction, and gophers. Roadside flora and fauna were studied at two locations, and several historical study plots around the NTS were recensused to determine vegetation changes over long time spans. Three subsidence craters resulting from below-ground nuclear weapons tests were also studied. A major influence on plants and animals during the report period was a severe drought during 1989 and 1990, followed by more moderate drought in 1991.

Vegetation was severely impacted by drought from 1989 through 1991. In a few areas nearly all perennial plants died, and in most lower-elevation sites shrubs were dormant, died back, or died altogether during 1989 and 1990. Dominant, drought hardy, long-lived species fared best, while herbaceous, short-lived perennials largely died out at lower elevations. Older (i.e. larger) dominants died back, but generally survived at reduced sizes. Many or most smaller and non-dominant species declined significantly in numbers, and sizes decreased sharply among survivors. Several small rainshowers in 1991 allowed minimal regrowth of surviving plants. At elevations above about 1400 meters (4500 feet) death of shrubs was less common, and drought resulted primarily in reduced growth and failure to flower and fruit.

Ephemeral plants are most common in the lower, desert areas of the NTS, where they germinate in fall, winter, or early spring, depending on rainfall. In 1989 germination of ephemeral plants occurred only at high elevations, above about 1900 meters (6200 feet). Sparse germination occurred in 1990 at some lower elevations, generally only in disturbed areas. In 1991 germination was late (early March) and sparse, but subsequent growth was good, and most plants

successfully reproduced. Ephemeral populations continued to be dominated by introduced species, primarily the annual grasses *Bromus rubens* (red brome) and *Bromus tectorum* (cheatgrass), and *Salsola australis* (Russian thistle). The latter was restricted to disturbed areas.

Small mammals such as granivorous rodents and mice inhabit essentially the whole of the NTS. During the report period both numbers and species present declined on most study sites. Merriams kangaroo rat (*Dipodomys merriami*) and the little pocket mouse (*Perognathus longimembris*) declined during 1989 and 1990, but rebounded to their 1987-88 population levels in 1991. Several other species nearly disappeared during the drought, and did not recover significantly during the study period. Small mammal diversity thus decreased significantly. Diversity was also reduced on areas cleared of vegetation, whether by fire, blast, or construction work. Roadside animals reproduced more than those living far from roads, indicating the roadside acted as a refuge from drought.

Populations of the side-blotch lizard (*Uta stansburiana*) were reduced by drought, largely through failure of this species to reproduce. Population densities fell about 50%, but the decline was tempered by improved survival of adult lizards. This species was not able to colonize cleared areas, an effect which was attributed to absence of protective cover. Predation by birds and other lizards was postulated to limit *Uta* densities on disturbed areas.

A fenced desert tortoise population studied since 1963 was censused throughout the drought. In spite of absence of ephemeral plants, all 17 known tortoises survived the drought, though growth was minimal or absent, and dehydration was occasionally severe. None of these tortoises, or the 75 free-roaming tortoises marked on the NTS since 1987, showed signs of upper respiratory disease.

Numbers of feral horses on the NTS ranged from 57 to 59 adults, plus variable numbers of foals and yearlings. These animals ranged over the north-central portions of the NTS, and depended in summer on one spring and some man-made water sources. Adults had good survival, but foaling rates were low, and foal survival was low. Predation by mountain lions was postulated to be limiting foal survival. Despite presence of large horse herds just north of the NTS, no new adult horses were seen during the study, indicating the NTS herds are an isolated population.

Mule deer used twenty water sources, the majority at higher elevations. Their distribution was probably limited by cover provided by pinon-juniper woods. Sighting rates of deer during spotlight surveys on Pahute and Rainier Mesas declined about 50% during the study period, suggesting a significant decline in population during drought.

Bird monitoring began in 1988. Numbers of quail and doves sighted at water sources appeared to decrease from 1988 to 1990, then increased in 1991. Of 222 species reported on the NTS, 144 were seen in 1989 - 1991. One raptor, Swainson's hawk, was conspicuous by its absence. Swainson's hawk was once common on the NTS, but has recently declined throughout the region.

TRENDS IN REPTILE POPULATIONS ON THE NEVADA TEST SITE

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Monitoring an area the size of the Nevada Test Site is necessarily a group effort, with many facets. For this effort, we are grateful for the continuing funding of the Department of Energy, which supported this work through the Nevada Operations Office's Basic Environmental Compliance and Monitoring Program. Work was done under State of Nevada scientific collection permits S10630 (1988-1989), S1598 (1989-90), S3048 (1990-91) and S5017 (1991-2) and U. S. Fish and Wildlife permit PRT-744522 (1990-94). The program management, data collection, analysis, proofing, and manuscript preparation were all group efforts, accomplished with the help of the following: F. Au, K. Bowdridge, C. Corlett, C. Dull, B. Edwards, R. Emanuel, E. Essington, A. Giannotti, R. Gilbert, J. Grace, N. Gray, P. Greger, O. Haworth, C. Herr, P. Jarry, R. Kessler, R. Kinnison, N. Lee, D. Lopez, M. Lynch, E. M. Romney, C. Maguire, R. McArthur, C. Norelli, D. Norman, L. Richardson, M. Russell, M. Schierman, L. Sygitowicz, D. Tippie, and T. Webb. We are grateful for the help of all those involved.

ABSTRACT

During the period 1989 through 1991, reptile populations were monitored on the Nevada Test Site (NTS). The nearly ubiquitous lizard *Uta stansburiana* was monitored with mark-recapture techniques on an NTS-wide set of permanent plots, established in both disturbed areas and nearby undisturbed areas. Other species of lizards were monitored on a selected portion of these plots with transect techniques. A long-term study of fenced desert tortoises in Rock Valley was continued, and free-roaming tortoises were marked and measured whenever encountered.

On the areas studied, there were two prime factors affecting lizard populations. On areas cleared of vegetation by any agent (fire, weapons tests, scraping, gophers) the population of *Uta stansburiana* declined severely or disappeared altogether. Reinvasion by hatchlings and adults occurred, but summer predation rates in the absence of cover appeared to prevent successful recolonization. Transect studies suggested the decline did not occur in other common species, most of which are predators of *Uta*.

Drought was the second major influence on lizard populations. Severe drought was coincidental with a marked decline in reproduction in 1989, followed in 1990 by an overall decline in populations to about half of 1987-88 levels. The decline in overall numbers, which occurred in all species, was tempered by improved survival of lizards hatched before the drought began.

All 17 desert tortoises (*Gopherus agassizii*) in the Rock Valley enclosures survived the drought, although annual plants were absent for two years. Growth was minimal in 1989 and 1990, the most severe drought years. None showed any symptoms of upper respiratory tract disease. By the end of 1991, 75 free-roaming tortoises were marked and measured. These also appeared to be disease-free.

INTRODUCTION

Numerous studies of reptiles have been performed on the NTS, the first published work being that of Tanner and Jorgensen (1963). Studies have been primarily focussed on radiation effects (e.g., Turner and Medica 1977; Turner et al. 1969a, 1969b; Turner et al. 1973) and populations inhabiting radioactively contaminated areas (e.g., Bradley and Moor 1975, 1976). The growth and survival in an enclosed population of tortoises in Rock Valley has been studied since 1963 (Turner et al. 1987; Germano 1988). A summary of this history is reported in Hunter and Medica (1989).

Reptile studies under the Basic Environmental Compliance and Monitoring Program (BECAMP) were initiated in 1987 in response to the National Environmental Protection Act (NEPA). Goals are to measure and record effects of Department of Energy (DOE) activities upon native species of reptile populations and to determine the distributions and changes in time of the populations of the common lizards on the NTS. The program was designed to make repeated measurements, at identified sites, in order to detect changes in these populations.

The BECAMP reptile sampling project includes quantitative surveys of natural populations of the nearly ubiquitous lizard *Uta stansburiana* on essentially undisturbed "baseline" study plots in Yucca Flat, Jackass Flats, Frenchman Flat, and Pahute Mesa. It also includes sampling on some representative disturbed areas, and on undisturbed adjacent areas. The data collected on the density of this species provide information on the stability of the populations over time, and on the success of reproduction and health status of individuals. Relative densities of other lizard species are assessed with line transect techniques.

Each year the baseline plot in Yucca Flat was sampled in spring and summer, and the Pahute Mesa baseline plot was sampled each summer. In 1989, *Uta* sampling also occurred in Yucca Flat within three subsidence craters. In 1990, *Uta* sampling occurred on four disturbed plots. One was in an area burned by a lightning-caused fire. Two were in 1950's nuclear blast areas (ground zeroes - GZ's) in Yucca Flat (T2 and T4), created by above-ground nuclear detonations. The fourth was in an area in Frenchman Flat adjacent to a moderately traveled paved road. This last plot was sampled to determine if roadside effects on plants and animal populations could be quantified. In 1991, *Uta* populations were sampled at six disturbed locations. One plot was

in an area of Mercury Valley which had been denuded by gophers, two were at old GZ locations in Yucca Flat (T1 and T3), and one was adjacent to a cleared waste dump (3B). Undisturbed plots were located adjacent to each disturbed area, except for the roadside plot. Its control was approximately 0.5 km to the north, which was halfway between the two closest paved roads. There were also three plots at varying distances (457 m, 1067 m, and 1601 m) northeast of the Sedan excavation test. The farthest plot was in undisturbed vegetation, whereas the two closer plots were covered by throwout from the crater of approximately 365 cm deep (457 m) and less than or equal to 30 cm (1067 m) (Martin 1962; Turner 1963).

Other lizard species were sampled between 1989 and 1991 by walking transects on four baseline study plots (Yucca Flat, Frenchman Flat, Jackass Flats, and Pahute Mesa), in three blast areas in Yucca Flat (T1, T2, and T4), and in one burned area. Transects were continued into undisturbed plots marked near each of the disturbed sites, for comparison.

In 1963, the University of California, Los Angeles, Laboratory of Biomedical and Environmental Sciences (then the Laboratory of Nuclear Medicine and Radiation Biology) initiated a growth and survivorship study on the desert tortoise (*Gopherus agassizii*) in Rock Valley. Attempts were made to capture the tortoises in the spring and fall of every year since the study began (Medica et al. 1975, Turner et al. 1987). These semiannual captures were continued under the BECAMP monitoring program, except for the fall of 1989. That year the tortoise was listed as "endangered" under the 1973 Endangered Species Act, and REECO did not receive a permit to handle these tortoises until March 1990. In addition to the continuation of this study, free-ranging tortoises throughout NTS were marked, measured, and released. After the tortoise was listed as endangered (later threatened), this activity was limited to chance encounters with free-roaming tortoises, due to the fact that endangered species are handled by another contractor.

METHODS

SAMPLING LOCATIONS AND DATES

From 1989 through 1991, a total of 28 plots were sampled for *Uta* populations, including the undisturbed control plots (Table 1). One plot (YUF001) was

Table 1. BECAMP plots on which lizards were sampled between 1989 and 1991, and the years when each has been sampled.

<u>Plot (control plot)</u>	<u>Years Sampled</u>
<u>Baseline</u>	
FRF001	1987, 1988, 1991
JAF001	1987, 1988, 1990
YUF001	1987, 1988, 1989, 1990, 1991
PAM001	1988, 1989, 1990, 1991
<u>Disturbance</u>	
FRF003 (FRF004)	1990
MER002 (MER003)	1991
YUF002 (YUF003)	1987, 1988, 1990
YUF009 (YUF010)	1988, 1991
YUF011 (YUF012)	1988, 1991
YUF013 (YUF012)	1988, 1991
YUF014 (YUF015)	1990
YUF016 (YUF018)	1991
YUF017 (YUF018)	1991
YUF019 (YUF020)	1989
YUF021 (YUF022)	1989
YUF023 (YUF024)	1989
YUF025 (YUF026)	1990

sampled annually, both spring and summer, and one (PAM001) was sampled each summer. All others were sampled on a three year rotating schedule, therefore only once between 1989 and 1991.

Throughout this report, plots are designated with three letter codes designating the valley or landform, combined with a three number code designating the order in which they were installed. Appendix A lists the plot designations, the latitude and longitude, and the elevation for each plot sampled between 1987 and 1991.

In 1989, six new 75 m x 75 m (0.56 ha) *Uta* plots were established in Yucca Flat. The *Uta* plots are located within mammal trapping grids, whose dimensions are 105 m x 105 m (1.1 ha). Three of the 0.56 ha plots are located at the bottom of subsidence craters. (Subsidence craters result from the ground subsiding after an underground nuclear detonation.) These craters range in age from 11 to 26 years. An undisturbed plot was also selected next

to each of the craters, in vegetation with no obvious man-caused disturbance and thought to be long-established. Spring *Uta* populations on these plots were sampled between late March and the end of April, and summer sampling occurred between late July and early September. Appendix B lists the exact sampling dates of the BECAMP lizard density plots in 1989.

In 1990, six new plots were established and two were resampled. Two 0.56 ha plots were established within blast areas: one southeast of T2 GZ, and the other southwest of T4 GZ. Two plots were established near the blast areas in undisturbed habitat. Two elongated plots (0.5 ha) were established in Frenchman Flat, one adjacent to the 5-05 Road (FRF003), and its control (FRF004) located 0.5 km to the north, in undisturbed vegetation. Two plots in Yucca Flat (YUF002 and YUF003) which had been sampled in 1987 and 1988 were sampled again in 1990. YUF002 was in an area which had been burned by a lightning-caused fire in June 1985, and YUF003 was the nearby undisturbed plot. Appendix C lists the exact dates that the BECAMP lizard density plots were sampled for *Uta* in 1990.

In 1991, six previously established disturbed plots (0.56 ha each) were resampled. Five of the plots were in Yucca Flat. Two are located near old blast areas, one southeast of T3 GZ (YUF013), and the other southeast of T1 GZ (YUF009). Their control plots are located in nearby undisturbed areas. One plot (YUF011) is a bladed (bare) area near T3. This site was a contaminated waste dump which was cleared in 1987-88 and revegetated by UCLA personnel in the summer of 1989. Two plots located northeast of the Sedan GZ at 457 m (YUF016) and 1067 m (YUF017), where mammals were sampled in 1988, were also sampled for lizards in 1991. Plots YUF016 and YUF017 are located in areas disturbed by overburden, which was thrown out when the crater was formed. YUF018 (1601 m NE of GZ) is located in an area of natural vegetation dominated by *Coleogyne ramosissima* at the edge of the Sedan blast area. The final disturbance plot for 1991 is located in Mercury Valley. Plot MER002 is in an area which has been denuded by gophers (*Thomomys umbrinus*) and other rodents (Hunter et al. 1980). The site has little shrub vegetation, but maintains a population of a herbaceous, grazing, resistant shrub, *Stanleya pinnata*. The undisturbed plot (MER003) is located to the northwest of MER002 in a mature stand of *Larrea tridentata*. Appendix D lists the dates on which *Uta* sampling occurred on the BECAMP lizard density plots in 1991.

The relative abundances of lizards other than *Uta stansburiana* were determined by walking 500-m transect lines on the baseline plots between 1989 and 1991.

The Yucca Flat baseline plot (YUF001) was sampled in all three years, the Jackass Flats plot (JAF001) was sampled in 1990, and the Frenchman Flat (FRF001) and Pahute Mesa (PAM001) plots were sampled in 1991. In addition, two blast areas in Yucca Flat and their controls and one burned area and its control were sampled in 1990. In 1991, the T1 blast area (YUF009) and its control (YUF010) were sampled. The specific plots and dates that were sampled with transect observations are in Appendix E.

Marked free-ranging tortoises were searched for in the spring of 1989, in the areas of Frenchman Flat, that had been sampled in 1987-1988. The areas searched included washes, caliche overhangs, and certain dirt roads where desert tortoises had been observed previously. In 1990 and 1991, this effort was reduced to chance encounters of animals during other work, which largely restricted captures to paved roadsides. Rock Valley tortoises were recaptured and measured spring and fall of each year except for fall of 1989.

REPTILE SAMPLING TECHNIQUES

Adult *Uta*

Uta stansburiana population densities were measured in the spring (usually March/April) of each year. Plots were sampled during the lizard's early morning activity period for at least 5 days (consecutive when possible). Three or four people sampled the 1.1 ha baseline plot, and 2 people sampled each 0.56 ha disturbed plots, with the disturbed and undisturbed plots sampled simultaneously. All captured *Uta* were toe clipped with a unique number so individuals could be permanently identified, and were painted with a unique paint pattern for short-term identification. *Uta* weights (to the nearest 0.05 g) and snout-vent lengths (in mm) were recorded and the lizards were released at the site of capture. Details of the techniques used and sample data sheets appear in Medica (1992) and Hunter and Medica (1989) and are exhaustively detailed in the REEC Co Lizard Study Procedure No. AABAF.D.05.00, dated 8-28-91.

Density estimates were normally calculated following Seber (1982) from data recorded on the final day of sampling, when the number of recaptures should be sufficient for a valid estimate. Density estimates based on fewer than 7 captures are questionable. They have been calculated for convenience, but are marked with asterisks. Standard errors are hypothetical, and are zero when either all animals are captured on the last day, or when only previously captured animals are captured the last day. Estimates of adult *Uta*

survivorship to the end of the reproductive season were based upon those marked individuals which were recaptured in July/August.

Hatchling *Uta*

Juvenile *Uta* were marked and released in the summer. In normal years, hatchlings first appear in mid-June at lower elevations (Medica and Turner 1976) and in mid-July at higher elevations (Tanner and Hopkin 1972). Sampling for hatchlings began in July at lower elevations and was completed by early September at higher elevations. The sampling techniques and density calculations for hatchlings were identical to those for adults.

Line Transect Monitoring

Line transects were used to inventory populations of *Cnemidophorus tigris*, *Callisaurus draconoides*, *Phrynosoma platyrhinos*, and *Gambelia wislizenii*. Permanent transect lines on baseline study plots are 500 m long and are spaced 100 m apart. There are 5 transects per plot. The transects are surveyed for 5 days, by 3 individuals walking approximately 7.5 m apart. On the disturbed plots the number of lines was reduced to 4 and the length of the lines varied depending upon the habitat. On the burned area in Yucca Flat (YUF002), lines range from 325-425 m. Lines are 400 m on both T-2 and T-4 blast areas, and 500 m on the T-1 blast area. Similar transects were set up on the associated undisturbed plots. In most instances, a 100 m ecotone, between what was considered blast area and control vegetation, was recorded separately. The only exception was T-2, which has three 100 m and one 180 m ecotone lines due to the broader gradation of the vegetation southeast from GZ. In each instance, the lines were still at least 100 m apart and sampling was accomplished using three individuals walking 7.5 m apart. In order to make the data comparable, all values are expressed in mean number of lizards seen per ha, calculated as total numbers of lizards seen divided by total area searched. The area searched was estimated by assuming lizards are visible within 3.75 m to each side of each observer.

Lizard transect sampling normally began when soil surface temperatures averaged approximately 35°C and continued until lizard activity ceased. One pass of the entire plot usually was completed prior to cessation of lizard activity, which normally occurs when soil temperatures approach 50°C (Medica 1967).

Desert Tortoise Monitoring

Seventeen desert tortoises residing within the three fenced Rock Valley enclosures were recaptured in the spring of 1989. They were weighed, measured, and their health was evaluated, using a standard data sheet (Appendix F). Because of the emergency listing of the desert tortoise as "endangered" in August 1989, the Rock Valley tortoises could not be recaptured in the fall of that year, as there was no provision made to issue scientific collection permits to those researchers that had ongoing studies. The necessary federal permit was obtained by the spring of 1990, and the Rock Valley tortoises were recaptured in the spring and fall of 1990 and 1991, thereby maintaining 28 years of growth and survivorship records on these marked, known-age animals. A summary of the Rock Valley work appears in Gibson (in preparation).

Because of the threat of the spread of an upper respiratory tract disease, special handling procedures were implemented. These included wearing latex gloves and disinfecting equipment with bleach after handling each tortoise. The three fenced plots in Rock Valley were treated as separate populations and care was taken to wear different shoes or disposable shoe covers when visiting more than one plot. Lath stakes used to 'tap' burrows were not used in more than one plot.

RESULTS

UTA POPULATIONS, BASELINE PLOTS

Yucca Flat

The adult *Uta* density on the Yucca Flat baseline plot (YUF001) declined in 1989 and 1990 to nearly half of what it was in 1988 (Table 2). Declines in adult densities from spring to summer (Tables 2 and 3) reflect that adult survivorship was greatest (58%) in 1989, which was the first year of drought. Survivorship of marked adults was 34% in 1988 (Medica 1992) and 58% in 1990 (the second year of drought), and 50% in 1991.

Table 2. Estimated density (n/ha $\pm$ sem) of *Uta stansburiana* in spring (March) on the Yucca Flat baseline monitoring plot (1.1 ha). Parentheses enclose total numbers of distinct individuals captured.

	1988	1989	1990	1991
Adult lizards	91 $\pm$ 10	75 $\pm$ 10	48 $\pm$ 6	64 $\pm$ 6
Male	(40)	(34)	(17)	(33)
Female	(50)	(40)	(32)	(33)
Total	(90)	(74)	(49)	(66)

Table 3. Estimated densities (n/ha $\pm$ 2 sem) of the lizard *Uta stansburiana* in summer on the Yucca Flat (YUF001) baseline study plot. Parentheses enclose total number of distinct individuals captured.

	1987	1988	1989	1990	1991
Adults	33 $\pm$ 6	41 $\pm$ 13	77 $\pm$ 26	22 $\pm$ 7	32 $\pm$ 12
Male	(16)	(17)	(24)	(9)	(16)
Female	(17)	(19)	(33)	(12)	(9)
Total	(33)	(36)	(57)	(21)	(25)
Hatchlings	123 $\pm$ 18	101 $\pm$ 34	11 $\pm$ 5	51 $\pm$ 24	121 $\pm$ 25
Male	(57)	(39)	(5)	(19)	(53)
Female	(56)	(29)	(5)	(19)	(49)
Total	(113)	(68)	(10)	(38)	(102)

In 1989, hatchling *Uta* ranged in size from 23-27 mm in snout-vent (s-v) length on the Yucca Flat plot and were aged as 0 and 1 month of age (lizards >25 mm in s-v length were aged as 1 month). This range of sizes and ages so late in the summer indicates the occurrence of at least 2 clutches of eggs. In the spring of 1990, none of the 11 hatchlings from the 1989 clutches were recaptured. Two unmarked animals, small enough to be considered hatchlings from 1989, were captured in 1990. One was a male, weighing 1.85 g, and with a s-v length of 39 mm. Its age was estimated as 9 months. The other capture was a female, weighing 1.45 g, and with a s-v length of 35 mm. Its age was estimated as 8 months. Under normal conditions, hatchling *Uta* grow to sexual maturity by April of the following season. The small sizes of the two individuals captured in 1990 suggest they were probably not sexually mature.

Pahute Mesa

The Pahute Mesa baseline study plot (PAM001) was sampled only during the late summer (August/September) of each year (1988-1991). There was a marked

increase in the adult population from 1988 to 1989, then the population remained relatively stable through 1991 (Table 4). The largest number of hatchlings was recorded in 1988, and then there was a decline in 1989, as there was on Yucca Flat. We believe the decline was drought related. Small density fluctuations in 1990 and 1991 did not mirror those which occurred on the Yucca Flat baseline plot.

Table 4. Estimated densities ($n/ha \pm 2 \text{ sem}$) of the lizard *Uta stansburiana* in late summer on the Yucca Flat (PAM001) baseline study plot (1.1 ha). Parentheses enclose total number of distinct individuals captured.

	1988	1989	1990	1991
Adult lizards	28 $\pm$ 11	83 $\pm$ 15	93 $\pm$ 8	80 $\pm$ 12
Male	(8)	(43)	(51)	(52)
Female	(16)	(38)	(42)	(23)
Total	(24)	(81)	(93)	(75)
Hatchling Lizards	42 $\pm$ 28	80 $\pm$ 19	97 $\pm$ 10	72 $\pm$ 11
Male	(62)	(33)	(40)	(31)
Female	(55)	(37)	(56)	(38)
Total	(117)	(70)	(96)	(69)

On Pahute Mesa hatchlings ranging in size from 23-34 mm s-v length were aged as 0 months (<26 mm), 1 month (26-30 mm), and 2 months (>30 mm). As with the Yucca Flat baseline plot, this range in size and age classes indicated at least 3 clutches in 1989. Both the Pahute Mesa (PAM001, 1923 m) and Yucca Flat (YUF001, 1237 m) baseline sites exhibited a significant decrease in reproduction during 1989. This decrease was documented in the number of hatchlings recorded over a six day sampling period with 47 man-hours effort on the Pahute Mesa plot and a 5 day, 34.4 man-hour effort on the Yucca Flat plot. In both instances, the amount of time spent on the plot in man-hours reflects the time required to make two complete passes each day. On the Pahute Mesa plot, sampling began about 0830 hours with soil surface temperatures averaging $28 \pm 2^\circ\text{C}$ and ceased at approximately 1100 hours when temperatures reached $37.9 \pm 0.9^\circ\text{C}$. On Yucca Flat, sampling began about 0700 hours with soil temperatures averaging $20 \pm 2^\circ\text{C}$ and concluded about 0845 hours when they reached $42 \pm 1^\circ\text{C}$.

Jackass Flats

In 1990, the Jackass Flats baseline plot (JAF001) was resampled to determine *Uta* density. Table 5 illustrates the changes in density that occurred since

this plot was first sampled in the summer of 1987. There was a threefold decline in density on this plot between the spring of 1988 and the spring of 1990. During the summer of 1990, no hatchling *Uta* was observed on the 1.1 ha study plot, despite a sampling effort involving a total of 27.45 man-hours over a period of 5 days. *Uta* survivorship from spring to late summer in 1988 was 12%, and in 1990 it was 23%.

Table 5. Estimated density ($n/ha \pm 2$ sem) of *Uta stansburiana* on the Jackass Flats baseline study plot (JAF001). Parentheses enclose total numbers of distinct individuals captured.

	1987 Summer	1988 Spring	1988 Summer	1990 Spring	1990 Summer
Adults	19±19	97±15	21±18	26±5	6±2*
Male	(7)	(40)	(7)	(12)	(2)
Female	(4)	(51)	(4)	(14)	(4)
Total	(11)	(91)	(11)	(26)	(6)
Hatchlings	50±12	---	135±81	---	No hatchlings captured
Male	(20)	---	(25)	---	
Female	(26)	---	(30)	---	
Total	(46)	---	(55)	---	

*Totals captured < 7, and/or estimate impossible to calculate.

Frenchman Flat

The Frenchman Flat plot was resampled in 1991. The density on this baseline study plot decreased from 1988 to 1991 by about two thirds (Table 6). The lack of rainfall in Frenchman Flat from 1989 through early 1991 (approximately 182 mm between the summer of 1989 and the fall of 1991; NOAA/U. S. Weather Service records) reduced the numbers of *Uta* dramatically. Similar effects were observed in rodent populations (Saethre, mammals section).

Table 6. Estimated density ($n/ha \pm 2$ sem) of *Uta stansburiana* on the Frenchman Flat baseline study plot (FRF001). Parentheses enclose total numbers of distinct individuals captured.

	1987 Summer	1988 Spring	1988 Summer	1991 Spring	1991 Summer
Adults	24±20	33±2	3±2*	10±1	no estimate

Table 6, continued.

	1987 Summer	1988 Spring	1989 Summer	1991 Spring	1991 Summer
Male	(5)	(15)	(2)	(3)	(0)
Hatchlings	66±15	---	54±35	---	8±3
Male	(27)	---	(12)	---	(5)
Female	(34)	---	(16)	---	(3)
Total	(61)	---	(28)	---	(8)

*Totals captured < 7, and/or estimate impossible to calculate.

On May 2, 1990, an emaciated *Uta* was observed on the lower Liquefied Gaseous Fuels Spill Facility study plot, on the edge of Frenchman playa in southeast Frenchman Flat. The animal's vertebrae were clearly visible, and its skin appeared loose and wrinkled. On July 12, 1990, a leopard lizard (*Gambelia wislizenii*) was observed in Jackass Flats in a similar emaciated condition and was photographed (Figure 1a, 1b). In times of severe drought, long-lived species such as the leopard lizard have been known to remain relatively inactive for a full year in Rock Valley. Such individuals have been recaptured in subsequent years (Turner et al. 1969).

UTA POPULATIONS, DISTURBANCE PLOTS

Subsidence Craters

Three subsidence craters, the direct result of underground nuclear weapons tests, were sampled during 1989. The dates of the tests and the sizes of the resulting craters are listed in Table 7. All three craters are similar in width, but crater U7au is not as deep as the other two craters. Vegetation in the two oldest craters includes somewhat more shrubs than in U7au, the youngest (Hunter, perennials section).

Figure 1a - Emaciated leopard lizard, *Gambelia wislizenii*, observed in Jackass Flats 12 July 1990.

Figure 1b - A normal lizard photographed June 6, 1988.

Table 7. Dimensions (m) and dates of formation of subsidence craters sampled for *Uta Stansburiana* in 1989.

Crater	Date	Depth	Width
U3cn	September 1963	25	393
U7au	September 1978	16	398
U10af	September 1967	23	347

There was no apparent trend in *Uta* density when the craters were compared to their controls (see Tables 8, 9, and 10). When the craters and their controls were compared with one another, it was found that crater U10af and its control had a considerably lower density of *Uta* than the other plots. U10af is 100-200 m from a crater which was being used as an NTS garbage dump, and that garbage tended to draw ravens. On April 25, 1989, at least 24 ravens were observed circling just below the lip of the crater. The presence of ravens, which eat lizards to some extent (see Greger and Romney, raven surveys), could be affecting the survival and dispersal of *Uta* into the crater and its vicinity.

Table 8. Estimated densities (n/ha $\pm$ 2 sem) of *Uta stansburiana* on 0.56 ha U3cn crater (YUF001) and undisturbed (YUF020) plots in eastern Yucca Flat in 1989. Parentheses enclose total numbers captured.

	Spring 1989		Summer 1989	
	U3cn	Control	U3cn	Control
Adult lizards	85 $\pm$ 0	48 $\pm$ 42	44 $\pm$ 8	41 $\pm$ 19
Male	(29)	(7)	(12)	(7)
Female	(19)	(5)	(11)	(10)
Total	(48)	(12)	(23)	(17)
Hatchlings			12 $\pm$ 12*	20 $\pm$ 12
Male			(2)	(5)
Female			(2)	(3)
Total			(4)	(8)

* Totals captured < 7, and/or estimate impossible to calculate.

Table 9. Estimated densities ($n/ha \pm 2 \text{ sem}$) of *Uta stansburiana* on 0.56 ha U7au crater (YUF021) and undisturbed (YUF022) plots in central Yucca Flat in 1989. Parentheses enclose total numbers captured.

	Spring 1989		Summer 1989	
	U7au	Control	U7au	Control
Adult lizards	39 $\pm$ 0	74 $\pm$ 45	21 $\pm$ 0	64 $\pm$ 4
Male	(10)	(11)	(5)	(12)
Female	(12)	(12)	(7)	(23)
Total	(22)	(23)	(12)	(35)
Hatchlings			5 $\pm$ 5*	5 $\pm$ 0*
Male			(0)	(1)
Female			(2)	(2)
Total			(2)	(3)

* Totals captured < 7, and/or estimate impossible to calculate.

A total of 9 hatchling *Uta* were captured within all of the crater study plots. The total was 13 for the control plots. This poor reproductive effort was similar to that on the Yucca Flat baseline plot as well (see above), and is attributable to drought.

Table 10. Estimated densities ($n/ha \pm 2 \text{ sem}$) of *Uta stansburiana* on 0.56 ha U10af crater (YUF023) and undisturbed (YUF024) plots in 1989. Parentheses enclose total numbers of distinct individuals captured.

	Spring 1989		Summer 1989	
	U10af	Control	U10af	Undisturbed
Adult lizards	11 $\pm$ 0*	7 $\pm$ 0*	5 $\pm$ 5*	No estimate*
Male	(2)	(2)	(1)	(1)
Female	(4)	(2)	(0)	(0)
Total	(6)	(4)	(1)	(1)
Hatchling Lizards			3.6 $\pm$ 0*	1.8 $\pm$ 0*
Male			(1)	(0)
Female			(2)	(1)
Total			(3)	(1)

* Totals captured < 7, and/or estimate impossible to calculate.

Burned Study Area (Yucca Flat)

Lizard sampling on the burned (YUF002) and unburned (YUF003) areas in Yucca Flat first occurred in late August of 1987. Data collected in 1987 and 1988 have been reported in Hunter and Medica (1989) and Medica (1992). These study plots were resampled in the spring and summer of 1990 (Tables 11 and 12).

Table 11. Estimated densities ($n/ha \pm 2 \text{ sem}$) of *Uta* on 0.56 ha burned plot YUF002 in 1987, 1988, and 1990. Parentheses enclose total numbers of distinct individuals captured.

	1987	1988		1990	
	August	April	August	April	August
Adults	No lizards	54 $\pm$ 7	9 $\pm$ 5*	21 $\pm$ 3	5 $\pm$ 0*
Male	(0)	(10)	(0)	(2)	(2)
Female	(0)	(18)	(4)	(9)	(1)
Total	(0)	(28)	(4)	(11)	(3)
Hatchlings	66 $\pm$ 13	---	109 $\pm$ 15	---	29 $\pm$ 7
Male	(16)	---	(24)	---	(6)
Female	(16)	---	(32)	---	(9)
Total	(32)	---	(56)	---	(15)

*Totals captured < 7, and/or estimate impossible to calculate.

Table 12. Estimated densities ($n/ha \pm 2 \text{ sem}$) of *Uta* on 0.56 ha unburned plot YUF003 in 1987, 1988, and 1990. Parentheses enclose total numbers of distinct individuals captured.

	1987 August	1988 April	1988 August	1990 April	1990 August
Adult Lizard	10 $\pm$ 4*	59 $\pm$ 9	30 $\pm$ 18	71 $\pm$ 9	43 $\pm$ 14
Male	(3)	(9)	(2)	(16)	(6)
Female	(2)	(22)	(9)	(22)	(12)
Total	(5)	(31)	(11)	(38)	(18)
Hatchling Lizards	75 $\pm$ 23	---	216 $\pm$ 98	---	129 $\pm$ 70
Male	(19)	---	(38)	---	(20)
Female	(14)	---	(21)	---	(16)
Total	(33)	---	(59)	---	(36)

*Totals captured < 7, and/or estimate impossible to calculate.

In late summer of 1987, approximately equal numbers of *Uta* hatchlings were recorded on both of the plots. By spring of 1988 there were 28 adult *Uta* on the burned plot and 31 on the unburned plot. Probably the majority of the adults captured were hatchlings of the previous year. The sex ratio of the spring adults did not differ significantly (chi-square, $p > 0.05$) from 1:1 on the burned area, but was significantly different ($p > 0.02$) on the unburned plot (Medica 1992).

By the summer of 1988, the estimated adult *Uta* density drastically decreased from 54 ± 7 to 9 ± 5 per ha. The drop in numbers was not so drastic on the unburned plot, but there was a decline from 59 ± 9 to 30 ± 18 *Uta*/ha. According to mark-recapture analysis, the density of hatchlings on the unburned plot was twice as great as the density of hatchlings on the burned plot. (Based on chi-square analysis, there was no significant difference ($p > 0.05$) between the number of hatchlings on the burned and unburned plots. This reflects a higher proportion of unmarked animals caught on the last sample day in the unburned area.) A greater number of hatchlings were produced in 1988 than had been produced in 1987. In the spring of 1990, more adults of breeding size were present on the unburned area than on the burned area (Tables 11 and 12, chi-square, $p > 0.01$). The number of hatchlings found in the unburned area was again twice as great as the number produced in the burned area. The reduced numbers of adults and hatchlings seen on the burned plot were probably due to heavier predation on the burned area, most likely by other lizards and possibly by birds. The reduced shrub cover caused by the 1985 fire was the most probable cause of the increased predation.

The amount of live shrub cover on the burned plot was only about 1% (Hunter 1992). The *Uta* adapted behaviorally to the lack of shrub cover by utilizing rodent burrows as refuges from predation (Hunter and Medica 1989). In addition to the *Uta*, these areas were inhabited by several other species of lizard. In August 1988, 2 *Gambelia wislizenii* were captured within each of the plots. The number of *Gambelia* observed in the following year was 0 in the burned plot and 1 (a female) in the unburned plot. Horned lizards (*Phrynosoma platyrhinos*) also occurred on both plots. In 1988, 3 hatchling *Phrynosoma* were captured on the burned area, while 1 adult female and 5 hatchlings were found on the unburned area. In August 1990, 4 *Phrynosoma* were found on the burned plot (2 hatchlings and 2 juveniles), but none were recorded on the unburned area.

Tower (T) Blast Sites

Blast sites T1 and T3, along with their control plots, were sampled in both 1988 and 1991 (see Tables 13, 14, 15, and 16). There was a significant difference (chi-square, $p > 0.01$) in the number of *Uta* captured on the area outside the T1 blast zone (YUF010) between the springs of 1988 and 1991 (Table 13). The drop in the number of adults resulted in a significant reduction (chi-square, $p < 0.05$) of hatchlings produced in the summer of 1991 compared to the summer of 1988 (Table 14). In contrast, the density of adults on the T1 blast area was virtually the same for the two years studied, and was much lower than on the undisturbed plot. Again, predation in the absence of significant plant cover is a likely explanation.

Table 13. Spring density of adult *Uta stansburiana* ($n/ha \pm 2$ sem) on the T1 blast (YUF009) and the undisturbed (YUF010) plots in 1988 and 1991. Parentheses enclose total numbers of distinct individuals captured.

	T1 Blast		T1 Undisturbed	
	Spring 1988	Spring 1991	Spring 1988	Spring 1991
Adult lizards	13 $\pm$ 12*	12 $\pm$ 7*	122 $\pm$ 15	67 $\pm$ 8
Male	(1)	(4)	(27)	(12)
Female	(3)	(1)	(34)	(23)
Total	(4)	(5)	(61)	(35)

Table 14. Summer density of adult and hatchling *Uta stansburiana* ($n/ha \pm 2$ sem) on the T1 blast (YUF009) and undisturbed (YUF010) plots in 1988 and 1991. Parentheses enclose numbers of distinct individuals captured.

	T1 Blast		T1 Undisturbed	
	Summer 1988	Summer 1991	Summer 1988	Summer 1991
Adult lizards	No lizards	5 $\pm$ 0*	24 $\pm$ 4	15 $\pm$ 6
Male	(0)	(0)	(13)	(4)
Female	(0)	(3)	(12)	(3)
Total	(0)	(3)	(25)	(7)
Hatchling Lizards	*	16 $\pm$ 0*	219 $\pm$ 62	118 $\pm$ 22
Male	(0)	(7)	(41)	(28)
Female	(3)	(2)	(41)	(28)
Total	(3)	(9)	(82)	(56)

* Totals captured < 7 , and/or estimate impossible to calculate.

Uta densities at both the T3 blast site (YUF013) and the T3 undisturbed site (YUF012) were lower in 1991 than in 1988. The decrease on the T3 blast area was significant ($p < 0.05$) based on chi-square analysis (Tables 15 and 16).

Table 15. Spring densities of *Uta stansburiana* ($n/ha \pm 2$ sem) on the T3 blast (YUF013) and undisturbed (YUF012) plots in 1988 and 1991. Parentheses enclose total numbers of distinct individuals captured.

	T3 Blast		T3 Undisturbed	
	Spring 1988	Spring 1991	Spring 1988	Spring 1991
Adult lizards	38±14	11±0*	80±54	28±9
Male	(7)	(2)	(13)	(5)
Female	(10)	(4)	(12)	(8)
Total	(17)	(6)	(25)	(13)

Table 16. Summer densities of adult *Uta stansburiana* ($n/ha \pm 2$ sem) on the T3 blast (YUF013) and undisturbed (YUF012) plots in 1988 and 1991. Parentheses enclose total numbers of distinct individuals captured.

	T3 Blast		T3 Undisturbed	
	Summer 1988	Summer 1991	Summer 1988	Summer 1991
Adult lizards	Not sampled	No Lizards	Not sampled	9±5*
Male		(0)		(2)
Female		(0)		(2)
Total		(0)		(4)
Hatchlings		16±8		46±31
Male		(5)		(2)
Female		(2)		(12)
Total		(7)		(14)

* Totals captured < 7, and/or estimate impossible to calculate.

Blast sites T2 (YUF014) and T4 (YUF025) were sampled in 1990 along with their undisturbed sites (YUF015 and YUF026). In a chi-square analysis of the spring densities, the numbers in the T2 and T4 blast areas were significantly different ($p < 0.01$ and $p < 0.005$, respectively) from the number in the undisturbed plots. The mortality of adults in the spring has an effect on the number of clutches produced in the summer. This is reflected in the low numbers of hatchlings which were captured during summer sampling efforts (Table 17).

Table 17. Density estimates ($n/ha \pm 2 \text{ sem}$) for *Uta stansburiana* on the T2 blast (YUF014) and undisturbed (YUF015) plots in 1990. Parentheses enclose total numbers of distinct individuals captured.

	T2 Blast		T2 Undisturbed	
	April	August	April	August
Adult lizards	7 $\pm$ 0*	No Lizards	53 $\pm$ 26	29 $\pm$ 10
Male	(3)	(0)	(9)	(6)
Female	(1)	(0)	(13)	(8)
Total	(4)	(0)	(22)	(14)
Hatchlings	---	11 $\pm$ 0*	---	*
Male	---	(3)	---	(0)
Female	---	(3)	---	(1)
Total	---	(6)	---	(1)

* Totals captured < 7, and/or estimate impossible to calculate.

We have no explanation for the small number of *Uta* hatchlings ($n=1$) recorded on the T2 undisturbed area. In a chi-square analysis, the two T2 plots were not significantly different ($p > 0.05$). There was a significant difference ($p < 0.01$) in the numbers of hatchlings captured on the T4 and undisturbed plots (Table 18). One possible explanation for the difference in hatchling numbers between the two areas (T2 and T4) is that the numbers of adult *Uta* on the T2 plot from 1989 were too few and the hatchlings were too small to be of reproductive size in 1990. For example, of the 22 adults captured in April on the T2 undisturbed area only 7 males and 6 females could be considered large enough to reproduce. Many of the animals that were aged as 8, 9, or 10 months old were still very small. Four males which were aged as 8-10 months old were 32-41 mm s-v length (37 ± 5 , mean 2 sem), and seven females were 31-40 mm s-v length (34 ± 3 , mean 2 sem). These individuals were much smaller than those captured in the springs of previous years on other Yucca Flat plots.

Of those *Uta* captured on the T2 blast area, none were hatchlings from 1989, all of the animals were older adults aged as >21 months old.

Table 18. Density estimates ($n/ha \pm 2 \text{ sem}$) for *Uta stansburiana* on the T4 blast (YUF025) and undisturbed (YUF026) plots in 1990. Parentheses enclose total numbers of distinct individuals captured.

	T4 Blast		T4 Undisturbed	
	April	August	April	August
Adult lizards	9 $\pm$ 0*	7 $\pm$ 0*	28 $\pm$ 16	17 $\pm$ 8
Male	(2)	(1)	(6)	(5)
Female	(3)	(3)	(6)	(3)
Total	(5)	(4)	(12)	(8)
Hatchlings		14 $\pm$ 0*		50 $\pm$ 11
Male		(3)		(10)
Female		(5)		(15)
Total		(8)		(25)

* Totals captured < 7, and/or estimate impossible to calculate.

Roadside Plots

Two 0.5 ha plots (3 x 25 grid, 10 m interval) were sampled for *Uta* during March and July of 1990. A total of 8 adults were captured on each study plot (3 males:5 females on the undisturbed FRF004, and 4 males:4 females on roadside plot FRF003). Of these 16 adults, only 3 survived until late July (1 on the roadside and 2 in the control). Due to the low numbers of *Uta* present in both plots, no conclusions could be reached as to whether or not roads affect lizard populations (Table 19). However, as mammals apparently reproduced better on the roadside (Saethre, Mammal section), and there were more surviving hatchling *Uta* but fewer adults on the roadside, it is possible that reproduction was also better for lizards on the roadside.

Table 19. Density estimates ($n/ha \pm 2 \text{ sem}$) of *Uta stansburiana* on roadside (FRF003) and undisturbed (FRF004) plots in 1990. Parentheses enclose total numbers of distinct individuals captured.

	Spring 1990		Summer 1990	
	Roadside	Control	Roadside	Control
Adult lizards	17 $\pm$ 3	16 $\pm$ 0	2 $\pm$ 0	9 $\pm$ 3
Male	(4)	(3)	(1)	(0)
Females	(4)	(5)	(0)	(4)

Table 19. continued.

	Spring 1990		Summer 1990	
	Roadside	Control	Roadside	Control
Total	(8)	(8)	(1)	(4)
Hatchlings			16±0	10±10*
Males			(6)	(3)
Females			(2)	(0)
Total			(8)	(3)

* Totals captured < 7, and/or estimate impossible to calculate.

Bladed Dump

The 3B site was bladed in the fall of 1987 and was completely devoid of vegetation. In the spring of 1989 the 11 ha area was ripped and *Atriplex canescens* (Hunter 1992) shrubs were transplanted to the site at a density of about 0.1/m².

In 1991, the density of adult *Uta* was greater on the 3B consolidation site than what it was in 1988 (density went from 0 to 9 ± 5 - Table 20).

Gopher Plot

Lizards were sampled on the Mercury Valley gopher-denuded area for the first time in 1991, following two years of severe drought. In spring, there were no adult *Uta* at all seen on the gopher area, but 32 ± 7 per hectare on the undisturbed area nearby. In summer, hatchlings were 4 ± 0 on the gopher area, and ten times that (44 ± 21) on the undisturbed area (Table 21). This indicated there was some immigration onto the disturbed site, but it also suggested there was no continuous population on this relatively open area.

Table 20. Estimated densities (n/ha ± 2 sem) of *Uta stansburiana* on 3B waste consolidation site in 1988 and 1991. The undisturbed site is YUF012 (Table 15). Parentheses enclose total numbers captured.

	3B Consolidation		3B Consolidation	
	Spring 1988	Spring 1991	Summer 1988	Summer 1991
Adult lizards	No lizards	9+5	Not sampled	*

Table 20. continued.

	3B Consolidation		3B Consolidation	
	Spring 1988	Spring 1991	Summer 1988	Summer 1991
Male		(2)		(0)
Female		(2)		(1)
Total		(4)		(1)
Hatchlings			Not sampled	30±30
Male				(4)
Female				(5)
Total				(9)

* Totals captured < 7, and/or estimate impossible to calculate.

Table 21. Estimated densities ($n/ha \pm 2$ sem) of *Uta stansburiana* on the gopher (MER002) and undisturbed (MER003) plots in Mercury Valley in 1991. Parentheses enclose total numbers of distinct individuals captured.

	Spring 1991		Summer 1991	
	MER002	MER003	MER002	MER003
Adult lizards	No lizards	32±7	No lizards	22±9
Males		(12)		(6)
Females		(4)		(4)
Total		(16)		(10)
Hatchlings			4±0*	44±21
Males			(2)	(9)
Females			(0)	(8)
Total			(2)	(17)

* Totals captured < 7, and/or estimate impossible to calculate.

(Cover in 1991 was about 6% in summer, about half by dead and half by live *Stanleya pinnata* - Hunter, perennials section.) As on burned sites (Tables 11, 12, and Medica 1992) and GZs (Tables 13-18), the probable explanation is increased predation of *Uta* in the absence of cover.

Sedan Plots

The numbers of *Uta* captured on all the Sedan plots were low both in spring and summer of 1991. This was true in spite of a wide range of shrub cover on the three plots (1 to 18%, see Discussion, Table 29). In the undisturbed area at

1601 m, survival of adults into the summer appeared to be better than on the recovering blast and throwout areas, and reproduction appeared also to be greater in the undisturbed area. Numbers captured were too low for statistical tests of those hypotheses (Table 22).

Table 22. Estimated densities ($n/ha \pm 2 \text{ sem}$) of *Uta stansburiana* on Sedan plots (YUF016, 17, and 18) at 457, 1067, and 1601 m ENE of Sedan GZ in 1991. Parentheses enclose total numbers of distinct individuals captured.

	457 m		1067 m		1601 m	
	Spring 1991	Summer 1991	Spring 1991	Summer 1991	Spring 1991	Summer 1991
Adults	$7 \pm 0^*$	No lizards	$5 \pm 0^*$	No lizards	$7 \pm 0^*$	$5 \pm 0^*$
Males	(1)	(0)	(1)	(0)	(3)	(2)
Females	(3)	(0)	(2)	(0)	(1)	(1)
Total	(4)	(0)	(3)	(0)	(4)	(3)
Hatchlings		*		$9 \pm 9^*$		22 ± 9
Males		(1)		(0)		(4)
Females		(0)		(3)		(6)
Total		(1)		(3)		(10)

OTHER SPECIES, TRANSECT RESULTS

Transect studies used observations to determine relative numbers and species composition of lizard populations on and in the near vicinity of the BECAMP plots. Because observing conditions change dramatically with weather, plant cover, and animal behavior, the transect studies cannot be used to provide estimates of actual numbers of a species on a given area. The results of these studies can be used to illuminate predation intensity by other lizards on the *Uta stansburiana* populations, and may be used to indicate major changes in population densities of the less-common species.

The BECAMP transect results on baseline plots are summarized for all years since 1987 in Tables 23 through 26, with the exception of the Yucca Flat burned area, reported in Hunter and Medica (1989). The best-sampled plot was the Yucca Flat baseline plot, YUF001. As seen in Table 23, all species but *Uta stansburiana* declined gradually in relative numbers from 1987 through 1990, then rebounded moderately in 1991. These fluctuations are easily explained by drought.

Table 23. Lizard relative abundance (mean number of lizards observed per hectare searched) on transects on the Yucca Flat baseline plot (YUF001) during late spring, 1987-1991.

	1987	1988	1989	1990	1991
<i>Cnemidophorus tigris</i>					
Adults	9.67	3.41	3.96	3.41	5.98
Juveniles	2.12	1.00	2.00	1.39	0.59
Total	11.79	4.41	5.96	4.80	6.57
<i>Gambelia wislizenii</i>	0.48	0.26	0.04	0.15	0.24
<i>Callisaurus draconoides</i>	0.13	0.15	0.22	0.03	0.03
<i>Phrynosoma platyrhinos</i>	0.20	0.19	0.11	0.00	0.03

An analysis of variance (Minitab, Tukey test) of *Cnemidophorus tigris* adults for all years on the YUF001 plot showed the mean numbers seen per transect line fell into three groups, 1987, 1988-90, and 1991, at the $p=0.05$ level. Juvenile populations were lower in 1991 than in 1987 and 1989 (Tukey test). *Cnemidophorus tigris* was the second most abundant species after *Uta stansburiana*, which was sampled with mark-recapture techniques. Other species of lizard observed (*Callisaurus draconoides*, *Gambelia wislizenii*, and *Phrynosoma platyrhinos*) were so rare on transects that year-to-year changes were not significantly different at the 0.05 level. The species present did not change, except that in 1990, no *Phrynosoma platyrhinos* were seen on YUF001.

Table 24. Lizard relative abundance (mean number of lizards observed per hectare searched) on transects on the Frenchman Flat baseline plot (FRF001) during late spring, 1987-1988, 1991.

	1987	1988	1991
<i>Cnemidophorus tigris</i>			
Adults	2.55	3.23	1.57
Juveniles	0.11	0.62	0.03
Total	2.66	3.85	1.60
<i>Callisaurus draconoides</i>			
Adults	2.58	1.27	0.42
Juveniles	0.77	0.65	0.09

Table 24. continued.

	1987	1988	1991
Total	3.35	1.92	0.51
<i>Gambelia wislizenii</i>			
All	0.73	0.77	0.53
<i>Phrynosoma platyrhinos</i>			
All	0.06	0.21	0.00

Table 25. Lizard relative abundance (mean number of lizards observed per hectare searched) on transects on the Jackass Flats baseline plot (JAF001) during late spring, 1987-1988, 1991.

	1988	1991
<i>Cnemidophorus tigris</i>		
Adults	7.14	4.47
Juveniles	1.63	0.59
Total	8.77	5.06
<i>Callisaurus draconoides</i>		
Adults	0.03	0.00
Juveniles	0.03	0.00
Total	0.06	0.00
<i>Gambelia wislizenii</i>		
Adults	0.65	0.06
<i>Phrynosoma platyrhinos</i>		
All	0.21	0.12

Table 26. Lizard relative abundance (mean number of lizards observed per hectare searched) on transects on the Pahute Mesa baseline plot (PAM001) during late spring, 1988 and 1991.

	1988	1991
<i>Cnemidophorus tigris</i>		
Adults	0.07	0.12
Juveniles	0.04	0.06
Total	0.11	0.18
<i>Gambelia wislizenii</i>		
Adults	0.11	0.21

Table 26. continued.

	1988	1991
Juveniles		
Total	0.15	0.21
<i>Phrynosoma platyrhinos</i>		
All	0.04	0.00
<i>Crotaphytus insularis</i>	0.07	0.00
<i>Sceloporus occidentalis</i>		
All	0.11	0.24

Annual data were not available in the three other baseline plots sampled (JAF001, FRF001, PAM001). On the Jackass Flats and Frenchman Flat plots, the sum of all species other than *Uta stansburiana* declined from 1987-88 to 1991 (Tables 24, 25, and Figure 1; ANOVA-Tukey, $p = 0.05$), explainable by the severe drought conditions of 1989-90. The Pahute Mesa plot included two other species (*Crotaphytus insularis* and *Sceloporus occidentalis*). There were no apparent changes in relative abundance among the Pahute Mesa species between 1988 and 1991 (Table 26), consistent with the relatively mild drought effects on the vegetation on this plot (Hunter, perennials report).

Transects were sampled at three of the GZ blast areas to assess *Uta* predator changes in open areas. Total lizard numbers other than *Uta* did not differ between the open blast areas, the ecotones, and the undisturbed areas (Table 27). It was therefore only *Uta stansburiana* whose numbers were reduced in the disturbed areas. The addition of *Sceloporus magister* to the species list on the blast areas was probably due to the presence of power poles and Joshua trees on and near these areas. These lizards normally live on and near tree-trunks and rock outcrops, which they adeptly use to escape from predators. The Yucca Flat baseline plot is in an area with sparse Joshua trees, but was relatively far from power lines and other structures. *Sceloporus magister* was caught once in a mammal trap on YUF001, but was not seen on transect lines.

On the Yucca Flat burned plot (YUF002) more of each species was observed on the burned than the unburned area (Table 28). For *Cnemidophorus tigris* the adult numbers seen were significantly greater on the burned area (sign test, $n=20$, Conover 1971). Numbers of *Phrynosoma platyrhinos* were 8 on the burned area and 1 on the unburned (significant at 0.10, not 0.05 - sign test).

Table 27. Late spring lizard relative abundance (mean number of lizards observed per hectare searched) on the blast area locations in Yucca Flat. T2 and T4 were sampled in 1990 and T1 in 1991.

Species	T2			T4			T1		
	Blast	Control	Ecotone	Blast	Control	Ecotone	Blast	Control	Ecotone
<i>Cnemidophorus tigris</i>									
Adult	3.8	2.5	4.43	3.0	2.83	3.33	3.47	4.04	3.11
Juvenile	0.28	0.22	0.19	0.17	0.06	0.00	0.58	0.36	1.33
<i>Gambelia wislizenii</i>									
Adult	0.11	0.17	0.00	0.00	0.06	0.00	0.18	0.04	0.00
<i>Callisaurus draconoides</i>									
Adult	0.11	0.06	0.00	0.06	0.11	0.00	0.36	0.00	0.22
Juvenile	0.00	0.00	0.00	0.17	0.22	0.00	0.09	0.00	0.00
<i>Phrynosoma platyrhinos</i>									
Adult	0.61	0.11	0.00	0.33	0.28	0.00	0.18	0.00	0.00
<i>Sceloporus magister</i>									
Adult	0	0	0	0.06	0	0	0	0	0
Total Lizards	4.90	3.06	4.62	3.78	3.56	3.33	4.84	4.44	4.67

Uta numbers observed on transects were uniformly far below the densities estimated by mark-recapture techniques. The data are not presented in Tables 24 - 28, but are discussed below.

Table 28. Number of lizards per hectare searched on burned (YUF002) and unburned (YUF003) plots in Yucca Flat, late spring transects, 1990.

	Burned YUF002	Unburned YUF003
<i>Cnemidophorus tigris</i>		
Adult	3.1	1.7
Juvenile	0.6	0.5
<i>Gambelia wislizenii</i>	0.1	0
<i>Phrynosoma platyrhinos</i>	0.38	0.05
<i>Sceloporus magister</i>	0.05	0

Desert Tortoise

Between 18 September 1987 and 5 September 1991, a total of 75 desert tortoises (*Gopherus agassizii*) were marked, measured, and released on the NTS by BECAMP. A special effort was made to search for tortoises in Frenchman Flat during the spring and early summer of 1989. In addition to the above tortoises, 17 tortoises residing in three 9-ha fenced plots in Rock Valley have been recaptured yearly to document growth and survival. While not all of the 17 tortoises were captured every year, all were captured in the spring or late summer of 1991, indicating that the 17 tortoises survived the drought years of 1989 and 1990. Two tortoises, (male #4, plot A and female #3, plot C) were not observed in 1989, but both were captured in 1990. None of the tortoises captured in 1989 through 1991 showed signs of upper respiratory tract disease.

Reviewing the capture records of the 75 free-ranging tortoises on the NTS indicated that 14 of 43 or 33% of the tortoises from 1987 through 1988 were captured on or along roads. Table 29 outlines the first capture location of these animals from 1987 through 1991. After 1988, 20 of 32 tortoises (63%) were captured on roads, 3 of 20 were caught on dirt roads and 17 were on paved roads. Eight of these 17 were on an abandoned paved road in Frenchman Flat.

Table 29. Capture location of free-ranging tortoises on the NTS from 1987 through 1991.

Year	Transects, Washes or Other Tortoise Habitat	ROADS			Total
		Remote Dirt and Graded	Major Paved	Abandoned Paved	
1987	8	1			9
1988	21	10	3		34
1989	3	1	1		5
1990	3	1	7	5	16
1991	6	1	1	3	11
Total	41	14	12	8	75

It may be important to note that tortoise captures along and on roads seem to follow the drying cycle of the vegetation away from roads: annual plants at the roadside tend to remain green until later in the summer than the plants located away from the road. The availability of green, succulent food along the shoulders of the roads, particularly on paved roads, may be an important source of water and/or nutrition. From August 1989 to March 1990, no tortoises were captured or measured due to lack of a permit.

Table 30 lists the capture data by year and location for the free-ranging tortoises on NTS in 1989 through 1991. It should be noted that the southern portions of Frenchman Flat, Mercury Valley, and Rock Valley were the most frequently driven areas and therefore had the greatest opportunity for observing a tortoise along the road. The abandoned "Burma" road in southern Frenchman Flat was also frequently driven during or just after a rain shower, when tortoises were most likely to be active along this road (Figure 2).

The size distribution of all free-ranging tortoises measured between 1987 and 1991 showed that the greatest proportion were between 220 and 260 mm in plastron length (Figure 3), which was also true in 1987 and 1988 (Medica 1992, Figure 3.7). Approximately the same number of males and females were captured in this plastron range or less. However, with animals greater than 260 mm plastron length, males outnumbered females 7 to 1 (Figure 3). The overrepresentation of larger and therefore older animals does not necessarily mean that there are significantly fewer younger animals in the NTS population

Table 30. Desert tortoises (*Gopherus agassizii*) captured on the NTS from 1989 through 1991.

<u>Location</u>	<u>Animal Number</u>	<u>Sex</u>	<u>Plastron length (mm)</u>	<u>Carapace Length (mm)</u>	<u>Weight (g)</u>
<u>1989</u>					
Frenchman Flat	44	F	235	258	3100
	45	F	236	254	2900
	46	F	232	251	2650
	47	M	256	268	2950
	48	F	213	249	2250
<u>1990</u>					
Frenchman Flat	50	I	58	62	<50
	51	M	154	161	880
	52	M	255	268	3775
	54	F	193	215	2050
	56	M	234	265	3525
	57	M	263	285	4125
	60	I	148	153	800
	61	M	242	260	3200
	62	M	234	253	1850
Mercury Valley	81	I	51	54	35
	49	F	233	257	3450
	55	F	237	258	3075
	58	M	212	229	2350
Rock Valley	59	I	43	49	23
	53	M	264	283	3800
Jackass Flats	63	F	142	155	700
<u>1991</u>					
Frenchman Flat	70	I	134	143	575
	71	F	237	252	2825
	72	M	191	213	1900
Mercury Valley	64	F	215	232	2300
Rock Valley	66	F	206	232	2600
	67	I	166	173	1100
	68	M	223	247	2850
	69	F	231	244	2600
	82	I	91	104	228
	83	I	109	117	375
Jackass Flats	65	M	238	268	3700

Figure 2 - Capture locations of free-ranging desert tortoises on NTS in 1987-1991. N = 75.

Figure 3 - Plastron length (mm, by sex) of 75 desert tortoises (*Gopherus agassizii*) captured 1987 - 1991.

of tortoises. Results from several other areas in the Mojave desert have shown a similar age distribution, mostly due to the difficulty of finding very young tortoises (Berry 1990; Berry, et al. 1990; Shields 1991). When an area was intensively searched to remove all tortoises, the proportion of hatchling and juvenile tortoises in the population was much greater (Knowles and Knowles 1991).

The tortoises in the fenced enclosures in Rock Valley were recaptured in the spring and late summer of 1989 to 1991 (Table 31), maintaining records on animals first captured in the early 1960's (Medica et al. 1975; Turner et al. 1987; Germano 1988). These tortoises have now been captured for 29 years, with the oldest tortoise aged at 31 years old. During the drought, minimal growth of plastron and carapace length was observed in this population of tortoises. The overall mean of 2.0 mm growth (range 0 to 6 mm) in 1988 was greater than in 1989 (< 0.1 mm, -1 to 4 mm) and 1990 (0.2 mm, -2 to 3 mm) but only slightly higher than the overall growth of 1.3 mm in 1990 (range -1 to 4 mm). Growth in plastron size during 1989 could not be recorded directly since tortoises could not be handled during the fall of that year. Most growth occurs in the late spring and early summer (Medica et al. 1975). Growth was therefore calculated based on spring 1989 capture or late 1988 capture measurements and the spring 1990 measurements.

One tortoise of unknown sex, known to be at least 1 year of age in 1963 grew 4 mm in 1988, but grew only 1 mm in 1990. This tortoise has grown very little since 13 years of age and has not shown any secondary sexual characteristics. Overall, the growth of the 17 tortoises has slowed down in the last few years (Figure 4), most likely due to lack of quality forage during the drought. Free-ranging tortoises that were recaptured during 1989 through 1991 were too few for any valid comparisons. Only one (#29, Frenchman Flat) was recaptured in 1989 and showed no growth (actual, -3 mm). Four tortoises recaptured in 1991 (three originally captured in 1988 and 1 in 1990) showed a mean growth of 3.25 mm (range -3 to +7 mm).

Negative growth may be attributed to error in accurately reading the millimeter ruler, but may also be due to shrinkage of the shell due to dehydration. Several of the 17 tortoises in Rock Valley showed physical signs of severe dehydration in 1989 and 1990 - sagging skin and shrunken head scales. After a rainfall in 1990, tortoises that were recaptured showed a marked increase in weight, indicating that large quantities of water had been imbibed.

Table 31. Capture data for tortoises in Rock Valley fenced plots from 1989 through 1991. NS = Not seen.

Plot	Animal Number	Sex	Year	Spring			Autumn		
				Plastron (mm)	Carapace (mm)	Weight (g)	Plastron (mm)	Carapace (mm)	Weight (g)
Plot A									
	4	F	89		NS			NS	
			90	218	226	2150		NS	
			91	219	226	2250		NS	
	5	M	89	240	270	3450		ALIVE	
			90	239	270	3500	240	271	3725
			91	240	271	3950	242	273	3775
	11	M	89		NS			ALIVE	
			90		NS			NS	
			91		NS		235	250	2750
Plot B									
	1	M	89	250	283	4075		NS	
			90	249	282	3925	250	282	4025
			91	248	283	3975	250	283	3550
	2	M	89	251	272	4050		NS	
			90	251	271	3700	251	271	4000
			9	253	271	3700	253	273	3525
	3	M	89		NS	NS		NS	
			90	238	258	3475	238	261	3675
			91	237	261	3375	241	262	3475
	4	F	89	206	223	1750		NS	
			90		NS		205	223	2025
			91	205	223	1975	205	222	1900
Plot C									
	1	M	89	226	244	2275		NS	
			90	227	242	2500	226	243	2350
			91	227	244	2600	231	248	2600

Table 31, continued.

Plot	Animal Number	Sex	Year	Spring			Autumn		
				Plastron (mm)	Carapace (mm)	Weight (g)	Plastron (mm)	Carapace (mm)	Weight (g)
Plot C, continued									
	2	F	89	211	221	2250	211	NS	2275
			90	211	221	2100		221	
			91	212	219	2125		221	
	3	F	89		NS		247	NS	2825
			90	245	250	2750		253	
			91	248	252	3000		263	
	4	M	89	227	253	2550	227	ALIVE	2850
			90	227	253	2525		253	
			91	226	251	2700		254	
	5	F	89	224	233	2150	226	NS	2325
			90	224	233	2150		233	
			91	224	233	2225		233	
	6	F	89	220	233	2100	226	NS	2325
			90	219	233	2325		NS	
			91	219	234	2225		NS	
	8	M	89		NS		220	ALIVE	2500
			90	220	237	2275		237	
			91	218	236	2575		238	
	9	I	89	161	175	1125	161	NS	1100
			90		NS			172	
			91	162	172	1025		NS	
	10	F	89	222	233	2300	219	ALIVE	2375
			90	220	231	2125		NS	
			91	218	233	2350		233	
	11	F	89	215	230	2200	216	NS	2500
			90	215	228	2250		227	
			91	215	228	2325		229

Figure 4 - Yearly growth of Rock Valley tortoises from 1963 through 1991. Points with standard error bars are means of 11 tortoises.

Several juvenile-sized burrows were observed in the southwest quarter of Plot A in late September 1989. A small tortoise, estimated to be <100 mm in plastron length, was observed in one of these burrows on February 2, 1990, approximately 30 cm from the entrance. After BECAMP received a federal collection permit, this tortoise was not observed again and therefore was never marked. This brought the total of known tortoises residing in the three fenced enclosures to 17 marked adults plus one unmarked juvenile.

DISCUSSION

EFFECTS OF DISTURBANCE

The data on *Uta stansburiana* density show a clear pattern of reduced population size wherever shrubs have been removed, by virtually any agency. Fires, gophers, nuclear weapons tests, and scraping all appeared similar in reducing lizard densities. Table 32 is a compilation of *Uta* densities and shrub cover data from this report and the perennial plant reports (Hunter, perennials section; Hunter 1992). There was a strong correlation between cover and both spring and summer densities ($r = 0.63$ and 0.60 respectively). Selecting only the Yucca Flat plots to reduce habitat variability increases these correlation coefficients to $+0.69$ and $+0.72$, respectively. (These correlation coefficients are significantly different from 0 at $p < 0.01$, by f test.)

The most probable cause of this relationship between perennial cover and lizard density is that shrub and grass cover reduces the risk of predation. Supporting this hypothesis is that the correlation between perennial plant cover and survivorship expressed as the ratio of summer to spring adult densities (Table 32) was $+0.37$, significant at $p > 0.05$.

An alternative hypothesis, that *Uta* merely avoids open areas, is not so plausible as predation. Hatchlings invade or hatch in the open areas each year (see, e.g., Tables 11, 14, and 16), and adult populations are rarely zero in the spring. Even in the absence of shrub cover, there were generally small mammal burrows, rocks, and other objects to protect a small population from temperature extremes (see Hunter and Medica 1989 on the YUF002 site). Wilson (1991) examined mortality rates in *Uta* populations, and concluded that predation, rather than emigration, was "the only source of activity season mortality that is of demographic importance." It is thus probable that the

Table 32. A comparison of spring and summer adult *Uta stansburiana* estimated densities (n/ha) and summer survivorship with shrub cover for 1988-1991. Data are sorted by cover.

Adults						Adults					
Plot	Spr	Sum	Cover	Year	Sum/Spr	Plot	Spr	Sum	Cover	Year	Sum/Spr
YUF014	7	0	0	1990	0	FRF001	10	0.9	20.0	1991	0.09
YUF011	0	0	0	1988	-	U7AUC0	74	64	24.6	1989	0.86
YUF016	7	0	1	1991	0	FRF001	33	3	24.9	1988	0.09
YUF011	9	1.8	1.3	1991	0.2	YUF012	28	9	25.3	1991	0.32
T1GZ	12	5.4	1.4	1991	0.45	T1CONT	67	15	25.4	1991	0.22
T3GZ	11	0	1.8	1991	0	YUF012	80	-	26.4	1988	-
U10AFC	7	1.8	2.2	1989	0.26	JAF001	26	6	32.2	1990	0.23
T3GZ	38	-	2.2	1988	-	T1CONT	122	24	33.0	1988	0.20
U10AF	11	5	2.6	1989	0.45	YUF001	48	20	33.3	1990	0.42
YUF002	54	9	2.6	1988	0.17	YUF026	28	17	33.3	1990	0.61
T1GZ	12	0	2.9	1988	0	YUF003	59	30	36.0	1988	0.51
YUF025	9	7	3.7	1990	0.78	YUF001	64	32	36.2	1991	0.50
U7AU	39	21	4.8	1989	0.54	YUF001	75	77	36.3	1989	1.03
U3CN	85	44	9.3	1989	0.52	YUF001	91	42	40.7	1988	0.46
YUF002	21	5.4	9.8	1990	0.26	YUF003	71	43	42.4	1990	0.61
YUF017	5	0	10.2	1991	0	PAM001	-	80	42.8	1991	-
MER002	0	0	13.2	1991	-	PAM001	-	93	43.1	1990	-
U3CNCO	48	41	17.0	1989	0.85	JAF001	97	21	41.0	1988	0.22
YUF015	53	29	17.4	1990	0.55	MER003	32	22	50.6	1991	0.69
YUF018	7	5	17.8	1991	0.71	PAM001	-	28	54.9	1988	-

main effect of land disturbance by both Department of Energy activities and natural forces on *Uta* populations is to increase risk of predation by removing perennial plant cover.

Turner and Gist (1965) reported similar effects of disturbance on the area denuded by the Sedan test. The detonation killed close-in adult populations by burial and blast, but mortality at greater distances was delayed, and likely due to habitat destruction. Although adults of all three species studied (*Cnemidophorus tigris*, *Gambelia wislizenii*, and *Uta stansburiana*) were exterminated near the crater, eggs of all three hatched from 792 m outward. These hatchlings disappeared in a few months from the denuded areas. Tanner and Jorgensen (1963) found that in 1959, *C. tigris* was evenly distributed in the disturbed area surrounding T1 GZ. *U. stansburiana* was distributed evenly from 805 m outward but was absent closer to GZ. 1959 was only two years after the last test was conducted at this site so it was likely that the available cover was not suitable for UTA.

EFFECTS OF DROUGHT

Lizard monitoring from 1989 through 1991 showed a decline in populations that was largely attributable to drought. The decline in adult *Uta* populations on the Yucca Flat baseline plot (YUF001) to 20/ha in 1990 (Table 3), and the decline in other species to their minima the same year (Table 24) are most easily explained as due to drought. In this case the population declines were not due to unexpected mortality, but to failure to reproduce.

Hatchling numbers were very low in summer of 1989, which led to a decrease in adults the following year. Using ratios of summer hatchlings to spring adults from the undisturbed and baseline plots in Tables 2 through 21, an analysis of variance shows 1989 was a poor year for reproduction (Table 33).

Table 33. Mean ratios of summer hatchlings to spring adults. Means followed by the same letter are not significantly different, (Tukey, Minitab).

Year	n	Mean $\pm$ sd
1988	5	1.9 $\pm$ 1.0 ^a
1989	4	0.22 $\pm$ 0.15 ^b
1990	4	1.2 $\pm$ 0.9 ^{ab}
1991	5	2.0 $\pm$ 0.7 ^a

In contrast to reproduction, survival from spring to summer was improved by drought, an observation also noted by Wilson (1991). The mean ratios of summer adult density to spring adult density (from Table 32) show 1989 was the best year for survival. One-way analysis of variance showed the means were not equal at $p = 0.028$ (Table 34). Although Wilson (1991) suggested the improved survival associated with drought was likely due to reduced activity levels, and hence reduced predation, we believe it is also possible that the low reproductive effort associated with drought led to increased female survival. Table 35 presents an analysis of BECAMP data from the actual captures on Yucca Flat from 1988 through 1991. The correlation coefficient between female survival and hatchlings per female is -0.947 , which is not significant at $p = 0.05$ ($n = 4$), but suggests a negative relationship might be confirmed with more years of data.

Table 34. Mean ratios of summer to spring adults densities, 1988-1991.

Year	n	Mean $\pm$ sd
1988	7	0.23 ± 0.19
1989	7	0.60 ± 0.22
1990	8	0.43 ± 0.25
1991	11	0.29 ± 0.27

Table 35. Analysis of male/female survivorship for all captures on Yucca Flat plots, 1988-1991. Data are from Tables 3 and 8-17.

	1988	1989	1990	1991
Spring females	149	94	86	69
Spring males	107	94	55	56
Summer hatchlings	268	31	129	188
Male survival	0.30	0.68	0.53	0.39
Female survival	0.30	0.87	0.48	0.25

Turner et al. (1974) analyzed survivorship of *Uta* in Rock Valley, and did not find a similar relationship. Their data are reproduced in Table 36, and show little relationship of annual survival to drought (1970-71 and 1971-72 were drought years for annuals - see Hunter, ephemerals section) or sex. Note however that they present annual survival, rather than spring-summer survival.

Wilson (1991) found only "weak differences" between male and female mortality, and lumped these together for his analysis.

Table 36. Annual survival of adult male and female *Uta Stansburiana* in 0.4 ha enclosures. (From Turner et al. 1974).

Years	Males	Females
1969-70	0.15	0.20
1970-71	0.29	0.31
1971-72	0.48	0.41
1972-73	0.34	0.35
All years combined	0.33	0.33

The most reasonable mechanism for drought to affect lizard numbers is through food limitation affecting reproduction. BECAMP at the present time has no data on insect abundance, so evidence is scarce to support that hypothesis. Analysis of weights of hatchlings on the Yucca Flat baseline plot gives some evidence that the few hatchlings from 1989 were smaller than normal in the spring of 1990 (Table 37 - see also results on T2 GZ, p.18). Another weak line of evidence is the rough correlation between ephemeral plant densities and hatchling production (Table 38). Turner et al. (1982) previously documented the effects of winter irrigation on the promotion of growth in ephemerals and the subsequent production of additional clutches in *Uta*.

Table 37. Mean snout-vent lengths for 7 to 10 month old *Uta stansburiana* in spring on plot YUF001, 1988-1991.

	1988		1989		1990		1991	
	n	mm $\pm$ sem	n	mm $\pm$ sem	n	mm $\pm$ sem	n	mm $\pm$ sem
Females	43	43.6 $\pm$ 0.7	27	40.9 $\pm$ 1.1	1	35	22	42.3 $\pm$ 0.7
Males	27	45.8 $\pm$ 1.1	21	44.2 $\pm$ 1.1	1	39	14	43.3 $\pm$ 1.2

Table 38. Mean densities of winter annuals and changes in *Uta* reproductive effort on the Yucca Flat study plot (YUF001), 1987-1991.

Year	Mean number per m ²	Mean g/m ²	<i>Uta</i> hatchlings number/hectare
1987	1938* $\pm$ 496	52 $\pm$ 10	123 $\pm$ 18
1988	1713 $\pm$ 316	21 $\pm$ 3	101 $\pm$ 34

Table 38, continued.

	1988		1989		1990	
	n	mm $\pm$ sem	n	mm $\pm$ sem	n	mm $\pm$ sem
1989		0		0		11 $\pm$ 5
1990		0		0		53 $\pm$ 25
1991		76 $\pm$ 28		0.5 $\pm$ 0.2		121 $\pm$ 25

* 1987 ephemeral data are from plot YUF002 located 1.6 km SW of YUF001.

Direct evidence, such as stomach content analyses or water turnover analyses, can be collected, but would require special efforts.

Drought severity and recovery was not uniform throughout the NTS. Higher altitude areas like Pahute Mesa showed minimal effects, while Frenchman and Yucca Flat were more severely affected. Jackass Flats and Rock Valley had some extra thundershowers in 1990 that tempered the drought. These spatial variations in drought severity are not well reflected in the BECAMP data because only two sites were sampled annually. Using the YUF001 plot as a representative plot for the whole of the NTS was a compromise.

METHODS

The mark-recapture data on *Uta stansburiana* are almost exact, and can be used to infer actual population sizes, sex ratios, survivorship, etc., as demonstrated in this report. Particularly useful are the mark-recapture data done every year on plots YUF001 and PAM001, although we have made some use of pooled data from the plots sampled every third year. However, the measurement of relative abundance using transect data is decidedly inferior to mark-recapture.

Measures of relative abundance can be used as a measurement of lizard species present and they provide a crude proxy of their density. Such line transect methods do not reflect true density, as has been shown in Degenhardt (1966) and Medica et al. (1971). Transects are biased towards adult individuals, which are more visible than juveniles. They are also biased towards more active species, and are affected by visibility changes due to vegetative cover. Line transect techniques do provide information that can be used to indicate trends in relative abundance when comparing data from year to year, as in Tables 24-27. For that purpose they are more labor-efficient, but

considerably less exact than the mark-recapture technique. Trends can be statistically defined in only the most common species (generally only *Cnemidophorus tigris* on the NTS). Transect techniques are not well suited to measuring differences on small areas with differing visibility characteristics, such as the ground zeroes and controls (Table 28).

Transect data on *Uta* account for only a small proportion of the populations measured by mark-recapture techniques. This is largely because their activity periods are earlier in the day than those of other lizards. *Phrynosoma* results on transects may be misleading because they aren't usually visible until they move, which is unusual unless one approaches within a meter.

Because the transect data have only been adequately quantitative for showing trends in *Cnemidophorus tigris* from year to year, in the future we expect to limit their use to those plots sampled each year, currently YUF001 and PAM001 baseline plots. This will allow more time to search new locations and develop distribution maps of the less-common species. Such species are often of likely future interest as threatened or endangered species, and information on their distribution, habitats, and population sizes are likely to be of greater importance than the transect results.

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

Plot	Latitude Longitude (NAD 1983)			Elevation (M)	Location
FF66	36° 115°	49' 55'	12.3" N 57.8" W	948	LGF 3 km line Frenchman Flat
FF67	36° 115°	49' 55'	8.5" N 32.7" W	947	LGF 3 km line Frenchman Flat
FF81	36° 115°	49' 55'	45.0" N 7.4" W	951	LGF 5 km line Frenchman Flat
FF84	36° 115°	50' 55'	5.3" N 6.3" W	957	LGF 5 km line Frenchman Flat
FOR001	37° 116°	8' 15'	7.8" N 23.4" W	1756	Beatley Plot 61 (UCLA)
FOR002	37° 116°	8' 15'	27.5" N 25.9" W	1750	Beatley Plot 62 (UCLA)
FOR003	37° 116°	8' 15'	48.8" N 21.6" W	1554	Jct. Stockade Wash and Pahute Mesa Roads
FRF001	36° 115°	48' 59'	48.0" N 12.0" W	965	Frenchman Flat
FRF002	36° 116°	48' 0'	25.9" N 23.3" W	977	Frenchman Flat (Roadside)
FRF003	36° 115°	48' 58'	45.8" N 48.2" W	965	Frenchman Flat (Roadside 5-05 Road E. End)
FRF004	36° 115°	49' 58'	9.0" N 42.5" W	965	Frenchman Flat Control (N. Power Line Rd. E. End)
FRF005	36° 115°	50' 56'	38.0" N 8.0" W	963	GMX GZ
FRF006	36° 115°	50' 56'	45.6" N 28.7" W	963	GMX Control
FRF007	36° 115°	49' 57'	2.9" N 56.9" W	960	Tritium Well, Atriplex Site

Plot	Latitude Longitude (NAD 1983)			Elevation (M)	Location
GOL001	37° 116°	13' 13'	42.2" N 2.3" W	2060	Gold Meadows
JAF001	36° 116°	46' 22'	10.9" N 37.0" W	954	Jackass Flats
JAF002	36° 116°	45' 22'	11.0" N 35.5" W	937	Beatley Plot 8 (UCLA)
JAF003	36° 116°	46' 21'	16.1" N 14.1" W	963	Gopher Area (E. of Beatley Plot 7)
JAF004	36° 116°	45' 22'	11.0" W 35.5" W	963	Beatley Plot 7 (UCLA)
MER001	36° 115°	39' 59'	59.6" W 52.0" W	1161	Mercury Water Balance Plots
MER002	36° 116°	39' 7'	8.7" N 9.3" W	1076	Gopher Denuded Area
MER003	36° 116°	39' 7'	26.8" N 8.1" W	1103	Undisturbed Area N. of MER002
MER004	36° 116°	40' 7'	18.2" N 53.9" W	1088	Beatley Plot 2 (UCLA)
MID001	36° 116°	53' 11'	46.5" N 31.0" W	1448	Plant Transects, (N.End) E. Side Saddle Road.
MID002	36° 116°	53' 11'	52.1" N 59.0" W	1445	Burn, July 1986 W. Side Saddle Road.
MID003	36° 116°	53' 12'	45.9" N 4.8" W	1452	Unburned, W. Side Saddle Road.
MID004	36° 116°	58' 10'	28.3" N 46.3" W	1439	Mid Valley Bladed Area
MID005	36° 116°	58' 10'	28.3" N 57.9" W	1445	Mid Valley Undisturbed Area
MID006	36° 116°	57' 11'	36.2" N 1.8" W	1445	Beatley Plot 42, SE Corner (UCLA)
MID007	36° 116°	57' 11'	38.3" N 1.0" W	1445	Beatley Plot 41, SE Corner (UCLA)

Plot	Latitude Longitude (NAD 1983)			Elevation (M)	Location
PAM001	37° 116°	15' 26'	11.2" N 54.8" W	1923	Pahute Mesa
PAM002	37° 116°	14' 28'	49.4" N 13.1" W	1911	U20ao Drill Pad
PAM003	37° 116°	14' 28'	44.9" N 26.0" W	1910	U20ao Undisturbed Area
PAM004	37° 116°	17' 19'	28.7" N 38.5" W	2103	U19e Drill Pad
PAM005	37° 116°	17' 19'	25.8" N 42.2" W	2103	U19e Undisturbed Area
PAM006	37° 116°	16' 8'	29.1" N 37.8" W	2134	U19ac Drill Pad
PAM007	37° 116°	17' 18'	1.7" N 2.1" W	2134	U19ac Undisturbed Area,
PAM008	37° 116°	11' 16'	46.1" N 45.8" W	1920	Pinyon Scale Plot
RAM001	37° 116°	11' 13'	20.9" N 0.9" W	2283	Rainier Mesa
RAM002	37° 116°	11' 12'	51.8" N 35.1" W	2263	Beatley Plot 64 (UCLA)
RED001	37° 116°	4' 13,	51.5" N 29.0" W	1612	Burned Area, July 1988 Redrock Valley
RED002	37° 116°	4' 13'	47.8" N 3.5" W	1612	Unburned Area Redrock Valley
ROV001	36° 116°	41' 11'	17.5" N 31.1" W	1032	Rock Valley UCLA Plot A
ROV002	36° 116°	41' 11'	26.8" N 9.8" W	1049	Rock Valley UCLA Plot B
ROV003	36° 116°	41' 11'	11.1" N 41.6" W	1033	Rock Valley UCLA Plot C
ROV004	36° 116°	41' 11'	29.0" N 24.5" W	1033	Rock Valley UCLA Plot D

Plot	Latitude Longitude (NAD 1983)			Elevation (M)	Location
ROV005	36° 116°	41' 11'	9.1" N 19.4" W	1036	Beatley Plot 3, SE Corner (UCLA)
ROV006	36° 116°	41' 10'	59.5" N 24.5" W	1049	Beatley Plot 4, SE Corner (UCLA)
ROV007	36° 116°	41' 11'	29.6" N 29.9" W	1030	Rock Valley IBP Plot 16
ROV008	36° 116°	41' 11'	10.0" N 16.6" W	1039	Rock Valley, Plot B W. 1/4 Mammal Grid
WAH001	36° 116°	48' 9'	48.0" N 47.2" W	1311	Beatley Plots 66 & 67 (UCLA)
YUF001	37° 116°	0' 4'	26.0" N 58.1" W	1237	Yucca Flat
YUF002	37° 116°	00' 6'	0.9" N 10.5" W	1288	Yucca Flat Burn (June 1985)
YUF003	36° 116°	59' 6'	49.8" N 15.8" W	1301	Yucca Flat Unburned
YUF004	37° 116°	3' 6'	6.0" N 19.0" W	1295	T1 Plots Romney UCLA #1
YUF005	37° 116°	3' 6'	8.0" N 29.0" W	1301	T1 Plots Romney UCLA #2
YUF006	37° 116°	3' 6'	12.0" N 39.0" W	1306	T1 Plots Romney UCLA #3
YUF007	37° 116°	3' 6'	13.0" N 51.0" W	1282	T1 Plots Romney UCLA #4
YUF008	37° 116°	3' 7'	16.0" N 0.0" W	1326	T1 Plots Romney UCLA #5
YUF009	37° 116°	2' 5'	50.8" N 45.0" W	1279	T1 Blast Area 960 M SE, GZ
YUF010	37° 116°	2' 5'	29.6" N 18.8" W	1267	T1 Undisturbed 1760 M SE, GZ
YUF011	37° 116°	2' 0'	52.0" N 23.0" W	1242	3B Consolidation Site

Plot	Latitude Longitude (NAD 1983)			Elevation (M)	Location
YUF012	37° 116°	2' 0'	57.8" N 8.9" W	1239	3B Undisturbed Area
YUF013	37° 116°	3' 0'	1.4" N 30.0" W	1236	T3 Blast Area ESE of GZ
YUF014	37° 116°	8' 6'	13.5" N 50.9" W	1371	T2 Blast Area
YUF015	37° 116°	8' 5'	46.0" N 54.0" W	1338	T2 Undisturbed Area
YUF016	37° 116°	10' 2'	44.6" N 25.9" W	1318	Sedan, 457 M NE GZ, 16A Line
YUF017	37° 116°	10' 2'	54.5" N 6.6" W	1327	Sedan, 1067 M NE GZ, 16A Line
YUF018	37° 116°	11' 1'	0.4" N 31.0" W	1335	Sedan, 1600 M NE GZ, 16A Line
YUF019	37° 116°	3' 1'	46.1" N 2.2" W	1213	U3cn Crater
YUF020	37° 116°	3' 1'	30.0" N 7.4" W	1241	U3cn Control
YUF021	37° 116°	4' 3'	48.3" N 7.7" W	1234	U7au Crater
YUF022	37° 116°	4' 2'	48.7" N 57.7" W	1251	U7au Control
YUF023	37° 116°	9' 3'	10.8" N 12.9" W	1277	U10af Crater
YUF024	37° 116°	9' 3'	10.6" N 24.8" W	1300	U10af Control
YUF025	37° 116°	5' 6'	35.1" N 4.5" W	1317	T-4 Blast Area
YUF026	37° 116°	5' 6'	19.8" N 28.4" W	1320	T-4 Undisturbed
YUF027	37° 116°	0' 4'	32.3" N 55.2" W	1227	Beatley Plot 46 (UCLA)

Plot	Latitude Longitude (NAD 1983)			Elevation (M)	Location
YUF028	37° 115°	2' 59'	33.4" N 30.4" W	1268	Beatley Plot 57 (UCLA)
YUF029	37° 116°	2' 5'	42.4" N 30.1" W	1305	T-1 Transition Zone
YUF030	37° 116°	10' 8'	48.8" N 23.4" W	1509	Beatley Plot 51 (UCLA)
YUF031	36° 115°	57' 59'	44.3" N 28.4" W	2104	Beatley Plot 60 (UCLA)

APPENDIX B
DATES BECAMP STUDY PLOTS WERE SAMPLED FOR *UTA STANSBURIANA* IN 1989

Plot	Spring		Summer	
	Started	Completed	Started	Completed
YUF001	March 28	April 3	July 20	July 26
YUF019	April 4	April 10	July 27	August 2
YUF020	April 4	April 10	July 27	August 2
YUF021	April 11	April 21	August 7	August 11
YUF022	April 11	April 21	August 7	August 11
YUF023	April 20	April 28	August 14	August 18
YUF024	April 20	April 28	August 14	August 18
PAM001	---	---	August 22	September 1

APPENDIX C
DATES BECAMP STUDY PLOTS WERE SAMPLED FOR *UTA STANSBURIANA* IN 1990

Plot	Spring		Summer	
	Started	Completed	Started	Completed
JAF001	March 12	March 16	July 22	July 30
FRF003	March 19	March 23	July 16	July 20
FRF004	March 19	March 23	July 16	July 20
YUF001	March 26	April 2	July 31	August 6
YUF002	April 3	April 11	August 6	August 13
YUF003	April 3	April 11	August 6	August 13
YUF014	April 13	April 26	August 14	August 22
YUF015	April 13	April 26	August 14	August 22
YUF025	April 26	May 7	August 20	August 27
YUF026	April 26	May 7	August 20	August 27
PAM001	---	---	September 4	September 10

APPENDIX D
DATES BECAMP STUDY PLOTS WERE SAMPLED FOR *UTA STANSBURIANA* IN 1991

Plot	Spring		Summer	
	Started	Completed	Started	Completed
FRF001	March 13	March 26	July 22	July 26
YUF001	March 29	April 3	August 19	August 23
PAM001	---	---	September 9	September 17
MER002	March 4	March 12	July 15	July 19
MER003	March 4	March 12	July 15	July 19
YUF009	April 8	April 17	August 26	August 30
YUF010	April 8	April 17	August 26	August 30
YUF011	April 18	April 24	August 12	August 17
YUF012	April 18	April 24	August 12	August 17
YUF013	April 18	April 24	August 12	August 17
YUF016	April 25	May 1	August 5	August 9
YUF017	April 25	May 1	August 5	August 9
YUF018	April 25	May 1	August 5	August 9

APPENDIX E
DATES BECAMP LIZARD TRANSECT LINES WERE SAMPLED (1989-1991)

Year	Plot	Date Started	Date Completed
<u>1989</u>			
	YUF001	May 17	June 2
<u>1990</u>			
	JAF001	May 8	May 14
	YUF001	May 15	May 21
	YUF002	May 21	June 5
	YUF003	May 21	June 5
	YUF025	June 6	June 18
	YUF026	June 6	June 18
	YUF014	June 18	June 26
	YUF015	June 18	June 26
<u>1991</u>			
	FRF001	June 3	June 7
	YUF001	June 17	June 21
	PAM001	June 24	July 2
	YUF009	July 3	July 11
	YUF010	July 3	July 11

APPENDIX F
STANDARD DATA SHEET FOR RECORDING MEASUREMENTS AND HEALTH STATUS OF DESERT
TORTOISES (*GOPHERUS AGASSIZII*) ON THE NTS

Date _____

Fieldworker _____

Tortoise Number _____

Study site location _____

Yr. first marked _____

Verif. of ID _____

County _____ State _____

Sex _____ Capture type _____

Time (PST) _____

Behavioral Data for Tortoises _____

Tortoise location _____

Tortoise behavior _____

Feeding of foods (all tortoises) _____

Body Measurements

MCL _____

M3 (post) _____

M4 (mid) _____

M7-8 (seam) _____

Gr Width _____
at _____

Ht (mid central) _____

3 _____

PLN _____

PLT _____

Wt (g) _____

void/feces _____

total _____

Anomalies, injuries
& parasites: place
on diagram

No. and type of
parasites _____

New growth

present _____

absent _____

Epoxied Number

present _____

legible _____

Finish time _____

Mark locations of
all notches on
diagram

Animals Health

Yes

No

Nares dry _____

Healthy looking _____

wheezing _____

clicking _____

Nares plugged
(crusty) _____

Nares moist
(glistening) _____

Nasal discharge
bubbles _____

white pigment _____

Eyes

sunken _____

swollen _____

lack luster _____

General appearance
animal healthy _____

**TRENDS IN SMALL MAMMAL POPULATIONS ON THE NEVADA TEST SITE:
1989 THROUGH 1991**

M. B. SAETHRE

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ABSTRACT

Five years of monitoring selected small mammal populations on the Nevada Test Site were completed in 1991. Monitoring, which began in 1987, focused on trends in heteromyid rodent populations on five baseline sites and included several sites disturbed by the Department of Energy nuclear testing program and site maintenance (e.g., craters, drill pads, blast areas) and by naturally occurring disturbances (e.g., lightning strike fires and gopher areas).

Results from the baseline site in western Yucca Flat indicated that small mammal populations declined coincidentally with a local drought from 1988 to 1990. Two species, *Dipodomys merriami* and *Perognathus longimembris*, rebounded during 1991, a year of good ephemeral plant biomass production.

Besides animal abundance on baseline sites, monitoring showed that areas where perennial vegetation had been removed by blasting, fires, grading, or gophers supported fewer species of rodents. More complex habitats in the undisturbed areas tended to have significantly greater species diversity. However, with the spring rainfall in 1991, ephemeral plants fared especially well on sites where competition from perennial plants was low (i.e., blasted, graded, gopher areas). Consequently, these sites had higher summer populations of kangaroo rats after spring reproduction and survival of juveniles.

INTRODUCTION

Mammal studies on the Nevada Test Site (NTS) began in 1959, with work by Brigham Young University (BYU) to determine species present on the NTS and habitat distributions of those species (Allred and Beck 1963a; Jorgensen and Hayward 1965). Since that time, work has included intensive small mammal studies in Rock Valley by University of California Los Angeles (UCLA) and other researchers, which included animal abundance, home range size, the effect of chronic radiation, and life spans in desert rodent populations (French 1964; French et al. 1966, 1967; French et al. 1974; French et al. 1968; Maza et al. 1973). Additional small mammal population studies were undertaken by the International Biological Program (IBP) in Rock Valley (Chew 1975; Dingman 1975; Turner 1973, 1974, 1975), and by the Nevada Applied Ecology Group (NAEG) in plutonium contaminated environments on the NTS (Moor and Bradley 1974; Bradley and Moor 1975, 1976, 1978; Moor et al. 1976; Bradley et al. 1976, 1977; Moor et al. 1977).

To date, 54 mammal species (including 9 bat species) have been documented as occurring on or in the vicinity of the NTS (Jorgensen and Hayward 1965; O'Farrell and Emery 1976; Medica 1990; EG&G/EM 1992). Most of the terrestrial species on the NTS are rodents. Many of the 23 rodent species inhabiting the NTS have adaptations for living in a desert environment, some of which are nocturnal behavior and physiological adaptations for water conservation.

The NTS straddles the transition zone between the communities of the Mojave (*Larrea - Ambrosia*) and Great Basin (*Artemisia*) deserts. Thus, available habitat on the NTS varies in vegetation, soil type, and elevation. While discrete communities of both deserts occur on the NTS, aspects of each are intermingled in the transition zone, yielding complex and unique habitats. These various vegetation communities (Allred et al. 1963; Beatley 1974; O'Farrell and Emery 1976) support rodent species which typify each habitat, with intergradation also occurring in the transitional areas (Jorgensen and Hayward 1965).

The abundance of rodents and species richness vary among habitats. Also important are seasonal activity changes such as breeding, dispersal, torpor, and hibernation (Allred and Beck 1963b; Allred et al. 1963; French et al. 1974). Annual fluctuations in rainfall may also cause changes in the available food supply (Beatley 1969, 1976). Most of the small mammals on the NTS are herbivores or granivores, and therefore depend on adequate quantities

of plant biomass, particularly green vegetation, for reproductive and growth energy (Kenagy 1972, 1973; Van De Graaff and Balda 1973; Reichman and Van De Graaff 1975; Kenagy and Bartholomew 1981). The dominant influence on the population size of small mammals on NTS has been an ongoing drought, most severe during 1989 and 1990. The below normal amount of rain on the NTS has severely depleted the live plant population (see R. B. Hunter, Perennials and Ephemerals sections of this report).

BECAMP STUDY SITES

Monitoring of small mammals on the NTS under the Basic Environmental Compliance and Monitoring Program (BECAMP) began in 1987 on permanent baseline sites in three major valley areas on the NTS (Hunter and Medica 1989). One disturbed site, a burned area, and an undisturbed area nearby were also censused that year. During the spring and summer of 1988 monitoring continued on the three existing baseline sites, and two new baseline sites were added on the tops of mesas. Along with those five sites, eight disturbed sites were studied in 1988. These sites included areas disturbed by aboveground nuclear tests and fire, and a gopher-denuded site (Saethre and Medica 1992). Each disturbed site was studied in conjunction with a plot in a nearby undisturbed area, which served as an undisturbed comparison.

The third, fourth, and fifth years of small mammal monitoring on the NTS were completed by BECAMP in 1989 through 1991. One baseline site (YUF001) was chosen to be censused yearly for small mammals, plants, and reptiles. The remaining baseline sites are to be censused every four years, while disturbed areas are to be sampled on a three-year cycle. Through 1991, the natural populations of small mammals were enumerated on the Yucca Flat (YUF001) baseline study site for five consecutive years. Three nonconsecutive years of small mammal data have been obtained from baseline plots in Jackass Flats (JAF001: 1987, 1988, 1990) and Frenchman Flat (FRF001: 1987, 1988, 1991), while two years of monitoring have been completed on the Pahute Mesa baseline plot (PAM001: 1988, 1990). A baseline site on Rainier Mesa (RAM001) has not been censused since 1988.

Disturbed areas that were censused for the first time in 1989 were three subsidence craters in Yucca Flat (YUF019, YUF021, and YUF023); a bladed area in Mid Valley (MID004); and a drill pad on Pahute Mesa (PAM002). The alpha-contaminated area in eastern Frenchman Flat, GMX (FRF005), was studied again in 1989 after 14 years. A burned area in Redrock Valley (RED001), which was

first sampled in 1988, was trapped again for small rodents in 1989 and 1990 - one and two years after the occurrence of a brush fire. An additional burned area in Yucca Flat (YUF002) that was first trapped in 1987 was also recensused in 1990. Two new study sites in 1990 were areas affected by aboveground nuclear testing (T2, YUF014 and T4, YUF025).

in 1989, while trapping in conjunction with monitoring the effects of liquid gaseous fuel spill testing, it was noted that on a control located near a paved road, the trap success was significantly higher than on a control farther away from paved surfaces (Hunter et al. 1991). In addition, nearly all of the adult kangaroo rats (*Dipodomys merriami* and *D. microps*) captured on the roadside control showed signs of reproductive activity. On two other controls, the majority of rodents did not appear to be reproductive. It was decided to set up two trap lines, one next to a paved road and one approximately 500 m away from any paved roads, to study the potential effect a roadside may have on reproduction and survivorship in rodents. These lines were trapped in July 1989 and then monthly from March 1990 to August 1990.

In 1991, no new disturbed sites were added to the small mammal monitoring program. Instead, the disturbed sites that were censused in 1988 were studied, completing the first three-year cycle of small mammal monitoring on the NTS. Sites studied in 1991 included a burned area in Mid Valley (MID002), a gopher-denuded site in Mercury Valley (MER002), Sedan (YUF016, YUF017), two aboveground blast areas (T1, YUF009 and T3, YUF013), a Rock Valley fenced plot (ROV008), and a waste consolidation site (3B, YUF012) that had been cleaned and where revegetation had begun. The locations of all of the above plots are shown in Figure 1. Locations in latitude and longitude and elevation are found in Appendix A, Trends in Reptiles section of this report.

Resident mammals on the Yucca Flat, Frenchman Flat, Jackass Flats, and Pahute Mesa baseline plots were sampled to provide information on species composition, relative densities of the most common species, and sex distributions of populations on relatively "pristine" sites. From the data obtained on disturbed sites and their controls, the effects of disturbances, if any, were evaluated. Plots with historical data (Sedan, Rock Valley, T2, and GMX) were resampled to document the stability of the populations over time.

Figure 1 - Locations of BECAMP small mammal study plots studied in 1989 through 1991.

METHODS

SMALL MAMMAL SAMPLING TECHNIQUES

Baseline Monitoring Sites

Small mammals were trapped on the baseline monitoring sites for three consecutive nights. Small nocturnal mammals were captured in Sherman live traps (8 x 9 x 30 cm) which were set to capture animals over 5 g (approximately the weight of a juvenile *Perognathus longimembris*). Each permanent study plot consisted of a 12 x 12 staked grid (144 stations) with 15 m between stakes (2.72 ha) and two traps set at each station (288 total traps). Two traps were used to provide more opportunities for animals to be captured in the short trapping period. Traps were baited in the early evening (1730+ hours) with a mixture of rolled oats and birdseed and placed under a metal (half-cylinder) trap cover to prevent hyperthermia from direct sunlight. Traps were checked shortly after sunrise for a total of 864 trap nights (number of traps times nights trapped) at each site, and closed for the day.

Each rodent was permanently marked. Kangaroo rats (*Dipodomys* spp.) and an occasional lagomorph (*Lepus californicus* and *Sylvilagus* spp.) were given individually numbered ear tags. One toe (number 500, see Hunter and Medica 1989, Figure 14) was removed on *Dipodomys* spp. to indicate a recapture in subsequent captures if the tag fell off. All other rodents, including squirrels, were toe-clipped with no more than one toe amputated per foot. Beginning in 1990, all rodents (except *Dipodomys deserti*) were marked with toe clips. Species, capture status (new or recapture), animal number, sex, reproductive condition, and grid location were recorded on field data sheets (Hunter and Medica 1989, Figure 15). Any bait was removed from cheek pouches and each animal was weighed to the nearest gram and released at the point of capture. Mean weights were analyzed using ANOVA, while sex ratios and trap success were analyzed using contingency tables in conjunction with chi-squared (X^2) statistics.

Disturbed Sites

Procedures on these plots did not differ from the baseline monitoring procedure except for plot size. Each subsidiary plot was smaller (1.08 to 1.17 ha) with the grid configuration depending on the shape of the disturbed area. In general, an 8 x 8 grid (1.10 ha) plot was used on the disturbed site

while a similarly-sized grid in an adjacent undisturbed area served as a control. On the roadside study area, two trap lines consisting of 150 traps at 10 m intervals were used. One line of traps was set up parallel and 20 m north of the center line of an existing paved road, while the other line was established approximately 500 m to the north, away from any paved roads.

In 1990, a grid system was constructed at the center of each trap line used in the roadside study. This consisted of two lines, 10 m on either side of the existing line and 26 traps long (0.50 ha). The south line on the roadside was on the berm of the road. In addition, 4 assessment lines were constructed at the center of and perpendicular to each line. These lines were 80 m apart and were each 31 traps long with traps at 10 m intervals. This was used to assess how far a rodent was captured at the roadside, where food apparently is abundant, how far a rodent might travel for food as compared to an animal trapped on the control line, where food patches might be more sparsely distributed.

Density Estimation

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

Data used to estimate the population size and results of the Seber equations for all plots sampled in 1989 to 1991 are listed in Appendix G. Data for 1988 density estimations are found in Saethre and Medica (1992, Appendix 4C). Because the variances are hypothetical and no degrees of freedom could be assigned, statistical tests for differences between estimated densities were not appropriate.

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

Species Diversity Index

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

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

was used as an index to measure 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 or to compare the same site between different years. Any differences between two sites or changes over time in the species diversity may indicate a loss of diversity (a decrease in H') or an increase in maturity, due to succession (increase in H') at a site.

LAGOMORPH CENSUS - TRANSECT LINES

Censuses for hares (*Lepus californicus*) and rabbits (*Sylvilagus* spp.) on the NTS were performed concurrently with the line transects for enumeration of lizards (see Medica et al., this report). Transects on baseline sites consisted of five parallel lines, 500 m long and 100 m apart. Lines on disturbed sites (burned and blasted areas) were of varying length, but generally consisted of four parallel lines with 400 m of each line in the disturbed area, 100 m in an ecotone, and another 400 m in the undisturbed area. Each line was walked simultaneously by three observers, 7.5 m apart.

When a rabbit or hare was observed, the flushing distance and angle when first observed were estimated and recorded along with time of observation.

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

$$D = \left(\frac{N}{2 r L} \right) * (10,000 \text{ m}^2/\text{ha})$$

L = Total distance walked in the transect in meters

N = Number of flushes

r = Mean flushing distance in meters.

The estimated densities of a species were averaged for all of the days that transects were walked (usually 5), and the standard error was calculated. Estimated densities and species observed at a site were compared to previous years' results whenever possible.

RESULTS

Species names appear in the results tables as the abbreviations listed in Table 1. Descriptions of the perennial and ephemeral plant compositions on all plots studied by BECAMP in 1989 through 1991 are discussed in the vegetation sections of this report and should be referred to for a more detailed account of the flora on these sites.

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*. This site has the most complete trapping record from 1987 to 1991, and a trend in small mammal populations emerged. During summer trapping in 1987 (28-30 July), 143 individual rodents were captured 283 times for an average capture rate of 1.98. After trapping on 26-28 April 1988, 97 animals were captured a total of 192 times for a similar average capture rate of 1.99. In 1989, 53 different animals were captured on 9, 10, and 12 May a total of 105 times for an average capture rate of 1.98 times per animal. On 16-18 May 1990, the average rate of

capture decreased to 1.69 (39 captured 66 times) but then increased to 2.08 on 7-9 May 1991 (62 captured 129 times). It is apparent that while the animals remained to be caught an average of two out of three trap nights (except for 1989), the total number of individuals decreased to a low of 39 animals in 1990.

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

	<u>Scientific Name</u>	<u>Common Name</u>
RODENTIA		
<u>Sciuridae</u>		
AMM LEU	<i>Ammospermophilus leucurus</i>	White-tailed antelope squirrel
SPE TER	<i>Spermophilus tereticaudus</i>	Round-tailed ground squirrel
<u>Heteromyidae</u>		
CHA FOR	<i>Chaetodipus formosus</i>	Long-tailed pocket mouse
DIP DES	<i>Dipodomys deserti</i>	Desert kangaroo rat
DIP MER	<i>Dipodomys merriami</i>	Merriam's kangaroo rat
DIP MIC	<i>Dipodomys microps</i>	Great Basin kangaroo rat
DIP ORD	<i>Dipodomys ordii</i>	Ord's kangaroo rat
MIC MEG	<i>Microdipodops megacephalus</i>	Dark kangaroo mouse
PER LON	<i>Perognathus longimembris</i>	Little pocket mouse
PER PAR	<i>Perognathus parvus</i>	Great Basin pocket mouse
<u>Muridae</u>		
NEO LEP	<i>Neotoma lepida</i>	Desert woodrat
ONY TOR	<i>Onychomys torridus</i>	Southern grasshopper mouse
PER CRI	<i>Peromyscus crinitus</i>	Canyon mouse
PER ERE	<i>Peromyscus eremicus</i>	Cactus mouse
PER MAN	<i>Peromyscus maniculatus</i>	Deer mouse
PER TRU	<i>Peromyscus truei</i>	Pinyon mouse
REI MEG	<i>Reithrodontomys megalotis</i>	Western harvest mouse
<u>Geomyidae</u>		
THO BOT	<i>Thomomys bottae</i>	Botta's pocket gopher
LAGOMORPHA		
<u>Leporidae</u>		
LEP CAL	<i>Lepus californicus</i>	Black-tailed jack rabbit
SYL AUD	<i>Sylvilagus audubonii</i>	Desert cottontail rabbit
SYL NUT	<i>Sylvilagus nuttallii</i>	Nuttall's cottontail rabbit
CARNIVORA		
<u>Mustelidae</u>		
MUS FRE	<i>Mustela frenata</i>	Long-tailed weasel

Estimates of spring density (number of animals per hectare $\pm$ two standard errors) for the most common rodents captured on YUF001 in 1988 through 1991 also indicated a continual reduction in the density at this site until 1991, when densities increased on this plot for two species (Table 2). Most

noticeable was the 53% decrease in density of *Perognathus longimembris* in 1989, and followed by a decrease of 9% in 1990, and a 61% increase in 1991. These results coincide with low rainfall in 1989 and 1990 and higher rainfall in 1988 and 1991.

Table 2. Estimated densities (number per hectare $\pm$ 2 SE) and species diversity (H') of small mammals on the BECAMP baseline plot in Yucca Flat from 1987 to 1991. Numbers in parentheses are individuals captured.

Species	1987 28,29,30	1988 26,27,28	1989 9,10,12	1990 16,17,18	1991 7,8,9
DIP MER	9.8 $\pm$ 0.3	5.2 $\pm$ 0	3.4 $\pm$ 0	5.0 $\pm$ 1.3	7.4 $\pm$ 0
DIP MIC	5.0 $\pm$ 0.7	5.2 $\pm$ 0.8	2.7 $\pm$ 0.7	2.3 $\pm$ 1.0	1.4 $\pm$ 0
PER LON	27.8 $\pm$ 2.4	19.0 $\pm$ 1.8	9.0 $\pm$ 1.6	8.2 $\pm$ 4.7	13.2 $\pm$ 3.5
PER MAN	*(1)	---	*(4)	---	---
ONY TOR	*(9)	*(2)	*(3)	*(3)	---
AMM LEU	*(2)	*(4)	*(1)	---	*(1)
SYL AUD	---	*(1)	---	---	---
N/ha	44.1 (143)	29.9 (97)	16.4 (53)	12.0 (39)	19.1 (62)
Species	6	6	6	4	4
H'	0.5057	0.5097	0.6052	0.5292	0.4110
* Species present but data insufficient to estimate density.					

While the densities of *Dipodomys merriami* and *P. longimembris* increased from 1990 to 1991, the estimated density of *Dipodomys microps* continued to decline. This species rarely has more than one reproductive cycle per year and is dependent on green perennial vegetation for reproductive energy (Beatley 1969; Kenagy 1973). Although sufficient late winter/early spring precipitation caused an abundant annual plant germination in the spring of 1991 (Hunter, Trends In Ephemeral Plant Populations On The Nevada Test Site, 1989 through 1991), the standing live perennial biomass might not have been sufficient for a successful reproductive season in *D. microps*. However, *D. merriami* and *P. longimembris* are able to gain water and food resources for reproduction from green material of annual plants, and may successfully produce offspring for most of the active year (Bradley and Mauer 1971; Kenagy 1973).

The distribution of the total captured population among species for the five years (Table 3) changed drastically. In 1987 and 1988, 92% and 93% of the captured population of animals consisted of the heteromyid rodents, *Dipodomys* spp. and *Perognathus longimembris*. In 1989, this percentage decreased slightly to 85%, mainly due to the fact that only half as many individual *D. microps* (50% decrease) and *P. longimembris* (55% decrease) were captured in 1989 compared to 1988, while the number of murid rodents (*Onychomys torridus* and *Peromyscus maniculatus*) increased to 13% of the captured population. Furthermore, *D. merriami* showed a 35% decrease in the total number of individuals captured from 1988 to 1989 (Table 2). As a result of the change in species distribution, species diversity (H') decreased significantly in 1991 (t-test, $0.02 < p < 0.05$).

Table 3. Percent of total captured population (%T) and sex ratio (M/F = male : female) of small mammals on the baseline plot, YUF001, in 1987 to 1991.

Species	1987		1988		1989		1990		1991	
	%T	M/F	%T	M/F	%T	M/F	%T	M/F	%T	M/F
DIP MER	22.4	13:19	17.5	11:6	20.7	5:6	35.9	9:5	38.7	12:12
DIP MIC	11.2	9:7	16.5	9:7	15.1	6:2	15.4	4:2	6.5	2:2
PER LON	58.0	44:39	58.8	27:30	49.1	13:13	41.0	3:13 ^b	53.2	14:19
PER MAN	0.7	0:1	---	---	7.5	3:1	---	---	---	---
ONY TOR	6.3	2:7	2.1	2:0	5.7	2:1	7.7	2:1	---	---
AMM LEU	1.4	0:2	4.1	2:2	1.9	0:1	---	---	1.6	1:0
SYL AUD	---	---	1.0	I ^a	1.9	0:1	---	---	1.6	1:0

^aOne juvenile of indeterminate (I) sex was captured.

^bSignificantly different from 1:1 ($\chi^2 = 6.25, 0.01, p < 0.025$).

While species diversity decreased significantly from 1990 to 1991, the Yucca Flat baseline site appeared to be recovering from the drought in 1991, after reaching a low of only 8.2 *P. longimembris* per/ha in 1990. Although the density of *D. merriami* increased from 1989 to 1990, both *P. longimembris* and *D. microps* continued to decline, with *D. microps* continuing to decline into 1991 to only 1/4 the 1988 population size.

Trap success (number of total captures divided by trap nights) decreased significantly from 22% in 1988 to 12% in 1989 and 8% in 1990 (χ^2 , $p < 0.05$), except *P. longimembris* in 1990 ($\chi^2 = 6.25, 0.01 < p < .025$) while a significant increase was seen in 1991 to 15%. This plot was trapped in the summer of 1987 and had a trap success of 33%, which was significantly higher than all other years (χ^2 , $p < 0.05$), but was in a different season (summer). Overall, there was a dramatic decrease in the resident population of rodents, most likely due to the effect of drought on the ephemeral and perennial plants used as a food source.

The sex ratios (Table 3) for all species captured on YUF001 from 1988 to 1991 did not differ significantly from 1:1 (χ^2 , $p > 0.05$), except *P. longimembris* in 1990 ($\chi^2 = 6.25, 0.01 < p < .025$). The mean weight of adult male *Dipodomys merriami* (Table 4) was significantly greater than that of adult females in 1989 (ANOVA, $0.02 < p < 0.05$) and in 1988 (Saethre and Medica 1992), but not in 1990 nor 1991 ($p > 0.10$). The mean weight of adult male *Perognathus longimembris* (Table 4) did not differ significantly from the mean weight of adult females in 1988, nor in 1989 and 1990 ($p > 0.10$), but was significantly greater in 1991 ($0.02 < p < 0.05$).

Table 4. Spring mean weights (grams $\pm$ 2 SE) by sex and age of heteromyid rodents captured on the Yucca Flat baseline plot in 1988 through 1991.

Species	Sex	Age	1988		1989		1990		1991	
			N	Weight	N	Weight	N	Weight	N	Weight
PER LON	M	A	27	8.3 $\pm$ 0.3	13	7.6 $\pm$ 0.5	3	8.5 $\pm$ 1.0	14	8.4 $\pm$ 0.3
	F	A	30	8.0 $\pm$ 0.2	13	7.6 $\pm$ 0.3	13	8.0 $\pm$ 0.5	19	7.7 $\pm$ 0.3
DIP MER	M	A	11	42.5 $\pm$ 0.9	4	42.6 $\pm$ 2.1	8	40.8 $\pm$ 1.7	12	39.7 $\pm$ 2.2
	F	A	6	39.6 $\pm$ 2.0	5	38.2 $\pm$ 2.6	4	37.6 $\pm$ 3.0	10	40.4 $\pm$ 2.1
	M	J	0		1	22.0	1	22.5	0	22.3 $\pm$ 1.3
	F	J	0		1	20.5	1	30.0	2	
DIP MIC	M	A	5	63.2 $\pm$ 4.2	4	58.9 $\pm$ 3.3	4	62.9 $\pm$ 4.6	1	69.3
	F	A	5	58.8 $\pm$ 5.2	0		0		2	55.8 $\pm$ 8.3
	M	J	4	36.7 $\pm$ 2.7	2	36.0 $\pm$ 4.0	0		1	45.0
	F	J	1	47.0	2	31.5 $\pm$ 3.0	2	44.8 $\pm$ 6.3	0	

Jackass Flats - JAF001

The baseline site in Jackass Flats, in the southwestern corner of the NTS in a *Larrea tridentata* - *Ambrosia dumosa* plant community, was first trapped for small mammals during late summer of 1987 (4-6 August). Since 1987, two spring censuses have been completed: 12-14 April 1988 and 9-11 May 1990. From April 1988 to May 1990, the number of small mammals residing on this plot decreased by nearly 75% (101 individual animals captured in 1988 compared to 26 captured in 1990). The estimated density of *Dipodomys merriami* on this plot by over 56% (from 10.6 in 1988 to 4.6 in 1990) while the density of *Perognathus longimembris* dropped by 82% (Table 5).

Table 5. Estimated density (N/ha $\pm$ 2 SE) and species diversity (H') of small mammals on the BECAMP baseline site in Jackass Flats during 1987, 1988, and 1990. Numbers in parentheses are individuals captured.

Species	1987 4,5,6 August		1988 12,13,14 April		1990 8,10,11 May	
DIP DES	*	(1)	*	(1)	---	
DIP MER	13.4 $\pm$ 4.0	(40)	10.6 $\pm$ 0.8	(33)	4.6 $\pm$ 0.8	(14)
PER LON	40.9 $\pm$ 6.9	(101)	34.5 $\pm$ 11.4	(67)	6.2 $\pm$ 5.2	(10)
ONY TOR	---		---		*	(1)
AMM LEU	*	(1)	---		*	(1)
SPE TER	*	(1)	---		---	
N/ha	44.4	(144)	31.2	(101)	8.0	(26)
Species	5		3		4	
H'	0.3075		0.2968		0.4132	

* Species present but data insufficient to estimate density.

Although the average number of captures per animal remained relatively consistent among the three trapping periods (1.64 in 1987, 1.57 in 1988 and 1.73 in 1990), the percent trap success dropped considerably (27, 18 and 5% in 1987, 1988 and 1990, respectively). At this site, two heteromyid rodents (*Dipodomys merriami* and *Perognathus longimembris*, accounted for over 90% of the entire captured population (Table 6). Sex ratios of the two most commonly trapped rodents (Table 6) did not differ significantly from 1:1. Species diversity (H') did not change from 1988 to 1990 (Table 5) but not significantly. This area is considerably more sandy than the Yucca Flat

baseline site and had lower plant density and fewer plant species (Hunter 1992).

Table 6. Percent of total captured population (%T) and sex ratio (M/F) of small mammals on the BECAMP Jackass Flats baseline plot, JAF001, in 1987, 1988, and 1990.

Species	1987		1988		1990	
	%T	M/F	%T	M/F	%T	M/F
DIP DES	0.7	1:0	1.0	0:1	---	---
DIP MER	27.8	24:16	32.7	21:12	53.8	10:4
PER LON	70.1	55:46	66.3	31:36	38.5	5:5
ONY TOR	---	---	---	---	3.8	*
AMM LEU	0.7	0:1	---	---	3.8	0:1
SPE TER	0.7	0:1	---	---	---	---

*one animal of undetermined sex not included.

The mean spring weights of *Perognathus longimembris* (Table 7) did not change significantly from 1988 to 1990 (ANOVA, $p > 0.10$). However, the mean weight of adult *Dipodomys merriami* was significantly greater for both sexes in 1988 than in 1990 ($p < 0.001$). Female kangaroo rats showed no physical evidence of reproductive activity in 1990, while 50% of the female kangaroo rats on this site in the spring of 1988 showed such evidence. Males in both years were reproductively active.

Table 7. Spring mean weights (grams $\pm$ 2 SE) by sex of the most common rodent species on the Jackass Flats baseline site in 1988 and 1990. Only adults were captures.

Species	Sex	Age	1988		1990	
			N	Weight	N	Weight
PER LON	M	A	31	7.3 $\pm$ 0.9	5	7.2 $\pm$ 0.4
	F	A	36	7.4 $\pm$ 0.8	5	6.8 $\pm$ 0.8
DIP MER	M	A	21	40.9 $\pm$ 1.3	10	34.1 $\pm$ 1.0
	F	A	12	41.6 $\pm$ 2.3	4	30.9 $\pm$ 1.0

Frenchman Flat - FRF001

Small mammals were first trapped by BECAMP personnel on the Frenchman Flat baseline site on 7-9 July 1987. Spring censuses were done on this site on 12-14 April 1988 and 30 April-2 May 1991. This site was also trapped for small mammals on 5 August 1988 to determine the summer resident mammals and again in 18-19 June 1991. The site was trapped in June 1991 because early morning temperatures in late April - early May were low (~7°C) and very few little pocket mice (*Perognathus longimembris*) were captured. To determine whether or not the pocket mice were inactive due to the low temperature or declined drastically in density from 1988 levels (Table 8) due to drought conditions, the site was retrapped during warmer weather.

Table 8. Estimated density (H/ha $\pm$ 2 SE) and species diversity (H') of small mammals on the BECAMP baseline site in Frenchman Flat during 1987, 1988, and 1991. Numbers in parentheses are individuals captured.

Species	1987 7,8,9 July		1988 12,13,14 April		1991 30 April, 1,2 May	
CHA FOR	---		---		*	(1)
DIP MER	11.4 $\pm$ 0.8	(36)	4.9 $\pm$ 0	(16)	4.3 $\pm$ 0	(14)
PER LON	26.6 $\pm$ 2.9	(77)	24.2 $\pm$ 4.0	(64)	*	(2)
ONY TOR	*	(3)	*	(1)	---	
AMM LEU	*	(4)	*	(1)	---	
SPE TER	*	(1)	---		---	
N/ha	37.4	(121)	25.3	(82)	5.2	(17)
Species	5		4		3	
H'	0.3875		0.2204		0.2512	

*Species present but data insufficient to estimate density.

The density of kangaroo rats on this plot did not decrease significantly from 1988 to 1991. However, a dramatic decrease in *Perognathus longimembris* was seen from 64 animals in the spring of 1988 to only two animals in 1991. When this site was trapped later in 1991, only one other *P. longimembris* was captured, indicating that the decline in the estimated population was a real phenomenon. While trap success declined from 1988 (17%) to 1991 (5%), the average number of captures for each individual increased from 1.78 captures per animal in 1988 to 2.35 in 1991, indicating that the trap success in 1991 would have been lower except for "trap-happy" rodents. There was no

significant change in species diversity index (H' , Table 8) from 1988 to 1991 (t-test, $p>0.10$).

While *Perognathus longimembris* was the dominant rodent in 1987 and 1988, in 1991, *Dipodomys merriami* accounted for 82% of the animals captured (Table 9). These two species of rodents still comprised over 90% of the animals in all three years. Occasional captures of grasshopper mice (*Onychomys torridus*), squirrels (*Spermophilus tereticaudus* and *Ammospermophilus leucurus*) and one other pocket mouse (*Chaetodipus formosus*) accounted for the other 6 to 8% of the animals captured. *C. formosus*, while abundant in the valleys just south of Frenchman Flat (see Mercury Valley gopher and Rock Valley sites, this report), was captured for the first time at this site in 1991, although it was captured on the roadside transect approximately 100 m away in 1990.

Sex ratios for the most common rodents (Table 9) did not differ significantly from 1:1 (χ^2 , $p>0.05$). Mean weights (Table 10) did not differ significantly between sex or year for *Dipodomys merriami* (ANOVA, $p>0.05$). This site

Table 9. Percent of total captured population (%T) and sex ratio (M/F) of small mammals on the BECAMP Frenchman Flat baseline site, FRF001, in 1987, 1988, and 1991.

Species	1987		1988		1991	
	%T	M/F	%T	M/F	%T	M/F
CHA FOR	---	---	---	---	5.9	1:0
DIP MER	29.8	15:21	19.5	9:7	82.3	6:8
PER LON	63.6	39:38	78.1	25:39	11.8	1:1
ONY TOR	2.5	2:1	1.2	0:1	---	---
AMM LEU	3.3	2:2	1.2	1:0	---	---
SPE TER	0.8	0:1	---	---	---	---

Table 10. Spring mean weights (grams $\pm$ 2 SE) by sex and age of the common rodent species in the Frenchman Flat baseline site in 1988 and 1991.

Species	Sex	Age	April 1988		May 1991		June 1991	
			N	Weight	N	Weight	N	Weight
Per LON	M	A	25	7.8 $\pm$ 0.3	1	7.7	2	8.5 $\pm$ 1.0
	F		39	7.5 $\pm$ 0.3	0		1	7.0
			0		0		0	

Table 10, continued.

Species	Sex	Age	April 1988		May 1991		June 1991	
			N	Weight	N	Weight	N	Weight
DIP MER	M	A	0		1	6.0	0	
			8		0	6.0	8	
			9	41.6 $\pm$ 1.0	6	40.3 $\pm$ 1.1	5	40.4 $\pm$ 0.9
	F	A	7	39.7 $\pm$ 2.9	6	39.6 $\pm$ 3.4	3	37.7 $\pm$ 4.1
			0		0		0	
			0		2	32.2 $\pm$ 2.7	0	

appeared to be one of the areas most affected by the drought, with little precipitation and no ephemeral germination taking place in 1990. Precipitation in 1991 in Frenchman Flat was lower than in other areas monitored on the NTS and little germination or growth of annual plants occurred. This area also had a severe loss of live perennial biomass from 1988 to 1991. Therefore, it was not surprising that this area showed a marked population decline.

Pahute Mesa - PAM001

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

In 1988, a new species for this area was recorded (Medica 1990; Saethre and Medica 1992) when one dark kangaroo mouse, *Microdipodops megacephalus*, was captured on this site (Table 11) in and near the wash. Also in 1988, due to inexperience, no distinction could be made as to which species of *Peromyscus* were captured. In 1990, it was determined that the species were *P. crinitus*, the canyon mouse, *P. maniculatus*, the deer mouse, and *P. truei*, the pinyon mouse. *Perognathus parvus* and *Peromyscus* spp. were the most commonly captured species in 1988 and 1990 and species diversity (H' , Table 11) did not change significantly from 1988 to 1990.

Overall, as on the rest of the NTS, the number of animals captured on this site declined from 1988 to 1990 (Table 11). The most common species captured in 1988, *Perognathus parvus*, was present in 1990 at less than half of the 1988 estimated density (Table 11). Trap success in 1990 (5.6) was also only 50% of the 1988 success (11%), while average captures per animal remained approximately equal between 1988 (1.85 times) and 1990 (1.77 times). While this area also had lower than normal winter precipitation in 1988 to 1991, annual precipitation was higher than at other sites at lower elevations.

Table 11. Estimated density (N/ha $\pm$ 2 SE), percent of captured population (%T), sex ratio (M/F) and species diversity (H') of small mammals on the baseline site on Pahute Mesa in 1988 and 1990. Numbers in parentheses are individuals captured.

Species	June 1988				June 1990			
	Density	%T	M/F		Density	%T	M/F	
DIP MIC	* (2)	3.7	1:1		* (2)	7.4	1:2	
MIC MEG	* (1)	1.9	1:0		* (3)	11.1	1:2	
PER PAR	10.9 $\pm$ 0.9 (34)	63.0	20:14		4.4 $\pm$ 0.4 (14)	51.9	7:7	
NEO LEP	* (2)	3.7	2:0		* (1)	3.7	1:0	
PER CRI	---				* (1)	3.7	0:1	
PER MAN	---				1.7 $\pm$ 0.7 (5)	18.5	2:3	
PER TRU	---				* (1)	3.7	1:0	
PER SPP ^a	4.3 $\pm$ 0.8 (13)	24.1	9:4		2.8 $\pm$ 1.4 (7)	25.9	3:4	
AMM LEU	* (1)	1.8	1:0		---			
SYL NUT	* (1)	1.8	1 ^b		---			
N/ha	16.4 (54)				8.3 (27)			
Species	7+				7			
H'	0.4828				0.6323			

* Species present but data insufficient to estimate density.

^a*Peromyscus* species not differentiated.

^bOne juvenile of indeterminate (I) sex was captured.

While the total number of individuals captured decreased from 1988 to 1990 on this site, it appears that the decrease occurred over all of the species, with two of those, *Sylvilagus nuttallii* and *Ammospermophilus leucurus*, not even captured in 1990. That the ground squirrel, *A. leucurus*, was not captured did not mean a disappearance of this species. It is a diurnal mammal and not

regularly captured on any plot during night trapping on NTS. Capturing rabbits in the Sherman-type traps used is also a rare occurrence. Sex ratios (Table 11) of the most commonly captured species did not differ significantly from 1:1 (chi-square, $p>0.05$), and mean weights of the animals captured on the Pahute Mesa site were also not significantly different between the two years (Table 12).

Table 12. June mean weights (grams $\pm$ 2 SE) by sex and age of the common rodent species on the Pahute Mesa baseline site in 1988 and 1990.

Species	Sex	Age	1988		1990	
			N	Weight	N	Weight
PER PAR	M	A	9	20.0 $\pm$ 1.5	4	18.5 $\pm$ 3.0
	F	A	6	19.8 $\pm$ 1.7	2	17.8 $\pm$ 3.5
	M	A	11	12.7 $\pm$ 0.9	3	14.0 $\pm$ 1.2
	F	A	8	11.5 $\pm$ 1.3	5	12.6 $\pm$ 0.9
MIC MEG	M	A	1	13.0	1	13.0
	F	A	0		2	12.7 $\pm$ 0.7
DIP MIC	M	A	1	50.0	1	47.0
	F	A	0		1	46.0
	M	J	0		0	
	F	J	1	32.0	0	
PER SPP*	M	A	6	18.3 $\pm$ 2.1		
	F	A	2	17.0 $\pm$ 2.0		
	M	J	3	12.5 $\pm$ 1.0		
	F	J	2	13.0 $\pm$ 1.0		
PER TRU	M	A			1	18.0
PER CRI	F	A			1	19.0
PER MAN	M	A			2	15.8 $\pm$ 2.5
	F	A			2	18.8 $\pm$ 0.5
	M	J			0	
	F	J			1	12.0

*In 1988, the mean weight includes all *Peromyscus* species captured.

DISTURBED AREAS

Subsidence Craters

Three subsidence craters were studied in Yucca Flat along with a corresponding control plot in relatively undisturbed habitat outside of and adjacent to the

crater area. The three craters were of varying depth and diameter with distinctive vegetational differences. However, the bottoms of all three craters resembled a small playa and had little vegetation, with the exception of a few small ephemeral plants, most noticeably *Salsoia* spp. Depth, diameter, and date of test for the three craters are given in Table 13.

Table 13. Date of test and maximum depth and width of the three craters sampled by BECAMP in 1989.

Crater	Date of Test	Maximum Depth (m)	Maximum Width (m)
U3cn	September 13, 1963	25.0	393.2
U7au	September 27, 1978	15.7	398.4
U10af	September 7, 1967	22.7	347.5

Vegetation characteristics and lizard densities for the crater plots and controls are found in the Perennials, Ephemerals, and Reptiles sections of this report. All three craters are on the eastern side of Yucca Flat (Figure 1). However, plant communities (including species richness and cover) of the three control plots were dissimilar.

Trapping grids were constructed as close as possible to the center of each crater with the outer perimeter trap lines usually ending up on one slope of the craters. A road exists to the bottom of crater U3cn so that the plot grid was actually in the southeastern corner of the crater bottom. A plot of equal size was located outside the crater impact area. Plot sizes were 8 x 8 (1.10 ha) except for U7au and its control, which were 9 x 7 (1.08 ha). Also at the bottom of U3cn is a ~1.5-m- diameter and 3-m-high casing pipe that has been repeatedly used as a nesting site for ravens, *Corvus corax*. An anomaly at the U10af crater is a sanitary landfill less than 100 m south of the crater. This dump was frequented by numerous ravens until better burial procedures were implemented in 1990. Since then, the number of ravens has decreased (P. D. Greger, this report).

The most abundant species of rodent captured on all six of the plots, *Dipodomys merriami*, ranged from a low of 3 animals in U7au crater and its control plot to a high of 31 animals on the U10af control (Table 14). There

was no clear trend in animal abundance or species composition (Table 15) common to all three sites which might distinguish a crater from undisturbed habitat, although species diversity (H') was significantly greater (t-test, $0.02 < p < 0.05$) on the U7au control as compared to the U7au crater bottom.

Percent trap success did not differ significantly between the U3cn crater plot (13%) and its control (12%), nor between the U7au crater plot (2%) and its control (2%) (χ^2 , $p > 0.05$). The trap success on the U10af control plot, 23%, was significantly greater than the 11% in U10af crater ($p < 0.001$). Temperature was possibly a factor in the low trap success on the U7au plots: a reading of 7°C was common on the three mornings between 0630 and 0730 hours on the U7au sites (sampled April 25-27), while temperatures of 13 to 17°C were more common at the other four crater sites during the same time of day (U3cn was sampled May 17-19 and U10af was sampled during May 23 to June 1). Crater U7au was also the shallowest and the youngest crater studied (Table 13), so any conclusions on the effect of cold, depth, or age can only be tentatively made. Heteromyid rodents (*Dipodomys* and *Perognathus*) comprised between 57.2% (U7au control) to 95.5% (U3cn control) of the total captured population (Table 14).

Nearly all of the rodents captured on the crater plots were in edge traps located closest to relict stands of perennial vegetation that were growing on the slopes of the craters. Again, crater U3cn differed in that large shrub clumps were sparsely distributed over 75% of the plot. While males were captured more frequently than females, the ratios of males to females for the most abundant species (Table 15) on each of the six plots were not significantly different from 1:1 (χ^2 , $p > 0.05$). There were no significant differences between mean weights of males and females on any of the six plots or between a crater and its control (Table 16).

Table 14. Estimated spring densities (N/ha $\pm$ 2 SE) and species diversity (H') of small mammals on the Yucca Flat crater and control plots in 1989. Numbers in parentheses are individual animals captured.

SPECIES	YUF019 U3CN		YUF020 CONTROL		YUF021 U7AU		YUF022 CONTROL		YUF023 U10AF		YUF024 CONTROL	
DIP ME	12.0 $\pm$ 0.8	(17)	9.3 $\pm$ 1.0	(13)	*	(3)	*	(3)	11.8 $\pm$ 0	(17)	24.3 $\pm$ 5.0	(31)
DIP MIC	*	(4)	---		---		*	(1)	*	(4)	7.1 $\pm$ 0.8	(10)
PER LON	---		6.0 $\pm$ 1.4	(8)	---		---		*	(1)	*	(1)
ONY TOR	---		---		---		*	(2)	---		*	(1)
PER MAN	*	(1)	*	(1)	*	(2)	---		*	(4)	*	(3)
AMM LEU	*	(1)	---		---		*	(1)	*	(1)	---	---
N/ha	19.0	(23)	15.3	(22)	3.5	(5)	4.9	(7)	18.8	(27)	31.9	(46)
Species	4		3		2		4		5		5	
H'	0.3476		0.3558		0.2923		0.5446		0.4783		0.4092	

*Species present but data insufficient to estimate density.

Table 15. Percent of total captured population (%T) and sex ratio (M/F) of small mammals on the BECAMP Yucca Flat crater sites on NTS in 1989.

SPECIES	U3cn				U7au				U10af			
	CRATER		CONTROL		CRATER		CONTROL		CRATER		CONTROL	
	%T	M/F	%T	M/F	%T	M/F	%T	M/F	%T	M/F	%T	M/F
DIP MER	73.9	12:5	59:1	10:3	60.0	2:1	42.9	3:0	63.0	11:6	67.4	18:13
DIP MIC	17.4	2:2	---	---	---	---	14.3	1:0	14.8	2:2	21.7	5:5
PER LON	---	---	36.4	4:4	---	---	---	---	3.7	1:0	2.2	0:1
ONY TOR	---	---	---	---	---	---	28.5	0:2	---	---	2.2	0:1
PER MAN	4.4	1:0	4.5	0:1	40.0	1:1	---	---	14.8	1:2 ^a	6.5	2:1
AMM LEU	4.3	0:1	---	---	---	---	14.3	0:1	3.7	1:0	---	---

^aOne animal of undetermined sex not included.

2 of 6

Table 16. Spring mean weights (grams $\pm$ 2 SE) sex and age of heteromyid rodents captured at three crater sites and controls in Yucca Flat in 1989.

Species	Sex	Age	U3cn				U7au				U10af			
			Crater		Control		Crater		Control		Crater		Control	
			N	Weight	N	Weight	N	Weight	N	Weight	N	Weight	N	Weight
PER LON	M	A	0		3	8.0 $\pm$ 0	0		0		1	8.0	0	
	F	A	0		1	7.0	0		0		0		0	
	M	A	0		1	6.7	0		0		0		0	
	F	J	0		3	6.0 $\pm$ 0	0		0		0		1	6.0
DIP MER	M	A	10	42.2 $\pm$ 3.0	8	41.8 $\pm$ 2.1	1	41.0	3	42.0 $\pm$ 4.6	10	42.8 $\pm$ 1.9	13	39.1 $\pm$ 1.9
	F	A	4	42.2 $\pm$ 3.0	3	40.3 $\pm$ 3.5	1	44.0	0		6	39.8 $\pm$ 1.9	11	40.0 $\pm$ 2.5
	M	J	2	30.2 $\pm$ 1.0	2	21.0 $\pm$ 2.0	1	33.0	0		1	32.5	4	24.7 $\pm$ 2.6
	F	J	1	20.0	0		0		0		0		2	26.7 $\pm$ 6.7
DIP MIC	M	A	2	72.5 $\pm$ 5.0			0		1	59.3	1	65.0	3	53.8 $\pm$ 3.7
	F	A	0				0		0		1	55.3	5	49.2 $\pm$ 3.7
	M	J	0				0		0		1	44.0	2	39.8 $\pm$ 6.3
	F	J	2	41.5 $\pm$ 7.0			0		0		1	45.0	0	

T-Sites

Four blast areas where tower-supported nuclear detonations were conducted (T-sites) from 1952 to 1957 have been sampled by BECAMP for small mammals. Three of these sites, T1, T2, and T4, are on the western side of Yucca Flat, while the fourth site, T3, is on the eastern side (see Figure 1). T1 and T3 blast zones were first trapped by BECAMP in 1988 and then again in 1991. The blast areas at T2 and T4 were trapped by BECAMP only in 1990. Historically, T1 was studied by BYU (Jorgensen and Hayward 1965) while T2 was sampled for small mammals by EG&G from June 1982 to May 1983 (O'Farrell and Sauls 1987b). In the future, all four sites will be sampled for small mammals in the same year so that direct comparisons can be made.

T1

The ground zero (GZ) located at T1 was the site of four tower-supported test series between 1952 and 1957 (Kordas and Anspaugh 1982). The blast effects from these tests completely cleared the large shrub vegetation in a circular area of approximately 500 ha. This area has since been reinvaded by *Salsola* spp., *Stipa speciosa*, *Bromus rubens*, and *Bromus tectorum*. Several salt bush shrubs, *Atriplex canescens*, also became established in the blast zone (see Hunter, this report). Small mammals at this site were studied by BYU during intensive trapping studies from 1959 to 1965 (White and Allred 1961; Jorgensen and Hayward 1965). Two BECAMP plots are located on a BYU trap line, 960 and 1760 m southeast of GZ. The 960 m plot is located outside the fence which encloses the radiation exclusion (RADEX) area immediately surrounding GZ. The 1760 m plot is located in an undisturbed *Grayia-Lycium* plant community (as defined by Allred et al. 1963 and Beatley 1974), but had an abundance of *Atriplex canescens* and perennial bunch grasses as well.

Mammals were trapped at the T1 blast zone and control plots on 4, 16-18 May and 9-10 August 1988, and on 21-23 May 1991. By August, most of the nocturnal rodents were inactive, with the exception of *Dipodomys merriami* which was still abundant at both sites (Table 17). Summer trapping was performed only to assess the summer resident species. Two additional species were captured on the blasted area in August, *Amмосpermophilus leucurus* and *Reithrodontomys megalotis*, both of which were captured on the control plot in May (Table 17).

The estimated spring densities (Table 17) of the most commonly captured species at the T1 blast area and undisturbed site decreased from 1988 to 1991.

The decline in the estimated population size of *Perognathus longimembris* on each site, however, was the most drastic. Thirty-eight pocket mice were captured on the undisturbed area in 1988 and only 5 in 1991 (Table 17). The species diversity (H' , Table 17) declined significantly from May 1988 to May 1991 on both areas, and continued to be significantly greater on the control area than on the blast area.

Table 17. Estimated densities ($N/ha \pm 2$ SE) and species diversity (H') of small mammals on the BECAMP plots at the T-1 blast zone in 1988 and 1991. Numbers in parentheses are individuals captured. Densities were not calculated for August.

Species	T-1 Blast Area - YUF009			Control Area - YUF010		
	1988	1991		1988	1991	
	May	August	May	May	August	May
CHA FOR	*(1)	---	---	---	(1)	---
DIP MER	19.6 $\pm$ 2.0		12.9 $\pm$ 2.3	14.8 $\pm$ 4.8		10.5 $\pm$ 0.4
DIP MIC	---	---	---	3.9 $\pm$ 1.5		*
PER LON	5.0 $\pm$ 0.6		---	27.3 $\pm$ 2.1		4.5 $\pm$ 2.7
ONY TOR	*(1)	---	---	*(3)	(3)	*(1)
PER MAN	*(4)	---	*(1)	---	---	---
REI MEG	---	(1)	---	*(4)	(5)	---
AMM LEU	---	(1)	---	*(3)	(1)	---
THO BOT	*(1)	---	---	---	---	---
N/ha	28.5	25.0	12.5	48.6	20.8	15.3
Species	6	4	2	6	7	4
H'	0.4672	0.1643	0.0932	0.5635	0.7170	0.3817
*Species present but data insufficient to estimate density.						

The most common species captured on the undisturbed area in 1988 was the little pocket mouse at 54% of all animals captured (Table 18). In 1991, *Dipodomys merriami* was the most common species on this plot at 68% of the animals captured. While *D. merriami* was the most commonly captured species on the blast area in 1988 (66%), this species was the only species captured in 1991, with the exception of one deer mouse, *Peromyscus maniculatus*. During summer trapping in 1988, *D. merriami* was the sole dominant species on both sites.

Table 18. Percent of total captured population (%T) and sex ratio (M/F) of small mammals captured in spring on the T-1 blast site and control in 1988 and 1990.

Species	T-1 Blast Area - YUF009				Control Area - YUF010			
	1988		1991		1988		1991	
	%T	M/F	%T	M/F	%T	M/F	%T	M/F
CHA FOR	2.4	1:0	---	---	---	---	---	---
DIP MER	65.9	17:10	94.4	8:9	24.3	11:6	68.2	10:5
DIP MIC	---	---	---	---	7.1	4:1	4.6	1:0
PER LON	17.1	5:2	---	---	54.3	17:21	22.7	3:2
ONY TOR	2.4	0:1	---	---	4.3	2:1	4.6	0:1
PER MAN	9.8	1:3	5.6	0:1	---	---	---	---
REI MEG	---	---	---	---	5.7	2:2	---	---
AMM LEU	---	---	---	---	4.3	3:0	---	---
THO BOT	2.4	0:1	---	---	---	---	---	---

Sex ratios (Table 18) did not differ significantly from 1:1 and mean weights of the most commonly captured species in the spring of 1988 and 1991 were not significantly different between the two years (Table 19).

Table 19. Mean weight (grams $\pm$ 2 SE) by sex and age of the most commonly captured rodents at the T1 blast site and control in 1988 and 1991.

Species	Sex	Age	T1 Blast Area - YUF009				Control Area - YUF010			
			1988		1991		1988		1991	
			N	Weight	N	Weight	N	Weight	N	Weight
PER LON	M	A	5	7.3 $\pm$ 0.5	0		17	7.7 $\pm$ 0.3	3	8.2 $\pm$ 0.3
	F	A	2	7.6 $\pm$ 0.5	0		21	8.1 $\pm$ 0.4	2	7.5 $\pm$ 1.0
DIP MER	M	A	1	44.1 $\pm$ 1.5	8	42.0 $\pm$ 2.2	11	43.3 $\pm$ 1.6	10	40.9 $\pm$ 1.4
	F	A	9	42.6 $\pm$ 1.9	6	39.6 $\pm$ 2.3	4	42.1 $\pm$ 2.4	5	40.2 $\pm$ 1.9
	M	J	1	18.0	0		0		0	
	F	J	1	26.0	3	25.2 $\pm$ 6.8	2	23.5 $\pm$ 1.0	0	
	M	A					3	69.7 $\pm$ 6.6	1	69.0
DIP MIC	F	A					3	47.7	0	
	M	J					1	36.3	0	
	F	J					0		0	

T4

T4 GZ is approximately 4.8 km north of T1 GZ. This site was the location of four test series from 1952 to 1957 (Kordas and Anspaugh 1982). An 8 x 8 trapping grid was established 571 m SSW of T4 GZ outside of the RADEX fence, but within the blasted area. Another 8 x 8 plot was set up 1355 m SW of GZ in relatively undisturbed blackbrush (*coleogyne ramosissima*) habitat. This area was trapped by BECAMP personnel on 26-28 June 1990.

The only species captured on the blast area for this site was Merriam's kangaroo rat, *Dipodomys merriami*, while a total of four species were captured on the control area. *D. merriami* was dominant on the control site as well (Table 20). The estimated densities of kangaroo rats were identical on the two sites (7.7 ± 0.5), indicating that habitat requirements for *Dipodomys merriami* were satisfied by these dissimilar sites.

Table 20. Estimated summer density (N/ha $\pm$ 2 SE), percent of total captured opulation (%T), sex ratio (M/F) and species diversity (H') of small mammals on the T4 GZ blast area and control in 1990. Numbers in parentheses are individuals captured.

T4 Blast Area - YUF025					Control Area - YUF026			
Species	Density		%T	M/F	Density		%T	M/F
DIP MER	7.7 ± 0.5	(11)	100.0	7:4	7.7 ± 0.5	(11)	64.7	4:7
DIP MIC	---				*	(3)	17.7	0:3
PER LON	---				*	(2)	11.7	1:1
ONY TOR	---				*	(1)	5.9	0:1
N/ha	7.6	(11)			11.8	(17)		
Species	1				4			
H'	0				0.4370			

*Species present but data insufficient to estimate density.

Numbers of captures were too low to make any valid comparisons of weights between the two plots. However, male *D. merriami* tended to be slightly heavier than females on both plots (Table 21). Sex ratios for kangaroo rats captured on the two plots tended to favor males, but the ratio was not statistically different from 1:1.

Table 21. Spring mean weights (grams $\pm$ 2 SE) by sex and age of the most commonly captured species at the T4 blast area and control in 1990.

Species	Sex	Age	T4 Blast Area		Control Area	
			N	Weight	N	Weight
PER LON	M	A			1	9.0
	F	A	0		1	7.0
DIP MER	M	A	5	42.4 $\pm$ 1.8	2	43.3 $\pm$ 8.0
	F	A	4	40.4 $\pm$ 1.9	5	41.1 $\pm$ 2.9
	M	J	2	29.7 $\pm$ 1.3	2	32.6 $\pm$ 2.2
	F	J	0		2	29.8 $\pm$ 1.7
DIP MIC	F	A	0		0	
	F	A	0		3	56.2 $\pm$ 10.6

T2

The site at T2, located approximately 5.2 km north of T4 GZ, was the location of four tower-supported nuclear detonations (14 to 43 kiloton) between 1952 and 1957 (Kordas and Anspaugh 1982). In addition, at one site ~1500 m southeast, T2a, and at one ~1500 m northeast, T2b, single nuclear devices of 17 kt each were tested in 1957. The subsequent disturbance from the blasts -- intense ionizing radiation and thermal radiation and blast damage -- cleared perennial shrubs from the immediate area out to approximately 1300 m. The blasted area has since been reinvaded by perennial grasses and annuals with scattered *Hymenoclea* spp. (Shields, Wells and Rickard 1963; O'Farrell and Sauls 1987b). Most of the vegetation on this site was dead in 1990 (Hunter, this report). Roads and drag lines cross the blast area from east to west and north to south and other disturbances from test site activity also occur at this site.

This site was trapped for small mammals between July 1982 and May 1983 on a monthly basis by EG&G personnel as part of the NAEG program (O'Farrell and Sauls 1987b). In that study, transect lines of 210 m (15 traps at 15 m) were set up at 152 and 457 m from each of the 3 GZs and at 762 m south of T2b and 1524 m east of T2. The 1524 m line was located in an area where original shrub cover was present. BECAMP established plots at 400 m (outside of the RADEX area) and 1650 m east of T2, and trapping took place on 26-28 June 1990. These two sites are in close proximity to the EG&G plots for T2: T2-3 at 457 and T2-5 at 1524 m E of GZ (Figure 2).

Figure 2 - Location of BECAMP and EG&G trapping sites at T2 blast area.

Species diversity (H' Table 22) was significantly higher on the undisturbed sites in 82-83 as compared to blasted areas (t-test $p < 0.001$), but there was no significant difference between the two sites in 1990 ($p > 0.10$). A total of nine different species were captured in 1982-83 on T2-3 and T2-5, with an additional species, *Reithrodontomys megalotis*, captured 152 m from the T2 GZ (T2-1 trap line) and 457 m from T2b GZ (T2b-9 trap line). Only 5 species were captured in 1990 on both of the plots, with *Peromyscus crinitus* being captured over 1000 m further from T2 GZ in 1990 than in 1982-83 (Table 22).

Table 22. Estimated density ($N/ha \pm 2 SE$) and species diversity (H') at the T2 blast area July 1982 - May 1983 and 26-28 June 1990. Numbers in parentheses are individuals captured

Species	T2 Blast Area		Control Area	
	T2-3 ^a	YUF014	T2-5 ^a	YUF015
	(457 m E)	(400 m E)	(1525 m E)	(1650 m E)
	1982-83	1990	1982-83	1990
CHA FOR	(1)	* (2)	(1)	---
DIP MER	(40)	7.1 $\pm$ 2.1 (9)	(21)	22.5 $\pm$ 2.1 (31)
DIP MIC	---	---	(6)	---
PER LON	(5)	---	(16)	* (1)
NEO LEP	(1)	---	---	---
PER CRI	(1) ^b	---	---	* (1)
PER ERE	(1)	---	---	---
PER MAN	(32)	---	(10)	---
AMM LEU	(1)	* (2)	(12)	* (2)
N/ha	(83)	9.0 (13)	(73)	25.0 (36)
Species	9	3	7	5
H'	0.5246	0.3607	0.7597	0.3554

^aData from O'Farrell and Sauls 1987b.

^bIt was not clear whether the *Peromyscus* species in 82-83 was the pinyon mouse, *P. truei* (O'Farrell and Sauls 1987b, table 3), or the canyon mouse, *P. crinitus* (O'Farrell and Sauls 1987b:292).

*Species present but data insufficient to estimate density.

O'Farrell and Sauls (1987b) found an inverse relationship between the number of *Dipodomys merriami* and *Peromyscus maniculatus* captured and the distance from GZ. However, in 1990, more *D. merriami* were captured on the control and

no *P. maniculatus* (co-dominant in 1982-83) were captured on either plot. Over three times as many *D. merriami* were captured on the control in 1990 as on the disturbed site, and *D. merriami* was the dominant species on both plots (Table 23). The 1982-83 data were combined captures of all individuals for the four different seasons and traps were baited with peanut butter and rolled oats, so any differences between years cannot be considered to be solely due to drought conditions. However, Yucca Flat experienced high rainfall in 1982 and 1983.

Table 23. Percent of total captured population (%T) and sex ratio (M/F) on EG&G and BECAMP plots near the T2 GZ.

Species	T2 Blast Area			Control Area		
	T2-3	YUF014		T2-5	YUF015	
	1982-83 ^a	1990		1982-83 ^a	1990	
	%T	%T	M/F	%T	%T	M/F
CHA FOR	1.2	15.4	2:0	1.4	---	---
DIP MER	48.2	69.2	7:2	28:8	86.1	11:20
DIP MIC	---	---	---	8.2	---	---
PER LON	6.0	---	---	21.9	2.8	1:0
NEO LEP	1.2	---	---	---	---	---
ONY TOR	1.2	---	---	9.6	2.8	1:0
PER CRI ^b	1.2	---	---	---	2.8	1:0
PER ERE	1.2	---	---	---	---	---
PER MAN	38.6	---	---	13.7	---	---
AMM LEU	1.2	15.4	1:0 ^c	16.4	5.6	0:2

^aData from O'Farrell and Sauls 1987b.

^bSee note b, Table 22.

^cOne animal of undetermined sex not included.

Trap success was also three times higher on the area unaffected by the blast (19.5%), but individual animals were captured an average of 2.08 times (36 animals captured 75 times) as compared to 1.85 on the blast area (13 captured 24 times). Overall trap success in 1982-1983 for all eight trap lines was 51%. This was considerably higher than the overall success of 13% in 1990.

However, two traps were activated at each trap station in 1990, while one trap was opened in 1982-83 unless trap success exceeded 50%, at which time a second trap was opened (O'Farrell and Sauls 1987b). Since capturing animals in both traps at a station was a rare occurrence in 1990, calculating the trap success with one trap per station would give 26% -- still only half the success of 1982-83.

The sex ratio favored male *D. merriami* on the blast area in 1990, but was not significantly different from 1:1 (χ^2 , $p>0.10$). The number of individual animals captured of other species was too low for any statistical comparison. Male kangaroo rats were heavier than females on both plots (Table 24), but numbers were too low for valid statistical analysis on the blast area.

Table 24. Mean weights (grams $\pm$ 2 SE) by sex and age of the most common species captured in 1990 on the T2 blast area and control plots.

Species	Sex	Age	T4 Blast Area		Control Area	
			N	Weight	N	Weight
CHA FOR	M	A	2	18.5 $\pm$ 1.0	0	
PER LON	M	A	0		1	7.0
DIP MER	M	A	5	43.0 $\pm$ 2.6	10	41.4 $\pm$ 0.9
	F	A	1	38.0	9	36.7 $\pm$ 1.1
	M	J	2	22.3 $\pm$ 0.7	1	21.0
		J	1			

T3

The fourth T-site studied by BECAMP was the T3 area. This ground zero is located on the eastern side of Yucca Flat and was also the site of four tower-supported nuclear tests from 1952 to 1957 (Kordas and Anspaugh 1982). A BECAMP trapping grid is located 1000 m SE of T3 GZ in the blast zone with another plot located 1000 m E of the blast zone plot in relatively undisturbed vegetation habitat consisting mainly of *Atriplex canescens*, *Ceratoides lanata*, *Acamptopappus shockleyi* and bunch grasses. These sites had 14 x 5 grid (15 m intervals) at each location.

Mammals were trapped on the blast area and in the undisturbed site on 20, 25, and 26 May 1988 and again on 21-23 May 1991. From 1988 to 1991, both sites showed a significant decrease in species diversity ($p<0.001$) and a decrease in

the density of individual species captured at the sites (Table 25). The live vegetation on the blast area consisted almost entirely of *Oryzopsis hymenoides*, a perennial bunch grass, which provided very little cover for rodents. As on the other T-sites, the control area supported more individuals and species of animals.

D. merriami was the dominant species on the blast area in 1988, and was the only species captured on this area in 1991; *D. merriami* and *Perognathus longimembris* were the codominant species on the control area, but in much lower numbers in 1991 (Table 25). More male than female rodents were captured on both plots in 1991 (Table 26), but numbers were for statistical analysis.

Table 25. Estimated density (N/ha $\pm$ 2 SE) and species diversity (H') at the T3 blast site and control plots in 1988 and 1991. Numbers in parentheses are individuals captured.

Species	T3 Blast Area - YUF013				Control Area - YUF012			
	1988		1991		1988		1991	
DIP MER	8.5 $\pm$ 1.0	(13)	5.7 $\pm$ 0	(9)	10.8 $\pm$ 0	(18)	4.4 $\pm$ 0	(7)
DIP MIC	---		---		4.1 $\pm$ 1.1	(5)	*	(1)
PER LON	*	(1)	---		12.6 $\pm$ 1.7	(19)	2.5 $\pm$ 0	(4)
ONY	---		---		*	(1)	---	
PER MAN	---		---		*	(2)	---	
AMM LEU	*	(2)	---		*	(7)	---	
N/ha	10.2	(16)	5.7	(9)	33.0	(52)	7.6	(12)
Species	3		1		6		3	
H'	0.2614		0		0.6217		0.3855	

*Species present but data insufficient to estimate density.

Table 26. Percent of total captured population (%T) and sex ratio (M/F) on the T3 blast area and control plots in 1988 and 1991.

Species	T-3 Blast Area - YUF013				Control Area - YUF012			
	1988		1991		1988		1991	
	%T	M/F	%T	M/F	%T	M/F	%T	M/F
DIP MER	81.3	8:5	100.0	7:2	34.6	9:9	58.3	4:3
DIP MIC	---	---	---	---	9.6	2:3	8.3	1:0
PER LON	6.3	1:0	---	---	36.5	8:11	33.3	3:1

Table 26. continued.

Species	T-3 Blast Area - YUF013				Control Area - YUF012			
	1988		1991		1988		1991	
	%T	M/F	%T	M/F	%T	M/F	%T	M/F
ONY TOR	---	---	---	---	1.9	1:0	---	---
PER MAN	---	---	---	---	3.9	0:2	---	---
AMM LEU	12.5	2:0	---	---	13.5	3:4	---	---

Adult males captured on the control plot in 1988 were significantly heavier than males captured on the blast area in that year (ANOVA, $p < 0.05$), but were not significantly different in 1991 (Table 27). Female *D. merriami* on the control also tended to be heavier than on the blast area, but this was also not significant.

Table 27. Mean spring weight (grams $\pm$ 2 SE) by sex and age of heteromyid rodents captured on the T3 blast area and control in 1988 and 1991.

Species	Sex	Age	T3 Blast Area - YUF013				Control Area - YUF012			
			1988		1991		1988		1991	
			N	Weight	N	Weight	N	Weight	N	Weight
PER LON	M	A	1	9.0	0		7	8.3 $\pm$ 0.4	3	8.1 $\pm$ 1.0
	F	A	0		0		11	9.5 $\pm$ 0.9	1	7.7
	M	J	0		0		1	7.0	0	
	F	J	0		0		0		0	
DIP MER	M	A	8	41.3 $\pm$ 1.3	7	41.2 $\pm$ 2.7	8	45.0 $\pm$ 2.3	4	40.8 $\pm$ 1.1
	F	A	4	41.8 $\pm$ 4.9	2	43.7 $\pm$ 5.3	3	48.2 $\pm$ 6.0	3	41.9 $\pm$ 5.1
	M	J	0		0		1	22.0	0	
	F	J	1	32.0	0		5	21.6 $\pm$ 1.6	0	
DIP MIC	M	A	0		0		2	67.3 $\pm$ 11.5	0	
	F	A	0		0		2	51.0 $\pm$ 7.2	0	
	M	J	0		0		0		0	
	F	J	0		0		1	37.0	0	

Sedan

The thermonuclear cratering test in northeastern Yucca Flat, Sedan, was detonated on 6 July 1962. The 100 kt blast deposited a large amount of radioactive overburden, or throw-out, on the surrounding soil and vegetation. This area was unique in that ecological impact studies were undertaken both

Figure 3 - Location of BECAMP, BYU, and EG&G trapping locations at the Sedan Crater Site.

before and after the detonation (Jorgensen et al. 1963) to study the immediate, close-in effects of the blast on small vertebrates. BYU set up plots on the 16A azimuth and trapped mammals on grids on this line at the following distances from GZ: 305 m, 610 m, 915 m, 1220 m, 1524 m, 2134 m, and 2743 m. In 1982-1983, this area was trapped by EG&G with trap lines located southeast and northeast of GZ (O'Farrell and Sauls 1987b). BECAMP established grids in 1988 at 457 m, 1067 m, and 1600 m on the NE 16A azimuth of BYU, and the area was trapped on 12-14 July 1988 and 9-11 July 1991 (Figure 3). BYU utilized the Hayne method of estimating density (Allred et al. 1964) and reported results on only four species. EG&G trapped only transect lines (O'Farrell and Sauls 1987b), so that direct comparisons on abundance cannot be made.

The explosion created a crater 98 m deep and ejected earth out to 762 m. Close in to the crater (305 m from GZ), depth of overburden was up to 11 m on the 16A line, tapering to less than 1 m at 601 m from GZ and to 0.1 m or less at 762 m (Turner 1963; Turner and Gist 1965). The lip of the crater was up to 38 m at other locations. After the detonation, animals were not trapped in areas closer than 915 m due to complete burial by overburden. Vegetation was destroyed out to 601 m due to either burial or blast effects. This zone is now dominated by *Oryzopsis hymenoides*. Between 601 m and 1524 m, vegetation was not completely destroyed by the blast, and beyond 1524 m no effect of the event was visible.

It is apparent that the kangaroo rat *Dipodomys merriami* has invaded close to ground zero (Tables 28a - 28c). O'Farrell and Sauls (1987b) reported the presence of *D. merriami* on the closest trap line to GZ to the southeast (305 m), but none on the lines at 610 and 915 m SE. The 305 m line of O'Farrell and Sauls was unique in that it was the only location trapped in the overburden area where a sparse cover of *Atriplex canescens* was present.

P. longimembris was the most common species captured on all sites pre-test and post-test past 914 m (Jorgensen et al. 1963). This was not the case in 1982-83 when *D. merriami* and *P. longimembris* were most abundant at greater than 1068 m from GZ, and *P. longimembris* and *Peromyscus maniculatus* were most common within 915 m of GZ (O'Farrell and Sauls 1987b). By 1988, *P. longimembris* disappeared out to 1600 m, where it was the third most common species (Table 28c). *P. longimembris* was captured on the 1067 m plot in 1991 (1 individual, Table 28b), but was still not common at 1600 m.

Species diversity (H' , Tables 28a-c) decreased at all sites since 1982-83 (years of better than average rainfall), but not significantly from 1988 to 1991. Overall trap success in 1982-83 was 49%. The capture of one *Neotoma lepida* (desert wood rat) at 1600 m in 1991 was not unique. This species is common to all areas of the NTS and was reported in this area by BYU (Jorgensen and Hayward 1965).

The species distribution at 457 and 1067 m from GZ changed only slightly from 1988 to 1991, while at 1600 m, *D. merriami* became more dominant due to the drop in *D. microps* numbers (Table 29). Sex ratios did not differ significantly from 1:1 in 1988 or 1991 (Table 29), and mean weights remained relatively stable, as did the age structure of the three *D. merriami* populations (Table 30).

Table 28a. Estimated densities (N/ha $\pm$ 2 SE) and species diversity (H') of small mammals at plots out to 610 m at the Sedan crater site. Numbers in parentheses are individuals captured.

Species	NE 305 M		SE 305 M	NE 610 M		SE 610 M	NE 457 M		
	Pre-test		Post-test	Pre-test		Post-test	YUF016	YUF016	
	1962 ^a	1962 ^a	1982-83 ^b	1962 ^a	1962 ^a	1982-83 ^b	1988	1991	
CHA FOR			---			---	*	(1)	---
DIP MER	1.5	NT ^c	(11)	1.7	NT	---	23.7 $\pm$ 2.6	(32)	17.1 $\pm$ 1.3 (24)
DIP MIC	0.3	NT	---	0.3	NT	---	---		* (1)
PER LON	7.9	NT	(9)	5.7	NT	(15)	---	---	
PER PAR	1.6	NT	---	1.4	NT	---	---	---	
PER CRI			(2)			(1)	---	---	
PER ERE			(1)			---	---	---	
PER MAN			(8)			(25)	---	---	
PER TRU			---			(2)	---	---	
REI MEG			(2)			---	---	---	
AMM LEU			---			---	*	(1)	---
N/ha			(33)			(43)	23.6	(34)	17.4 (25)
Species	4+		6	4+		4	3		2
H'			0.6557			0.3964	0.1149		0.0729

*Species present but data insufficient to estimate density.

^aData from Jorgensen et al. 1963.

^bData from O'Farrell and Sauls 1987b.

^cNT = not trapped due to apparent complete destruction.

Table 28b. Estimated densities (N/ha $\pm$ 2 SE) and species diversity (H') of small mammals at plots from 915 m to 1220 at the Sedan crater site. Numbers in parentheses are individuals captured.

Species	NE 915 M		SE 915 M	NE 1220 M		NE 1068 M	NE 1067 M		
	Pre-test		Post-test	Pre-test		Post-test	YUF017	YUF017	
	1962 ^a	1962 ^a	1982-83 ^b	1962 ^a	1962 ^a	1982-83 ^b	1988	1991	
DIP MER	1.2	0	---	3.0	0.3	(49)	20.0 $\pm$ 0	(24)	27.7 $\pm$ 2 (38)
DIP MIC	0.9	0	---	0.9	0.9	---	---		* (2)
PER LON	10.3	0.9	(5)	0.9	0.6	(37)	---		* (1)
PER PAR	3.1	0	(1)	0.6	0	---	---		---
ONY TOR			---			(3)	*	(1)	---
PER CRI			(1)			(1)	---		---
PER ERE			(2)			(1)	---		---
PER MAN			(12)			(7)	---		---
PER TRU			(3)			---	---		---
REI MEG			(5)			---	---		---
AMM LEU			---			(1)	*	(2)	* (2)
SLY AUD			---			---	*	(1)	---
N/ha			(28)			(99)	22.9	(33)	29.9 (43)
Species	4+		7	4+		7	4		4
H'			0.6623			0.4988	0.2151		0.2094

*Species present but data insufficient to estimate density.

^aData from Jorgensen et al. 1963.

^bData from O'Farrell and Sauls 1987b.

^cNT = not trapped due to apparent complete destruction.

Table 28c. Estimated density (N/ha $\pm$ 2 SE) and species diversity (H') of small mammals at plots from 1524 to 2135 at the Sedan crater site. Numbers in parentheses are individuals captured.

Species	NE 1524 M		NE 1525	NE 2134 M		NE 2135	NE 1600 M			
	Pre-test		Post-test	Pre-test		Post-test	YUF018		YUF018	
	1962 ^a	1962 ^a	1982-83 ^b	1962 ^a	1962 ^a	1982-83 ^b	1988		1991	
DIP MER	0.9	0.6	(49)	0	0	(40)	10.8 $\pm$ 1.2	(15)	10.4 $\pm$ 0	(15)
DIP MIC	2.3	8.5	(9)	7.5	8.2	(13)	5.8 $\pm$ 0.9	(8)	2.8 $\pm$ 0	(4)
PER LON	29.7	29.5	(33)	11.0	27.6	(26)	4.3 $\pm$ 0.7	(6)	4.5 $\pm$ 2.7	(5)
PER PAR	0.6	0.3	---	0.6	0	---	---	---	---	(1)
NEO LEP			---			---	---	---	*	(1)
ONY TOR			(9)			(17)	*	(4)	*	(1)
PER CRI			---			(1)	---	---	---	(1)
PER MAN			(3)			(6)	---	---	*	(1)
AMM LEU			(3)			(6)	4.2 $\pm$ 0	(6)	---	---
SYL AUD			---			---	*	(1)	---	
N/ha			(106)			(109)	27.8	(40)	18.8	(27)
Species	4+	4+	6	3+	2+	7	6		6	
H'			0.5822			0.7016	0.6868		0.5482	

*Species present but data insufficient to estimate density.

^aData from Jorgensen et al. 1963.

^bData from O'Farrell and Sauls 1987b.

Table 29. Percent of total captured population (%T) and sex ratio (M/F) of the small mammals captured at the Sedan crater plots in 1988 and 1991.

Species	YUF016				YUF017				YUF018			
	1988		1991		1988		1991		1988		1991	
	%T	M/F	%T	M/F	%T	M/F	%T	M/F	%T	M/F	%T	M/F
CHA FOR	2.9	1:0	---	---	---	---	---	---	---	---	---	---
DIP MER	94.1	17:15	96.0	13:11	88.0	18:11	88.4	20:18	37.5	8:7	55.6	7:8
DIP MIC	---	---	4.0	0:1	---	---	4.7	2:0	20:0	5:3	14.8	1:3
PER LON	---	---	---	---	---	---	2.3	0:1	15.0	3:3	18.5	3:2
NEO LEP	---	---	---	---	---	---	---	---	---	---	3.7	0:1
ONY TOR	---	---	---	---	3.0	1:0	---	---	10.0	1:3	3.7	0:1
PER MAN	---	---	---	---	---	---	---	---	---	---	3.7	1:0
AMM LEU	2.9	0:1	---	---	6.1	0:1 ^a	4.7	1:1	15.0	4:2	---	---
SLY AUD	---	---	---	---	3.0	0:1	---	---	2.5	0:1	---	---

^aDoes not include one animal of undetermined sex.

Table 30. Mean weight (grams $\pm$ 2 SE) by sex and age of heteromyid rodents captured at the BECAMP plots at Sedan in 1988 and 1991.

Species	Sex	Age	YUF016 - 457 M NE OF GZ				YUF017 - 1067 M NE OF GZ				YUF018 - 1600 M NE OF GZ			
			1988		1991		1988		1991		1988		1991	
			N	Weight	N	Weight	N	Weight	N	Weight	N	Weight	N	Weight
Per Lon	M	A							0		3	8.2 $\pm$ 0.9	1	7.0
	F	A							1	11.0	2	7.8 $\pm$ 1.7	2	7.0 $\pm$ 0
	M	J							0		0		2	5.5 $\pm$ 1.0
	F	J							0		1	7.0	0	
Dip Mer	M	A	14	43.3 $\pm$ 2.0	10	41.6 $\pm$ 2.5	12	43.6 $\pm$ 2.2	13	42.0 $\pm$ 2.2	5	42.8 $\pm$ 1.8	6	43.9 $\pm$ 1.5
	F	A	9	39.6 $\pm$ 2.3	5	41.2 $\pm$ 4.4	7	37.8 $\pm$ 1.3	11	38.9 $\pm$ 3.3	5	38.9 $\pm$ 3.3	5	37.2 $\pm$ 1.6
	M	J	3	25.7 $\pm$ 2.7	3	26.7 $\pm$ 3.3	6	30.9 $\pm$ 2.2	7	26.0 $\pm$ 3.1	3	29.5 $\pm$ 1.1	1	23.3
	F	J	6	29.3 $\pm$ 4.9	6	23.8 $\pm$ 5.4	4	28.7 $\pm$ 0.2	7	26.4 $\pm$ 1.8	2	27.5 $\pm$ 7.0	3	29.2 $\pm$ 5.7
Dip Mic	F	A	0		0		0		1	54.0	3	58.0 $\pm$ 9.4	1	50.0
	M	A	0		0		0		0		2	64.0 $\pm$ 0	3	58.0 $\pm$ 5.8
	F	J	0		0		0		1	41.0	2	44.0 $\pm$ 2.0	0	
	F	J	0		1	41.0	0		0		1	45.0	0	

Bladed Areas

Mid Valley and Pahute Mesa

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

The estimated densities of the most commonly captured rodents and presence of other species on the four plots (Table 31) varied between the four sites. The two control areas had vastly different habitats, including elevation, soil, and vegetation (although both sites are located in virtual monocultures), and therefore had different species of animals present. The Mid Valley site is located at an elevation of 1439 m. The "normal" habitat in this area consists primarily of *Coleogyne ramosissima*. The undisturbed plant community near the Pahute Mesa bladed area is almost entirely *Artemisia tridentata* and is located at an elevation of 1910 m.

Table 31. Estimated density (N/ha $\pm$ SE) and species diversity (H') of small mammals on the BECAMP subsidiary plots on bladed sites and controls in Mid Valley and on Pahute Mesa in 1989. Numbers in parentheses are individual animals captured.

Species	MID004 Bladed	MID005 Control	PAM002 Bladed	PAM003 Control
CHA FOR	---	12.9 $\pm$ 2.3 (17)	---	---
DIP MER	* (1)	6.4 $\pm$ 0.6 (9)	---	---
DIP MIC	* (1)	6.1 $\pm$ 1.6 (8)	---	* (1)
DIP ORD	---	---	9.5 $\pm$ 1.4 (13)	* (2)
PER PAR	* (2)	---	---	4.2 $\pm$ 0 (6)
ONY TOR	---	* (1)	---	---
PER MAN	* (3)	4.3 $\pm$ 0.7 (7)	* (2)	9.7 $\pm$ 1.7 (12)
PER TRU	* (1)	3.9 $\pm$ 1.5 (5)	---	---

Table 31. continued.

	MID004		MID005		PAM002		PAM003	
Species	Bladed		Control		Bladed		Control	
N/ha	5.6	(8)	32.7	(47)	10.4	(15)	14.6	(21)
Species	5		6		2		4	
H'	0.6489		0.6904		0.1705		0.4567	

*Species present but data insufficient to estimate density.

The most abundant species on the Pahute Mesa bladed area was Ord's kangaroo rat, *Dipodomys ordii*. This species was previously captured in recent years by BECAMP only on the Redrock burned area (Table 43). It was also captured on the control, PAM003, but in low numbers. It was not captured on the Pahute Mesa baseline plot approximately 1 km to the north, studied in 1988 and 1990 (Saethre and Medica 1992, Tables 4.2; this report, Table 11). The most abundant species captured on the control plot on Pahute Mesa was *Peromyscus maniculatus*, which comprised 57% of the total captured population (Table 32).

Table 32. Percent of total captured population (%T) and sex ratio (M/F) of small mammals on the BECAMP subsidiary plots on bladed areas and controls on NTS in 1989.

Species	T-1 Blast Area - YUF013				Control Area - YUF012			
	1988		1991		1988		1991	
	%T	M/F	%T	M/F	%T	M/F	%T	M/F
CHA FOR	---	---	36.2	13:4**	---	---	---	---
DIP MER	12.5	0:1	19.2	6:3	---	---	---	---
DIP MIC	12.5	1:0	17.0	5:3	---	---	4.8	1:0
DIP ORD	---	---	---	---	86.7	6:7	9.5	1:1
PER PAR	25.0	1:1	---	---	---	---	28.6	3:3
ONY TOR	---	---	2.1	0:1	---	---	---	---
PER MAN	37.5	1:2	14.9	4:3	13.3	0:2	57.1	5:7
PER TRU	12.5	1:0	10.6	2:2*	---	---	---	---

*One individual of undetermined sex not included.

** Significantly different from 1:1 ($X^2=4.76$, $0.025 < p < 0.05$).

Five rodent species were captured on the Mid Valley bladed area, with the most abundant also being *P. maniculatus*, at three individuals captured, or 37% of

the total captured population. *Chaetodipus formosus* (36%) was the most abundant rodent in the undisturbed area in Mid Valley (Table 32). Species diversity was not significantly greater on the Mid Valley control site as compared to the bladed site, but the control site on Pahute Mesa had a significantly greater species diversity compared to the bladed area ($p < 0.005$).

Only eight different animals were captured on the Mid Valley bladed plot a total of 14 times (average of 1.75), while 47 animals were captured 95 times (2.07 average) on the control for this plot. Fifteen animals were captured 30 times (average of 2.00) on the Pahute Mesa drill pad plot, and 21 animals were captured 44 times (2.10 average) on the control. The percent trap successes were 4% and 8% on the Mid Valley and Pahute Mesa bladed plots and 25% and 12% on their respective controls.

After analyzing sex ratios for the most commonly captured species on the bladed plots and controls (Table 32), the only species which differed significantly from a 1:1 ratio was the long-tailed pocket mouse, *Chaetodipus formosus*. On the Mid Valley control plot, over three times as many males were captured than females. Mean weights for the most common species captured are listed in Table 33.

Table 33. Mean weight (grams $\pm$ 2 SE) by sex and age of heteromyid rodents captured on bladed areas on the NTS in 1989.

Species	Sex	Age	MID004 Bladed		MID005 Control		PAM002 Bladed		PAM003 Control	
			N	Weight	N	Weight	N	Weight	N	Weight
CHA FOR	M	A	0		1	19.0 $\pm$ 1.0				
	F	A	0		1	18.9 $\pm$ 1.6				
	M	J	0		3	8.0 $\pm$ 0				
	F	J	0		2	10.0				
					1					
PER PAR	M	A	1	19.0	0		0		3	19.7 $\pm$ 2.1
	F	A	1	15.3	0		0		1	16.7
	M	J							0	
	F	J							2	15.7 $\pm$ 0.7
DIP MER	M	A	0		4	39.4 $\pm$ 7.3				
	F	A	1	36.7	3	41.7 $\pm$ 5.9				
	M	J	0		2	25.7 $\pm$ 0.7				
	F	J	0		0					

Table 33. continued.

Species	Sex	Age	MID004 Bladed		MID005 Control		PAM002 Bladed		PAM003 Control	
			N	Weight	N	Weight	N	Weight	N	Weight
DIP MIC	M	A	1	59.0	3	62.7±6.8	0		1	60.0
	F	A	0		1	56.5	0		0	
	M	J	0		2	47.5±5.0	0		0	
	F	J	0		2	44.0±4.0	0		0	
DIP ORD	M	A					6	47.8±2.7	0	
	F	A					4	45.9±2.7	1	39.0
	M	J					0		1	32.0
	F	J					1	35.0	0	

Revegetation Site - YUF011

For several decades, beginning in the mid-1950s, radioactive debris from aboveground nuclear detonations (scrap metal, concrete, cable, lumber, and topsoil) remained at one of several waste sites. In 1987, the 3B waste site was cleaned, which included removing all aboveground material and several inches of topsoil, and hence, all vegetative material. The total area disturbed in this endeavor was approximately 5 ha. In 1988, BECAMP established a 14 x 5 trapping grid on the cleared area to document resident rodents and recolonization of this site. The control for this site was the same as the control for the T3 blast area, immediately to the south of the cleared area. Mammals were trapped on the 3B site for the first time on 20, 25, and 26 May 1988. In the spring of 1989, the entire fenced area was "ripped" to loosen the topsoil and revegetation commenced using *Atriplex canescens*, *Atriplex polycarpa*, and *Larrea tridentata*. Revegetation continued in 1990 and 1991, and the site was trapped for small mammals again on 21-23 May 1991. Although revegetation was undertaken during a drought, only the transplanted *L. tridentata* did not survive.

In 1988, animals were captured on the cleared area only within 30 m of the north and east edges of the fence, where some shrubs remained and *Salsola* became established. Rodent burrows were located only near the remaining vegetation in 1988. In 1991, although captured individuals decreased on the control, the number of *Perognathus longimembris* residing on the cleared area increased as evidenced by two pocket mice captured near the center of the cleared area and small burrows located near the trap sites. The effect of the

drought was evident from the absence of *Dipodomys microps* on the 3B site and the decreased number of this species (down from five in 1988) on the control area (Table 34). Less than one-fourth of the number of animals captured in 1988 on the undisturbed area were captured in 1991.

Table 34. Estimated spring density (N/ha $\pm$ 2 SE) and species diversity (H') of small mammals captured in 1988 and 1991 on the 3B waste site after cleanup and at a control. Numbers in parentheses are individuals captured.

Species	Cleared Area-YUF011				Control Area-YUF012			
	1988		1991		1988		1991	
DIP MER	5.2 $\pm$ 0.5	(8)	5.1 $\pm$ 3.1	(6)	10.8 $\pm$ 0	(18)	4.4 $\pm$ 0	(7)
DIP MIC	*	(1)	---		4.1 $\pm$ 1.1	(5)	*	(1)
DIP LON	*	(2)	3.1 $\pm$ 0.9	(4)	12.6 $\pm$ 1.7	(19)	2.5 $\pm$ 0	(4)
ONY TOR	---		---		*	(2)	---	
PER MAN	---		---		*	(1)	---	
AMM LEU	---		---		*	(7)	---	
N/ha	7.0	(11)	6.4	(10)	33.0	(52)	7.6	(12)
Species	3		2		6		3	
H'	0.3730		0.2923		0.6217		0.3855	
*Species present but data insufficient to estimate density.								

Some recolonization of small mammals occurred on the cleared area, after transplanted vegetation and invading *Salsoia* on this site established minimal cover for small mammals. However, the decreased number of individuals living outside the fenced area (potential emigrants) likely kept colonization on this site to a minimum. It should be noted that the fence was to keep out jackrabbits and not rodents.

The species diversity (significantly greater on the control in 1988) decreased significantly on both sites from 1988 to 1991 (Table 34, $p < 0.05$). There was no significant difference in species diversity between the two sites in 1991. Sex ratios of the most abundant animals on the bladed area did not differ from 1:1 (Table 35). Mean weights of the rodents captured at this site (Table 36) were about the same for the two years, although sample size was too small for a statistical comparison.

Table 35. Percent of total captured population (%T) and sex ratio (M/F) of small mammals captured at the 3B waste site in 1988 and 1991.

Species	1988		1991	
	%T	M/F	%T	M/F
DIP MER	72.7	4:4	60.0	4:2
DIP MIC	9.1	1:0	---	---
PER LON	18.2	0:2	40.0	1:3

Table 36. Mean weight (grams $\pm$ 2 SE) by sex for rodents captured on the 3B waste consolidation site in 1988 and 1991. Only adults were captured.

Species	Sex	Age	1988		1991	
			N	Weight	N	Weight
PER LON	M	A	0		1	7.0
	F	A	2	8.0 $\pm$ 0	3	7.1 $\pm$ 1.0
DIP MER	M	A	4	45.7 $\pm$ 0.7	4	42.9 $\pm$ 1.9
	F	A	4	42.8 $\pm$ 2.6	2	23.5 $\pm$ 3.0
DIP MIC	M	A	1	58.0	0	

The effect of cleanup and treatment of contaminated areas was investigated previously by EG&G (O'Farrell and Sauls 1987a). Before cleanup of a contaminated area, it was found that rodent burrows numbered an average of 300 per hectare. After removal of all shrubs and the top 2-5 cm of soil, rodents were completely extirpated from the area for two years. This appears to agree with the results from the 3B site, however, reinvasion at the 3B site may have been hastened by the added shrub cover.

Alpha-Contaminated Area - GMX

GMX is a small fenced area (~259 ha) located in northeastern Frenchman Flat. Approximately 107 ha inside of this fenced area was contaminated by plutonium from "safety shots" conducted between December 1954 and February 1956. During these safety shots, explosives were detonated in close proximity to a small amount of plutonium, contaminating the area surrounding the detonation. Small mammals in this area were studied between August 1972 and April 1975 as part of the NAEG radiation monitoring and compliance studies (Bradley and Moor 1975, 1976; Moor and Bradley 1974; Moor et al. 1977). BECAMP sampled small

mammals inside the contaminated area and at an uncontaminated area outside the fenced area between June 29 and July 6, 1989.

Estimated densities of the most commonly trapped animals on the GMX site in 1973, 1975, and 1989 and on the control in 1989 are compared in Table 37. The 1973 and 1975 densities reported in NAEG studies (Moor and Bradley 1974; Bradley and Moor 1976; Moor et al. 1976) were calculated using the method described by Hayne (1949):

$$P = (C * M) / R$$

where (P) is the population estimate of the plot, (C) is the number of animals captured during the last sample, (M) is the total number of marked animals in the area, and (R) is the number of recaptured animals. The NAEG density in number per hectare was then calculated using a plot size adjusted for the home range of a species (Moor et al. 1976).

The adjusted grid size used by NAEG took into account the animal's home range, which may vary between seasons and years (White and Allred 1969; Maza et al. 1973; Frank and Heske 1992). To make the densities from the NAEG studies comparable to those from BECAMP, the densities from 1973 and 1975 were recalculated by BECAMP (Table 37) using the actual plot size (given in Moor et al. 1976a) with a perimeter of one-half the distance between traps (4.59 ha) rather than a grid size adjusted for home range.

Looking at individual species in the contaminated area, *Dipodomys merriami* increased in density since 1975 (absent in April 1973 to 4.3/ha in 1989), while *Dipodomys microps* decreased considerably from 4.58/ha in 1975 to less than 1/ha in 1989, after an increase from 1973 to 1975. An increase in the granivores *Dipodomys merriami* and *Dipodomys microps* from 1973 to 1975 was apparently due to abundant precipitation and production of green plants needed for successful reproduction (Bradley and Moor 1976).

The percent of the total population for each species captured in 1973, 1975, and 1989 varied considerably, with the most commonly captured animal being a different species each year (Table 38). The most abundant rodent at the GMX site in July 1973 was the diurnal ground squirrel, *Ammospermophilus leucurus* (Tables 37 and 38). The methodology of Moor et al. (1976) involved trapping over four days, every two months when possible. Traps were checked every four hours during spring and summer breeding seasons. However, during the winter, traps were opened in the early evening, checked twice and then closed until

early morning. During summer, traps were closed in the morning and opened early in the evening. It is likely that fewer diurnal squirrels were captured

Table 37. Estimated summer densities ($N/ha \pm 2 SE$) and species diversity (H') of small mammals on a Frenchman Flat alpha-contaminated site in 1973, 1975, and 1989 and a control site in 1989. Numbers in parentheses are individuals captured.

Species	GMX ^a		July 1989		
	Apr 1973	Jul 1973	Apr 1975	FRF005 GMX	FRF006 Control
DIP MER	---	0.64 (3)	3.91 (18)	4.3±0.7 (6)	6.3±0 (9)
DIP MIC	0.21 (1)	1.08 (5)	4.58 (21)	* (1)	---
PER LON	0.64 (3)	1.31 (6)	0.13 (1)	* (3)	* (5)
PER MAN	---	---	---	---	* (1)
AMM LEU	0.21 (1)	1.74 (8)	3.02 (14)	* (1)	---
NEO LEP	---	0.46 (2)	---	---	---
ONY TOR	0.23 (1)	---	0.23 (1)	---	---
N/ha	1.29 (6)	5.23 (24)	11.87 (55)	7.64 (11)	10.4 (15)
Species	4	5	5	4	3
H'	0.5396	0.6543	0.5330	0.4868	0.3706

*Species present but data insufficient to estimate density.

^aData from Moor and Bradley 1974, Bradley and Moor 1976.

Table 38. Percent of total captured population (%T) and sex ratio (M/F) of small mammals at GMX from 1973 NAEG studies and on the BECAMP study plots in 1989.

	GMX ^a			July 1989			
	Apr 73		Apr 75	GMX		Control	
	%T	%T	%T	%T	M/F	%T	M/F
DIP MER	---	12.5	32.7	54.5	4:2	60.0	4:5
DIP MIC	20.0	20.9	38.2	9.1	1:0	---	---
PER LON	40.0	25.0	1.8	27.3	2:1	33.3	3:2
PER MAN	---	---	---	---	---	6.7	1:0
AMM LEU	20.0	33.3	25.5	9.1	0:1	---	---
NEO LEP	20.0	8.3	1.8	---	---	---	---

by BECAMP because traps were set later in the day and closed soon after sunrise.

The total number of animals captured on both sites in 1989 was low -- 11 individual animals captured 21 times on GMX and 15 animals captured 28 times on the control. The average captures, 1.91 on GMX and 1.87 on the control, were not significantly different. Percent trap successes on both plots were also low and did not differ significantly (5.5% on GMX and 7.3% on the control).

Species diversity was not significantly different between the alpha site and control in 1989 (Table 37). This is not at all surprising since the vegetational composition on these two sites is similar -- contamination in the alpha-area did not destroy the plants. Although sex ratios for the most rodents in 1989 favored males (2:1) on the alpha-contaminated area (Table 38), the sample size was too small for any statistical analysis. Mean weights of the most commonly trapped rodents in 1989 are listed in Table 39.

Table 39. Mean weight (grams $\pm$ 2 SE) by sex and age of the most commonly captured rodents at the GMX site and control in 1989.

Species	Sex	Age	N	GMX	N	Control
				Weight		Weight
PER LON	M	A	2	7.8 $\pm$ 0.5	3	8.0 $\pm$ 0
	F	A	1	7.7	2	7.0 $\pm$ 2.0
DIP MER	M	A	3	40.5 $\pm$ 4.0	4	38.4 $\pm$ 3.7
	F	A	1	34.3	5	37.9 $\pm$ 3.2
	M	J	1	26.7	0	
	F	J	1	27.0	0	
DIP MIC	M	A	1	5.0	0	

Rock Valley - ROV007 and ROV008

Rock Valley, located on the southern edge of the NTS, contains three fenced and one unfenced 9-ha circular plots and a 0.46-km² IBP validation site (Figure 4). Numerous years of data are available for this relatively undisturbed area of the NTS. From 1964 to 1981, one of these plots, Plot B, was continuously exposed to gamma radiation from a cesium-137 (¹³⁷Cs) source.

Key:

Five-sided polygon = IBP validation site (0.46 km²)

Circular areas 1 - 3 (A - C) = 9-ha fenced plots (B had the ¹³⁷Cs source)

Circular area 4 (D) = 9-ha unfenced area

Square areas 12, 15, and 16 = IBP mammal plots (2.72-ha)

Square areas 11 and 12 = IBP arthropod and reptile plots

Roman numerals I - V = abiotic stations (a weather station at V is still in use)

Figure 4 - Layout of Rock Valley study plots.

Small mammals, lizards, and plants were assayed to determine the effects, if any, of chronic low-level radiation (French et al. 1964, 1974). This area was also part of IBP from 1970 through 1976 (Turner 1973, 1974, 1975). Two 12 x 12 grids on two of the historical plots, the southwestern quarter of Plot B (ROV008) and the southwestern quarter of Plot D (IBP plot 16, ROV007), were trapped by BECAMP for small mammals on 14-16 June 1988 and 11-13 June 1991. The results of the 1988 and 1991 trapping were then compared with earlier studies at this site to document any changes in the populations of the resident rodents.

The 1991 estimated densities of *Dipodomys microps* captured on these sites (Table 40) decreased greatly since 1988. *D. merriami* was present at lower numbers on the fenced plot in 1991 (one in 1991 as compared to six in 1988) while *Perognathus longimembris* was present on the unfenced area at sharply lower numbers (6 in 1991, down from 33 in 1988).

Both sites showed a shift in the most common species: from co-dominance of *D. microps* and *P. longimembris* in 1988 to mostly *D. merriami* in 1991 on the fenced area (Table 41), and from *D. microps* to *Chaetodipus formosus* on the unfenced plot (Table 41). *P. longimembris* was reported on both sites in 1964 and 1966 (French et al. 1967, 1974). However, the density of this species inside the fence decreased considerably after exposure to radiation. On this area in 1988, nearly 75% of the animals captured were *D. microps*, but this dropped to less than 15% in 1991. While species diversity was significantly greater on the unfenced area in 1988, this was not the case in 1991 where H' was greater, but not significantly so.

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Table 40. Estimated density ($N/ha \pm 2 SE$) and species diversity (H') of small mammals in the fenced plot at Rcok Valley in 1988 and 1991 and the unfenced area in 1972, 1973, 1988, and 1991 (ROV007). Numbers in parentheses are individuals captured.

Species	Unfenced Area - IBP Plot 16 (ROV007)			Fenced Area (ROV008)			
	June 1972 ^a	Apr 1972 ^b	Aug 1973 ^b	June 1988	June 1991	June 1988	June 1991
CHA FOR	12.0 (39)	1.5 (5)	25.6 (83)	* (2)	* (2)	2.9±0.4 (9)	1.5±0 (5)
DIP MER	3.7 (12)	---	1.5 (5)	4.4±0.4 (14)	4.6±1.8 (12)	1.9±0.1 (6)	* (1)
DIP MIC	4.6 (15)	7.4 (24)	5.6 (18)	11.8±0. (38)	* (1)	26.4±0. (85)	* (1)
PER LON	34.9 (113)	15.1 (49)	50.3 (163)	10.4±0. (33)	* (6)	---	---
ONY TOR	1.5 (5)	1.9 (6)	16.2 (20)	3.1±0 (10)	---	1.9±0 (6)	---
PER CRI	0.6 (2)	0.3 (1)	0.3 (1)	---	---	---	---
PER MAN	---	---	---	* (2)	---	---	---
AMM LEU	0.9 (3)	---	0.9 (3)	* (5)	* (3)	* (7)	---
THO BOT	---	1.9 (6)	2.5 (8)	---	---	---	---
MUS FRE	---	---	---	* (1)	---	* (1)	---
Other ^c	---	---	0.3 (1)	---	---	---	---
N/ha	58.33 (189)	28.08 (91)	93.21 (302)	32.41 (105)	7.41 (24)	35.19 (114)	2.16 (7)
Species	7	6	9	8	5	6	3
H'	0.5295	0.5439	0.5574	0.6794	0.5757	0.4090	0.3458

*Species present but data insufficient to estimate density.

^aDensity calculated from data in Turner 1973.

^bDensity calculated from data in Turner 1974.

^c*Neotoma lepida* and or *Spermophilus tereticaudus*.

Sex ratios for the most commonly captured species did not differ from 1:1 for any year or site. Sample size was too small in 1991 to make any valid statistical comparisons between weights (Table 42) on the two sites and between years for *D. microps*, the most common species captured on both sites in 1988.

It is evident from the 1988 data for the fenced area that the fence is not a barrier for recolonization. French et al. (1974) reported that kangaroo rats did not survive well in the irradiated enclosure and were extirpated in less than one year after initiation of the radiation treatment. By 1988, the population of *Dipodomys microps* was the highest for any site trapped on the NTS in that year. French et al. also noted that after five years, kangaroo rats died out inside of one of the fenced unirradiated plots and persisted in very low numbers on the third fenced plot, indicating that radiation was not the only adverse factor in the environment.

The capture of two long-tailed weasels (*Mustela frenata*) in Rock Valley extended the known range of this species on the NTS approximately 58 km south of previous recorded localities (Jorgensen and Hayward 1965; Medica 1991). This area has no above ground permanent water source. There is, however, a tinaja approximately 5 km to the west which collects water from runoff and is rarely dry. With the intensive trapping effort in this relatively small portion of the trap site (an estimated minimum of 505,976 trap nights between 1962 and 1975), it is probable that this species was not present in the Rock Valley area of the NTS prior to 1975.

Table 41. Percent of total captured population (%T) and sex ratio (M/F) of small mammals captured on the Rock Valley fenced and control areas in 1988 and 1991 and %T of small mammals captured on IBP plot 16 (unfenced area) in 1972 and 1973.

Species	Unfenced Area - IBP Plot 16 (ROV007)					Fenced Area (ROV008)					
	June 1972 ^a	Apr 1973 ^b	Aug 1973 ^b	June 1988	June 1991	June 1988	June 1991	June 1988	June 1991	June 1988	June 1991
	%T	%T	%T	%T	M/F	%T	M/F	%T	M/F	%T	M/F
CHA FOR	20.6	5.5	27.5	1.9	0:2	8.3	1:1	7.9	4:4 ^c	71.4	2:3
DIP MER	6.3	---	1.7	13.3	9:5	50.0	5:7	5.3	3:3	14.3	0:1
DIP MIC	7.9	26.4	6.0	36.2	20:18	4.2	1:0	74.6	41:44	14.3	1:0
PER LON	59.8	53.9	54.0	31.4	19:14	25.0	3:3	---	---	---	---
ONY TOR	2.7	6.6	6.6	9.5	7:3	---	---	5.3	4:1 ^c	---	---
PER CRI	1.1	1.1	0.3	---	---	---	---	---	---	---	---
PER MAN	---	---	---	1.9	1:1	---	---	---	---	---	---
AMM LEU	1.6	---	1.0	4.8	3:2	12.5	1:2	6.1	1:4 ^c	---	---
THO BOT	---	6.6	2.6	---	---	---	---	---	---	---	---
MUS FRE	---	---	---	1.0	0:1	---	---	0.9	0:1	---	---

^aData from Turner 1973.

^bData from Turner 1974.

^cOne animal of undetermined sex not included.

Table 42. Mean weights (grams $\pm$ 2 SE) by sex and age of the most commonly captured rodents at the Rock Valley plots in 1988 and 1991.

Species	Sex	Age	Unfenced Area - ROV007				Fenced Area - ROV0080			
			1988		1991		1988		1991	
			N	Weight	N	Weight	N	Weight	N	Weight
CHA FOR	M	A	0		1	19.0	4	21.7 $\pm$ 2.2	1	20.0
	F	A	2	18.8 $\pm$ 7.1 $\pm$	1	15.5	3	20.8 $\pm$ 1.2	1	22.0
	M	J	0		0		0		1	14.3
	F	J	0		0		1	12.0	2	14.9 $\pm$ 1.2
PER LON	M	A	1	8.0 $\pm$ 0.3	3	9.7 $\pm$ 1.3	0		0	
	F	A	1	8.3 $\pm$ 0.3	3	9.7 $\pm$ 1.3	0		0	
	M	J	2	5.5 $\pm$ 1.0	0		0		0	
DIP MER	M	A	8	41.0 $\pm$ 1.4	4	39.6 $\pm$ 5.3	3	42.2 $\pm$ 3.8	0	
	F	A	5	37.7 $\pm$ 1.9	1	41.1 $\pm$ 4.6	2	46.8 $\pm$ 1.5	1	43.5
	M	J	1	25.0	1	17.0	0		0	
	F	J	0		4	18.1 $\pm$ 5.0	1	29.5	0	
DIP MIC	M	A	1	59.0 $\pm$ 12.9	1	49.0	30	57.3 $\pm$ 1.9	1	59.0
	F	A	1	55.4 $\pm$ 11.2	0		28	53.4 $\pm$ 1.5	0	
	M	J	8	44.6 $\pm$ 8.7	0		11	41.1 $\pm$ 3.6	0	
	F	J	7	42.6 $\pm$ 11.5	0		16	41.4 $\pm$ 2.1	0	

Burned Areas

Redrock Valley

Small mammals on the burned area in Redrock Valley (RED001) and its control (RED002) were trapped on 26-28 July 1988 (six days after a brush fire), 25-27 July 1989 (one year after the fire), and 31 July - 2 August 1990 (two years after the fire) for a total of 420 trap nights each year. For further background information on this site, see Saethre and Medica 1992.

Estimated summer densities and species present on the plot in the burned area and a control in an unburned area for 1988, 1989, and 1990 are given in Table 43. The number of kangaroo rats (*Dipodomys* spp.) increased on both plots from 1988 to 1989 but decreased from 1989 to 1990. 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. Two species captured in 1988 but not in 1989 and 1990 were *Chaetodipus formosus* (found on both plots in 1988) and *Sylvilagus audubonii* (found on the control plot in 1988). *P. parvus* was not captured on either plot in 1990, and *Onychomys torridus* was not captured in 1990 on the burned area, despite an abundance of ants on this site.

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). Species diversity (H') decreased significantly on the burned site from 1989 to 1990, and although H' also decreased on the control, it was not a significant change.

Table 43. Estimated July density ($N/ha \pm 2$ SE) and species diversity (H') of small mammals on the BECAMP subsidiary plots in Redrock Valley during 1988, 1989, and 1990. Numbers in parentheses are individuals captured.

Species	RED001 (Burn)			RED002 (Undisturbed)		
	1988	1989	1990	1988	1989	1990
CHA FOR	* (2)	---	---	* (1)	---	---
DIP MER	15.4 $\pm$ 1.6 (24)	19.7 $\pm$ 0.3 (31)	14.1 $\pm$ 0.7 (22)	21.0 $\pm$ 2.4 (31)	23.8 $\pm$ 1.9 (36)	20.7 $\pm$ 2.1 (31)
DIP MIC	* (3)	6.8 $\pm$ 3.5 (8)	* (1)	8.2 $\pm$ 6.1 (8)	10.4 $\pm$ 0.8 (16)	5.7 $\pm$ 0 (9)
DIP ORD	---	4.8 $\pm$ 0.9 (7)	* (3)	---	---	---
PER LON	4.1 $\pm$ 2.5 (5)	* (1)	---	5.7 $\pm$ 4.0 (6)	4.4 $\pm$ 1.8 (6)	* (2)
PER PAR	5.1 $\pm$ 3.1 (7)	* (3)	---	5.3 $\pm$ 2.2 (7)	3.2 $\pm$ 0 (5)	---
PER MAN	* (4)	* (1)	* (1)	* (3)	* (3)	* (1)
ONY TOR	* (1)	* (5)	---	---	* (1)	* (3)
SYL AUD	---	---	---	* (4)	---	---
N/ha	29.2 (46)	35.6 (56)	17.1 (27)	38.1 (60)	42.5 (67)	29.2 (46)
Species	7	7	4	7	6	5
H'	0.6415	0.6000	0.2845	0.6468	0.5591	0.4268

*Species present but data insufficient to estimate density.

The number of individuals captured was highest on both plots in 1989 and considerably lower in 1990. Trap success was also highest in 1989--29% on the burned area and 34% on the undisturbed plot. Trap success was only 16% in 1990 on the burned plot and 23% on the control. The trap success of 34% on the control plot in 1989 was significantly higher than the trap success on the burned area in 1989 and on both sites in 1990 (23% on the burn and 25% on the control) and 1990 (χ^2 , 0.001 < p < 0.005).

Dipodomys merriami comprised over 50% of the total captured population on both sites in 1988, 1989, and 1990 (Table 44). Sex ratios of the most common rodents were not significantly different from 1:1 (χ^2 , p > 0.05) in any year (Table 45). The mean weight of male *D. merriami* was significantly heavier than females of that species captured on the burned area in 1989 (ANOVA, 0.002 < p < 0.005). However, on the control plot, there were no statistically 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 44. Percent of total captured population (%T) and sex ratio (M/F) of small mammals on the BECAMP plots on NTS in Redrock Valley in July 1988, 1989, and 1990.

Species	Burned Area - RED001						Control Area - RED002					
	1988		1989		1990		1988		1989		1990	
	%T	M/F	%T	M/F	%T	M/F	%T	M/F	%T	M/F	%T	M/F
CHA FOR	4.3	1:1	---	---	---	---	1.7	0:1	---	---	---	---
DIP MER	52.2	14:10	55.3	15:16	81.5	10:12	51.7	18:13	53.7	15:16	67.4	14:17
DIP MIC	6.5	2:1	14.3	2:6	3.7	0:1	13.3	5:3	23.9	4:12	19.6	3:6
DIP ORD	---	---	12.5	4:2 ^a	11.1	2:1	---	---	---	---	---	---
PER LON	11.0	3:2	1.8	0:1	---	---	10.0	3:3	9.0	0:6	4.3	2:0
PER PAR	15.2	4:2 ^a	5.4	3:0	---	---	11.7	3:4	7.5	4:1	---	---
PER MAN	8.7	3:1	1.8	1:0	3.7	0:1	5.0	2:1	4.5	1:2	2.2	0:1
ONY TOR	2.2	^a	8.9	1:4	---	---	---	---	1.6	1:0	6.5	1:2
SYL AUD	---	---	---	---	---	---	6.7	^b	---	---	---	---

^aOne animal of undetermined sex not included.

^bOnly juveniles of indeterminate sex were captured.

Table 45. Mean weights (grams ± 2 SE) by sex and age of the most common rodents captured on the Redrock Valley burned area and control in 1988, 1989, and 1990.

Species	Sex	Age	BURNED AREA - RED001						CONTROL AREA - RED002					
			1988		1989		1990		1988		1989		1990	
			N	Weight	N	Weight	N	Weight	N	Weight	N	Weight	N	Weight
PER LON	M	A	3	8.0 $\pm$ 1.2	0		0		1	7.0	0		2	7.8 $\pm$ 0.5
	F	A	2	6.5 $\pm$ 1.0	1	8.0	0		3	8.0 $\pm$ 1.2	6	8.2 $\pm$ 2.2	0	
	M	J	0		0		0		2	6.5 $\pm$ 1.0	0		0	
	F	J	0		0		0		0		0		0	
PER PAR	M	A	2	20.0 $\pm$ 1.0	3	20.7 $\pm$ 2.2	0		1	29.0	4	20.1 $\pm$ 4.6	0	
	F	A	1	18.5	0		0		3	18.0 $\pm$ 6.0	1	15.0	0	
	M	J	2	8.8 $\pm$ 0.7	0		0		1	9.5	0		0	
	F	J	1	9.0	0		0		0		0		0	
DIP MER	M	A	8	41.2 $\pm$ 3.3	10	43.3 $\pm$ 1.9	9	41.0 $\pm$ 1.6	11	40.0 $\pm$ 3.2	10	40.8 $\pm$ 2.4	12	41.7 $\pm$ 1.5
	F	A	5	39.9 $\pm$ 3.2	11	38.9 $\pm$ 1.8	8	38.5 $\pm$ 2.9	10	43.1 $\pm$ 1.9	9	38.9 $\pm$ 1.1	13	40.7 $\pm$ 2.9
	M	J	6	29.2 $\pm$ 3.0	5	30.3 $\pm$ 3.2	1	27.0	7	27.3 $\pm$ 1.7	7	31.2 $\pm$ 7.8	2	32.3 $\pm$ 0.5
	F	J	5	26.3 $\pm$ 7.4	5	22.6 $\pm$ 5.5	4	25.8 $\pm$ 2.5	3	26.9 $\pm$ 3.0	10	29.7 $\pm$ 8.8	4	31.7 $\pm$ 2.7
DIP MIC	M	A	2	52.2 $\pm$ 5.0	2	65.5 $\pm$ 4.2	0		5	58.4 $\pm$ 8.2	4	60.4 $\pm$ 5.6	3	61.0 $\pm$ 4.4
	F	A	1	51.3	5	57.3 $\pm$ 5.8	1	49.0	3	54.3 $\pm$ 9.3	11	53.9 $\pm$ 2.6	6	57.3 $\pm$ 5.2
	M	J	0		0		0		0		0		0	
	F	J	0		1	47.5	0		0		0		0	
DIP ORD	M	A	0		3	47.1 $\pm$ 1.8	2	50.1 $\pm$ 2.8	0					
	F	A	0		2	43.2 $\pm$ 1.7	1	43.3	0					
	M	J	0		1	43.2 $\pm$ 1.7	0		0					
	F	J	0		0	16.0	0		0					

Yucca Flat

This study area 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 the other BECAMP subsidiary study plots. This site was then trapped on 14-16 August 1990, 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 (Table 46). Although the density of *D. microps* was not initially high on the unburned area in 1987, this species was not captured at all in 1990 on either plot. This result was consistent with the decrease in number and even disappearance of this species from other plots on the NTS since 1988. In 1987, 98% of the captured population on the burned area consisted of three heteromyid rodent species (*Dipodomys* and *Perognathus*), while 89% of the control animals were heteromyid rodents (four species).

Table 46. Estimated summer density (N/ha $\pm$ 2 SE) and species diversity (H') of small mammals captured on the Yucca Flat burned area and control in 1987 and 1990. Numbers in parentheses are individuals captured.

Species	Yucca Flat Burn - YUF002				Control Area - YUF003			
	1987 ^a		1990		1987 ^a		1990	
CHA FOR	---		---		* (2)		---	
DIP MER	37.3 $\pm$ 3.5	(29)	12.5 $\pm$ 0	(18)	14.7 $\pm$ 2.8	(11)	10.6 $\pm$ 2.1	(14)
DIP MIC	*	(3)	---		6.2 $\pm$ 2.8	(5)	---	
PER LON	37.7 $\pm$ 22.1	(18)	6.3 $\pm$ 4.4	(6)	30.8 $\pm$ 3.5	(24)	*	(2)
ONY TOR	*	(1)	*	(1)	*	(2)	---	
AMM LEU	---		---		*	(2)	---	
SYL AUD	---		---		*	(1)	---	
N/ha	63.0	(51)	17.4	(25)	58.0	(47)	11.1	(16)
Species	4		3		7		2	
H'	0.4049		0.3074		0.6108		0.1636	

*Species present but data insufficient to estimate density.

^aDensity calculated from data in Hunter and Medica 1989.

The percent of the total captured population in 1990 was vastly different on the undisturbed area as compared to 1987. One hundred percent of the captured rodents were only two species of heteromyids (Table 47). The most common species on the burned site in both years was the kangaroo rat *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). One additional species, *Peromyscus maniculatus*, was captured in 1987 on the transect line in the burned area, but was not captured in the undisturbed area either on the grid or the transect lines (Hunter and Medica 1989).

Table 47. Percent of total captured population (%T) and sex ratio (M/F) of small mammals captured on the Yucca Flat burned area and control in 1987 and 1990.

Species	Yucca Flat Burned Area - YUF002				Control Area - YUF003			
	1987		1990		1987		1990	
	%T	M/F	%T	M/F	%T	M/F	%T	M/F
CHA FOR	---	---	---	---	4.3	2:0	---	---
DIP MER	56.6	17:12	72.0	7:11	23.4	8:3	87.5	7:7
DIP MIC	5.9	2:1	---	---	10.6	0:5	---	---
PER LON	35.3	10:8	24.0	6:0	51.1	14:10	12.5	0:2
ONY TOR	2.0	1:0	4.0	0:1	4.3	1:1	---	---
AMM LEU	---	---	---	---	4.3	1:1	---	---
SYL AUD	---	---	---	---	2.1	I*	---	---

*One individual of indeterminate (I) sex was captured.

Sex ratios of the most common species did not differ significantly from 1:1 (Table 47), except that six male *P. longimembris* were captured on the burned area in 1990 when no females of this species were captured. Mean weights were not significantly different between years, plot, or sex (Table 48). One note of interest in 1990, occurred when the bait was put into the traps in the evening at the control area and was cleaned out of the traps in the morning 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.

Table 48. Mean weights (grams $\pm$ 2 SE) by sex and age of the most common rodents on the Yucca Flat burned area and control in 1987 and 1990.

Species	Sex	Age	N	Yucca Flat Burn - YUF002				Unburned Area - YUF003			
				1987		1990		1987		1990	
				Weight	N	Weight	N	Weight	N	Weight	N
PER LON	M	A	10	8.3 $\pm$ 0.4	5	8.6 $\pm$ 0.5	14	8.8 $\pm$ 0.4	0		
	F	A	8	8.5 $\pm$ 0.6	0		10	7.7 $\pm$ 2.9	2	8.0 $\pm$ 0	
	M	J	0		1	6.0	0		0		
	F	J	0		0		0		0		
DIP MER	M	A	13	38.4 $\pm$ 1.4	7	40.4 $\pm$ 1.4	5	40.7 $\pm$ 4.3	5	44.1 $\pm$ 2.7	
	F	A	9	40.3 $\pm$ 1.3	10	37.5 $\pm$ 2.0	1	39.0	7	39.8 $\pm$ 1.3	
	M	J	4	30.4 $\pm$ 1.6	0		3	30.6 $\pm$ 1.1	2	28.8 $\pm$ 9.7	
	F	J	3	26.9 $\pm$ 3.3	1	32.0	2	27.3 $\pm$ 3.5	0		
DIP MIC	M	A	2	61.0 $\pm$ 14.0	0		0		0		
	F	A	0		0		3	58.3 $\pm$ 2.4	0		
	M	J	0		0		0		0		
	F	J	1	46.0	0		2	47.3 $\pm$ 2.54	0		

Mid Valley

A lightning fire burned an 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. Most of the species present on the control site in 1988 were also present on the burned area with the exception of a jackrabbit, *Lepus californicus* (one juvenile) and one western harvest mouse, *Reithrodontomys megalotis* (Table 49). 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. Species diversity (H' , Table 49) decreased significantly on both plots between 1988 and 1991 (t-test, $p < 0.001$).

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 on this plot, only 4 species accounted for 93% of the captured individuals (Table 50). One of the more common species in 1988, *P. maniculatus*, was not captured on either plot in 1991. 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*.

Table 49. Estimated summer density ($N/ha \pm 2 SE$) and species diversity (H') for small mammals captured on the Mid Valley burn and control plots in 1988 and 1991.

Species	Mid Valley Burn - MID002				Control Area - MID003			
	1988		1991		1988		1991	
CHA	*	(2)	---		*	(3)	*	(3)
DIP MER	8.9 ± 0	(15)	11.3 ± 1.6	(18)	3.4 ± 1.2	(5)	*	(3)
DIP MIC	*	(1)	---		3.6 ± 0	(6)	*	(4)
PER LON	3.6 ± 0	(6)	*	(1)	3.6 ± 0	(6)	*	(1)
PER PAR	---		---		---		*	(3)
ONY TOR	*	(1)	---		*	(4)	---	
PER MAN	*	(1)	---		4.1 ± 2.7	(5)	---	

Table 49. continued.

Species	Mid Valley Burn - MID002				Control Area - MID003			
	1988		1991		1988		1991	
REI MAN	---		---		* (1)		---	
LEP CAL	---		---		* (1)		---	
N/ha	15.4	(26)	11.3	(19)	18.4	(31)	8.3	(14)
Species	6		2		8		5	
H'	0.5337		0.0895		0.6655		0.5443	

*Species present but data insufficient to estimate density.

Table 50. Percent of total captured population (%T) and sex ratio (M/F) for small mammals captured on the Mid Valley burn and control plots in 1988 and 1991.

Species	Mid Valley Burn - MID002				Mid Valley Control - MID003			
	1988		1991		1988		1991	
	%T	M/F	%T	M/F	%T	M/F	%T	M/F
PER FOR	7.7	1:1	---	---	9.7	2:1	21.4	2:1
DIP MER	57.7	11:4	94.7	12:6	16.1	3:2	21.4	1:2
Dip MIC	3.8	1:0	---	---	19.4	2:4	28.6	1:3
PER LON	23.1	3:3	5.3	1:0	19.4	3:3	7.1	1:0
PER PAR	---	---	---	---	---	---	21.4	3:0
ONY TOR	3.8	0:1	---	---	12.9	1:3	---	---
PER MAN	3.8	0:1	---	---	16.1	4:1	---	---
REI MEG	---	---	---	---	3.2	1:0	---	---
LEP CAL	---	---	---	---	3.2	I*	---	---

*One juvenile of indeterminate (I) sex was captured.

The percent trap successes on the two sites in 1988 were the same -- 11% on the burned area and 0% on the control area. In 1991, however, trap success on the burn (7%) was nearly twice that on the control (4%). Individual animals were also captured a greater number of times on the burn than on the control in both years (1.88 and 1.74 times on the burn and 1.55 and 1.21 times on the

Table 51. Mean weights (grams $\pm$ 2 SE) by sex and age of the most common rodents on the Mid Valley burn site and control in 1988 and 1991.

Species	Sex	Age	Mid Valley Burn - MID002				Control - MID003			
			1988		1991		1988		1991	
			N	Weight	N	Weight	N	Weight	N	Weight
PER LON	M	A	3	8.2 $\pm$ 2.0	1	10.0	3	8.3 $\pm$ 0.7	1	10.5
	F	A	3	10.0 $\pm$ 3.1	0		2	9.5 $\pm$ 1.0	0	
	M	J					0			
	F	J					1	6.0		
DIP MER	M	A	8	43.6 $\pm$ 3.2	12	44.5 $\pm$ 2.1	3	41.0 $\pm$ 2.0	1	49.0
	F	A	4	44.1 $\pm$ 3.7	5	38.6 $\pm$ 3.5	2	38.7 $\pm$ 6.7	2	40.5 $\pm$ 1.0
	M	J	3	27.1 $\pm$ 2.3	0		0		0	
	F	J	0		1	23.0	0		0	
DIP MIC	M	A	0		0		1	67.5	1	79.0
	F	A	0		0		1	64.0	1	74.7
	M	J	1	44.5	0		1	28.5	0	
	F	J	0		0		3	37.2 $\pm$ 8.4	2	44.5 $\pm$ 1.0

unburned area). Sex ratios 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 51). Mean weights also were not significantly different between plots or years.

Gopher Denuded Area - Mercury Valley

Gophers and other rodents have disturbed several areas on the NTS for an estimated total of about 1000 ha. Several of these areas are large, up to ~65 ha (Hunter 1981), and contain almost no perennial vegetation. One of the larger areas, located in southwestern Mercury Valley on the southern edge of the NTS, was trapped for small mammals on 21, 22, and 26 July 1988 and again on 9-11 July 1991. Although escape cover on this site was limited to dispersed *Stanleya pinnata* and several small dead shrubs, the estimated population on the gopher denuded area was the highest of any site studied in 1991 on the NTS (Table 52). This is most likely due to the abundance of annual vegetation which flourished on this site in the absence of any competition from larger perennial shrubs.

While the number of *D. merriami* captured on the undisturbed area showed only a minimal increase from 1988, nearly six times as many *D. merriami* were captured on the gopher area in 1991 as in 1988 (Table 52). Other species present on the gopher area in 1988 either decreased or disappeared, with the exception of *Chaetodipus formosus*, which was captured for the first time on the gopher area in 1991, but was the most common rodent on the control in 1988. Species diversity decreased significantly at both plots in 1991. No gophers (*Thomomys* spp.) were captured on this site, most likely due to the fact that these fossorial creatures are not likely to be captured aboveground.

Table 52. Estimated summer density (N/ha $\pm$ 2 SE) and species diversity (H') of small mammals captured on the Mercury Valley gopher area and control in 1988 and 1991. Numbers in parentheses are individuals captured.

Species	Mercury Valley Gopher Area				Control Area			
	1988		1991		1988		1991	
CHA FOR	---		*	(1)	18.6 $\pm$ 6.8	(20)	10.6 $\pm$ 2.1	(14)
DIP MER	6.9 $\pm$ 0	(10)	39.8 $\pm$ 1.8	(56)	10.5 $\pm$ 0.6	(15)	14.1 $\pm$ 2.1	(19)
DIP MIC	4.5 $\pm$ 1.2	(6)	*	(3)	6.4 $\pm$ 0.8	(9)	---	
PER LON	---		---		8.0 $\pm$ 2.7	(10)	5.4 $\pm$ 1.6	(7)
ONY TOR	*	(2)	---		*	(3)	*	(2)

Table 52. continued.

Species	Mercury Valley Gopher Area				Control Area			
	1988		1991		1988		1991	
AMM LEU	*	(2)	---		*	(1)	*	(1)
N/ha	13.9	(20)	41.7	(60)	40.3	(58)	29.9	(43)
Species	4		3		6		5	
H'	0.5074		0.1227		0.6655		0.5443	
*Species present but data insufficient to estimate density.								

As at other sites on the NTS in recent years, the number of *Dipodomys microps* decreased considerably from 1988 on both the control and gopher area (Table 53). The percent composition of the different species present on the two plots remained fairly stable, except that *D. merriami* increased while *D. microps* decreased.

Table 53. Percent of total captured population (%T) and sex ratio (M/F) for the small mammals captured on the Mercury Valley gopher denuded area and control in 1988 and 1991.

Species	Gopher Area - MER002				Control Area - MER003			
	1988		1991		1988		1991	
	%T	M/F	%T	M/F	%T	M/F	%T	M/F
CHA FOR	---	---	1.7	0:1	34.5	10:10	32.6	8:6
DIP MER	50.0	5:5	93.3	29:27	25.9	8:7	44.2	10:9
DIP MIC	30.0	2:4	5.0	2:1	15.5	5:4	---	---
PER LON	---	---	---	---	17.2	5:5	16.3	2:5
ONY TOR	10.0	1:1	---	---	5.2	2:1	4.6	1:1
AMM LEU	10.0	1:1	---	---	1.7	1:0	2.3	0:1

The sex ratios of the most common species on the two sites (Table 53) did not differ significantly from 1:1 and mean weights (Table 54) showed no significant changes, except that a greater proportion of the *D. merriami* on the gopher area were juveniles.

Table 54. Mean weights (grams $\pm$ 2 SE) by sex and age of the most common rodents captured on the Mercury Valley gopher area and control in 1988 and 1991.

Species	Sex	Age	Mercury Valley Gopher Plot				Control Plot			
			1988		1991		1988		1991	
			N	Weight	N	Weight	N	Weight	N	Weight
CHA FOR	M	A	0		0		10	15.9 $\pm$ 3.2	6	18.2 $\pm$ 2.9
	F	A	0		0		10	17.3 $\pm$ 5.5	3	18.8 $\pm$ 4.5
	M	J	0		0		0		2	12.5 $\pm$ 1.0
	F	J	0		1	12.5	0		3	13.6 $\pm$ 0.6
PER LON	M	A	0		0		3	6.7 $\pm$ 0.7	2	8.0 $\pm$ 2.0
	F	A	0		0		5	7.4 $\pm$ 1.0	5	8.3 $\pm$ 0.9
	M	J	0		0		2	5.5 $\pm$ 1.0	0	
	F	J	0		0		0		0	
DIP MER	M	A	4	40.9 $\pm$ 7.8	14	40.6 $\pm$ 2.2	7	39.6 $\pm$ 3.3	9	42.1 $\pm$ 2.9
	F	A	4	40.5 $\pm$ 5.4	14	38.6 $\pm$ 1.9	4	38.3 $\pm$ 4.0	7	37.6 $\pm$ 2.1
	M	J	1	30.5	15	25.2 $\pm$ 1.7	1	25.3	1	33.3
	F	J	1	32.3	13	24.8 $\pm$ 3.0	3	29.7 $\pm$ 2.9	1	29.0
DIP MIC	M	A	2	54.8 $\pm$ 3.7	0		4	55.8 $\pm$ 5.4	0	
	F	A	3	61.2 $\pm$ 9.7	1	52.0	3	56.2 $\pm$ 4.6	0	
	M	J	0		2	38.3 $\pm$ 3.3	1	47.0	0	
	F	J	1	46.0	0		1	40.5	0	

Roadside Study

From 1986 through 1991, small mammals were trapped on lines located 3 and 5 km downwind of the Department of Energy's Liquefied Gaseous Fuels Spill Test Facility (LGF) in Frenchman Flat as part of a monitoring program. During that time period, drought effects were noticeable in that the number of rodents captured decreased markedly (Hunter et al. 1991).

In the early years of trapping, it was noted that the 5-km control lines, which were located outside of the spill zone and next to a paved road, had a trap success that was significantly greater (range was 26 to 62%) than the other control at 3 km (13 to 53%). After trapping in June 1989, the LGF control located by the road had a 49% trap success, while the other control had a significantly lower trap success of 13% (χ^2 , $p < 0.001$). Consequently, a new control was added farther away from the road.

In 1989, the LGF roadside control also showed a lack of drought effect in that a high percentage of the female kangaroo rats showed evidence of reproduction. It was decided to set up an experiment to determine if roadsides might provide refugia from drought-stricken areas. A line of 150 traps spaced at 10 m intervals was set up next to a moderately travelled road in Frenchman Flat (FRF003). A similar line was located 500 m away from the road to the north (FRF004). The Frenchman Flat baseline site is ~200 m south of the same road.

Roadside and control lines were first trapped on 12 July 1989 for one night. *Dipodomys merriami* captured on the roadside, although significantly more abundant (χ^2 , $p < 0.05$), did not appear to show any greater reproductive activity than the rodents captured on the control. It appeared that it was either too late in the season or that the drought had adversely affected summer reproduction of the roadside populations similarly to those on the control area.

This site was trapped monthly in 1990 beginning in March, to follow one full season of reproduction. A 3 x 26 grid (0.50 ha) was made in 1990 at the center of each trap line by adding two lines of 26 traps on either side of the existing line. One of these 26-trap lines was located on the berm of the roadside where there was a lack of vegetation.

The results of the trapping at this site are summarized in Table 55. Rodents of any species were rarely captured on the berm of the road. Although trap success and the number of individuals captured were consistently higher on the roadside, trap success was significantly different only in late June 1990 (χ^2 , $p < 0.001$). Of the individual animals captured for each species, significantly more *Dipodomys merriami* were captured on the roadside (108) than on the control (70). However, the total number of all individuals captured on the roadside (187) was not significantly different from the control (161). Sex ratios at the two sites for each month were never significantly different from 1:1 for *D. merriami* or the other commonly captured species, *P. longimembris*. However, significantly more individual male (65) than female (43) *D. merriami* were captured overall on the roadside (χ^2 , $p < 0.05$). Males were also significantly heavier than females at both sites (ANOVA, $p < 0.05$) when all trapping dates were pooled. A significant increase in the weight of adult females was observed on the roadside between March, April, and May. This coincided with an increase in the number of pregnant rodents at this site. Only a slight increase in the weight of adult females was observed on the control line at this time.

Table 55. Results of trapping at the roadside study area in 1989 and 1990. Numbers are the total number of individuals captured for each trapping period.

	1989 12 July	1990 21-23 March	25 April	22,23 May	5,6 June	28,29 June	20 July	7,8,9 August	10 August	Total
Species										
Roadside-FRF003										
CHA FOR	--	--	--	--	1	1	1	2	4	7
DIP MER	36	38	42	40	38	45	41	33	42	108
PER LON	9	--	3	17	18	28	12	11	8	64
ONY TOR	--	1	1	--	--	--	--	--	--	2
AMM LEU	--	--	--	1	--	--	--	--	--	1
SPE TER	--	--	--	2	1	1	--	--	1	85
N	45	39	46	60	58	75	54	46	55	187
Species	2	2	3	4	4	4.3429	3	3	4	6
H'	0.3451	0.1576	0.1323	0.3718	0.3368	0.3009	0.3167	0.3010	0.2847	0.4258
Nights	150	606	202	404	404	404	202	372	202	2574
% success	30.00	16.17	22.77	23.51	23.02	29.46	27.23	25.27	27.23	23.76
Control-FRF004										
CHA FOR	--	--	--	--	1	--	--	--	--	1
DIP DES	--	--	--	--	--	--	1	--	--	1
DIP MER	22	35	30	25	23	25	31	18	21	70
PER LON	9	1	3	25	26	24	16	18	12	83
ONY TOR	--	1	--	--	--	--	--	--	--	1
PER CRI	1	--	--	--	--	--	--	--	--	1
PER MAN	1	--	--	1	--	--	--	--	--	2
AMM LEU	--	1	--	1	--	--	--	--	--	2
N	33	38	33	52	50	49	48	36	33	161
Species	4	4	2	4	3	2	3	2	2	8
H'	0.2173	0.0518	0.1495	0.3515	0.3388	0.3208	0.2681	0.3113	0.3265	0.3941
Nights	150	606	202	404	404	404	202	372	202	2574
% success	22.00	14.52	16.34	19.80	18.81	18.07	23.76	16.13	16.34	17.79

Figure 5 - Distribution of the female *Dipodomys merriami* captured on the roadside study site from March to August, 1991.

Figure 6 - Distribution of the female *Dipodomys merriami* captured on the control site for the roadside study area from March to August, 1991.

A greater number of female *D. merriami* appeared to be reproductively active throughout the entire season on the roadside as compared to the control (Figures 5 and 6). However, some females at both sites appeared to be pregnant at what we considered to be lower than normal weights. Immature females (juveniles) were captured in the roadside population two months earlier than the control (Table 56, Figures 5 and 6). Male reproductive condition was not included in the results, as males (except very young juveniles) may exhibit scrotal testes during most of the active year (Bradley and Mauer 1971; Reichman and Van De Graaff 1973). When both males and females are considered, consistently more juvenile and sub-adult rodents were captured on the roadside (Table 56).

Table 56. Populations at the roadside and control partitioned by weight. Numbers in parentheses are females.

Weight	1989 12 July	1990 21-23 March	25 April	22,23 May	5,6 June	28,29 June	20 July	10 August
<u>Roadside</u>								
<20	1(1)	0	0	2(1)	0	0	0	0
20 - <25	3(2)	0	0	1(1)	3(1)	0	4(2)	2(2)
25 - <30	2(1)	0	1	2(1)	5(3)	1(1)		5(1)
30 - <35	1(1)	13(12)	4(3)	3(2)	2(2)	6(6)	5(4)	4(3)
35 - <40	11(9)	19(9)	16(11)	16(11)	19(10)	23(14)	17(12)	15(14)
40 - <45	15(8)	4	20(7)	15(6)	11(3)	7(1)	13(4)	11(5)
> = 45	3	0	2(1)	2(1)	1(1)	3	0	5
<u>Control</u>								
<20	0	0	0	0	1	1(1)	0	0
20 - <25	2(1)	0	0	0	0	0	3(3)	0
25 - <30	0	0	0	0	0	0	4(4)	1(1)
30 - <35	1(1)	11(10)	5(5)	3(3)	3(3)	3(3)	3(2)	2(1)
35 - <40	8(4)	15(5)	14(7)	13(6)	12(4)	10(3)	6(6)	10(7)
40 - <45	9(4)	7	9(3)	8(2)	7(1)	8(3)	14(2)	7
> = 45	0	2	2	1	0	3	1	1

After trapping was completed on 20 July 1990, assessment lines were trapped on 7-9 August, followed by one more day of trapping on the regular traplines. Two *D. merriami* females that were captured on the roadside line were captured across the road, at 50 and 140 m from their last capture locations. One of these rodents moved back across the road within one night, while the other was not captured again on the roadside line. Two other kangaroo rats initially captured on the roadside line before August were captured 70 and 100 m away from the road on the assessment lines. However, the majority of the rats were recaptured within 40 m from the north side of the road.

On the control line, rodents marked before August were recaptured up to 100 m in both directions from the trap line. On the average, *D. merriami* captured on the control and then on assessment lines moved significantly greater distances than those captured on the roadside lines (ANOVA, $p < 0.5$). When an animal was captured two days in a row from March to August 1990, the roadside animals also moved a significantly shorter average distance (ANOVA, $0.02 < p < 0.05$) between trapping (25.3 m) than the control rodents (33.4 m). There was no effect of sex on the average distance moved between trappings, although males of some species are known to have larger home ranges than females (Maza et al. 1973; O'Farrell 1980; Frank and Heske 1992).

Unmarked rats (21) were uniformly caught between 20 and 120 m north and south from the roadside on the assessment lines. Only two new animals were captured within 30 m from the control line, while eight were captured 90 m or greater from the line.

These results seem to indicate that the rodents on the control area are moving greater distances in search of food (bait was removed from traps and cheek pouches, so no benefit was gained except from what a rodent took away in its stomach). The road did appear to be a barrier to dispersal in one direction, and the rodents tended to stay close to the road. Although there was very little ephemeral vegetation next to the roadside in 1990, some benefit was gained by living next to the road, either from the perennial vegetation or seed caches from better years. Garland (1980) found a significant positive relationship between distance from the road and number of captures, with "normal" densities occurring at 50 m from the road. The change in rodents inhabiting the area was attributed to the negative impact of the roadside disturbance and habitat fragmentation. No relationship was found between distance from the road and species richness, however, species diversity did increase significantly with increasing distance from the road (Garland 1980).

RABBIT AND HARE SURVEYS

Line transect surveys were conducted for lizards and lagomorphs on the Yucca Flat baseline site over 5 days in late spring 1989, 1990, and 1991. Transects were also performed on the Jackass Flats, T2, and T4 sites in 1990, and on the Frenchman Flat and Pahute Mesa baseline sites and T1 and the Yucca Flat burned areas in 1991. Density estimates on the Yucca Flat (YUF001) baseline site for the black-tailed jackrabbit, *Lepus californicus*, ranged from a low of 0.01/ha in 1988 to a high of 0.43/ha in 1989 (Table 57). Mean flushing distance for this species ranged from a low of 7 m in 1991 to a high of 27 m in 1988. Stoddart (1972) found that in Idaho populations, jackrabbits had a shorter mean flushing distance in fall than in spring. Mean flushing distance was also positively correlated with density. If this is true, then it would appear that jackrabbits on the YUF001 plot were underestimated in 1988, when flushing distance was the greatest.

Table 57. Summary of plain lagomorph densities (N/ha $\pm$ 1 sem) on NTS transects in 1988 through 1991. Numbers in parentheses are mean flushing distance in meters $\pm$ 1 Sem.

Site	1988	1989	1990	1991
<u><i>Lepus</i></u>				
FRF001	0.11 $\pm$ 0.14 (33 $\pm$ 19)	ND	ND	0
JAF001	0.11 $\pm$ 0.19 (13 $\pm$ 8)	ND	0	ND
PAM001	0.53 $\pm$ 0.55 (10 $\pm$ 10)	ND	ND	0
YUF001	0.01 $\pm$ 0.03 (27)	0.43 $\pm$ 0.44 (17 $\pm$ 16)	0.04 $\pm$ 0.09 (10)	0.06 $\pm$ 0.13 (7)
<u><i>Sylvilagus</i></u>				
FRF001	0	ND	ND	0
JAF001	0	ND	0	ND
PAM001	1.00 $\pm$ 0.43 (5 $\pm$ 4)	ND	ND	0
YUF001	0.14 $\pm$ 0.38 (11 $\pm$ 7)	0	0	0
*ND = not done in this year.				

The Pahute Mesa baseline site (PAM001) had the highest estimated density of all plots for both *Lepus* and *Sylvilagus* in 1988. In 1991, however, no lagomorphs were observed at this site. The Frenchman Flat and Jackass Flats plots were similarly affected by the drought -- no hares or rabbits were flushed. Jackrabbits were observed on the T1 blast and control areas in 1988 and 1991, but not on the T2, T4, or Yucca Flat burn areas and controls. YUF001 and the T1 blast area are located on the western side of Yucca Flat, which has not been as heavily utilized for nuclear testing activity as have been the eastern side and areas more to the north of these sites (T2 and T4).

The method used to estimate the abundance of lagomorphs is rather crude, and involves biases in flushing behavior of the animals, observer behavior, and duplicate counting (Stoddart 1972). However, it may provide a quick estimate of the density in an area as well as changes in that area over time. For example, it appeared that in 1988 the cottontail rabbit was more common in Yucca Flat than the jackrabbit. In 1988 the density of this species was estimated to be 0.14 animals per hectare. There were no desert cottontail rabbits observed on YUF001 in 1989, 1990, or 1991 (Table 57). In 1988, however, the density of this species was estimated to be 0.14 animals per hectare. However, there were no desert cottontail rabbits observed on YUF001 in 1989, 1990, or 1991 (Table 57). With the drought and subsequent loss of green vegetation, the cottontail rabbits disappeared from this area and were apparently replaced by jackrabbits.

After an initially high density of jackrabbits on YUF001 in 1989, the density declined in 1990, possibly as a result of continued loss of food and lack of water during drought conditions. Many small *Yucca brevifolia* plants (a potential water source) on the Yucca Flat baseline site were devoured by rabbit grazing in 1989. The estimated density for jackrabbits appeared to increase from 1990 to 1991, when green vegetation at this site also increased slightly (see Hunter, this report) and was again available as a food source.

Indirect evidence of the decrease in lagomorph populations on the NTS was the low number of road-killed animals observed in 1989 and 1990 as compared to 1988 (personal observations). In 1991, the number of animals struck and killed by vehicles was more noticeable. Stoddard (1972) observed higher juvenile and adult mortality in years of population decreases, and attributed this to predation by coyotes rather than food limitations. Coyotes are present in Yucca Flat, but tend to inhabit areas near human activity where they may pick up food scraps.

DISCUSSION: TRENDS IN SMALL MAMMAL POPULATIONS IN YUCCA FLAT

Deserts are known to support fewer species of small mammals and at lower abundance than areas with greater precipitation (Mares 1976, 1980, 1983; Morton 1979). It is apparent from the yearly data on the Yucca Flat baseline plot that animal abundance decreased markedly on the NTS from 1988 through 1991, most likely due to drought conditions which have prevailed from August 1988 into the spring of 1991. The lack of rainfall and consequently the lack of annual forage severely limited the reproductive output of small mammals, and led to major shifts in rodent populations.

It is not likely that density estimates on plots sampled for the first time during the drought years reflect the density which would be present during a "good" (i.e., average precipitation and food resources) year. Previous studies revealed that annual herbs provide adequate energy for reproduction in *Dipodomys merriami*, while *Dipodomys microps* gains energy for reproduction from the leaves of perennial vegetation (Beatley 1969; Bradley and Mauer 1971; Kenagy 1973). Perennial plants decreased in biomass in 1989 and annual plants showed virtually no germination in 1989 or 1990 (Hunter, this report).

Of the three sites studied in 1989 which had density data from previous years, YUF001 showed a drastic reduction in the density of the common kangaroo rats and pocket mice, and the *D. microps* at GMX virtually disappeared. The other site, Redrock Valley, showed an increase of *Dipodomys merriami* on the burned plot in 1989 (31 animals) from July 1988 (24 animals), but this was actually a decrease from August and October 1988 when 34 individuals were captured (Saethre and Medica 1992). The unburned plot showed an increase in 1989, 36 animals, up from 31 individuals in July and 32 in October 1988. It is possible that the drought conditions of 1989 were not as evident at the higher elevations where winter rainfall was adequate for ephemeral germination and therefore the Redrock Valley and Pahute Mesa sites were not as impacted by lack of annual plants. In 1990, the Redrock Valley and Pahute Mesa plots showed some decreases in the estimated populations of small mammals (Tables 11 and 43).

Table 58 summarizes the Yucca Flat plots studied in 1987 through 1991 for mean species diversity, number of species, average times an animal was captured, percent trap success for each plot, and total density. Although plots located on the eastern side of the valley are located in habitat that appears less desirable than on the western side, both areas showed similar trends. In

Table 58. Summary of Yucca Flat plots studied by BECAMP on 1987 through 1991 on NTS. Error terms are 1 SE.

Year	Number of Plots Surveyed	Mean H'	Mean Number of Species	Mean Average Capture	Mean Percent Success	Mean Total Density
1987						
All	3	0.5071±0.1030	5.67±1.53	1.89±0.10	39.02±6.29	55.04±9.76
Undisturbed	2	0.5583±0.0743	6.50±0.71	1.88±0.13	35.85±4.31	51.08±9.81
Disturbed	1	0.4049	4	1.92	45.37	62.96
1988						
All	9	0.4237±0.1953	4.78±1.48	2.12±0.24	18.16±6.56	25.72±12.31
Undisturbed	4	0.5954±0.0762	6.00± 0	1.88±0.08	22.40±2.75	29.94±9.43
Disturbed	5	0.2863±0.1372	3.80±1.30	2.30±0.13	14.77±6.94	18.42±9.32
1989						
All	7	0.4347±0.1155	4.00±1.41	1.78±0.29	10.79±7.22	15.25±9.45
Undisturbed	4	0.4812±0.1179	4.25±1.50	1.78±0.33	12.37±8.63	17.13±11.13
Disturbed	3	0.3027±0.1706	3.67±1.53	1.77±0.31	8.69±5.75	12.75±8.10
1990						
All	7	0.2933±0.1757	3.14±1.34	2.01±0.27	10.27±5.01	13.43±5.95
Undisturbed	4	0.3463±0.1667	3.75±1.26	1.91±0.25	11.08±5.80	14.99±6.69
Disturbed	3	0.2227±0.1947	2.33±1.15	2.15±0.27	9.20±4.67	11.34±5.26
1991						
All	9	0.2660±0.1837	3.11±1.55	2.07±0.39	11.39±6.01	14.74±7.75
Undisturbed	4	0.4316±0.0788	4.25±1.26	2.14±0.32	11.76±3.17	15.21±5.35
Disturbed	5	0.1336±0.1163	2.20±1.10	2.02±0.47	11.09±8.02	14.36±9.91
Total Mean						
All	35	0.3664±0.1808	3.94±1.63	2.00±0.31	15.16±9.99	20.85±14.65
Undisturbed	17	0.4741±0.1356	4.78±1.44	1.92±0.26	16.78±9.57	23.94±14.78
Disturbed	18	0.2524±0.1519	3.06±1.34	2.08±0.34	13.43±10.42	17.60±14.20

1988, the control plots in Yucca Flat (3) and the baseline site all had six species captured on the plot, five of which were the same: *Dipodomys merriami*, *D. microps*, *Perognathus longimembris*, *Onychomys torridus*, and *Ammospermophilus leucurus*. However, the densities of these species varied among the four sites (Saethre and Medica 1992).

In 1988, disturbed areas in Yucca Flat consistently had fewer species captured than the corresponding control (Saethre and Medica 1992). In 1989, only the baseline site had six species captured (including the five species observed on all Yucca Flat plots in 1988) and only one of the crater plots (U7au) had fewer species than its control plot, as did the bladed plots in Mid Valley and Pahute Mesa. Only one Yucca Flat control plot in 1989 did not have *D. microps* present (the control for U3cn), and only one plot did not have *P. longimembris* present (U7au control). The dates when the U7au plots were trapped were probably too cold for this small rodent, which generally becomes inactive or torpid during cold nights to avoid excessive heat loss. The number of species on the Yucca Flat baseline and control sites decreased consistently from 1988 to 1990, after which it increased slightly. The mean H' for Yucca Flat sites was significantly higher on control areas than on disturbed sites in all years (ANOVA, $p < 0.05$).

The average percent trap success on undisturbed plots in Yucca Flat was higher than on disturbed areas all years, but not with any statistical significance ($0.10 < p < 0.20$). These changing parameters might indicate that during a year of inadequate food, differences between a disturbed site and its control may be less pronounced than in marginal or good years, and that when monitoring a population, environmental stressors should be taken into account when making comparisons and drawing conclusions. In fact, disturbed sites which have less competition from perennial plants seem to produce more ephemeral plants (see Ephemerals report), which provide food for the *D. merriami* even though the lack of cover precludes protection from predation.

CONCLUSIONS

It is readily apparent that the equilibrium between populations of *Dipodomys merriami* and *D. microps* may be partially controlled by rainfall. This is particularly true for areas where the vegetation has not been degraded and therefore shrub cover has not been diminished. However, on areas that have been disturbed by above and below ground testing and fires, reduction of cover appears to be a major factor in limiting recovery. Cook (1959) found that

when cover was destroyed (by fire) an increase in predation by raptors on medium-sized mammals occurred. Recovery of an area usually involved an increase in the abundance of annual plants, which favors seed-eating rodents. Consequently, an increase in rodents such as *Reithrodontomys megalotis* and species of pocket mice (*Perognathus*) was observed (Cook 1959; Bock 1978). On disturbed areas on the NTS, an increase in the granivorous kangaroo rat, *D. merriami*, was observed.

Overall, a change from a brush habitat to one of predominantly grasses and annuals, such as had occurred in blast areas, scraped areas, craters, and burned areas, was accompanied by a species shift from high cover brush habitat species (e.g., *Dipodomys microps* and *Peromyscus maniculatus*) to low cover seed eating species (*D. merriami*). Monitoring of rodent populations may be useful in predicting population responses to alterations in habitats (Douglass 1989). However, with the three year cycle of monitoring individual plots (with the exception of the Yucca Flat baseline site) changes may go undetected. It may also not be possible to determine the timing or cause of a drastic change in population parameters when sampling is done infrequently. In addition, it appears that roadsides appeared to be drought refugia and may have significant effects on overall population changes over greater time spans.

Intensive small mammal trapping in certain areas of the NTS may yield answers to changes in geographical and ecological distributions of some rodent species. Jorgensen and Hayward (1965) reported collection sites of 27 small mammals on the NTS during the early 1960s. Two of these species, *Dipodomys ordii* and *D. deserti*, seem to have disappeared from Yucca Flat. *D. deserti* was collected by BYU in eastern Yucca Flat (Jorgensen and Hayward 1965) but has not been reported in that area for at least 25 years. It has, however, been captured by BECAMP in eastern Frenchman Flat and northwestern Jackass Flats (Hunter and Medica 1989; Hunter et al. 1991; Saethre and Medica 1992; this report Tables 5 and 55).

At the Sedan crater site in northeastern Yucca Flat, *D. ordii* was reportedly captured within 335 m of the crater lip approximately 10 years after the test (Hatch et al. 1970; Martin and Koranda 1971). It was not captured in this area by O'Farrell and Sauls (1987b) 20 years after the cratering test, nor by BECAMP nearly 30 years after the 1962 test (Tables 28a-c). BYU reported collection sites for this species in northeastern Yucca Flat (near Sedan and U10af), western Yucca Flat (by the T1 blast area), and eastern Yucca Flat (in

the vicinity of the T3 blast area and 3B site). BECAMP did not capture *D. ordii* at any of these sites from 1987 through 1991.

D. ordii was also collected by BYU in Frenchman Flat (Jorgensen and Hayward 1965). The capture site was near the present location of the FRF001 baseline site, where this species was not captured in 1987, 1988, or 1991. Between July 1972 and August 1973 it was captured in Plutonium Valley (one mountain range east of southern Yucca Flat) and in June of 1972 it was captured in a valley northeast of Yucca Flat (Moor and Bradley 1974). It was also captured between 1977 and 1980 (Moor and Bradley 1987) and between August 1988 and August 1990 (Saethre and Medica 1992; Table 43) west of Yucca Flat. Captures of *D. ordii* were reported on two disturbed areas on Pahute Mesa on the northwestern edge of the NTS between May 1980 and June 1982 (O'Farrell and Sauls 1987b) and in August 1990 (Table 31). Capture locations in the last 15 to 20 years seem to indicate that this species persists north and west of Yucca Flat at higher elevations and in more Great Basin Desert habitat (Moor and Bradley 1987; O'Farrell and Sauls 1987b; Table 31, 43).

Several technical problems, such as low sampling frequency, will be partially corrected as the length of the records increases. In addition, as more experience is gained on particular disturbances and with more documentation of varied rainfall patterns, the changes in small mammal population parameters should become more readily explainable.

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APPENDIX G
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*/HECTARE = Estimated number of animals per hectare.
- V = Estimated variance.
- 2 SE/HA = Two times the estimated standard error per hectare for N*/HA.

$$N^* = \frac{(N1 + 1) (N2 + 1)}{(M2 + 1)} - 1$$

$$SE = \sqrt{\frac{(N1 + 1) (N2 + 1) (N1 - M2) (N2 - M2)}{(M2 + 1)^2 (M2 + 2)}}$$

FRF001 1991 SPRING DENSITY

	30-Apr-91	01-May-91	02-May-91
DIP MER			
N1		9	14
XB		5	0
M2		9	12
N2		14	12
N*/HA		4.32	4.32
V		0	0
2*SE/HA		0	0
PER LON			
N1		1	1
XB		0	1
M2		1	1
N2		1	2
N*/HA		0.31	0.62
V		0	0
2*SE/HA		0	0

FRF005 1989 SUMMER DENSITY

	29-Jun-89	30-Jun-89	06-Jul-89
DIP MER			
N1		4	5
XB		1	1
M2		2	4
N2		3	5
N*/HA		3.94	4.31
V		1.11	0.23
2*SE/HA		1.46	0.68

FRF006 1989 SUMMER DENSITY

	29-Jun-89	30-Jun-89	06-Jul-89
DIP MER			
N1		7	7
XB		0	2
M2		5	7
N2		5	9
N*/HA		4.86	6.25
V		0	0
2*SE/HA		0	0

JAF001 1990 SPRING DENSITY

	09-May-90	10-May-90	11-May-90
DIP MER			
N1		8	11
XB		3	3
M2		7	8
N2		10	11
N*/HA		3.51	4.63
V		0.51	1.60
2*SE/HA		0.44	0.78
PER LON			
N1		2	5
XB		3	5
M2		2	1
N2		5	6
N*/HA		1.54	6.17
V		0	69.88
2*SE/HA		0	5.16

MER002 1991 SUMMER DENSITY

	23-Jul-91	24-Jul-91	25-Jul-91
DIP MER			
N1		39	15
XB		11	6
M2		32	41
N2		43	47
N*/HA		36.34	39.78
V		3.66	1.74
2*SE/HA		2.66	1.83
DIP MIC			
N1		5	3
XB		1	0
M2		4	3
N2		5	3
N*/HA		4.31	2.08
V		0.24	0
2*SE/HA		0.68	0

NER003 1991 SUMMER DENSITY

	23-Jul-91	24-Jul-91	25-Jul-91
DIP MER			
N1	11		15
XB	4		4
M2	10		11
N2	14		15
N*/HA	10.67		14.12
V	0.50		2.19
2*SE/HA	0.98		2.05
PER LON			
N1	5		6
XB	1		1
M2	4		3
N2	5		4
N*/HA	4.31		5.38
V	0.24		1.31
2*SE/HA	0.68		1.59
CHA FOR			
N1	6		9
XB	3		5
M2	4		7
N2	7		12
N*/HA	7.08		10.59
V	2.24		2.26
2*SE/HA	2.08		2.09

MID005 1989 SPRING DENSITY

	06-Jun-89	07-Jun-89	08-Jun-89
DIP MER			
N1		8	9
XB		1	0
M2		5	5
N2		6	5
N*/HA		6.60	6.25
V		0.75	0
2*SE/HA		1.20	0
DIP MIC			
N1		4	6
XB		2	2
M2		3	4
N2		5	6
N*/HA		4.51	6.11
V		0.75	1.31
2*SE/HA		1.20	1.59
CHA FOR			
N1		12	13
XB		1	4
M2		10	9
N2		11	13
N*/HA		9.15	12.92
V		0.21	2.86
2*SE/HA		0.64	2.35
PER MAN			
N1		3	5
XB		2	2
M2		2	5
N2		4	7
N*/HA		3.94	4.86
V		1.11	0
2*SE/HA		1.46	0
PER TRU			
N1		2	4
XB		2	1
M2		2	2
N2		4	3
N*/HA		2.78	3.94
V		0	1.11
2*SE/HA		0	1.46

PAM001 1990 SUMMER DENSITY

	20-Jun-90	22-Jun-90	23-Jun-90
PER PAR			
N1		5	12
XB		7	2
M2		4	10
N2		11	12
N*/HA		4.14	4.43
V		3.35	0.46
2*SE/HA		1.13	0.42
PER MAN			
N1		3	4
XB		1	1
M2		1	2
N2		2	3
N*/HA		1.54	1.75
V		1.99	1.11
2*SE/HA		0.87	0.65

PAM002 1989 SUMMER DENSITY

	08-Aug-89	09-Aug-89	10-Aug-89
DIP ORD			
N1		7	10
XB		3	3
M2		7	10
N2		10	11
N*/HA		6.94	9.49
V		0	0.98
2*SE/HA		0	1.37

PAM003 1989 SUMMER DENSITY

	08-Aug-89	09-Aug-89	10-Aug-89
PER MAN			
N1		7	9
XB		2	3
M2		5	5
N2		7	8
N*/HA		6.71	9.72
V		1.02	4.30
2*SE/HA		1.40	2.88
PER PAR			
N1		5	6
XB		1	0
M2		5	6
N2		6	6
N*/HA		4.17	4.17
V		0	0
2*SE/HA		0	0

RED001 1989 SUMMER DENSITY

	25-Jul-89	26-Jul-89	27-Jul-89
DIP MER			
N1		21	29
XB		8	2
M2		20	28
N2		28	30
N*/HA		18.65	19.73
V		0.52	0.07
2*SE/HA		0.92	0.34
DIP MIC			
N1		3	6
XB		3	2
M2		2	2
N2		5	4
N*/HA		4.44	6.77
V		2.01	7.77
2*SE/HA		1.80	3.54
DIP ORD			
N1		5	7
XB		2	0
M2		3	4
N2		5	4
N*/HA		5.08	4.44
V		1.79	0
2*SE/HA		1.70	0

RED001 1990 SUMMER DENSITY

	31-Jul-90	01-Aug-90	02-Aug-90
DIP MER			
N1		16	18
XB		2	4
M2		16	17
N2		18	21
N*/HA		11.43	14.11
V		0	0.27
2*SE/HA		0	0.66

RED002 1989 SUMMER DENSITY

	25-Jul-89	26-Jul-89	27-Jul-89
DIP MER			
N1		26	33
XB		7	3
M2		23	22
N2		30	25
N*/HA		21.51	23.77
V		1.21	2.29
2*SE/HA		1.40	1.92
DIP MIC			
N1		10	15
XB		5	1
M2		8	11
N2		13	12
N*/HA		10.23	10.37
V		1.90	0.45
2*SE/HA		1.75	0.85
PER PAR			
N1		3	5
XB		2	0
M2		3	3
N2		5	3
N*/HA		3.17	3.17
V		0	0
2*SE/HA		0	0
PER LON			
N1		4	5
XB		1	1
M2		2	2
N2		3	3
N*/HA		3.60	4.44
V		1.11	2.01
2*SE/HA		1.34	1.80

RED002 1990 SUMMER DENSITY

	31-Jul-90	01-Aug-90	02-Aug-90
DIP MER			
N1		25	29
XB		4	2
M2		22	16
N2		26	18
N*/HA		18.74	20.65
V		0.66	2.85
2*SE/HA		1.03	2.14
DIP MIC			
N1		4	9
XB		5	0
M2		3	5
N2		8	5
N*/HA		6.51	5.71
V		2.81	0
2*SE/HA		2.13	0

ROV007 1991 SPRING DENSITY

	11-Jun-91	12-Jun-91	13-Jun-91
DIP MER			
N1		5	7
XB		2	5
M2		4	4
N2		6	9
N*/HA		2.28	4.63
V		0.56	8.00
2*SE/HA		0.46	1.75

ROV008 1991 SPRING DENSITY

	11-Jun-91	12-Jun-91	13-Jun-91
CHA FOR			
N1		3	5
XB		2	0
M2		3	4
N2		5	4
N*/HA		1.54	1.54
V		0	0
2*SE/HA		0	0

YUFO01 1989 SPRING DENSITY

	09-May-89	10-May-89	11-May-89
DIP MER			
N1	8	10	
XB	2	1	
M2	8	10	
N2	10	11	
N*/HA	3.09	3.40	
V	0	0	
2*SE/HA	0	0	
DIP MIC			
N1	3	6	
XB	3	2	
M2	3	4	
N2	6	6	
N*/HA	1.85	2.72	
V	0	1.32	
2*SE/HA	0	0.71	
PER LON			
N1	13	22	
XB	9	4	
M2	10	12	
N2	19	16	
N*/HA	7.55	8.97	
V	5.22	6.63	
2*SE/HA	1.41	1.59	

YUFO01 1990 SPRING DENSITY

	16-May-90	17-May-90	18-May-90
DIP MER			
N1		11	11
XB		0	3
M2		9	6
N2		9	9
N*/HA		3.40	4.98
V		0	4.27
2*SE/HA		0	1.32
DIP MIC			
N1		4	4
XB		0	2
M2		3	2
N2		3	4
N*/HA		1.23	2.26
V		0	2.78
2*SE/HA		0	1.03
PER LON			
N1		6	10
XB		4	6
M2		3	3
N2		7	9
N*/HA		4.01	8.18
V		8.41	57.73
2*SE/HA		1.79	4.69

YUFO01 1991 SPRING DENSITY

	07-May-90	08-May-90	09-May-90
DIP MER			
N1		17	20
XB		3	4
M2		16	20
N2		19	24
N*/HA		6.23	7.41
V		0.21	0
2*SE/HA		0.28	0
DIP MIC			
N1		4	4
XB		0	0
M2		4	4
N2		4	4
N*/HA		1.23	1.23
V		0	0
2*SE/HA		0	0
PER LON			
N1		19	24
XB		5	9
M2		11	11
N2		16	20
N*/HA		8.44	13.19
V		7.26	32.81
2*SE/HA		1.66	3.54

YUFO02 1990 SUMMER DENSITY

	14-Aug-90	15-Aug-90	16-Aug-90
DIP MER			
N1		13	16
XB		3	2
M2		11	16
N2		14	18
N*/HA		11.46	12.50
V		0.67	0
2*SE/HA		1.14	0
PER LON			
N1		2	4
XB		2	2
M2		1	1
N2		3	3
N*/HA		3.47	6.25
V		1.99	9.99
2*SE/HA		1.96	4.39

YUFO03 1990 SUMMER DENSITY

	14-Aug-90	15-Aug-90	16-Aug-90
DIP MER			
N1		11	12
XB		1	2
M2		3	7
N2		4	9
N*/HA		9.72	10.59
V		5.99	2.26
2*SE/HA		3.40	2.09

YUFO09 1991 SPRING DENSITY

	14-May-91	15-May-91	16-May-91
DIP MER			
N1		10	14
XB		4	3
M2		7	9
N2		11	12
N*/HA		10.76	12.85
V		2.75	2.66
2*SE/HA		2.30	2.26

YUFO10 1991 SPRING DENSITY

	14-May-91	15-May-91	16-May-91
DIP MER			
N1		11	14
XB		3	1
M2		10	13
N2		13	14
N*/HA		9.91	10.47
V		0.35	0.08
2*SE/HA		0.82	0.38
PER LON			
N1			4
XB			1
M2			1
N2			2
N*/HA			4.51
V			3.75
2*SE/HA			2.69

YUF011 1991 SPRING DENSITY

	21-May-91	22-May-91	23-May-91
DIP MER			
N1			2
XB			4
M2			1
N2			5
N*/HA			5.08
V			6.00
2*SE/HA			3.11
PER LON			
N1		2	3
XB		1	1
M2		1	1
N2		2	2
N*/HA		2.22	3.17
V		0.75	2.00
2*SE/HA		0.55	0.90

YUF012 1991 SPRING DENSITY

	21-May-91	22-May-91	23-May-91
DIP MER			
N1		5	7
XB		2	0
M2		5	7
N2		7	7
N*/HA		4.44	4.44
V		0	0
2*SE/HA		0	0
PER LON			
N1		3	4
XB		1	0
M2		3	3
N2		4	3
N*/HA		2.54	2.54
V		0	0
2*SE/HA		0	0

YUF013 1991 SPRING DENSITY

	21-May-91	22-May-91	23-May-91
DIP MER			
N1		7	9
XB		2	0
M2		6	8
N2		8	8
N*/HA		5.90	5.71
V		0.37	0
2*SE/HA		0.77	0

YUF014 1990 SUMMER DENSITY

	26-Jun-90	27-Jun-90	28-Jun-90
DIP MER			
N1		6	7
XB		1	2
M2		5	4
N2		6	6
N*/HA		4.98	7.08
V		0.19	2.24
2*SE/HA		0.61	2.08

YUF015 1990 SUMMER DENSITY

	26-Jun-90	27-Jun-90	28-Jun-90
DIP MER			
N1		20	25
XB		5	6
M2		18	20
N2		23	26
N*/HA		17.73	22.52
V		0.70	2.18
2*SE/HA		1.16	2.05

YUF016 1991 SUMMER DENSITY

	09-Jul-91	10-Jul-91	11-Jul-91
DIP MER			
N1		15	21
XB		6	3
M2		14	17
N2		20	20
N*/HA		14.86	17.13
V		0.56	0.90
2*SE/HA		1.04	1.32

YUF017 1991 SUMMER DENSITY

	09-Jul-91	10-Jul-91	11-Jul-91
DIP MER			
N1		27	32
XB		5	6
M2		20	24
N2		25	30
N*/HA		23.38	27.72
V		2.63	3.02
2*SE/HA		2.25	2.41

YUF018 1991 SUMMER DENSITY

	09-Jul-91	10-Jul-91	11-Jul-91
DIP MER			
N1		10	15
XB		5	0
M2		7	12
N2		12	12
N*/HA		11.72	10.42
V		3.72	0
2*SE/HA		2.68	0
DIP MIC			
N1		1	1
XB		0	3
M2		1	1
N2		1	4
N*/HA		0.69	2.78
V		0	0
2*SE/HA		0	0
PER LON			
N1		1	2
XB		1	3
M2		0	1
N2		1	4
N*/HA		2.08	4.51
V		2.00	3.75
2*SE/HA		1.96	2.69

YUF019 1989 SPRING DENSITY

	17-May-89	18-May-89	19-May-89
DIP MER			
N1		14	15
XB		1	2
M2		10	13
N2		11	15
N*/HA		10.67	12.00
V		0.49	0.35
2*SE/HA		0.98	0.82

YUF020 1989 SPRING DENSITY

	17-May-89	18-May-89	19-May-89
DIP MER			
N1		9	11
XB		2	2
M2		7	9
N2		9	11
N*/HA		7.99	9.31
V		0.68	0.51
2*SE/HA		1.16	1.01
PER LON			
N1		3	5
XB		2	3
M2		1	4
N2		3	7
N*/HA		4.86	5.97
V		5.19	0.93
2*SE/HA		3.21	1.36

YUF023 1989 SPRING DENSITY

	23-May-89	31-May-89	01-Jun-89
DIP MER			
N1		6	17
XB		11	0
M2		5	9
N2		16	9
N*/HA		13.08	11.81
V		5.21	0
2*SE/HA		3.17	0

YUF024 1989 SPRING DENSITY

	23-May-89	31-May-89	01-Jun-89
DIP MER			
N1		22	29
XB		7	2
M2		18	9
N2		25	11
N*/HA		21.16	24.31
V		2.33	13.12
2*SE/HA		2.12	5.03
PER LON			
N1		7	8
XB		1	2
M2		7	7
N2		8	9
N*/HA		5.56	7.12
V		0	0.32
2*SE/HA		0	0.78

YUF025 1990 SUMMER DENSITY

	26-Jun-90	27-Jun-90	28-Jun-90
DIP MER			
N1		9	10
XB		1	1
M2		6	9
N2		7	10
N*/HA		7.24	7.71
V		0.62	0.11
2*SE/HA		1.09	0.46

YUF026 1990 SUMMER DENSITY

	26-Jun-90	27-Jun-90	28-Jun-90
DIP MER			
N1		10	10
XB		0	1
M2		9	9
N2		9	10
N*/HA		6.94	7.71
V		0	0.11
2*SE/HA		0	0.46

FERAL HORSE MONITORING AT THE NEVADA TEST SITE FROM 1989-91

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ABSTRACT

Monitoring of a small feral horse population at the Nevada Test Site was conducted from 1989 through 1991. During three years of monitoring, the total number of horses (yearling and older) increased from 60 to 65 individuals. The number of adults in the population (3 years and older) stayed nearly constant at about 59 horses. Thirteen foals were missing during 1990-91. Mountain lion predation on foals appeared to be significant on the NTS, probably controlling the growth rate of the herd.

INTRODUCTION

Since feral horses were placed under federal protection, with the Wild and Free-Roaming Horse and Burro Act of 1971, much interest has focused around populations in the western United States. Studies were initiated to evaluate growth rates and status of populations because they were thought to be in a state of decline (Ryden 1970). Horse populations have been increasing steadily over the last dozen or more years, (National Research Council 1980, 1982) although initial population projections were controversial (Conley 1979, Wolfe 1982). Estimates for total numbers of feral horses in the western United States exceed 40,000, with the largest component, about 28,000 or more occurring in Nevada (Berger 1986). There has also been concern about recent increases in horse populations in central Nevada bordering regions due north of the Nevada Test Site (NTS).

Monitoring of feral horses *Equus caballus* at the NTS began in 1989 by the University of California at Los Angeles (UCLA) under the U.S. Department of Energy's (DOE) Basic Environmental Compliance and Monitoring Program (BECAMP). The objective was to address concerns by estimating population size and monitoring the long-term trends in the horse population. The NTS, located approximately 100 km northwest of Las Vegas, Nevada, was commissioned in 1950 for nuclear weapons testing. Cattle and other livestock grazed by local ranchers were removed from the NTS prior to the commencement of testing in January of 1951. A small herd of feral horses was known to occupy this region after removals, although a census was never performed. Since then, with the exception of some experimental cattle grazing, the 3500 km² of the NTS has been protected from livestock grazing.

METHODS

The initial phase of the horse study began with road surveys to count horses. Teams of observers performed monthly counts from vehicles and on foot in remote areas during the summer of 1989. These counts indicated that total population size was small. Work was modified the same year to study individuals. During 1989-90 all horses were sexed, photographed, and recognized as individuals from color patterns. All bands that persisted for at least three months or longer were described and given a letter designation (A,B,C etc). Associations of bachelor males were also recorded. Bands were located approximately monthly in the peak foaling season (March-June) and again in the fall (October-November) to assess foal survival and to describe

movement patterns between winter and summer range. Additional data recorded were changes in band structure, and presence or absence of foals. Approximate locations of bands were plotted on maps to illustrate usage of the available range between years. Because road surveys were performed much more often than field surveys in remote areas (i.e. off-road areas), the locations of bands recorded are biased towards roads.

The finite rate of increase, defined as the change in population size (foals included) per unit time, was determined for each year (calculated after each fall survey). Natural springs and well reservoirs (storage ponds at well-heads) were monitored for horse usage. Locations of all water sources monitored for potential horse activity are given in Tables 1 and 2.

Table 1. Approximate elevation and location of natural springs on the Nevada Test Site monitored for wildlife utilization.

Spring	Elevation (m)	NTS Area	Nevada Grid Coordinates	
Cane	1237	5	N 746,300	E 667,400
Tippipah	1585	16	N 835,000	E 635,100
Topopah	1774	29	N 797,000	E 616,300
Reitman	1402	7	N 853,900	E 702,300
White Rock	1539	12	N 892,800	E 656,700
Captain Jack	1792	12	N 880,700	E 645,050
Oak	1783	15	N 909,000	E 672,800
Tub	1594	15	N 907,300	E 681,700
Gold Meadow	2048	12	N 902,900	E 634,100

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

Reservoir	Elevation (m)	NTS Area	Nevada Grid Coordinates	
Mercury	1103	23	N 694,400	E 691,840
Well J11	1048	25	N 740,880	E 611,700
Well J12	954	25	N 733,440	E 580,800
Well J13	1000	25	N 750,800	E 579,000
Nuwax	932	25	N 725,000	E 581,250

Table 2, continued.

Reservoir	Elevation (m)	NTS Area	Nevada Grid Coordinates	
Well 5B	943	5	N 747,440	E 704,560
Well Ue5c	978	5	N 760,080	E 701,000
Cambric-stream	954	5	N 755,000	E 704,600
Well C1	1195	6	N 790,400	E 692,000
Decon	1195	6	N 796,800	E 684,300
CP sewage	1228	6	N 794,800	E 680,260
Well 3	1210	6	N 818,000	E 677,680
Mud Plant	1227	3	N 836,880	E 686,000
Well 16D	1426	16	N 844,720	E 646,800
Well 2	1365	2	N 880,000	E 669,040
Mud Plant	1372	2	N 878,800	E 666,640
Sewage	1554	12	N 892,500	E 651,300
N Tunnel	1753	12	N 891,000	E 641,000
Camp 17	1756	18	N 878,750	E 618,750
Well 8	1737	18	N 878,875	E 609,200
19C Lower	2036	19	N 916,250	E 600,000
19C Upper	2103	19	N 918,750	E 602,500
Pahute Lake	1964	20	N 922,000	E 570,800

RESULTS AND DISCUSSION

Horses resided on the Eleana Range and peripheral areas within a 325 km² region of transition zone between the Mohave and Great Basin deserts (Figure 1). Horses occupied habitats between 1300 and 2000 m elevation and made seasonal altitudinal adjustments within this range based on temperature changes, snowfall, and forage availability. The habitat was dominated by desert shrubs, largely blackbrush (*Coleogyne ramosissima*) and sagebrush (*Artemisia tridentata* or *A. nova*), with intermixed grasses such as galleta (*Hilaria jamesii*), ricegrass (*Oryzopsis hymenoides*), and needlegrass (*Stipa speciosa*). Mean rainfall (1976-91) measured at Tippihah Spring weather station (TSWS) was 240 mm. Winters were mild with limited snowfall. Feral horses exhibiting seven types of color patterns (bay, gray, sorrel, black,

Figure 1 - Approximate area utilized by a population of feral horses on the Nevada Test Site from 1989-1991.

palomino, buckskin and roan) were observed at the NTS. Descriptions of these and other color patterns of feral horses are given in Table 3. The most numerous color type was bay, followed by black and gray.

Only seven of the approximately 30 water sources available for wildlife usage were utilized by feral horses from 1989-91 (Figure 2). These included Gold Meadow Sump, Captain Jack Spring, reservoir 2-Area 2, N-tunnel ponds, Camp 17 pond and well reservoir U19c, (upper and lower). Water sources in the higher elevations, such as reservoir U19c, were used with much less frequency by horses than reservoirs or springs at mid to lower elevations. In addition, Gold Meadow sump became dry during July 1989, shifting some of the activity towards other water sources such as Camp 17 pond in Area 18. Horse activity around water sources was concentrated at mid-elevation sites (1500-1800 m) in the Eleana Range, and centered around two prime water sources, Camp 17 pond and Captain Jack Spring. About 40 horses (yearlings and older) are primarily dependent on Camp 17 pond as a summer water source. Gold Meadow sump is used as an alternate source. Similarly, Captain Jack Spring, while small in storage volume (<1.0 m³) serves as a significant summer water source for about 23 horses foraging on the east side of the Eleana Range and in areas of Yucca Flat. The Area 2 pond and N-tunnel ponds are used less frequently than Captain Jack Spring. Horses appeared to avoid water sources located near construction camps such as Area 2 mud plant and Area 12 sewage ponds. T-tunnel ponds were not used by horses.

Table 3. A list of common horse color patterns with descriptions of their characteristics.

1.	Bay	Any shade of brown with a black mane and tail.
2.	Gray	Ranges from white to almost black, distinctions are a) dappled and b) flea-bitten.
3.	Sorrel	Reddish color with matching mane and tail (mane and tail may be a blond color called flaxen).
4.	Black	Must be solid black, if the muzzle is brown, it's a bay.
5.	Palomino	Golden color with a lighter mane and tail.
6.	Buckskin	Tan color with a black mane and tail.
7.	Paint	Distinct white spots, first distinction is color; skewbald is black and white, any other color is piebald; if the horse has white over the withers it is a tobiano, the absence of color on the withers denotes an ovato.

Figure 2 - Feral Horse Utilization of water sources at the Nevada Test Site During 1989-1991.

Table 3, continued.

8. Appalossa	A spotted horse; a) leopard is white with distinct spots all over, b) blanket has a white patch over the hind quarters with spots on it.
9. Roan	Mottled looking, can be most any combination of colors. There are no distinct markings.
10. Dun	Light brown all over with variegated hair. May have a reddish mane and tail.

Initial road survey counts of feral horses recorded during 1989 (Table 4) suggested a small total population present on the NTS. Based on the known minimum number of horses (64) identified during 1989, the largest fraction of the population counted on any attempt was only 59 percent (mean = 43 %).

Table 4. Feral horse counts determined by road surveys on the NTS during 1989.

Color pattern	Survey Dates					
	5-3	6-1	7-7	8-4	8-28	9-6
Bay	21	28	12	15	21	15
Black	4	2	4	4	1	5
Gray	3	5	2	3	3	3
Sorrel		1		1	2	2
Roan		1				
Buckskin					1	1
Palomino		1				
Foal			1	1	2	1
Totals	28	38	19	24	30	27
% of population counted*	44	59	30	37	47	42

* minimum known population number in 1989 was 64 horses.

On January 20, 1990, a helicopter survey for feral horses was organized by DOE and performed with the participation of the Air Force, Bureau of Land Management, and BECAMP/UC/ A personnel (Figure 3). The region searched during the flight was about 518 km² (200 miles²), but excluded most of the known

horse habitat on the NTS because the Air Force and BLM have no responsibilities on those areas. The survey occurred just two days after a fresh snow covered the NTS. No horses or other large game were observed nor was any evidence of activity (tracks) or movement observed. The absence of horses from this region surveyed in winter is consistent with present knowledge of distribution (Figure 1) and known altitudinal adjustments made at this time. Horses generally move off the higher elevations of the NTS after the first snowfall, occupying regions below 1500 m. In addition, no horses were observed in the area of Forty Mile Wash, Cat Canyon, and Buckboard Mesa suggesting these areas are not presently within the winter range of this species. During winter and spring, horses become independent of water sources generally after the first major snowfall and become quite difficult to locate from roads or on foot for several successive months. Aerial surveys would be more useful in locating bands during this interval if flown in the region south-east (Eleana Range) of the previously worked region.

The horse population consisted of about 15 fairly stable bands and a number of unstable bachelor groups from 1989-91. All individuals were sexed and classified into bands (Table 5). A band is a social unit of horses ranging in size from 2 to 20 or more individuals. Normally a band is defined by one stallion and one or more adult females and their offspring. A band with more than one adult male is called a multimale band. When two or more males occur in a band, one is dominant, limiting access to his females while other males are subordinate. Subordinate males have been shown to perform several functions important to maintaining band integrity. Among these are aiding the dominant male in defense of their mares from other males, and preventing females from wandering off and leaving the band (Berger 1986, Stevens 1990). Bands can be short lived (several months) or persist for years. Stable bands are those which normally do not incur a stallion change within a period of a year. Groups of bachelor males (those not associated with harems) also form associations which may last only days or weeks. Some characteristics of bands during 1990 are illustrated in Table 6. Seven bands (47%) had some change in number during the year while two incurred stallion changes. One male takeover of a band was known during 1990. In this case, stallion (number 15) of band I procured two females from band D. Berger (1986) reported that such male takeovers sometimes resulted in forced copulations on the procured females, causing fetal abortions in more than 50 percent of the cases. During 1991 most bands maintained themselves as distinct social units. Two bands (O,P), were broken up during 1991 and one new band (Q) was formed (Figures 5-5).

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Figure 3 - Nevada Test Site Helicopter Horse Survey (20 January 1990).

Table 5. Feral horse associations at the NTS 1990.

Band	Horse Identification Numbers		
A	Bays	8,9, <u>11</u> , Bay foal	
B	Blacks	26, <u>27</u> , <u>28</u> ,30, Bay <u>20</u> ,	
C	Bays	1,21,22, Buckskin 39, Gray <u>46</u>	
D	Bays	<u>23</u> ,24, <u>25</u> , Gray 38, Disbanded in 1990	
E	Bays	<u>13</u> ,16,17,18, Sorrel 41, Grays 35,37	
F	Bays	<u>4</u> ,52,53,62	
G	Bays	<u>50</u> ,51, Sorrel 47, Gray 55	
H	Bays	<u>2</u> ,58,60, Black 61	
I	Bays	6,7, <u>15</u> ,24, Gray 38	
J	Bays	<u>3</u> , <u>57</u> , Gray 56	
K	Bay	<u>19</u> , Sorrel <u>40</u> , Black 29, Black foal	
L	Sorrel	Sorrel <u>54</u> , Bay 64	
M	Bay	<u>43</u> , Palomino 32 - Disbanded in 1990	
N	Bays	<u>48</u> , 34, Palomino 32	
O	Gray	33, Sorrel <u>45</u>	
P	Bays	<u>10</u> ,12, Gray <u>36</u>	
Bachelor males	Bays	<u>14</u> , <u>23</u> , <u>25</u> , <u>42</u> , <u>43</u> , <u>44</u> , <u>49</u> , <u>65</u> , Roan <u>5</u>	

Sorrel 41 and Roan 5 missing in 1990. Males are underlined.

Table 6. Initial band characteristics of feral horses at the NTS during 1990. Stallion changes shown with an asterisk. Foals were excluded from band size calculation. Harem size was calculated excluding daughters.

Band	Total Number		No. Adults		Yr/s	Sightings	Location
	Initial	Final	F	M			
A	5	3	2	1		9	Eleana Range, Yucca Flat
B	6	5	2	3		10	Eleana Range, Yucca Flat
C	5	5	4	1		13	Area 18
D	4	0*	-	-		5	Area 18, disbanded
E	7	6	5	1		13	Area 18
F	4	4	3	1		4	Area 18
G	4	4	3	1		8	Area 18
H	4	4	3	1		9	Area 18, Gold Meadow
I	3	5	3	1	1	12	Area 18
J	3	3	1	2		7	Area 18
K	3	3	1	2		5	Eleana Range, Yucca Flat

Table 6, continued.

Band	Total Number		No. Adults		Yr/s	Sightings	Location
	Initial	Final	F	M			
L	2	2	1	1		8	Area 18
M	2	0	1	1		2	Area 18, disbanded
N	2	3	2	1		8	Eleana Range, Yucca Flat
O	2	2	1	1		4	Eleana Range, Yucca Flat
P	3	3	1	1	1	4	Eleana Range, Yucca Flat
Totals		52	32	18	2	121	

Mean band size = 3.7 ± 0.3 , N=14
Mean harem size = 2.3 ± 0.3 , N=14
Male to female sex ratio = 0.81:1.0; N=58 adults, 8 bachelors included

Mean band and harem size ($\pm$ sem) for 1990 were also low (3.7 ± 0.3 and 2.2 ± 0.3 respectively). The male to female sex ratio in 1990 was 0.84:1.0 (N=57) and changed little during the study (Table 6). Mean band sizes plotted against sex ratios are shown (Figure 4) for a number of populations studied (including the NTS). Mean band size determined for the NTS population is lower than others reported in the west (Berger 1986).

Records of reproduction and foal survival are listed in Tables 7 and 8. Field observations suggest that most foal births occurred from March through May. Of the foals that were missing, few lived past the end of June indicating that foal mortality was highest during the first six months of life. Although it is possible that some foals were missed, only 9 of 33 adult mares (27%) produced foals in 1990, and 12 of 31 adult mares (39%) produced foals in 1991. These rates are generally at the lower end of the range (0.37-0.71) of foaling rates reported (Turner et al. 1992).

Reproductive capability or foaling rates in horses increases with age. Normally, horses begin foaling at age three or older, although rare cases have been reported where two year old mares gave birth (Berger 1986). Horses aged between about 5 and 12 years are the most fecund individuals in most populations. Berger (1986) reported that foaling rates for horses (five years and older) from numerous populations varied from about 50 to 70% or greater. Although detailed knowledge of age structure for the NTS population is not known, most of the 31 monitored females were believed to be older than 3 years in age in 1991.

Table 7. Mare reproductive summary and status of foals 1989-90. Missing foals are presumed dead, if absent from mare's band. N is the number of sightings.

Mare	Band	Dates of Foals ^a		N	Status	Color
		Initial	Final			
Grey 56	J	6-13-89	7-07-89	2	missing	roan
Grey 37	E	8-04-89	9-26-89	2	missing	bay
Bay 9	A	8-27-89		5	alive	bay
Bay 6	I	8-28-89		12	alive	bay
Bay 22	C	3-28-90	4-11-90	3	missing	bay
Black 30	B	4-10-90	6-27-90	8	missing	bay
Bay 58	H	4-11-90	- - -	1	missing	bay
Bay 62	F	4-19-90	5-15-90	3	missing	bay
Black 29	K	4-20-90 ^b		4	alive	black
Grey 56	J	5-15-90	5-18-90	2	missing	bay
Bay 18	E	5-18-90	- - -	1	missing	bay
Grey 35	E	3-23-90	5-23-90	2	missing	bay
Bay 8	A	6-27-90		7	alive	bay

^a Dates that foals were observed.

^b A stillbirth black foal was also found off Orange road in Area 2 on this date; Identity of mare unknown.

Table 8. Mare reproductive summary and status of foals during 1991. N is the number of sightings.

Mare	Band	Dates of Foals		N	Foaling rate [*]	Status	Color
		Initial	Final				
Bay 21	C	4-24-91	6-12-91	7		missing	bay
Bay 52	F	4-25-91		7		alive	bay
Bay 62	F	4-25-91	5-29-91	3	c	missing	bay
Bay 6	I	4-29-91		7	a	alive	bay
Bay 18	E	5-13-91	- - -	1	c	missing	bay
Bay 9	A	5-14-91	- - -	1	a	missing	bay
Black 26	B	5-14-91		11		alive	bay
Black 30	B	5-14-91		11	c	alive	bay
Grey 24	I	5-29-91		6		alive	bay
Bay 58	H	6-07-91	- - -	1	c	missing	bay
Bay 64	L	6-07-91	8-14-91	5		missing	bay
Grey 56	J	7-02-91		4	c	alive	roan

* a = mare produced foals in alternate years.

c = mare produced foals in consecutive years.

Figure 4 - Adult sex ratios (males per female).

Figure 5 - Approximate locations of individual band sightings (N=40) during 1990 at the NTS.

Figure 6 - Approximate locations of individual band sightings (N=36) during 1991.

Lower than expected foaling rates are most likely related to drought conditions at the NTS. The quality of forage in this region may also be below that found in typical Great Basin habitats at more northern latitudes, possibly limiting foaling rates. Any interpretations of foaling rates of NTS horses must be conservative because reproduction varies greatly with age. Foal survival at the NTS was also low, resulting in a small proportion of younger age classes observed (Table 9). Only 2 of 9 foals (22%) in 1990 and 6 of 12 foals (50%) in 1991 were known to survive. Mountain lion predation could explain the sudden disappearance of healthy foals (15 missing from 1989-91). Other known causes of death for horses on the NTS include vehicle collisions on highways. Foal survival previously reported in North America ranged from 67 to 93% (Berger 1986, Siniff et al. 1986, Wolfe 1986).

Table 9. Total numbers of feral horses identified during seasonal surveys at the NTS. Percentages of the fall age classes are in parentheses.

	1989	1990		1991	
Age class	Fall	Spring	Fall	Spring	Fall
Adults ^a	59 (95.2)	59	58 (93.5)	57	57 (85.0)
Two year olds	0	0	0	2	2 (3.0)
Yearlings	1 (1.6)	2	2 (3.2)	2	2 (3.0)
Foals ^b	2 (3.2)	9	2 (3.2)	12	6 (9.0)
Total	62	70	62	73	67
Finite rate of increase λ	62/62 = 1.00		67/62 = 1.08		

^a Horses estimated to be at least 3 years old in 1989 based on relative body size and photographic records available.

^b Only four foals were observed in spring-summer of 1989, however, the census was regarded as incomplete.

A total of 59 adult horses were identified in the population during the first year of study. No additional adult horses were identified during 1990 and 1991, suggesting that the population was insular. This finding is noteworthy, considering that the Nellis Air Force Range located directly north of the NTS had a population exceeding 4000 and horses at this time. However, sightings of large groups of horses (>80 individuals) have been reported on the northern boundary of the NTS, suggesting that the Kawich valley herd may be facing pressure to emigrate into adjacent regions.

Records of band sightings suggest that summer-fall range is spatially partitioned and bands showed a moderate to high degree of fidelity to regions inhabited between years. For example, bands A,B,K,N,O, and P were consistently located on the east slope of the Eleana Range and on Yucca Flat (Figures 5-6) during both 1990 and 1991. Conversely, most other bands (C,E,F,G,H,I,J,L) showed consistent summer and fall habitat usage on the west slope of the Eleana Range (Figures 7-10). The locations shown in the above cited figures are approximate only. Because road surveys heavily outnumbered surveys in remote areas, locations of bands plotted are strongly biased towards roads, however a clear spatial pattern of separation is still obvious.

The spatial segregation of different components of the herd in the summer and fall appears partly related to the location of water sources. During summer, when water needs are the greatest, a large number of horses (40) appear largely dependent on camp 17 pond as a water source. The remainder of the herd near Yucca Flat is heavily dependent on Captain Jack Spring as a summer water source.

Distribution of bachelor males seems to follow a similar pattern as bands (Figures 11-12) except certain individuals range over larger areas (e.g. numbers 42, 49). Bachelor males in the Granite Range of northern Nevada had larger home ranges and core areas than bands (Berger 1986). During 1991, we located lower elevation sites in Areas 30 and 17 which are important wintering areas not sampled extensively during 1990 (Figures 6, 8, and 10).

Mean adult survival of horses over a two year period was high (97%). Annual rates of increase (Table 9) over the same period were low (0 to 8%) in comparison to more recent rates reported (15-30%) for feral horses in the Great Basin (Eberhardt et al. 1982, Berger 1986, Wolfe 1986, Garrott et al. 1991).

Growth of the NTS horse population appeared limited by drought and predation pressure. During drought, the availability of milk to foals decreases making them weaker than older horses (Berger 1986). Weakened foals will be more vulnerable to other risks, such as predation. Because of drought, local mule deer populations in south central Nevada in recent years have declined significantly since the record peak reported in 1988 (Nevada Department of Wildlife 1989). Subsequently, mountain lions in southern Nevada (the major predator of deer) have persisted at relatively high population levels (personal communication, Bob Turner, Nevada Department of Wildlife 1991).

Figure 7 - Approximate locations of band sightings (N=45) during 1991 at the NTS. Band D was broken up in winter of 1990.

Figure 8 - Approximate locations of individual band sightings (N=38) during 1990 at the NTS.

Figure 10 - Locations of individual bachelor males (N=49) at the NTS during 1990.

Figure 11 - Locations of individual bachelor males (N=55) during 1991 at the NTS.

Figure 12 - Locations of individual bachelor males (N=55) during 1991 at the NTS.

With a reduced prey base, mountain lions are more likely to prey on feral horses: Ashman et al. (1983) noted that horses ranked second in importance in the diet of mountain lions in areas of Nevada where deer numbers were low. Recently, mountain lion predation in the Montgomery Pass Wild Horse Territory was determined to be a significant factor controlling the growth of a feral horse herd over four years (Turner et al. 1992).

The increase in recruitment and population growth noted for horses in 1991 (Table 9) is consistent with the increase in spring rainfall. Spring rainfall (January-May) measured in the Eleana Range was 39 mm, 67 mm, and 98 mm respectively for 1989-91 (Table 10). Foal recruitment for these years was 2, 2, and 6 horses respectively and seems related to the increasing moisture trend. Therefore, the effects of drought eased in the spring of 1991, allowing improved forage conditions for pregnant females entering their final trimester of development and for subsequent lactation, when energy demands are greatest (National Research Council 1989).

Table 10. Total and Spring rainfall (mm) measured at the Tippipah Spring weather station (Eleana Range) from 1987-1991.

Period	1987	1988	1989	1990	1991
Jan-May	191	127	39	67	98
Total	350	204	60	123	192

Low values for harem size, foaling rate, and foal survival imply energetic constraints for this population. In addition, because the population is small, predation may regulate recruitment and population growth. Although data are limited to three years, the NTS population has remained nearly stable over the period. The NTS population has increased in size from only about 60 to 65 individuals over three years, an average growth rate of about 2 or 3% each year. Assuming an annual rate of increase of 4% and average rainfall, it is conceivable the NTS herd could grow to nearly 100 individuals in ten years. However, the irregularity of rainfall in the Mojave desert, both yearly and seasonally, makes prediction of long term population trends very difficult.

This study was initiated during a severe drought. Monitoring of feral horses should be continued on a yearly basis to compare drought years to normal or above normal rainfall years. Future work should concentrate on measuring parameters (e.g., foaling rate and foal survival) which reflect the relative

well-being of the population. Also, predation as a natural mechanism of population control could be more closely examined. Furthermore, grazing exclosures should be constructed in several habitats to measure effects of horse activity on the vegetation. It is recommended that a density of about one horse per square mile be adopted as a reasonable level to assure protection against overgrazing by horses. Therefore, considering the area of heavy usage (80-100 mi²), the population on the NTS should not be allowed to increase appreciably over 100 individuals in the future. Should numbers increase from within by population growth or from without by intrusion from other herds, the excess number of individuals should be removed. The NTS is ecologically valuable as a natural lands preserve and a relatively large proportion of the land area (90%) is still undisturbed. Historically, very few areas in the west have received any protection from grazing. The natural ecosystem on the NTS, by contrast, has not been impacted severely by grazing of livestock and therefore has ecological and scientific as well as cultural value. Growth of the feral horse herd, if left unregulated, is a threat to this value and should be managed with concern for maintaining the ecosystem within reasonable limits.

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**TRENDS IN WILDLIFE UTILIZATION OF WATER SOURCES AND ADJACENT
HABITATS AT THE NEVADA TEST SITE 1989-91.**

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ABSTRACT

This report summarizes three years of qualitative field observations of wildlife during a drought in the Mojave desert. The Nevada Test Site, located on a portion of the Pacific flyway, is a natural stopping point for more than 100 common species of migratory birds. More than 20 man-made well reservoirs were biologically valuable, offering forage and resting habitat for thousands of individual birds during each migratory season.

Quarterly counts of large granivorous species of birds at springs and well reservoirs indicated that mourning doves had recovered from initial drought effects but Gambel's quail had not. Other numerically important birds such as ravens have benefited from the presence of man, including nesting in man-made structures, and from foraging in landfills and sewage lagoons. Local knowledge of birds at the NTS was limited due to lack of long-term monitoring over the last 20 years. Only 36 species of birds out of about 220 known from the region have been documented as breeders. Three years of casual observations of raptors suggest that red-tailed hawks are the most common species observed. Two species, the ferruginous hawk and Swainson's hawk, conspicuous by their absence, may have suffered regional declines in numbers.

Night spotlighting surveys of mule deer provided evidence that the population has declined during the drought. Significant losses of feral horse foals were consistent with mountain lion predation. The reduction in deer numbers available as prey during the drought may be a factor allowing predation on alternate prey, such as horses.

INTRODUCTION

A preliminary assessment of the status of large mammals on the Nevada Test Site (NTS) was performed during 1988 by personnel from the University of California, Los Angeles (UCLA) under the Department of Energy's Basic Environmental Compliance and Monitoring Program (BECAMP). The initial focus of this study was to describe large mammal use of the water sources at the NTS, prompted by the original studies of Giles (1976) and Giles and Cooper (1985). However, observations were not restricted just to the water sources, but involved searching habitats adjacent to or somewhat distant from these areas. Relative abundance of large mammals on the NTS was originally described by Allred et al. (1963) and Jorgenson and Hayward (1965).

During 1989-91, work was expanded to include monitoring of other biological resources including passerine birds, migratory waterfowl and raptors. The combined objectives were to: 1) describe what species utilize the available water sources, 2) implement a mule deer census technique to examine trends and 3) update the species list for birds on the NTS. Feral horses were studied as part of this task, but those results are reported elsewhere (Greger and Romney 1992; Section 3 above).

This study covers a period of several years of extreme drought in southern Nevada. While 1988 represents a normal year for precipitation, 1989 and 1990 were two of the driest years on record followed by 1991, an easing of the drought with increased spring rains. The comparison of dry versus normal years allows an opportunity to observe effects of drought on trends of wildlife in a desert ecosystem.

METHODS

Springs and well reservoirs were visited throughout the year and examined for wildlife utilization. Springs are for the most part natural water sources (Gold Meadow sump was modified by construction of a dike to contain water) that are small in surface area and have limited surface flow. Springs, seeps, or sumps are generally synonymous referring to natural water that accumulates in pools at the surface. Seeps and sumps may be distinguished from springs as standing pools that lack surface flow. Spring flows vary between years and seasons related to amounts of precipitation (Ingraham et al 1991). Small caves were excavated by ranchers at some springs (Tippipah, Tub) which contain underground pools of water used by birds to drink or escape summer heat. The

walls of such caves are also used for nesting. External spring pools sometimes dry up in summer. Cane Spring, however, appears to have a very dependable surface flow, indicated by a population of hydrobiid snails (*Pyrgulopsis micrococcus*), a species that needs flowing water to survive.

Well reservoirs by contrast are man-made impoundments supplied continually by deep well water pumped to the surface. Well reservoirs have limited stream outflows, but have surface areas significantly larger than springs. One major outflow was Cambric, a man-made stream in Area 5 that maintained flow from 1976 until 1991, when pumping ceased. Well reservoirs have numerous biota introduced by man including frogs, crayfish, a turtle and several species of fish. These introductions should be discouraged even though they probably have had no effect on desert wildlife.

During 1988-89 surveys were performed at ad-libitum times during the day. However, in 1990-91, observations were restricted primarily to morning hours (0700-1200) in order to census passerine species of birds which are more active at this time. Identification of wildlife followed recommendations given in Burt and Grossenheider (1976) for mammals and in Peterson (1961, 1990) and Robbins et al. (1983) for birds. Counts of mammals recorded were exact. Counts of large flocks of birds were conservative estimates. Qualitative use was determined by the animal signs observed (i.e., tracks and scats) following recommendations in Murie (1974). An example of the field data sheet used for each water source visit is shown in Figure 1. Specific location and elevation for spring and well reservoir study sites are listed in Tables 1 and 2. The geographic distribution of the sites on the NTS is shown in Figure 2.

Table 1. Approximate elevation and location of natural springs on the Nevada Test Site monitored for wildlife utilization.

Spring	Elevation (m)	NTS Area	Nevada Grid Coordinates	
Cane	1237	5	N 746,300	E 667,400
Tippipah	1585	16	N 835,000	E 635,100
Topopah	1774	29	N 797,000	E 616,300
Reitman	1402	7	N 853,900	E 702,300
White Rock	1539	12	N 892,800	E 656,700
Captain Jack	1792	12	N 880,700	E 645,050
Oak	1783	15	N 909,000	E 672,800

LOCATION: _____ TIME: Start: _____ Finish: _____
DATE: _____ WIND SPEED: _____ Meters/Sec. from _____
TECH: _____ PI: _____ AIR TEMPERATURE: _____ °C
WATER SAMPLES: _____ BENCHMARK PHOTOS: _____
WEATHER: _____ Turbo Meter: _____ Presence = 1

[illegible]

Figure 1 - Field data sheet used to record wildlife sightings at water sources.

Figure 2 - Natural springs and well reservoirs monitored for wildlife utilization at the Nevada Test Site during 1989-1991.

Table 1, continued.

Spring	Elevation (m)	NTS Area	Nevada Grid Coordinates	
Tub	1594	15	N 907,300	E 681,700
Gold Meadow	2048	12	N 902,900	E 634,100
Rock Valley	1048	25	N 708,000	E 625,750

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

Reservoir	Elevation (m)	NTS Area	Nevada Grid Coordinates	
Mercury	1103	23	N 694,400	E 691,840
Well J11	1048	25	N 740,880	E 611,700
Well J12	954	25	N 733,440	E 580,800
Well J13	1000	25	N 750,800	E 579,000
Nuwx	932	25	N 725,000	E 581,250
Well 5B	943	5	N 747,440	E 704,560
Well Ue5c	978	5	N 760,080	E 701,000
Cambric-stream	954	5	N 755,000	E 704,600
Well C1	1195	6	N 790,400	E 692,000
Decon	1195	6	N 796,800	E 684,300
CP sewage	1228	6	N 794,800	E 680,260
Well 3	1210	6	N 818,000	E 677,680
Mud Plant	1227	3	N 836,880	E 686,000
Well 16D	1426	16	N 844,720	E 646,800
Well 2	1365	2	N 880,000	E 669,040
Mud Plant	1372	2	N 878,800	E 666,640
Sewage	1554	12	N 892,500	E 651,300
N-Tunnel	1753	12	N 891,000	E 641,000
Camp 17	1756	18	N 878,750	E 618,750
Well 8	1737	18	N 878,875	E 609,200
19C Lower	2036	19	N 916,250	E 600,000
19C Upper	2103	19	N 918,750	E 602,500
Pahute Lake	1964	20	N 922,000	E 570,800

Intensive monitoring of migratory birds was performed at weekly intervals at three or four well reservoirs at the NTS for the spring migration period, February-June 1990-91. Some ponds were visited much less frequently. Reservoirs were monitored in different geographical areas and elevations of the NTS to investigate different species assemblages. Times of observation

were generally in the morning between 0800 hours and 1200 hours for most locations except Pahute lake, which was visited more often in the afternoon. Total time spent at each site generally varied from about 30 to 90 minutes, with an average of about one hour. On several occasions, sites were specifically visited on consecutive days to determine if the species mix of birds changed on a day to day basis. Normally, visitations were done once or twice a week with several days of spacing between each visit. Monitoring involved slowly approaching the site by vehicle, stopping, and beginning the census from within the vehicle. It was often necessary to leave the vehicle to identify birds. The census proceeded by slowly walking around the water source and pausing often, which allows birds to adjust to the observer's presence. Time spent in observation at each site was recorded along with air temperature and wind speed, recorded in meters/second with a hand held turbometer.

Mule deer relative abundance was assessed by spotlighting animals from vehicles on three consecutive nights during August or September on Rainier and Pahute mesas. The approximate mileage driven during each census was measured as the one-way distance traveled on any road and the total number of bucks, does, and fawns observed along the route was counted. A sighting rate, number of deer/km, was determined from the counts to evaluate trends in the deer population over time.

Raven abundance was estimated in 1990-91 by surveys of areas where ravens commonly occurred (landfills, sewage ponds, town sites, and roads). Ravens were counted by six teams of observers in separate vehicles assigned to different regions of the NTS. The counts were initiated simultaneously at all locations to minimize double counting of individuals. Evidence of raven nesting was recorded during each year from opportunistic sightings.

Wildlife report cards (Figure 3) were distributed to interested individuals to record sightings of wildlife at the NTS. BECAMP personnel also made use of these cards to record opportunistic sightings of mammals or birds of interest. Sightings of mammals and birds recorded from wildlife cards were tallied by year. The NTS bird list was summarized in Appendix A.

Quantitative road surveys were implemented in 1989 to measure sighting frequency of raptors (number/km driven). Dates, locations, and times of day were recorded along with each species identification along a standardized course. Distances traveled were recorded from odometer readings or estimated

from road maps. In addition, locations of raptor sightings tallied from wildlife report cards were combined with data from road surveys and water source visits and plotted on NTS maps to illustrate abundance and distribution of some common species.

RESULTS AND DISCUSSION

Springs and Well Reservoirs

During 1989, Oak Spring was essentially dry most of the year and monitoring was discontinued. Gold Meadows sump also became dry during July 1989. Topopah Spring was nearly dry by November 1989 with only two small puddles of water remaining. This small supply continued to support a wide variety of wildlife including birds (chukar and quail) and deer. Topopah Spring was reported to be dry by the summer of 1991 and was not monitored that year.

Tables 3-5 illustrate qualitative usage of the natural springs by wildlife during 1989-91, as determined from sightings and the presence of animal tracks and scats. Similarly, Tables 6-8 list wildlife utilization at well reservoirs during 1989-91. Daylight counts of large mammals observed near springs and well reservoirs were very low (Tables 3-8), except for some winter sightings of deer at Topopah Spring. Several groups of birds comprised the most numerous sightings. These were primarily migratory species such as ducks and many species of shorebirds as well as permanent residents (ravens, chukar, and Gambel's quail). In general double counting of individuals appeared minimal due to spacing of visits. However for ravens, repeated counting of individuals on successive visits was a regular event (at Mercury and Area 12 sewage ponds and lagoons). The most recognizable trends identified from visits to water sources are for mourning doves and Gambel's quail (Table 9).

Counts suggest that the resident population of Gambel's quail, while abundant in 1988, declined significantly in subsequent years due to drought and did not recover by 1991. Mourning doves, a migratory species, also showed a several year decline but recovered on the NTS in the spring of 1991, possibly aided by spring and summer precipitation. Statewide levels of doves were reported up about 15% from 1990-91, but base levels of quail in southern Nevada were very low resulting in poor production (Nevada Department of Wildlife Report 1991). Production and survival of quail may be regulated by food limitation during drought.

WILDLIFE OBSERVATIONS ON NTS

We wish to obtain the cooperation of NTS employees in aiding our office to record the less common species of wildlife observed on NTS. Please complete this card when any of the following animals are observed: desert tortoise, elk, kit fox, grey fox, badger, ringtail, bobcat, mountain lion, antelope or eagle.

Species Observed _____ Date _____

Location: Area _____ Nearest Rad/State Marker # _____

Name of Observer _____ Phone # _____

Return this completed card to the BECAMP/ECOLOGY Office M/S 740.

Your cooperation would be greatly appreciated.

Figure 3 - Wildlife Report Card used to record opportunistic sightings of wildlife, including raptors.

Table 3. Total numbers of wildlife observed at natural springs at the Nevada Test Site during 1989. (P) indicates presence of a species inferred from tracks or scats.

	Cane Spring	Captain Jack Spring	Gold Meadow Sump	Oak Spring	Tipitoh Spring	Topopah Spring	Tub Spring	Reliman Seep	White Rock Spring	Totals			
Number of Visits	3	8	6	2	5	3	4	4	5	40			
Feral Horse		39	7							46			
Cattle										0			
Mule Deer	P	6	15	P	P	27	P	P	P	41			
Antelope										0			
Mountain Lion						P				0			
Bobcat										0			
Coyote	P	P	P		P	P	P	P	P	0			
Cottontail Rabbit					1				2	3			
Jack Rabbit													
Chukar		6				200				>200			
Gambel's Quail		10			20	40	7		4	81			
Mourning Dove		3								3			
Common Raven	2	2		1	5	2				12			

* Hundreds of Chukar were observed but an accurate count could not be made.

Table 4. Total numbers of wildlife observed at natural springs at the Nevada Test Site during 1990. (P) indicates presence of a species inferred from tracks or scats.

	Cane Spring	Captain Jack Spring	Gold Meadow Sump	Oak Spring	Reitman Seep	Tippipah Spring	Topopah Spring	Tub Spring	White Rock Spring	Totals			
Number of Visits	0	8	4	0	4	6	1	3	4	30			
Feral Horse		10	4							14			
Cattle										0			
Mule Deer		3	3		P	P	13	P	P	19			
Antelope			2							2			
Mountain Lion		*1								1			
Bobcat										0			
Coyote					P	P				0			
Cottontail Rabbit									1	1			
Jack Rabbit		2								2			
Chukar										0			
Gambel's Quail									1	1			
Mourning Dove			2		2	18				22			
Common Raven		2								2			

* This individual was a kitten (3-5 months old) which died the next day, apparently from starvation.

Table 5. Total numbers of wildlife observed at natural springs at the Nevada Test Site during 1991. (P) indicates presence of a species inferred from animal sign.

	Cane Spring	Captain Jack Spring	Gold Meadow Sump	Tipipah Spring	Topopah Spring	Tub Spring	Reitman Seep	White Rock Spring	Rock Valley Spring	Totals			
Number of Visits	2	4	2	4	0	1	1	1	1	16			
Feral Horse		2	P							2			
Cattle	P								0				
Mule Deer	P	P	P	P		P	P	P		0			
Antelope			1							1			
Mountain Lion		1*								1			
Bobcat									P**	0			
Coyote							P		P	0			
Desert Cottontail				1						1			
Jack Rabbit										0			
Chukar		20								20			
Gambel's Quail										0			
Mourning Dove	30	130	5	110		30	3	15		323			
Desert Tortoise									P				

* Hundreds of Chukar were observed but an accurate count could not be made.

** skeletal remains collected.

Table 6. Total numbers of wildlife observed at well reservoirs at the Nevada Test site during 1989. (P) denotes presence inferred from tracks or scats.

	Area 23 Sewage Pond	Area 25 Well J11	Area 25 Well J12	Area 25 Well J13	Area 25 Nuwaq Pond	Area 5 Well 58	Area 5 Well Ue5c	Area 5 Stream	Area 6 CP Sewage	Area 6 Well 3	Area 6 Well C1	Area 3 Mud Plant	Area 16 Well 16D	Area 2 Well 2	Area 2 Mud Plant	Area 12 Sewage Pond	Area 12 N Tunnel	Area 18 Well 8	Area 18 Camp 17	Area 19 U19c upper	Area 19 U19c lower	Area 20 Pahute Lake	Totals
Number of Visits	11	5	5	4	4	9	9	6	3	7	4	6	5	4	3	5	4	3	7	2	4	2	112
Feral Horse														14			P		22	P	P		36
Cattle		P	18	P																			18
Mule Deer		P		P		8	P	P					P	P		P	4	P	P	P	P	P	12
Antelope																							0
Mountain Lion																							0
Bobcat																							0
Coyote	3	P	P	1	P	P	1	P	1	1	P	1	P	P	P	P	P	P	P	P	P	P	8
Cottontail Rabbit			1													1							2
Jack Rabbit										1													1
Chukar																							0
Gambel's Quail																	6						6
Mourning Dove		1		3		1				1	2	1	1	4	5	4	1						24
Common Raven	123	2							5	2	1	3	1		3	19	2	1				2	164
Ducks (all)	78			2		21	1			9	15	12				11						9	158
Shorebirds (all)	23	1		1			1	5	4		3	3	2			10	1	3				6	63
Gulls (all)	27																						27

Table 7. Total numbers of wildlife sightings recorded at well reservoirs at the Nevada Test Site during 1990. (P) denotes presence of a species inferred from animal sign.

	Area 23 Sewage Pond	Area 25 Well J11	Area 25 Well J12	Area 25 Well J13	Area 25 Nuwax Pond	Area 5 Well 5B	Area 5 Well U6bc	Area 5 Stream	Area 6 CP Decon Pond	Area 6 Well 3	Area 6 Well C1	Area 3 Mud Plant	Area 16 Well 16D	Area 2 Well 2	Area 2 Mud Plant	Area 12 Sewage Pond	Area 12 N Tunnel	Area 18 Well 8	Area 18 Camp 17	Area 19 U19c upper	Area 19 U19c lower	Area 20 Parute Lake	Totals
Number of Visits	18	3	2	2	2	4	5	4	15	5	4	6	2	7	0	14	6	2	7	4	4	12	127
Feral Horse														7			P		P				7
Cattle		P	P	P	P													P	P				0
Mule Deer							P	P					P			P	P	P	P	P	P	P	
Antelope																							0
Mountain Lion																							0
Bobcat							P																0
Coyote					P	P	P	P	P	2	P	3	P	P		P			P				5
Cottontail Rabbit																							0
Jack Rabbit																							0
Chukar																							0
Gambel's Quail				2																			2
Mourning Dove						8						3				1			10			16	38
Common Raven	*108		2	2		1	1	5		2		1		11		153			1				287
Ducks (all)	189	1		2		2	1	6	12			11		4		66			3			22	318
Shorebirds (all)	163				1	2	2	4	30	7	1	11				63	3		4		3	57	351
Gulls (all)	133								16			2											151

* 100 ravens at sewage lagoon (primary treatment pond).

Table 8. Total numbers of wildlife sightings recorded at well reservoirs at the Nevada Test Site during 1991. (P) denotes presence of a species inferred from animal sign.

	Area 23 Sewage Pond	Area 25 Well J11	Area 25 Well J12	Area 25 Well J13	Area 25 Nuwas Pond	Area 5 Well 58	Area 5 Well U6c	Area 5 Stream	Area 6 CP Decon Pond	Area 6 Well 3	Area 6 Well C1	Area 3 Mud Plant	Area 16 Well 16D	Area 2 Well 2	Area 2 Mud Plant	Area 12 Sewage Pond	Area 12 N Tunnel	Area 16 Well 8	Area 16 Camp 17	Area 19 U19c upper	Area 19 U19c lower	Area 20 Pahute Lake	Totals
Number of Visits	21	3	2	2	2	0	14	3	10	4	4	2	3	3	1	0	1	0	3	0	2	1	81
Feral Horse														P			P		P				0
Cattle										P									P				0
Mule Deer										P			P						P		P		0
Antelope																							0
Mountain Lion																							0
Bobcat							P			P													0
Coyote	2		P	P	P		P		1	1													4
Cottontail Rabbit											1								1				2
Jack Rabbit																							0
Chukar																							0
Gambel's Quail																							0
Mourning Dove	5	34		200			5			6	10		64				10		2				336
Common Raven	7	2	4				3			1									1			2	20
Ducks (all)	113						1		28		4	4		2					1			4	157
Shorebirds (all)	439	3					23		28	1	5	2		1	1				1				504
Gulls (all)	21														13								34

Table 9. Trends in the total number of sightings of two common granivorous species of birds from 1989-91. Counts are from springs and well reservoirs combined.

Species	1988	1989	1990	1991	Totals
Number of visits	143	152	154	97	546
Gambel's quail	533	87	3	0	623
Mourning dove	115	27	60	659	861
Total birds	648	114	63	659	

Large groups (numbering in the hundreds) of introduced chukars were observed at Topopah Spring on several occasions during 1988-90. No other location on the NTS was known to support such large concentrations of a single species (Tables 3-8). Topopah Spring provides an important source of drinking water for this species. Chukars were impacted severely during 1991 as the source of water at Topopah Spring diminished. Chukars were not observed at Topopah spring in early June of 1992, further indicating a population reduction. Large concentrations of chukars are common around springs in many areas of southern Nevada (Pers. comm. Charles Douglas, University of Nevada, Las Vegas).

Migratory Birds

Individual ponds at the NTS vary from about 0.02 to 1.5 hectares (ha) in surface area. Total surface area of the 20 or more well reservoirs at the NTS is approximately 8 ha. Although the total surface area for the region is small, these ponds do provide significant resources to many species of migratory birds common to this region. During 1989-91 approximately 125 species of birds were identified at well reservoirs and springs combined. About 108 species (86%) have been observed at well reservoirs (Tables 10-17) as opposed to springs. The difference in numbers of species was due largely to migratory waterfowl and shorebirds (48 species) which appear to utilize well reservoirs exclusively because of their larger surface areas. Generally, larger reservoirs such as the Mercury ponds produced higher mean and total counts of birds as well as higher species numbers than smaller ponds (Tables 10,11). Hopper (1972) reported that duck numbers and activity increased with increasing size of man-made ponds or potholes in Colorado. Migrating species use the well reservoirs as resting and foraging stops during their spring and fall migrations. While several species, including coots, avocets, and

Table 10. Species sightings of migratory birds (February-June) at well reservoirs during 1990.

Numbers = Total of all birds counted for all visits, maximum number observed on any given day in parentheses; % = percent frequency of occurrence. N = Number of visits.

<u>Common name</u>	(N=18)			(N=17)			(N=13)			(N=12)		
	<u>Mercury sewage</u>			<u>Area 6 Decon</u>			<u>Area 12 sewage</u>			<u>Area 20 Pahute lake</u>		
	<u>Number</u>	<u>%</u>		<u>Number</u>	<u>%</u>		<u>Number</u>	<u>%</u>		<u>Number</u>	<u>%</u>	
Eared grebe	1	(1)	5.5				1	(1)	7.7	1	(1)	8.3
Pied-billed grebe	1	(2)	5.5							1	(1)	8.3
Brown pelican ^a	1	(2)	5.5									
White-faced ibis				1	(1)	5.9	2	(2)	7.7	1	(1)	8.3
Black c. night heron				1	(1)	5.9						
Snowy egret	1	(1)	5.5	3	(3)	5.9				1	(1)	8.3
Wood duck	2	(2)	5.5									
Northern pintail	7	(3)	16.7									
American wigeon				2	(2)	5.9	2	(2)	7.7	2	(2)	8.3
Northern shoveler	6	(6)	5.5									
Green-winged teal	84	(29)	27.8	5	(5)	5.9	51	(16)	61.5	8	(6)	16.7
Cinnamon teal	25	(14)	22.2				9	(6)	15.4			
Blue-winged teal										2	(2)	8.3
Mallard	14	(9)	22.2							2	(2)	8.3
Gadwall	5	(4)	11.1									
Lesser scaup							1	(1)	7.7	4	(4)	8.3
Redhead				2	(2)	5.9				3	(3)	8.3
Ring-necked duck	8	(3)	16.7				2	(2)	7.7			
Canvasback	1	(1)	5.5									
Canada goose	16	(16)	5.5	3	(3)	5.9	1	(1)	30.1 ^b			
Bufflehead	18	(5)	33.3									

Table 10. Migratory birds at Well Reservoirs (continued).

Numbers = Total of all birds counted for all visits, maximum number observed on any given day in parentheses; % = percent frequency of occurrence. N = Number of visits.

<u>Common name</u>	(N=18)			(N=17)			(N=13)			(N=12)		
	<u>Mercury sewage</u>			<u>Area 6 Decon</u>			<u>Area 12 sewage</u>			<u>Area 20 Pahute lake</u>		
	<u>Number</u>	<u>%</u>		<u>Number</u>	<u>%</u>		<u>Number</u>	<u>%</u>		<u>Number</u>	<u>%</u>	
Ruddy duck	1	(1)	5.5							1	(1)	8.3
Common merganser	2	(2)	5.5									
Turkey vulture							1	(1)	7.7			
Red-tailed hawk	1	(1)	5.5									
Killdeer	51	(8)	83.3				10	(3)	38.5	3	(1)	25.0
Semipalmated plover										1	(1)	8.3
Black-necked stilt				1	(1)	5.9				6	(6)	8.3
American avocet	10	(10)	5.5	1	(1)	5.9						
Spotted sandpiper	10	(5)	16.7	15	(5)	41.2	12	(10)	15.4	28	(25)	25.0
Western sandpiper	38	(30)	16.7	2	(2)	5.9				2	(2)	8.3
Common snipe	1	(1)	5.5				2	(2)	7.7			
Least sandpiper	25	(15)	11.1				26	(15)	15.4	6	(3)	16.7
Long-billed dowitcher	3	(1)	16.7				6	(4)	23.1	9	(9)	8.3
Marbled godwit				2	(1)	11.8						
Greater yellowlegs							2	(1)	15.4			
Wilson's phalarope	20	(18)	11.1	4	(4)	5.9	1	(1)	7.7			
Red-necked phalarope	2	(2)	5.5									
California gull	66	(32)	39.0	2	(2)	5.9						
Ring-billed gull	67	(56)	16.7	14	(9)	11.8						
Mourning dove							1	(1)	7.7	16	(6)	41.7
Rock dove	2	(1)	5.5									

Table 10. Migratory birds at Well Reservoirs (continued).

Numbers = Total of all birds counted for all visits, maximum number observed on any given day in parentheses; % = percent frequency of occurrence. N = Number of visits.

Common name	(N=18)			(N=17)			(N=13)			(N=12)		
	<u>Mercury sewage</u>			<u>Area 6 Decon</u>			<u>Area 12 sewage</u>			<u>Area 20 Pahute lake</u>		
	<u>Number</u>	<u>%</u>		<u>Number</u>	<u>%</u>		<u>Number</u>	<u>%</u>		<u>Number</u>	<u>%</u>	
White-throated swift	3	(3)	5.5							1	(1)	8.3
Belted kingfisher	2	(2)	5.5				1	(1)	7.7			
Say's phoebe	2	(2)	5.5									
Western kingbird	2	(2)	5.5									
Common raven	108	(40)	66.7				153	(40)	69.2			
Cliff swallow										1	(1)	8.3
Tree swallow	12	(8)	16.7				2	(2)	7.7			
Violet-green swallow	10	(8)	11.1				7	(6)	15.4	49	(15)	41.7
N.r. winged swallow	2	(2)	5.5				3	(3)	7.7	2	(2)	8.3
Barn swallow							7	(6)	15.4			
Mountain bluebird							7	(6)	15.4			
American pipit	12	(8)	22.2				7	(4)	23.1	4	(2)	25.0
Starling	9	(5)	11.1									
Yellow-rumped warbler							6	(5)	15.4			
Lark sparrow										1	(1)	8.3
Savannah sparrow	6	(4)	11.1	4	(4)	5.9	4	(2)	15.4	6	(3)	33.3
Red-winged blackbird	2	(2)	5.5				8	(8)	7.7			
Brewer's blackbird	3	(2)	11.1				11	(8)	15.4	19	(8)	41.7
Y.-headed blackbird	2	(2)	5.5							1	(1)	8.3

Table 10. Migratory birds at Well Reservoirs (continued).

Numbers = Total of all birds counted for all visits, maximum number observed on any given day in parentheses; % = percent frequency of occurrence. N = Number of visits.

<u>Common name</u>	(N=18)	(N=17)	(N=13)	(N=12)
	<u>Mercury</u>	<u>Area 6 Decon</u>	<u>Area 12 sewage</u>	<u>Area 20 Pahute lake</u>
	<u>Number %</u>	<u>Number %</u>	<u>Number %</u>	<u>Number %</u>
Total Number	665	62	346	189
Species	44	16	29	29
Total number of species = 61				
Mean Number/visit ^c	31.8 ± 6.2	3.8 ± 1.3	15.2 ± 3.8	16.4 ± 5.3

^a Brown Pelican observed by Thane Webb on July 9, 1990

^b an individual Canada goose was observed repeatedly over a period of several months.

^c means exclude numbers of ravens due to probable double counting of individuals.

Table 11. Species sightings of migratory birds (February-December) at well reservoirs during 1991. N is number of individual visits.

Number = Total number of sightings counted for all visits. % = percent frequency of occurrence. N is the total number of visits.

Common name	(N=22) Mercury Sewage		(N=10) Area 6 Decon		(N=14) Area 5 UE5C	
	Number	%	Number	%	Number	%
Western grebe	1	4.5				
Eared grebe	8	22.7				
Pied-billed grebe	2	4.5				
Great blue heron			1	10.0	1	7.1
Great egret	11	9.1				
Snowy egret	2	4.5				
Black-crowned night heron					1	7.1
White-faced ibis			1	10.0	1	7.1
Northern shoveler			4	10.0		
Green-winged teal	21	18.2	7	10.0	1	7.1
Cinnamon teal	25	18.2	5	20.0		
Blue-winged teal	1	4.5	2	10.0		
Mallard	4	9.1	2	10.0		
Redhead	4	9.1				
Ring-necked duck	2	4.5				
Canada goose	19	9.1	2	10.0		
Bufflehead	8	13.6	3	20.0		
Common goldeneye	1	4.5				
Ruddy duck	21	27.3				
American kestrel					1	7.1
American coot					1	7.1
Killdeer	69	72.7	2	10.0		
Black-necked stilt	8	13.6	4	10.0		
American avocet	20	36.4	6	20.0		
Spotted sandpiper	17	22.7	8	30.0	3	14.3
Western sandpiper	124	27.3	7	10.0	2	7.1
Least sandpiper	161	36.4			14	7.1
Willet	1	4.5				
Common snipe	4	18.2			1	7.1
Long-billed dowitcher	6	18.2				
Lesser yellowlegs	2	9.1				
Greater yellowlegs	3	18.2				
Wilson's phalarope	26	27.3				
Red-necked phalarope	4	4.5				
California gull	5	4.5				
Ring-billed gull	13	27.3				
Mourning dove	5	9.1			5	14.3
White-throated swift	10	13.6				
Belted kingfisher					2	14.3

Table 11. Migratory birds at well reservoirs in 1991 (continued).

Common name	(N=22)		(N=10)		(N=14)	
	Mercury	Sewage	Area 6	Decon	Area 5	Ue5c
	Number	%	Number	%	Number	%
Western wood-pewee	1	4.5				
Black phoebe					2	14.3
Say's phoebe					6	28.6
Ash-throated flycatcher					1	7.1
Western kingbird	3	9.1			1	7.1
Horned lark					8	7.1
Cliff swallow	25	13.6				
Barn swallow	15	22.7			3	21.4
Bank swallow	2	4.5				
Northern r. winged swallow	12	9.1			1	7.1
Tree swallow	16	22.7				
Violet green swallow	13	22.7			1	7.1
Common raven	21	36.4			3	21.4
Ruby-crowned kinglet					1	7.1
American robin	2	9.1				
American pipit	115	59.1				
Loggerhead shrike					1	7.1
Yellow-rumped warbler	7	18.2			7	35.7
Yellow warbler					2	14.3
Common yellowthroat	1	4.5			1	7.1
Wilson's warbler	1	4.5				
Sage sparrow					10	14.3
Lark sparrow					1	7.1
Song sparrow					2	7.1
Savannah sparrow	11	27.3				
Chipping sparrow					2	7.1
White-crowned sparrow					2	7.1
Red-winged blackbird	4	13.6			7	35.7
Brewer's blackbird	8	4.5	3	10.0		
Brown-headed cowbird	9	18.2				
Great-tailed grackle					1	7.1
Yellow-headed blackbird	30	4.5			2	10.0
House finch					17	35.7
Grebe (unid.)	4	4.5	2	10.0		
Duck (unid.)	3	4.5	3	20.0		
Hummingbird (unid.)					1	7.1
Total number	911		62		116	
Species	53		17		36	
Mean Number/visit	44.0±10.3		6.2±1.1		8.35±1.9	
Total number of species = 74						

Table 12. Species sightings of migratory birds (February-December) at well reservoirs on or near Yucca Flat during 1990.

Counts = Total number of birds observed for all visits combined.
 % = percent frequency of occurrence in parentheses. N = Number of visits.

	<u>Well C1</u>	<u>Well 3</u>	<u>Mud</u>	<u>Well 2</u>	<u>N Tunnel</u>
	Area 6	Area 6	Area 3	Area 2	Area 12
	N=4	N=5	N=6	N=7	N=6
<u>Common name</u>					
Snowy egret		4 (40)	1 (17)		
Great blue heron	1 (25)				
Cinnamon teal				3 (29)	
Gadwall ^a					
Canada goose			1 (17)		
Lesser scaup			1 (17)		
American coot		1 (20)	8 (67)		
Common moorhen ^b		2 (40)			
Killdeer			1 (17)		3 (33)
Spotted sandpiper		1 (20)	5 (33)		
California gull			1 (17)		
Ring-billed gull			1 (17)		
Mourning dove			3 (17)		
Lesser nighthawk				1 (14)	
Say's phoebe					1 (17)
Western kingbird		2 (20)			
Horned lark		2 (20)	10 (17)	49 (57)	
N. R. winged swallow			1 (17)		
Common raven		2 (20)	1 (17)	31 (29)	
American robin					1 (17)
Yellow-rumped warbler	2 (25)		4 (17)		
Yellow warbler		1 (20)	1 (17)		
Wilson's warbler		1 (20)			
Lark sparrow			2 (17)	1 (14)	
Savannah sparrow	6 (25)				
Black-throated sparrow					1 (17)
White-crowned sparrow	1 (25)			4 (14)	1 (17)
Scott's oriole		1 (20)			
Red-winged blackbird			2 (17)		
Brewer's blackbird				1 (14)	
Yellow-headed blackbird	2	(20)	1 (17)		
House finch		3 (40)	2 (33)	2 (14)	
House sparrow		10 (20)	2 (17)		
Number of Species	4	13	19	8	5

Total species = 35

^a = 6 Gadwalls observed at CP sewage ponds, N=1 visit.

^b = New species record for the NTS.

Table 13. Sightings of migratory birds on Yucca Flat (April-October) during 1991.

Counts = Total number of birds observed for all visits combined.
N = Number of visits to each site.

	(N=4) Well C1	(N=4) Well 3	(N=2) Mud	(N=4)* Well 2	(N=3) Well 16D
Common name	Area 6	Area 6	Area 3	Area 2	Area 16
Great blue heron	1			1	
Green-backed heron		1			
American bittern			1		
Snowy egret				1	
Cinnamon teal	4		3		
Canada goose			1		
Redhead				2	
American coot			1		
Killdeer	7				
Black-necked stilt	2				
Ring-billed gull				13	
Mourning dove	10	6			64
Yellow-billed cuckoo ^b	1				
Ash-throated flycatcher	1				
Common raven		1			
Loggerhead shrike					1
Sage sparrow		2			
Dark-eyed junco		1			
Song sparrow		2			
Savannah sparrow		2			
White-crowned sparrow		5			
Red-winged blackbird		1	5		
Brown-headed cowbird			5		7
Yellow-headed blackbird			1	9	
American goldfinch		2			
House finch	2	80			4
House sparrow		3			
Species	8	12	7	5	4

Total species = 27

* = two reservoirs combined

^b = new species record for the NTS

Table 14. Species sightings of migratory birds (February-May) at well reservoirs on Frenchman Flat during 1990. See Table 11, pond Ue5c for birds in Frenchman Flat for 1991.

Counts = Total number of birds observed for all visits combined.
 N = number of visits to each site. % = Percent frequency of occurrence in parentheses.

<u>Common name</u>	<u>N=4</u> <u>Well 5B</u>	<u>N=6</u> <u>Well Ue5c</u>	<u>N=4</u> <u>Cambric</u>
Great blue heron	2 (50)		
Green-winged teal	1 (25)		
Cinnamon teal	1 (25)		5 (25)
Common merganser		1 (17)	
Northern harrier			1 (25)
Killdeer			4 (50)
Long-billed dowitcher		1 (17)	
Mourning dove		8 (25)	
Lesser nighthawk ^a		2 (17)	
Black phoebe	1 (25)		
Say's phoebe		1 (17)	
Western kingbird	1 (25)		1 (25)
Barn swallow			1 (25)
Common raven	1 (25)	1 (17)	5 (25)
Mountain bluebird ^b	2 (25)		
Loggerhead shrike	1 (25)		
Yellow-rumped warbler		1 (17)	
Yellow warbler	2 (25)		
Lark sparrow	1 (25)		
Great-tailed grackle	2 (50)		
House finch	5 (25)		
House sparrow	4 (25)		
Number of Species	14	6	6

Total species = 22

^a = observed between 2000 and 2200 hours.

^b = wintering birds observed in March.

Table 15. Species sightings of migratory birds (February-April) at well reservoirs on Jackass Flats during 1990.

Counts = Total of all birds observed for all visits. Percent frequency of occurrence in parentheses. N = Number of visits to each site.

<u>Common Name</u>	<u>N=3 J11</u>	<u>N=2 J12</u>	<u>N=2 J13</u>	<u>N=2 Nuwx</u>
Green-winged teal	1 (33)			
Cinnamon teal			2 (50)	
American kestrel			1 (50)	
Prairie falcon		1 (50)		
Gambel's quail				2 (50)
Killdeer				1 (50)
Belted kingfisher	1 (33)			
Say's phoebe	1 (33)	2 (50)	4 (50)	
Western kingbird	1 (33)		1 (50)	
Horned lark			2 (50)	
Barn swallow	1 (33)			
Violet green swallow			4 (50)	
Common raven		2 (50)	2 (50)	
Mountain bluebird*				1 (50)
Northern mockingbird	1 (33)		1 (50)	
European starling	1 (33)			
Yellow-rumped warbler	7 (67)		4 (50)	1 (50)
Common yellowthroat			1 (50)	
Savannah sparrow	1 (33)			1 (50)
White-crowned sparrow	3 (67)			
Northern oriole	1 (33)			
Red-winged blackbird	3 (67)			
Brewer's blackbird	7 (33)			
Brown-headed cowbird	3 (33)			
Western meadowlark				1 (50)
Accipiter (unid.)*			1 (50)	
Number of Species	14	3	11	5
Total Species = 26				

* = commonly observed on low desert in winter.

Table 16. Species sightings of migratory birds at well reservoirs on Jackass Flats (June-December) during 1991. Visits were in June, July, and December.

Counts = Total of all birds observed for all visits. Percent frequency of occurrence in parentheses. N = Number of visits to each site.

	<u>N=3</u> <u>J11</u>	<u>N=2</u> <u>J12</u>	<u>N=2</u> <u>J13</u>	<u>N=2</u> <u>Nuwax</u>
<u>Common Name</u>				
Snowy egret	1			
Sharp-shinned hawk ^a			1	
American kestrel			1	
Spotted sandpiper	2			
Mourning dove	34		200	
Black phoebe	1			
Horned lark ^a				80
Common raven		2		
Northern mockingbird	1			
Leconte's thrasher		1		
Loggerhead shrike		1		
Sage sparrow ^a	8	4	20	1
Black-throated sparrow ^b	5	5	1 ^c	6
Dark-eyed junco ^a			6	
Song sparrow ^a			1	
White-crowned sparrow ^a		2		
Brown-headed cowbird	40			
House finch ^a	2	8	10	
Wren (unid.)		3		
<hr/>				
Species	9	8	8	3

Total species = 19

^a = some counts include wintering birds observed during 1 visit in December.

^b = Juveniles observed in July.

^c = 1 wintering adult observed in December.

Table 17. Species sightings of migratory birds at well reservoirs in Areas 18 and 19 (February-December) during 1990. Number of visits in parentheses.

Counts = Total of all birds observed for all visits.

<u>Common Name</u>	<u>(N=2) Well 8</u>	<u>(N=7) Camp 17 Pond</u>	<u>(N=4) U19C Lower</u>	<u>(N=4) U19C Upper</u>
Pied-billed grebe			1	
Blue-winged teal		3		
Spotted sandpiper		3		
Killdeer			3	
Wilson's phalarope		1		
Mourning dove		10		
Belted kingfisher			1	
Northern flicker		1		
Black phoebe	1	2		
Ash-throated flycatcher		1		
N. rough-winged swallow				3
Violet green swallow		2		3
Common raven		1		
Mountain chickadee		2		
Yellow-rumped warbler				2
Wilson's warbler		1		
Red-winged blackbird		3		1
Brewer's blackbird		3		
Bullock's oriole		1		
Species	1	14	3	4
Total species = 19				

killdeer, were observed to reproduce in some ponds over the last three years, space and available cover for the rearing of young may be limited. This is suggested by the low numbers of young fledged in each case.

Species lists from sites that were visited most regularly are shown in Tables 10 and 11. Additional species records for ponds visited less frequently are listed in Tables 12-17. The most common or frequently observed duck species during 1990-91 were green-winged teal, cinnamon teal, mallard, and bufflehead (Tables 10,11). Consecutive daily visits to selected well reservoirs indicate that species mixes of waterfowl may change each day. The duration of rest stops by individual birds at ponds may vary between several minutes to several days. About 18 species of ducks and 30 species of shorebirds were regularly observed on the NTS. Some common species of shorebirds were killdeer, least, western and spotted sandpipers, ring-billed gull, snowy egret, and American avocet (Tables 10,11). The largest concentrations of shorebirds observed were mixed flocks of least and western sandpipers sometimes numbering greater than 100 individuals. These birds migrate long distances from their wintering grounds in central and south America to Alaska, where they breed.

Some of the uncommon species inferred from lower frequencies, were wood duck, black-crowned night heron, American bittern, semipalmated plover, red-necked phalarope, and white-faced ibis. Of interest is the sighting of a brown pelican (a rare visitor from the pacific coast) at Mercury (Table 10). The snowy plover is an example of a migrant that was once recorded at least occasionally around playa lakes at the NTS (Hayward et al. 1963), but today it appears to be quite rare. Because of apparent declines in numbers, the snowy plover is now a category 2 candidate for federal listing. Table 18 contains known sighting records of listed species of birds (endangered) and candidates for listing that may be observed on the NTS. These records suggest that regional declines in populations of some migratory species have occurred over the last 10-15 years such as the ferruginous and Swainson's hawks. It is possible that some additional species of birds (Table 12) may become listed in the near future.

Spring habitats are used most often by a variety of passerine (perching) migratory species. Common perching birds observed include numerous species of warblers, blackbirds, sparrows, flycatchers, and thrushes. Spring habitats, although small in area, are biologically valuable for birds in the desert ecosystem, offering trees or other vegetation for cover, which may be limited at well reservoirs. Thus, springs serve as resting and foraging stops for migrating species, as well as breeding habitats for residents. Rare or uncommon vagrants (those found outside their normal range) often show up at spring habitats where they may survive for days or weeks before leaving.

Table 18. Status of listed species of birds (endangered) and candidate species for listing that may occur on the NTS.

Listed species	Records of Sightings
Bald eagle <i>Haliaeetus leucocephalus</i>	3 sightings, Feb, 1977. (Castetter and Hill 1979).
American peregrine falcon <i>Falco peregrinus</i>	Several sightings near Yucca Flat, 1976. (O'Farrell and Emery 1976).
<u>Candidate species category 2*</u>	
Snowy plover <i>Charadrius alexandrinus</i>	35 sightings from 1961-63. (Hayward et al. 1963); 2 sightings, March 1977. Unpublished field notes, (Castetter 1975-77).
Black Tern <i>Chlidonias niger</i>	13 sightings from 1975-77. (Castetter and Hill 1979)
Least bittern <i>Ixobrychus exilis</i>	1 individual, May 1961. (Hayward et al. 1963)
Loggerhead shrike <i>Lanius ludovicianus</i>	Many sightings, seen in every month of the year, peak in March-June). Fifteen specimens (Hayward et al. 1963); 21 sightings from 1975-77. Unpublished field notes (Castetter 1975-77); 7 sightings from 1990-91. (Becamp UCLA, 1991).
White-faced ibis <i>Plegadis chihi</i>	3 sightings, May 1961. (Hayward et al. 1963); 12 sightings from 1988-91. (Becamp UCLA, 1991)
Ferruginous hawk <i>Buteo regalis</i>	9 sightings from 1959-62. (Hayward et al. 1963).
Swainson's hawk <i>Buteo swainsoni</i>	Sighted often from April-August on Yucca Flat. Breeding recorded. (Hayward et al. 1963); 1 sighting near Echo Peak, September, 1975. Unpubl. field notes (Castetter 1975-77).
Northern Goshawk <i>Accipiter gentilis</i>	1 sighting, immature, September 1976, Shoshone Mountain. (Castetter and Hill 1979).

* = Category 2: Taxa for which existing information indicated may warrant listing, but for which substantial biological information to support a proposed rule is lacking.

Springs are important watering locations for some of the most numerically abundant birds of the region including house finches, horned larks, and mourning doves. Only 33 species of birds were identified at springs during 1990-91 (Tables 19,20), although sampling effort at springs was considerably less than for well reservoirs during this period. Overall, about 125 species of birds out of 142 (87%) observed at the NTS during 1990-91 were in some way associated with spring or well reservoir habitats. The remainder of species were generally found in cooler higher elevation habitats during the summer.

In general, a accurate evaluation of trends in bird populations cannot be determined from only two years of counts made at water sources on the NTS. Previous investigators have reported the most numerically abundant species on the NTS were horned larks, house finches, and mourning doves (Allred et al. 1963, Hayward et al. 1963). Qualitatively, concerning relative abundance of the above named species, our observations agree with the assessments made nearly thirty years ago.

Table 19. Species sightings of migratory birds at springs at the Nevada Test Site (February-December) 1990. Number of visits in parentheses.

Counts = total number of all birds observed for all sites.

<u>Common Name</u>	(N=4) <u>White R.</u>	(N=3) <u>Tub</u>	(N=4) <u>Reitman</u>	(N=4) <u>Gold M.</u>	(N=8) <u>C.J.</u>	(N=6) <u>Tipp.</u>
Gambel's quail	1					
Mourning dove			2	2		18
Long-eared owl	2					
Northern flicker				1		
Say's phoebe		2				
Common raven					2	
Ruby-crowned kinglet					1	
Mountain bluebird				2		
American robin				4		
Cedar waxwing	1					
Wilson's warbler	2					
Western tanager	2					
Black-headed grosbeak	1					
Sage sparrow			3*			
Black-throated sparrow	1	1				4
Brown-headed cowbird				1		
House finch		5				39
Species	7	3	2	5	2	3
Total number of species = 17						

* = wintering birds observed in December.

Table 20. Species sightings of migratory birds at springs (June-October) during 1991. Number of visits in parentheses.

Counts = Total number of birds observed for all visits.

	(N=2) Cane	(N=1) White	(N=1) Tub	(N=1) Reitman	(N=3) Gold	(N=4) C.J.	(N=4) Tipp.
<u>Common name</u>							
Turkey vulture		1			1		
Red-tailed hawk							1
Golden eagle						2	
Chukar					20		
Mourning dove	30	15	30	3	5	130	110
Long-eared owl		2					
Violet-green swallow					1		
Scrub Jay			2				2
Pinion jay					2		
Common raven		3			4	1	5
American robin					3		
Northern mockingbird			1		1		1
Wilson's warbler					1		
Lazuli bunting					1		
Indigo bunting*					1		
Black-throated sparrow		6	3				1
Green-tailed towhee					1		
Brewer's sparrow		2			2		
Chipping sparrow					3		
White-crowned sparrow						3	1
Brown-headed cowbird					25		
Lesser goldfinch					4		
Cassin's finch					3		
House finch	20	1	10	20	20		21
Species	2	6	6	2	16	7	8
Total species = 24							
* = new species record for the NTS							

Passerine Species

Present knowledge of known passerine breeders on the NTS is limited to about 36 species (see Appendix H, NTS species list). Passerine species identified as breeders during 1990-91 include common raven, great tailed grackle, rock wren, horned lark, Say's phoebe, and black-throated sparrow (Table 34). Some of these species used man-made structures for breeding just as several species of waterfowl made use of man-made ponds to breed and rear young. However, these records are few and limited to chance observations. Our knowledge of breeding birds known on the NTS could be expanded from the present list, if

future work is planned to accomplish this. Castetter and Hill (1979) recommended that about 30 of the previously recorded birds of the NTS need revision as to seasonal and/or breeding status. More work on birds inhabiting the northern portions of the NTS should be initiated to accomplish this.

The black-throated sparrow, *Amphispiza bilineata* is an example of a hardy Mojave desert species commonly not found around water. Smyth and Bartholomew (1966) concluded that black-throated sparrows were exceptional at maintaining water balance shown in experiments by their ability to concentrate chloride in the urine. Field observations also revealed they could obtain their water for most of the year from insects or green vegetation and drank only during the driest season when they consumed only seeds. On the NTS, large flocks of juveniles (no adults) were observed drinking from water sources in various basins (J11 in particular) during August, an exceptionally dry period.

This species breeds on the NTS over a wide range of habitats and elevations (900-1800 meters) and generally retreats to the south at lower elevations in winter. While it is generally accepted that birds may be sensitive indicators of environmental change, long term-data on passerine density and productivity are generally lacking for most habitats on the NTS. The only quantitative studies available for birds at the NTS are from Rock Valley from 1971-73 (Hill 1971, 1972, Hill and Burr 1973). The black-throated sparrow is a key resident species for this region and would be a suitable species for monitoring because it inhabits a wide range of habitats on the NTS.

Recently, because many populations of landbird species, particularly neotropical migrants have declined, attributed to numerous causes including climate change, Desante (1991) instituted a continent-wide system of monitoring avian productivity and diversity. The Monitoring Avian Productivity and Survivorship (MAPS) program was implemented to provide an additional tool for assessing productivity and survivorship of birds that is more precise than conventional methods (trend data and density estimates) available. Because numerous stations (at least 30 in each of six major regions of the continent) are planned for MAPS to effectively operate, we suggest that long-term plots for monitoring key landbird species may be developed on the NTS and integrated into such a system.

Two years of casual observations of birds provided evidence (although numbers are low) that reproductive activity increased during 1991 over 1990. Opportunistic sightings of eggs, nests, and juveniles during May-June of 1991 (Table 34) indicate that at least 10 species of birds were known to breed verses only three species (Table 31) during 1990. Food was probably more

available in 1991 than in 1990, which was one of the driest years on record, with only 2.14 inches (54mm) recorded (BJY weather station). Most species of birds forage on insects as juveniles, which were much more abundant region-wide in 1991 than the previous year because of increased spring rainfall.

Common Raven Census

Initial observations of common ravens *Corvus corax* on the NTS indicated they were most concentrated at sewage ponds and lagoons, town sites, and land fills, but were seen less frequently in undisturbed desert or remote areas even when a water source was present (Tables 3-8). However, initial counts of ravens made at well reservoirs were often biased because of double counting of individuals. Therefore, a census was implemented in 1990 to estimate the minimum population size of ravens present on the NTS (Table 21). The counts suggest that the NTS raven population easily exceeds 100 or more individuals in each year. Fluctuations in the counts are not surprising because a moderate portion of the non-breeding birds may migrate considerable distances. The reduced number of ravens observed at CP is consistent with closure of the

Table 21. Summary of Common Raven counts made during 1990-91 at the NTS.

Region	1990	1991
Mercury camp	50	28
Area 25 camp	0	0
Area 5 roads	1	5
CP camp	91	14
Area 2 camp*		9
Area 3 camp*		27
Area 10 landfill	28	38
Yucca flat roads	6	2
Area 12 camp	41	23
Area 18, 19, 20	6	10
Totals	223	156
* area not surveyed in 1990.		

landfill in this region in 1991. At three separate locations in the last three years (Topopah Valley, Echo Peak, and Mid-Valley burn), large communal associations of ravens sometimes exceeding 100 individuals have been observed. Large roosts or gatherings of corvids are common and are believed to serve as "mobile information centers" for locating and sharing food (Heinrich 1989).

Sixteen raven nest sites were located on the NTS during three years of study (Figure 4). Four locations also showed evidence of owl habitation. During

1990, three sites were known to fledge raven young. One nest inside the work bay at the Area 6 decon facility was reported with five nestlings. Eight known nests fledged young in 1991 (Table 22). Seven of these nests (87%) were constructed on man-made structures. Five inactive cliff nests of unknown identity were located in remote areas. It is possible these nests were used by raptors or ravens. Common ravens are known to alternate use of nests with raptors or other ravens (Ryser 1985). A large roost of ravens observed in Mid-valley on June 4 was primarily non-breeding individuals. Even assuming that some raven nests were missed in 1991, only about 10-15 percent of the spring-summer population was currently breeding.

Knowles et al. (1989) reported that surveys conducted by the U.S. Fish and Wildlife Service suggest that common raven populations in the Mojave desert have increased about 1500% from 1968-1988, with an annual mean of almost 15% increase. No long-term quantitative evidence for raven increase exists for the NTS but anecdotal reports by individuals observing apparent increased numbers over this period have been made.

Food habits of ravens on the NTS were studied by Maguire (1991), who identified frequencies of remains from regurgitated food pellets. Ravens consumed a diverse assemblage of plant, animal, and inorganic items. Preliminary findings indicated the most frequently occurring identified category was small mammals (78%) followed by stones (34%), insects (27%) and man-made materials (26%). Iguanid lizard remains occurred with a frequency of about 17%. Ravens are known to form associations with many predators including wolves, coyotes, and polar and grizzly bears (Heinrich 1989). On the NTS, ravens were associated with groups of coyotes. For example, coyotes have been observed digging up refuse in land-fills as flocks of ravens wait nearby. The food habits data as well as field observations indicate that ravens are gaining benefit from human activity at the NTS. Fresh remains of the desert tortoise have not been observed on the NTS around nests or areas where raven activity is common. Concern may be warranted where ravens are abundant and sympatric with the range of the threatened desert tortoise, because ravens were known to prey on the young of this species (Luckenbach 1982, Berry 1986).

Figure 4 - Common raven *Corvus corax* and owl nest sites 1989-1991.

Table 22. Summary of reproductive characteristics of the common raven nesting at the NTS (Maguire 1991). Mean $\pm$ 1 standard error shown below.

Nest site location	Estimated period of egg laying	Number of nestlings/nest	Fledge date	Number of fledglings
Area 6, Casing Warehouse C	30 March-8 April	3	3 June	2
Area 6, Decon Facility	3 April-12 April	2	7 June	1
Area 6, Orange Road	9 April-18 April	1	13 June	1
Area 5, Gravel Gurdy	9 April-18 April	3	13 June	1
Area 3 Building	9 April-18 April	2	13 June	1
Mine Mt. road Bunker	9 April-18 April	1	13 June	2
U3CN Bilby Crater	12 April-22 April	2	17 June	2
Rainier Power Substation	2 May-11 May	2 $\bar{X}=2.0\pm0.26$	6 July	2 $\bar{X}=1.37\pm0.18$

Raptor observations

Records of raptor sightings as well as incidence of breeding on the NTS over the last 30 years are very limited. Although breeding is likely during wet years at the NTS, only four records of nesting activity are known since 1976. Test site employees have observed a few red-tail hawks nesting in remote areas such as on ledges near Captain Jack Spring and in Schooner Crater, although records were not kept. Two nesting occurrences are known from 1982-83 for Frenchman flat on man-made structures. One hawk nested on a crane boom parked at the Defense Waste Management site. In general, little is known of raptor breeding here because a sustained program to locate nesting sites of raptors has never been performed. The most relevant information available for raptors was provided by Hayward et al. (1963), and consists primarily of a species list followed by some annotations regarding breeding and species occurrence. Therefore, we are attempting to update the knowledge of the species presently inhabiting the NTS, possibly for comparison to past records, and in time develop adequate information on the relative abundance of the more common species.

A three year summary of opportunistic raptor sightings for the NTS is shown in Table 23. Species sightings probably reflect a large number of non-breeding birds or migrating individuals. These counts are useful as relative sighting frequencies and are indicative of which species are common and which are uncommon or difficult to observe. For example, turkey vultures are the most readily observed species while accipiters are rarely seen because of the forested habitat they frequent. Ospreys, rough-legged hawks, and harriers are probably uncommon for this time period as suggested by the low counts. Assuming roughly equal field effort for all years, a drop in count frequency for 1990 may be a result of an extremely severe drought year. The general status of raptors are described in Table 24.

Table 23. Summary of raptor counts form successive years at the NTS.

Species	1989	1990	1991	Total
Turkey vulture	48	24	70	142
Golden eagle	37	14	22	73
Red-tailed hawk	69	35	44	148
Rough-legged hawk	9	0	2	11
Norther harrier	3	2	1	6
Osprey	1	1	2	4
Prairie falcon	18	6	7	31
American kestrel	18	25	19	62
Accipiters*	3	1	2	6
Long-eared owl	0	2	2	4
Burrowing owl	7	7	9	23
Great horned owl	1	1	1	3
Totals	214	118	181	513

* - Two species observed include Cooper's hawk and the sharp-shinned

Table 24. General status of raptors observed at the Nevada Test Site during 1989-91.

Common Name	Species	General Status
Red-tailed Hawk	<i>Buteo jamaicensis</i>	Abundant, permanent resident
Rough-legged Hawk	<i>Buteo regalis</i>	Uncommon, winter-spring visitor
Golden Eagle	<i>Aquila chrysaetos</i>	Common, permanent resident
Turkey Vulture	<i>Cathartes aura</i>	Common, summer resident
Prairie Falcon	<i>Falco mexicanus</i>	Common, permanent resident
American Kestrel	<i>Falco sparverius</i>	Common, permanent resident

Figure 5 - Approximate road course (bold) driven for quantitative raptor surveys in 1989.

Table 24. continued.

Common Name	Species	General Status
Cooper's Hawk	<i>Accipiter cooperii</i>	Common, permanent resident
Sharp-shinned Hawk	<i>Accipiter striatus</i>	Common, permanent resident
Northern Harrier	<i>Circus cyaneus</i>	Uncommon, permanent resident
Osprey	<i>Pandion haliaetus</i>	Uncommon, spring-fall migrant
Long-eared Owl	<i>Asi otus</i>	Uncommon, permanent resident
Burrowing Owl	<i>Athene cunicularia</i>	Common, permanent resident
Great-Horned Owl	<i>Bubo virginianus</i>	Uncommon, permanent resident

Abundant = the dominant species observed year-round.

Common = can be regularly observed but is not numerically abundant.

Uncommon = not regularly observed but may occupy a restricted habitat.

A rough quantitative measure of relative abundance for raptors was developed by performing road surveys (Table 25, Figure 5). Most observations were made on Frenchman Flat and Yucca Flat where birds were observed perched on utility poles near roads. Overall, about 10 raptors (10.3 ± 2.1) were observed for every 100 miles driven in the survey. The sighting rate on Yucca Flat (16.5 ± 3.8 raptors/100 miles) was higher than the rate determined for Frenchman Flat (3.6 ± 1.3 raptors/100 miles). However, sighting frequencies varied considerably (0 to 24 raptors/100 miles) from one survey to another (Table 25). These preliminary data suggest that Yucca Flat may support more raptors than Frenchman Flat. This is consistent with prey base levels. Small mammal populations on Yucca Flat generally have maintained higher densities than those on Frenchman Flat during recent drought years (Saethre 1992). Conversely, small mammal populations on Frenchman Flat near the LGF facility declined considerably from 1989 through 1991 (Hunter et al. 1991).

Table 25. Number of raptors counted on road surveys at the NTS during 1989.

Date	Frenchman Flat			Yucca Flat			Total		
	No.	Miles	R/100	No.	Miles	R/100	No.	Miles	R/100
1-31-89	1	23.0	4.3	4	20.0	20.0	5	43.0	11.6
2-23-89	1	18.0	5.5	7	20.0	35.0	8	38.0	21.0
3-06-89	2	19.0	10.5	2	23.0	8.7	4	42.0	9.5
3-21-89	0	18.0	0.0	10	23.0	43.5	10	41.0	24.4
4-19-89	1	24.0	4.2	1	6.0	16.7	2	30.0	6.7
5-16-89*	0	19.2	0.0	3	26.0	11.5	3	45.2	6.6

Table 25, continued.

Date	Frenchman Flat			Yucca Flat			Total		
	No.	Miles	R/100	No.	Miles	R/100	No.	Miles	R/100
6-05-89	0	24.0	0.0	3	26.0	11.5	3	50.0	6.0
7-12-89*	1	21.3	4.7	2	26.8	7.5	3	48.1	6.2
7-28-89*	2	18.3	10.9	3	31.5	9.5	5	49.8	10.0
8-23-89*	0	16.0	0.0	0	21.0	0.0	0	37.0	0.0
11-09-89	0	22.0	0.0	6	33.0	18.2	6	55.0	10.9
Totals	8	222.8		41	256.3		49	479.1	
Mean R/100		3.6±1.2			16.5±3.8			10.3±2.1	
R/100 = Raptors sighted per 100 miles, or Number x (100/miles)									
* Distance traveled on dates shown was recorded from vehicle odometer, all others were estimated from road maps.									

During 1989-91, 13 raptor species were identified compared to 16 recorded by Hayward et al. in 1963. Two species of interest not recorded in recent years were Swainson's hawk (*Buteo swainsoni*) and the ferruginous hawk (*Buteo regalis*). Swainson's hawks were apparently observed with some regularity on utility poles at Yucca Flat during the early 1960's (Hayward et al. 1963). Rickard (1961) reported a Swainson's hawk nest with eggs and young in a Joshua tree from Yucca Flat, but gave no exact location or date. The most recent record for this species on the NTS was September 10, 1975, from Echo Peak road in Area 19 (R. Castetter, unpublished field notes 1975-77). The decline of this species throughout the Great Basin since the 1950's has been noted by Ryser (1985). Ferruginous hawks were considered to be irregular visitors to the NTS in the 1960's (Hayward et al., 1963). Historical declines in their numbers in the west may be linked to the development of agriculture in the Great Basin (Ryser 1985), and subsequently this species has rarely been observed on the NTS. Woffinden and Murphy (1989) documented a 20 year decline of a ferruginous hawk population in Utah following a crash in its prey population, the black-tailed jackrabbit. In general, regional declines of these and other raptors in the west are not well understood.

The most abundant species observed was the western red-tailed hawk. Red-tails have adapted well to the presence of man in the west and occur in all habitats and elevations on the NTS. Other species regularly observed were the golden eagle, turkey vulture, prairie falcon, American kestrel, Cooper's hawk and northern harrier. An example of an uncommon species is the rough-legged hawk, which was observed with much less frequency than the red-tailed hawk (Figure 6). Rough-legged hawks spend winter in the Great Basin and migrate into

northern Canada and Alaska in the spring where they breed on the arctic tundra (Ryser 1985). This species is regarded as an irregular visitor (numbers fluctuating heavily between years) at the NTS.

Sighting records for the golden eagle indicate this species was widely distributed over all habitats (Figure 7) and was present throughout the year. Other raptors, such as the turkey vulture, were observed mostly in summer and only in areas near the mesas (Figure 7), possibly where air currents and thermal updrafts (important for soaring flight) are more predictable. Turkey vultures feed only on carrion such as jackrabbit roadkills and are often observed in association with feral horses. They probably take advantage of horse afterbirth remains as do ravens. Scant sighting records for all species of raptors in Areas 19 and 20 were probably a result of minimal field effort in those areas and are not an indication of low relative numbers (Figures 6-8).

Certain raptors are more habitat specific than others. For example, accipiters such as Cooper's hawk and sharp-shinned hawk, which feed primarily on small birds, are found in summer near forested habitats on or around the mesas. These species are adapted as ambush predators, often perching in trees while waiting for prey to approach, and are rather inconspicuous. Accipiters are not powerful flyers, but are highly maneuverable in thick cover and are capable of quick bursts of speed. Sharp-shinned hawks are possible breeders in trees near the mesas during the summer, although there is no direct evidence of this.

The American kestrel, a member of the falcon family, is inconspicuous because of its small size (9-12 inches total length). It is primarily an insectivore, foraging heavily on large insects such as grasshoppers. This species is abundant in areas around the mesas, possibly breeding in cavities on the cliff walls. They were commonly observed perching on utility poles and wires and foraging over shrub habitats on Frenchman and Yucca Flat (Figure 8). A larger and related species, the prairie falcon, is widely distributed in desert shrub habitats at the NTS, but appeared more common on the flats than the mesas (Figure 8). Prairie falcons feed on many kinds of birds and mammals, but their preferred prey include horned larks, mourning doves, western meadowlarks, and ground squirrels (Ryser 1985). These types of prey may be more common on disturbed grasslands (Yucca Flat) where many of our sightings were made.

Figure 6 - Sightings of Red-tailed Hawks, *Buteo jamacensis* (N=69) from January - December 1989 and Rough-legged Hawks, *Buteo lagopus* (N=9) during February and March, 1989.

Figure 7 - Sightings of Turkey Vultures *Cathartes aura* (N=48) from April - August, and Golden Eagles *Aquila chrysaetos* (N=37) from January - December 1989.

Figure 8 - Total number of individual sightings of falcons recorded at the NTS from 1989-1991.

Northern harriers were uncommonly observed in open desert shrub habitats around water sources during in recent years. Sightings have not been numerous and were restricted to winter and spring. This differs from sighting records of Hayward et al (1963), who observed harriers commonly (126 records), distributed during all months of the year except June. They were normally seen flying low over the desert in pursuit of prey with their wings formed into the typical deep-v or dihedral position. Northern harriers are a ground nesting species, however it is not likely that they breed on the NTS. This species feeds on a broad assemblage of small and medium sized mammals and birds, reptiles, amphibians, and insects (Johnson 1981).

Revision of the NTS Bird Species List

The initial bird inventory performed at the NTS (Hayward et al. 1963) described about 190 species. Some additional observations by Castetter and Hill (1979) added about 24 species to the list. About seven new species have been added to the historical species list from 1989-91. Other bird studies at the NTS developed some site specific information (Hill 1971, 1972, Hill and Burr 1973, Moor and Bradley 1974). O'Farrell and Emery (1976) listed several sightings of the endangered peregrine falcon from Yucca Flat. Approximately 144 of the 222 species (65%) known to occur historically on the NTS have been observed during 1989-91 (see appendix A). These sightings represent the majority of common species likely to be observed at the NTS. A breakdown of birds at the NTS by functional type is shown in Table 26. Sixty to 70 percent of the species are migrants. About 75 species (34%) are classified as permanent and summer residents. About 45 of these species have not been documented with respect to breeding status or capability on the NTS (see species list). This suggests that many more than the known number of breeding species (36) are potential breeders. A dozen or more species (permanent or summer residents) found at the higher elevations of the NTS have not been observed in recent years (e.g., Clark's nutcracker, ladder-backed woodpecker) probably because of limited observations in those habitats.

Table 26. Functional classification of birds on the Nevada Test Site. Percent of fauna based on 222 species.

Functional Type	Number	% of fauna
Spring-fall migrant	126	56.7
Summer resident	38	17.1
Winter resident	9	4.0
Permanent resident	37	16.7

Table 26. continued.

Functional Type	Number	% of fauna
Recorded breeder	36	16.2
Rare vagrant	23	10.4

Resident Bird Communities on the NTS

Bird communities on the NTS generally vary according to the structure and the vertical complexity of the vegetation and are probably regulated by water constraints. As a rule, communities in the lower shrub desert have fewer breeding species than those in pinion-juniper habitat at higher elevations. The lower desert including Jackass, Frenchman, and Yucca Flats supports common species such as the black-throated sparrow, Say's phoebe, western kingbird, ash-throated flycatcher, western meadowlark, horned lark, Scott's oriole and Leconte's thrasher, just to name a few (Tables 13-17). Some of the most widely distributed residents of this region include common raven, black-throated sparrow, mourning dove, northern mockingbird, house finch, and rock wren. These species either are more adaptable to varying environments or have found a specific way to exploit certain habitats. By contrast, some species such as sage sparrow and sage thrasher are more restricted to certain habitats (sagebrush) during normal rainfall years. Horned larks are capable of using disturbed habitats such as burned areas and ground zeros in grassland succession. Low desert species are probably more efficient in maintaining water balance than species that live at higher elevations. The black-throated sparrow, which can survive without drinking for extended periods is arguably the best adapted seed eating bird in the North American deserts (Smyth and Bartholomew 1966). Similarly, Brewer's sparrows are regarded as more efficient in maintaining or conserving water than species such as the chipping sparrow which lives at higher elevations or in more mesic habitat (Dawson et al. 1979).

Partitioning of the available habitat by closely related birds is evident for several groups using elevation as a gradient. For example, Cassin's kingbird inhabits the high desert (above 4500 ft) compared to the western kingbird which is much more abundant in lower regions. Similarly, Cassin's finch compared to the house finch, and the northern oriole versus Scott's oriole occur at high and low elevations respectively. Spatial partitioning may be due to different abilities to maintain water balance. Examples are segregating at different elevations or use of specific micro-habitats. For instance, on the lower desert, the black phoebe is often seen in association

with water while its close relative, Say's phoebe, is commonly observed far from water. The rock wren occurs at a range of elevations because it is specialized in using rocky outcrops. There it can forage on ground insects, obtaining needed water, and retreat to crevices to minimize water loss (Smyth and Bartholomew 1966). The canyon wren, by contrast, appears restricted on the NTS to steep canyons and cliff walls in the Eleana Range.

Finally, the sage sparrow, a close relative of the black-throated sparrow, is most the abundant resident in open sagebrush at higher elevations in summer (Pahute Mesa). Moldenhauer and Wiens (1970) reported that sage sparrows could survive on water consumed from fleshy fruits and insects but that its water balance efficiency was only intermediate compared to desert species. The black-throated sparrow, however, can survive on a diet of dry seeds for extended periods of time (Smyth and Bartholomew 1966).

The Eleana Range represents a more vegetatively diverse and structurally complex habitat for birds than the adjacent community on Yucca Flat nearby. Differences in vegetation can have significant effects on species richness for bird populations. The presence of Joshua trees alone in the habitat can greatly increase the foliage height diversity allowing additional nesting sites. Pinyon and Juniper trees further expand the range of structural habitats at higher elevations. Commonly observed species of birds in the Eleana Range (lower slopes) include Brewer's sparrow, black-throated sparrow, Cassin's kingbird, cactus wren, northern mockingbird, and loggerhead shrike. At higher points in the Eleanas (in pinyon-juniper), other species are abundant such as the blue-grey gnatcatcher, bustit, pinion and scrub jays, mountain chickadee, dark-eyed junco and mountain bluebird, etc. Some common species observed at water sources near higher elevation are listed (Tables 18-20). Brown-headed cowbirds including flocks of juveniles were observed at Gold Meadow sump in summer (July) associated with house finches and robins. They parasitize broods of many species of passerine birds and may be affecting abundances of some species. Cowbirds have historically increased in the western United States since the end of the last century as livestock flourished and as the land became settled (Ryser 1985). Cowbirds are often observed with bands of horses on the NTS and probably benefit from the association.

Mule Deer Utilization

Mule deer (*Odocoileus hemionus*) are the most abundant species of large mammal on the NTS. Giles and Cooper (1985) stated there are about 1500-2000 deer occupying the NTS. Furthermore, the deer population has two components, the

Pahute Mesa and Rainier Mesa herds, of which the Pahute Mesa component is estimated to be significantly larger. Both herds intermix to some degree during the wintering period near the Timber Mountain area. Giles and Cooper (1985) concluded that while a few deer may migrate long distances off of the NTS, the majority of the population remains locally resident year-round.

Mule deer commonly utilize about twenty permanent or semi-permanent water sources throughout much of the year (Figure 9). The most heavily used sites occurred at higher elevation in or near pinion-juniper habitat. Water sources located at lower elevations in desert shrub habitats (Areas 5 and 25) were under-utilized, possibly due to lack of preferred forage and cover near these sites. Water sources on Yucca Flat were probably used less because of their proximity to construction activity.

Seasonal utilization patterns of water sources by mule deer seemed to follow two patterns. Many water sources at mid to high elevations (1500-2000 m) were used heavily in the summer and fall (e.g., Pahute Lake, Gold Meadow, Captain Jack Spring) and much less in the winter. Similarly, this appeared to be the case for White Rock, Tub, and Reitman Springs. Tippihah and Topopah springs were different, showing heaviest usage during late fall and winter (Nov-Dec). This is consistent with movement patterns known for deer at the NTS. A few deer will winter at higher elevations making some altitudinal adjustments, however the majority of individuals vacate the summer range in mid-November and move to the wintering range at lower elevations (Giles and Cooper, 1985). Topopah Spring (Area 29) and Tippihah Spring (Area 16) are both located in the winter range of deer at the NTS. Small groups of deer were observed in consecutive years (December, 1989-90) near Topopah Spring illustrating usage of this region as winter range (Tables 3 and 4).

Daylight sightings of mule deer around water sources were very infrequent. Sightings of deer near water sources seemed to be limited to chance observations in the morning (0500-0700 hrs), such as at well 5B or in remote areas such as Topopah Spring (Tables 4,5). Some occasional deer sightings were also made during mid-day in pinion-juniper habitats near Captain Jack Spring and Gold Meadow sump.

Deer may be forced to move from habitats around water sources during periods of reduced availability of water. Usage at one site, N Tunnel ponds, appeared to increase (as evidenced by the increase in tracks observed) in July of 1989, as a nearby water source; Gold Meadows sump, dried up. Dependency of wildlife on certain water sources also has inherent risks. Four deer were sighted on

Figure 9 - Mule Deer Utilization at the water sources of the Nevada Test Site during 1989-1991.

the morning of November 30, 1989, at the N tunnel ponds. One of the deer fell through the ice and became trapped. The doe (suffering from hypothermia) was pulled from the water by several workers and was later revived (massaged) and released. Deer are sometimes killed by mountain lions around water sources as happened at Area 12 sewage pond in 1988.

The preferred forage base for mule deer at the NTS appears to consist primarily of bitterbrush and scrub oak. Two species of bitterbrush, *Purshia tridentata* (found on elevations above 1800 m) and *Purshia glandulosa* (on elevations between 900-1800 m) provide forage availability over a wide range of elevation. Observations during 1988-89 indicate forage in close proximity to water sources was heavily grazed (e.g., Gold Meadow, Tub Spring) while forage found far from water was generally under-utilized. Man-made well reservoirs which provide water in the proximity of deer forage and cover, probably support higher deer numbers than would otherwise occur from the natural water sources alone.

Night spotlighting surveys have been previously employed to census the relative abundance of deer as well as other aspects of their biology (Progulske and Duerre 1964, Gunson 1979, McCullough 1982). Deer surveys of this nature are generally regarded as useful by investigators, but with varying levels of success. McCullough (1982) examined some of the problems associated with spotlighting on the George Reserve in Michigan, and concluded that counts over fixed routes may be rough estimators of population trend. Gunson (1979) concluded that night-lighted counts prior to the fall hunting season in Canada may provide a more reliable deer census than winter aerial counts.

Night spotlighting for mule deer was performed for three consecutive years to assess trends in numbers on selected areas of their summer range (Table 27, Figure 10). A reduction in mean sighting rate (number/km) has occurred during the last two years. This measure suggests deer numbers have declined at the NTS from drought effects and is consistent with state trends reported by NDOW (Figure 11). Limited animal sign (tracks) of deer as well as lack of grazing pressure on bitterbrush near water sources from 1990-91 also supports the contention of a much reduced deer population on the NTS.

Currently, an accurate estimate of population number for mule deer on the NTS is lacking. The only estimate available is from Giles and Cooper (1985), from a study specifically designed to measure migration rather than population

number. Furthermore, some rather large confidence intervals reported in this study suggest lack of precision in their estimate. Finally, after three continued years of drought in southern Nevada, it is probable that the resident population is significantly reduced, possibly numbering only several hundred animals.

Table 27. Mule Deer *Odocoileus hemionus* observed on Rainier and Pahute Mesa during three nights of spotlighting in late summer 1989-91.

Date	Km ^a	Bucks	Does	Fawns	Unknown	Total	Deer/Km
8-21-89	60	18	16	4	-	38	0.63
8-22-89	77	13	10	5	7	35	0.45
8-23-89	77	23	19	4	-	46	0.60
<hr/>							
Total		54	45	13	7	119	X=0.56±0.05

Date	Km	Bucks	Does	Fawns	Unknown	Total	Deer/Km
9-10-90	74	12	7	5	3	27	0.36
9-11-90	75	13	11	-	4	28	0.37
9-12-90	79	11	9	3	2	25	0.32
<hr/>							
Total		36	27	8	8	80	X=0.35±0.01

Date	Km	Bucks	Does	Fawns	Unknown	Total	Deer/Km
9-16-91	81	6	12	-	1	19	0.23
9-17-91	83	6	8	1	2	17	0.20
9-23-91	82	10	11	2	-	23	0.28
<hr/>							
Total		22	31	3	3	59	X=0.24±0.02

^a Mileage was estimated after the survey in 1989, but in all other years mileage was measured during the survey.

Figure 10 - Approximate region where roads (dashed) were driven to census Mule deer in August - September 1989-1991.

Figure 11 - Population and Buck Ratio Trends for Nevada.
Reprinted from Nevada Department of Wildlife Report on the Status of Mule Deer (1991) Reno, Nevada

Mountain Lion and Bobcat Records

The two large carnivores, mountain lions *Felis concolor* and bobcats *Felis rufus*, have never been studied in detail at the NTS. Giles and Cooper (1985) reported instances when mountain lions were accidentally caught in clover traps while trapping deer and on several occasions killed deer that had been radio-collared and released. No quantitative population estimates for felids exist for the test site region. However, Ashman et al. (1983) reported a plausible population estimate of about 9 mountain lions occurring in the Belted Range-Pahute Mesa area. This estimate is based on a subjective rating of the habitat as moderate to poor quality (about 1 lion per 40 miles²) and a total area of 342 mi². Applying this habitat rating to the NTS indicates that fewer than 9 mountain lions can survive here. The home range of this species varies significantly with sex. Females normally range over an area of about 50-80 miles², while males have a much larger territory of about 80-150 miles². The range of an individual can often overlap an area defended by another animal. Few historical records of mountain lion and bobcats sightings exist for the NTS (Figures 12 and 13) although they are commonly observed. Four low elevation sighting records (< 1300 m) have been reported on or near the NTS, suggesting that presence of mountain lions at lower elevations might not be an irregular occurrence. Bobcats are generally distributed over a wide range of elevations on the NTS (900-2000 m). Koehler and Hornocker (1991) reported bobcats and mountain lions generally avoided interactions by partitioning prey types (size, species) and habitats (forest type, snow depth) in Idaho. However, during winter when resources were more confined (due to snow depth), mountain lions occupied lower elevations, sometimes killing bobcats while defending their food caches.

Presently, mountain lion abundance in southern Nevada is generally regarded to be high following a peak in deer numbers in 1988 (pers. comm. Bob Turner, NDOW, 1991). However, coincident with the drought, deer numbers appear much reduced, possibly contributing to a food shortage for lions. During 1990 and 1991, we have recorded two instances of lion starvation: an emaciated kitten (<5 months old and weighing about 8 kg), and a 20 month old female weighing about 36 kg, which attacked a BECAMP field biologist. Their condition and behavior appear related to starvation. Furthermore, disappearance of healthy foals in consecutive years (1990-92), including all known foals lost in 1992, is evidence that lions may be selecting horses as an alternate, but more available resource than mule deer, their preferred prey. Mountain lions in southern Nevada may increase their predation on horses in time of drought (food limitation) and may have learned to select horses (especially foals), because they may be easier to locate and kill when deer are not abundant.

Figure 12 - Historical records of Mountain lion *Felis concolor* sightings and observations of activity at the NTS (N=37).

Figure 13 - Historical records of Bobcat *Lynx rufus* sightings and sign on the NTS and environs (N=32).

Wildlife Report Card Summary

The wildlife report cards used at the NTS can be a useful way to record and report information regarding new species distributions and occurrences. The most noteworthy record of 1991 was the sighting of 2 bighorn sheep rams on the NTS in Area 23. Sighting of sheep, however, was not unexpected because they were known to be stocked during 1990 (25 animals) in the nearby Specter Range. Also noteworthy were frequent cattle sightings in 1990 in Jackass Flats and Mid-valley which were not observed in 1991. Yearly summaries of mammal and bird records for 1989-91 are listed in Tables 28-34.

Table 28. Summary of mammal sightings from wildlife report cards in 1989.

Mammals	N	Period observed	Areas
Cattle	10	March-December	18,25
Mule deer	9	August	5,20
Antelope	2	July	5
Bobcat	3	July-December	19,25
Coyote	11	April-November	3,5,6,16
Grey fox	1	May	19
Kit fox	1	July	3
Ringtail	1	October	23
Badger	2	May, November	2,3
Rock squirrel	2	September	12
Total	42		

Table 29. Summary of mammal sightings from wildlife report cards in 1990.

Mammals	N	Period observed	Areas
Mule deer	1	October	5
Cattle	5	August	25,30
Antelope	2	Fall	25
Coyote	1	September	17
Ringtail	1	January	6
Badger	2	February, July	6
Rock squirrel	2	May	12,19
Total	19		

Table 30. Summary of mammal sightings from wildlife report cards during 1991. (N) is the total number of live sightings. (D) is number of roadkills reported.

Mammals	N	D	Period observed	Areas
Mule deer	19	2	April-August	5,12,29,20,30
Bighorn sheep	2		October	22
Antelope	5		July	12
Mountain lion	7		March-August	12,18,19
Coyote	7	2	July-October	1,2,4,5,6,12
Kit fox	1	1	June	5,25
Cottontail	10	3	May-September	6,18,19,20,23
Jackrabbit	15	39	June-October	2,3,5,6,10,18,19,22,26
Rabbit (unid.)		8	June-July	1,17,18,22,25
Rock squirrel		2	September-October	19
Cliff chipmunk	1		July	19
Ground squirrel*	1		November	5
Total	67	57		

**Ammosperophilus leucurus*. Bighorn sheep (rams) were observed on October along Mercury highway.

Table 31. Summary of bird sightings from wildlife report cards during 1989. (N) is the total number of sightings.

Birds	N	Period observed	Areas
Great blue heron	1	July	3
Turkey vulture	46	April-August	1,2,3,6,12,18,20
Osprey	1	June	5
Golden eagle	34	April-December	1,2,3,5,6,17,18,22,25
Red-tailed hawk	22	May-December	1,3,4,5,6,16,17,18,23,25
Northern harrier	1	September	1
Prairie falcon	7	June-December	3,5,18,22,23
American kestrel	2	May, November	6,12
Gambel's quail	2	May	16
Greater roadrunner	1	March	23
Great horned owl	1	August	18
Total	118		

Table 32. Summary of bird sightings from wildlife report cards and field notes during 1990. (N) is the total number of sightings.

Birds	N	Period observed	Areas
American wigeon	5	February	22
Snowy egret	1	September	25
Turkey vulture	24	April-August	1,2,12,18,19
Osprey	1	April	22
Golden eagle ^a	14	Feb-August	1,5,6,17,18,20,22
Red-tailed hawk	28	March-Dec	2,3,4,5,6,12,17,20,22,25
Northern harrier	1	November	5
Prairie falcon ^b	6	February-Nov	2,3,22,25
American kestrel	25	Feb-Dec	1,2,6,12,17,18,19,25
Chukar/young	14	May	5,22
Common snipe	1	September	25
Greater roadrunner	3	April-June	23
Burrowing owl	7	May-June	5,2
Great horned owl	1	September	25
Scrub jay	13	September	25
Ravens/young	14	April-May	1,14,16
Western meadowlark	1	September	25

Total 159

^a = 1 roadkill in Area 5

^b = 1 report is a possible feline kill

Table 33. Summary of raptor sightings from wildlife report cards for 1991. (N) is total number of sightings. (F) is flying, (P) is perched, (RK) is at a rabbit roadkill and (GD) is observed on the ground.

Common name	N	Period observed	Activity observed			
			F	P ^a	RK	GD
Turkey vulture	70	March-October	43	1	19	1
Osprey	2	April, October		2		
Golden eagle	22	January-November	8	6	2	
Red-tailed hawk	44	January-December	3	35		
Rough-legged hawk	2	November		2		
Northern harrier	1	November	1			
Prairie falcon	7	June-December	4	3		
American kestrel	18	March-October	6	11		
Burrowing owl	9	April-October	1	1		7
Great horned owl	1	September		1		
Unid. Buteo	1	October		1		
Unid. Accipiter	1	October	1			

Totals 178 67 63 21 8

^a = where activity was described, 31 of 35 red-tails were observed perching on utility poles, the remainder on trees.

Table 34. Additional records of birds recorded from various habitats or locations on the NTS during 1991. (N) is the sum of sightings of adults plus juveniles.

Common name	N	Period	Locations	Remarks
American bittern	1	October	Area 3 mud plant	New record
Green-backed heron	1	June	Area 6 well 3	At well pond
Snowy egret	4	May	Area 3	Near well pond
Green-winged teal	20	February	Area 25	At well pond
Bufflehead	1	February	Area 25	At well pond
Redhead duck	3	June	Area 2,25	At well ponds
Canada goose	1	February	Area 5	In Larrea, sick
Common merganser	1	March	Area 25	At well pond
Chukar/young	14	July	Area 23 camp	4 young
Gambel's quail	11	January	Area 23 camp	In Mercury
Pigeon	1	March	Area 23 camp	Dead
Mourning dove	>30	July	Area 16,25	Juveniles present
Yellow-billed cuckoo	1	June	Area 6, well C1	New record
Common nighthawk	11	June, July	Area 12, 20	In pinion-juniper
Common poorwill	1	April	Area 3 camp	Sick or unhealthy
Belted kingfisher	1	June	Area 3 mud plant	Captured a fish
Killdeer/young	>2	July	Area 6, well C1	2 young seen
American avocets	3	June, July	Area 23 sewage	1 hatchling
Willet	2	June	Area 5, 23	In Larrea
Say's phoebe/nest	5	June	Area 9,18	eggs present
Cassin's kingbird	2	May	Area 18	In pinion juniper
Western kingbird	2	May	Rock Valley	In Larrea
Horned lark	>1	April	Sedan plot	Nest/2 eggs
Ash-throated flycatcher	1	June	Area 6 well C1	At well pond
Common raven/nest	>10	April-June	Area 3,5,6,12,14	Juveniles present
Rock wren	>9	July	Area 23,14,17	Juveniles present
Mountain bluebird	2	June	Area 19	In pinion juniper
Varied thrush	1	September	Area 5, in Larrea	New record
Northern mockingbird	1	May	Area 2	Yucca-blackbrush
Loggerhead shrike	2	July	Area 5, 10	In Larrea
European starling	>80	December	Area 12,23	Flock at 12 camp
Wilson's warbler	1	May	Rock Valley	In Larrea
Western Tanager	3	May	Rock Valley	In Larrea
Indigo bunting	1	July	Gold Meadows	New record
Black-throated sparrow	>8	May-June	Area 3,5,17,25	Juveniles present
Brewer's sparrow	>2	May	Area 16,25	Blackbrush
Green tailed Towhee	1	June	Gold Meadows	In pinion-juniper
Great tailed-grackle	>5	July	Area 23 camp	Colonial nests
Cassin's finch	>3	June	Gold Meadows	At sump

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APPENDIX H

BIRD LIST FOR THE NEVADA TEST SITE CLASS AVES: BIRDS

Status

Order *PODICIPEDIFORMES*: Grebes

Family Podicipedidae: Grebes

<i>Aechmophorus occidentalis</i>	Western Grebe	M*
<i>Podiceps nigricollis</i>	Eared Grebe	M*
<i>Podilymbus podiceps</i>	Pied-billed Grebe	M*

Order *PELECANIFORMES*: Totipalmate Swimmers

Family Pelecanidae: Pelicans

<i>Pelecanus erythrorhynchos</i>	American White Pelican	M
<i>Pelecanus occidentalis</i>	Brown Pelican	MR*

Family Phalacrocoracidae: Cormorants

<i>Phalacrocorax auritus</i>	Double-crested Cormorant	M
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Order *CICONIFORMES*: Herons, Ibises, and Storks

Family Ardeidae: Herons, Egrets, and Bitterns

<i>Ardea herodias</i>	Great Blue Heron	M*
<i>Botaurus lentiginosus</i>	American bittern	M*
<i>Bubulcus ibis</i>	Cattle Egret	M
<i>Butorides striatus</i>	Green-backed Heron	M*
<i>Casmerodius albus</i>	Great Egret	M*
<i>Egretta thula</i>	Snowy Egret	M*
<i>Ixobrychus exilis</i>	Least Bittern	M, R
<i>Nycticorax nycticorax</i>	Black-crowned Night-Heron	M*

Family Threskiornithidae: Ibises and Spoonbills

<i>Ajaia ajaja</i>	Roseate Spoonbill	M, R
<i>Plegadis chihi</i>	White-faced Ibis	M*

Order *ANSERIFORMES*: Waterfowl

Family Anatidae: Swans, Geese, and Ducks

<i>Aix sponsa</i>	Wood Duck	M*
<i>Anas acuta</i>	Northern Pintail	M*
<i>Anas americana</i>	American Wigeon	M*

Order ANSERIFORMES: Waterfowl (Continued)

<i>Anas clypeata</i>	Northern Shoveler	M*
<i>Anas crecca</i>	Green-winged Teal	M*
<i>Anas cyanoptera</i>	Cinnamon Teal	M*
<i>Anas discors</i>	Blue-winged Teal	M*
<i>Anas platyrhynchos</i>	Mallard	M*
<i>Anas strepera</i>	Gadwall	M*
<i>Aythya affinis</i>	Lesser Scaup	M*
<i>Aythya americana</i>	Redhead	M*
<i>Aythya collaris</i>	Ring-necked Duck	M*
<i>Aythya valisineria</i>	Canvasback	M*

Order ANSERIFORMES: Waterfowl

Family Anatidae: Swans, Geese, and Ducks (Continued)

<i>Branta canadensis</i>	Canada Goose	M*
<i>Bucephala albeola</i>	Bufflehead	M*
<i>Bucephala clangula</i>	Common Goldeneye	M*
<i>Chen caerulescens</i>	Snow Goose	M
<i>Cygnus columbianus</i>	Tundra Swan	M
<i>Melanitta perspicillata</i>	Surf Scoter	M, R
<i>Mergus merganser</i>	Common Merganser	M*
<i>Mergus serrator</i>	Red-breasted Merganser	M
<i>Oxyura jamaicensis</i>	Ruddy Duck	M*

Order FALCONIFORMES: Diurnal Birds of Prey

Family Cathartidae: American Vultures

<i>Cathartes aura</i>	Turkey Vulture	PR*
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Family Accipitridae: Hawks, Kites, and Eagles

Subfamily Pandioninae: Ospreys

<i>Pandion haliaetus</i>	Osprey	M*
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Subfamily Accipitrinae: Kites, Hawks, Eagles, and Harriers

<i>Accipiter cooperii</i>	Cooper's Hawk	PR*
<i>Accipiter gentilis</i>	Northern Goshawk	M, R
<i>Accipiter striatus</i>	Sharp-shinned Hawk	PR*
<i>Aquila chrysaetos</i>	Golden Eagle	PR, B*
<i>Buteo jamaicensis</i>	Red-tailed Hawk	PR, B*
<i>Buteo lagopus</i>	Rough-legged Hawk	WR*
<i>Buteo regalis</i>	Ferruginous Hawk	WR
<i>Buteo swainsoni</i>	Swainson's Hawk	B

Order FALCONIFORMES: Diurnal Birds of Prey (Continued)

<i>Circus cyaneus</i>	Northern Harrier	WR*
<i>Haliaeetus leucocephalus</i>	Eagle	M, R

Family Falconidae: Falcons and Caracaras

<i>Falco mexicanus</i>	Prairie Falcon	PR, B*
<i>Falco peregrinus</i>	Peregrine Falcon	M, R
<i>Falco sparverius</i>	American Kestrel	PR, B*

Order GALLIFORMES: Gallinaceous Birds

Family Phasianidae: Pheasants, Grouse, and Quail

Subfamily Phasianinae: Partridges, Francolins, and Pheasants

<i>Alectoris chukar</i>	Chukar	PR, B*
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Subfamily Odontophorinae: New World Quails

<i>Callipepla gambelii</i>	Gambel's Quail	PR, B*
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Order GRUIFORMES: Rails, Cranes, and Allies

Family Rallidae: Rails, Gallinules, and Coots

<i>Fulica americana</i>	American Coot	PR, B*
<i>Gallinula chloropus</i>	Common Moorhen	M*

Order CHARADRIIFORMES: Shorebirds, Gulls, and Alcids

Family Charadriidae: Plovers

<i>Charadrius alexandrinus</i>	Snowy Plover	M
<i>Charadrius montanus</i>	Mountain Plover	M, R
<i>Charadrius semipalmatus</i>	Semipalmated Plover	M*
<i>Charadrius vociferus</i>	Killdeer	M, B*
<i>Pluvialis dominica</i>	Lesser Golden-Plover	M
<i>Pluvialis squatarola</i>	Black-bellied Plover	M

Family Recurvirostridae: Avocets and Stilts

<i>Himantopus mexicanus</i>	Black-necked Stilt	M*
<i>Recurvirostra americana</i>	American Avocet	M, B*

Family Scolopacidae: Sandpipers and Allies

Subfamily Scolopacinae: Sandpipers, Turnstones, Surfbirds and Snipes

<i>Actitis macularia</i>	Spotted Sandpiper	M*
<i>Calidris alpina</i>	Dunlin	M, R
<i>Calidris bairdii</i>	Baird's Sandpiper	M

Calidris himantopus Stilt Sandpiper M

Order Gharadriiformes: Rails, Cranes, and Allies (Continued)

Calidris mauri Western Sandpiper M*

Calidris melanotos Pectoral Sandpiper M, R

Calidris minutilla Least Sandpiper M*

Catoptrophorus semipalmatus Willet M*

Gallinago gallinago Common Snipe M*

Limnodromus scolopaceus Long-billed Dowitcher M*

Limosa fedoa Marbled Godwit M*

Numenius americanus Long-billed Curlew M*

Tringa flavipes Lesser Yellowlegs M*

Tringa melanoleuca Greater Yellowlegs M*

Tringa solitaria Solitary Sandpiper M*

Subfamily Phalaropodinae: Phalaropes

Phalaropus lobatus Red-necked Phalarope M*

Phalaropus tricolor Wilson's Phalarope M*

Family Laridae: Gulls, Terns, and Allies

Subfamily Larinae: Gulls

Larus californicus California Gull M*

Larus delawarensis Ring-billed Gull M*

Larus philadelphia Bonaparte's Gull M

Larus pipixcan Franklin's Gull M

Subfamily Sterninae: Terns

Chlidonias niger Black Tern M

Sterna caspia Caspian Tern M

Sterna forsteri Forster's Tern M

Order Columbiformes: Pigeons and Allies

Family Columbidae: Pigeons and Doves

Columba livia Domestic pigeon R*

Zenaida macroura Mourning Dove SR, B*

Order Cuculiformes: Cuckoos and Allies

Family Cuculidae: Cuckoos, Roadrunners, and Anis

Coccyzus americanus Yellow-billed Cuckoo M*

Geococcyx californianus Greater Roadrunner PR, B*

Order STRIGIFORMES: Owls

Family Tytonidae: Barn-owls

Tyto alba Common Barn-Owl PR, B

Family Strigidae: Typical Owls

Asio flammeus Short-eared Owl WR
Asio otus Long-eared Owl PR, B*
Athene cunicularia Burrowing Owl PR, B*
Bubo virginianus Great Horned Owl PR*

Order CAPRIMULGIFORMES: Goatsuckers and Allies

Family Caprimulgidae: Nightjars

Chordeiles acutipennis Lesser Nighthawk SR*
Chordeiles minor Common Nighthawk SR*
Phalaenoptilus nuttallii Common Poorwill SR*

Order APODIFORMES: Swifts and Hummingbirds

Family Apodidae: Swifts

Aeronautes saxatalis White-throated Swift SR*

Family Trochilidae: Hummingbirds

Calypte costae Costa's Hummingbird SR, B
Selasphorus platycercus Broad-tailed Hummingbird SR
Selasphorus rufus Rufous Hummingbird M

Order CORACIIFORMES: Rollers, Kingfishers, and Allies

Family Alcedinidae: Kingfishers

Ceryle alcyon Belted Kingfisher M*

Order PICIFORMES: Woodpeckers and Allies

Family Picidae: Woodpeckers and Wrylecks

Colaptes auratus Northern Flicker PR*
Melanerpes lewis Lewis's Woodpecker SR*
Picoides scalaris Ladder-backed Woodpecker SR
Picoides villosus Hairy Woodpecker PR
Sphyrapicus nuchalis Red-naped Sapsucker M

Order PASSERIFORMES: Perching Birds

Family Tyrannidae: Tyrant Flycatchers

Subfamily Fluvicolinae: Fluvicoline Flycatchers

<i>Contopus borealis</i>	Olive-sided Flycatcher	M*
<i>Contopus sordidulus</i>	Western Wood-Pewee	SR*

Family Tyrannidae: Tyrant Flycatchers (Continued)

<i>Empidonax difficilis</i>	Western flycatcher	M
<i>Empidonax hammondi</i>	Hammond's flycatcher	SR
<i>Empidonax oberholseri</i>	Dusk Flycatcher	M
<i>Empidonax wrightii</i>	Gray Flycatcher	SR
<i>Pyrocephalus rubinus</i>	Vermilion Flycatcher	R
<i>Sayornis nigricans</i>	Black Phoebe	SR*
<i>Sayornis saya</i>	Say's Phoebe	SR, B*

Subfamily Tyranninae: Kingbirds and Allies

<i>Myiarchus cinerascens</i>	Ash-throated Flycatcher	SR*
<i>Tyrannus forficatus</i>	Scissor-tailed Flycatcher	M, R
<i>Tyrannus verticalis</i>	Western Kingbird	SR, B*
<i>Tyrannus vociferans</i>	Cassin's Kingbird	SR, B*

Family Alaudidae: Larks

<i>Eremophila alpestris</i>	Horned Lark	PR, B*
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Family Hirundinidae: Swallows

<i>Hirundo pyrrhonota</i>	Cliff Swallow	M*
<i>Hirundo rustica</i>	Barn Swallow	M*
<i>Riparia riparia</i>	Bank Swallow	M*
<i>Stelgidopteryx serripennis</i>	Northern Rough-winged Swallow	PR*
<i>Tachycineta bicolor</i>	Tree Swallow	M*
<i>Tachycineta thalassina</i>	Violet-green Swallow	PR*

Family Corvidae: Jays, Magpies, and Crows

<i>Aphelocoma coerulescens</i>	Scrub Jay	PR*
<i>Corvus brachyrhynchos</i>	American Crow	WR, R
<i>Corvus corax</i>	Common Raven	PR, B*
<i>Cyanocitta stelleri</i>	Steller's Jay	SR
<i>Gymnorhinus cyanocephalus</i>	Pinyon Jay	PR*
<i>Nucifraga columbiana</i>	Clark's Nutcracker	SR
<i>Pica pica</i>	Black-billed Magpie	M

Family Paridae: Chickadees and Titmice

<i>Parus gambeli</i>	Mountain Chickadee	PR*
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Order PASSERIFORMES: Perching Birds (Continued)

<i>Parus inornatus</i>	Plain Titmouse	SR*
Family Aegithalidae: Bushtits and Long-tailed Tits		
<i>Psaltiriparus minimus</i>	Bushtit	PR, B*
Family Sittidae: Nuthatches		
<i>Sitta canadensis</i>	Red-breasted Nuthatch	WR
<i>Sitta carolinensis</i>	White-breasted Nuthatch	SR
Family Troglodytidae: Wrens		
<i>Campylorhynchus brunneicapillus</i>	Cactus wren	PR, B*
<i>Catherpes mexicanus</i>	Canyon Wren	SR*
<i>Cistothorus palustris</i>	Marsh Wren	M
<i>Salpinctes obsoletus</i>	Rock Wren	PR, B*
<i>Thryomanes bewickii</i>	Bewick's Wren	PR
<i>Troglodytes aedon</i>	House Wren	SR
Family Muscicapidae: Old World Flycatchers and Allies		
Subfamily Sylviinae: Old World Warblers, Kinglets, and Gnatcatchers		
<i>Polioptila caerulea</i>	Blue-gray Gnatcatcher	SR*
<i>Polioptila melanura</i>	Black-tailed Gnatcatcher	R
<i>Regulus calendula</i>	Ruby-crowned Kinglet	M*
Subfamily Turdinae: Thrushes		
<i>Catharus guttatus</i>	Hermit Thrush	M
<i>Catharus ustulatus</i>	Swainson's Thrush	M
<i>Ixoreus naevius</i>	Varied Thrush	M*
<i>Myadestes townsendi</i>	Townsend's Solitaire	M
<i>Sialia currucoides</i>	Mountain Bluebird	PR*
<i>Sialia mexicana</i>	Western Bluebird	PR*
<i>Turdus migratorius</i>	American Robin	M*
Family Mimidae: Mockingbirds and Thrashers		
<i>Dumetella carolinensis</i>	Gray Catbird	M, R
<i>Mimus polyglottos</i>	Northern Mockingbird	SR, B*
<i>Oreoscoptes montanus</i>	Sage Thrasher	M*
<i>Toxostoma dorsale</i>	Crissal Thrasher	R
<i>Toxostoma lecontei</i>	Le Conte's Thrasher	PR, B*
<i>Toxostoma rufum</i>	Brown Thrasher	M, R
Family Motacillidae: Wagtails and Pipits		
<i>Anthus rubescens</i>	American Pipit	M*

Order PASSERIFORMES: Perching Birds (Continued)

Family Bombycillidae: Waxwings

Bombcilla cedrorum Cedar Waxwing M*

Family Ptilogonatidae: Silky-Flycatchers

Phainopepla nitens Phainopepla R*

Family Laniidae: Shrikes

Lanius ludovicianus Loggerhead Shrike PR, B*

Family Sturnidae: Starlings

Subfamily: Sturninae

Sturnus vulgaris European Starling PR*

Family Vireonidae: Vireos

Vireo gilvus Warbling Vireo SR

Vireo solitarius Solitary Vireo SR

Vireo vicinior Gray Vireo SR

Family Emberizidae: Emberizid Finches and Allies

Subfamily Parulinae: Wood-Warblers

Dendroica coronata Yellow-rumped Warbler M, B*

Dendroica nigrescens Black-throated Gray Warbler SR*

Dendroica petechia Yellow Warbler M*

Dendroica townsendi Townsend's Warbler M

Geothlypis trichas Common Yellowthroat M*

Icteria virens Yellow-breasted Chat M

Oporornis tolmiei MacGillivray's Warbler M

Setophaga ruticilla American Redstart M

Family Emberizidae: Emberizid Finches and Allies

Subfamily Parulinae: Wood-Warblers

Vermivora celata Orange-crowned Warbler M

Vermivora ruficapilla Nashville Warbler M

Vermivora virginiae Virginia's Warbler SR

Wilsonia pusilla Wilson's Warbler M*

Subfamily Thraupinae: Tanagers

Piranga ludoviciana Western Tanager M*

Subfamily Cardinalinae: Cardinal-Grosbeaks

Guiraca caerulea Blue Grosbeak M

Order PASSERIFORMES: Perching Birds (Continued)

<i>Passerina amoena</i>	Lazuli Bunting	SR*
<i>Passerina cyanea</i>	Indigo Bunting	M*
<i>Pheucticus melanocephalus</i>	Black-headed Grosbeak	SR*
Subfamily Emberizinae: American Sparrows and Towhees		
<i>Amphispiza belli</i>	Sage Sparrow	PR, B*
<i>Amphispiza bilineata</i>	Black-throated Sparrow	SR, B*
<i>Calcarius lapponicus</i>	Lapland Longspur	R
<i>Chondestes grammacus</i>	Lark Sparrow	M*
<i>Junco hyemalis</i>	Dark-eyed Junco	PR*
<i>Melospiza lincolni</i>	Lincoln's Sparrow	M
<i>Melospiza melodia</i>	Song Sparrow	M*
<i>Passerculus sandwichensis</i>	Savannah Sparrow	M*
<i>Pipilo chlorurus</i>	Green-tailed Towhee	M*
<i>Pipilo erythrophthalmus</i>	Rufous-sided Towhee	PR*
<i>Pooecetes gramineus</i>	Vesper Sparrow	M*
<i>Spizella atrogularis</i>	Black-chinned Sparrow	R
<i>Spizella breweri</i>	Brewer's Sparrow	SR, B*
<i>Spizella passerina</i>	Chipping Sparrow	SR, B*
<i>Zonotrichia atricapilla</i>	Golden-crowned Sparrow	M, R
<i>Zonotrichia leucophrys</i>	White-crowned Sparrow	M*
Subfamily Icterinae: American Blackbirds and Orioles		
<i>Agelaius phoeniceus</i>	Red-winged Blackbird	M*
<i>Euphagus cyanocephalus</i>	Brewer's Blackbird	M*
<i>Icterus galbula</i>	Northern Oriole	SR*
<i>Icterus parisorum</i>	Scott's Oriole	SR*
<i>Molothrus ater</i>	Brown-headed Cowbird	SR, B*
<i>Quiscalus mexicanus</i>	Great-tailed Grackle	SR, B*
<i>Sturnella neglecta</i>	Western Meadowlark	M*
<i>Xanthocephalus xanthocephalus</i>	Yellow-headed Blackbird	M*
Family Fringillidae: Old World Finches and Allies		
Subfamily Carduelinae: Cardueline Finches		
<i>Carduelis pinus</i>	Pine Siskin	WR
<i>Carduelis psaltria</i>	Lesser Goldfinch	PR*
<i>Carduelis tristis</i>	American Goldfinch	WR*
<i>Carpodacus cassinii</i>	Cassin's Finch	SR*
<i>Carpodacus mexicanus</i>	House Finch	PR, B*
<i>Carpodacus purpureus</i>	Purple Finch	M, R

Order PASSERIFORMES: Perching Birds (Continued)

Family Fringillidae: Old World Finches and Allies

Subfamily Carduelinae: Cardueline Finches

Coccothraustes vespertinus Evening Grosbeak

M

Loxia curvirostra Red Crossbill

M, R

Family Passeridae: Old World Sparrows

Passer domesticus House Sparrow

PR, B*

* Nomenclature follows Banks et al. (1987).

Status: * = species was observed during 1989-91 on the NTS;

B = breeds on the NTS;

SR = Summer resident;

WR = Winter resident;

PR = Permanent resident;

M = Spring-fall migrant;

R = rare or unusual sighting.

Revised as of 9-18-92

TRENDS IN PERENNIAL PLANT POPULATIONS ON THE NEVADA TEST SITE - 1989-1991

Richard B. Hunter

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4 of 6

ACKNOWLEDGEMENTS

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ABSTRACT

Perennial plant populations have been measured annually on the Nevada Test Site at numerous locations since 1987. This report covers the calendar years 1989 through 1991, a period dominated by severe drought. Studies were performed to document vegetation changes associated with natural climate fluctuations, natural and man-caused fires, animal disturbances, and the activities of the Department of Energy. The studies of DOE effects included progress of recovery from above ground nuclear weapons tests conducted in the 1950s, the changing patterns of vegetation on the slopes of subsidence craters generated by underground weapons tests, recovery of vegetation on scraped areas, the changes in perennial vegetation associated with active and abandoned roads, and changes downwind of a facility testing spills of toxic and hazardous gases.

By far the major influence on vegetation during the study period was drought, which selectively killed most perennial bunchgrasses and many shrubs below 1500 meters. In some locations virtually the whole perennial plant population was killed. In most areas, however, the drought-hardy dominant species survived with moderate to severe die-back, and the more sensitive species died. Recovery of vegetation, which may be considered "succession", was delayed or set back significantly. Survival of bunchgrasses was greatest on disturbed areas, and some recovery on burned areas proceeded. There was evidence for better bunchgrass survival and recruitment on the north-facing slopes of subsidence craters, and shrub survival was enhanced within 15 meters of an active paved road.

Recensusing of plots sampled in historical studies suggests there has been little change in the undisturbed NTS vegetation since the early 1960s. However, there are suggestive data showing a significant growth in size of shrubs near Frenchman Lake from 1981 through 1988, followed by severe die-back during the drought. Significant recovery of native shrub communities since 1962 is evident on the Sedan cratering experiment ground zero, with invasion of grasses on the area of throwout deposits occurring between 1975 and 1988, and shrub invasion up to the margin of throwout deposits. Only sparse recruitment of new shrubs occurred in Mid Valley since a fire in 1959. In general, historical data were not adequate to measure subtle changes in vegetation, and too scarce to compare plant species distributions over long time periods.

The 1989 through 1991 efforts included significant efforts to improve the quality of data collection and analysis procedures. Comparing data from a single site from 1987 through 1989 showed significant numbers of plants are not obvious to inexperienced observers, and much of the population turnover and new recruitment was not possible to distinguish from measurement errors without improved search and measurement techniques. By 1991, techniques were implemented which resulted in accurate recognition and recensusing of 91% of individuals censused the previous year, compared to only 41% in 1989-1990. The improved techniques allowed recognition of the establishment of new seedlings and the disappearance of small and dead plants. The techniques established during this period should allow effective monitoring of temporal vegetation changes on the NTS in the future.

INTRODUCTION

In 1987, the U.S. Department of Energy (DOE) Nevada Operations Office initiated a program (Basic Environmental Compliance and Monitoring Program, BECAMP) to, among other things, monitor the trends in plant and animal populations on the Nevada Test Site (NTS) and to develop an understanding of changes in their distributions. This report summarizes results of monitoring perennial plants during the calendar years 1989, 1990, and 1991. Combined with reports for 1987 (Hunter and Medica 1989) and 1988 (Hunter 1992), it provides a short-term view of perennial plant population dynamics on small portions of the Mojave Desert, a transition zone between the Mojave and Great Basin Deserts, and the Great Basin Desert.

The major driving factor for change in perennial plant populations during the 1989-91 study period was a continuing drought, which was severe from August 1988 through June 1990. The drought followed a relatively mesic period of slightly wetter than normal weather (1982-88) during which perennial plants generally flourished (Hunter 1989). It resulted in severe dieback and death of many of the shrubs and herbaceous perennials on the NTS. Therefore, the time-frame of this report includes a time of major change in plant populations on the NTS. Above about 1400 m in altitude, the perennial plant populations were more stable.

The NTS includes the best-studied portion of the Mojave Desert and transition zone floras. Botanical studies began under Laura Shields in 1957 (Shields and Rickard 1961; Shields et al. 1963), and continued through the 1960s under UCLA (Beatley 1965a,b, 1967; Martin 1963). During the early and mid-1970s, the U.S. International Biological Program studied an NTS site in Rock Valley (Rundel and Gibson, in review) to determine basic Mojave Desert ecosystem processes. A hiatus occurred from 1976 through 1986, with only a few focussed studies (Turner and Vollmer 1980, 1982; Hunter 1987). In 1987 the current monitoring program began. These historical studies were not directed towards monitoring long-term changes, and although they allow glimpses of conditions at particular times and places, they have not allowed determination of trends in perennial plant populations.

The BECAMP program was from the beginning aimed at monitoring trends, as opposed to status at particular times. Knowledge of the previous studies, and the high spatial variability in plant populations revealed by the earlier studies, led us to attempt to study temporal changes at specific points,

rather than to attempt to evaluate populations over broad areas. During the five years of the BECAMP program, techniques have been modified to more exactly monitor the vegetation at selected, very specific points. There has been emphasis on and continual improvement in quality, as experience increased and analyses of data revealed flaws in both training of the work force and precision of plant measurements. The result is essentially a new technique for monitoring perennial plant population changes, which we believe will serve well the needs of those needing to know how perennial vegetation is changing with time, and the factors driving those changes.

STUDY SITES

The NTS consists of approximately 3500 km² of desert rangelands. The altitude varies from about 945 m in the southwest corner to 2250 m on Rainier Mesa, near the northern boundary. Two closed basins (Frenchman Flat and Yucca Flat) were used in the past to test nuclear weapons above ground. Current weapons testing is underground beneath Yucca Flat and beneath Pahute and Rainier Mesas.

The vegetation on the NTS varies from Mojave Desert shrubland at lower elevations to Great Basin sagebrush and pinion-juniper woodlands at the highest elevations. Between those communities lies a transition zone dominated by blackbrush (*Coleogyne ramosissima*). Figure 1 shows the distribution of broadly defined vegetative communities as determined by J. C. Beatley (1976).

All BECAMP study sites and their altitudes and coordinates are listed in Appendix 1 of the reptile section (Medica et al.). The study plots were named using a three-letter acronym derived from the valley or mountain name from USGS maps, and numbered in the order of their initiation. Perennial plants were measured on almost all those plots during the 1989-1991 studies (exceptions were PAM004, PAM005; FRF007; JAF002, 003, and 004; and YUF028, 030, and 031). Most of the plots were associated with disturbances such as blast zones, subsidence craters, brush fires, or scraped areas. Some were relatively pristine "baseline" sites chosen for lack of visible disturbance, or sites where perennial plants were measured between 1963 and 1975 by J. C. Beatley (Beatley 1979) and sampled to provide historical continuity. Two of the BECAMP baseline plots (FRF001 and YUF001) include plots (23 and 46) established by Dr. Beatley.

Figure 1 - Dominant vegetation types on the NTS.

METHODS

TRANSECT STUDY METHODS

Methods for studying perennials changed significantly from 1989 to 1991. Most changes were instituted to more accurately relocate individual plants on a transect. The basic technique remained to identify and measure all plants within a defined 50 m x 2 m area, using steel fence posts and a surveyor's tape to mark off the area of the transect. To make the process more exact, changes were made in many of the measurements recorded. These changes can be seen in the sample data sheets (Figures 2-4) for plot YUF001.

Location

In 1989, the location of a plant within a 2 m x 50 m transect was recorded as a "quadrat" equal to the meter along the tape (0 to 49), and a "sector" defined as a 25 cm wide area ranging from "1" on the far left hand side of the transect to "8" on the far right (Figure 2, upper right). This was the same system used in 1988 (Hunter 1992). After it became apparent that plants measured in 1987 and 1988 could not be matched well at later censuses, several changes were instituted. First, the center of the tape was pinned by two lath stakes placed at 25 m along the transect, to prevent wind from blowing the tape to one side or the other. Plants marginally outside of transects (more than 100 cm from the tape) were marked with a plastic bird tag placed on a visible branch to prevent measuring them in subsequent years. In 1990 and 1991, the "sector" was replaced by an actual measurement of the distance from the tape in centimeters (Figure 3). Direction from the tape (east or west) was converted to (+ or -) at keypunching, and in 1991 only the sign (+ or -) was used (Figure 3). For some of the final transects measured in 1990, and several in 1991 the distance along the tape was recorded to the nearest decimeter or centimeter, using a fiberglass rather than a steel 50 m surveyor's tape.

In July 1991, we began to use a data sheet constructed from a printout of earlier data. This forced workers to identify the previously measured plants in the field and replace the previous location, size, and condition data with new information. Only changes in apparent location were entered on the printout of the original data. If acceptable, the original data were not changed (Figure 4).

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BECAAMP VEGETATION DATA

MO	DAY	YEAR	OBSERVERS	LOCATION	TRANSECT NO.			TRANSECT DIMENSIONS			REPRODUCTIVE STATE CODES:			REMARKS
7	13	89	YUF001 V3	TRW CED	V3			50m x 2m			0 = Veg., 1 = fr. buds, 2 = flowering 3 = fruiting, 4 = dormant DEAD: 0-9, 1 = <25; 2 = 25-75; 3 = >75; 4 = 100%			
QUAD	QUAD SECTOR	SPECIES NO.	SPECIES	HEIGHT (cm)	WIDTH	WIDTH	NO. of INDIV.	CRWS.	WEIGHT	NO. WEIGHED	% DEAD	REPRO. ST.	% GRAZED	REMARKS
0	2	10	Cer lan	22	16	19	clump				3	0		TRW measure
	2	1	Aca sho	11	15	20					4	-		CED record
	5	1	Aca sho	26	24	25					3	4		Old flowers/fruit
	5	19	Dry hum	20	2						4	-		
	4	12	Gra spl	54	34	37					1	0		
	4	16	Lyc and	37	63	65					2	0		
	3	19	Oryhym	18	4	4					4	-		
	5	31	Stl Spe	40	4	7					4	-		(Check grass)
1	6	2	Atr Can	24	40	25					1	0		Old grazing
	6	12	Gra spl	26	15	19					1	0		
	7	12	Gra spl	20	7	9					3	0		
	7	2	Atr can	36	8	8					1	0		Has a gall
	7	12	Gra spl	41	26	28					2	0		
	6	10	Cer lan	31	28	30					2	0		
	4	12	Gra spl	52	60	66					2	0		
	4	2	Atr can	59	67	64					2	0		
2	5	16	Lyc and	50	24	55					1	4		
	3	2	Atr can	57	135	47					3	0		
3	4	10	Cer lan	45	20	37					1	0		
	7	12	Gra spl	56	67	40					1	0		
	4	12	Lyc and	60	90	77					2			
3	4	12	Gra spl	74	45	47					1	0		

Figure 2 - A sample data sheet used to collect perennial plant data in 1989 and 1990.

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BECAMP PERENNIAL VEGETATION DATA

MO.	DAY	YEAR	OBSERVERS	LOCATION	TRANSECT NO.	TRANSECT DIMENSIONS	REPRODUCTIVE STATE CODES:				REMARKS
							0 = Veg.	1 = Fr. buds	2 = Flowering	3 = Fruiting	
7	3	91	JLP Measures M.J. - Records	3 B Control	YUF012	2x100 m	DEAD: 0-2, 1 = 50; 2 = 50-75; 3 = 75; 4 = 100%				
Last sampled 8/5/88 2 yrs. 10 mo 28 days = 2.9103.											
Salsola measured every											
10th meter only, ignored											
elsewhere (0,10,20...)											
0	-79	71	Sal spl	24	20	23			1	0	
0	-9	71	Sal spl	22	11	10			1	0	
0	-88	71	Sal spl	17	5	4			1	0	
0	+20	71	Sal spl	34	20	21			1	0	
0	+7	71	Sal spl	10	5	4			1	0	
0	-74	71	Sal spl	7	3	1			1	0	
0	-74	71	Sal spl	9	3	3			1	0	
0	-100	71	Sal spl	13	11	11			1	0	
0	+8	61	UDS (Tet gla)	60	75	63			4	-	
0	+5	61	UDS (Tet gla)	53	95	87			4	-	
0	-9	71	Sal spl	25	10	7			1	0	
0	-95	71	Uds (Tet gla)	56	103	75			4	-	
0	-80	10	Ler lan	41	18	57			2	0	
0	-79	2	Atr can	37	48	31			4	-	
0	-90	10	Dead grass	19	5	4			4	-	
1	-44	2	Tet gla	60	101	80			4	-	
1	-53	2	Atr can	50	51	38			3	3	
1	-32	-7	Atr can	66	103	75			4	-	
1	-1	61	Tet gla	63	77	110			4	-	
2	-45	10	Cer lan	40	26	25			4	-	
2	+21	2	Atr can	23	11	7			3xMJS	0	
2	-48	10	Cer lan	49	42	43			4	-	
2	-20	2	Atr can	48	83	74			4	-	
2	-29	7	Atr can	35	41	27			4	-	

Figure 3 - A sample data sheet used to collect perennial plant data in 1991.

16.700

X	Y	SPECIES	HT	W1	W2	IND	CRNS	DEAD	REPRO	GRAZE	REMARKS
18	55+35	10	1627	524	420	1	1	1	4	-	Q
18	23+3.11	12	3142	1347	834	1	1	1	4	0	Q - Could not find microlabell. p. 10/18/91
18	64+60	10	2534	1840	835	1	1	1	3	3 10	Q started change in 90 but did not end.
18	52+50	12	6630	5030	3414	1	1	1	2	3 00	Q
19	37+32	16	5760	11800	7788	1	1	1	2	3 10	Q
19	20+21	12	5544	4240	4122	1	1	1	2	3 00	Q
19	16+14	10	3430	2230	1522	1	1	1	2	2 03	Q
19	14+10	66-101	3017	68	24	1	1	1	4	-	Q
19	7-1	10	1210	520	420	1	1	1	3	4 0-	Q Root dead this year
19	97+100	2	4042	4940	2340	1	1	1	2	1 3 3	Q
19	82+80	10	1920	1915	2013	1	1	1	4	-	Q

YUFO01V2 1990 MEASURE RECORD DATE 7/31/91
not 1/1/91

Figure 4 - A sample data sheet generated from 1990 data used to collect perennial plant data after July 1991.

Species

Species was determined throughout 1989 and 1990 on the basis of training and experience. Samples of unknown species were brought to Mercury and compared with herbarium specimens. During data analysis, it became apparent that in a few cases species were being misidentified. In general, those which could be reasonably questioned were checked in the field, because the transects are permanently marked (Hunter and Medica 1989). However, use of a printout of previous data in 1991, provided workers with a record of the previous species determination. Only those workers confident in their abilities to distinguish species would make changes, so the danger changed from misidentifying a species to one of perpetuating a previous error. The latter system we considered to result in far fewer errors, and those errors should eventually be eliminated for plants living long enough to be censused several times, as the data are checked in the field by senior personnel before being accepted.

Size Measurements

In general, there were no changes in the techniques of measuring size. The maximum live height, maximum live width, and the live width perpendicular to the maximum were measured to the nearest centimeter. The live dimensions included heights of flower stalks and fruit if those were alive. If the fruit were dry but not dispersed, only the green, vegetative part of the stalk was measured.

During the drought years of 1989 and 1990, it was sometimes difficult or impossible to determine the live portions of plants. For certain species there were no live green parts, either leaves, flowers, or young stems. Only the older stems with heavy bark survived. For drought deciduous species like *Acamptopappus shocklyi*, *Ambrosia dumosa*, and *Artemisia spinescens*, the live portion could often not be determined; for those plants, an asterisk was placed on the data sheet indicating it was alive, but the total size (including dead parts) was measured. For *Ephedra nevadensis* dead stems were identified by color (they bleach yellow in the sun) or feel -- a dead stem breaks rather than bends. Grasses were often totally dead above ground, and were recorded as 100 percent dead (category 4 on the data sheet). Only green parts of bunchgrasses were measured, but all live parts of a single "bunch" were presumed connected below ground, an unlikely situation in many cases.

The widths of bunchgrasses were measured across the base rather than across the leaf-tops.

Numbers of Plants

The number of plants of a given species at a particular location was often difficult to determine. What appeared as a single canopy of a non-rhizomatous species could really be several plants. These were difficult to distinguish when the plants had leaves, but easier when they were dormant or dead. Similarly, some species are rhizomatous (e.g., *Ephedra nevadensis*, *Hilaria rigida*) or produce multiple stems from below ground over time (e.g., *Larrea tridentata*, *Krameria parvifolia*). An attempt was made to count actual numbers of genetically distinct individuals. However, in some cases that was impossible or impractical. At higher altitudes (Mid Valley, Pahute Mesa), *Ephedra nevadensis* occurred as scattered small sprouts, whose positions and sizes were measured individually even though they presumably originated as one or a few individuals. At lower altitudes *Ephedra nevadensis* occurred primarily as single closed canopies, which were measured as one plant, but occasional rhizomatous shoots occurring outside this canopy were measured as separate individuals.

The result of these problems in identifying individuals was a certain ambiguity in numbers. This is important because population changes caused by germination and establishment of new individuals are a rare and important event in desert shrub communities. To minimize these difficulties, in 1990 and 1991 notes were made on the data sheet to explain changes in number. A comment "missed last year" meant the plant did not appear to be a seedling; a comment "called one last year" would mean what was now being called two close individuals was previously considered a single plant. On occasion, in spite of drought, there appeared to be new seedlings established since the last census. These were marked by small size and an obvious location as opposed to one hidden beneath other shrubs. The comment on such a plant would normally be "new seedling" or "possible new seedling".

Occasionally, where there were numerous similar individuals or rhizomatous sprouts in a small area, a single approximately median-sized plant was measured, and the number of individuals was merely counted. On analysis, all these were considered to be the same size as the measured plant.

Crowns

In certain species, notably *Larrea tridentata*, as a plant ages it breaks up into "crowns" separated slightly. These were counted, but the count was somewhat subjective. The use of that column on the data sheets was rare, but when used most often indicated a plant that might be considered multiple individuals, but was judged to be a single clone.

Dead

From 1988 through 1991, a single technique was used to determine the percent of a plant which was dead. Plants with no visible dead parts (not even one dead leaf) were in category "0"; plants less than 25 percent dead (by volume of canopy) were called category "1"; plants 25 to 75 percent dead were called "2"; plants alive, but more than 75 percent dead were "3"; plants totally dead above ground were "4".

During 1989 and 1990, soils were dry during perennial plant measurements, and many shrubs were dormant. Drought deciduous species like *Acamptopappus shockleyi*, *Ambrosia dumosa*, and *Artemisia spinescens* often had no green parts showing. In general, on the first two, a bit of bark was scraped to bare a green layer just below the cortex on some older stems to determine whether they were live or dead. On *Artemisia spinescens* this did not work, and a terminal bud was often cut off and pulled apart to reveal tiny, green, undeveloped leaves on live individuals. Bunchgrasses (*Oryzopsis hymenoides*, *Stipa speciosa*, and occasionally *Sitanion jubatum*) were examined by pulling up several tillers and searching for green meristematic tissue. These destructive techniques could not be used exhaustively without damaging the plants, so a level of uncertainty was accepted. In 1991, most areas were wet enough to have produced new growth, and a small percentage of "dead" plants were found to be alive.

Reproductive States

The codes for recorded reproductive states at censuses were "0" for vegetative plants; "1" for those with flower buds (live or aborted) but no flowers or fruits; "2" for those flowering (live or dead flowers) but not fruiting (often male plants); and "3" for plants producing or with evidence of having produced fruit the year censused. Dormant plants were called "4", and were usually totally leafless. *Ephedra nevadensis*, a largely leafless shrub, was called

dormant when it had only dry, dull, green internodes, without new tender shoots. Only one reproductive state was allowed; thus vegetative or dormant plants which had flowered or fruited earlier were called flowering ("2") or fruiting ("3").

Grazing Damage

In general 1989-1991, was a very difficult period for jackrabbits (see Saethre, Mammal Trends Report), and very few plants were grazed. For those that were grazed, the approximate percent missing from an imagined normal canopy was recorded.

Sources of Error

When comparing data sets for a transect between years, it became obvious that some errors occurred. In order to estimate growth rates, a plant was matched with the same plant the previous year. Inability to match a plant had several causes, but some were due to errors made during plant measurements. I analyzed the data from one transect for 1989 through 1991 in order to evaluate changes made in the data collection process during 1991. The results of that analysis are in Table 1. Matched plants, either live or dead, had to be measured the same way each year, had to be the same species, and in the same place. They could not be confused with other nearby plants of the same species and size.

The major cause of inability to match plants was death of a plant, because measurement techniques differed for live and dead plants. The purpose of matching was different also -- we wanted to record growth and shrinkage of live parts, but only shrinkage and decay of dead plants. Although we estimated the percent dead of living plants, we did not measure both dead and live parts of live plants. Plants which were called dead the first year and live the next were mismeasured the first year for the same reason -- different parameters were measured. The error was normally in calling a live plant dead, which was fairly reasonable for dormant shrubs. As the drought progressed and most shrubs were dormant, it became quite difficult to distinguish live from dead plants. By 1991, when there was enough spring rain to produce leaves, this problem was insignificant.

Table 1. Causes of inability to match plant data taken one year with the identical individual in the previous year's record. Items include both live and dead plants.

	1989-90	1990-91
Plants successfully matched	107	309
Plants which died during the year	70	86
Plants which probably actually disappeared	8	5
"Resurrected" plants, dead one year, live the next	8	7
Inability to distinguish live from dead parts	31	6
Tape placement - edge plants out in the second year	26	0
Ambiguous numbers of individuals at one location	66	2
Ambiguous location	18	0
Plants in clumps missed the first year	38	18
Plants in clumps missed the second year	15	0
Plants mismeasured or misrecorded	10	0
New small plants, either missed or seedlings	15	3
Species misidentified first year	19	3
New, easily visible, older plants	17	2
Totals	446	441
% matched of those possible	29%	88%

During 1989 and 1990, many plants without leaves could be proven alive by scraping the bark and revealing green stem. However, there was no way to determine what proportion of these plants was alive. This category included about 7 percent of the plants in Table 1, but in Jackass Flats in 1990, it included essentially all the *Ambrosia dumosa* and *Acamptopappus shockleyi*. Live size was not measured or calculated for those plants.

Ambiguous numbers of individuals usually resulted from several plants growing together as a single individual. As the drought progressed, the stems and bases became more visible, and many plants measured as one were found to be multiple. Occasionally, a plant's crown split and the base became buried. The determination of whether that was one or two plants was subjective. In 1991, the data were recorded on a printout of the 1990 data, and the two plants unmatchable in 1991 for this cause indicate those measuring disagreed with the 1990 determination. Ebert and McMaster (1981) discussed this error with respect to desert shrub censuses. It is difficult to determine actual shrub numbers when canopies are leafed out, and I expect it to be partially addressed by reference to the previous year's data, but new individuals

growing under a member of the same species will likely be difficult to detect in many years.

Table 2 shows that certain species were more likely to have ambiguous numbers than others. *Ephedra nevadensis* is somewhat rhizomatous, but at lower altitudes the shoots clumped together into an approximate single canopy, which was measured as one. Outlying shoots, however, were sometimes considered separate individuals, depending on who measured the plant. *Acamptopappus shockleyi* and *Artemisia spinescens* tend to grow apart from other species (Wallace et al., 1972 pp 205-229.), but occurred together in clumps of a single species often measured as one plant. *Grayia spinosa* grew almost uniformly mixed in with other shrubs (normally *Lycium andersonii*), and its base was often hidden and mixed with the bases of other shrubs. *Lycium andersonii* bases tended to split into multiple crowns with age, as did those of *Larrea tridentata* and *Coleogyne ramosissima*, which were not present on the transect analyzed for Table 2 (species abbreviations used in tables are reported in Appendix 1).

Table 2. Species with ambiguous numbers of individuals found on transect YUF001 V1 in 1990. Ambiguity arises when the number at a location was different in 1990 from the number in 1989.

Species	1990	
	Ambiguous	Total
Aca sho	8	16
Art spi	7	15
Eph nev	20	56
Cer lan	10	45
Gra spi	12	35
Hym sal	2	4
Lyc and	3	11
Dead sh	4	154

Considering these errors and ambiguities (Tables 1 and 2), it must be understood that the plant numbers recorded in the following tables are somewhat ambiguous. Relative volumes were somewhat more accurate, as they were dominated by the larger, most visible plants. Plant numbers measured in 1987 and 1988 should be considered somewhat conservative. In the absence of drought, they were probably 10 to 20 percent low due to measurement of multiple individuals as single plants.

INDIVIDUALS STUDY METHODS

To study those species with sparse populations, but large sizes, a new study protocol was instituted in 1989. A group of individuals was defined, and each plant was marked with a metal stake or tag. The species marked were *Yucca brevifolia* on plot YUF001; *Juniperus osteosperma* on plot PAM001; *Yucca schidigera* on plots near the Mercury Sewage Lagoon initiated by Dr. E. M. Romney in 1968; mixed cactus species on plot YUF001; and *Pinus monophylla* on plots PAM007, PAM008, and RAM001. These plants were measured and described in the same manner as those on transect studies. Because of the need to find and recensus these plants in the future, all were on plots with some sort of mapping system already instituted. Either the total population on a plot was marked, or a random portion (*Pinus monophylla*) selected and marked.

TAXONOMIC METHODS

Plant taxonomy followed Munz (1974) or Welsh et al. (1987), with synonymy as determined by Kartesz and Kartesz (1982).

SOIL MOISTURE METHODS

Soil moisture was measured with fiberglass resistance sensors (Colman and Hendrix 1949). Individual sensors were placed in the sidewalls of pits excavated by hand in 1985 (Mercury) and 1989 (Frenchman Flat, Yucca Flat, and Jackass Flats) near three baseline plots. Readings were taken with an MC-302 soil moisture/temperature meter supplied by SoilTest, Inc. (Lake Bluff, IL). Readings were corrected for temperature fluctuations using a graph supplied by the manufacturer. Precipitation was measured in gauges placed near each soil moisture station and read at one-week or two-week intervals. For this report, soil was considered "wet" when corrected resistance readings were less than 900,000 ohms.

ANALYTICAL METHODS

Analyses were described largely in Hunter and Medica (1989). Briefly, volume was calculated as that of an ovate cylinder of height equal to the maximum height, and radii equal to the maximum width and the width perpendicular to the maximum. Biomass was estimated with largely experimentally determined regressum lines of volume versus weight determined by E. M. Romney in the 1970's (listed in Hunter and Medica 1989). Biomass of some species without

regression lines was estimated using that for an "average" shrub (2.5 kg per m³ of calculated canopy volume) or a plant of similar habit (e.g., bunchgrass, herbaceous sub-shrub). The biomass of *Pinus monophylla* was estimated from data published by Tausch and Tueller (1988).

Statistical analyses were done with either the spreadsheet RS1 (BBN Software) or Minitab (Minitab Inc., State College, PA). In general, RS1 was used to calculate means and standard errors, and to perform T-tests or similar comparisons, while Minitab was used to make multiple comparisons. Standard errors of the mean were calculated without checking for normal distributions, and are provided to indicate the extent of variation without implying distribution.

RESULTS

Detailed results for plots sampled 1989-1991 are in Appendix 2. Vegetation characteristics reported in the text below are largely only summaries of numbers and volumes reported by species.

PRECIPITATION

On the NTS, the precipitation during calendar year 1989 was the lowest of 27 years of record. However, because shrubs generally grow in spring, utilizing water built up in the soil during winter, we present NOAA data for September-April precipitation (Figure 5) for rain gauges in the major valleys and Pahute Mesa. It is apparent that the 1989 and 1990 growing seasons were the driest two years of record. Severe drought extended from August 1988 to July 1990, after which time infrequent light showers provided water for survival, and minimal regrowth. The result of this drought period was widespread dieoff of shrubs at the lower elevations. We present data on perennial plant population changes on baseline plots to indicate the general pattern of drought. Many other undisturbed plots showed the same pattern, and will be discussed when considering the adjacent disturbed sites.

SOIL MOISTURE

Precipitation at soil moisture stations and the spatio-temporal distribution of wet soil is shown in Figure 6. From 1989 through 1991, only Jackass Flats in 1991 ever wet to 50 cm or deeper. Rainfall in summer did not generally wet soil long enough or deeply enough to be measured at biweekly intervals.

Figure 5 - September to April rainfall on the NTS from 1964 through 1991.

Figure 6 - Wet soil on four BECAMP plots, 1989-1991.

BASELINE PLOT TRANSECTS

Jackass Flats

The only REECO/BECAMP plot in Jackass Flats where perennials were sampled was JAF001, on level, sandy soil near J12 Well, about 1 km east of Forty-Mile Wash. Vegetation was sampled on JAF001 in 1987 (5 transects), 1988 (5 transects), 1990 (3 transects), and 1991 (1 transect). Data are summarized for 1990 and 1991 in Appendix 2, but data from the one transect sampled four of five years are presented in Table 3.

Table 3. Perennial plants, numbers, and volumes (liters) on plot JAF001, transect VI, 1987-91, by species. The plot is on a level, deep, sandy soil at an altitude of 954 m.

Species	1987		1988		1990		1991	
	n	V	n	V	n	V	n	V
Aca sho	131	3,858	133	4,430	40*	353	80	606
Amb dum	64	2,559	62	2,580	44*	5*	67	1,597
Cer lan	5	202	488	176	4	57	5	38
Lar tri	12	13,354	9	17,509	7	14,903	7	12,690
Men spi	16	1,260	18	1,626	20	1,495	20	1,372
Ory hym	40	73	37	38	0	0	0	0
Total	268	21,306	263	26,355	115	15,652*	179	16,303
Dead plants		13 ²	66		199	4,407	145	1,572

* Live volume and numbers could not be measured accurately because of dormancy.
² Dead grasses were not censused in 1987.

Note from Table 3 the general drop in live plant numbers from 268 in 1987 to 179 in 1991. In 1990, many plants appeared to be dead, but resprouted at the base in 1991. In Jackass Flats, the soil was wet nearly continuously from October 1990 through June 1991, and the 1991 census shows the result of regrowth from the severe 1989-90 conditions. The decrease in numbers was solely due to the loss of two species, *Acamptopappus shockleyi* and *Oryzopsis hymenoides*. The changes in numbers of *Larrea tridentata* and *Menodora spinescens* were not significant, as the *Larrea* changes were due to clonal plants being defined differently in the different years. One new small plant of *Menodora* was found in 1990, which could have been a seedling or missed in previous censuses.

The shrubs in Jackass Flats were apparently less severely affected than in Frenchman Flat and Yucca Flat because the winter rainfall of 1990-91 allowed survival and regrowth of many severely stressed plants. This regrowth resulted from sprouting of new branches from the live bases of many *Ambrosia dumosa* and *Acamptopappus shockleyi*, as seen in Figure 7.

Frenchman Flat

The baseline plot in Frenchman Flat, FRF001, was sampled in 1987 (5 transects), 1988 (5 transects), and 1991 (3 transects). Because the quality of the 1987 data were poor, only one transect (V1) was analyzed for the period 1987-1988. Data on V1, V3, and V5 for 1987 through 1991 are in Appendix 2.

The Frenchman Flat baseline plot is on a slight east-facing slope with a sandy soil. It includes Beatley Plot 23, lumped with other plots in what she called a "Larrea + Ambrosia/Larrea-Grayia-Lycium" community. In 1975, she found 142 live and dead plants intersected by 1100 feet (335 m) of line transect, with cover totalling 14.9 percent (Beatley 1979). On nine similar sites she reported 17 species. She did not include the herbaceous perennials (usually *Oryzopsis hymenoides* and *Sphaeralcea ambigua*) in Frenchman Flat.

The REECO/BECAMP data for FRF001 V1 (Table 4) showed there were originally 13 species in 100 m², but by 1991 only eight were present. The dominant species was *Larrea tridentata*, which made up 70 percent of live volume in 1987, 61 percent in 1988, but 96 percent in 1991. The species which did not tend to die out were *Larrea tridentata*, *Ephedra nevadensis*, *Ceratoides lanata*, and *Lycium andersonii*. Two small *L. tridentata* died. The majority of the *Acamptopappus shockleyi* and *Ambrosia dumosa* and half the *Grayia spinosa* shrubs died, and the herbaceous perennials (*Oryzopsis hymenoides* and *Sphaeralcea ambigua*) and nearly all *Hymenoclea salsola* died.

Precipitation data from Well 5B show this area of Frenchman Flat had near average rainfall through the 1980s (Figure 5) until the drought of 1989 and 1990. Winter precipitation in 1991 was only 56 mm and the soil moisture readings showed very little available for winter 1990-91 (Figure 6). In contrast to Jackass Flats, therefore, there were no saving rainstorms and shrubs in general failed to resprout or regrow.

Figure 7 - Drought-stricken *Ambrosia dumosa* resprouting near the base (3-90).

Table 4. Perennial plant numbers and volumes (l) on plot FRF001 transect V1 in 1987, 1988, and 1991. This plot is at an altitude of 965 m.

Species	1987		1988		1991	
	n	V	n	V	n	V
Aca sho	15	274	15	265	3	4
Amb dum	50	1,505	49	1,497	15	64
Cer Lan	9	302	10	338	8	65
Eph nev	1	143	1	203	1	83
Gra spi	6	431	7	510	3	107
Hym sal	67	2,253	50	2,953	2	2
Lar tri	11	14,239	10	11,591	6	12,357
Lyc and	3	1,059	3	1,434	2	230
Ory hym	12	6	7	-	0	0
Pso fre	1	20	1	20	0	0
Sph amb	1	3	0	0	0	0
Tet axi	1	11	1	16	0	0
Amb X hym	1	0	0	0	0	0
Totals	178	20,246	154	18,827	40	12,913
Dead Plants	0*	0	5*	709	111	3,896

* Does not include dead grass

The dieoff of perennial plants in Frenchman Flat represents a major change in the vegetation. Total numbers of perennials declined from 178/100 m² in 1987 to 40/100 m² in 1991. Total live volume declined from 20 m³ to 13 m³ with 96 percent of the 1991 volume being *Larrea tridentata*. Total cover declined from 23 to 11 percent, and again *Larrea* contributed the vast majority (87%). Beatley (1979) measured average live *Larrea* cover on a set of similar plots as 6.3 percent in 1975, or 31 percent of the average 21.3 percent live cover.

Yucca Flat

The baseline plot in Yucca Flat (YUF001) was sampled every year from 1987 through 1991. Five transects were sampled in 1987 and 1988, and three in each succeeding year. This plot is located on a gentle east-facing slope in southwest Yucca Flat at an altitude of 1238 m. Soils are gravelly sandy loams. The plot includes Beatley plot 46, in what she considered a *Grayia-Lycium* community (Beatley 1979). Tables 5 and 6 show changes in the numbers and live volumes for the vegetation on this site for transect V2 from 1987 through 1991.

Table 5. Counts of live perennial plants by species, on a 100 square meter baseline plot in southwestern Yucca Flat (YUF001 V2) 1987-1991.

Species	1987	1988	1989	1990	1991
<i>Acamptopappus shockleyi</i>	44	34	26	13	11
<i>Arabis pulchra</i>	0	1	0	0	0
<i>Artemisia spinescens</i>	49	47	38	21	6
<i>Atriplex canescens</i>	36	38	38	41	31
<i>Ceratoides lanata</i>	65	58	53	54	42
<i>Ephedra nevadensis</i>	22	18	21	21	21
<i>Erioneuron pulchellum</i>	28	17	0	2	0
<i>Grayia spinosa</i>	40	35	34	44	33
<i>Hymenoclea salsola</i>	11	9	8	10	8
<i>Lycium andersonii</i>	20	15	18	20	14
<i>Menodora spinescens</i>	1	1	1	1	1
<i>Mirabilis pudica</i>	7	4	0	0	1
<i>Oryzopsis hymenoides</i>	8	6	5	0	0
<i>Sitanion jubatum</i>	28	8	0	0	0
<i>Sphaeralcea ambigua</i>	71	26	2	0	1
<i>Stipa speciosa</i>	6	10	5	8	3
<i>Tetradymia axillaris</i>	2	2	2	2	2
TOTALS	438	329	251	237	175
Dead grasses			8	32	44
Dead shrubs			55	167	449

Table 6. Estimated live volumes (liters per 100 m²) of perennial plants on a baseline plot in southwestern Yucca Flat (YUF001 V1) 1987-1991.

Species	1987	1988	1989	1990	1991
<i>Acamptopappus shockleyi</i>	592	344	381	16	41
<i>Arabis pulchra</i>	0	1	0	0	0
<i>Artemisia spinescens</i>	732	537	575	47	32
<i>Atriplex canescens</i>	2085	1535	1264	921	893
<i>Ceratoides lanata</i>	798	461	611	378	265
<i>Ephedra nevadensis</i>	5007	5320	5015	4482	4130
<i>Erioneuron pulchellum</i>	1	2	0	0	0
<i>Grayia spinosa</i>	2498	3195	3915	1598	1392
<i>Hymenoclea salsola</i>	420	196	188	44	41
<i>Lycium andersonii</i>	4073	3511	2681	2521	2630
<i>Menodora spinescens</i>	1	1	1	0	1
<i>Mirabilis pudica</i>	5	1	0	0	1
<i>Oryzopsis hymenoides</i>	14	10	2	0	0
<i>Sitanion jubatum</i>	11	2	0	0	0
<i>Sphaeralcea ambigua</i>	34	20	0	0	0
<i>Stipa speciosa</i>	2	30	3	2	1
<i>Tetradymia axillaris</i>	1732	1583	1869	1636	1514
TOTALS	18,482	16,722	15,604	11,646	10,941
Dead grasses			4	21	57
Dead shrubs			2429	3487	5184

Although the drought was severe in Yucca Flat (1989-91 were the three driest winters since 1969), the decline of perennial plants was less severe than at lower altitudes. This may be partially attributed to the higher altitude, which has a greater ratio of precipitation to temperature (Beatley 1974), but also to a difference in soil type. Soil moisture data showed a wetter soil below the root zone, and a steeper gradient in moisture between 100 cm and 50 cm than is found in the deep sands in Frenchman Flat and Jackass Flats.

On YUF001 V2, total numbers of live perennials declined throughout the period studied from 438/100 m² in 1987 to 175 in 1991, a drop of 60 percent. The only species which did not decline in numbers was *Ephedra nevadensis*. Other species which declined only slightly were *Atriplex canescens*, *Grayia spinosa*, and *Lycium andersonii*. Although Beatley (1979) felt *Grayia spinosa* and *Lycium andersonii* were dominant, on all three transects measured in 1991, *Ephedra nevadensis* contributed the most live volume of any species, making up 33, 38, and 77 percent of live volumes on the three transects.

Total live volume on YUF001 V2 declined from 18.5 m³ to 10.9 m³, a decline of 41 percent. Numbers of species declined from 16 to 12. The species which died out were largely grasses -- *Erioneuron pulchellum*, *Oryzopsis hymenoides*, *Sitanion jubatum* and the herbaceous shrub *Sphaeralcea ambigua*.

The vegetation on plot YUF001 was strongly clumped. As shrubs died or lost their leaves, a significant number of "new" plants (not seedlings) became visible. Many were single stems reaching from ground level into the canopy, with little branching. Numbers should therefore have increased as more hidden plants were found. That the numbers and live volume continually decreased attests to the real severity of the drought.

Pahute Mesa

The baseline plot on Pahute Mesa (PAM001) is situated on a broad rocky ridge at an altitude of 1923 m. Soils appeared to be very rocky sandy loams. The vegetation was strongly dominated by *Artemisia nova*. One transect was measured in 1988 and 1990, and half of it (25 m) was measured in 1991. The results for the first 25 m are reported in Table 7 for the three years. More complete results are in Appendix 2.

Unlike plants at lower altitudes, those on the Pahute Mesa plot generally did not die during the drought. The dominant species, *Artemisia nova*, did not

Table 7. Perennial plant populations (numbers and live volumes in liters) on the first 25 m of a baseline transect on plot PAM001, at an altitude of 1923 m.

Species	1988		1990		1991	
	n	V	n	V	n	V
Art nov	182	6,018	191	5,120	197	5,776
Ast pur	---	---	2	---	6	0
Cer lan	0	0	1	14	1	43
Chr vis	---	---	2	9	2	23
Eph nev	35	56	35	76	40	121
Eri caes	0	---	1	0	1	0
Ory hym	14	4	1*	1*	14	9
Sit jub	91	13	7*	1*	110	13
Sti com	---	---	---*	---*	2	0
Grass	0	0	111	13	33	0
Unknown	4	16				
Totals	326	6,108	349	5,234	406	5,986
Dead plants	19	215	126	364	111	281

* Bunchgrasses did not fruit and could not be positively identified in 1990. Many were dead above ground in 1990 but resprouted in 1991.

flower well in 1990. Most of the bunchgrasses also failed to flower, and although many died, the majority survived. A few grasses which were dead above ground in 1990 resprouted in 1991.

One noteworthy occurrence in 1991 was the prolific spring fruiting of *Stipa comata* on Pahute Mesa (Figure 8). It was unusually visible because the seed stalks stick up above the shrubs. Note two *Stipa comata* were identified on the 50 m² sampled in 1991 (Table 7). They were probably present, without fruiting, at the previous two censuses.

Ephedra nevadensis on Pahute Mesa consisted of a population of rhizomatous shoots averaging about 20 cm tall (see Appendix 2). If it can be assumed that clusters of shoots occurring with more than a 1 m gap are actually separate plants, then the 40 live shoots seen in 1991 (Table 7) represented 5 individuals with 2, 12, 24, 2, and 1 shoots. The largest "clone" (including dead shoots) extended from 9.2 m to 15.0 m, suggesting the spread of a single plant over a 5 m diameter. The gaps between clones were 1.2, 5.2, 6.1, and 1.8 m. If we defined the required gap between shoots to be greater than 2 m,

Figure 8 - *Stipa comata* growing on Pahute Mesa, September 1991.

there would be only 3 individuals with extents along the transect of 3.8, 5.8, and 2.3 m. New genetic techniques examining variations in chloroplast or nuclear DNA could no doubt be used to determine the extent of these clones, given enough interest to generate funding. Several of the *Ephedra* shoots were new in 1991, with fresh green stems extending from ground level.

DISTURBED AREAS

REECo/BECAMP personnel examined a number of areas disturbed by man or natural events. These plots were generally sampled at three-year intervals, so most such sites were sampled only once in the 1989-91 period, although for many it was the second sample period. With each disturbed area, an adjacent undisturbed site was sampled to suggest what might be present in the absence of the disturbance. The results of these studies are summarized below by disturbance type.

Ground Zeroes

Five ground zeroes (GZs) have been sampled for perennial plants - T1, T2, T3, T4, and Sedan. The sampled areas are outside the radiation exclusion zones marked by fences and warning signs, and were damaged primarily by the blast waves from nuclear weapons tests (T1-T4) or a nuclear excavation experiment (Sedan). The recovery of vegetation on these areas was the subject of several journal articles in the early 1960s (Shields and Rickard 1961; Shields et al. 1963; Beatley 1965, 1966), but since then it has been documented in government reports (Romney et al. 1988, Hunter 1982). T1, T3, and Sedan were sampled twice each (1988 and 1991), and T2 and T4 once (1990) by BECAMP.

T1 Ground Zero

The blast area around T1 ground zero is a nearly circular area with a diameter of about 2.3 km and is easily visible on Landsat images (Zimmerman et al. 1991). The early vegetative recovery was diagramed by Tanner and Jorgensen (1963). The return of grass populations was monitored on a sporadic basis by E. M. Romney and those observations and initial BECAMP results were reported by Hunter (1992). Table 8 summarizes the vegetation in the denuded blast zone in 1988 and 1991. Note the transect was 200 m², rather than 100 m².

Table 8. Perennial plants on T1 GZ blast zone, 1988 and 1991. A 200 m² area was censused.

Species	1988		1991	
	n	V	n	V
Hym sal	1	545	0	0
Ory hym	68	316	41	101
Sti spe	14	94	11	52
Totals	83	955	52	153
Dead plants	18	119	39	251

The T1 ground zero remained very sparsely vegetated in 1991. The one shrub on the transect in 1988 disappeared by 1991; a stub was found in an animal burrow, but the above-ground portion was missing. It was very likely killed by gophers, whose mounds were present in the immediate vicinity. The two bunchgrasses present on the transect, *Oryzopsis hymenoides* and *Stipa speciosa*, did reasonably well. Only 40 percent of the *Oryzopsis* and 20 percent of the *Stipa* died. Plants alive both years and matchable either maintained their size ($k = 0.00 \pm 0.12$, $n = 28$ - *Oryzopsis*) or grew slightly ($k = + 0.10 \pm 0.15$, -*Stipa*) (the growth coefficient k is $[\ln(\text{vol } 2/\text{vol } 1)]/\text{time}$). This contrasts significantly with undisturbed areas, where the bunchgrasses tended to die out completely (see Tables 3-7). The live cover by perennial plants declined from 1.14 percent to 0.20 percent. The absence of cover evidently prevented successful lizard colonization on the ground zero, although burrowing mammals can do well (see reports in this volume by Medica et al. and Saethre).

A transition zone occurred on the southeast edge of the T1 blast area, which was called a mixed grass zone by Tanner and Jorgensen (1963). It was a section of the edge of the blast evidently recolonized by *Atriplex canescens* following the series of tests on T1 GZ. It was not censused in 1988, but in 1991, it was felt necessary to characterize it in order to understand results of the reptile transect line counts. The perennial plant population on a 100 m² transect in this zone (YUF029) consisted of 19 *Atriplex canescens* (337 l live volume), 1 *Lycium andersonii* (1 l), 1 *Oryzopsis hymenoides* (0.1 l), and 23 shoots of the rhizomatous herb *Mirabilis pudica* (737 l). There were also 200 dead bunchgrasses and 107 dead shrubs, almost all of them *A. canescens*. Live cover was 4.7 percent, 3.7 percent by *M. pudica*, but cover by dead plants was 19.2 percent. The most likely sequence of events here was rather dense invasion of the *A. canescens*, growth of that near monoculture for about 30

years, and death of the whole aging population during the 1989-90 drought. The death of almost the whole bunchgrass population was likely due to rapid use of water by the relatively dense vegetation, while in the sparsely vegetated area bunchgrasses had a greater volume of soil to draw water from.

The plant transect (100 m²) in undisturbed vegetation southeast of the T1 blast zone also fared worse than the denuded area. Table 9 details some of the dramatic changes from 1988 to 1991.

Table 9. Perennial plant populations on plot YUF010, T1 undisturbed, in 1988 and 1991.

Species	numbers		volumes (1)	
	1988	1991	1988	1991
Atr can	68	21	973	275
Cer lan	20	11	484	96
Chr vis	58	27	3,377	133
Eph nev*	18	15	4,685	2,460
Gra spi	17	3	1,496	116
Hil jam*	67	87	21	6
Lyc and	5	4	297	217
Ory hym	21	3	54	4
Sit jub	165	0	281	24
Tet axi	0	1	0	2
Totals	508	173	11,847	3,333
Dead Plants	58	343	3,861	8,037

*Rhizomatous species; numbers are not precise.

On the T1 undisturbed transect live bunchgrasses decreased from 255 to 4 individuals, a 98 percent decrease. Live shrubs decreased from 186 to 82, a 56 percent decrease. Total live volume decreased 72 percent. The species which did best under these conditions were *Ephedra nevadensis* (-17%), *Lycium andersonii* (-20%), and *Hilaria jamesii* (a rhizomatous grass - +30% in numbers of shoots).

On the whole, perennial plants near T1 GZ declined with drought, both in size and numbers. However, plants on the blast area did relatively well, while those in the transition and undisturbed areas were severely affected.

One interesting observation is that the rhizomatous species, which can resprout from below ground when the shoots die back, did relatively well under the drought conditions. On the T1 transition and undisturbed transects these species were *Ephedra nevadensis* (which did not die to ground level), *Hilaria jamesii*, and *Mirabilis pudica*. The latter two species die to ground level annually.

T3

The perennial plant transect on T3 ground zero is on the eastern edge of the blast zone, near a cleaned-up waste dump. Soils are sandy, in contrast to the rocky loams on other GZs studied. Results of the 1988 and 1991 censuses are in Table 10.

Table 10. Perennial plant numbers and live volumes on T3 Ground Zero, 1988 and 1991.

Species	Numbers		Volumes	
	1988	1991	1988	1991
Ory hym	151	2	442	1
Mir pud*	3	8	10	8
Totals	154	10	452	9
Dead Plants	14	168	27	209

On the T3 GZ transect there were no live shrubs in 1988, only the bunchgrass *Oryzopsis hymenoides* and the rhizomatous herb *Mirabilis pudica*. Ninety-nine percent of the bunchgrasses died by 1991. The *Mirabilis pudica* shoots increased, but total volume decreased. This ground zero therefore behaved differently from T1, where the bunchgrasses tended to survive on the blast area. The differences are due to both the species (*O. hymenoides* seems less drought hardy than *Stipa speciosa*) and the sandy soil. Although sandy soils allow more water to be used by desert vegetation (Pavlik 1980), in this case the low hydraulic conductivity of the sandy soils probably prevented water from flowing to roots of the dormant grasses fast enough to keep small portions alive (Bristow et al. 1984).

The dead plants on T3 GZ included only 4 shrubs in 1991, so that 98 percent were bunchgrass remains. These will decay relatively quickly, and barring significant germination and establishment, this area will be totally bare in a

few years, except for the growth of annuals like *Salsola australis* (Russian thistle).

T2 and T4

T2 ground zero is on the northwestern slopes of Yucca Flat. Soils are rocky loams on a gently sloping surface. The transect in the blast area was just east of the radiation exclusion fence, and the undisturbed transect lay farther east, beyond the blast zone. The blast transect, sampled in July 1990 had no live plants, but 1264 dead grasses and the remains of seven dead shrubs. The dead grasses were mostly small *Stipa speciosa*, with a small number of *Erioneuron pulchellum*. The dead shrubs were old remains, not identifiable to species.

T4 GZ lies between T1 and T2 on the west side of Yucca Flat. Soils are rocky, on gentle east-facing slopes. The perennial vegetation on T4 GZ was sampled on the south side of GZ, several hundred meters north of the edge of the blast zone. It was quite different from the other four ground zeroes studied in that it was dominated by dicotyledonous shrubs rather than grasses (Table 11).

Table 11. Perennial vegetation on T4 GZ in 1990.

Species	Number	Volume (l)
Eri pul	10	0
Hym sal	36	1,147
Sph amb	246	17
Sti spe	87	55
Totals	379	1,219
Dead Plants	343	44

The majority of the volume was contributed by young shrubs of *Hymenoclea salsola*, probably germinated in the early 1980s (refer to Sedan data, page 275). The majority of the numbers were due to numerous small plants of *Sphaeralcea ambigua*. These plants were uniformly small and it is unlikely they germinated before the spring of 1988. It is possible they germinated in 1990 if T4 received rainfall not recorded at the rain gauge at BJY several kilometers distant.

Vegetation transects on undisturbed areas east of T2 and south of T4 were similar, and unusual. Populations were made up largely of species which

either survive fire by sprouting after being burned off (*Ephedra nevadensis*, *Lycium andersonii*), or are short lived enough to have grown up since the 1950s tests. (See Hunter and Medica 1989 for a description of resprouting after fires). Data for both plots are in Table 12.

Table 12. Perennial plant numbers and volumes (l) on undisturbed plots east of T2 blast zone (YUF015) and south of T4 blast zone (YUF026), sampled in July/August 1990.

Species	T2		T4	
	n	V	n	V
Atr can	9	2,202	0	0
Cer lan	22	260	11	427
Eph nev	1	422	13	2,256
Eri coo	3	33	1	46
Gra spi	7	89	10	1,241
Hym sal	26	338	8	53
Lyc and	11	620	17	2,361
Opu bas	0	0	2	2
Sph amb	0	0	1	2
Sti spe	1	1	2	3
Total	80	3,965	65	6,394
Dead Plants	255	4,505	180	8,861*

*Some dead plants were not measured.

We have searched early reports on the T4 vegetation (Shields et al. 1963) and found no evidence of fire resulting from the nuclear tests. Similarly, plots set up by Beatley in 1963 in burned areas in Mid Valley showed very little recolonization over 30 years (see below). We conclude that it is possible there was a range fire on the northwest end of Yucca Flat within the last several centuries which destroyed the vegetation. An alternative hypothesis is that periodic droughts such as occurred in 1989-90 may kill most of the shrubs in this area, preventing recovery to a more climax situation.

Sedan

The vegetation around Sedan has been studied for a longer period than most plots. We have data extending from before the blast (July 2, 1962), for two summers following it (H. O. Hill, personal communication), and sporadically

from 1975 through 1988 (Hunter et al. 1987; Hunter 1992). The numbers of plants found per 100 m² sampled are in Table 13. Prior to the Sedan experiment the area 305 m NE of ground zero was not undisturbed, but was recovering from nearby 1957 atmospheric tests. It had a significant population of two bunchgrasses (*Oryzopsis hymenoides* and *Sitanion jubatum*) and many shoots of a perennial rhizomatous grass (*Hilaria jamesii*). Those plants were sheared off and buried by deposits of throwout material from the crater. Recovery occurred at that distance only in the 1980s, when bunchgrasses reinvaded. No shrubs or shrub seedlings were present even 29 years after the Sedan test. Circumstantial evidence suggests the subsoil deposited by the Sedan test inhibited germination and growth of shrubs at this distance. Invasion occurred much more rapidly at distances greater than 762 m from GZ, the edge of the "throw-out zone" (Martin 1963).

Table 13. Plant numbers (per 100 m²) found at 305, 914, and 1524 m from Sedan ground zero, along study line 16A established by UCLA in 1962. Data for 1962-1975 are from 3 m radius circular plots, and after 1975 from 100 m² belt transects.

305 Meters						
Species	1962	1965	1976	1983	1988	1991
Hil jam	1,525	0	0	0	0	0
Ory hym	96	0	0	16	80	86
Sit jub	17	0	0	1	0	0
Sti spe	0	0	0	2	27	7
Totals	1,638	0	0	19	107	96
914 Meters						
Atr can	10	0	0	1	0	0
Cer lan	10	0	1	0	0	0
Gra spi	24	0	0	0	0	0
Hym sal	62	3	1	3	57	48
Lyc and	0	0	1	3	3	3
Ory hym	75	7	102	73	101	58
Sph amb	0	3	0	0	2	0
Sit jub	48	0	13	37	0	0
Sti spe	0	0	13	1	6	7
Totals	239	13	131	118	169	116

Table 13, continued.

	1524 Meters					
	1962	1965	1975	1986	1988	1991
Col ram	45	34	21	56	64	75
Eph nev	14	0	0	0	0	0
Gra spi	41	7	0	0	0	0
Hym sal	7	0	0	18	11	8
Lyc and	7	14	21	7	6	7
Men spi	0	0	0	1	0	0
Ory hym	38	34	38	27	26	2
Sit jub	31	24	38	11	0	0
Sti spe	0	3	3	5	1	1
Totals	183	116	121	125	108	93

In 1983, it was noted that annual grasses tended to occur only on decaying patches of *Salsola australis* on the throw-out mounds near the crater, suggesting some organic matter was necessary for germination or growth. Note the bunchgrasses did not die during the 1989-90 drought at 305 m, as on T1 GZ, probably due to the low densities and the absence of competition.

The transect at 914 m was just outside the zone where throwout material from the crater covered the vegetation. It is at the inner edge of Martin's (1963) Zone B, "Shallow throw-out and blast damage". At this distance, invading shrubs and grasses appeared by 1965 and were fairly numerous by 1976. By 1988, *Hymenoclea salsola* and *Oryzopsis hymenoides* covered nearly 10 percent of the surface, near half of normal cover, although with reduced diversity. Livecover declined with drought to 8 percent, as some of the *H. salsola* and *O. hymenoides* died.

At 1524 m, there was essentially no damage to the vegetation by either the Sedan test or previous atmospheric events. The vegetation has been undisturbed from before the beginning of monitoring in 1962. The vegetation was dominated by *Coleogyne ramosissima* at all censuses. However, in 1962, before the Sedan test, there was a significant population of *Grayia spinosa* present which apparently disappeared by 1975. In addition to the census of a 29 m² area (Table 13), Hill also measured 73 m of line transect to determine cover (H. O. Hill, personal communication). Table 14 compares that pre-test cover and 1991 cover as determined by belt transect. Although the *Coleogyne*

ramosissima persisted throughout the period, *Grayia spinosa* disappeared from the cover measurements. Similar cover measurements along this line in 1962 showed *Grayia* present at 1 to 7 percent cover from 914 m to 3048 m, suggesting its absence was not due to different locations of the measurement sites. At the present time, I cannot explain the decline of *Grayia spinosa* at Sedan. It was not totally absent, as a few plants were seen at 2438 and 2743 m east of Sedan and at 1829 m NE of Sedan when those sites were sampled in 1986. Those distances have not been sampled since.

Table 14. Cover by shrubs and perennial grasses at 1524 m NE of the Sedan GZ, 1962 and 1991. (1962 data from H. O. Hill, personal communication.)

Species	% Cover	
	1962	1991
Col ram	14.1	13.1
Gra spi	6.9	0
Hym sal	2.6	0.7
Lyc and	0	2.5
Ory hym	2.7	0.0
Sit jub	0.2	0
Sti spe	0	0.0
Totals	26.5	16.3

Subsidence Craters

Subsidence craters form on the surface from collapse of an underground chamber formed by a nuclear explosion. What forms on the surface can be described as a shallow bowl-shaped depression. The three subsidence craters studied by BECAMP in July and August 1989 were chosen with several criteria. We were looking for large size, ease of access (requiring gentle slopes), a range of ages, and suitable adjacent undisturbed areas. All three craters are in the northern portion of Yucca Flat. Due to a misunderstanding on crater ages, we selected two from the 1960s (U3cn - September 1963 and U10af - September 1967) and one created in September 1978 (U7au).

The environment of the subsidence craters was found to be complex. During preparation for the underground test the immediate surface was scraped and sometimes graveled, a drilling-mud pond was created, and vegetation was cleared from cable runs. After collapse, the larger craters extend into undisturbed vegetation, and the scraped and graveled surfaces and mud pond lie

on the slopes near the center. Erosion occurs into the crater center, creating gullies on the slopes and a silty mini-playa in the center. Russian thistle (*Salsola australis*) grows on the slopes and the surrounding disturbed areas and blows into the craters, where the dead plants are trapped as thick mats in the gullies and low spots.

Initial examination of these craters showed an apparent difference in vegetation between the north-facing and south-facing slopes. The north-facing slopes appeared to have denser vegetation, especially of the bunchgrass *Oryzopsis hymenoides*, while the south-facing slopes appeared to have less vegetation, barer surfaces, and more numerous erosion channels. Sampling was directed at measuring those differences. Three parallel east-west oriented transects were measured in each crater, crossing the south slope (north-facing), the center, and the north slope (south-facing). Results of these measurements are in Tables 15, 16, and 17.

Table 15. Total numbers and live volumes (l) of perennial plants in three subsidence craters sampled in 1989.

Crater	U3cn-1968		U10af-1967		U7au-1978	
Location	n	V	n	V	n	V
South facing slope	116	29	19	373	78	2,251
Center	2	544	3	1	1	432
North-facing slope	138	1,744	95	1,063	29	1,786
Undisturbed	342	4,956	103	405	203	8,011

Table 16. Mean volumes (l) and standard errors of the mean for *Oryzopsis hymenoides* growing in three subsidence craters in 1989.

Crater	U3cn-1968	U10af-1967	U7au-1978
South-facing slope	0.25±0.05	0.10±0.02	0.19±0.10
North-facing slope	1.72±0.35	1.12±0.28	0.07±0.02
Outside, undisturbed	2.44±0.25	0.11±0.01	0.19±0.10

Table 17. Numbers and total live volumes (l) of *Oryzopsis hymenoides* growing in three subsidence craters sampled in 1989.

Crater	U3cn-1968		U10af-1967		U7au-1978	
Location	n	V	n	V	n	V
South facing slope	113	28	16	1.6	10	1.9
Center	0	0	3	0.7	0	0
North-facing slope	114	192	72	80.8	19	1.3
Undisturbed	191	466	96	10.3	6	1.2

There was a strong tendency for the centers of the craters to have almost no perennial plants (1 to 4 per 100 m²) (Table 15). Those in the centers of two craters were *Atriplex canescens* shrubs, while U10af had three live *Oryzopsis hymenoides*. There are two causes for this low density -- the scraping and pre-test construction activities, and the silt deposition in the crater bottoms. The silt deposition should be considered the primary cause, as scraped areas on the slopes of even the youngest crater had higher densities than the centers of the older ones.

The two older craters show a distinct pattern. The north-facing slope had considerably higher perennial plant volume than the south-facing slope (Table 15). They also had greater numbers of plants on the north-facing slopes. In crater U3cn, the transect on the north-facing slope was in undisturbed vegetation, while for safety reasons the transect on the south-facing slope was closer to the center, in a scraped area. The major difference in total volumes can therefore be attributed to pre-test construction activities, although differences in *Oryzopsis hymenoides* sizes (Table 16) and total volumes can be attributed to conditions prevailing after subsidence - *Oryzopsis hymenoides* generally lives less than 25 years (Pearson 1975), and almost all plants in scraped or undisturbed areas should be younger than the crater itself.

The transects on slopes in crater U10af (1967) were in largely undisturbed vegetation. Both transects, as well as the undisturbed control, were dominated by *Oryzopsis hymenoides*. The few shrubs present were primarily on the north-facing slope, consisting of *Atriplex canescens*, *Ceratoides lanata*, *Grayia spinosa* and *Lycium andersonii*. The undisturbed control had six *C. lanata* and the south-facing slope had one *C. lanata* and one *G. spinosa*. The "undisturbed" vegetation was unusually sparse in this area. In 1963,

vegetation sampled within about 1000 feet of this crater consisted of about 60 shrubs per 100 m², mostly *Ceratoides lanata*, but also including some *Atriplex canescens*, *Grayia spinosa*, and *Lycium andersonii*. There were also about 86 bunch grasses per 100 m², primarily *Oryzopsis hymenoides*, but also including *Sitanion jubatum* (H. O. Hill, personal communication). In 1989, the species appeared to be the same, but shrub density was much lower. Because much of the nearby area was disturbed in the 1950s and 1960s it is difficult to know whether the sparse vegetation found next to this crater was natural or was caused by man.

As in crater U3cn, the *Oryzopsis hymenoides* in U10af were much larger on the north-facing slope (Table 16). They were also more numerous (Table 17). I believe that is due to the more mesic conditions prevailing on the north-facing slope. There were not enough shrubs to compare sizes, but the greater numbers and total volumes of perennial plants on the north-facing slope (Table 15) suggest the more mesic conditions there also favor shrub survival.

Crater U7au was created in September 1978, and therefore had 11 years to recover when sampled in 1989. The transect on the south-facing slope was in original vegetation, although excess erosion was apparent on unprotected surfaces. The north-facing slope was evidently scraped off for laying cables, and the three live shrubs had apparently grown since the crater formed. The differences between north-facing and south-facing slopes were therefore confounded. At the time of sampling the scraped north-facing slope had not recovered to the shrub population size and volume of the natural numbers and volume of the south-facing slope. *Oryzopsis hymenoides* numbers were somewhat higher, but sizes smaller, on the north-facing slope. I believe this is a reflection of processes which should in time bring vegetation in all three craters to similar conditions -- i.e., significant differences between the north- and south-facing slopes.

In the period since 1989, nearly all the *Oryzopsis hymenoides* in Yucca Flat has died of drought. It should be interesting to see if the *O. hymenoides* on these north-facing slopes survived better than on the south-facing ones.

BURNED AREAS

Four burned areas were studied between 1989 and 1991. They were sites 1.) on the lower slopes of Mine Mountain in Yucca Flat which burned June 24, 1985, 2.) in southern Mid Valley which burned July 20, 1986, 3.) at two adjacent plots of Janice Beatley in and next to an area in Mid Valley which burned in

1959 (Beatley 1965a), and 4.) in Red Rock Valley which burned in July 1988. The first two were studied with transects established in 1987 crossing the edges of the burned areas. The latter two were studied with two transects, one wholly in the burned area and the other in wholly undisturbed vegetation.

Beatley 41, 42 - Mid Valley

The plots Beatley studied in Mid Valley (MID006, MID007) are about 68 m apart. One is in a burned area (Figure 9), the other in an unburned area which is a near monoculture of *Coleogyne ramosissima* (Table 18). Beatley did not report the vegetative composition of the disturbed plots she sampled (Beatley 1979), but for plot 41 (unburned) in 1963, she reported 1100 feet (335 m) of line transect intersected 409 plants, of which 26 were dead. For three sites of similar vegetation the average composition included 317 *Coleogyne ramosissima* (91%), 31 *Ephedra nevadensis* (9%), 3 *Yucca baccata* (1%), and 1 each of several other species. Her 1975 data were essentially similar, but with 423 rather than 350 plants intersected. Using a belt transect we found essentially identical proportions of species -- 90 percent *Coleogyne*, 8 percent *Ephedra*, 2 percent other mixed species (Table 18). Since both *Coleogyne ramosissima* and *Ephedra nevadensis* are long-lived, it is plausible that not only the same species, but essentially the same plants were present on that plot from 1963 through 1989. Extrapolating slightly backwards in time, I would venture there was almost no change in the individual plants present for 30 years following the fire.

Table 18. Perennial plant numbers and volumes inside Beatley plots 41 and 42 (MID 006, 007) in Mid Valley, sampled July 1989.

Species	Burned (42)		Unburned (41)	
	n	V	n	V
Aca sho	1	151	0	0
Ara pul	0	0	4	0
Art tri	0	0	1	21
Chr nau	1	124	0	0
Col ram	2	143	223	21,853
Eph nev	15	18,874	19	4,173
Eri pul	14	1	0	0
Opu ech	0	0	1	31
Sph amb	1	0	0	0
Sti spe	1	0	0	0
Totals	35	19,299	248	26,079
Dead plants	22	490	41	1,131

Figure 9 - The edge of a Mid Valley burned area next to Beatley, plot 41.

This does not imply the individual plants did not grow or die back during 30 years. The appearance of plot 41 plants was that of old, multi-crowned *Coleogyne* individuals. *Ephedra nevadensis* plants, being rhizomatous, must have produced numerous shoots. They did appear to be suppressed in size when compared to those on the burned area. Mean volumes were 219 ± 108 (unburned) and 1258 ± 211 (burned).

On the unburned plot there was one live *Artemisia tridentata*, but there were also five dead ones, three long dead and two dead less than one year. The live plant was small, and therefore probably young, but two long-dead remains were large (>1 m diameter). The implication is that the vegetation is progressively becoming more and more a monoculture of *Coleogyne*, as *Artemisia tridentata* dies out.

The burned area was dominated by *Ephedra nevadensis*. As shown by Hunter and Medica (1989), *Ephedra* crown-sprouted following fires in Yucca Flat and Mid Valley. It is probable, therefore, that the *Ephedra nevadensis* which dominated the burned area vegetation was present before the fire and grew since then to the large size seen in Table 18. That implies that in 30 years there was almost no germination and establishment of shrubs after the 1959 fire. Indeed, *Coleogyne ramosissima* seedlings were seen only within a meter or two of the unburned vegetation. This is slow when compared to recovery rates on ground zeroes and subsidence craters.

This does not imply there were no plants on the burned site, just a scarcity of perennials. The introduced annual brome grasses have done very well on Mid Valley burned areas (Beatley 1965a; Hunter 1991).

Mid Valley - 1986 Fire

Another Mid Valley burned area being monitored was first sampled in 1987 (Hunter and Medica 1989). The fire occurred in June 1986 and recovery (resprouting of *Yucca brevifolia*, *Ephedra nevadensis*, *Lycium andersonii*, and *Stipa speciosa*) was apparent the following year. Table 19 details some of the transect results. The unburned area was dominated by *Artemisia tridentata*, *Coleogyne ramosissima*, and *Ephedra nevadensis*, which together contributed 91 percent of total volume. Bunchgrasses were scarce compared to 1987 results ($19/\text{m}^2$ in 1990 vs $70/\text{m}^2$ in 1987). On the unburned area the loss of grasses could be attributed to drought. Increases in perennial numbers from 1987 to 1991 (Appendix 2) were in most cases due to methodological problems -- the

1987 sampling missed many of the less obvious plants. Decrease in *Phlox stansburyi* from 6 to 1 was probably drought related, but the absence above-ground of this rhizomatous species does not imply it died.

Table 19. Perennial plants in burned and unburned sections of transect MID001 in 1990. Values are adjusted to 100 m² area (zero values are < 0.5).

Species	Burned		Unburned	
	n	V	n	V
Art tri	1	5	52	8,480
Atr can	1	149	0	0
Cer cti	0	0	1	0
Chr ter	1	82	5	500
Chr vis	0	0	24	962
Col ram	1	7	38	4,587
Eph nev	7	402	54	3,855
Eri coo	0	0	5	170
Eri cae	0	0	0	0
Eri pul	0	0	0	0
Gra spi	0	0	1	46
Lyc and	1	7	0	0
Men spi	0	0	0	0
Opu ech	1	1	1	2
Opu eri	0	0	2	18
Ory hym	2	0	1	0
Phl sta	2	1	1	0
Sph amb	38	13	4	1
Sti spe	41	10	18	6
Unknown	2	3	1	0
Yuc bre	1	14	2	8
Totals	100	642	208	18,638
Dead plants	158	580	204	5,046

Total volume of perennial plants on the burned area was only three percent of that on the unburned transect sections in 1990. Bunchgrasses (*Stipa speciosa* and *Oryzopsis hymenoides*) were the most numerous plants, but were closely matched by new seedlings of *Sphaeralcea ambigua*, an herbaceous perennial which

sometimes dominates disturbed areas elsewhere in the Mojave Desert (see Table 11). The crown sprouts of *Ephedra nevadensis* and *Lycium andersonii* were essentially static over the three year period. *Phlox stansburyi*, a herbaceous perennial which produces above-ground growth only under good conditions, declined 80 percent in numbers of shoots and 99 percent in total volume. Other species were largely incidental, although a number of *Artemisia tridentata* seedlings were found (7 in 500 m²), suggesting it may begin to invade the burned area. The few plants of *Coleogyne ramosissima* and *Atriplex canescens* found in the burned part of the transect appeared to have been protected from fire by a dirt road and boulders, rather than to be new seedlings.

Near the transect, 100 Joshua trees (*Yucca brevifolia*) were marked in 1987 and resampled in 1990. Sixty-four were on the burned area and 36 on the unburned area. Of the 64 on the burned area, five had live main trunks, the rest having been killed by fire. Twenty-seven of the 59 with killed trunks had live sprouts at the base. Table 20 describes characteristics of these two groups.

About 92 percent of the central trunks were killed by the fire, but 52 percent of the individual plants survived until 1990, most by producing basal sprouts. The basal sprouts were present by August 1987, just a year after the fire. By July 1990, however, many basal sprouts had died, and the average number per plant declined from 5.7 to 3.1 (Table 20). On the burned area the average height ($\pm$ sem) of living plants was 34 ± 9 cm, while the average live height on the unburned area was 192 ± 18 cm. It appears therefore that *Yucca brevifolia* populations survive range fires relatively well.

Table 20. Characteristics in July 1990 of Joshua tree (*Yucca brevifolia*) marked on burned and adjacent unburned areas in Mid Valley (plot MID001).

	Burned		Unburned	
	1987	1990	1987	1990
# marked	64	64	36	36
# with live trunks	-	5	36	36
# with live basal sprouts	31	30	3	7
Average # of live sprouts	5.7 ± 0.8	3.1 ± 0.3	1.0 ± 0.0	1.3 ± 0.3
# live fruiting 1990	-	1	-	13
Mean height cm	-	34 ± 9	189 ± 18	192 ± 18

During 1990, there was a herd of 12 to 15 cows ranging on the western side of the NTS. This burned site had numerous "cow pies", tracks, and grazed bunchgrasses. On one burned section of transect where grazing damage was recorded, 47 percent of *Stipa speciosa* and 36 percent of *Sphaeralcea ambigua* were grazed. Cows appeared responsible for the grazing damage. Most perennial plant grazing damage on the NTS is caused by rabbits, but deer pellets were seen occasionally on this site in Mid Valley.

Yucca Flat - 1985 Fire

A transect was set up in 1987 in a burned area near the junction of Mine Mountain Road and Tippipah Highway. The fire was ignited by lightning on June 24, 1985, and a bladed firebreak surrounds the site. The transect crossed from the burned into the unburned vegetation in order to determine whether vegetative recovery proceeded from the edge inward towards the center. However, the recovery process was so limited that analysis could not be done on invasion after the 1990 census. Comparisons of the burned and unburned populations are shown in Table 21.

Table 21. Perennial plant populations on a burned site in southwestern Yucca Flat, plot YUF002. The first 90 m were unburned, and 90-200 m was in the burned area. Values are adjusted to 100 m².

Species	Burned				Unburned			
	1987		1990		1987		1990	
	n	V	n	V	n	V	n	V
Amb x Hym	0	0	0	0	0	0	1	0
Art spi	0	0	0	0	1	0	0	0
Cer lan	0	0	0	0	1	173	1	-
Col ram	0	0	0	0	3	1,048	4	1,060
Eph nev	2	125	2	162	10	3,192	7	2,163
Eri coo	0	0	1	0	1	348	3	83
Gra spi	1	0	0	25	21	4,348	8	1,860
Hym sal	1	9	2	12	20	268	4	259
Lyc and	10	61	13	75	12	2,222	12	3,192
Ory hym	0	0	0	0	1	0	1	1
Sit jub	0	0	0	0	1	1	0	0
Sti spe	112	52	42	21	41	419	11	12
Unknown	0	0	0	0	1	30	0	0
Yuc bre	1	33	0	40	0	0	0	0
Totals	127	281	61	335	112	12,605	52	8,630
Dead plants			109	1,220			93	4,882

One major trend during 1987-90 on the burned and unburned sites was death or dieback of shrubs and grasses due to drought. On the burned area 60 percent of bunchgrass volume died, but in the unburned area 97 percent was lost. The primary grass involved, *Stipa speciosa*, did better on the burned area, due undoubtedly to lack of competition with shrubs. By 1990, total *Stipa* numbers and volume were considerably higher on the burned area than on the unburned one. The few shrubs which resprouted after the fire did not fare so well. *Ephedra nevadensis* was approximately static on the burned area, but grew slightly. *Lycium andersonii* grew on both the burned and unburned sites, but did proportionately better in the unburned area. This was not noticeably due to grazing, which often occurs preferentially on the greener plants on disturbed areas. *Lycium* was not grazed on either part of the transect. It appeared rather that the *Lycium andersonii* crown sprouts were not vigorous, perhaps because the small shoots were supporting large root systems. A fair number of *Lycium* crown sprouts died on the burned area. At the time of the census there was a rainstorm (July 16, 1990) which allowed some of the live sprouts on the burned area to break dormancy. All on the unburned area were dormant.

One species, *Ericameria cooperi*, had new seedlings present on the burned area in 1990, at a density of about 1 plant per 100 m² (Table 21). If *Ericameria cooperi* successfully invades burned areas, it would add to the evidence of an early fire near T4 ground zero, where 50 percent of the population was made up of *Ephedra nevadensis*, *Lycium andersonii*, *Ericameria cooperi*, and *Stipa speciosa* (Table 12), and the rest was made up of relatively short-lived species (*Atriplex canescens*, *Ceratoides lanata*, *Grayia spinosa*, and *Hymenoclea salsola*).

The unburned transect portions at this site were significantly impacted by drought. Most *Grayia spinosa*, *Hymenoclea salsola*, and bunchgrasses died and total live shrub volume declined about 32 percent. Those species which best survived the drought were *Coleogyne ramosissima* and *Lycium andersonii*, both long-lived dominants.

Red Rock Valley - 1988 Fire

In late July 1988, a fire occurred in Red Rock Valley next to Pahute Mesa Road. The small valley is on the western slope of the Eleana Range and drains into Forty Mile Canyon. Soil on most of the burned area was a deep sand deposit. In July 1989, one transect was measured on the burned area and

another across Pahute Mesa Road in unburned vegetation. Results of the census are in Table 22.

Table 22. Perennial plant populations on burned and unburned site in Red Rock Valley, sampled in July 1989.

Species	Burned		Unburned	
	n	V	n	V
Atr can	0	0	9	2,518
Eph nev	3	1,201	3	8,479
Ory hym	94	10	6	2
Pso pol	1	0	31	13,893
Totals	98	1,211	49	25,893
Dead plants	-	-	19	6,081

One year after this fire *Ephedra nevadensis* and *Oryzopsis hymenoides* crown sprouts had returned about 5 percent of live volume to the burned area. This is consistent with all other burned sites studied, although the bunchgrass species involved was *Oryzopsis* instead of *Stipa speciosa*. *Oryzopsis hymenoides* is common on sandy soils, and *Stipa speciosa* is generally absent on deep sands. The one shrub of *Psoralea polydenius* found on the burned area was a new seedling.

The unburned site had an unusual plant community dominated by *Psoralea polydenius*. There were remains of many *P. polydenius* on the burned area, indicating it had a similar population before the fire, but there was no crown sprouting of that or *Atriplex canescens*. The unusual abundance of *P. polydenius* at this site has not previously been noted by other botanists working on the NTS.

Drill Pads

Prior to a test of a nuclear explosive device a deep hole is drilled. The required drilling activities and sensor emplacement and monitoring are facilitated by clearing areas of several hectares. These may be scraped, watered, graveled, or compacted. Heavy equipment and vehicles are driven across the site. In Yucca Flat, where subsidence craters form, this cleared area ends up in the middle of a crater. On Pahute Mesa, most tests do not result in subsidence, and the "drill pad" is the major surface disturbance at the site. BECAMP has studied perennial vegetation on two Pahute Mesa drill pads, one in 1989 and one in 1991.

Drill Pad U20ao

Drill pad U20ao, the pad nearest the junction of Buckboard Mesa Road and Pahute Mesa Road, was constructed in late 1984 or in 1985. The south end was fenced off as a potential crater area. Plant sampling was done near the north end of the broad scraped area. In August 1989, there were no live perennial plants in 100 m² on the drill pad, although there were hundreds of small *Halogeton glomeratus* and about one small *Salsola australis* per square meter (both are introduced summer annual weeds).

The undisturbed vegetation about 100 m to the west of the drill pad was totally dominated by *Artemisia tridentata*. In 100 m², there were 136 *A. tridentata* with a total live volume of 22.2 m³ and 28 unidentified bunchgrasses, with a total live volume of 0.008 m³. The bunchgrasses were dormant and had not flowered in 1989, and were therefore not identified. Dead plants numbered 151 with a total volume of 2.8 m³. Most (110) of the dead plants were bunchgrasses, recently killed by drought.

Drill Pad U19ac

Drill pad U19ac is adjacent to Dead Horse Flat Road at an elevation of approximately 2134 m. It is on a ridge near a wooded canyon. The south end was again roped off as a potential crater area, and vegetation was sampled on the north scraped area (PAM006). It was probably scraped in 1979 or 1980, and censused in July 1991 (Table 23).

Table 23. Vegetative characteristics on the scraped portion of drill pad U19ac (PAM006) and a nearby undisturbed area (PAM007) in July 1991.

Species	U19ac Drill Pad		U19ac Control	
	n	V	n	V
Are con			2,380	360
Art tri			41	4,821
Cactus			1	6
Ch vi p			19	80
Cry fla			7	0
Del par			10	0
Eri cae			39	9
Eri ova			1	0
Jun ost			5	2,974
Ory hym	44	780	2	6
Pen spf			44	15
Per gra	115	38	77	24

Table 23, continued.

Species	U19ac Drill Pad		U19ac Control	
Pin mon			8	14,510
Phl sta			183	16
Poa fen			11	59
Sit jub	1	2	37	28
Sti com	121	549	0	0
Sti spe			6	3
Unknown			3	0
Totals	271	1,370	2,874	22,913
Dead plants	0	0	39	536

The undisturbed area sampled near U19ac was around 150 m east in pinyon-juniper woodland. A 100 m² transect was censused in July 1991 (Table 23), and in addition 50 pine trees were marked and measured. The pine population is described below (see p. 77), and was judged to be relatively young. Herbaceous perennials dominated numerically, with *Arenaria congesta* making up 83 percent of the population. *Stipa comata*, a bunchgrass invading the drill pad, was totally absent from the undisturbed area. In volume, *Pinus monophylla* contributed 63 percent, *Artemisia tridentata* 21 percent, and *Juniperus osteosperma* 13 percent. These dominant species contributed 97 percent of total volume.

As on drill pad U20ao, U19ac had large populations of *Salsola australis*, which was absent from the undisturbed site.

Scraped Areas

Although drill pads might be considered scraped areas, the activities and surface treatments were felt to be significant in changing the nature of the surface. Two sites have been studied in which the primary disturbance appears to have been the removal of vegetation. One was an area where radioactive wastes were removed along with the top few inches of soil (Waste Management Consolidation Site 3B - YUF011), and the other was cleared apparently for some high explosives tests (MID004).

3B Consolidation Site

The YUF011 site was censused in 1988 about a year after completion of work. In 1989, it was ripped and desert shrubs (largely *Atriplex canescens*) were

planted by UCLA (E. M. Romney, personal communication). It was recensused in 1991. The undisturbed 100 x 2 m transect sampled nearby was instituted for another project, and is also the undisturbed transect for T3 GZ. Table 24 provides results of the transect on the 3B scraped site (YUF011), and for the undisturbed site (YUF012). *Salsola australis* seedlings were present on this site both years.

Table 24. Perennial vegetation on waste consolidation site 3B (YUF011) and an adjacent undisturbed site (YUF012) sampled in 1988 and 1991.

	n		Live volumes (l)	
	1988	1991	1988	1991
<u>Disturbed - scraped</u>				
<i>Atriplex canescens</i>	0	7	0	531
Undisturbed - TOTALS	499	171	23,348	5,120
<i>Acamptopappus shockleyi</i>	80	22	1372	48
<i>Atriplex canescens</i>	67	16	3354	326
<i>Ceratoides lanata</i>	80	57	1942	360
<i>Chrysothamnus viscidiflorus</i>	19	0	1932	0
<i>Ephedra nevadensis*</i>	13	6	3270	3396
<i>Hymenoclea salsola</i>	2	0	8	0
<i>Lycium andersonii</i>	5	4	694	275
<i>Menodora spinescens</i>	14	13	863	444
<i>Mirabilis pudica*</i>	9	12	15	205
<i>Oryzopsis hymenoides</i>	98	1	115	2
<i>Polygala subspinos*</i>	85	43	9	57
<i>Sitanion jubatum</i>	39	0	9	0
<i>Sphaeralcea ambigua</i>	4	0	17	0
<i>Stephanomeria pauciflora</i>	0	1	0	2
<i>Stipa speciosa</i>	0	1	0	0
<i>Tetradymia glabrata</i>	26	1	9604	5
Unknown	4	0	144	0
Dead grasses**	4	139	1	103
Dead shrubs**	28	250	641	18666

*Rhizomatous species - numbers are ambiguous.

**Dead plants are not included in totals.

Mid Valley Bladed Area

The bladed area in Mid Valley sampled in 1989 (MID004) and an adjacent undisturbed area lie in the north-central area of Mid Valley at an elevation of about 1442 m. The area was bladed in the mid-1980s.

The perennial vegetation in the undisturbed area was similar to that at the nearby burned site Beatley studied (Beatley 41,42; see page 42). *Coleogyne ramosissima* was strongly dominant, with *Ephedra nevadensis* a small subcomponent. Among the dead plants on this site were two large, long-dead *Artemisia tridentata*. Also present in the area were scattered golden cholla (*Opuntia echinocarpa*) which stood out above the *Coleogyne* canopies, but which were not present on the 100 m² transect (Table 25).

Table 25. Perennial vegetation on two 100m² transects on bladed and undisturbed areas in north-central Mid Valley. Sampled in 1989.

Species	Bladed		Undisturbed	
	n	V	n	V
Chr nau	1	3	0	0
Col ram	1	1	163	23,570
Eph nev	3	31	5	4,716
Ory hym	1	0	1	0
Sti spe	0	0	12	2
Totals	6	34	181	28,288
Dead plants	0	0	6	446

The bladed area had several small shrubs. The *Ephedra nevadensis* plants were potentially sprouts from plants present before blading, but the *Coleogyne* and *Chrysothamnus* and *Oryzopsis hymenoides* were seedlings. *Chrysothamnus nauseosus* became established during the 1980s in northern Yucca Flat on disturbed areas and roadsides where it was previously absent. Mid Valley is at a similar elevation and the one *C. nauseosus* seedling on the bladed area transect probably represents the same phenomenon -- invasion from higher altitude during the 1980s.

The absence of a significant population of bunchgrasses on this bladed area was somewhat unusual. It implies conditions were unfavorable for bunch grass germination or establishment in the years between the disturbance and the 1989 census.

As on the drill pads, there were numerous *Salsola australis* on this bladed area, and none on the undisturbed area.

Roadsides

Two roadsides in Frenchman Flat have been studied. One was studied in 1988 with a transect laid parallel to the roadbed, on the scraped area next to the asphalt pavement. Although I was unhappy with the transect design (Hunter 1992), it was resampled in 1991 to characterize the difference in growing conditions between the road edge and the undisturbed vegetation nearby.

During 1990, another roadside was studied. In this case, eight 2 x 25 m transects were randomly placed perpendicular to the roadbed along a 100 m section of 5-05 Road. These transects began at the centerline and crossed the scraped road verge and drainage channels, the visibly larger shrubs immediately past the scraped area, and extended into the beginning of what appeared to be undisturbed vegetation. Eight similar transects were set up roughly 500 m north, far from the road.

Abandoned Roadside - 5-03

Results of the census of the edge of the asphalt and an undisturbed area to the south of 5-03 Road are in Table 26. The species composition was similar, with both areas dominated by *Larrea tridentata*, *Ephedra nevadensis*, and *Ambrosia dumosa*. The relative volumetric proportions vary, with *Ephedra* and *Ambrosia* on the roadside being considerably larger than those on the undisturbed transect, and *Larrea* being considerably smaller. Note, however, that during these drought years only *L. tridentata* on the roadside grew -- all other species' populations decreased in volume. On the undisturbed transect numbers and volumes of all species declined, but on the roadside, numbers increased slightly for most species and total volumes declined less (23% vs. 36%) than on the undisturbed transect.

Table 26. Perennial vegetation near the west end of 5-03 Road in Frenchman Flat and an adjacent control area, measured in 1988 and 1991.

Species	Roadside				Control			
	1988		1991		1988		1991	
	n	V	n	V	n	V	n	V
Amb dum	34	1,112	41	521	41	1,028	37	163
Eph nev	2	2,282	3	2,117	8	1,830	7	858
Eri pul	1	0	0	0	0	0	0	0

Table 26, continued.

Species	Roadside				Control			
	1988		1991		1988		1991	
	n	V	n	V	n	V	n	V
Gra spi	0	0	0	0	3	506	2	49
Lar tri	2	67	2	110	7	22,714	6	15,748
Lyc and	0	0	0	0	1	139	1	69
Opu bas	0	0	1	0	0	0	0	0
Ory hym	4	4	2	0	0	0	0	0
Sti spe	0	0	0	0	1	64	0	0
Totals	43	3,787	49	2,948	61	26,282	53	16,887
Dead plants	0	0	3	15	9	265	28	1,084

Not apparent in these data are the large *Larrea tridentata* occurring along the edge of the scraped road edge. If the road were not abandoned the plants on the edge of the asphalt would be killed every few years, and the large *Larrea* at the edge of the scraped area would be the only permanent perennial plants with roots able to withdraw the roadside water supplies. The shrubs now growing next to the asphalt will presumably continue to grow and invade this still underpopulated area.

The drought of 1989 and 1990 was particularly severe at this location. Although the well-established *Larrea tridentata* in the undisturbed area shrank about 31 percent in total volume, the *Ambrosia dumosa* (84%), *Ephedra nevadensis* (53%), and *Grayia spinosa* (90%) died back significantly more. A drought-damaged *Larrea* from this site is shown in Figure 10.

Active Roadside - 5-05 Road

This roadside plot (FRF003) is near plot FRF001 in the center of Frenchman Flat about midway along 5-05 Road. The non-roadside area selected as a control was approximately 500 m north, approximately midway between 5-05 and 5-07 Roads. The vegetation was sampled in 1990, the second year of drought, which affected the results somewhat.

The summary of findings for all eight 25 x 2 m transects on these roadside and non-roadside sites is in Table 27. The roadside transects started at the pavement center, and the first nine to ten meters were virtually devoid of perennial plants. The overall patterns of total volumes, summed by distance

Figure 10 - Resprouting of drought-damaged *Larrea tridentata*, May 1991.

from the start of the transects, are demonstrated by bargraphs in Figure 11.

Table 27. A summation of plant numbers and volumes for eight 50 m² transects on the north side of 5-05 Road and a nearby non-roadside area in Frenchman Flat. Transects were measured in August 1990.

Species	Roadside		Control	
	n	V	n	V
Aca sho	0	0	8	177
Amb dum	85	1,276	75	177
Art spi	5	65	0	0
Atr can	0	0	1	6
Cer lan	3	22	14	216
Eph nev	5	195	30	1,432
Gra spi	14	1,584	4	205
Hym sal	30	1,663	0	0
Kra par	0	0	1	0
Lar tri	19	23,627	37	38,125
Lyc and	8	1,088	17	3,398
Pso fre	8	4,779	2	259
Tet axi	2	183	0	0
Totals	179	34,481	189	44,568
Dead plants	267	8,616	386	13,006

Using the eight transects as replicates, the roadside did not differ significantly by T-test in number of species per transect (6.62 vs 5.62), total live volume per transect (4.3 m³ vs 5.6 m³), total number of live and dead plants per transect (56 vs 72), or total cover per transect (8.4 m² vs 11.2 m²) from the non-roadside area. This is partially a reflection of the high point-to-point variability in these parameters when measured in 50 m² portions. It is also a reflection of reality -- the roadside within 25 m of the centerline had approximately the same numbers, live volumes, etc. as the non-roadside transects, even though 40 percent had been paved and repeatedly scraped and was void of perennial plants. The greater growth of plants next to the scraped roadside has partially compensated for the loss of plants and space caused by road construction and maintenance. Live volumes per occupied square meter of transect were 0.165m³ on the roadside, and 0.128m³ on the non-roadside area. This was 29 percent higher, but was not significantly different.

A major difference, however, between the roadside and non-roadside populations was the species composition. Grouping the species with fewer than five

Roadside Vegetation

Figure 11 - Total plant volumes on 16m² areas distributed along 25m transects.

individuals on either area into one category, the numbers of the remaining seven species and the grouped ones were significantly different at $p < 0.001$ by chi square. The very long-lived, extremely drought-hardy species were reduced in frequency, while several less hardy species increased. I propose that the decrease in long-lived species was due to the scraping and construction activities. The increase in the less drought-hardy species (*Hymenoclea salsola*, *Artemisia spinescens*, *Psoralea fremontii*, and *Grayia spinosa*) on the roadside I attribute to a moderation of drought conditions due to runoff from the asphalt and absence of plant cover on the roadside. *Ambrosia dumosa*, which is relatively long-lived and drought-hardy, germinated in great numbers in 1983 (Hunter 1989), increasing density to comparable values on the roadside and non-roadside areas.

Not only was live *Hymenoclea salsola* found only on the roadside transects (one dead one was found on the 8 non-roadside ones), it was essentially restricted to the area between the scraping (9 m) and 15 m from the center of the road (Table 28). In addition, 85% of its total live volume was restricted to the first meter adjacent to the scraping, and 96% was in the first two meters. This seems powerful evidence that roadside conditions are more mesic than those of the undisturbed desert.

Table 28. Distribution of live *Hymenoclea salsola* with distance from the road center, as found on eight transects perpendicular to Road 5-05.

Distance, m	n	Mean	Total
		Vol ($1 \pm \text{sem}$)	Vol (1)
0	0	0	0
7	3	10 ± 81	31.1
8	0	0	0
9	1	0.2	0.2
10	9	158 ± 82	1420.
11	7	26 ± 17	180
12	2	$.020 \pm .001$	.04
13	0	0	0
14	1	.003	.003
15	5	6.3 ± 2.6	31.7
16-24	0	0	0

The mesic roadside conditions may also explain the presence of *Artemisia spinescens* in small numbers (Table 27) on the roadside transects. This species was absent not only from the 400 m² of non-roadside transects, but also from 300 m² of transect on plot FRF001, which is about 200 m west of the

roadside plot, and 100 m² of the control transect of FRF002, about 2.4 km southwest. It was absent from all of 59 transects measured in 1981-1988 by R. Hunter and E. M. Romney northwest of Frenchman Lake for studies of the Liquified Gaseous Fuels Spill Test Facility (Hunter et al. 1991). It was present in only 1 of 29 100 m² transects in Frenchman Flat reported by Romney et al. (1973). Beatley (1979) did not find it on any plot in "Mojave Desert" vegetation associations. She did, however, report it in or below all the mountain ranges surrounding Frenchman Flat, and she did report it in some plots in the "Transition desert" vegetation associations, none of which was lower than 1218 m. Our roadside plot is at an altitude of about 965 m, Romney et al.'s (1973) report places *A. spinescens* at 988 m, while two herbarium specimens of T. L. Ackerman place it at 1005 and 1036 m. (NTS herbarium accession numbers 17775 and 9848; 1968 and 1969). The five live individuals on two roadside transects were between 11 and 19 m from the road center, and two dead ones on the same transect were at 13 and 14 m from the center.

Radiation Exclusion Area - GMX

Radiation exclusion (Radex) areas are fenced areas where humans would or could acquire an excessive radiation dose. They have warnings posted and require permission and guidance by trained personnel while working inside the fence. Some are in disturbances of various sorts, and others are in undisturbed vegetation. Extensive studies of the effects of radiation on Mojave Desert flora and fauna were conducted in Rock Valley in the 1960s and early 1970s (Turner 1975; French et al. 1974; Turner and Medica 1977; Kaaz et al. 1971). In general, long-term doses of about 500 R were necessary to measure effects in lizards and small mammals, and 5000 R were necessary in plants (Kaaz et al. 1971; Vollmer and Bamberg 1975). Because these dose rates are not currently attainable on the NTS, and because of the difficulty of working in Radex areas, we monitored only one Radex area, GMX, a small area in northeast Frenchman Flat contaminated by transuranics.

The plant transect in the GMX zone of highest contamination (Romney et al. 1975) and the transect outside the fence are about 500 m apart. There were some differences in plant population at the two sites (Table 29), with different *Atriplex* species being the biggest difference. This is consistent with a previous study (Rhoads 1974) who found the GMX site occurs in a vegetation gradient between an *Atriplex canescens* monoculture and *Larrea-Lycium* community.

Although it is not reasonable to postulate effects on plants by the low levels of alpha radiation found at GMX, it is perhaps worth noting that the two plant species found to be most affected by gamma radiation (*Ephedra nevadensis*, Kaaz et al. 1971; *Krameria parvifolia*, Vollmer and Bamberg 1975) were more numerous and larger on the contaminated area (Table 29).

Table 29. Perennial plant numbers and live volumes on a transect in the GMX contaminated zone and another outside the Radex fence. These were sampled September 1989.

Species	GMX		Uncontaminated	
	n	V	n	V
Aca sho	6	241	9	146
Amb dum	3	16	11	121
Atr can	0	0	3	342
Atr con	21	1,026	0	0
Cer lan	5	80	10	153
Eph nev	2	174	1	14
Gra spi	1	70	6	1,208
Kra par	1	32	0	0
Lar tri	10	11,006	18	15,146
Lyc and	0	0	2	256
Ory hym	2	0	2	0
Pol sub	1	23	0	0
Unknown	0	0	1	6
Totals	52	12,667	62	17,393
Dead plants	92	2,907	71	847

Gopher-Denuded Areas

Mercury

In the Mojave Desert portions of the NTS there are a number of areas where the shrubs have been eliminated by gophers and other burrowing rodents (Hunter 1980). The gophers slowly kill the established shrubs by cutting off roots, and other rodents and rabbits prevent reestablishment by grazing new seedlings. Some of these areas are many hectares in area; others are less than one hectare. The borders are occasionally distinct, especially where outcrops of rock or washes prevent burrowing. In other cases, there is a

gradient from a totally bare central area, through vegetation where the more tolerant species survive, to a natural mixed shrub population.

One gopher area monitored by BECAMP in 1988 and 1991 (MER002) is found in west Mercury Valley at the southwestern border of the NTS. The control transect lies approximately 560 m to the north in an area apparently unaffected by gophers. Results are in Table 30.

Table 30. Perennial plants on gopher-denuded plot MER002 and a nearby undisturbed plot MER003 in 1988 and 1991.

Species	n		V	
<u>Gopher area:</u>	1988	1991	1988	1991
Mir pud	6	49	2	578
Ory hym	0	1	0	0
Sit jub	2	0	0	0
Sph amb	1	3	1	22
Sta pin	19	17	2,892	981
Totals	28	70	2,894	1,581
Dead plants	45	65	6,744	6,786
<u>Undisturbed</u>				
Aca sho	118	37	3,284	349
Amb dum	9	7	170	107
Cer lan	2	2	24	58
Eph nev	4	7	1,150	1,236
Gra spi	24	13	2,500	799
Hym sal	8	6	73	60
Lar tri*	3	4	16,163	23,851
Lyc and	13	12	2,820	1,492
Opu bas	1	0	0	0
Ory hym	1	1	2	6
Sph amb	9	4	26	50
Totals	192	93	26,212	28,009
Dead plants	66	174	3,033	8,383

* Numbers are ambiguous.

The vegetation of gopher-denuded areas is unusual. As seen in Table 30, the denuded site is dominated by *Stanleya pinnata*, an herbaceous shrub which is avoided by jackrabbits (Hunter 1987). The other species present are herbaceous species with rapid population turnover (*Oryzopsis hymenoides*, *Sitanion jubatum*, *Sphaeralcea ambigua*) and an herbaceous rhizomatous species (*Mirabilis pudica*). In 1991, eleven of the 17 *Stanleya pinnata* were small

seedlings. Many of the 1988 *S. pinnata* were dead from drought.

The area without gophers, sampled nearby, experienced a severe decline in shrub numbers, again explained by drought. *Acamptopappus shockleyi* was the most seriously depleted, but *Grayia spinosa* also declined markedly. This site behaved as most others on the NTS from 1988-91, although spring 1991 rains may have been somewhat heavier here than elsewhere. Good growth on surviving *Sphaeralcea ambigua* and new sprouts from *Ephedra nevadensis* rhizomes suggested a period of good growing conditions.

On this plot, one *Larrea tridentata* was measured as a single plant in 1988 and as two plants in 1991. It is not possible to compare these size measurements or the computed volumes. Most of the change in *Larrea* volume should be attributed to that change in technique, rather than to a growth of the *Larrea* on this transect.

HISTORICAL PLOTS

In order to allow comparisons between historical and present vegetation on the NTS, a number of locations were censused solely because they had been measured in the past. Plots which were permanently marked in the past were those established in 1963 by J. C. Beatley (1979), transects set up in 1981 with permanent end-posts by Romney and Hunter to study the Frenchman Flat vegetation downwind of the Liquified Gaseous Fuels Spill Test Facility, plots set up in 1968 near the Mercury sewage ponds by Romney et al. (Wallace et al. 1972; Hunter et al. 1976), and transects at Sedan measured by Hunter in 1976. Some measurements were taken at each of these sets of plots, but results at Sedan were reported above, and censusing of *Yucca schidigera* at Romney's sewage pond plots is considered below.

Beatley Plots

Eleven of Dr. Beatley's 68 plots were resampled in 1989. Of these, four were paired plots in and out of a disturbance. The paired burned and unburned plots 41 and 42 were considered above. The other disturbed plot was in an area scraped in 1927 at the Wahmonie mining camp site (Beatley plot 67). We do not have access to Dr. Beatley's data on disturbances, but she published (Beatley 1979) summary results of her studies on different "vegetation associations" on the NTS as measured in 1963 and 1975. Those summaries were often pooled data from several plots in one "association", but were occasionally from single plots.

One Beatley plot, in Rock Valley, was sampled in 1989 using both line intercepts as practiced by Beatley and belt transect measurements used in BECAMP work. The line intersect technique involves stretching a tape over shrubs and recording what point on the tape lies over the beginning and ending of the canopy of each shrub it crosses. The height and species for each shrub were also recorded. The belt transect uses a tape stretched out on the ground, and each plant whose base is within 1 m of the tape is measured, as described in methods. These two techniques measure different properties of the vegetation, and comparison of results between the two requires understanding the differences. Table 31 presents the results for both techniques performed in late June and early July 1989.

Table 31. Comparison of vegetation characteristics for Beatley Plot 3 (ROV005) in Rock Valley as determined by Beatley's (1979) line intercept technique and the BECAMP belt transect procedure (Hunter and Medica 1989).

Species	% of Population*		% Cover**		mean HT (cm)	
	line	belt	line	belt	line	belt
Aca sho	1.3	0	0.1	0	32	
Amb dum	39.3	48.3	11.4	10.9	39	30±2
Cer lan	0.9	3.5	0.1	0.3	50	40±5
Col ram	2.6	1.7	0.6	3.2	66	64±7
Eph nev	13.5	15.7	4.6	6.4	58	43±4
Gra spi	7.4	5.8	2.0	1.5	56	51±4
Kra par	1.7	1.2	1.7	1.3	44	32±13
Lar tri	10.0	5.8	6.8	12.8	109	81±14
Lyc and	7.0	7.6	3.0	4.5	60	55±5
Lyc pal	6.1	2.6	2.4	1.5	70	48±2
Ory hym	0	0.6	0	0.0		3
Pso fre	0.9	0	0.5	0	61	
Sph amb	0.4	0.6	0.0	0.0	6	4
Sti spe	0	0.6	0	0.0		1
Xyl tor	1.7	5.2	0.2	0.3	49	27±5
			34.0	42.7		

* Numbers of plants were 229 (line intercept) and 172 (belt transect).

** Total cover was 29.9%, 34% includes overlapping canopies; the belt transect data include overlapping canopies.

Note first that the mean heights for the different species are all larger using line intercept than for the belt transect. This is because a random line preferentially hits larger plants. Since height and width are correlated, a tall (wide) plant has a greater probability of being under the tape than does a small one. Therefore, while the line intercept accurately measures "cover", it gives a distorted view of mean plant size.

This over-sampling of larger plants has another consequence. Not only are larger individuals of a given species selected, but species with larger mean sizes are preferentially selected. Therefore, the differences between the species distributions using the two techniques are not random, but are proportional to mean size. The correlation coefficient (Pearson's) between mean width as measured in a belt transect and the difference in percent population between line and belt transects was $r = 0.55$, which is significant at $p=0.05$ (by f test).

Another distortion arises from the way cover is calculated. We estimate cover by individual shrubs as the area of an oval with radii equal to $1/2$ the maximum width and the width perpendicular to that (the two widths are highly correlated, $r = 0.95$ or greater). The areas are thus calculated as proportional to the squares of plant radius. The line intersect technique calculates cover as the sum of shrub widths at random points, as opposed to a sum of widths squared. The difference between line intercept cover and belt transect cover is therefore significantly correlated ($r = .72$; $p < 0.01$) with the square of mean width.

Finally, although random line intercepts should accurately reflect cover, Beatley used eleven 100 foot lines spaced parallel to each other 10 feet (3.05 m) apart. There is a considerable body of literature showing that desert shrubs are not randomly located, but are often either clumped together or dispersed (Cody 1986a,b; Ebert and McMaster 1981; Ghent and Zucker 1990; Philps and MacMahon 1981; Rogers 1989).

Taken together these problems mean that comparisons of data taken by the two techniques should be made very carefully. With that caveat, Table 32 compares published observations by Beatley made in 1975 with results from the same plots censused in 1989. We can ask of these data whether there have been, within the accuracy of the techniques, any significant changes in cover by particular species. It appears that *Ephedra nevadensis*, *Larrea tridentata*, *Lycium andersonii*, and dead shrubs increased in cover, and the three *Artemisia* species, *Grayia spinosa*, *Hymenoclea salsola*, and *Ceratoides lanata* decreased

Table 32. A comparison of cover values (percent), by species, for nine plots instituted by Dr. J. C. Beatley and measured in 1975, with BECAMP values from 1989 samples.

Beatley Plots	3		2		66		60		41		51		62		61		64		Trend
	1975	1989	1975	1989	1975	1989	1975	1989	1975	1989	1975	1989	1975	1989	1975	1989	1975	1989	
<u>Species</u>																			
Aca sho			1.9	5.3	1.9	0.6													
Amb dum	4.0	10.9	1.7	2.8	1.7	0.0													
Art nov															38.1	27.5	9.8	8.2	-
Art spi							1.4	0.4											
Art tri									0.2	0.0			37.2	28.1	0.0	5.3*			
Atr can			0.4	0.0	0.4	0.0	1.9	0.3											
Cer lan	2.8	0.3	2.1	1.5	2.1	0.0	4.7	1.3											
Chr vis			0.1	0.0	0.1	0.0	1.7	4.3	0.1	0.0							0.3	0.1	0
Col ram	1.6	3.2	0.3	0.0	0.3	0.7			44.4	44.4	44.4	49.8							0
Eph nev	1.6	6.4	2.4	1.2	2.4	11.2	4.7	0.0	3.3	7.1	3.3	5.0	0.4	0.7	1.8	1.7			+
Eph vir																	0.0	0.1	0
Eri cae													0.4	0.3			0.0	0.2	0
Eri kea																	0.7	1.0	0
Eri mic																	0.7	0.2	0
Eri umb																			0
Gra spi	3.4	1.5	8.7	5.6	8.7	7.8	10.9	2.2							1.9	0.1			-
Hym sal			1.3	0.6	1.3	0.0													-
Jun ost													0.0	0.0					0
Kra par	1.6	1.3																	0
Lar tri	6.6	12.8	6.3		6.3	17.0													+
Lyc and	2.3	4.5	4.6	3.8	4.6	10.6	5.2	8.2							0.0	0.1			+
Lyc pal	2.9	1.5																	0
Opu ech									0.4	0.1									0
Opu eri																	1.2	1.5	0
Pin mon																	16.9	2.4	0
Pur trt																	3.7	8.1	+
Rib vel																	0.3	1.8	0
Tet gla			0.5	0.0	0.5	0.0	4.8	15.0											
Tha mon					0.5	4.8													
Yuc bac									0.6	0.0	0.6	1.3							0
Yuc bre							0.0	0.0											0
Dead sh	1.7	4.2	2.9	6.0	2.9	3.5	1.7	1.0	1.0	4.7	1.0	0.0	4.4	6.4	2.2	3.1	1.7	10.1	+

in cover. However, knowing the belt transect cover value is higher for larger species (Table 31), the increases are all probably spurious. The decreases in *Artemesia nova* and *A. tridentata* of about 5 percent may be real, because the data were reported from single plots, and the near mono-cultures involved suggest differences in plant size should not cause very large biases. The decrease in *Grayia spinosa* is consistent with data from Sedan and elsewhere, but considering the differences in measurement technique it would be rash to conclude the decrease was widespread based on Beatley's baseline data.

One pair of Beatley plots (66 and 67) was enclosed in a single fence at the townsite of Wahmonie, a mining camp established in 1928 and abandoned the same year. Although Dr. Beatley never reported any data from the disturbed section of this plot pair (#67), other researchers have reported vegetation data from the streets of this "ghost town" (Wells 1961; Webb and Wilshire 1980). Table 33 is a comparison of densities of plants, by species, on these streets and adjacent undisturbed areas for the three census years 1961, 1979, and 1989. It should be noted that the data in Table 31 were collected in three different places, by three different groups, with two different techniques. This implies that small differences are not significant. However, it is plausible that densities of *Stipa speciosa* and *Thamnosma montana* did indeed increase significantly. It is not likely that low-density species died out by 1989, because the minimum detectable density on a 100 m² transect was 100 plants/ha.

Table 33. Perennial plant densities (#/ha) at the Wahmonie ghost town in 1961, 1979, and 1989. Data from 1961 and 1979 are from Webb and Wilshire, 1980.

Species	Wahmonie-Old Main Road			Undisturbed		
	1961	1979	1989	1961	1979	1989
Aca sho	79	38	400	12	60	100
Amb dum	0	6	0	0	0	0
Cer lan	10	0	0	12	60	0
Col ram	35	6	0	500	250	200
Eph nev	940	510	1,100	650	1,140	1,200
Gra spi	110	38	200	2,680	1,350	1,800
Hap coo	10	0	0	0	0	0
Hym sal	270	360	100	0	50	0
Kra par	10	0	0	12	0	0
Lar tri	45	25	0	850	350	700
Lep fre	10	13	0	0	0	0
Lyc and	870	210	1,100	1,400	1,060	1,200
Opu aca	0	0	0	12	10	0

Table 33, continued.

Species	Wahmonie-Old Main Road			Undisturbed		
	1961	1979	1989	1961	1979	1989
Ory hym	0	44	0	0	60	0
Pso fre	10	0	0	0	0	0
Sal mex	200	190	300	0	240	100
Sti spe	2,600	4,160	7,500	340	3,800	1,700
Tet axi	0	0	100	0	0	0
Tha mon	380	540	3,000	52	400	3,800
Yuc bre	0	0	0	12	40	0
Totals	5,567	6,140	13,800	6,532	8,700	10,800

LGF Plots

The area downwind of the Frenchman Lake site of the Liquified Gaseous Fuels Spill Test Facility was considered by Beatley (1976) to be an "Atriplex" community, which she considered a Great Basin Desert type. The vegetation is dominated by two species, *Atriplex canescens* and *Atriplex confertifolia*. Further from the playa *Larrea tridentata* becomes dominant. In 1981, UCLA set up 52 plant transects in that area. They were marked with permanent stakes and tags at one end. In 1986, ten were recensused by UCLA and the other end was marked with a metal post. Four of these transects were measured between 1987 and 1991 by BECAMP workers. They demonstrate a trend of increasing live volumes from 1981 to 1987, followed by a catastrophic decline in *Atriplex* species live volume from 1987 through 1991 (Table 34). On the transect with *Larrea tridentata* (FF84) all plants except *Larrea* died, but because *Larrea* dominated the total live volume, it decreased only moderately in comparison with live volumes on *Atriplex* dominated transects.

Table 34. Numbers and total live volumes (m³) for four 100 m² plant transects northeast of the LGF Spill Test Facility on Frenchman Lake.

Transect	1981	1986	1987	1988	1989	1990	1991
<u>Numbers</u>							
FF66	113	117	145	137	111	10	26
FF67	87	53	66	72	48	15	1
FF81	83	117	---	55	46	5	0
FF84	16	19	---	---	10	8	5

Table 34, continued.

Transect	1981	1986	1987	1988	1989	1990	1991
<u>Live volumes m³</u>							
FF66	3.8	10.6	11.3	12.3	7.0	0.2	0.05
FF67	2.4	4.4	5.6	5.2	2.6	0.7	0.06
FF81	3.1	5.6	---	3.7	3.7	0.5	0.00
FF84	13.3	12.8	---	---	12.0	11.3	9.10

INDIVIDUALS

The norm for most transects and indeed for plot studies of animals as well as plants, is for there to be one or a few dominant species, and low numbers of numerous other species. Occasionally, the rarer species are also large, so that they may be important parts of total volume and biomass. On the NTS, BECAMP has marked and measured individual plants of *Yucca brevifolia* (Joshua trees), *Yucca schidigera* (Mojave yucca), *Juniperus osteosperma* (Utah juniper), *Pinus monophylla* (pinyon pine), and various cacti to try to monitor some of these less common, but important species.

Yucca brevifolia

All *Yucca brevifolia* plants seen on BECAMP plot YUF001 have been marked, and were measured annually since May 1989. A few plants outside the 300 x 300 m plot were also marked. Of a total of 84 plants marked, only 34 remained alive in July 1991. They were marked during a period when rabbits were grazing them, most likely finding them a significant water source during drought.

This population of Joshua trees, which must include nearly all present on the 9 ha plot, consisted of two adult "trees" 4 to 5 m tall. Both fruited in 1990 and 1991. The remaining 82 plants were all less than 45 cm tall. They generally were found inside shrub clumps, or on the edge of clumps, or under single shrubs.

During the drought years, in which these plants were censused, the majority were killed by jackrabbits. A pile of dead leaves, fecal pellets, and often a shallow pit were found at the site of a marking stake (Figure 12). In this manner, 49 of the 84 plants died. One small plant apparently died of drought. It was found intact, but dead.

Figure 12 - A small Joshua tree (*Yucca brevifolia*) killed by a rabbit.

In addition to size measurements, notes were taken of the position of these young *Yucca brevifolia* inside a clump. It was found that those recorded as "inside" a clump were significantly more likely to survive (X^2 , $p < 0.001$) than were those on the edge of a clump. Table 35 shows a summary of these data for the 77 plants for which position information was available.

Table 35. Mortality of *Yucca brevifolia* seedlings in relation to their positions inside a clump.

	Edge	Middle
Survived	10	20
Killed 89-91	35	12
% Killed	78	38

Juniperus osteosperma

Juniper trees were marked on plot PAM001 on Pahute Mesa. Between September 1989 and September 1991, nineteen trees were marked. One tree, in a drainage channel at the edge of the plot, was about 5 m tall and fruited all three years. The remainder were all under 186 cm tall and none fruited in any year. Mean heights (cm $\pm$ sem) in each year for the whole censused population were 100 ± 28 (1989), 96 ± 26 (1990), and 99 ± 28 (1991). There was therefore no growth, within measurement error limits, in the two years these trees were followed.

Pinus monophylla

Pinyon pine trees (*Pinus monophylla*) were marked in 1991 at three locations. The first site, labelled PAM008, is in the northern part of Big Burn Valley, north of 17 Camp. This population of trees, in an area of roughly 3 km², was being defoliated by an attack of pinyon needle scale insects, *Matsucoccus acalyptus*. Fifty random live trees were marked within the affected area, and 50 more were marked and measured on each of two other BECAMP plots selected for other reasons (RAM001, a baseline plot established in 1988, and PAM007, the undisturbed plot near drill pad U19ac).

Trends in the pinyon pine population cannot be defined because we have only sampled one time. However, the population distributions (Figure 13) of the three groups of trees appear different. PAM008, the plot with a scale

Figure 13 - Pinyon pine size distributions by 50cm height increments.

infestation, has a few large trees and many small trees, 50 to 150 cm tall. Very few trees were found (6%) less than 50 cm tall. The population on PAM007 (drill pad control) appeared to be an almost normal curve with a mean height between 150 and 200 cm, suggesting a new population from a single, relatively recent germination event. The population on RAM001 was well distributed with old, medium, and young trees well mixed. It was the only population with a significant number (24%) of very young plants, those under 50 cm tall. That plot also had mistletoes (*Arceuthobium divaricatum*) growing on some of the older trees, suggesting an older, established population.

The course of the pinyon needle scale outbreak cannot be predicted. The scale can weaken large trees and kill small ones, and it may increase susceptibility to other parasites.

Yucca schidigera

Of the 25 plots set up by E. M. Romney in 1968 below the Mercury sewage ponds, 21 were intact in 1990. Four had been destroyed in an expansion of the ponds several years earlier. Of the 133 *Yucca schidigera* measured on the remaining plots in 1968, 105 (79%) could be matched with plants still living in 1990. Six were dead, six were unmatchable due to coalescence with other plants, and 16 were missing. In addition, 23 new plants were found and one split into two.

DISCUSSION

The BECAMP monitoring program was set up to monitor not only the trends in flora and fauna on the NTS, but also what DOE activities are doing to the ecosystem. In the five years of monitoring (1987-1991) by far the major agent for change was drought, but evidence was also collected for other agents. Recovery of vegetation on the areas blasted clean in the 1950s, changing vegetation patterns on the slopes of subsidence craters, the establishment of the less-drought-hardy shrubs along roadsides, and increases in shrub volume during the "normal" years prior to drought all left their marks on the current perennial plant population of the NTS.

RADIOACTIVE CONTAMINATION

It was not surprising that there was no apparent effect of radioactive contamination on perennial plants. Kaaz et al. (1971) and Vollmer and Bamberg

(1975) showed that low levels of ionizing radiation have to accumulate to about 5000 R before having any measurable effects on the growth patterns (not survival) of the most sensitive species. Romney et al. (1975) showed that transuranics such as the plutonium contaminating the GMX site get into leaves primarily as dust transported through air, rather than through uptake through roots. Thus, although the popular perception of the NTS is of a radioactive wasteland (Figure 14), in fact the fairly extensive areas of radioactively contaminated soils are essentially undisturbed. Indeed, they are protected from more severe disturbances by being fenced to exclude humans, who potentially could be affected by the contaminants. The GMX site studied (Table 27) showed no discernible radiation effects. Although there were some differences in species composition between the GMX and control transects, especially in *Atriplex* species, it was recognized when selecting locations that no good control could be found outside the fenced area due to spatial variation in the vegetation. W. A. Rhoads (1974) analyzed vegetation around GMX, and his analysis concurs in showing significant changes in species dominance near the site (Figure 15). He found shrub densities of about 10 to 33 per 100 m² area, somewhat lower than our values, and cover values around 10-12%, also lower than our values (Appendix 2). Because techniques varied so greatly, however, we cannot conclude there were significant vegetation changes from the early 1970s to 1989 from their data.

This is not to say that radiation does not affect plant growth. A number of reports of radiation kill due to fallout on and near the NTS have been published (Beatley 1965b; Rhoads et al. 1969a, 1969b), but Wallace et al. (1972), in a summary article, showed that two weeks of protection from fallout radiation with a 6 ml plastic cover prevented shrub death, indicating the rapid decline of radiation doses below lethal levels. At the present time, radiation levels on the NTS are apparently not hazardous to perennial plants.

GROUND ZEROES AND SCRAPED AREAS

There are significant similarities between the recovery patterns of ground zeroes, which have had vegetation removed by shearing winds caused by explosions, and scraped areas, which have had the surface scraped off with heavy equipment. The oldest such area studied was the Wahmonie ghost town whose streets were scraped in 1928 (Webb and Wilshire 1980), and the youngest was the 3B waste consolidation site cleared in 1986-87. Early studies of the recovery of vegetation on such areas showed an invasion by *Salsola australis* (Russian thistle) on the ground zeroes (Shields et al. 1963; Martin 1963)

Figure 14 - The GMX experiment.

similar to that seen on the 3B site. After a number of years, perennial bunchgrasses became established and competed sufficiently with the *Salsoia* to keep its size reduced. (However, even after 30 years, all of the ground zeroes areas had significant populations of *Salsoia* seedlings -- see the ephemerals section of this report). In no case was the shift to bunchgrasses well documented, but E. M. Romney provided some evidence of multiple grass germination events during the 1970s, and establishment of bunchgrasses is apparent in the Sedan GZ vegetation records (Hunter 1992; Hunter et al. 1987). On the west side of Yucca Flat the grass was largely *Stipa speciosa*, while on the east side, recovery was largely dominated by *Oryzopsis hymenoides*. The difference is likely due to edaphic factors, as the soils on the west side are rocky, and on the east side they are sandy.

Around Sedan, *Oryzopsis hymenoides* invaded the blast zone outside of 762 m from the blast center by 1975, but invasion by the mixed bunchgrasses (*O. hymenoides*, *Stipa speciosa*, and *Sitanion jubatum*) on the nearer areas occurred in the late 1970s and early 1980s (Hunter et al. 1987).

The only shrub species which successfully reinvaded the ground zeroes by 1991 was *Hymenoclea salsoia*, which earlier invaded the Wahmonie townsite (Webb and Wilshire 1980). The population on the ground zeroes apparently germinated and established in the early 1980s, as shown in the Sedan data (Table 13). It was present on all the ground zeroes on the west side of Yucca Flat, but largely absent on the east side, which again is likely due to edaphic factors. At Wahmonie, which is at a somewhat higher altitude, another shrub, *Thamnosma montana*, also appeared to have established significantly on the scraped area after 61 years. *T. montana* is only locally common on the NTS, and we see no evidence of its invasion on other scraped areas, so I would not expect it to be part of a successional pattern.

The time necessary for vegetation to recover on the ground zeroes cannot be estimated. In more than 60 years, the Wahmonie site is still not approaching what could be considered a normal diversity. This attests to the slow nature of natural revegetation processes in the Mojave Desert (Wallace et al. 1980; Webb et al. 1986; Kay 1979; Lathrop and Archbold 1980). Data on the changes in vegetation over long time spans in the Mojave Desert (Spaulding 1985; Wells and Jorgensen 1964; Cole and Webb 1985; Hunter 1991) and changes which have been hinted at in these studies, suggest that there are relatively continual shifts in the natural vegetation on time scales of centuries. The course of recovery of vegetation on these ground zeroes and scraped areas may be

influenced by climatic factors affecting both the rate and composition of invading vegetation.

That the moisture conditions on the ground zeroes and scraped areas are more favorable than in undisturbed vegetation can be seen in the comparisons of death of the bunchgrasses during the recent (1989-90) severe drought. Almost all perennial bunchgrasses in undisturbed areas died during these years, but on the Sedan and T1 GZs they survived in higher proportions. On T4, the abundant *Sphaeralcea ambigua* seedlings on the GZ indicated moister soil conditions than on the control transect. On T2 and T3 GZs, however, the grass populations were nearly totally eradicated during the drought. Adams et al. (1991) showed in a northwestern forest that soil moisture levels were improved for a few years on logged tree stands, until shrubs grew up to significant sizes. It is routine for NTS areas which have had the shrubs removed to show evidence of increased available soil moisture for years (Hunter 1989, Romney et al. 1981).

One unusual finding was the "transition zone" of largely dead *Atriplex canescens* shrubs on the east side of the T1 GZ. This area was defined in an early map of the blast area by Tanner and Jorgensen (1963) as a "grass zone." There was no evidence in this area that the *Atriplex* (dead of drought in 1991) was the first invader of a normal mixed shrub community. *Atriplex canescens* grows well on disturbed areas (Hunter, unpublished) and is often used in revegetation planting, but neither *A. canescens* nor *O. hymenoides* significantly populated the ground zero even though they were present in this transition zone shortly after the cessation of testing.

Although *Ephedra nevadensis* is nearly ubiquitous on the NTS, it has neither reestablished from below ground nor invaded the GZs. Its seeds germinated from rodent caches (Hunter, unpublished observations) on other disturbed areas. The ground squirrels likely responsible for caching *Ephedra* seeds are present at least in small numbers on the GZs (Saethre and Medica 1992).

BURNED AREAS

A major difference between burned areas and scraped/blast areas is that species which sprout from below ground appear quickly on the burned areas. These species include *Stipa speciosa*, *Ephedra nevadensis*, *Lycium andersonii*, and *Yucca brevifolia* (Hunter and Medica 1989). Below-ground perennials like *Mirabilis pudica* and *Phlox stansburyi* also seem to survive fires well. This

leads to a significant perennial cover within a year after a fire. Three of the burned areas studied by BECAMP personnel were burned after 1985 and showed only initial stages of recovery. However, the burned area in Mid Valley where Dr. Beatley documented the date of the fire (1959; Beatley 1966a) showed very little further recovery in the subsequent 30 years. The plants which probably survived the fire below ground (*Ephedra nevadensis*) grew to a very large size, but did not successfully reproduce. Neither of the two dominant species (*Coleogyne ramosissima* and *Ephedra nevadensis*) recolonized the burned area. Even the *Stipa* present on the burned area, which germinated on the ground zeroes in the late 1970s, appeared to be old and large on the burned area, suggesting a failure to reproduce.

The slow recovery of perennial plants on burned and scraped areas is not universal. An area of Jackass Flats, scraped in the late 1970s for the MX missile program, became essentially recolonized by the dominant species, *Ambrosia dumosa*. This occurred in 1983, when a 10-day period of August storms germinated hundreds of seeds per square meter (Hunter 1989). An area of radiation-killed *Artemisia tridentata* and *Artemisia nova* was reinvaded by *Artemisia* seedlings within 10 years of the disturbance (Romney et al. 1980). In both those cases, the reestablishment was associated with unusually wet years. But why didn't the ground zeroes, the Wahmonie townsite, or the burned site in Mid Valley recover those same years? Soil compaction was suggested by Webb and Wilshire (1980) and appears to be the only plausible hypothesis at this time.

SUBSIDENCE CRATERS

In geological terms, phenomena like the subsidence craters resulting from underground nuclear explosions are very recent. Analogous structures might be found in Meteor Crater, Arizona, various volcanic craters, and more recently open-pit mines. I am not aware of any botanical studies of these phenomena, although north-south facing slopes are commonly known to differ in vegetative parameters (e.g. Delgado et al. 1989; Lipscomb and Nigau 1990; Parker 1991).

The most interesting facets of the subsidence craters are the development of a mini-playa in the bottom and the development of differences in the north-facing and south-facing slopes. The mini-playa is caused by erosion of the slopes and deposition of fine soil at the bottom of the crater. Just as at the bottoms of the closed valleys on the NTS, the playas are essentially devoid of vegetation (Yucca Lake and Frenchman Lake), so this deposit in a

crater bottom is unvegetated. In crater U10af, fenceposts were buried to near the top (Figure 16), indicating several feet of sediment have been deposited in a period of about 23 years. Similar bare areas were seen in Daggett, California, on lenses of fine soil in a sandy area. Unpublished observations at that site showed that after a rainstorm the finer soils were not wet as deeply. Also, the larger, deeper-rooted shrub species were absent from the silt-clay lenses. During winter, some of the smaller lenses were home to *Schismus arabicus*, a diminutive annual grass introduced from eastern Mediterranean areas, and *Plantago insularis*, a diminutive drought hardy annual native to California and Nevada. Larger lenses had no vegetation.

Although salty soils often develop in areas where runoff water pools and evaporates, I do not believe the absence of vegetation from these crater bottoms is due to salt. I believe it is due to two factors. The first is that the surface becomes smooth and hard, which is unfavorable for seed lodging. The other, and more important factor is that hydraulic conductivity of the soil is so great that either the whole soil volume dries too rapidly, with evaporation occurring to the atmosphere, or dry and wet soil volumes equilibrate so rapidly that no area is wet long enough for germination and establishment. That the soil is not too salty for plant growth is shown by the few plants which occur on playas on man-made mounds (Hunter et al. 1991) or wind-blown loess mounds (Vasek and Lund 1980), and by the riparian vegetation which develops in areas where man has created run-in pits on Frenchman Lake or where man has pumped water onto the playa.

The other interesting facet of subsidence crater ecology is the development of differences in vegetation on the north and south slopes. We found grasses in particular more abundant or larger on the north-facing slopes in two of the three craters. The oldest crater was 26 years old when first studied, not enough time to expect major differences to develop. The differences that do appear in the data suggest trends may develop further as time passes.

A less noticeable, but possibly significant factor in the ecology of subsidence craters is the reduced wind speed that one would expect. I would presume reduced wind would reduce evaporation and allow more efficient use of available soil water by plants in the craters. That might lead eventually to increased plant cover and/or volume occurring in the craters, to differential survival of drought by plants in and out of the craters, or development of differences in species composition inside and outside of the crater. At the

Figure 15 - A buried six-foot fencepost in crater U10af demonstrates erosion.

present time, these structures are too new and have been treated too differently from control areas to show any such effects.

ROADSIDES

Of the several hundred miles of paved roads on the NTS, we have studied only a few hundred meters. Our studies demonstrated reduced drought-induced dieback on the road verge next to the pavement of an abandoned roadway. We also found hints of changes in species composition and total plant volume at the edge of the scraped section of an actively maintained roadway.

There is some literature on the enhancement of vegetative growth along paved roads. Johnson et al. (1975) claimed productivity increased significantly due to the presence of the pavement. Artz (1989) found increases, but not statistically significant ones, of density and cover within two meters of a dirt road. Vasek's work is biased by placement of his transects within the areas of major visible effects, and Artz's was limited statistically by small sample areas in the area immediately adjacent to the roadway. My sampling design was changed from 1988 to 1989 to attempt to correct these sample-area problems, but the total area sampled (16 m² for each meter from the road center to 25 m N of the road) was still insufficient to thoroughly characterize the complex vegetation patterns.

In spite of these technical problems, it is fairly clear from the data on *Hymenoclea salsola* (Table 28) that this species occurred (or survived) only between 7 and 15 m of the road center, and that the vast majority of the total live volume for that species was concentrated at 10 m from the center.

I also found no statistically significant differences in overall cover, density, or total live volumes of perennial plants along the roadside (Table 27 and discussion). The obvious implication is that the edge-enhancement effect, which is very striking visually (Figure 17), is a result of displacing vegetative growth to a band of vegetation (in this case 9-10 m from the center) without either increasing or decreasing the total live volume, cover, or density. The tendency, not statistically significant, was for the roadside values to be reduced, rather than enhanced, when averaged over the whole 25 m belt.

Johnson et al. (1975) also reported increases in diversity along a roadside. They found six more species along the roadside than in control transects. I

Figure 16 - Roadside study site FRF003 in Frenchman Flat.

found an average of one more species on roadside transects than on control transects, but on pooled data, each set of transects (400 m²) had 10 live species. Rather than consider "diversity" as a mathematical property of the two populations, however, I prefer to explain the differences in species composition as due to differing ecological factors in the two environments. The three species found only on the roadside (Appendix 2) (*Hymenoclea salsola*, *Artemisia spinescens*, and *Tetradymia axillaris*) are normally seen at higher altitudes (see, e.g., YUF001 data, 1237 m in Appendix 2). The three species seen only on the control transects (*Acamptopappus shockleyi*, *Atriplex canescens*, and *Krameria parvifolia*) are common at lower altitudes, as well, and can be presumed to be more drought hardy. The species common to both the roadside and control areas (*Larrea tridentata*, *Ambrosia dumosa*, *Psoralea fremontii*, *Ephedra nevadensis*, *Ceratoides lanata*, *Lycium andersonii*, and *Grayia spinosa*) are, with the possible exception of *Psoralea fremontii*, long-lived species which were very likely individually present at both sites from prior to construction of the 5-05 road. Insufficient time has passed for the ecological forces present at the two sites to have affected presence/absence of these long-lived, dominant species.

Overall, the road appeared not to have an enhancing effect on vegetation, but it did appear to change conditions enough to affect the species present. Also, it did concentrate growth and live plant volume in a band next to the scraped area. At certain times of the year, this band of vegetation and the scraped areas between the pavement and the edge of the perennial population may have green and growing plants, when vegetation in areas farther from the road is dormant. This prolonged vegetative state is a likely mechanism for producing the concentrated live volume, and is also apparent to animals dependent on green vegetation for food. At that time of year, herbivores such as jackrabbits, desert tortoises, and desert iguanas may be attracted to roadsides and face an increased risk of being killed by traffic (Chew and Butterworth 1964).

REVEGETATED SITES

Although revegetation of scraped areas on the NTS has been researched since the early 1970s by UCLA (e.g., Hunter et al. 1980; Hunter 1987; Wallace et al. 1980), there was never any assessment of the effects of revegetation on the return of fauna. In 1991, BECAMP sampled reptiles and small mammals on a site revegetated in 1989 by UCLA. The transplanted shrubs had by 1991 grown to a volume roughly 20% of that on the undisturbed area, and the return of the

common lizard *Uta stansburiana* to this scraped area can be considered related to the plant cover. (See the section on reptiles by Medica et al. in this report.)

DROUGHT

By far, the greatest influence on NTS perennial plants in many years was the severe drought which persisted from August 1988 through June 1990. Small storms in July 1990 and thereafter resulted in a partial reduction in drought stress, so that only severely weakened plants died after that time.

Rainfall was not uniformly low throughout the NTS. U.S. Weather Service precipitation records from several sampling stations around the NTS are summarized in Table 36. If we consider any year in which rainfall is less than two standard errors below the mean to be a drought year (Chang and Kleopa 1991), then it is seen that it is relatively common to have two consecutive years of drought. In the most recent series of drought years, Frenchman Flat and Yucca Flat experienced 3 and 4 consecutive years of drought, respectively. Jackass Flats, Mercury Valley, and Pahute Mesa each experienced two consecutive years of drought. The year of lowest precipitation was 1989 for each area except Jackass Flats, whose lowest year was 37 mm in 1975.

Table 36. A summary of calendar year precipitation (mm) for several areas of the Nevada Test Site. Asterisks indicate years ≥ 2 sem below the 1969-1991 average.

Year	Jackass Flats	Frenchman Flat	Mercury	Yucca Flat	Pahute Mesa
1969	211	190		271	243
1970	104*	80*		129*	142*
1971	85*	85*		158	201
1972	112	96*	167	158	176
1973	153	160	176	209	197
1974	83*	132	109*	190	163
1975	37*	63*	75*	179	174
1976	202	123	158	210	255
1977	114	118	100*	170	187
1978	293	221	144	308	324
1979	119	107	116*	102	106*
1980	125	137	161	212	148*
1981	87*	94*	119*	92*	158

Table 36, continued.

Year	Jackass Flats	Frenchman Flat	Mercury	Yucca Flat	Pahute Mesa
1982	116	187	190	211	239
1983	303	223	266	350	170
1984	258	225	276	276	267
1985	≥69*	83*	104*	106*	74*
1986	171	152	178	154	135*
1987	205	180	211	203	244
1988	132	111	133	114*	118*
1989	52*	29*	24*	63*	69*
1990	108*	83*	105*	54*	155
1991	137	79*	146	>118*	156
Mean	142	129	153	176	178
± Sem	±15	±11	±14	±16	±13
Beatley Mean	122	123	179	179	

There was more to the drought years 1989-1990 than is apparent from the rainfall data. Also of importance were altitude (and thus temperature and potential evapotranspiration), plant population numbers and volumes, soil type, and plant species.

Above an altitude of about 1400 m, shrub live volumes did not significantly decrease. At Mid Valley, volumes decreased only 14% from 1987 to 1990 (Table 37) and a similar volume decrease on Pahute Mesa was recorded, largely due to failure to flower of *Artemisia nova*. Grasses fared badly in Mid Valley (-73%), but only declined 15% on Pahute Mesa.

Table 37. Indications of drought severity on BECAMP plots sampled in 1987 or 1988 and again in 1990 or 1991, arranged by altitude. Sites with asterisks were dominated by *Larrea tridentata*.

Plot	Altitude	% Dead	grass #'s	Shrub volumes
FF66	@ 940m	83	--	- 99
FF67	@ 940	99	--	- 99
FF81	@ 945	100	- 100	- 100
FF84*	@ 950	62	- 100	- 29

Table 37. continued.

Plot	Altitude	% Dead	% Decline	
			grass #'s	Shrub volumes
JAF001 V1*	954	45	- 100	- 38
JAF001 V5	954	52	- 100	- 97
FRF001 V1*	965	74	- 100	- 27
FRF001 v3*	965	74	- 100	- 23
FRF001 V5*	965	76	- 100	- 28
FRF002 V2*	977	35	- 100	- 36
MER003*	1,103	65	0	- 43
YUF001 V1	1,237	67	- 89	- 47
YUF001 V2	1,237	60	- 93	- 38
YUF001 V3	1,237	63	- 97	- 21
YUF012	1,239	69	- 99	- 78
YUF010	1,267	66	- 98	- 71
YUF002	1,288	64	- 73	- 29
YUF018	1,335	51	- 89	- 34
MID001	1,445	50	- 73	- 14
PAM001	1,928	21	- 15	- 14

The age distribution of the plant population can vary in time. At the beginning of the 1989-1990 drought, there were many young plants which had germinated in the late 1970s and early 1980s. Data from Sedan (Table 13; Hunter 1992; Hunter et al. 1985) and Romney's observations on T1 ground zero (Hunter 1992) show an increase in grasses on these blast areas during those years. Many *Hymenoclea salsola* and *Ambrosia dumosa* apparently germinated and established in the early 1980s (Hunter et al. 1985; Hunter 1989). These young, small plants are more susceptible to drought-kill (Parker 1982; Hunter 1989).

Another factor in vegetative condition is size. In 1988, after a series of moderately good years, some established shrubs northeast of Frenchman Lake (transects FF66,67) were apparently two to three times the volume when first measured in 1981. A nearly two-fold increase in shrub biomass resulted from artificial doubling of rainfall for two summers in Mercury Valley (Romney et

al. 1978). I believe in many areas of the NTS shrub live volumes increased significantly during the unusually wet summers of 1983 and 1984, and the series of moderately good years from 1985 through 1988 did not decrease volumes sufficiently to prevent severe competition for water during the 1989-90 drought.

Plant species showed strong differences in abilities to survive extended drought. The dominant species tended to survive with the least shrinkage. As can be seen in Table 37, essentially all grasses died below 1300 m. An exception was the rhizomatous grass *Hilaria jamesii*. This grass was not common, but survived well in central Yucca Flat on the T1 and Sedan blast areas. Much of the *Hymenoclea salsola* on the NTS died during the drought, except in washes, disturbed areas, and on roadsides (e.g., Tables 4, 13, 28).

The different strategies of drought tolerance played a role in differential survival. Three dominant evergreen species (*Larrea tridentata*, *Ephedra nevadensis*, and *Coleogyne ramosissima*) which tolerate and remain green at low water potentials did very well with minimal dieback (Clark et al. 1974; Parsons et al. 1981). The species which store water in stems or trunks also had no trouble tolerating long periods of drought, but these plants were often severely damaged by grazing animals (Table 35). Drought deciduous shrubs, which drop their leaves during drought, fared poorly. Many died, and most died back to the central basal stem. Of these, the smaller species, *Acamptopappus shockleyi* and *Artemisia spinescens*, declined the most. However, the *Ambrosia dumosa* population was also severely damaged.

One group of plants, which die to below ground level each year, fared well. This group includes the rhizomatous grass *Hilaria jamesii* mentioned above, two low woody species, *Kochia americana* and *Polygala subspinosa*, and the herb *Mirabilis pudica*. These species are rarely of significant size, but they tended to survive better than many of the larger shrubs. Other species with this habit, usually sampled with ephemeral plants, are the lily and onion bulbs and the low herb *Phlox stansburyi*.

Although we often had species of differential drought susceptibility occurring on the same plots, we could not rank the different species on an absolute scale. They tended to behave differently in different environments. For example, *Menodora spinescens* survived on the sandy soil of Jackass Flats with almost no net shrinkage from 1988-1991, doing better than *Larrea tridentata* there. But in Yucca Flat (YUF012) it shrank 50%, worse than *Ephedra*

nevadensis, which itself did worse than the co-occurring *Larrea tridentata* in Frenchman Flat.

Similarly, on the fine soils near Frenchman Lake, which have long been populated by near monocultures of *Atriplex canescens* and *A. confertifolia* (Beatley 1976), these two species were completely killed, although in mixed shrub populations on Yucca Flat *A. canescens* tended to survive when growing in mixed clumps.

A general summary of relative drought tolerance of the major species on the NTS is given in Table 38. At the present time, this is the best that can be offered. The BECAMP data could be analyzed to relate individual plant sizes, shading by other species, soil type, and length of drought to plant survival. That work is beyond the scope of this report.

Drought may have exacerbated the effects of the scale insect attacking pinyon pine trees in Big Burn Valley. This population extends to the lower limits of pine tree distribution. The sparse needles produced during drought years may be partially responsible for the apparent severity of this attack.

Table 38. Relative drought hardiness of NTS plants found below 1400 m in the Mojave Desert and transition communities.

Most hardy	Very hardy	Hardy	Least hardy
<i>Col ram</i>	<i>Amb dum</i>	<i>Aca sho</i>	<i>Hym sal</i>
<i>Eph nev</i>	<i>Cer lan</i>	<i>Art spi</i>	<i>Ory hym</i>
<i>Lar tri</i>	<i>Gra spi</i>	<i>Atr con</i>	<i>Sit jub</i>
<i>Lyc and</i>		<i>Chr vis</i>	<i>Sph amb</i>
<i>Men spi</i>		<i>Hap coo</i>	<i>Sti spe</i>
		<i>Koc ame</i>	
		<i>Mir pud</i>	
		<i>Pol sub</i>	
		<i>Tet axi</i>	
		<i>Tet gla</i>	

There are a number of facets of drought. Even short, seasonal drought can stress desert plants and tolerance of low water potentials is a requirement for nearly all NTS perennials for that reason. A few studies have been done

on desert plants to measure carbon gain and water loss at low water potentials (e.g. Clark et al. 1974; Sisson 1989; Tenhunen et al. 1989; Bamberg et al. 1975; Strain 1970). These studies document drought hardiness of established plants of the dominant species, but no such information is available for the less drought-hardy species which compete with the dominants.

It is rare for researchers to document the length of drought conditions. Survival for extended dry periods was an important property of the dominant species on the NTS in 1989-1991. The grouping in Table 38 reflects that facet more than tolerance of low water potentials. Parsons et al. (1981) documented survival of a two year drought by the chaparral shrub *Arctostaphylos viscida*. In the Atacama Desert of Chile, some shrubs survived as many as ten years of drought, with several different strategies (Rundel et al. 1980).

A final important facet is seedling survival during drought. During 1991, we found a few small plants which were not censused three years earlier and which were probably seedlings. For example, north of Sedan in a *Coleogyne ramosissima* community (YUF018) three live *Coleogyne* seedlings 4 to 6 cm tall and two dead ones were found in the open, easily visible, which were not noted in the 1988 data. On Pahute Mesa and in Yucca Flat, new shoots of *Ephedra nevadensis* were occasionally found which had clearly sprouted from below ground the same year. With those exceptions, there was essentially no recruitment of new perennial plants from 1988 through 1991. This observation is similar to that noted by Jordan and Nobel (1979, 1981) for establishment of the succulents *Ferocactus acanthodes* and *Agave deserti*, in which it was rare for conditions to favor both germination and survival for long enough for establishment to occur. Similarly, Smith and Monson (1990) showed drought prevented establishment of a cohort of *Encelia farinosa* seedlings except in a wash.

THE FUTURE

This survey of changes in NTS perennials over the few years available from current records is partially intended to document present conditions and some of the forces leading to change. I believe we have documented effects of some of the factors which might cause fluctuations about an equilibrium, such as drought, fire, and grazing damage. I have also indicated factors which might lead to permanent changes, such as changes in slope in subsidence craters and changes in water availability along roadsides. Over a longer term, there are some additional factors which may lead to significant change. One of the

greatest potential influences of man is introduction of new species. For NTS perennial plants, the most significant introductions so far are annual grasses, which change fire frequency, and large herbivores -- horses and cows.

There are reports from all around the world of major changes in flora and fauna caused by species introductions. The native plants and animals of the Galapagos Islands (Schofield 1989) and Hawaii (Hughes et al. 1991) are seriously threatened. In Texas, the Chinese Tallow tree is displacing grassland (Cameron 1988). By the 1930s, Talbot et al. (1939) reported "... the native vegetation over vast areas in California has been replaced by plants introduced from the old world." The colonization of New Zealand humans led to "extinction or reduction of much of the vertebrate fauna, destruction of half of the lowland and montane forests, and widespread soil erosion" (McGlone 1989).

Climate change is of much current interest and past climate changes have significantly changed the NTS vegetation (Spaulding 1990). However, man has had greater effects than climate. For example, McGlone (1989) looked at both climate change and human effects in New Zealand and found that human ones predominated. Grover and Musick (1990) examined expansion of *Larrea tridentata* into New Mexico grasslands and concluded that the expansion was "triggered by extreme livestock overgrazing at the end of the nineteenth century, which coincided with rainfall regimes that were unfavorable for perennial grass growth". I believe that in the future human activities will be the major factor for change in the NTS ecosystem. The most threatening activities are species introductions and expansion of those already introduced (horses and grasses in particular). Roads will provide invasion routes for these and other species. Disturbance of existing vegetation will provide foci for invasion and spread of new introductions.

More subtle effects can also be expected from regional pollution and human-induced climate changes, but these may be masked by the normal climate fluctuations in the desert.

The monitoring program established by BECAMP in 1987 is beginning to document these changes. It is the first step in what should be a program to manage the NTS flora and fauna, so that when changes do occur they are planned rather than accidental.

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5 of 6

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APPENDIX I

SPECIES NAMES AND ABBREVIATIONS

Appendix 1. Perennial plant species names, authorities, and the abbreviations used in the tables for this report.

SPECIES AND AUTHORITY	ABBREVIATION
<i>Acamptopappus shockleyi</i> Gray	ACA SHO
<i>Ambrosia dumosa</i> (Gray) Payne	AMB DUM
<i>Ambrosia dumosa</i> X <i>Hymenoclea salsola</i>	AMBXHYM
<i>Arceuthobium divaricatum</i> Engelm.	ARC DIV
<i>Arenaria congesta</i> Nutt. ex Torr. & Gray	ARE CON
<i>Artemisia nova</i> A. Nels.	ART NOV
<i>Artemisia spinescens</i> D.C. Eat.	ART SPI
<i>Artemisia tridentata</i> Nutt.	ART TRI
<i>Atriplex canescens</i> (Pursh) Nutt.	ATR CAN
<i>Atriplex confertifolia</i> (Torr. & Frem.) S. Watts	ATR CON
Perennial bunchgrass (not identified)	BUNCHGR
Cacti (unidentified to species)	CACTI
<i>Ceratoides lanata</i> (Pursh) J.T. Howell	CER LAN
<i>Chrysothamnus nauseosus</i> (Pallas) Britt.	CHR NAU
<i>Chrysothamnus teretifolius</i> (Dur. & Hilg.) Hall	CHR TER
<i>Chrysothamnus viscidiflorus</i> (Hook.) Nutt.	CHR VIS
<i>Chrysothamnus viscidiflorus</i> ssp. <i>puberulus</i> (D. C. Eat.) Hall & Clements	CH VI p
<i>Coleogyne ramosissima</i> Torr.	COL RAM
<i>Cryptantha flavoculata</i> (A. Nels.) Payson	CRY FLA
<i>Delphinium parishii</i> Gray	DEL PAR
<i>Ephedra nevadensis</i> S. Wats.	EPH NEV
<i>Ericameria cooperi</i> (Gray) Hall	ERI COO
<i>Eriogonum caespitosum</i> Nutt.	ERI CAE
<i>Eriogonum ovalifolium</i> Nutt.	ERI OVA
<i>Erioneuron pulchellum</i> (H.B.K.) Tateoka	ERI PUL
<i>Grayia spinosa</i> (Hook.) Moq.	GRA SPI
<i>Hilaria jamesii</i> (Torr.) Benth.	HIL JAM
<i>Hymenoclea salsola</i> Torr. & Gray ex Gray	HYM SAL
<i>Juniperus osteosperma</i> (Torr.) Little	JUN OST
<i>Kochia americana</i> Benth.	KOC AME
<i>Krameria parvifolia</i> Benth.	KRA PAR
<i>Larrea tridentata</i> (Sesse & Moc. ex DC.) Coville	LAR TRI

Appendix 1, continued.

SPECIES AND AUTHORITY	ABBREVIATION
<i>Lepidium fremontii</i> S. Wats. Gray	LEP FRE
<i>Lycium andersonii</i> Gray	LYC AND
<i>Lycium pallidum</i> Miers	LYC PAL
<i>Menodora spinescens</i> Gray	MEN SPI
<i>Mirabilis pudica</i> Barneby	MIR PUD
<i>Opuntia basilaris</i> Engelm. & Bigelow	OPU BAS
<i>Opuntia echinocarpa</i> Engelm. & Bigelow	OPU ECH
<i>Opuntia erinacea</i> var. (A. Weber) Parish	OPU ERI
<i>Oryzopsis hymenoides</i> (Roemer & Schultes) Ricker	ORY HYM
<i>Penstemon</i> species (not identified)	PEN sp
<i>Phlox stansburyi</i> (Torr.) Heller to species)	PHL STA
<i>Pinus monophylla</i> Torr. & Frem.	PIN MON
<i>Poa fendleriana</i> (Steud.) Vasey	POA FEN
<i>Polygala subspinoso</i> S. Wats.	POL SUB
<i>Psoralea fremontii</i> (Torr. ex Gray) Barneby	PSO FRE
<i>Psoralea polydenius</i> (Torr. ex S. Wats.) Rydb.	PSO POL
<i>Salazaria mexicana</i> Torr.	SAL MEX
<i>Sitanion jubatum</i> J.G. Sm.	SIT JUB
<i>Sphaeralcea ambigua</i> Gray	SPH AMB
<i>Stanleya pinnata</i> (Pursh) Britt.	STA PIN
<i>Stipa comata</i> (Pursh) Britt.	STI COM
<i>Stipa speciosa</i> Trin. & Rupr.	STI SPE
<i>Tetradymia axillaris</i> A. Nels.	TET AXI
<i>Tetradymia glabrata</i> Torr. & Gray	TET GLA
<i>Thamnosma montana</i> Torr. & Frem.	THA MON
<i>Xylorhiza tortifolia</i> (Torr. & Gray) Greene	XYL TOR
<i>Yucca baccata</i> Torr.	YUC BAC
<i>Yucca brevifolia</i> Engelm.	YUC BRE
<i>Yucca schidigera</i> Roez1 ex Ortgies	YUC SCH

APPENDIX J

The following are tables of summary data for perennial plants censused throughout the Nevada Test Site during calendar years 1989 through 1991. Except where otherwise noted, the data are for 100 square meter belt transects. The tables are ordered by valley or mesa, and within each landform by altitude of the undisturbed plots for each disturbance type. Table numbers are as follows:

Site , Type of Plot	Tables
Jackass Flats	
JAF001; Baseline	1-3
WAH001; Wahmonie ghost town	4,5
Frenchman Flat	
FF66,67,81,84; LGF monitoring	6-9
FRF005,006; GMX	10,11
FRF001; Baseline	12-14
FRF003,004; Roadside	15,16
FRF002; Roadside	17,18
Mercury Valley	
MER002, 003; gopher denuded	20,21
MER004; Beatley Plot 2	22
Yucca Flat	
YUF031; Beatley Plot 60	23
YUF013; T3 GZ	24
YUF011, 012; 3B Waste Consolidation Site	25,26
YUF001; baseline	27-29
YUF019, 020; Crater U3cn (Bilby)	30-33
YUF021, 022; Crater U7an	34-37

Appendix 2, continued.

Site , Type of Plot	Tables
YUF009, 010, 029; T1 GZ	38-40
YUF002, 003; 1985 burned area	41-42
YUF023, 024; Crater U10af	43-46
YUF025, 026; T4 GZ	47,48
YUF016, 017, 108; Sedan blast area	49-51
YUF014, 015; T2 GZ	52,53
YUF030; Beatley Plot 51	54
Mid Valley	
MID004, 005; MX bladed area	55,56
MID006, 007; 1959 fire, Beatley plots 41, 42	57,58
MID001; 1986 burned area	59,60
Forty Mile Canyon	
RED001, 002; 1988 burned area	61,62
FOR001, 002; Beatley Plots 61,62	63,64
Pahute Mesa	
PAM002, 003; Drill pad U20ao	65
PAM001; Baseline	66,67
PAM006, 007 Drill pad U19ac	68,69
Rainier Mesa	
RAM002; Beatley Plot 64	70

Table 1. Population characteristics of perennial plants on baseline plot JAF001, transect V1, sampled July 12, 1988 (top line), June 19, 1990 (second) and Aug. 12, 1991 (third). Elevation 954 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ACA SHO	143	21±1	36±1	33±1	10.9±0.7	15.6	33.2±2.7	4743	103±8.4	14.7
ACA SHO*	40	28±3	40±6	37±6	13.5±3.6	*	44.1±14.4	*	137±45	*
ACA SHO	80	19±1	23±1	16±1	3.52±0.38	2.82	7.57±1.04	606	23.5±3.2	1.88
AMB DUM	72	28±1	40±2	38±2	14.2±1.4	10.2	46.7±5.67	3361	117±14	8.40
AMB DUM*	44	17	25	15	2.95	*	5.01	*	12.5	*
AMB DUM	67	25±1	35±1	29±1	8.92±0.67	5.97	23.8±2.1	1596	59.6±5.3	3.99
CER LAN	5	33±8	31±4	31±7	8.51±2.63	0.43	35.2±18.5	176	113±59	0.56
CER LAN	4	31±10	29±5	18±7	4.54±2.63	0.14	19.1±15.0	57.3	61.1±47.9	0.18
CER LAN	5	28±2	22±4	18±2	2.91±0.44	0.15	7.65±0.63	38.3	24.5±2.0	0.12
LAR TRI	11	89±8	148±17	137±18	179±41	19.7	1885±611	20736	2451±794	27.0
LAR TRI	7	90±11	165±28	128±23	193±58	13.5	2129±814	14903	2768±1058	19.4
LAR TRI	7	84±9	161±30	117±23	179±59	12.5	1813±718	12690	2357±933	16.5
MEN SPI	19	22±2	58±8	56±7	32.8±7.4	6.24	90.2±25.0	1714	749±207	14.2
MEN SPI	20	17±2	34±7	28±6	11.0±3.4	1.42	25.7±10.0	334	213±83	2.77
MEN SPI	20	19±2	52±8	44±7	26.5±7.9	5.30	68.6±24.6	1373	570±204	11.4
ORY HYM	38	131	7±1	7±1	0.75±0.26	0.29	1.10±0.36	41.6	1.21±0.40	0.05
ORY HYM	0	-	-	-	-	-	-	-	-	-
ORY HYM	0	-	-	-	-	-	-	-	-	-

* In 1990 many *Acamptopappus shockley* and *Ambrosia dumosa* were so dormant that live size could not be measured. Cover, volume, and biomass were calculated on incomplete portions of the populations.

Table 1, continued.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
DEAD GR	3	16±2	10±4	7±1	0.55±0.26	0.02	0.81±0.31	2.43	-	-
DEAD GR	53	19±1	8±1	7±1	0.67±0.19	0.35	1.22±0.42	64.6	-	-
DEAD GR	49	13±1	9±1	7±1	0.86±0.30	0.42	1.11±0.43	54.2	-	-
DEAD SH	10	13±2	25±3	19±3	4.13±0.90	0.41	6.35±2.00	63.5	-	-
DEAD SH	146	24±1	38±1	31±1	10.8±0.6	15.7	29.7±2.2	4342	-	-
DEAD SH	96	18±1	31±2	23±1	7.14±0.61	6.85	15.8±1.8	1518	-	-
TOTALS	288	-	-	-	-	52.5	-	30772	-	64.9
TOTALS	115	-	-	-	-	16.2	-	15652	-	23.4
TOTALS	179	-	-	-	-	26.8	-	16303	-	33.9

Table 2. Population characteristics of perennial plants on baseline plot JAF001, transect V4, sampled July 11, 1988 (top line), June 25, 1990 (second line). Elevation 954 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOL	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ACA SHO	107	25±1	34±1	29±1	8.51±0.6	9.10	24.2±2.2	2589	75.0±6.7	8.02
ACA SHO*	28	25	26	17	3.47	*	8.68	8.68	26.9	*
AMB DUM	64	31±1	47±4	40±3	20.6±3.4	13.2	87.2±19.7	5584	218±49	14.0
AMB DUM*	42	-	-	-	-	-	-	-	-	-
CER LAN	13	30±3	28±3	25±3	6.12±1.16	0.80	21.2±5.1	275	67.7±16.2	0.88
CER LAN	11	27±3	19±3	13±2	2.23±0.50	0.22	6.80±1.89	68.0	21.8±6.1	0.22
LAR TRI	2	102±13	235±5	281±29	518±42	10.4	5223±239	10447	6790±311	13.6
LAR TRI	2	99±5	328±35	242±20	629±118	12.6	6248±1446	12496	8122±1879	16.2
MEN SPI	5	19±5	56±24	51±24	40.7±27.6	2.04	132±103	662	1098±857	5.49
MEN SPI	5	12±5	34±15	30±14	12.9±9.5	0.52	28.8±24.5	11503	239±203	0.95
ORY HYM	45	14±1	4±0	4±0	0.17±0.05	0.08	0.28±0.09	12.5	0.31±0.10	0.01
ORY HYM	0	-	-	-	-	-	-	-	-	-
DEAD GR	6	20±3	10±3	10±4	1.31±0.90	0.08	1.78±1.06	10.7	-	-
DEAD GR	64	15±1	8±1	6±1	0.59±0.10	0.38	0.72±0.17	46.2	-	-
DEAD SH	27	15±1	27±3	24±3	6.58±1.35	1.78	13.1±3.4	353	-	-
DEAD SH	140	21±1	38±1	32±1	11.4±1.0	16.0	31.1±3.9	4354	-	-
TOTALS	236	-	-	-	-	35.5	-	19568	-	41.9
TOTALS	88*	-	-	-	-	13.4	-	12688	-	17.4

* It was difficult to distinguish live from dead plants of these species.

Table 3. Population characteristics of perennial plants on baseline plot JAF001, transect V5, sampled July 11, 1988 (top) and June 29,1990 (second). Elevation 954 m. *See note on Table 2.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ACA SHO	94	26±1	42±2	37±2	14.0±1.0	13.1	40.4±3.3	3797	1250±10.3	11.8
ACA SHO*	51	-	-	-	-	-	-	-	-	-
AMB DUM	84	25±1	38±3	35±3	16.0±2.2	13.5	58.6±9.4	4926	147±23	12.3
AMB DUM*	58	18±5	17±6	14±8	3.39±2.68	*	11.8±10.7	59.2	29.6±26.8	*
CER LAN	18	23±3	23±5	18±3	5.31±1.83	0.96	19.4±7.8	348	61.9±25.1	1.11
CER LAN	7	22±5	15±2	13±4	1.85±0.80	0.13	6.02±3.84	42.1	19.3±12.3	0.13
KRA PAR	1	14	9	21	1.48	0.02	2.08	2.1	4.16	0.00
KRA PAR	1	9	22	20	3.46	0.04	3.11	3.1	6.22	0.01
LAR TRI	1	32	49	26	10.0	0.10	32.0	32.0	41.6	0.04
LAR TRI	1	33	45	30	10.6	0.11	35.0	35.0	45.5	0.05
MEN SPI	6	18±4	35±13	31±10	13.9±8.25	0.84	35.1±21.0	211	292±175	1.75
MEN SPI	8	17±3	27±9	25±7	8.69±4.42	0.70	22.7±12.6	182	189±105	1.51
ORY HYM	42	20±1	6±1	6±1	0.50±0.13	0.21	0.99±0.25	41.4	1.08±0.28	0.05
ORY HYM	0	-	-	-	-	-	-	-	-	-
DEAD GR	7	12±3	9±2	7±2	0.60±0.28	0.04	0.83±0.60	5.8	-	-
DEAD GR	56	15±1	10±1	8±1	0.96±0.18	0.54	1.63±0.38	91	-	-
DEAD SH	12	13±2	23±6	22±3	5.59±2.11	0.67	11.0±5.6	132	-	41.9
DEAD SH	83	20±1	33±2	26±2	9.27±1.08	7.70	25.6±3.6	2127	-	17.4
TOTALS	246	-	-	-	-	28.7	-	9357	-	27.0
TOTALS	246	-	-	-	-	28.7	-	9357	-	27.0

Table 4. Population characteristics of perennial plants on plot BEATLY66, WAH001-control (Beatley Plot 66), in the Wahmonie mining camp, sampled on Aug. 15, 1989. Elevation 1311 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ACA SHO	1	40	90	87	61.5	0.61	246	246	763	0.76
COL RAM	2	49±42	53±42	53±43	36.7±35.7	0.73	330±329	659	1714±1711	3.43
EPH NEV	12	65±3	107±9	103±10	93.4±15.5	11.2	6288±108	7533	879±152	10.6
GRA SPI	18	65±3	77±9	65±7	43.3±8.5	7.80	306±69	5510	704±160	12.7
LAR TRI	7	168±10	173±21	170±15	243±46	17.0	4307±1003	30149	5599±1304	39.2
LYC AND	12	56±4	113±18	81±	3.46	0.04	3.11	3.1	6.22	0.01
SAL MEX	1	67	75	72	42.2	0.42	2840	2840	7106	0.71
STI SPE	17	3±1	12±3	9±2	1.32±0.54	0.22	0.17±0.06	2.9	0.19±0.06	0.00
THA MON	38	25±2	34±4	33±4	12.5±2.6	4.76	42.4±9.6	1610	72.0±16.3	2.74
DEAD GR	28	33±3	16±2	12±2	2.25±0.50	0.63	9.28±2.16	260	-	-
DEAD SH	7	24±5	73±21	61±17	49.9±20.9	3.50	150±84	1048	-	-
TOTALS	108	-	-	-	-	53.4	-	53074	-	85.6

Table 5. Population characteristics of perennial plants on plot WAH001-roadway (Beatley Plot 67), in a scraped area of Wahmonie mining camp in eastern Jackass Flats, sampled Aug. 16, 1989. Elevation 1311 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ACA SHO	5	37±3	39±4	37±9	11.6±3.7	0.46	46.7±19.2	187	145±59	0.58
EPH NEV	11	65±8	103±20	93±15	95.9±27.8	10.6	792±272	8711	1109±380	12.2
GRA SPI	2	47±18	53±26	33±21	18.3±15.8	0.37	1158±107	2303	264±246	0.53
HYM SAL	1	8	7	5	0.27	0.00	0.22	0.22	0.70	0.00
LYC AND	11	49±5	09±13	93±14	77.6±17.2	8.54	405±83	4457	891±182	9.81
SAL MEX	3	69±2	108±13	102±5	85.6±7.0	2.57	589±40	1766	1472±101	4.42
STI SPE	75	1±0	20±1	18±1	3.35±0.31	2.51	0.33±0.03	25.1	0.37±0.03	0.03
TET AXI	1	33	60	53	25.0	0.25	82.4	82.4	223	0.22
THA MON	30	29±3	34±5	29±4	11.9±2.97	3.56	54.1±16.4	1624	92.0±27.8	2.76
DEAD GR	15	34±2	25±3	20±2	4.31±0.73	0.65	15.1±2.7	227	-	-
DEAD SH	12	22±6	29±8	26±6	9.70±4.35	1.16	48.4±28.6	5818	-	-
TOTALS	138	-	-	-	-	28.8	-	17082	-	30.5

Table 6. Population characteristics of perennial plants on plot FF66 on the north edge of Frenchman Lake, sampled on June 6, 1990 (top) and May 21, 1991 (second). Elevation 940 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ATR CON	8	29±4	34±6	24±5	7.85±2.50	0.63	26.4±8.8	211.2	124±42	0.99
ATR CON	3	27±6	31±9	17±4	4.67±2.29	0.14	15.4±10.1	46.3	72.5±47.3	0.22
KOC AME	2	6±5	5±4	4±3	0.19±0.18	0.00	0.19±0.18	0.4	0.6±0.6	0.00
KOC AME	23	7±1	3±16	3±0	0.13±0.07	0.03	0.19±0.13	4.3	0.6±0.4	0.01
DEAD GR	132	30±1	46±3	39±3	22.2±2.5	29.2	103±14	13621	-	-
DEAD GR	126	32±1	49±3	41±3	23.7±2.6	29.9	111±15	14033	-	-
TOTALS	10	-	-	-	-	0.63	-	212	-	0.99
TOTALS	26	-	-	-	-	0.17	-	50.6	-	0.23

Table 7. Perennial plant population characteristics on plot FF67, on the north edge of Frenchman Lake, sampled June 11, 1990 (top) and June 3, 1991 (second). Elevation 940 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ATR CAN	6	36±9	35±8	24±6	8.6±2.7	0.52	41±16	246	107±43	0.64
ATR CAN	1	49	41	36	11.6	0.12	57	57	148	0.15
ATR CON	9	35±4	40±7	33±5	12.4±4.1	1.12	54±22	483	252±104	2.27
ATR CON	0	-	-	-	-	-	-	-	-	-
DEAD SH	64	32±1	47±3	38±2	16.8±1.8	10.8	67±9	4313	-	-
DEAD SH	78	32±1	46±2	37±2	16.2±1.7	12.6	62±8	4847	-	-
TOTALS	15	-	-	-	-	1.63	-	729	-	2.91
TOTALS	1	-	-	-	-	0.12	-	57.0	-	0.15

Table 8. Population characteristics of perennial plants on plot FF81, northeast of Frenchman Lake, sampled June 14, 1990 (top line) and June 3, 1991 (second). Elevation 945 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ATR CAN	4	34 $\pm$ 8	42 $\pm$ 22	36 $\pm$ 23	23.5 $\pm$ 21.0	0.94	131 $\pm$ 124	524	341 $\pm$ 322	1.36
ATR CAN	0	-	-	-	-	-	-	-	-	-
ORY HYM	1	8	4	3	0.09	0.00	0.08	0.08	0.08	0.00
ORY HYM	0	-	-	-	-	-	-	-	-	-
DEAD GR	0	-	-	-	-	-	-	-	-	-
DEAD SH	23	7 $\pm$ 1	9 $\pm$ 1	8 $\pm$ 1	0.64 $\pm$ 0.13	0.15	0.51 $\pm$ 0.19	11.7	-	-
DEAD SH	81	24 $\pm$ 2	39 $\pm$ 4	31 $\pm$ 3	16.6 $\pm$ 2.9	13.4	73.3 $\pm$ 15.6	5938	-	-
DEAD SH	68	30 $\pm$ 2	48 $\pm$ 4	39 $\pm$ 4	21.0 $\pm$ 3.3	13.9	87.4 $\pm$ 16.5	5770	-	-
TOTALS	5	-	-	-	-	0.94	-	524	-	1.36
TOTALS	0	-	-	-	-	0.00	-	0	-	0.00

Table 9. Population characteristics of perennial plants on plot FF84, northeast of Frenchman Lake, sampled June 15, 1990 (top) and June 4, 1991 (second). Elevation 945 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ATR CAN	1	38	51	48	19.2	0.19	73.1	73.1	190	0.19
ATR CAN	0	-	-	-	-	-	-	-	-	-
HYM SAL	1	9	17	14	1.87	0.02	1.68	1.78	5.38	0.01
HYM SAL	0	-	-	-	-	-	-	-	-	-
LAR TRI	5	107±14	155±23	138±26	186±55	9.29	2242±777	11210	2915±1011	14.6
LAR TRI	5	96±17	147±29	114±28	157±58	7.83	1820±768	9100	2366±998	11.8
PSO POL	1	24	40	32	10.05	0.10	24.1±15.6	24.1	60.3	0.06
PSO POL	0	-	-	-	-	-	-	-	-	-
DEAD GR	1	13	17	20	2.67	0.03	3.47	3.5	-	-
DEAD GR	1	13	32	23	5.78	0.06	7.51	7.5	-	-
DEAD SH	5	48±5	80±9	72±10	47.9±11.2	2.39	230±63	1152	-	-
DEAD SH	8	40±5	68±10	53±9	32.3±8.2	2.59	147±44	1177	-	-
TOTALS	8	-	-	-	-	9.60	-	11309	-	14.8
TOTALS	5	-	-	-	-	7.83	-	9100	-	11.8

Table 10. Population characteristics of perennial plants on plot FRF005 (GMX), sampled Sept. 21, 1989.
Elevation 963 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ACA SHO	6	30±2	47±3	35±3	13.1±1.8	0.79	40.2±8.3	241	124±26	0.75
AMB DUM	3	16±1	22±3	19±1	3.34±0.27	0.10	5.38±0.61	16.1	13.4±1.5	0.04
ATR CON	21	29±3	41±6	31±4	13.3±3.2	2.79	48.8±14.1	1026	230±66	4.82
CER LAN	5	32±8	25±5	19±3	4.05±1.19	0.20	16.0±6.5	80.2	51.3±20.8	0.26
EPH NEV	2	42±8	45±25	37±25	18.1±16.0	0.36	87.0±80.0	174	122±112	0.24
GRA SPI	1	43	48	43	16.2	0.16	69.7	69.7	160	0.16
KRA PAR	1	16	52	49	20.0	0.20	32.0	32.0	64.0	0.06
LAR TRI	10	76±5	117±26	102±17	122±47	12.2	1101±484	11006	1431±629	14.3
ORY HYM	2	1±0	19±7	9±4	1.46±0.99	0.03	0.15±0.10	0.3	0.16±0.11	0.00
POL SUB	1	14	57	36	16.1	0.16	22.6	22.6	-	-
DEAD GR	2	21±2	14±0	9±2	0.99±0.22	0.02	2.09±0.32	4.2	-	-
DEAD SH	90	22±1	34±2	28±2	10.1±1.4	9.12	32.2±6.3	2903	-	-
TOTALS	52	-	-	-	-	17.0	-	12667	-	20.6

Table 11. Population characteristics of perennial plants on plot FRF006 GMX, sampled Sept. 21-25, 1989, Elevation 963 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ACA SHO	9	21±2	30±3	27±3	7.05±1.13	0.64	16.2±2.8	146	50.3±8.8	0.45
AMB DUM	11	17±2	27±4	20±4	5.41±1.74	0.60	11.0±4.3	122	27.6±10.7	0.30
ATR CAN	3	45±6	43±16	50±20	22.0±15.5	0.66	114±89	342	297±231	0.89
CER LAN	10	30±3	26±3	20±3	4.44±1.05	0.44	15.3±5.3	153	48.9±17.1	0.49
EPH NEV	1	22	31	26	6.33	0.06	13.9	13.9	19.5	0.02
GRA SPI	6	61±4	68±11	52±11	32.2±11.2	1.93	201±67	1208	463±153	2.78
LAR TRI	18	80±7	106±10	90±10	87.4±14.3	15.7	841±178	15146	1094±232	19.7
LYC AND	2	45±10	60±0	57±13	27.1±5.9	0.54	128±54	256	281±118	0.56
ORY HYM	1	1	8	6	0.38	0.00	0.04	0.0	0.04	0.00
UNKNOWN	1	20	20	20	3.14	0.03	6.28	6.3	-	-
DEAD GR	3	13±2	8±2	6±1	0.39±0.14	0.01	0.54±0.24	1.6	-	-
DEAD SH	68	17±1	26±2	23±2	5.58±0.66	3.98	12.4±1.8	846	-	-
TOTALS	62	-	-	-	-	20.6	-	17393	-	25.2

Table 12. Population characteristics of perennial plants on baseline plot FRF001, transect V1, sampled June 23, 1988 (top) and June 4, 1991 (second). Elevation 965 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ACA SHO	15	21±1	32±3	26±3	7.64±1.44	1.15	17.7±3.4	265	54.8±10.7	0.82
ACA SHO	3	13±2	11±4	8±4	0.92±0.73	0.03	1.49±1.29	4.5	4.62±3.99	0.01
AMB DUM	48	19±2	22±4	19±3	7.79±2.84	3.74	31.2±14.4	1497	78.0±36.1	3.74
AMB DUM	15	14±1	19±4	12±2	2.47±0.81	0.37	4.30±1.55	64.5	10.7±3.9	0.16
CER LAN	10	417±4	30±3	27±4	7.42±2.10	0.74	33.8±10.9	338	108±35	1.08
CER LAN	8	33±4	16±2	15±2	2.08±0.49	0.17	8.10±2.96	64.8	25.9±9.5	0.21
EPH NEV	1	56	84	55	36.35	0.36	203	203	284	0.28
EPH NEV	1	52	52	39	15.9	0.16	82.8	82.8	116	0.12
GRA SPI	6	50±3	45±5	40±5	14.1±2.0	0.85	73.0±12.5	438	168±29	1.01
GRA SPI	3	42±3	28±9	32±14	8.41±4.53	0.25	35.8±18.2	107	82.3±41.9	0.25
HYM SAL	50	27±2	29±4	25±4	10.7±3.0	5.37	59.1±21.8	2953	189±107	9.45
HYM SAL	2	20±10	10±1	9±2	0.63±0.08	0.01	1.18±0.47	2.4	3.77±1.51	0.01
LAR TRI	9	61±17	88±23	90±32	104±49	9.39	1269±810	11421	1650±1053	14.8
LAR TRI	6	100±19	143±31	112±25	155±65	9.27	2059±1228	12357	2677±1228	16.1

Table 12, continued.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
LYC AND	2	66±0	97±3	65±1	49.2±1.9	0.98	324±13	649	714±28	1.43
LYC AND	2	55±3	58±25	43±9	21.7±12.6	0.43	1159±63	230	253±139	0.51
ORY HYN	7*	15±2	-	-	-	-	-	-	-	-
ORY HYM	0	-	-	-	-	-	-	-	-	-
PSO FRE	1	26	37	27	7.85	0.08	20.4	20.4	51.0	0.05
PSO FRE	0	-	-	-	-	-	-	-	-	-
TET AXI	1	54	24	16	3.02	0.03	16.3	16.3	44.0	0.04
TET AXI	0	-	-	-	-	-	-	-	-	-
DEAD GR	0	-	-	-	-	-	-	-	-	-
DEAD GR	5	9±2	10±2	8±1	0.66±0.30	0.03	0.73±0.46	3.6	-	-
DEAD SH	16	20±4	38±6	33±6	13.6±3.6	2.18	44.3±17.0	709	-	-
DEAD SH	106	36±15	27±2	22±2	8.75±1.54	9.28	36.8±8.4	3895	-	-
TOTALS	150	-	-	-	-	22.7	-	17800	-	31.3
TOTALS	40	-	-	-	-	10.7	-	12913	-	16.8

* *Oryzopsis hymenoides* widths were measured wrong on this transect in 1988.

Table 13. Population characteristics of perennial plants on baseline plot FRF001, transect V3, sampled June 30, 1988 (top) and June 6, 1991 (second). Elevation 965 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ACA SHO	28	23±2	35±3	27±3	9.33±1.76	2.61	27.4±6.2	768	85.0±19.1	2.38
ACA SHO	9	15±1	14±2	11±1	1.27±0.26	0.11	1.98±0.51	17.8	6.14±1.59	0.06
AMB DUM	27	19±2	20±4	16±3	5.04±1.96	1.36	18.0±8.1	486	45.0±20.3	1.21
AMB DUM	17	11±2	13±2	12±2	1.76±0.55	0.30	2.87±1.01	48.9	7.19±2.52	0.12
CER LAN	1	22	22	21	3.63	0.04	7.98	8.04	25.5	0.03
CER LAN	0	-	-	-	-	-	-	-	-	-
GRA SPI	4	66±8	47±4	41±9	15.2±3.7	0.46	99.2±21.5	297	228±49	0.68
GRA SPI	2	57±11	43±4	40±1	13.5±1.2	0.27	77.6±22.4	155	178±52	0.36
HYM SAL	61	30±2	31±3	29±3	11.0±2.1	6.73	50.0±11.0	3049	160±35	9.76
HYM SAL	8	16±3	18±5	17±5	3.48±1.65	0.28	8.00±4.32	64.0	25.6±13.8	0.20
LAR TRI	6	118±23	179±39	179±33	3026±75	18.1	4347±1211	26085	5652±1574	33.9
LAR TRI	6	118±23	171±37	166±36	2745±72	16.43	3910±1078	23459	5083±1401	30.5

Table 13, continued.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
LYC AND		39	42	64	21.1	0.21	82.3	82.3	181	0.18
LYC AND	1	42	62	58	28.2	0.28	119	119	261	0.26
ORY HYM	8	25±1	9±2	6±1	0.51±0.14	0.04	1.33±0.42	10.6	1.46±0.46	0.01
ORY HYM	0	-	-	-	-	-	-	-	-	-
PSO FRE	2	22±6	43±17	32±20	13.5±11.0	0.27	36.5±32.1	72.9	91.2±80.4	0.18
PSO FRE	1	8	6	6	0.28	0.00	0.23	0.2	0.57	0.00
DEAD GR	0	-	-	-	-	-	-	-	-	-
DEAD GR	8	13±2	9±1	8±1	0.62±0.17	0.05	0.98±0.35	7.8	-	-
DEAD SH	14	21±5	34±7	26±5	9.73±4.22	1.36	37.5±22.7	524	-	-
DEAD SH	116	22±1	28±2	24±2	8.20±1.18	9.51	30.9±6.4	3583	-	-
TOTALS	138	-	-	-	-	29.8	-	30858	-	48.3
TOTALS	44	-	-	-	-	17.7	-	23864	-	31.5

Table 14. Population characteristics of perennial plants on baseline plot FRF001, transect V5, sampled July 5, 1988 (top) and June 11, 1991 (second). Elevation 965 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ACA SHO	15	22±2	25±3	20±3	4.90±1.21	0.73	11.9±3.9	179	36.9±12.1	0.55
ACA SHO	3	16±4	13±5	16±6	2.14±1.28	0.06	4.10±2.45	12.3	12.7±7.6	0.04
AMB DUM	45	21±2	23±3	20±2	5.60±1.15	2.52	17.6±4.4	791	43.9±10.9	1.98
AMB DUM	24	13±1	13±2	11±2	1.71±0.42	0.41	3.35±0.97	80.5	8.38±2.43	0.20
CER LAN	7	31±6	29±6	30±8	8.92±2.95	0.62	37.5±15.2	262	120±49	0.84
CER LAN	1	21	10	26	2.04	0.02	4.29	4.3	13.72	0.01
GRA SPI	5	44±8	40±9	41±6	13.1±4.2	0.39	63.0±30.2	189	145±70	0.44
GRA SPI	2	35±11	35±14	29±17	9.47±7.49	0.19	41.3±36.7	82.6	95.0±84.5	0.19
HYM SAL	55	25±2	25±3	25±3	7.67±1.54	4.22	32.3±7.9	1778	103±25	5.69
HYM SAL	3	13±3	14±3	10±4	1.23±0.61	0.04	1.89±0.95	5.7	6.04±3.04	0.02
LAR TRI	5	117±12	212±42	203±46	395±141	19.8	4883±1733	24413	6348±2254	31.7
LAR TRI	5	111±12	201±46	191±43	358±134	17.9	4142±1470	20710	5384±1910	26.9

Table 14, continued.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
LYC AND	6	44±7	80±22	70±24	61.9±26.1	3.72	336±141	2017	740±311	4.44
LYC AND	3	46±6	90±21	59±21	48.5±24.9	1.46	247±151	740	543±332	1.63
ORY HYM	5	22±3	12±2	11±2	1.16±0.43	0.06	2.81±1.18	14.1	3.09±1.30	0.02
ORY HYM	0	-	-	-	-	-	-	-	-	-
TET AXI	1	86	125	168	165	1.65	1418	1418	3830	3.83
TET AXI	1	72	72	65	36.8	0.37	265	265	715	0.71
DEAD GR	0	-	-	-	-	-	-	-	-	-
DEAD GR	7	11±2	13±2	9±3	1.15±0.52	0.08	1.46±0.81	10.3	-	-
DEAD SH	14	13±2	25±2	21±2	5.29±1.07	0.74	8.75±2.66	122	-	-
DEAD SH	119	20±1	25±2	21±2	6.88±1.01	8.19	24.2±4.7	2873	6.04±3.04	-
TOTALS	144	-	-	-	-	33.6	-	31062	-	49.5
TOTALS	42	-	-	-	-	20.4	-	21899	-	29.7

Table 15. Perennial plant population characteristics on plot FRF003 on the north edge of 5-05 road, eight transects combined, sampled Aug. 23-30, 1990. Elevation 965 m. Total sampled area was 400 m². (Cover is not in percent.)

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
AMB DUM		20±1	23±2	19±2	5.74±1.12	4.42	16.6±3.46	1276	41.4±8.7	3.19
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
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
EPH ENV	5	29±7	27±9	31±12	9.76±5.02	0.49	39.0±21.3	195	54.6±29.8	0.27
GRA SPI	14	53±4	55±4	45±5	20.8±3.1	2.71	122±24	1584	280±56	3.64
HYM SAL	30	26±4	27±6	21±5	10.6±4.8	2.98	59.4±28.9	1663	190±92	5.32
LAR TRI	19	90±9	110±15	95±13	109±24	20.6	1244±323	23628	1617±421	30.7
PSO FRE	8	34±14	58±27	50±24	59.5±40.1	4.76	597±450	47796	1494±1124	11.9
LYC AND	8	47±5	69±11	69±16	42.6±13.8	2.13	218±87	1088	479±191	2.39
TET AXI	2	84	21	132	21.8	0.22	183	183	494	0.49
DEAD GR	8	14±2	9±2	7±1	0.57±0.17	0.05	0.96±0.3	7.6	-	-
DEAD SH	259	22±1	27±1	23±1	8.63±0.87	22.2	33.5±4.80	8609	-	-
TOTALS	179	-	-	-	-	38.6	-	34481	-	58.3

Table 16. Perennial plant population characteristics on plot FRF004, an undisturbed area approximately 500m north of roadside plot FRF003, eight transects combined, sampled Sept. 14-19, 1990. Elevation 965 m. Total sampled area was 400m².

Species	n	HT cm	MAXWID cm	PERWID cm	AVG COVER dm ²	TOT COV m ²	AVG VOLUME l	TOT VOL l	AVG BIO g	TOTAL BIO Kg
ACA SHO	8	20±2	31±7	28±6	9.05±3.73	0.72	22.2±10.6	177	68.7±32.8	0.55
AMB DUM	75	16±1	20±2	14±2	3.96±0.97	2.66	11.2±3.7	749	28.0±9.19	1.87
ATR CAN	1	20	25	15	2.95	0.03	5.89	5.9	15.3	0.02
EPJ 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
CER LAN	14	32±2	220±35	19±3	3.89±1.04	0.55	15.5±5.4	216	49.5±17.4	0.69
GRA SPI	4	52±7	33±10	33±9	10.6±4.3	0.42	51.3±21.1	205	118±48	0.47
KRA PAR	1	6	9	5	0.35	0.00	0.21	0.2	0.42	0.00
LAR TRI	37	82±5	110±11	89±9	98.5±18.0	36.4	1030±229	38125	1340±298	49.6
LYC AND	17	47±3	82±7	57±5	39.6±5.81	6.74	200±35	3398	440±77	7.48
PSO FRE	8	34±14	59±27	50±24	59.5±40.1	4.76	597±450	4779	1494±1124	11.9
PSO FRE	2	42±3	62±17	60±7	30.0±10.9	0.60	129±55	259	324±137	0.65
DEAD GR	29	21±1	7±1	6±1	0.46±0.10	0.13	1.07±0.29	31.0	-	-
DEAD SH	357	23±1	34±1	28±1	10.4±0.75	37.1	36.4±4.1	12975	-	-
Totals	189					52.1		44568		

Table 17. Population characteristics of perennial plants on plot FRF002, transect V1, the roadside of abandoned 5-03 road, sampled Aug. 11, 1988 (top) and June 13, 1991 (second). Elevation 977 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
AMB DUM	34	23±1	36±2	37±3	12.1±1.8	4.11	32.7±6.7	1112	81.8±16.7	2.78
AMB DUM	41	17±1	27±2	22±2	5.85±0.93	2.40	12.7±6.7	522	31.8±6.5	1.30
EPH NEV	2	69±3	154±10	136±7	166±18	3.32	1141±75	2282	1597±105	3.19
EPH NEV	3	52±23	94±40	91±43	93±49	2.80	706±395	2117	988±553	2.96
ERI PUL	1	3	11	8	0.69	0.01	0.21	0.2	0.23	0.00
ERI PUL	0	-	-	-	-	-	-	-	-	-
LAR TRI	2	29±10	40±7	33±6	10.5±3.6	0.21	33.4±20.1	66.8	43.4±26.2	0.09
LAR TRI	2	33±9	45±14	38±12	14.6±8.2	0.29	55.4±40.2	111	72.1±52.3	0.14
ORY HYM	4	15±4	8±2	11±4	0.83±0.51	0.03	0.91±0.38	3.6	1.00±0.41	0.00
ORY HYM	2	13±1	2±1	2±1	0.04±0.03	0.00	0.05±0.04	0.1	0.06±0.05	0.00
OPU BAS	0	-	-	-	-	-	-	-	-	-
OPU BAS	1	4	8	5	0.31	0.00	0.13	0.1	-	-
PSO FRE	2	25±8	80±33	75±22	53.3±33.7	1.07	161±126	322	403±315	0.81
PSO FRE	3	17±6	51±25	41±23	25.7±18.9	0.77	66.0±55.1	198	165±138	0.50
DEAD GR	0	-	-	-	-	-	-	-	-	-
DEAD GR	3	11±4	11±6	12±8	1.80±1.61	0.05	3.14±2.94	9.4	-	-
DEAD SH	0	-	-	-	-	-	-	-	-	-
DEAD SH	3	16±3	14±2	9±1	1.07±0.23	0.03	1.78±0.59	5.3	-	-
TOTALS	45	-	-	-	-	8.75	-	3787	-	6.87
TOTALS	52	-	-	-	-	6.26	-	2949	-	4.91

Table 18. Population characteristics of perennial plants on plot FRF002, transect V2, an undisturbed area near abandoned 5-03 road, sampled Aug. 12, 1988 (top) and June 13, 1991 (second). Elevation 977 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
AMB DUM	41	21±2	27±3	27±3	8.35±1.58	3.42	25.1±5.6	1028	62.7±14.0	2.57
AMB DUM	37	14±1	17±2	13±1	2.34±0.45	0.87	4.40±1.04	163	11.0±2.6	0.41
EPH NEV	8	49±3	72±11	70±11	44.6±11.9	3.57	229±65	1830	320±92	2.56
EPH NEV	7	31±6	50±18	39±14	27.1±14.9	1.90	123±71	859	172±100	1.20
GRA SPI	3	56±4	58±10	62±8	29.1±7.7	0.87	169±51	506	388±117	1.16
GRA SPI	2	35±10	31±10	20±11	5.82±4.17	0.12	24.6±20.3	49.2	56.6±46.7	0.11
LAR TRI	7	109±11	182±27	174±25	279±67	19.5	3245±932	22714	4218±1212	29.5
LAR TRI	6	111±13	176±30	145±21	222±63	13.3	2625±888	15747	3412±1154	20.5
LYC AND	1	50	56	63	27.7	0.28	139	138	305	0.30
LYC AND	1	35	52	48	19.6	0.20	68.6	68.6	151	0.15
STI SPE	1	45	76	24	14.3	0.14	64.5	64.5	70.9	0.07
STI SPE	0	-	-	-	-	-	-	-	-	-
DEAD GR	0	-	-	-	-	-	-	-	-	-
DEAD GR	1	49	36	18	5.09	0.05	24.9	24.9	-	-
DEAD SH	9	18±3	37±9	30±8	12.9±6.7	1.16	29.4±16.5	265	-	-
DEAD SH	27	17±3	25±5	19±4	8.37±3.09	2.26	39.2±17.4	1059	-	-
TOTALS	61	-	-	-	-	27.8	-	26282	-	27.8
TOTALS	53	-	-	-	-	16.4	-	16887	-	16.4

Table 19. Population characteristics of perennial plants on plot ROV005 (Beatley Plot 3), sampled June 23 - July 8, 1989. Elevation 1036 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
AMB DUM	83	30±1	38±3	31±2	13.2±1.8	10.9	55.4±9.5	4594	138±24	11.5
CER LAN	6	40±5	26±5	23±3	4.93±1.14	0.30	21.3±5.7	128	68.2±18.2	0.41
COL RAM	3	64±7	117±17	110±23	107±35	3.21	728±285	2183	3784±1484	11.4
EPH NEV	27	43±4	52±7	41±6	23.6±5.0	6.38	140±35	3782	196±49	5.30
GRA SPI	10	51±4	46±5	40±3	14.8±1.9	1.48	80.4±13.5	804	185±31	1.85
KRA PAR	2	32±13	91±2	95±11	67.0±6.4	1.34	223±107	446	446±215	0.89
LAR TRI	10	81±14	113±23	106±22	128±33	12.8	1420±431	14200	1846±560	18.5
LYC AND	13	55±5	54±11	50±14	35.0±15.2	4.54	257±123	3346	566±271	7.36
LYC PAL	6	48±2	58±4	54±5	25.1±3.05	1.51	120±14	722	144±16	0.87
MAC TOR	9	27±5	19±5	14±3	3.04±1.29	0.27	11.6±5.7	105	21.0±10.2	0.19
ORY HYM	1	1	3	3	0.07	0.00	0.01	0.0	0.01	0.00
SPH AMB	1	4	3	3	0.07	0.00	0.03	0.0	0.01	0.00
STI SPE	1	1	6	5	0.24	0.00	0.02	0.0	0.03	0.00
DEAD SH	26	28±3	41±6	32±5	16.0±5.0	4.16	70.5±28.9	1832	-	-
TOTALS	172	-	-	-	-	42.7	-	30309	-	58.2

Table 20. Population characteristics of perennial plants on plot MER002, a gopher-denuded plot in west Mercury Valley, sampled July 28, 1988 (top) and June 24, 1991 (second). Elevation 1076 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
MIR PUD	6	5±1	7±2	5±1	0.32±0.18	0.02	0.30±0.23	1.8	0.13±0.10	0.00
MIR PUD	49	13±2	14±2	12±2	2.61±1.17	1.28	11.8±9.8	578	5.07±4.23	0.25
ORY HYM	0	-	-	-	-	-	-	-	-	-
ORY HYM	1	29	2	2	0.03	0.00	0.09	0.1	0.10	0.00
SIT JUB	2	19±1	4±1	4±1	0.10±0.03	0.00	0.18±0.04	0.4	0.20±0.05	0.00
SIT JUB	0	-	-	-	-	-	-	-	-	-
SPH AMB	1	16	5	10	0.39	0.00	0.63	0.6	0.27	0.00
SPH AMB	3	17±9	17±11	11±6	2.34±1.97	0.07	7.42±6.95	22.2	3.19±2.99	0.01
STA PIN	19	70±6	42±6	40±5	17.2±4.1	3.27	152±42	2892	65.4±18.2	1.24
STA PIN	17	22±7	16±6	16±6	6.97±4.23	1.18	57.7±39.7	981	24.8±17.1	0.42
DEAD SH	45	40±4	55±5	46±4	26.2±3.9	11.8	150±32	6744	-	-
DEAD SH	65	39±3	40±4	36±3	16.5±2.8	10.7	104±23	6786	-	-
TOTALS	28	-	-	-	-	3.29	-	2894	-	1.24
TOTALS	70	-	-	-	-	2.53	-	1581	-	0.68

Table 21. Population characteristics of perennial plants on plot MER003, an undisturbed site near plot MER002 sampled July 28, 1988 (top) and June 19, 1991 (second). Elevation 1103 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ACA SHO	118	25±1	32±2	29±1	8.93±0.86	10.54	27.8±3.8	3284	86.3±11.8	10.2
ACA SHO	37	21±1	23±2	19±1	3.81±0.54	1.41	9.43±1.93	349	29.2±6.0	1.08
AMB DUM	9	20±4	22±6	18±6	5.16±2.83	0.46	18.9±11.8	170	47.3±29.6	0.43
AMB DUM	7	31±10	24±6	23±5	5.57±2.62	0.39	15.2±8.3	107	38.1±20.7	0.27
CER LAN	2	22±11	18±15	16±13	3.66±3.59	0.07	12.0±11.9	24.0	38.4±38.2	0.08
CER LAN	2	34±12	27±13	23±16	6.60±5.65	0.13	29.2±27.1	58.4	93.5±86.9	0.19
EPH NEV	4	56±9	67±18	73±17	45.6±17.2	1.82	287±117	1150	402±163	1.61
EPH NEV	7	43±9	50±20	46±13	27.4±12.9	1.92	177±88	1236	247±124	1.73
GRA SPI	24	44±3±6	45±5±6	39±5±5	18.1±4.7	4.34	104±35	2500	240±81	5.75
GRA SPI	13	41±3	41±6	35±4	13.0±2.5	1.68	61.5±14.8	799	141±34	1.84
HYM SAL	8	27±3	19±4	18±3	3.02±0.87	0.24	9.14±3.09	73.1	29.3±9.9	0.23
HYM SAL	6	26±2	20±1	23±2	3.70±0.50	0.22	9.95±1.83	59.7	31.8±5.8	0.19
LAR TRI	3	151±14	210±28	223±13	356±64	10.7	5388±1206	16163	7004±1568	21.0
LAR TRI	4	139±22	216±39	195±48	373±148	14.9	5963±2811	23852	7752±3655	31.0

Table 21, continued.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
LYC AND	13	48±2	71±7	69±8	43.5±10.0	5.66	217±56	2820	477±124	6.20
LYC AND	12	44±5	53±8	47±8	24.3±5.6	2.92	124±30	1492	274±66	3.28
OPU BAS	1	11	5	5	0.20	0.00	0.22	0.2	-	-
OPU BAS	0	-	-	-	-	-	-	-	-	-
ORY HYM	1	30	10	10	0.79	0.01	2.36	2.4	2.59	0.00
ORY HYM	1	35	12	18	1.70	0.02	5.94	5.9	6.53	0.01
SPH AMB	9	19±3	13±3	10±1	1.14±0.31	0.10	2.85±0.97	25.6	1.23±0.42	0.01
SPH AMB	4	25±8	20±5	19±7	3.80±1.86	0.15	12.5±6.9	50.0	5.38±2.98	0.02
DEAD SH	66	18±2	39±3	37±3	15.7±2.6	10.34	46.0±10.4	3033	-	-
DEAD SH	174	22±1	42±2	37±2	15.4±1.4	26.81	48.2±6.5	8383	-	-
TOTALS	198	-	-	-	-	49.5	-	49384	-	75.6
TOTALS	93	-	-	-	-	23.8	-	28009	-	39.4

Table 22. Population characteristics of perennial plants on plot MER004 (Beatley Plot 2), sampled August 17, 1989. Elevation 1088 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ACA SHO	45	26±1	36±3	32±3	11.8±2.0	5.32	38.5±8.0	1733	119±25	5.37
EPH NEV	1	89	123	121	117	1.17	1040	1040	1456	1.46
CER LAN	21	34±2	28±4	24±4	7.14±2.25	1.50	30.9±12.0	649	99.0±38.4	2.08
AMB DUM	45	26±2	24±3	22±3	6.30±1.70	2.83	25.7±9.0	1154	64.1±9.0	2.89
GRA SPI	16	56±3	66±7	60±7	34.9±6.3	5.59	210±42	3352	482±96	7.71
HYM SAL	6	36±4	37±6	32±3	9.63±1.95	0.58	37.4±12.0	225	120±38	0.72
LAR TRI	5	163±19	170±17	159±33	229±62	11.4	4161±1381	20805	5409±1795	27.0
LYC AND	16	39±4	47±9	39±10	23.6±8.5	3.77	141±60	2254	310±132	4.96
ORY HYM	3	5±4	12±4	8±2	0.85±0.34	0.03	0.65±0.58	1.9	0.71±0.64	0.00
LEP FRE	1	28	97	42	32.0	0.32	89.6	89.6	287	0.29
DEAD SH	38	30±3	42±5	32±4	15.8±3.7	6.02	65.8±17.6	2502	-	-
TOTALS	159	-	-	-	-	32.5	-	31306	-	52.5

Table 23. Population characteristics of perennial plants on plot YUF031 (Beatley Plot 60), sampled August 23-24, 1989. Elevation 1204 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ART SPI	11	13±2	24±3	19±2	3.75±0.69	0.41	5.48±1.32	60.3	22.5±5.4	0.25
ATR CAN	4	46±7	35±8	26±9	8.33±3.73	0.33	42.9±19.1	1710	111±50	0.45
ATR CON	4	27±7	39±17	20±7	6.84±3.08	0.27	21.6±9.0	86.4	102±42	0.99
CER LAN	33	27±2	22±2	17±2	3.89±0.87	1.29	13.4±4.3	443	42.9±13.8	1.42
CHR VIS	37	30±1	39±3	33±3	11.6±1.7	4.31	39.3±6.3	1455	98.3±15.8	3.64
EPH NEV	1	34	11	2	0.17	0.00	0.59	0.6	0.82	0.00
GRA SPI	22	40±2	36±6	26±4	10.3±3.00	2.26	49.6±16.9	1091	114±39	2.51
LYC AND	24	45±2	66±5	59±6	34.4±6.02	8.25	158±28	3789	347±61	8.34
ORY HYM	8	1±10	11±2	9±1	0.87±0.20	0.07	0.09±0.02	0.7	0.10±0.02	0.00
SPH AMB	1	10	2	2	0.03	0.00	0.03	0.0	0.01	0.00

Table 23, continued.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
SIT JUB	46	1±0	8±1	7±0	0.51±0.07	0.23	0.05±0.01	2.3	0.06±0.01	0.00
STI SPE	16	1±0	7±1	5±0	0.32±0.05	0.05	0.03±0.01	0.5	0.04±0.01	0.00
TET GLA	40	50±3	68±4	63±4	37.6±4.0	15.0	200±25	8009	541±67	21.6
YUC BRE	1	24	16	15	1.88	0.02	4.52	4.5	-	-
DEAD GR	1	21	4	4	0.13	0.00	0.26	0.3	-	-
DEAD SH	13	20±5	29±6	24±6	8.04±3.3	1.05	32.2±20.3	458	-	-
TOTALS	248	-	-	-	-	32.5	-	15113	-	39.2

Table 24. Population characteristics of perennial plants on plot YUF013, T3 ground zero, sampled June 8, 1988 (top) and June 13, 1991. Elevation 1236 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
MIR PUD	3	18±2	15±6	14±3	1.96±1.16	0.06	3.33±1.78	10.0	1.43±0.77	0.00
MIR PUD	8	15±3	10±1	8±1	0.60±0.13	0.05	0.98±0.38	7.8	0.42±0.16	0.00
ORY HYM	151	18±1	11±1	10±1	1.22±0.17	1.84	2.93±0.59	442	3.22±0.64	0.49
ORY HYM	2	13±7	3±0	10±7	0.22±0.15	0.00	0.40±0.36	0.8	0.44±0.39	0.00
DEAD GR	13	7±1	14±2	13±2	1.98±0.64	0.26	2.05±1.06	26.7	-	-
DEAD GR	164	9±0	11±0	10±0	1.07±0.09	1.75	1.25±0.18	204	-	-
DEAD SH	1	5	9	7	0.49	0.00	0.25	0.2	-	-
DEAD SH	4	7±3	11±3	10±3	1.08±0.51	0.04	1.25±0.79	5.0	-	-
TOTALS	154	-	-	-	-	1.90	-	452	-	0.49
TOTALS	10	-	-	-	-	0.05	-	8.6	-	0.00

Table 25. Perennial plant population characteristics on 3B consolidation site (plot YUF011), on Yucca Flat, sampled June 17, 1991. Elevation 1242 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ATR CAN	7	34±7	44±8	44±9	18.4±5.0	1.29	75.9±24.9	531	197±65	1.38
TOTALS	7	-	-	-	-	1.29	-	531	-	1.38

Table 26. Perennial plant population characteristics on plot YUF012, an undisturbed site adjacent to T3 ground zero and 3B consolidation site (YUF011), sampled Aug. 5, 1988 (top line) and July 3, 1991 (second). Elevation 1239 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ACA SHO	80	20±1	26±2	25±2	6.69±0.71	53.5	17.1±2.2	1372	53.2±6.8	4.25
ACA SHO	22	14±1	12±2	8±1	1.14±0.40	0.25	2.18±0.94	47.9	6.76±2.90	0.15
ATR CAN	67	36±2	32±2	29±3	11.1±1.9	7.43	50.1±8.9	3354	130±23	8.72
ATR CAN	16	32±3	28±4	18±3	5.19±1.28	0.83	20.4±5.7	326	53.0±14.9	0.85
CER LAN	80	30±1	29±2	25±1	6.69±0.66	5.35	24.3±3.2	1942	77.7±10.4	6.21
CER LAN	51	22±1	16±2	12±2	2.29±0.47	1.17	7.06±1.76	360	22.6±5.6	1.15
CHR VIS	19	38±4	48±6	44±6	21.9±5.2	4.15	102±27	1932	254±68	4.83
CHR VIS	0	-	-	-	-	-	-	-	-	-
EPH NEV	13	50±7	54±12	60±13	36.2±11.9	4.70	252±93	3270	352±130	4.58
EPH NEV	6	60±8	111±16	84±16	82.3±21.8	4.94	566±175	3396	792±245	4.75
HYM SAL	2	18±8	25±5	14±5	1.85±1.14	0.04	4.23±3.53	8.47	13.5±11.3	0.03
HYM ALS	0	-	-	-	-	-	-	-	-	-
LYC AND	5	47±7	55±11	58±11	28.8±11.2	1.44	139±65	694	305±144	1.53
LYC AND	4	49±8	50±15	34±8	15.1±5.9	0.60	68.8±24.6	275	151±54	0.61
MEN SPI	14	15±2	47±11	43±9	25.8±7.9	3.62	61.7±20.4	863	512±170	7.17
MEN SPI	13	15±2	39±9	32±8	16.9±5.5	2.09	34.1±12.1	444	283±101	3.68
MIR PUD	9	13±2	9±2	10±3	0.97±0.42	0.09	1.67±0.78	15.0	0.72±0.34	0.01
MIR PUD	12	20±6	21±5	12±3	3.24±1.56	0.39	17.1±13.9	205	7.34±5.97	0.09

Table 26, continued.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
POL SUB	85	7±0	10±1	8±1	1.14±0.40	0.97	1.91±1.11	163	-	-
POL SUB	43	5±0	11±2	7±1	1.27±0.64	0.55	1.33±1.01	57.4	-	-
SIT JUB	39	19±1	3±0	3±0	0.13±0.04	0.05	0.22±0.05	8.73	0.25±0.06	0.01
SIT JUB	0	-	-	-	-	-	-	-	-	-
SPH AMB	4	18±4	15±5	14±1	1.85±0.78	0.07	4.30±2.62	17.2	1.85±1.13	0.01
SPH AMB	0	-	-	-	-	-	-	-	-	-
STE PAU	0	-	-	-	-	-	-	-	-	-
STE PAU	1	13	19	10	1.49	0.01	1.94	1.94	0.83	0.00
STI SPE	0	-	-	-	-	-	-	-	-	-
STI SPE	1	31	1	1	0.01	0.00	0.02	0.02	0.03	0.00
TET GLA	26	57±2	88±4	86±4	62.0±4.7	16.12	369±34	9604	997±92	25.9
TET GLA	1	33	15	14	1.65	0.02	5.44	5.44	14.7	0.01
UNKNOWN	4	23±5	40±12	32±10	12.9±5.0	0.52	36.1±14.4	144	-	-
UNKNOWN	0	-	-	-	-	-	-	-	-	-
DEAD GS	2	12±6	5±3	4±2	0.24±0.20	0.00	0.41±0.39	0.81	-	-
DEAD GS	139	12±1	7±1	5±0	0.48±0.06	0.67	0.74±0.13	103	-	-
DEAD SH	28	18±2	26±4	26±4	8.27±1.95	2.32	22.9±6.6	641	-	-
DEAD SH	250	28±1	39±2	31±2	15.6±1.5	39.01	74.7±9.1	18666	-	-
TOTALS	545	-	-	-	-	50.4	-	23503	-	63.4
TOTALS	171	-	-	-	-	10.9	-	5121	-	11.3

Table 27. Population characteristics of perennial plants on plot YUF001, transect V1, sampled annually from 1987 through 1991. Elevation 1237 m.

Species	YEAR	n	HT	MAXWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG RIO	TOTAL RIO
			cm	cm	dm ²	m ²	l	l	g	Kg
ACA SHO	1987	67	20±1	30±1	6.80±0.76	4.56	14.3±1.9	958	44.3±5.9	2.97
ACA SHO	1988	80	20±1	24±1	5.21±0.58	4.17	12.0±1.6	960	37.2±5.0	2.98
ACA SHO	1989	42	19±1	28±2	6.27±1.05	2.63	13.8±2.6	579	42.8±7.9	1.80
ACA SHO	1990	16	18±2	28±2	8.84±4.46	0.35	18.0±10.1	72	55.7±31.2	0.22
ACA SHO	1991	10	13±2	176±2	4.20±2.46	0.42	8.56±5.24	86	26.5±16.2	0.27
AMB x H	1987	-	-	-	-	-	-	-	-	-
AMB x H	1988	1	30	41	7.08	0.07	21.2	21	53.1	0.05
AMB x H	1989	0	-	-	-	-	-	-	-	-
ARA PUL	1987	-	-	-	-	-	-	-	-	-
ARA PUL	1988	1	45	20	1.57	0.02	7.07	7	3.04	0.00
ARA PUL	1989	0	-	-	-	-	-	-	-	-
ART SPI	1987	34	20±1	31±2	6.41±0.65	2.18	13.5±1.7	458	55.2±6.8	1.88
ART SPI	1988	42	23±1	29±2	6.69±0.66	2.81	16.4±2.2	687	67.0±9.2	2.82
ART SPI	1989	42	21±1	21±1	6.08±1.06	2.55	16.6±5.7	698	68.2±23.5	2.86
ART SPI	1990	15	-	-	-	-	-	-	-	-
ART SPI	1991	4	14±2	13±4	1.29±0.40	0.05	1.81±0.66	7	7.43±2.70	0.03
ATR CAN	1987	4	35±7	30±11	9.18±6.11	0.37	43.6±33.0	175	113±86	0.45
ATR CAN	1988	7	28±6	25±8	7.70±5.28	0.54	35.7±28.0	250	92.8±72.9	0.65
ATR CAN	1989	10	27±5	17±4	2.53±1.15	0.25	12.0±7.6	120	31.1±19.7	0.31
ATR CAN	1990	10	18±3	15±3	1.91±0.68	0.19	4.75±1.97	48	12.3±5.1	0.12
ATR CAN	1991	4	27±7	17±6	3.37±1.74	0.13	10.7±5.6	43	27.9±14.6	0.11

Table 27, continued.

Species	YEAR	n	HT	MAXWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
			cm	cm	dm ²	m ²	l	l	g	Kg
CER LAN	1987	45	26±2	22±2	4.02±0.64	1.81	12.1±2.3	546	38.8±7.4	1.75
CER LAN	1988	57	25±1	21±1	3.60±0.47	2.05	10.6±1.8	605	34.0±5.7	1.94
CER LAN	1989	51	24±1	22±2	3.74±0.60	1.91	12.3±3.3	627	39.4±10.6	2.01
CER LAN	1990	45	26±2	17±2	2.63±0.59	1.13	8.58±2.26	369	27.5±7.2	1.18
CER LAN	1991	20	26±2	20±2	2.72±0.59	0.54	8.37±2.05	168	26.8±6.6	0.54
CHR VIS	1987	2	14±4	20±2	2.47±0.49	0.05	3.56±1.78	7	8.91±4.45	0.02
CHR VIS	1988	2	17±4	21±1	3.13±0.49	0.06	5.00±0.28	10	12.5±0.7	0.02
CHR VIS	1989	1	33	28	2.69	0.03	8.86	9	22.2	0.02
CHR VIS	1990	1	10	23	3.79	0.04	3.8	4	9.48	0.01
CHR VIS	1991	0	-	-	-	-	-	-	-	-
EPH NEV	1987	44	48±2	69±4	32.5±3.6	14.3	177±23	7803	248±32	10.9
EPH NEV	1988	60	44±2	61±4	32.4±3.5	19.4	171±21	10232	239±30	14.3
EPH NEV	1989	56	44±2	58±4	30.8±3.7	17.2	165±22	9259	231±31	13.0
EPH NEV	1990	56	41±2	58±5	30.5±4.3	17.1	161±27	9029	226±38	12.64
EPH NEV	1991	58	37±2	51±5	24.3±3.6	13.8	123±23	7025	173±32	9.83
ERI PUL	1987	-	-	-	-	-	-	-	-	-
ERI PUL	1987	1	9	5	0.20	0.00	0.18	0	0.19	0.00
ERI PUL	1988	0	-	-	-	-	-	-	-	-
GRA SPI	1987	35	39±2	34±3	8.52±1.29	2.98	36.9±6.3	1293	84.9±14.5	2.97
GRA SPI	1988	41	38±2	33±3	9.61±1.51	3.94	43.1±7.8	1766	99.0±18.0	4.06
GRA SPI	1989	34	37±2	33±3	10.3±2.0	3.50	46.1±10.2	1567	106±23	3.60
GRA SPI	1990	35	39±2	30±3	8.16±1.72	2.53	37.1±8.6	1151	85.4±19.7	2.65
GRA SPI	1991	27	35±3	29±3	7.75±2.10	2.09	36.1±12.0	974	83.0±27.7	2.24

Table 27, continued.

Species	YEAR	n	HT	MAXWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
			cm	cm	dm ²	m ²	l	l	g	Kg
HYM SAL	1987	19	30±2	24±3	4.01±0.82	0.76	12.7±2.8	241	40.6±9.0	0.77
HYM SAL	1988	21	26±2	18±2	2.50±0.49	0.53	7.27±1.69	153	23.3±5.4	0.49
HYM SAL	1989	10	31±2	22±4	3.51±0.75	0.35	11.6±2.9	116	37.0±9.4	0.37
HYM SAL	1990	4	23±10	7±3	0.47±0.03	0.01	1.10±0.53	2	3.53±1.70	0.01
HYM SAL	1991	1	10	8	0.25	0.00	0.25	0	0.80	0.00
LYC AND	1987	8	40±3	56±11	20.3±5.6	1.62	84.5±27.3	676	186±60	1.49
LYC AND	1988	17	43±2	56±5	26.7±3.5	4.54	116±16	1969	255±34	4.33
LYC AND	1989	13	45±3	71±6	39.2±5.9	5.09	185±33	2409	408±73	5.30
LYC AND	1990	11	35±1	73±2	43.5±25.1	0.87	151±89	303	333±196	0.67
LYC AND	1991	11	34±3	39±5	10.7±2.6	1.18	40.2±11.4	442	88.3±25.1	0.97
ORY HYM	1987	13	37±2	15±3	2.24±0.73	0.29	9.22±3.26	120	10.1±3.6	0.13
ORY HYM	1988	14	18±2	8±1	0.67±0.21	0.09	1.28±0.53	18	1.41±0.58	0.02
ORY HYM	1989	8	16±2±1	5±1	0.17±0.05	90.01	0.32±0.12	2	0.35±0.14	0.00
ORY HYM	1990	2	20±2	8±6	0.68±0.64	0.01	1.48±1.42	3	1.63±1.57	0.00
ORY HYM	1991	1	231	3	0.07	0.00	0.16	0	0.18	0.00
SIT JUB	1987	13	25±3	6±2	0.45±0.23	0.06	1.47±0.84	19	1.62±0.93	0.02
SIT JUB	1988	0	-	-	-	-	-	-	-	-
SPH AMB	1987	23	10±1	10±1	0.63±0.14	0.14	0.86±0.29	20	0.37±0.12	0.01
SPH AMB	1988	18	13±1	10±1	0.82±0.18	0.15	1.25±0.33	22	0.54±0.14	0.01
SPH AMB	1989	3	3±0±3	3±0±3	0.06±0.01	0.00	0.02±0.00	0	0.01±0.00	0.00
SPH AMB	1990	1	29	3	0.05	0.00	0.14	0	0.06	0.00
SPH AMB	1991	0	-	-	-	-	-	-	-	-

Table 27, continued.

Species	YEAR	n	HT	MAXWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOI	AVG BIO	TOTAL BIO
STI SPE	1987	0	30±4	10±3	1.25±0.80	0.06	4.94±3.73	25	5.43±4.11	0.03
STI SPE	1988	19	18±2	5±1	0.26±0.07	0.05	0.61±0.21	12	0.67±0.23	0.01
STI SPE	1989	7	18±3	9±2	0.59±0.29	0.04	1.39±0.81	10	1.53±0.89	0.01
STI SPE	1990	11	17±2	5±2	0.33±0.20	0.03	0.83±0.59	8	0.91±0.65	0.01
STI SPE	1991	4	17±6	3±1	0.07±0.06	0.00	0.15±0.14	1	0.17±0.15	0.00
TET AXI	1987	1	78	69	17.9	0.18	139	139	377	0.38
TET AXI	1988	1	71	86	42.6	0.43	302	302	816	0.82
TET AXI	1989	1	63	57	20.6	0.21	130	130	350	0.35
TET AXI	1990	1	70	56	27.7	0.28	194	194	524	0.52
TET AXI	1991	1	74	92	43.4	0.43	321	321	866	0.87
DEAD GR	1987	-	-	-	-	-	-	-	-	-
DEAD GR	1988	2	26±4	9±2	0.56±0.23	0.01	1.54±0.82	3	-	-
DEAD GR	1989	30	23±2	9±1	0.72±0.16	0.22	1.75±0.46	53	-	-
DEAD GR	1990	51	20±1	6±1	0.38±0.12	0.20	0.83±0.26	42	-	-
DEAD GR	1991	56	17±1	5±0	0.24±0.03	0.13	0.45±0.07	25	-	-
DEAD SH	1987	-	-	-	-	-	-	-	-	-
DEAD SH	1988	25	16±3	24±4	7.11±3.43	1.78	29.3±23.0	732	-	-
DEAD SH	1989	48	20±1	24±2	4.79±0.75	2.30	12.6±2.6	606	-	-
DEAD SH	1990	154	20±1	29±1	6.91±0.68	10.6	18.4±2.9	2837	-	-
DEAD SH	1991	234	21±1	29±1	7.42±0.62	17.4	21.8±2.5	5111	-	-
TOTALS	1987	313	-	-	-	29.3	-	-	-	24.0
TOTALS	1988	394	-	-	-	38.9	-	17020	-	35.5
TOTALS	1989	278	-	-	-	33.8	-	15562	-	29.6
TOTALS	1990	208	-	-	-	22.5	-	11182	-	18.0
TOTALS	1991	141	-	-	-	18.7	-	9066	-	14.9

Table 28. Population characteristics of perennial plants on plot YUF001, transect V2, sampled annually from 1987 through 1991. Elevation 1237 m.

Species	YEAR	n	HT	MAXWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
			cm	cm	dm ²	m ²	l	l	g	Kg
ACA SHO	1987	44	19±1	30±2	6±1	2.50	13±3	592	42±8	1.84
ACA SHO	1988	40	20±1	25±2	4.77±0.60	1.91	10.4±1.6	414	32.1±5.0	1.28
ACA SHO	1989	27	21±1	29±3	6.26±0.98	1.69	14.3±2.5	387	44.4±7.8	1.20
ACA SHO	1990	13	13±2	15±3	1.48±0.68	0.12	2.02±0.93	16	6.25±2.88	0.05
ACA SHO	1991	11	13±1	16±3	2.22±0.90	0.24	3.69±1.73	40	11.4±5.4	0.13
ARA PUL	1988	1	27	7	0.38	0.00	1.04	1	0.45	0.00
ARA PUL	1989	0	-	-	-	-	-	-	-	-
ART SPI	1987	49	21±1	31±2	7±1	3.33	15±2	732	61±8	3.00
ART SPI	1988	50	20±1	27±2	5.44±0.61	2.72	11.4±1.4	568	46.6±5.7	2.33
ART SPI	1989	37	23±1	29±2	6.34±0.82	2.34	14.9±2.1	552	61.1±8.5	2.26
ART SPI	1990	21	18±3	31±5	6.20±2.04	0.43	14.2±7.1	99	58.1±29.3	0.41
ART SPI	1991	6	20±4	20±4	2.39±0.58	0.14	5.39±2.22	32	22.1±9.1	0.13
ATR CAN	1987	36	41±2	34±4	11±3	3.92	58±29	2085	151±48	5.42
ATR CAN	1988	41	35±2	27±3	8.12±2.30	3.33	37.5±11.7	1539	97.6±30.4	4.00
ATR CAN	1989	38	36±2	29±3	7.25±1.41	2.76	33.3±7.8	1264	86.5±20.2	3.29
ATR CAN	1990	40	31±2	26±3	5.59±1.46	2.24	23.0±7.3	920	59.8±19.0	2.39
ATR CAN	1991	31	33±2	32±3	7.07±1.19	2.19	28.8±6.9	893	74.9±17.8	2.32

Table 28, continued.

Species	YEAR	n	HT	MAXWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
			cm	cm	dm ²	m ²	l	l	g	Kg
CER LAN	1987	65	28±1	24±2	4±0	2.52	12±2	798	39±5	2.55
CER LAN	1988	61	25±1	19±1	2.98±0.31	1.82	8.43±1.16	514	27.0±3.7	1.64
CER LAN	1989	53	29±1	23±1	3.94±0.48	2.09	11.5±1.6	611	36.9±5.0	1.96
CER LAN	1990	55	22±1	13±1	1.69±0.60	0.93	5.19±1.90	286	16.6±6.1	0.91
CER LAN	1991	42	22±2	16±2	1.99±0.54	0.83	6.32±2.14	265	20.2±6.8	0.85
EPH NEV	1987	22	46±6	58±9	36±10	7.88	228±70	5007	319±97	7.01
EPH NEV	1988	20	44±4	68±11	49.2±11.7	9.85	297±80	5936	416±113	8.31
EPH NEV	1989	21	40±5	57±10	39.5±11.4	8.30	239±76	5015	334±107	7.02
EPH NEV	1990	21	31±4	57±12	41.8±13.3	8.79	213±75	4482	298±105	6.28
EPH NEV	1991	21	31±5	56±11	34.1±10.1	7.17	197±68	4130	275±95	5.78
ERI PUL	1987	28	5±0	4±0	-	0.03	0.0±0.0	1	0.1±0.0	0.00
ERI PUL	1988	19	4±0	6±1	0.32±0.07	0.06	0.13±0.03	2	0.14±0.03	0.00
ERI PUL	1989	0	-	-	-	-	-	-	-	-
ERI PUL	1990	2	3±1	3±1	0.05±0.02	0.00	0.01±0.01	0	0.02±0.01	0.00
ERI PUL	1991	0	-	-	-	-	-	-	-	-
GRA SPI	1987	40	45±2	45±4	14±2	5.75	74±11	2948	170±26	6.78
GRA SPI	1988	41	42±2	44±4	18.8±3.7	7.72	97.8±21.1	4009	225±49	9.22
GRA SPI	1989	34	46±2	47±3	17.3±2.5	5.89	88.7±14.8	3016	204±34	6.94
GRA SPI	1990	44	41±2	34±3	7.91±1.17	3.48	36.4±6.1	1604	83.8±14.0	3.69
GRA SPI	1991	33	39±2	37±3	9.22±1.57	3.04	42.2±7.7	1392	97.0±17.7	3.20

Table 28, continued.

Species	YEAR	n	HT	MAXWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
			cm	cm	dm ²	m ²	l	l	g	Kg
HYM SAL	1987	11	45 $\pm$ 1	39 $\pm$ 4	10 $\pm$ 2	1.08	38 $\pm$ 8	420	122 $\pm$ 26	1.34
HYM SAL	1988	9	32 $\pm$ 3	27 $\pm$ 5	6.09 $\pm$ 1.33	0.55	21.7 $\pm$ 5.6	196	69.9 $\pm$ 18.0	0.63
HYM SAL	1989	8	34 $\pm$ 2	31 $\pm$ 3	6.64 $\pm$ 0.80	0.53	23.5 $\pm$ 4.0	188	75.2 $\pm$ 12.8	0.60
HYM SAL	1990	10	26 $\pm$ 2	17 $\pm$ 3	1.97 $\pm$ 0.69	0.16	5.49 $\pm$ 2.23	44	17.6 $\pm$ 7.1	0.14
HYM SAL	1991	8	20 $\pm$ 2	19 $\pm$ 4	2.28 $\pm$ 0.83	0.18	5.10 $\pm$ 2.12	41	16.3 $\pm$ 6.8	0.13
LYC AND	1987	20	44 $\pm$ 3	72 $\pm$ 8	41 $\pm$ 8	8.22	204 $\pm$ 48	4073	448 $\pm$ 105	8.95
LYC AND	1988	15	43 $\pm$ 3	72 $\pm$ 7	41.4 $\pm$ 7.3	6.21	203 $\pm$ 43	3046	447 $\pm$ 95	6.70
LYC AND	1989	20	41 $\pm$ 3	62 $\pm$ 6	32.3 $\pm$ 7.3	6.46	152 $\pm$ 39	3049	335 $\pm$ 87	6.71
LYC AND	1990	20	44 $\pm$ 3	71 $\pm$ 10	37.6 $\pm$ 9.6	4.89	194 $\pm$ 56	2516	426 $\pm$ 122	5.53
LYC AND	1991	14	47 $\pm$ 3	60 $\pm$ 1	33.4 $\pm$ 14.1	4.68	188 $\pm$ 88	2631	413 $\pm$ 193	5.79
MEN SPI	1987	1	10	14	1	0.01	1.0	18	0.01	
MEN SPI	1988	1	9	14	1.21	0.01	1.09	1	9.04	0.01
MEN SPI	1989	1	9	14	1.21	0.01	1.09	1	9.04	0.01
MEN SPI	1990	1	8	7	0.49	0.00	0.40	0	3.29	0.00
MEN SPI	1991	1	10	10	0.71	0.01	0.71	1	5.87	0.01
MIR PUD	1987	7	13 $\pm$ 3	7 $\pm$ 1	-	0.03	0.7 $\pm$ 0.2	5	0.3 $\pm$ 0.1	0.00
MIR PUD	1988	4	8 $\pm$ 2	4 $\pm$ 2	0.16 $\pm$ 0.11	0.01	0.17 $\pm$ 0.14	1	0.07 $\pm$ 0.06	0.00
MIR PUD	1989	0	-	-	-	-	-	-	-	-
MIR PUD	1990	0	-	-	-	-	-	-	-	-
MIR PUD	1991	1	10	12	0.57	0.01	0.57	1	0.24	0.00

Table 28, continued.

Species	YEAR	n	HT	MAXWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
			cm	cm	dm ²	m ²	l	l	g	Kg
ORY HYM	1987	8	37±4	13±3	1±1	0.12	5.2±2.3	41	5.7±2.5	0.05
ORY HYM	1988	7	16±2	6±2	0.57±0.40	0.04	1.41±1.11	10	1.55±1.22	0.01
ORY HYM	1989	5	1±0	23±3	2.57±0.80	0.13	0.31±0.7	2	0.34±0.08	0.00
SIT JUB	1987	28	23±2	4±0	-	0.04	0.4±0.1	11	0.4±0.1	0.01
SIT JUB	1988	7	21±2	3±0	0.08±0.02	0.01	0.17±0.05	1	0.19±0.05	0.00
SIT JUB	1989	0	-	-	-	-	-	-	-	-
SPH AMB	1987	71	8±1	8±0	-	0.29	0.5±0.1	34	0.2±0.1	0.01
SPH AMB	1988	26	14±1	9±1	0.46±0.09	0.12	0.77±0.19	20	0.33±0.08	0.01
SPH AMB	1989	2	2±1	3±1	0.04±0.03	0.00	0.01±0.00	0	0.00±0.00	0.00
SPH AMB	1990	0	-	-	-	-	-	-	-	-
SPH AMB	1991	1	2	2	0.03	0.00	0.01	08	0.00	0.00
STI SPE	1987	6	28±3	5±1	-	0.01	0.4±0.1	2	0.4±0.1	0.00
STI SPE	1988	13	21±2	4±1	0.15±0.04	0.02	0.34±0.09	4	0.37±0.10	0.00
STI SPE	1989	5	15±3	8±1	0.51±0.26	0.03	0.54±0.11	3	0.60±0.12	0.00
STI SPE	1990	8	17±2	4±1	0.17±0.06	0.01	0.30±0.11	2	0.33±0.12	0.00
STI SPE	1991	3	16±4	5±2	0.21±0.10	0.01	0.34±0.15	1	0.37±0.17	0.00

Table 28, continued.

Species	YEAR	n	HT	MAXWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
			cm	cm	dm ²	m ²	l	l	g	Kg
TET AXI	1987	2	76±6	119±33	109±68	2.17	866±583	1733	2339±1573	4.68
TET AXI	1988	1	95	133	136	1.36	1290	1290	3483	3.48
TET AXI	1989	2	81±9	111±47	107±71	2.15	935±674	1869	2523±1819	5.05
TET AXI	1990	2	81±8	109±41	96.0±60.7	1.92	818±561	1636	2209±1514	4.42
TET AXI	1991	2	81±8	108±36	87.6±48.1	1.75	757±464	1514	2044±1254	4.09
DEAD GR	1987	-	-	-	-	-	-	-	-	-
DEAD GR	1988	3	13±1	8±3	0.66±0.39	0.02	0.92±0.62	3	-	-
DEAD GR	1989	8	9±3	8±2	0.65±0.27	0.05	0.48±0.27	4	-	-
DEAD GR	1990	32	19±2	7±1	0.33±0.04	0.10	0.66±0.12	21	-	-
DEAD GR	1991	44	12±1	9±1	0.72±0.18	0.32	1.30±0.44	57	-	-
DEAD SH	1987	-	-	-	-	-	-	-	-	-
DEAD SH	1988	43	23±2	35±4	14.8±3.6	6.37	53.1±17.2	2284	-	-
DEAD SH	1989	55	23±2	35±4	11.7±2.7	6.42	44.2±15.6	2429	-	-
DEAD SH	1990	167	21±1	30±1	7.72±0.83	12.9	21.4±3.7	3580	-	-
DEAD SH	1991	230	22±1	30±1	7.10±0.74	16.3	22.5±3.5	5184	-	-
TOTALS	1987	438	-	-	-	37.9	-	18482	-	41.7
TOTALS	1988	356	-	-	-	35.7	-	17553	-	37.6
TOTALS	1989	253	-	-	-	32.4	-	15948	-	35.0
TOTALS	1990	237	-	-	-	23.0	-	11606	-	23.8
TOTALS	1991	174	-	-	-	20.3	-	10941	-	22.4

Table 29. Population characteristics of perennial plants on plot YUF001, transect V3, sampled annually from 1987 through 1991. Elevation 1237 m.

Species	YEAR	n	HT	MAXWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
			cm	cm	dm ²	m ²	l	l	g	Kg
ACA SHO	1987	44	22±1	30±2	7.04±0.91	3.10	18.0±2.9	791	55.7±9.0	2.45
ACA SHO	1988	45	20±1	23±2	4.59±0.76	2.07	10.8±2.2	486	33.5±6.9	1.51
ACA SHO	1989	16	20±2	28±4	7.39±1.80	1.18	18.6±5.6	297	57.5±17.3	0.92
ACA SHO	1990	10	12±3	13±5	1.83±1.18	0.07	3.04±2.19	12	9.41±6.80	0.04
ACA SHO	1991	14	17±2	17±4	2.87±1.45	0.40	7.06±4.12	99	21.9±12.8	0.31
ART SPI	1987	26	22±1	29±2	6.74±1.01	1.75	17.5±3.6	456	71.9±15.0	1.87
ART SPI	1988	27	21±1	27±2	5.83±0.98	1.57	13.6±3.2	368	55.9±12.9	1.51
ART SPI	1989	23	22±2	32±3	7.96±1.29	1.83	19.9±4.3	458	81.7±17.8	1.88
ART SPI	1990	4	21±3	39±5	10.2±3.1	0.31	23.5±9.3	70	96.3±38.0	0.29
ART SPI	1991	7	21±2	26±5	5.24±1.86	0.37	13.0±5.6	91	53.2±22.9	0.37
ART CAN	1987	40	38±3	30±4	8.80±1.97	3.52	48.5±13.1	1942	126±34	5.05
ART CAN	1988	38	38±3	27±3	8.06±2.01	3.06	45.3±14.5	1722	118±38	4.48
ART CAN	1989	37	36±3	33±5	9.88±2.29	3.66	51.2±14.2	1895	133±37	4.93
ART CAN	1990	35	30±2	23±3	3.29±0.65	1.15	12.8±3.3	446	33.1±8.6	1.16
ART CAN	1991	28	30±2	27±3	5.30±1.18	1.48	20.1±5.5	5644	52.3±14.2	1.47
CER LAN	1987	97	26±1	18±1	2.89±0.32	2.80	8.73±1.10	84682	27.9±3.5	2.71
CER LAN	1988	90	24±1	18±1	2.46±0.22	2.21	6.87±0.76	61853	22.0±2.4	1.98
CER LAN	1989	67	23±1	17±1	2.78±0.33	1.87	7.64±1.07	51248	24.4±3.4	1.64
CER LAN	1990	62	20±1	14±1	1.41±0.18	0.87	3.66±0.63	22706	11.7±2.0	0.73
CER LAN	1991	36	21±1	13±1	1.29±0.22	0.46	3.50±0.80	126	11.2±2.6	0.40

Table 29, continued.

Species	YEAR	n	HT	MAXWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOI	AVG BIO	TOTAL BIO
			cm	cm	dm ²	m ²	l	l	g	Kg
EPH NEV	1987	13	56±6	77±12	37.7±7.2	4.90	249±62	3235	348±87	4.53
EPH NEV	1988	16	47±5	64±12	42.4±12.5	6.79	272±94	4356	381±131	6.10
EPH NEV	1989	16	44±6	71±13	44.5±12.2	7.11	288±93	4611	403±130	6.46
EPH NEV	1990	20	37±6	51±11	31.8±11.3	6.05	210±83	3987	294±177	5.58
EPH NEV	1991	19	36±6	49±10	29.2±10.4	5.55	192±79	3644	268±110	5.10
ERI PUL	1987	10	5±1	4±1	0.14±0.04	0.01	0.09±0.03	1	0.10±0.04	0.00
ERI PUL	1988	3	4±1	6±2	0.30±0.16	0.01	0.13±0.09	0	0.15±0.10	0.00
ERI PUL	1989	0	-	-	-	-	-	-	-	-
GRA SPI	1987	41	41±2	47±5	20.9±3.7	8.56	108±23	4417	248±53	10.2
GRA SPI	1988	39	41±2	44±5	18.5±3.7	7.20	85.0±18.7	3313	195±43	7.62
GRA SPI	1989	27	43±3	45±5	18.3±3.4	4.95	98.5±21.3	2660	227±49	6.12
GRA SPI	1990	25	42±3	31±4	9.90±2.29	2.28	49.8±12.1	1146	115±28	2.64
GRA SPI	1991	22	63±24	38±5	11.3±2.1	2.49	119±72	2622	274±165	6.03
HYM SAL	1987	31	32±3	30±4	11.1±3.8	3.45	62.4±26.9	1933	200±86	6.19
HYM SAL	1988	30	27±3	25±5	9.06±3.77	2.72	52.5±26.4	1576	168±84	5.04
HYM SAL	1989	23	22±3	19±3	4.51±2.03	1.04	20.0±12.4	460	64.0±39.7	1.47
HYM SAL	1990	11	31±6	35±10	13.2±6.7	1.32	72.9±46.1	729	233±148	2.33
HYM SAL	1991	8	22±6±2	25±10	7.61±5.57	0.61	40.0±33.8	320	128±108	1.02
LYC AND	1987	-	-	-	-	-	-	-	-	-
LYC AND	1988	6	43±5	62±1	31.0±4.4	1.86	137±31	819	300±68	1.80
LYC AND	1989	17	42±2	74±6	44.2±6.9	7.51	194±35	3299	427±77	7.26
LYC AND	1990	17	41±4	76±12	38.2±11.6	2.29	177±64	1059	388±140	2.33
LYC AND	1991	21	41±2	65±6	32.9±6.0	6.90	149±32	3139	329±70	6.91

Table 29, continued.

Species	YEAR	n	HT	MAXWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
			cm	cm	dm ²	m ²	l	l	g	Kg
MIR PUD	1987	4	16±4	8±3	0.34±0.15	0.01	0.69±0.36	3	0.30±0.16	0.00
MIR PUD	1988	3	11±2	5±3	0.32±0.27	0.01	0.27±0.21	1	0.12±0.09	0.00
MIR PUD	1989	0	-	-	-	-	-	-	-	-
MIR PUD	1990	1	7	7	0.16	0.00	0.12	0	0.05	0.00
MIR PUD	1991	2	21±3	15±15	3.55±3.45	0.07	8.49±8.31	17	3.65±3.57	0.01
ORY HYM	1987	11	36±2	9±2	0.58±0.12	0.06	2.02±0.45	22	2.22±0.50	0.02
ORY HYM	1988	8	18±2	9±1	0.68±0.15	0.05	1.16±0.23	9	1.28±0.26	0.01
ORY HYM	1989	1	17	5	0.20	0.00	0.33	0	0.37	0.00
ORY HYM	1990	0	-	-	-	-	-	-	-	-
SIT JUB	1987	9	22±4	4±1	0.14±0.05	0.01	0.38±0.16	3	0.42±0.18	0.00
SIT JUB	1988	2	20±5	3±0	0.07±0.00	0.00	0.14±0.03	0	0.15±0.03	0.00
SIT JUB	1989	0	-	-	-	-	-	-	-	-
SPH AMB	1987	3	11±3	7±2	0.37±0.16	0.01	0.50±0.34	2	0.22±0.14	0.00
SPH AMB	1988	8	11±2	9±1	0.56±0.16	0.04	0.74±0.24	6	0.32±0.10	0.00
SPH AMB	1989	1	2	2	0.03	0.00	0.01	0	0.00	0.00
STI SPE	1987	15	34±4	8±1	0.63±0.20	0.10	2.82±1.03	42	3.10±1.13	0.47
STI SPE	1988	19	21±2	5±1	0.39±0.12	0.07	1.05±0.35	20	1.15±0.39	0.02
STI SPE	1989	7	13±2	6±1	0.26±0.07	0.02	0.37±0.14	3	0.40±0.15	0.00
STI SPE	1990	0	-	-	-	-	-	-	-	-
STI SPE	1991	1	7	1	0.01	0.00	0.01	0	0.01	0.00

Table 29, continued.

Species	YEAR	n	HT	MAXWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
			cm	cm	dm ²	m ²	l	l	g	Kg
TET AXI	1987	1	68	105	88.2	0.88	600	600	1620	1.62
TET AXI	1988	1	62	114	94.9	0.95	588	588	1589	1.59
TET AXI	1989	2	55±14	67±38	52.7±45.5	1.05	349±319	697	941±861	1.88
TET AXI	1990	1	58	82	61.2	0.61	355	355	958	0.96
TET AXI	1991	1	59	75	53.6	0.54	316	316	854	0.85
DEAD GR	1987	-	-	-	-	-	-	-	-	-
DEAD GR	1988	9	16±2	7±1	0.60±0.19	0.05	0.89±0.32	8	-	-
DEAD GR	1989	26	18±1	10±2	0.96±0.31	0.25	1.79±0.60	47	-	-
DEAD GR	1990	72	16±1	7±0	0.45±0.06	0.33	0.89±0.15	64	-	-
DEAD GR	1991	72	14±1	6±0	0.34±0.04	0.25	0.58±0.09	42	-	-
DEAD SH	1987	-	-	-	-	-	-	-	-	-
DEAD SH	1988	38	21±2	35±5	14.5±4.7	5.51	63.9±28.6	2428	-	-
DEAD SH	1989	49	19±2	32±3	11.1±3.4	5.45	41.8±22.0	2049	-	-
DEAD SH	1990	157	21±1	31±2	8.63±1.34	13.6	29.6±7.0	4644	-	-
DEAD SH	1991	196	22±1	29±1	7.61±0.89	14.9	26.7±5.0	5234	-	-
TOTALS	1987	366	-	-	-	30.3	-	15228	-	35.9
TOTALS	1988	335	-	-	-	28.6	-	13884	-	31.66
TOTALS	1989	237	-	-	-	30.2	-	14893	-	32.55
TOTALS	1990	186	-	-	-	15.0	-	8032	-	16.9
TOTALS	1991	159	-	-	-	18.9	-	10938	-	22.5

Table 30. Population characteristics of perennial plants on the south-facing slope of plot YUF019 (Bilby crater, U3cn), sampled July 20-21, 1989. Elevation 1213 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ATR CAN	35	39±4	36±5	31±4	13.8±3.6	4.85	88.4±28.6	3094	230±74	8.04
ORY HYM	229	8±0	14±1	12±1	1.67±0.14	3.82	1.72±0.35	394	189±0.39	0.43
SPH AMB	1	3	3	3	0.70	0.00	0.02	0.0	0.01	0.00
MIR PUD	7	4±1	1±0	1±0	0.01±0.00	0.00	0.00±0.00	0.0	0.00±0.00	0.00
UNKOWN	3	1±0	1±0	1±0	0.02±0.01	0.00	0.00±0.00	0.0	-	-
DEAD GR	324	10±0	14±0	11±0	1.49±0.09	4.82	1.82±0.15	589	-	-
DEAD SH	30	39±4	63±7	52±6	-	10.0	-	4972	-	-
TOTALS	275	-	-	-	-	8.67	-	3488	-	8.48

Table 31. Population characteristics of perennial plants on the center of crater U3cn (Bilby, YUF019), sampled July 20, 1989. Elevation 1213 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ATR CAN	5	52±7	72±15	57±10	36.2±11.8	1.81	218±87	1088	566±227	2.83
DEAD SH	1	39	55	49	21.2	0.21	82.6	82.6	-	-
TOTALS	5	-	-	-	-	1.81	-	1088	-	2.83

Table 32. Population characteristics of perennial plants on the center of crater U3cn (Bilby, YUF019), sampled July 20, 1989. Elevation 1213 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
MIR PUD	3	4±1	6±4	3±1	0.16±0.13	0.00	0.06±0.05	0.2	0.03±0.02	0.00
ORY HYM	226	3±0	9±1	8±1	1.02±0.13	2.31	0.25±0.05	57.1	0.28±0.05	0.06
SPH AMB	3	3±2	18±5	15±3	2.36±0.87	0.07	0.34±0.02	1.08	0.15±0.01	0.00
STI SPE	1	1	7	3	0.16	0.00	0.02	0.0	0.02	0.00
DEAD GR	5	6±2	9±3	13±4	1.16±0.57	0.06	1.10±0.62	5.5	-	-
TOTALS	233	-	-	-	-	2.39	-	58.3	-	0.06

Table 33. Population characteristics of perennial plants on plot YUF020, and undisturbed area adjacent to Bilby crater (U3cn) sampled July 24, 1989. Elevation 1241 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ATR CAN	20	28±3	26±5	22±4	6.67±2.07	1.35	26.3±9.48	525	68.3±24.7	1.37
CER LAN	19	26±3	24±3	25±4	5.72±1.12	1.09	18.2±4.4	346	58.3±14.2	1.11
CHR VIS	54	30±1	36±4	32±3	12.9±2.89	6.98	52.3±15.1	2822	131±38	7.05
GRA SPI	1	35	24	26	4.90	0.05	17.2	17.2	39.4	0.04
LYC AND	1	43	60	35	16.5	0.16	70.9	70.9	156	0.16
ORY HYM	191	12±1	15±1	14±1	2.03±0.17	3.87	2.44±0.25	466	2.68±0.28	0.51
POL SUB	51	1±0	1±0	1±0	0.01±0.00	0.00	0.00±0.00	0.0	-	-
SPH AMB	1	9	12	10	0.94	0.01	0.85	0.8	0.36	0.00
TET GLA	4	42±7	64±16	62±14	35.6±14.2	1.42	177±82	708	478±222	1.91
DEAD GR	66	10±1	12±1	11±1	1.33±0.18	0.88	1.40±0.21	92.6	-	-
DEAD SH	238	2±0	2±0	2±1	0.50±0.21	1.18	1.86±0.82	444	-	-
TOTALS	324	-	-	-	-	14.9	-	4956	-	12.1

Table 34. Population characteristics of perennial plants on the south-facing slope of crater U7au (YUF021), sampled July 26, 1989. Elevation 1234 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ART SPI	1	15	29	32	7.29	0.07	10.9	10.9	44.8	0.04
ATR CAN	2	65±13	122±40	119±31	124±68	2.49	872±592	1773	2305±1539	4.61
ORY HYM	19	1±0	7±1	7±1	0.47±0.06	0.09	0.07±0.02	1.3	0.07±0.02	0.00
SIT JUB	6	1±0	6±1	5±1	0.28±0.09	0.02	0.03±0.01	0.2	0.03±0.01	0.00
STI SPE	1	1	3	4	0.09	0.00	0.01	0.0	0.01	0.00
DEAD GR	35	1±0	9±0	9±0	0.67±0.07	0.23	0.07±0.01	2.3	-	-
DEAD SH	2	21±11	30±12	25±2	6.08±2.83	0.12	15.9±12.6	31.8	-	-
TOTALS	29	-	-	-	-	2.67	-	1786	-	4.66

Table 35. Population characteristics of perennial plants in the center of crater U7au (YUF021), sampled July 26, 1989. Elevation 1234 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ATR CAN	1	50	100	110	86.4	0.86	432	432	1123	1.12
DEAD GR	2	1±0	8±0	11±2	0.66±0.09	0.01	0.07±0.01	0.1	-	-
TOTALS	1	-	-	-	-	0.86	-	432	-	1.12

Table 36. Population characteristics of perennial plants on the north-facing slope of crater U7au (YUF021), sampled July 26, 1989. Elevation 1241 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ATR SPI	14	17±1	24±2	21±2	4.49±0.77	0.63	8.61±1.66	114	33.5±6.79	0.47
ATR CAN	20	37±3	35±4	29±3	9.59±1.96	1.92	43.7±10.6	875	114±28	2.27
CER LAN	13	28±2	26±2	25±3	5.48±0.94	0.71	16.7±3.7	217	53.4±11.8	0.69
GRA SPI	10	38±3	45±5	36±4	14.2±3.2	1.42	56.8±13.8	568	131±32	1.31
LYC AND	7	30±2	37±5	37±4	11.4±2.6	0.80	34.6±8.2	242	76.1±18.1	0.53
ORY HYM	10	2±1	12±2	10±1	0.96±0.17	0.10	0.19±0.10	1.9	0.21±0.11	0.00
SPH AMB	2	6±3	7±5	4±2	0.30±0.27	0.01	0.23±0.22	0.5	0.10±0.10	0.00
TET GLA	1	57	85	61	40.7	0.41	232	232	627	0.63
DEAD GR	16	8±1	13±1	12±1	1.40±0.31	0.22	1.20±0.32	19.2	-	-
DEAD SH	24	40±4	43±4	43±5	17.5±3.2	4.19	91.4±21.7	2193	-	-
TOTALS	77	-	-	-	-	5.98	-	2251	-	5.90

Table 37. Population characteristics of perennial plants on plot YUF022, an undisturbed area adjacent to crater U7au, sampled July 26-27, 1989. Elevation 1251 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ART SPI	53	20±1	32±2	25±2	7.70±0.95	4.08	17.7±2.4	940	72.7±9.9	3.85
ATR CAN	44	34±2	33±3	28±2	8.67±1.23	3.82	33.5±6.1	1474	87.1±15.9	3.83
CACTUS	1	14	23	21	3.79	0.04	5.31	5.3	-	-
CER LAN	55	33±1	32±2	30±2	8.70±1.06	4.78	31.8±4.9	1751	102±16	5.60
CHR VIS	1	12	18	5	0.71	0.01	0.85	0.8	2.12	0.00
EPH NEV	1	14	37	30	8.72	0.09	12.2	12.2	17.1	0.02
GRA SPI	21	47±2	56±5	47±4	23.0±3.6	4.82	117±23	2455	269±53	5.65
LYC AND	13	40±4	45±8	44±8	21.1±6.8	2.74	105±37	1371	232±82	3.02
ORY HYM	6	5±2	6±1	6±1	0.34±0.11	0.02	0.19±0.10	1.2	0.21±0.11	0.00
SPH AMB	1	4	9	7	0.49	0.00	0.20	0.2	0.09	0.00
SIT JUB	7	1±0	8±1	7±1	0.44±0.11	0.03	0.04±0.01	0.3	0.05±0.01	0.00
DEAD SH	22	37±4	47±5	42±5	19.0±3.62	4.19	94.8±25.9	2086	-	-
TOTALS	203	-	-	-	-	20.4	-	8011	-	22.0

Table 38. Population characteristics of perennial plants on plot YUF009 (T1 ground zero), sampled August 12, 1988 (top) and June 24, 1991 (second). Elevation 1279 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
HYM SAL	1	62	112	100	88.0	0.88	545	545	1746	1.36
HYM SAL	0	-	-	-	-	-	-	-	-	-
ORY HYM	68	23±1	13±1	13±1	1.65±0.16	1.12	4.65±0.61	316	5.11±0.67	0.35
ORY HYM	41	29±2	9±1	6±1	0.63±0.17	0.26	2.46±0.81	101	2.71±0.89	0.11
STI SPE	14	25±3	14±3	13±2	2.01±0.51	0.28	6.70±1.79	93.8	7.37±1.97	0.10
STI SPE	11	34±3	13±3	9±2	1.22±0.46	0.13	4.76±1.83	52.4	5.24±2.01	0.06
DEAD GR	5	17±3	16±3	18±4	2.66±0.99	0.13	5.27±2.29	26.4	-	-
DEAD GR	33	22±2	20±2	16±1	2.88±0.36	0.95	7.52±1.22	248	-	-
DEAD SH	13	12±3	19±3	20±4	3.82±1.16	0.50	7.11±2.72	92.4	-	-
DEAD SH	6	5±3	14±2	10±2	1.15±0.25	0.07	0.46±0.12	2.7	-	-
TOTALS	83	-	-	-	-	2.28	-	955	-	1.81
TOTALS	52	-	-	-	-	0.39	-	153	-	0.17

Table 39. Population characteristics of perennial plants on plot YUF029, in the transition zone of T1 ground zero, which was invaded by grasses by 1963, sampled July 1, 1991. Elevation 1271 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ATR CAN	19	20±3	22±5	16±3	4.67±1.86	0.89	17.7±8.4	336	46.0±21.8	0.87
LYC AND	1	14	7	12	0.66	0.01	0.92	0.9	2.03	0.00
MIR PUD	20	17±1	49±8	31±6	18.7±6.7	3.74	35.6±13.3	711	15.3±5.7	0.31
ORY HYM	1	16	7	1	0.05	0.00	0.09	0.1	0.10	0.00
DEAD GR	200	11±0	10±1	8±0	0.95±0.11	1.90	1.37±0.19	2749	-	-
DEAD SH	107	30±1	40±3	32±3	16.1±2.6	17.3	64.6±11.1	6916	-	-
TOTALS	41	-	-	-	-	4.64	-	1049	-	1.18

Table 40. Population characteristics of perennial plants on plot YUF010, an undisturbed plot near T1 ground zero, sampled Aug. 9, 1988 and June 25, 1991. Elevation 1267 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ATR CAN	68	32±1	21±2	17±1	3.66±0.58	2.49	14.3±2.9	973	37.2±7.5	2.53
ATR CAN	21	27±3	21±3	16±2	3.38±0.93	0.71	13.1±5.0	276	43.1±13.1	0.72
CER LAN	20	31±3	26±4	22±3	6.04±1.50	1.21	24.2±8.0	484	77.5±25.7	1.55
CER LAN	11	25±3	19±3	15±3	2.72±0.69	0.30	8.74±2.75	96.2	28.0±8.8	0.31
CHR VIS	58	32±2	39±3	34±3	13.8±2.1	7.99	58.2±14.1	3377	146±35	8.44
CHR VIS	27	18±1	19±2	13±1	2.29±0.46	0.62	4.93±1.29	133	12.3±3.2	0.33
EPH NEV	18	43±5	57±12	54±11	41.6±12.5	7.48	260±92	4685	364±129	6.56
EPH NEV	15	39±4	57±13	37±9	29.3±13.0	4.39	164±83	2460	230±117	3.44
GRA SPI	17	44±3	41±7	35±6	16.1±4.5	2.74	88.0±28.7	1496	2024±66	3.44
GRA SPI	3	33±12	30±19	17±10	7.20±6.44	0.22	38.6±36.8	116	88.9±84.7	0.27
HIL JAM	67	15±1	4±0	5±0	0.25±0.04	0.16	0.31±0.05	20.7	-	-
HIL JAM	87	16±1	3±0	3±0	0.07±0.01	0.04	0.10±0.01	5.7	-	-
LYC AND	5	32±3	52±17	32±12	19.7±9.5	0.98	59.5±30.4	297	131±67	0.65
LYC AND	4	33±2	42±123	33±14	14.9±10.2	0.60	54.2±39.5	217	119±0.48	0.48
ORY HYM	21	23±2	11±1	10±1	1.01±0.17	0.21	2.56±0.52	53.7	2.81±0.57	0.06
ORY HYM	3	27±11	7±1	7±1	0.39±0.12	0.01	1.24±0.58	3.7	1.36±0.64	0.00

Table 40, continued.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
SIT JUB	165	25±1	6±0	6±0	0.42±0.04	0.69	1.09±0.13	180	1.20±0.14	0.20
SIT JUB	0	-	-	-	-	-	-	-	-	-
STI SPE	69	26±1	9±1	9±1	1.22±0.30	0.84	4.08±1.13	281	4.48±1.25	0.31
STI SPE	1	31	37	27	7.85	0.08	24.3	24.3	26.8	
TET AXI	0	-	-	-	-	-	-	-	-	-
TET AXI	1	38	9	9	0.64	0.01	2.42	2.4	6.53	0.01
DEAD GR	21	18±2	10±1	8±1	0.86±0.20	0.18	1.85±0.50	38.8	-	-
DEAD GR	212	13±0	8±1	6±0	0.64±0.13	1.36	1.18±0.27	251	-	-
DEAD SH	0	33±3	44±5	46±5	21.8±3.8	8.06	103±23	3822	-	-
DEAD SH	131	30±1	37±2	30±2	13.1±1.7	17.1	59.4±10.6	7786	-	-
TOTALS	508	-	-	-	-	24.8	-	11847	-	23.7
TOTALS	173	-	-	-	-	6.97	-	3333	-	5.58

Table 41. Population characteristics of perennial plants on the burned section of YUF002, sampled July 15, 1987 (top) and July 16, 1990 (second line). Burned area was 218m². Elevation 1288m. (Cover is not percent.)

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
EPH NEV	5	39±5	48±7	36±8	13.6±4.3	0.68	55.2±18.6	276	77.2±26.0	0.39
EPH NEV	5	31±7	51±11	39±9	18.5±5.9	0.92	71.2±24.3	356	99.7±34.0	0.50
GRA SPI	2	4±0	3±2	3±2	0.07±0.06	0.00	0.03±0.02	0.1	0.06±0.05	0.00
GRA SPI	1	56	45	28	9.90	0.10	55.4	55.4	127	0.13
HAP COO	0	-	-	-	-	-	-	-	-	-
HAP COO	2	7±0	6±0	6±2	0.26±0.07	0.01	0.18±0.05	0.4	0.45±0.12	0.00
HYM SAL	2	28±6	24±4	17±5	3.36±1.48	0.07	10.3±6.2	20.6	33.0±19.7	0.07
HYM SAL	4	20±5	20±5	15±3	2.74±0.86	0.11	6.70±2.57	26.8	21.4±8.2	0.09
LYC AND	23	16±1	17±3	14±2	2.77±0.70	0.64	5.86±1.74	135	12.9±3.8	0.30
LYC AND	29	15±2	22±4	14±2	3.18±0.75	0.83	6.33±1.57	165	13.9±3.5	0.36
STI SPE	246	9±0	4±0	3±0	0.26±0.05	0.65	0.47±0.11	114	0.51±0.12	0.13
STI SPE	93	7±0	6±1	5±0	0.42±0.07	0.39	0.50±0.09	46.2	0.55±0.10	0.05
YUC BRE	2	34±25	22±20	19±18	6.11±6.09	0.12	36.0±36.0	72.0	-	-
YUC BRE	1	66	43	39	13.2	0.13	86.9	86.9	-	-
DEAD GR	0	-	-	-	-	-	-	-	-	-
DEAD GR	101	6±1	7±1	6±0	0.48±0.07	0.49	0.44±0.11	44.2	-	-
DEAD SH	0	-	-	-	-	-	-	-	-	-
DEAD SH	139	15±2	23±2	15±1	5.24±0.83	7.28	19.0±3.9	2639	-	-
TOTALS	280	-	-	-	-	2.16	-	618	-	0.87
TOTALS	135	-	-	-	-	2.49	-	736	-	1.12

Table 42. Population characteristics of perennial plants on the unburned section of plot YUF002, sampled July 15, 1987 (top) and July 16, 1990 (second). Elevation 1301m. The area was 182m². (Cover is not percent.)

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
AMB x HYM	0	-	-	-	-	-	-	-	-	-
AMB x HYM	1	8	4	3	0.09	0.00	0.08	0.1	0.19	0.00
ART SPI	1	28	15	2	0.24	0.00	0.66	0.7	2.70	0.00
ART SPI	0	-	-	-	-	-	-	-	-	-
CER LAN	2	39±26	47±35	42±32	24.3±23.4	0.49	156±154	311	498±494	1.00
CER LAN	2	-	-	-	-	-	-	-	-	-
COL RAM	5	57±15	71±24	58±19	47.1±18.8	2.36	377±154	1887	1963±801	9.81
COL RAM	7	55±10	62±14	60±17	38.6±12.2	2.70	273±97	1908	1418±504	9.92
EPH NEV	18	57±6	75±9	64±8	46.2±8.7	8.32	319±67	5746	447±94	8.04
EPH NEV	13	48±6	72±11	64±11	46.3±11.6	6.02	299±89	3893	419±125	5.45
GRA SPI	38	57±3	56±5	55±5	30.5±4.7	11.6	206±35	7827	474±82	18.0
GRA SPI	14	61±6	63±9	52±9	32.8±9.3	4.27	258±86	3348	592±199	7.70
HYM SAL	36	28±3	22±4	21±4	7.11±2.27	2.56	41.2±15.6	1482	132±50	4.74
HYM SAL	8	28±9	20±11	23±13	10.2±8.5	0.72	66.6±60.0	466	213±192	1.49

Table 42, continued.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
LYC AND	22	43±4	65±8	50±7	34.2±7.0	7.51	182±43	3999	400±95	8.80
LYC AND	21	45±4	74±10	60±10	49.0±12.0	9.81	287±78	5746	632±171	12.6
ORY HYM	1	32	3	3±	0.07	0.00	0.23	0.2	0.25	0.00
ORY HYM	1	11	13	11+	1.12	0.01	1.24	1.2	1.36	0.00
STI SPE	74	35±2	16±1	15±1	2.40±0.27	1.78	10.2±1.3	755	11.2±1.4	0.83
STI SPE	20	13±1	9±1	8±1	0.76±0.19	0.15	1.10±0.30	22.0	1.21±0.33	0.02
SIT JUB	2	27±7	6±2	7±3	0.38±0.25	0.01	1.20±0.94	2.4	1.32±1.03	0.00
SIT JUB	0	-	-	-	-	-	-	-	-	-
UNKNOWN	1	48	55	26	11.2	0.11	53.9	53.9	-	-
UNKNOWN	0	-	-	-	-	-	-	-	-	-
DEAD GR	0	-	-	-	-	-	-	-	-	-
DEAD GR	79	30±1	11±1	9±1	0.92±0.11	0.73	3.26±0.47	258	-	-
DEAD SH	0	-	-	-	-	-	-	-	-	-
DEAD SH	88	31±2	46±3	37±3	20.1±2.5	17.7	96.9±15.0	8531	-	-
TOTALS	202	-	-	-	-	36.0	-	22689	-	52.8
TOTALS	93	-	-	-	-	24.0	-	15534	-	37.6

Table 43. Population characteristics of perennial plants on the south-facing slope of crater U10af (YUF023), sampled August 1, 1989. Elevation 1277 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
CER LAN	1	35	31	53	12.9	0.13	45.2	45.2	145	0.14
GRA SPI	1	64	89	73	51.0	0.51	327	327	752	0.75
ORY HYM	16	4±1	10±1	7±1	0.69±0.16	0.11	0.10±0.02	1.6	0.11±0.02	0.00
UNKNOWN	1	1	1	1	0.01	0.00	0.00	0.0	-	-
DEAD GR	30	10±1	14±2	11±1	1.78±0.52	0.54	3.32±1.70	99.7	-	-
DEAD SH	2	25±21	41±23	33±23	14.8±13.4	0.30	65.0±64.5	130	-	-
TOTALS	19	-	-	-	-	0.75	-	896	-	0.90

Table 44. Population characteristics of perennial plants in the center of crater U10af (YUF023), sampled August 1, 1989. Elevation 1277m. (Total cover is not percent.)

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ORY HYM	3	1+0	14±11	10±7	2.34±2.22	0.07	0.23±0.22	0.7	0.26±0.24	0.00
DEAD GR	6	5±2	5±1	4±1	0.16±0.04	0.01	0.11±0.06	0.6	-	-
DEAD SH	2	7±4	23±14	21±14	5.33±4.84	0.11	1.77±1.28	3.6	-	-
TOTALS	3	-	-	-	-	0.07	-	0.70	-	0.00

Table 45. Population characteristics of perennial plants on the north-facing slop of crater U10af (YUF023), sampled August 1, 1989. Elevation 1277 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ATR CAN	14	36±4	37±5	29±4	10.1±2.0	1.42	41.7±9.1	584	109±24	1.52
CER LAN	5	37±4	36±7	28±4	8.34±2.29	0.42	34.0±12.0	170	109±38	0.54
CHR VIS	1	29	40	28	8.80	0.09	25.5	25.5	63.8	0.06
LYC AND	2	47±0	53±9	48±19	21.4±11.2	0.43	101±53	202	222±116	0.44
ORY HYM	72	5±1	15±1	13±1	1.74±0.16	1.25	1.12±0.28	80.8	1.24±0.30	0.09
SPH AMB	1	13	10	9	0.71	0.01	0.92	0.9	0.40	0.00
DEAD GR	73	10±1	15±1	13±1	1.72±0.13	1.26	1.87±0.20	137	-	-
DEAD SH	6	27±10	38±17	31±15	19.5±12.8	1.17	79.6±46.8	478	-	-
TOTALS	95	-	-	-	-	3.61	-	1063	-	2.66

Table 46. Population characteristics of perennial plants on plot YUF024, an area adjacent to crater U10af, sampled August 2, 1989. Elevation 1300 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
CER LAN	6	31±6	40±9	40±10	15.9±5.3	0.95	65.6±25.6	393	210±81.9	1.26
ORY HYM	96	1±0	12±1	10±0	1.08±0.09	1.03	0.11±0.01	10.7	0.12±0.01	0.01
STI SPE	1	18	9	10	0.71	0.01	1.27	1.3	1.40	0.00
DEAD GR	25	6±1	9±1	7±1	0.60±0.13	0.15	0.37±0.09	9.2	-	-
DEAD SH	2	3±1	7±1	7±2	0.37±0.13	0.01	0.10±0.05	0.2	-	-
TOTALS	103	-	-	-	-	1.99	-	405	-	1.27

Table 47. Population characteristics of perennial plants on plot YUF025 (T4 ground zero), sampled July 26, 1990. Elevation was 1317 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ERI PUL	10	2 $\pm$ 0	3 $\pm$ 1	2 $\pm$ 0	0.04 $\pm$ 0.01	0.00	0.01 $\pm$ 0.00	0.1	0.01 $\pm$ 0.00	0.00
HYM SAL	36	24 $\pm$ 2	27 $\pm$ 4	22 $\pm$ 3	7.69 $\pm$ 2.22	2.77	31.8 $\pm$ 13.2	1147	102 $\pm$ 42	3.67
SPH AMB	246	4 $\pm$ 0	5 $\pm$ 0	4 $\pm$ 0	0.16 $\pm$ 0.01	0.40	0.07 $\pm$ 0.01	17.4	0.03 $\pm$ 0.00	0.01
STI SPE	87	10 $\pm$ 1	7 $\pm$ 1	6 $\pm$ 0	0.47 $\pm$ 0.07	0.41	0.63 $\pm$ 0.10	55.1	0.70 $\pm$ 0.11	0.06
DEAD GR	36	14 $\pm$ 3	5 $\pm$ 1	4 $\pm$ 1	0.24 $\pm$ 0.15	0.02	0.56 $\pm$ 0.45	3.9	-	-
DEAD SH	307	22 $\pm$ 11	17 $\pm$ 5	12 $\pm$ 2	2.00 $\pm$ 0.67	0.14	5.74 $\pm$ 2.99	40.2	-	-
TOTALS	379	-	-	-	-	3.58	-	1219	-	3.74

Table 48. Population characteristics of perennial plants on plot YUF026, an undisturbed area south of T4 ground zero, sampled July 24-26, 1990. Elevation 1320 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
CER LAN	11	35±3	36±5	28±4	9.54±2.56	1.05	38.9±12.2	427	124±39	1.37
EPH NEV	13	30±5	55±13	46±12	34.5±14.5	4.49	174±87	2257	243±122	3.16
GRA SPI	10	49±5	53±8	40±10	21.7±7.6	2.17	124±47	1241	285±108	2.85
HAP COO	1	27	73	30	17.20	0.17	46.4	46.4	116	0.12
HYM SAL	8	25±5	18±5	14±4	2.68±1.13	0.16	8.89±3.96	53.3	28.4±12.7	0.17
LYC AND	17	43±3	63±7	49±7	29.2±6.5	4.67	148±38	2362	325±85	5.20
OPU BAS	2	8±1	14±1	12±1	1.28±0.15	0.03	1.01±0.01	2.0	-	-
SPH AMB	1	13	18	9	1.27	0.01	1.65	1.7	0.71	0.00
STI SPE	2	18±5	15±1	9±3	1.08±0.42	0.02	1.71±0.25	3.4	1.88±0.28	0.00
DEAD GR	108	25±1	14±1	11±1	1.40±0.12	1.51	4.00±0.40	432	-	-
DEAD SH	72	28±2	50±5	42±4	26.4±5.1	19.0	117±30	8430	-	-
TOTALS	65	-	-	-	-	12.8	-	6394	-	12.9

Table 49. Population characteristics of perennial plants on plot YUF016, on the Sedan blast area at 305 m NE of GZ, sampled July 6, 1988 (top) and July 15, 1991 (second). Elevation 1318 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
BUNCHGR	0	-	-	-	-	-	-	-	-	-
BUNCHGR	8	13±1	1±0	1±0	0.02±0.01	0.00	0.02±0.01	0.1	0.02±0.01	0.00
ORY HYM	0	21±1	6±1	5±1	0.69±0.28	0.55	3.20±1.57	256	3.52±1.72	0.28
ORY HYM	81	20±1	4±0	3±0	0.15±0.02	0.12	0.35±0.07	28.0	0.38±0.07	0.03
STI SPE	27	17±2	6±1	6±1	0.38±0.09	0.10	1.12±0.37	30.1	1.23±0.41	0.03
STI SPE	7	21±2	11±2	9±2	0.99±0.35	0.07	2.47±0.99	17.3	2.71±1.09	0.02
UNKNOWN	1	3	7	10	0.55	0.01	0.16	0.2	-	-
UNKNOWN	0	-	-	-	-	-	-	-	-	-
DEAD GR	11	33±4	38±5	34±4	11.3±2.5	1.24	42.61±11.9	469	-	-
DEAD GR	25	15±2	20±2	16±2	3.24±0.68	0.81	6.82±1.82	171	-	-
TOTALS	108	-	-	-	-	0.66	-	286	-	0.31
TOTALS	96	-	-	-	-	0.19	-	45.4	-	0.05

Table 50. Population characteristics of perennial plants on plot YUF007, on the Sedan blast area at 914 m NE of GZ, sampled July 6, 1988 (top) and July 15, 1991 (second). Elevation 1327m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
HYM SAL	57	28±2	33±4	30±3	12.9±3.3	7.38	58.8±19.6	3355	188±63	10.7
HYM SAL	48	30±2	36±4	34±3	13.4±3.0	6.42	56.8±17.0	2724	182±54	8.72
LYC AND	3	52±3	69±4	73±2	39.9±2.2	1.20	209±22	626	459±48	1.38
LYC AND	3	53±2	68±7	62±6	33.4±6.5	1.00	175±31	525	385±68	1.15
ORY HYM	101	29±1	12±1	12±1	1.36±0.14	1.37	4.34±0.47	438	4.78±0.52	0.48
ORY HYM	58	23±1	10±1	8±1	0.94±0.21	0.55	2.51±0.61	146	2.76±0.68	0.16
SPH AMB	2	30±3	8±1	9±2	0.51±0.12	0.01	1.58±0.50	3.2	0.68±0.21	0.00
SPH AMB	0	-	-	-	-	-	-	-	-	-
STI SPE	6	27±3	9±1	9±2	0.71±0.17	0.04	2.20±0.73	13.2	2.42±0.80	0.01
STI SPE	7	21±3	9±2	8±1	0.66±0.19	0.05	1.63±0.56	11.4	1.79±0.62	0.01
DEAD GR	71	12±1	8±1	8±1	0.66±0.08	0.47	1.01±0.21	72.0	-	-
DEAD GR	103	10±1	14±1	11±1	1.59±0.17	1.64	2.04±0.29	210	-	-
DEAD SH	2	17±11	67±33	65±37	43.7±36.4	0.87	114±110	229	-	-
DEAD SH	2	17±11	59±39	45±25	28.5±25.4	0.57	76.2±74.6	152	-	-
TOTALS	169	-	-	-	-	9.99	-	4436	-	12.06
TOTALS	116	-	-	-	-	8.01	-	3406	-	10.0

Table 51. Population characteristics of perennial plants on plot YUF018, on the Sedan blast area at 1524 m NE of GZ, sampled July 8, 1988 (top) and July 15, 1991 (second). Elevation 1335 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOI	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
BUNCHGR	4	34±3	5±0	5±0	0.22±0.04	0.01	0.74±0.13	3.0	0.82±0.14	0.00
BUNCHGR	0	-	-	-	-	-	-	-	-	-
COL RAM	64	48±2	55±3	52±3	26.2±2.7	16.8	148±19	9481	770±99	49.3
COL RAM	75	42±2	49±3	37±2	17.5±1.9	13.1	87.4±11.3	6554	454±59	34.1
HYM SAL	11	34±6	35±10	36±8	15.7±6.4	1.73	86.8±40.6	955	278±130	3.06
HYM SAL	8	29±6	34±7	25±5	8.74±2.62	0.70	33.4±11.1	267	107±36	0.85
LYC AND	6	55±3	83±5	86±11	55.8±8.1	3.35	315±59	1891	693±130	4.16
LYC AND	7	46±5	68±13	56±10	36.2±9.6	2.53	192±58	1346	423±127	2.96
ORY HYM	22	31±2	14±2	13±2	1.99±0.54	0.44	6.77±2.57	149	7.45±2.82	0.16
ORY HYM	2	7±5	1±0	1±0	0.01±0.00	0.00	0.01±0.00	0.0	0.01±0.00	0.00
STI SPE	1	28	3	3	0.07	0.00	0.20	0.2	0.22	0.00
STI SPE	1	11	2	1	0.02	0.00	0.02	0.0	0.02	0.00
DEAD GR	15	11±2	13±2	13±2	1.59±0.39	0.24	2.07±0.59	31.0	-	-
DEAD GR	82	15±1	12±1	9±1	1.23±0.31	1.01	2.25±0.77	185	-	-
DEAD SH	4	16±5	36±7	36±7	10.8±3.6	0.43	15.5±4.9	61.8	-	-
DEAD SH	13	14±2	21±5	14±4	3.64±1.4	0.47	7.66±3.16	99.6	-	-
TOTALS	108	-	-	-	-	22.3	-	12479	-	56.7
TOTALS	93	-	-	-	-	16.3	-	8167	-	37.9

Table 52. Population characteristics of perennial plants on plot YUF014, (T2 ground zero), sampled July 31, 1990. Elevation 1371 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
DEAD GR	1264	3±1	5±2	6±13	0.22±0.11	0.00	0.06±0.04	0.1	-	-
DEAD SH	7	3±1	6±1	5±1	0.24±0.08	0.02	0.11±0.05	0.8	-	-
TOTALS	0	-	-	-	-	-	-	-	-	0.00

Table 53. Population characteristics of perennial plants on plot YUF015, an undisturbed area east of T2 ground zero, sampled August 1-2, 1990. Elevation 1338 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ATR CAN	9	49±6	54±17	42±15	33.1±23.2	2.98	245±188	2202	636±488	5.73
CER LAN	22	31±2	23±2	18±2	3.65±0.69	0.77	12.4±2.6	260	39.7±8.4	0.83
EPH NEV	1	54	126	79	78.18	0.78	422	422	591	0.59
GRA SPI	7	37±5	28±6	23±6	6.07±2.49	0.24	22.2±7.5	89	51.0±17.3	0.20
HAP COO	3	23±11	29±19	18±8	5.11±4.32	0.10	16.5±15.6	33	41.2±38.9	0.08
HYM SAL	26	19±2	18±3	14±3	3.54±1.38	0.92	13.0±6.8	338	41.6±21.8	1.08
LYC AND	11	39±7	59±19	53±20	33.2±17.6	1.33	155±84	620	341±184	1.36
STI SPE	1	22	7	7	0.38	0.00	0.85	0.8	0.93	0.00
DEAD GR	167	14±1	5±0	4±0	0.20±0.02	0.33	0.36±0.05	66	-	-
DEAD SH	88	22±2	32±2	25±3	11.3±2.0	9.94	50.5±11.0	4446	-	-
TOTALS	80	-	-	-	-	7.13	-	3966	-	9.88

Table 54. Population characteristics of perennial plants on plot YUF030, (Beatley Plot 51), sampled August 14, 1989. Elevation 1509 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
CACTUS	3	16±8	16±11	17±11	3.94±3.70	0.12	12.6±12.4	37.8		
COL RAM	241	43±1	51±1	46±1	20.6±1.0	49.8	96.0±5.6	23127	499±29	120
EPH NEV	13	43±6	68±10	56±11	38.7±10.6	5.03	219±91	2852	307±127	3.99
STI SPE	2	30±29	21±17	20±17	5.60±5.44	0.11	32.6±32.6	65.2	35.8±35.8	0.07
YUC BAC	1	72	128	134	135	1.35	970	970	-	-
DEAD GR	1	1	2	2	0.03	0.00	0.00	0.0	-	-
TOTALS	260	-	-	-	-	56.4	-	27052	-	124

Table 55. Population characteristics of perennial plants on plot MID004, a bladed area in Mid Valley, sampled July 28, 1989. Elevation 1439 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
CHR NAU	1	35	9	11	0.78	0.01	2.72	2.7	6.80	0.01
COL RAM	1	9	8	11	0.69	0.01	0.62	0.6	3.23	0.00
EPH NEV	3	25±9	29±9	22±6	5.86±2.73	0.18	10.2±3.1	30.6	14.3±4.4	0.04
ORY HYM	1	5	5	3	0.12	0.00	0.06	0.1	0.06	0.00
TOTALS	6	-	-	-	-	0.19	-	34.0	-	0.05

Table 56. Population characteristics of perennial plants on plot MID005, an undisturbed area adjacent to MID004 in Mid Valley, sampled July 31, 1989. Elevation 1445 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
COL RAM	163	46 $\pm$ 1	59 $\pm$ 2	53 $\pm$ 2	28.3 $\pm$ 1.8	46.2	145 $\pm$ 11	23570	752 $\pm$ 57	123
EPH NEV	5	59 $\pm$ 5	133 $\pm$ 27	120 $\pm$ 25	147 $\pm$ 45	7.33	943 $\pm$ 300	4716	1320 $\pm$ 421	6.60
ORY HYM	1	1	26	17	3.47	0.04	0.35	0.4	0.38	0.00
STI SPE	12	2 $\pm$ 1	9 $\pm$ 2	9 $\pm$ 2	0.92 $\pm$ 0.29	0.11	0.17 $\pm$ 0.08	2.0	0.18 $\pm$ 0.09	0.00
DEAD GR	2	37 $\pm$ 1	11 $\pm$ 3	9 $\pm$ 24	0.80 $\pm$ 0.30	0.02	2.97 $\pm$ 1.09	6.0	-	-
DEAD SH	4	20 $\pm$ 8	83 $\pm$ 16	57 $\pm$ 12	41.4 $\pm$ 16.5	1.65	110 $\pm$ 64	440	-	-
TOTALS	181	-	-	-	-	53.6	-	28288	-	129

Table 57. Population characteristics of perennial plants on plot MID006 (Beatley Plot 42), a burned area in Mid Valley next to MID007, sampled July 28, 1989. Elevation 1445 m. The fire occurred in 1959.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ACA SHO	1	28	78	88	53.9	0.54	151	151	468	0.47
CHR NAU	1	47	58	58	26.4	0.26	124	124	310	0.31
COL RAM	2	±7	40±14	50±6	16.6±7.1	0.33	71.6±40.1	143	372±208	0.74
EPH NEV	15	63±5	151±15	136±15	182±28	27.3	1258±211	18875	1762±295	26.4
ERI PUL	14	2±1	10±1	9±1	0.73±0.21	0.03	0.17±0.12	0.7	0.19±0.13	0.00
SPH AMB	1	4	2	2	0.03	0.00	0.01	0.0	0.01	0.00
STI SPE	1	12	9	5	0.35	0.00	0.42	0.4	0.47	0.00
DEAD GR	7	45±4	47±7	35±5	14.0±3.4	0.98	65.4±17.0	458	-	-
DEAD SH	15	9±2	17±2	14±2	2.12±0.36	0.32	2.14±0.72	32.1	-	-
TOTALS	35	-	-	-	-	28.4	-	19294	-	27.9

Table 58. Population characteristics of perennial plants on plot MID007 (Beatley Plot 41, an unburned control in Mid Valley), sampled on July 28, 1989. Elevation 1445 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ART TRI	1	43	35	18	4.95	0.05	21.3	21.3	38.3	0.04
ARA PUL	4	16±2	8±1	1±0	0.08±0.03	0.00	0.12±0.03	0.5	0.05±0.01	0.00
CACTUS	1	42	56	17	7.48	0.08	31.4	31.4	-	-
COL RAM	223	41±1	48±2	42±2	19.9±1.4	44.4	98.0±8.4	21853	510±44	114
EPH NEV	19	38±5	60±14	44±9	37.3±16.6	7.09	220±109	4173	307±153	5.84
DEAD GR	18	1±0	6±1	5±0	0.27±0.04	0.05	0.03±0.00	0.5	-	-
DEAD SH	23	21±4	40±8	34±8	20.5±7.9	4.71	49.2±17.4	1131	-	-
TOTALS	248	-	-	-	-	51.6	-	26079	-	120

Table 59. Population characteristics of perennial plants on the burned area of Plot MID001, sampled August 14, 1987 (top line) and Aug. 7, 1990 (second line). Elevation 1445m. Burned area was 500m². (Total cover is not percent.)

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ART TRI	0	-	-	-	-	-	-	-	-	-
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
ATR CAN	2	27±17	30±19	27±17	8.90±8.03	0.18	37.7±36.8	75.4	98.0±95.7	0.20
ATR CAN	5	35±11	48±18	40±15	23.4±15.9	1.17	149±120	745	387±312	1.94
CACTUS	0	-	-	-	-	-	-	-	-	-
CACTUS	1	3	3	2	0.05	0.01	0.01±	0.00	-	-
CHR TER	2	21±3	25±6	29±15	6.40±4.31	0.13	14.8±10.9	29.7	37.1±27.2	0.27
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 VIS	3	34±8	39±15	31±13	12.2±8.2	0.37	54.4±42.7	163	136±107	0.41
CHR VIS	0	-	-	-	-	-	-	-	-	-
COL RAM	0	-	-	-	-	-	-	-	-	-
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
ERI CAE	0	-	-	-	-	-	-	-	-	-
ERI CAE	1	4	6	4	0.19	0.00	0.08	0.1	-	-

Table 59, continued.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
EPH NEV	32	36±2	42±4	38±3	14.7±2.8	4.72	66.2±17.7	2118	92.6±24.8	2.96
EPH NEV	33	29±2	53±5	38±3	18.6±2.9	6.15	60.9±10.1	2008	85.2±14.2	2.81
ERI PUL	0	-	-	-	-	-	-	-	-	-
ERI PUL	1	1	2	1	0.02	0.00	0.00	0.0	0.00	0.00
LYC AND	3	25±3	32±8	25±5	6.89±2.68	0.21	18.1±7.21	54.2	39.7±15.8	0.12
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	0	-	-	-	-	-	-	-	-	-
MEN SPI	2	11±2	11±5	11±1	0.97±0.42	0.02	1.08±0.58	2.2	8.94±4.83	0.02
OPU ECH	0	-	-	-	-	-	-	-	-	-
OPU ECH	5	11±3	9±3	7±3	0.79±0.48	0.04	1.23±0.90	6.1	-	-
ORY HYM	227	15±0	5±0	4±0	0.27±0.02	0.61	0.43±0.05	98.0	0.48±0.05	0.11
ORY HYM	9	8±1	5±1	4±0	0.18±0.04	0.02	0.14±0.03	1.2	0.15±0.03	0.00
PHL STA	57	22±1	19±1	17±1	3.26±0.51	1.86	10.2±2.3	582	4.39±0.99	0.25
PHL STA	11	7±1	9±2	7±1	0.67±0.15	0.07	0.63±0.16	7.0	0.27±0.07	0.00
SPH AMB	0	-	-	-	-	-	-	-	-	-
SPH AMB	188	5±0	8±0	6±0	0.47±0.04	0.88	0.34±0.07	64.6	0.15±0.03	0.03

Table 59, continued.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
STI SPE	0	-	-	-	-	-	-	-	-	-
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
YUC BRE	5	229±52	46	46	16.6	0.17	91.4	91.4	-	-
YUC BRE	6	12±2	21±9	19±11	7.07±4.35	0.42	11.3±7.0	68.0	-	-
UNKNOWN	1	50	57	59	26.4	0.26	132	132	-	-
UNKNOWN	8	8±2	11±4	8±3	1.37±0.80	0.11	1.89±1.24	15.1	-	-
DEAD GR	-	-	-	-	-	-	-	-	-	-
DEAD GR	387	4±0	5±0	4±0	0.21±0.01	0.50	0.06±0.01	15.2	-	-
DEAD SH	-	-	-	-	-	-	-	-	-	-
DEAD SH	402	14±1	21±1	14±1	4.35±0.57	11.8	10.6±2.1	2885	-	-
TOTALS	332	-	-	-	-	8.50	-	3343	-	4.12
TOTALS	496	-	-	-	-	10.3	-	3208	-	5.52

Table 60. Population Characteristics of perennial plants on the unburned 200m² portion of plot MID001 sampled Aug. 14, 1987 (top) and Aug. 7, 1990 (second). Elevation 1452 m. (Total cover is not percent.)

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ART TRI	92	50±2	63±4	54±4	37.2±4.6	34.2	261±39	24007	470±70	43.2
ART TRI	103	41±2	54±4	41±3	25.8±3.6	26.6	165±28	16960	296±50	30.5
CACTUS	0	-	-	-	-	-	-	-	-	-
CACTUS	2	4±1	5±3	4±3	0.17±0.16	0.00	0.08±0.08	0.2	-	-
CHR TER	6	42±6	64±12	48±11	26.0±5.9	1.56	124±29	744	310±72	1.86
CHR TER	10	37±7	47±10	36±8	18.7±5.4	1.87	100±32	1001	250±80	2.50
CHR VIS	39	43±2	70±4	60±5	39.0±4.9	15.2	186±27	7271	466±67	18.2
CHR VIS	48	27±2	36±3	30±3	11.8±1.8	5.66	40.1±6.9	1923	100±17	4.81
COL RAM	60	44±2	58±4	50±3	27.7±3.4	16.6	140±20	8385	727±103	43.6
COL RAM	76	41±2	53±4	44±3	24.1±3.1	18.3	121±17	9174	628±90	47.7
EPH NEV	61	31±2	32±3	31±5	9.23±1.71	5.63	40.0±10.2	2440	56.0±14.2	3.42
EPH NEV	107	25±1	45±5	30±3	21.4±3.8	22.9	72.1±18.8	7710	101±26	10.8
ERI COO	8	26±2	40±7	37±8	14.5±5.20	1.16	44.6±18.0	357	112±45	0.89
ERI COO	11	24±3	35±6	26±6	9.72±3.36	1.07	30.9±12.2	340	77.3±30.6	0.85
GRA SPI	2	54±5	36±6	31±2	8.98±1.91	0.18	47.5±5.8	95.0	109±13	0.22
GRA SPI	1	45	51	51	20.4	0.20	91.9	91.9	211	0.21
OPU ECH	1	30	13	9	0.92	0.01	2.76	2.8	-	-
OPU ECH	1	24	17	15	2.0	0.02	4.81	4.8	-	-

Table 60, continued.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
OPU ERI	1	26	45	30	10.6	0.11	27.6	27.6	-	-
OPU ERI	4	22±5	20±11	12±6	33.3±2.54	0.13	9.27±12	37.1	-	-
ORY HYM	139	23±1	8±0	7±0	0.54±0.06	0.75	1.43±0.18	198	1.57±0.20	0.22
ORY HYM	1	8	8	7	0.44	0.00	0.35	0.4	0.39	0.00
PHL STA	13	-	-	-	-	-	-	-	-	-
PHL STA	1	3	5	2	0.08	0.00	0.02	0.0	0.01	0.00
SPH AMB	0	-	-	-	-	-	-	-	-	-
SPH AMB	8	5±1	6±2	4±1	0.28±0.14	0.02	0.26±0.21	2.1	0.11±0.09	0.00
STI SPE	0	-	-	-	-	-	-	-	-	-
STI SPE	37	16±1	5±1	4±0	0.19±0.03	0.07	0.33±0.06	11.7	0.36±0.07	0.01
UNKNOWN	0	-	-	-	-	-	-	-	-	-
UNKNOWN	2	3±2	2±1	2±1	0.02±0.01	0.0	0.01±0.01	0.0	-	-
YUC BRE	2	33±5	25±5	23±6	4.72±1.89	0.09	16.6±8.4	33.3	-	-
YUC BRE	3	20±6	17±4	14±6	2.22±1.07	0.07	5.81±3.25	17.4	-	-
DEAD GR	-	-	-	-	-	-	-	-	-	-
DEAD GR	338	16±1	6±1	5±1	0.71±0.45	0.46	1.48±0.99	94.9	-	-
DEAD SH	-	-	-	-	-	-	-	-	-	-
DEAD SH	70	30±2	72±5	56±5	43.0±6.1	29.7	145±27	9996	-	-
TOTALS	424	-	-	-	-	75.5	-	43561	-	112
TOTALS	415	-	-	-	-	76.9	-	37275	-	97.4

Table 61. Population characteristics of perennial plants on plot RED001, an area in Red Rock Valley which burned in July 1988, sampled July 12, 1989. Dead plants were not measured. Elevation 1612 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
EPH NEV	3	39±6	130±26	85±17	93.6±30.5	2.81	400±159	1201	561±223	1.68
ORY HYM	94	12±1	3±0	3±0	0.09±0.02	0.08	0.11±0.02	10.4	0.12±0.02	0.01
PSO POL	1	2	2	1	0.02	0.00	0.00	0.0	0.01	0.00
TOTALS	98	-	-	-	-	2.89	-	1212	-	1.69

Table 62. Population characteristics of perennial plants on plot RED002, an unburned site across Pahute Mesa Road from burned plot REED001 sampled on July 12, 1989. Elevation 1616 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ATR CAN	9	64 $\pm$ 7	68 $\pm$ 11	53 $\pm$ 12	35.1 $\pm$ 12.0	3.16	280 $\pm$ 125	2518	727 $\pm$ 325	6.55
EPH NEV	3	64 $\pm$ 32	122 $\pm$ 93	106 $\pm$ 85	225 $\pm$ 219	6.76	2826 $\pm$ 2797	8479	3957 $\pm$ 3916	11.9
ORY HYM	6	8 $\pm$ 2	7 $\pm$ 2	4 $\pm$ 1	0.28 $\pm$ 0.13	0.02	0.32 $\pm$ 0.17	1.9	0.35 $\pm$ 0.19	0.00
PSO POL	31	62 $\pm$ 3	94 $\pm$ 8	75 $\pm$ 6	65.9 $\pm$ 10.6	20.4	480 $\pm$ 98	14893	1201 $\pm$ 246	37.2
DEAD SH	19	46 $\pm$ 5	80 $\pm$ 11	64 $\pm$ 9	53.9 $\pm$ 13.2	10.2	320 $\pm$ 96	6081		
TOTALS	49	-	-	-	-	30.4	-	25892	-	55.6

Table 63. Population characteristics of perennial plants on plot FOR001 (Beatley Plot 61), sampled August 21, 1989. Elevation 1756 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ART NOV	124	30±1	53±2	46±2	22.2±1.8	27.5	78.8±8.5	9772	197±21	24.4
ART TRI	13	44±4	78±9	60±8	41.1±7.5	5.34	201±41	2611	361±73	4.70
EPH NEV	9	38±5	49±15	34±8	18.6±6.9	1.67	88.0±35.8	792	1235±50	1.11
GRA SPI	2	33±2	31±19	20±3	5.38±3.65	0.11	18.6±13.0	37.2	42.7±30.0	0.09
LYC AND	1	48	61	15	7.19	0.07	34.5	34.5	75.9	0.08
STI SPE	16	18±2	9±1	8±1	0.68±0.17	0.11	1.34±0.37	21.5	1.48±0.41	0.02
DEAD GR	11	6±1	9±1	6±1	0.45±0.08	0.05	0.27±0.08	3.0	-	-
DEAD SH	10	23±3	63±8	55±8	31.1±7.4	3.11	71.6±19.8	716	-	-
TOTALS	165	-	-	-	-	34.8	-	13268	-	30.4

Table 64. Population characteristics of perennial plants on plot FOR002 (Beatley Plot 62), sampled August 22, 1989. Elevation 1750 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ART TRI	46	58±4	89±6	73±6	61.0±8.2	28.0	428±80	19707	771±145	35.5
EPH NEV	4	43±7	50±4	41±10	17.0±5.8	0.68	85.1±44.5	340	119±62	0.48
ERI KEA	6	20±6	23±10	18±7	5.74±2.91	0.34	17.9±8.90	108	7.71±3.83	0.05
JUN OST	1	10	11	7	0.60	0.01	0.60	0.6	-	-
STI SPE	33	13±1	7±1	5±1	0.40±0.12	0.13	0.66±0.27	21.9	0.73±0.30	0.02
DEAD GR	6	15±4	10±3	8±2	0.72±0.31	0.04	1.10±0.54	6.6	-	-
DEAD SH	9	44±8	90±13	87±15	70.6±14.5	6.36	312±59	2806	-	-
TOTALS	90	-	-	-	-	29.2	-	20178	-	36.0

Table 65. Population characteristics of perennial plants on plot PAM003, an undisturbed site adjacent to drill pad U20au, sampled August 8, 1989. Elevation 1910m. The drill pad had no perennial plants.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ART TRI	136	45±2	61±3	47±3	28.3±2.60	38.5	163±22	22213	294±39	40.0
BUNCHGR	28	3±1	5±1	4±1	0.22±0.05	0.06	0.03±0.01	0.8	0.03±0.01	0.00
DEAD GR	110	7±0	7±0	6±0	0.45±0.05	0.50	0.42±0.06	47	-	-
DEAD SH	41	17±3	38±7	28±5	18.2±5.32	7.44	69.3±25.6	2841	-	-
TOTALS	164	-	-	-	-	38.5	-	22213	-	40.0

Table 66. Population characteristics of perennial plants on baseline plot PAM001 on Pahute Mesa. This 100 m² transect was sampled Sept. 4-11, 1990. Elevation 1923 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ART NOV	342	23±1	39±1	30±1	11.0±0.6	37.7	33.0±2.3	11279	82.4±5.8	28.2
BUNCHGR	192	12±10	3±0	2±0	0.08±0.01	0.16	0.11±0.02	21.6	0.12±0.03	0.02
CER LAN	1	35	26	20	4.08	0.04	14.29	14.3	45.7	0.05
CHR VIS	6	22±3	36±7	30±8	9.55±2.94	0.48	24.8±9.5	124.0	62.0±23.7	0.31
EPH NEV	45	22±1	13±1	9±1	1.12±0.18	0.50	2.92±0.56	131	4.08±0.79	0.18
ERI CAE	1	1	7	8	0.44	0.00	0.04	0.04	-	-
GRA SPI	1	19	35	18	4.95	0.05	9.40	9.4	21.6	0.02
ORY HYM	4	18±3	10±2	7±2	0.61±0.24	0.02	1.28±0.67	5.1	1.41±0.73	0.01
SIT JUB	6	16±1	3±1	3±1	0.09±0.03	0.01	0.14±0.03	0.8	0.15±0.04	0.00
STI SPE	3	17±1	5±1	2±1	0.11±0.05	0.00	0.19±0.08	0.6	0.21±0.09	0.00
DEAD GR	174	13±3	14±6	11±5	3.00±2.48	0.27	8.92±8.28	80.3	-	-
DEAD SH	63	16±1	27±3	19±2	6.34±1.41	3.86	12.6±2.7	772	-	-
TOTALS	601	-	-	-	-	39.0	-	11586	-	28.8

Table 67. Population characteristics of perennial plants on baseline plot PAM001, an undisturbed area on Pahute Mesa, sampled Sept. 4, 1990 (top) and Sept. 9, 1991 (second). Only 50m² is reported for each year. Elevation 1923 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ART NOV	191	22±1	37±1	27±1	9.48±0.62	18.1	26.8±2.2.4	5120	67.0±6.0	12.8
ART NOV	197	24±1	37±1	27±1	9.60±0.62	18.9	29.3±2.6	5776	73.3±6.5	14.4
AST PUR*	-	-	-	-	-	-	-	-	-	-
AST PUR	6	3±1	4±1	3±1	0.13±0.06	0.01	0.07±0.06	0.4	-	-
BUNCHGR	111	11±0	3±0	2±0	0.09±0.02	0.10	0.12±0.04	13.0	0.13±0.04	0.01
BUNCHGR	33	11±1	1±0	1±0	0.01±0.00	0.00	0.01±0.00	0.5	0.02±0.00	0.00
CER LAN	1	35	26	20	4.08	0.04	14.29	14.3	45.7	0.05
CER LAN	1	36	41	37	11.9	0.12	42.9	42.9	137	0.14
CHR VIS	2	15±0	27±19	11±4	3.11±2.67	0.06	4.67±4.01	9.3	11.7±10.0	0.02
CHR VIS	2	20±4	25±10	21±8	4.81±3.16	0.10	11.3±8.6	22.6	28.2±21.6	0.06
EPH NEV	35	21±1	11±1	8±1	0.85±0.15	0.30	2.16±0.49	75.5	3.02±0.68	0.11
EPH NEV	40	21±1	12±1	10±1	1.14±0.22	0.45	3.03±0.75	121	4.24±1.04	0.17
ERI CAE	1	1	7	8	0.44	0.00	0.04	0.0	-	-
ERI CAE	1	1	9	8	0.57	0.01	0.06	0.1	-	-
ORY HYM	1	17	8	6	0.38	0.00	0.64	0.6	0.70	0.00
ORY HYM	14	18±1	7±1	5±1	0.31±0.10	0.04	0.63±0.22	8.8	0.69±0.25	0.01

* Present but not measured in 1990.

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6 of 6

Table 67, continued.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
SIT JUB	7	16±1	4±1	3±1	0.10±0.03	0.01	0.16±0.04	1.1	0.17±0.05	0.00
SIT JUB	110	16±0	3±0	2±0	0.07±0.01	0.07	0.12±0.02	12.9	0.13±0.02	0.01
STI COM	0	-	-	-	-	-	-	-	-	-
STI COM	2	15±2	4±1	3±1	0.07±0.00	0.00	0.10±0.02	0.2	-	-
DEAD GR	35	12±2	7±2	6±2	0.57±0.34	0.04	0.72±0.48	5.0	-	-
DEAD GR	68	7±1	5±1	4±1	0.24±0.12	0.03	0.22±0.13	2.7	-	-
DEAD SH	41	12±2	24±3	16±2	5.15±1.88	2.06	8.98±2.80	359	-	-
DEAD SH	43	13±1	21±3	14±2	3.97±1.36	1.71	6.47±2.05	278	-	-
TOTALS	349	-	-	-	-	18.6	-	5234	-	13.0
TOTALS	406	-	-	-	-	19.7	-	5986	-	14.8

Table 68. Population characteristics of perennial plants on plot PAM006, abandoned drill pad U19ac on Pahute Mesa, sampled July 22, 1991. Elevation 2134 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
BUNCHGR	115	19±1	2±0	2±0	0.1±0.0	0.10	0.3±0.3	38.3	0.4±0.3	0.04
ORY HYM	44	46±2	21±2	16±1	3.4±0.5	1.50	17.7±2.5	780	19.5±2.8	0.86
SIT JUB	1	40	10	7	0.6	0.01	2.2	2.2	2.4	0.00
STI COM	121	53±3	7±1	6±0	0.5±0.1	0.65	4.5±0.7	549	5.0±0.8	0.60
TOTALS	281	-	-	-	-	2.25	-	1370	-	1.51

Table 69. Population characteristics of perennial plants on plot PAM007, an undisturbed site near PAM006, sampled July 23, 1991. Elevation 2134 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ARE CON	2380	70±3	53±2	36±1	1.68±0.11	3.99	1.51±0.14	360	0.65±0.06	0.15
ART TRI	41	40±2	62±5	43±4	26.0±3.6	10.7	118±18	4822	212±33	8.68
BUNCHGR	77	12±0	5±1	4±0	0.23±0.04	0.18	0.32±0.06	24.3	0.35±0.07	0.03
CACTUS	1	13	32	19	4.78	0.05	6.21	6.2	-	-
CH V. p	19	14±1	20±2	14±2	2.58±0.58	0.49	4.20±1.19	79.7	-	-
CRY FLA	7	4±1	4±0	3±0	0.12±0.02	0.01	0.06±0.02	0.4	0.02±0.01	0.00
DEL PAR	10	5±1	3±1	2±0	0.06±0.02	0.01	0.03±0.01	0.3	-	-
ERI CAE	39	5±0	7±1	5±0	0.38±0.06	0.15	0.24±0.05	9.2	-	-
ERI OVA	1	2	4	2	0.06	0.00	0.01	0.0	-	-
JUN OST	5	89±15	92±11	80±9	60.3±13.1	3.01	595±183	2974	1208±296	6.04

Table 69, continued.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ORY HYM	2	12±2	18±4	18±4	2.67±1.13	0.05	3.24±1.71	6.5	3.56±1.88	0.01
PEN sp.	44	4±1	6±1	4±0	0.26±0.08	0.11	0.33±0.26	14.5	-	-
PHL STA	183	12±1	8±0	6±0	0.22±0.02	0.21	0.17±0.02	16.0	0.07±0.01	0.01
PIN MON	8	108±27	101±25	95±25	109±36	8.69	1814±720	14510	2486±873	19.89
POA FEN	11	37±4	18±1	9±1	1.27±0.17	0.14	5.35±0.79	58.8	-	0.06
SIT JUB	37	16±1	7±1	5±1	0.39±0.12	0.15	0.77±0.29	28.4	0.84±0.32	0.03
STI SPE	6	14±2	6±2	5±1	0.32±0.18	0.02	0.54±0.35	3.2	0.60±0.39	0.00
UNKNOWN	3	5±1	4±1	2±1	0.08±0.04	0.00	0.05±0.03	0.1	-	-
DEAD GR	12	5±1	6±1	6±1	0.33±0.07	0.04	0.16±0.05	2.0	-	-
DEAD SH	27	14±3	31±6	22±4	10.1±3.6	2.72	19.8±7.2	534	-	-
TOTALS	2893	-	-	-	-	30.7	-	23449	-	34.90

Table 70. Population characteristics of perennial plants on plot RAM002 (Beatley Plot 64 on Rainier Mesa) sampled August 28 - Sept. 8, 1989. Elevation 2263 m.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
ACH MIL	3	3±1	5±2	4±2	0.21±0.15	0.01	0.10±0.08	0.3	0.40±0.03	0.00
ARE CON	89	2±0	5±0	4±0	0.22±0.02	0.20	0.05±0.01	4.3	0.02±0.00	0.00
ART NOV	73	19±1	29±4	25±3	11.3±3.04	8.25	45.4±17.0	3317	114±42	8.29
AST CAL	17	2±0	5±1	4±1	0.25±0.07	0.04	0.08±0.03	1.4	0.04±0.01	0.00
BUNCHGR	261	9±0	6±0	6±0	0.37±0.02	0.97	0.35±0.02	91.8	0.39±0.02	0.10
CHR VIS	5	13±2	17±4	15±3	2.20±0.85	0.11	3.50±1.66	17.5	8.75±4.16	0.04
CRY FLA	10	4±0	5±1	4±1	0.16±0.06	0.02	0.07±0.04	0.7	0.03±0.02	0.00
EPH VIR	1	63	62	23	11.2	0.11	70.6	70.6	98.8	0.10
ERI CAE	5	6±1	19±7	17±7	4.15±3.21	0.21	3.74±3.31	18.7	-	-
ERI MIC	192	5±0	8±0	6±0	0.51±0.05	0.98	0.33±0.04	64.3	-	-
ERI UMB	26	7±1	9±1	7±1	0.67±0.14	0.17	0.58±0.16	15.2	0.25±0.07	0.01

Table 70, continued.

Species	n	HT	MAXWID	PERWID	AVG COVER	TOT COV	AVG VOLUME	TOT VOL	AVG BIO	TOTAL BIO
		cm	cm	cm	dm ²	m ²	l	l	g	Kg
IPO CON	20	4±1	4±1	3±1	0.15±0.04	0.03	0.11±0.04	2.3	-	-
OPU ERI	20	13±1	28±4	24±4	7.72±2.51	1.54	14.0±5.48	281	-	-
PIN MON	10	49±14	44±12	40±12	23.9±8.88	2.39	224±103	2240	497±199	4.97
PUR TRI	25	32±4	54±7	51±9	32.2±9.34	8.06	141±38	3536	354±95	8.84
RIB VEL	2	101±2	103±21	98±52	87.5±58.6	1.75	897±607	1794	2243±1519	4.49
SIT HYS	44	12±0	9±1	7±1	0.63±0.10	0.28	0.80±0.17	35.4	0.88±0.19	0.04
UNKNOWN	29	10±1	12±2	8±1	1.24±0.35	0.36	2.22±0.83	64.5	-	-
DEAD GR	5	7±4	7±2	7±2	0.47±0.20	0.02	0.21±0.11	1.1	-	-
DEAD SH	52	8±3	14±6	14±8	19.3±18.11	10.0	323±326	17070	-	-
TOTALS	832	-	-	-	-	25.5	-	11556	-	26.9

**TRENDS IN EPHEMERAL PLANT POPULATIONS ON THE NEVADA
TEST SITE, 1989-1991**

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ABSTRACT

Ephemeral plant populations (winter annuals and some below-ground perennials) are being monitored on the Nevada Test Site in order to determine the effects of natural forces and Department of Energy activities. This report gives results from the years 1989, 1990, and 1991, and compares them to data collected from 1957 to the present. A major change is a widespread and continuing increase in populations of several introduced weedy species, the most significant being *Bromus rubens*, a weedy annual grass. Some evidence is presented that the introduced species are having deleterious effects on populations of native species. Areas of past and recent disturbance (mostly ground zeroes, subsidence craters, burned areas, and roadsides) have local effects that favor some of the introduced species, as well as ephemeral species in general. Miscellaneous interactions with shrub, mammal, bird, and reptile populations are discussed.

INTRODUCTION

Of the more than 700 plant species occurring on the Nevada Test Site (NTS), about 300 species are ephemeral plants which live less than one year. Their habit is generally to germinate and reproduce only after significant rainfall (Beatley 1974), then spend unfavorable periods as seeds. They are sensitive to germination conditions for numbers present, and various growing conditions affect size at maturity.

On the NTS in 1989 there were no rainstorms of sufficient intensity to germinate ephemerals in either the Mojave Desert or the transition zone between the Mojave and Great Basin Deserts. In 1990 conditions were similar, and germination of ephemerals was very rare. There was thus a near-absence of ephemerals below 6000 feet for two successive years, except where unusual conditions prevailed. A few sparse biennials and herbaceous perennials survived below that altitude. In 1991 enough rain fell in late February and early March to germinate low numbers of ephemerals over most of the NTS.

Ephemeral sampling from 1987 through 1991 had a primary goal of monitoring ephemerals on areas disturbed by human activities and on pristine areas affected by primarily natural forces, in order to determine the effects of Department of Energy (DOE) activities on the NTS flora. A total of 58 independent locations were sampled for ephemerals, including undisturbed areas and areas disturbed by nuclear weapons tests, drilling activities, road maintenance, shrub removal, fires, and gophers (Table 1).

Table 1. Sites and sample dates for plots sampled for ephemerals from 1987 through 1991. The nature of the disturbance, rough locations, and control plot names are included. See Appendix 2 for latitudes, longitudes and altitudes for each plot.

<u>Plot</u>	<u>Years Sampled</u>	<u>Location</u>	<u>Control plot</u>
<u>UNDISTURBED, BASELINE AND HISTORICAL PLOTS</u>			
JAF001	1988,90,91	Jackass Flats, E of J12 Well	
FRF001	1987,88,89,91	Frenchman Flat, off 5-05 Road	
YUF001	1988-91	SW Yucca Flat, NW of Well 3	
PAM001	1988,1991	Pahute Mesa, W of Pahute Lake	
RAM001	1988,1991	Rainier Mesa, S of weather tower	
GOL001	1989	Gold Meadows, W of pond	
ROV005	1987-91	Rock Valley, Beatley plot 3	

Table 1, continued.

<u>Plot</u>	<u>Years Sampled</u>	<u>Location</u>	<u>Control plot</u>
<u>UNDISTURBED, BASELINE AND HISTORICAL PLOTS</u>			
ROV006	1988-91	Rock Valley, Beatley plot 4	
JAF002	1987	Jackass Flats, Beatley plot 8	
YUF028	1990	Yucca Flat, Beatley plot 57	
<u>WEAPONS EFFECT (BLAST AND CRATER AREAS)</u>			
YUF014	1988, 1991	Yucca Flat, T2 GZ	YUF015
YUF016	1988, 1991	Yucca Flat, 305m NE of Sedan	YUF018
YUF017	1988, 1991	Yucca Flat, 914m NE of Sedan	YUF018
YUF019	1989	Yucca Flat, U3cn crater	YUF020
YUF021	1989	Yucca Flat, U7au crater	YUF022
YUF023	1989	Yucca Flat, U10af crater	YUF024
YUF025	1990	Yucca Flat, SE of T4 GZ	YUF026
YUF013	1991	Yucca Flat, E of T3 GZ	YUF012
<u>ROADSIDES</u>			
FRF002	1988, 1991	Frenchman Flat, W end of 5-03 Rd	FRF002c
FRF003	1990	Frenchman Flat, center of 5-05 Rd	FRF004
FRF007	1987, 1990	Frenchman Flat, near Cambric ditch	(none)
MER002	1988, 90, 91	West Mercury Valley	MER003
JAF003	1989	Jackass Flats, E of Beatley 7	JAF004
<u>BURNED AREAS</u>			
YUF002	1987, 90	Yucca Flat, by Mine Mt. RD.	YUF002c
MID001	1988, 91	S end of Mid Valley	MID001c
MID001	1989	Mid Valley, Beatley 41, 42	MID006
MER001W	1986-91	Mercury, adjacent to Bldg 790	MER001E
YUF011	1988, 91	Yucca Flat, E of T3 GZ	YUF012
MID004	1989	Mid Valley, central	MID005

Table 1, continued.

<u>Plot</u>	<u>Years Sampled</u>	<u>Location</u>	<u>Control Plot</u>
PAM002	1989	Pahute Mesa, U20ao pad	PAM003
PAM004	1990	Pahute Mesa, U19e pad	PAM005
PAM006	1991	Pahute Mesa, U19ac pad	PAM007
<u>MISCELLANEOUS DISTURBANCES</u>			
	1989	Frenchman Flat, GMX (PU contamination)	FRF006
FOR003	1990	Jct Pahute Mesa and Stockade Wash Rds (horse grazing)	(none)
BREN 73	1991	Jackass Flats, Bren Tower (fly-ash trails)	BREN70

METHODS:

Sites sampled from 1987 through 1991 and the nature of the disturbances are listed in Table 1. Figure 1 shows the locations of sites sampled, by year. Exact locations, plot designations, and altitudes for each plot are in Appendix 1 of the 1989-91 reptiles section of this report.

Sampling methods were essentially unchanged from those used in 1987 (Hunter and Medica 1989) and 1988 (Hunter 1992). They involved harvesting and weighing all ephemerals from twenty 0.025 m² quadrats randomly located along a 50 m tape, followed by recording the presence of other species in nested 100 m² and 1000 m² areas surrounding the quadrats (Hunter and Medica 1989; Hunter 1992). On occasion the quadrat size was increased where plant density was low, and numbers of quadrats sampled were modified slightly to maintain historical patterns.

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 a fiberglass block, which varies with absorbed water. Several assumptions were made to convert the readings 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/cm³, 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. 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. These assumptions are sometimes clearly inexact, and result in some distortions in the estimate of "available" soil water. The assumptions were necessary in order to make the estimation. The most serious flaw was that 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 temperature gradients during winter should cause condensation in the near-surface soils, we could not dismiss the 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.

Salsoia australis was sampled in spring with ephemerals. Its biomass was estimated on selected portions of perennial plant transects during summer by measuring plant size and fitting a regression line of size versus weight. For those fitting the lower-density canopy description for *Salsoia iberica* (Beatley 1973) the relationship used was $wt = 0.736 \text{ g/l}$, and for the denser growth form of *S. paulsenii* $wt = 2.61 \text{ g/l}$. The lines were determined on mature individual plants from Mercury Valley in 1975, and should be considered approximations only.

Taxonomy follows Kartesz and Kartesz (1980), after identification generally following Munz (1974). Field specimens were compared with NTS herbarium specimens to confirm identifications. *Salsoia* is referred to throughout the text as *Salsoia australis*, following Young (1991), because both *S. iberica* and *S. paulsenii* occur sympatrically throughout the NTS. I suspect these are two morphological forms of what should be considered a single species. This is opposed to the opinion of Beatley (1973).

RESULTS

Soil Moisture

Available soil moisture estimates for Mercury Township site from July 1, 1988,

through December 31, 1991, are shown in Table 2. Weather conditions from August 1988 through 1991 contrasted greatly with 1987-1988 conditions, being three years of severe drought. National Weather Service records for Mercury for 1987 - 1991 showed a (July-June) total of 178.6 mm for 1987-1988, but only 53.5 mm for 1988-1989, 50.8 mm for 1989-90, and 118.5 mm for 1990-91 (Table 3).

Table 2. Estimate soil moisture (mm) available to plants in the top 30 cm of soil in Mercury, Nevada from July 1, 1988 to December 31, 1991. * = first germination. Negative values imply < 5% soil water.

<u>Date</u>	<u>mm</u>	<u>Date</u>	<u>mm</u>	<u>Date</u>	<u>mm</u>	<u>Date</u>	<u>mm</u>
5 JUL 88	-1.4	26 MAY 89	0.9	24 SEP 90	7.1	25 SEP 91	0.2
12 JUL 88	-1.4	2 JUN 89	0.3	2 OCT 90	4.6	9 OCT 91	0.7
15 JUL 88	-1.2	9 JUN 89	-0.5	12 OCT 90	3.1	21 OCT 91	1.3
22 JUL 88	-1.4	16 JUN 89	-0.6	26 OCT 90	3.5	31 OCT 91	8.5
1 AUG 88	-1.7	27 JUN 89	2.1	2 NOV 90	3.4	6 NOV 91	4.1
5 AUG 88	-0.7	14 JUL 89	-0.9	9 NOV 90	3.1	13 NOV 91	3.4
26 AUG 88	-0.2	3 AUG 89	0.5	21 NOV 90	7.9	22 NOV 91	5.8
2 SEP 88	1.0	10 AUG 89	2.3	30 NOV 90	7.2	29 NOV 91	6.1
9 SEP 88	-0.6	25 AUG 89	-0.3	7 DEC 90	6.5	6 DEC 91	4.8
16 SEP 88	1.0	8 SEP 89	-0.3	14 DEC 90	6.0	16 DEC 91	9.7
23 SEP 88	0.5	27 SEP 89	0.3	21 DEC 90	7.4	26 DEC 91	9.6
30 SEP 88	-0.2	6 OCT 89	0.7	28 DEC 90	6.0		
14 OCT 88	0.4	23 OCT 89	2.2	11 JAN 91	8.7		
21 OCT 88	0.7	2 NOV 89	3.5	18 JAN 91	6.3		
28 OCT 88	1.1	13 NOV 89	2.1	25 JAN 91	7.7		
4 NOV 88	1.2	20 NOV 89	2.6	1 FEB 91	4.8		
11 NOV 88	3.6	1 DEC 89	3.8	15 FEB 91	3.5		
28 NOV 88	5.8	6 DEC 89	3.5	22 FEB 91	3.5		
2 DEC 88	5.1	18 DEC 89	4.2	1 MAR 91	21.1		
9 DEC 88	5.0	21 DEC 89	4.1	8 MAR 91	7.9*		
16 DEC 88	5.0	8 JAN 90	4.4	15 MAR 91	10.1		
23 DEC 88	8.6	14 JAN 90	7.4	22 MAR 91	11.5		
29 DEC 88	8.1	16 JAN 90	8.0	29 MAR 91	11.0		
6 JAN 89	9.2	26 JAN 90	11.6	5 APR 91	6.2		
13 JAN 89	8.0	2 FEB 90	11.9	11 APR 91	7.2		
20 JAN 89	6.0	9 FEB 90	9.9	18 APR 91	5.3		
27 JAN 89	6.2	16 FEB 90	9.2	25 APR 91	3.8		
3 FEB 89	5.2	1 MAR 90	6.3*	3 MAY 91	6.5		
10 FEB 89	11.3	7 MAR 90	8.0	9 MAY 91	3.1		
17 FEB 89	5.5	14 MAR 90	8.0	16 MAY 91	1.4		
24 FEB 89	3.7	22 MAR 90	4.2	23 MAY 91	1.3		
3 MAR 89	6.1	28 MAR 90	3.6	30 MAY 91	1.5		

Table 2. continued.

<u>Date</u>	<u>mm</u>	<u>Date</u>	<u>mm</u>	<u>Date</u>	<u>mm</u>	<u>Date</u>	<u>mm</u>
10 MAR 89	2.5	6 APR 90	4.0	10 JUN 91	0.9		
17 MAR 89	2.3	13 APR 90	1.8	20 JUN 91	0.4		
24 MAR 89	3.3	26 APR 90	1.0	26 JUN 91	0.3		
27 MAR 89	3.2	3 MAY 90	1.1	3 JUL 91	-0.9		
31 MAR 89	1.9	11 MAY 90	0.9	11 JUL 91	0.2		
7 APR 89	0.3	18 MAY 90	0.8	17 JUL 91	-0.4		
14 APR 89	0.6	1 JUN 90	2.1	24 JUL 91	-0.9		
21 APR 89	0.8	8 JUN 90	-0.9	6 AUG 91	1.5		
2 MAY 89	0.8	6 JUL 90	-0.8	14 AUG 91	2.4		
5 MAY 89	0.1	25 JUL 90	0.9	22 AUG 91	-0.3		
12 MAY 89	1.58	2 AUG 90	0.2	4 SEP 91	-0.6		

Table 3. Precipitation at Mercury, Nevada, July 1988 through June 1991 (USWB, Nuclear Support Office NOAA).

<u>Month</u>	<u>Precipitation (mm)</u>		
	<u>1988-89</u>	<u>1989-90</u>	<u>1990-91</u>
July	0.5	0.0	33.0
August	24.6	9.1	6.4
September	0.0	1.3	16.8
October	0.0	1.0	1.8
November	10.4	0.0	6.6
December	5.3	0.0	1.3
January	5.6	22.9	6.6
February	3.8	3.8	5.3
March	2.5	5.1	35.6
April	0.0	2.0	0.0
May	0.3	5.3	12.2
June	0.5	0.3	0.8
SEP-MAR	27.7	34.0	73.9

Detailed summaries of the ephemeral species, their densities, biomasses per square meter, and mean sizes for each site sampled are in Appendix 1. Plot summaries and general relationships are reported in the text.

1989

In 1989 only three sites sampled had ephemerals or herbaceous perennials in the 20 0.025-m² quadrats. Plot JAF003, a gopher-denuded area in Jackass Flats, had one *Euphorbia albomarginata* ($2 \pm 2/\text{m}^2$) which was sampled but lost. Also present were 13 *Tiquilia plicata* ($26 \pm 7/\text{m}^2$), a low growing below-ground perennial which was not sampled. The *T. plicata* was not found on the control (JAF004), and was therefore apparently associated with the gopher-denuded area.

Drill pads are scraped areas used as staging areas during drilling preparatory to nuclear weapons tests. One drill pad sampled on Pahute Mesa showed germination of large numbers of *Halogeton glomeratus* seedlings and some *Salsola australis* seedlings (for tabular data see Appendix 1). The *H. glomeratus* seedlings were barely visible, and weighed just 1.1 ± 0.2 mg/plant, but occurred at a high density, over 3000/m². The *S. australis* seedlings were larger, weighing 4.5 ± 0.9 mg each. When perennials were sampled on the site (August 8, 1989) four 1-m² areas were examined for annuals. There were then an estimated 265 ± 70 *H. glomeratus* per square meter, of which 1.3% were larger than 2 cm in any dimension. None was harvested or weighed at that time. Two *Salsola* seedlings, estimated at 2 cm in all dimensions, were present in the 4 m² ($0.5 \pm 0.5/\text{m}^2$). Their weight was estimated (see methods) as about 5 mg each, indicating that no significant growth occurred between April 17 and August 8. None was reproductive in August. No other species occurred on the drill pad, and neither *H. glomeratus* nor *Salsola* was found on the control site (PAM003).

The final site on which ephemerals were found in 1989 was an undisturbed area in Gold Meadow (GOL001 - Appendix 1). *Bromus tectorum* had germinated and was represented by 370 ± 119 plants per square meter. Of the 185 *B. tectorum* which occurred in the quadrats, 51 (28%) showed evidence of reproduction (flowering or fruiting) when sampled on May 3. The average weight per plant (14 ± 3 mg) was comparable to the range of 5 to 52 mg/plant found for *B. tectorum* in 1988 (Hunter 1992). Other species found on GOL001 which had germinated from seeds were *Cryptantha circumscissa*, *Lappula occidentalis*, and an unknown which was too small to identify. Also present in the quadrats were two herbaceous perennials, *Crepis intermedia* and *Lomatium nevadense*, both rather small representatives of their species but much larger than new seedlings would have been. The majority (17 of 23) of the species found in the 100-m² and 1000-m² areas were herbaceous perennials which germinated in

prior years and survived until spring of 1989.

In 1989 disturbed areas tended to have sparse or no ephemerals and only rare herbaceous perennials, while control areas were totally devoid of all such species. Each of the 7 disturbed areas had some live herbaceous plants present, while 9 of the 13 control plots had zero per 1000 m² (excluding shrubs).

Summer measurements were taken of the abundance and median sizes of the summer annuals *Salsola australis* and *Halogeton glomeratus*. *Salsola* was present in northern Yucca Flat at densities of up to 41/m² inside subsidence craters, and up to 5/m² on the control areas adjacent to the craters. These densities were much higher than those seen in late April, and were a result of rainfall ranging from 24 to 43 mm which fell between May 9 and 16 in northern Yucca Flat (U. S. Weather Service stations at BJY, A12, and PHS Farm) and other smaller amounts which fell in mid-June (4 to 22 mm). *Salsola* in the subsidence craters varied in size from less than 10 mg at U7au to near 100 mg/plant at U10af. The sizes appear to be related to rainfall rather than disturbance, because the vegetated control plots had *Salsola* seedlings approximately the same size as in the disturbed areas within the craters. Numbers of *Salsola* seedlings were highest in the center in two of the three craters. Mounds of dead *Salsola* occurred in the bottoms and in shallow erosion channels in the sides of the subsidence craters.

Two *Halogeton glomeratus* less than 2 cm tall were seen on the north-facing slope of crater U7au during perennial measurements July 20, and it was present on the center transect, but not measured. On the north side of crater U3cn, *Euphorbia albomarginata* plants were growing.

1990

The spring of 1990 saw a continuation of the severe drought which began after August 1988. As in 1989, ephemeral germination was extremely sparse. Thirteen of 21 sampled plots had no ephemerals or herbaceous perennials in the quadrats (usually totalling 0.5 m²) (Table 4). Nine had none in 1000 m², and eight of those were undisturbed plots with normal shrub populations. The only disturbed plot totally lacking ephemerals was on T4 ground zero (GZ).

Table 4. Ephemeral densities and biomasses on plots sampled in 1990. (A and B plots are replicates. YUF002 includes both disturbed and control areas.)

Plot	Date	n/m ²	g/m ²	Plot	Date	n/m ²	g/m ²
JAF001	APR 02	0	0	YUF001A	APR 12	0	0
ROV005A	MAR 28	16±16	0.06±0.06	YUF001B	APR 12	0	0
ROV005B	MAR 28	2±2	0.00±0.00	YUF002	APR 11	0	0
ROV006	MAR 26	12±12	0.04±0.04	YUF014	APR 16	0	0
MER002	APR 23	127±24	4.0±0.9	YUF015	APR 16	0	0
MER003	APR 25	10±8	0.12±0.09	YUF025	APR 18	0	0
MER001W	APR 05	8.0±3.3	0.09±0.04	YUF026	APR 18	0	0
MER001E	APR 05	0	0	YUF028	APR 19	0	0
FRF003	APR 04	0	0	FOR003	APR 30	8±2	0.5±0.2
FRF004	APR 09	0	0	PAM004	MAY 15	1194±256	21.1±2.7
FRF007A	APR 03	0	0	PAM005	MAY 15	12±4	0.8±0.6
FRF007B	APR 03	0	0				

As in 1989 the species present were largely short-lived herbaceous perennials or below-ground species which did not germinate in 1990, but survived from previous years. The herbaceous perennials most common were *Euphorbia albomarginata*, *Machaeranthera canescens*, *Allium nevadense*, *Dichelostemma pulchellum*, and *Cymopterus ripleyi*. In Rock Valley and Mercury Valley there was sparse germination of *Bromus rubens* deep inside shrubs, but in Jackass Flats, Frenchman Flat, and Yucca Flat there was virtually no germination at all.

Above 1300 m only two locations were sampled, one near the junction of Pahute Mesa and Stockade Wash roads (FOR003) and the other on drill pad U19e on Pahute Mesa (PAM004,005). The first, at about 1765 m altitude, had 8±2 plants per m² which had germinated from seed, and had grown to produce a biomass of 0.5±0.2 g/m². On the Pahute Mesa drill pad 1194±256 seedlings were found per square meter, largely *Salsola australis* and *Bromus tectorum*, producing 21±3 g/m² by May 15. The drought therefore did not reduce germination at 2134 m. In the control area for the drill pad, however, there were only 4±3 ephemerals germinated per square meter, producing less than 0.1 g/m². This indicates the perennials at that site (dominated by pinyon pine, *Pinus monophylla*) used enough water to prevent ephemeral germination.

On drill pad U19e only 15 of 138 (11%) of sampled *Bromus tectorum* were reproductive when sampled on May 15, but the average size of 34 mg was

sufficient to suggest most would eventually produce seed.

In 1990 a special effort was made to evaluate the effects of a road on ephemeral plant populations. In 30 m² of quadrats searched there were 0.1±0.07 *Euphorbia albomarginata* per square meter. This is a below-ground herbaceous perennial which is relatively common on the NTS where shrubs have been removed. There was also one *Gilia sinuata* found in 450 m² searched outside the quadrats, indicating germination of about 0.002 plants per m² near the roadside. The undisturbed area far from the road had no ephemerals or herbaceous perennials in 1500 m².

1991

In 1991 ephemerals germinated late, following a major rainstorm February 27 - March 2. Germination was sparse in comparison with 1987 and 1988, but was nevertheless much greater than in the two preceding years of drought. Of 26 per m², which was low compared to the 1987 (732/m²) and 1988 (962/m²) medians. independent sites examined, only one (FRF002 - roadside) had no ephemerals in the 20 0.025-m² quadrats (Table 5). That site had 11 species in the 100-m²

Table 5. Total densities (n/m²) and biomasses (g/m²) of ephemeral plants on sites sampled in 1991 on the NTS.

Plot	Date	n/m ²	g/m ²	Plot	Date	n/m ²	g/m ²
JAF001	MAY 07	164±38	9.7±5.1	YUF001A	APR 17	78±35	0.5±0.3
BREN70	APR 29	45±17	1.4±0.7	YUF001B	APR 17	74±44	0.4±0.2
BREN73	APR 29	29±16	0.6±0.4	YUF001E	MAY 06	30±13	1.1±0.5
ROV005	APR 03	106±31	0.5±0.2	YUF001W	MAY 06	48±18	1.6±0.7
ROV005NW	MAY 01	186±43	6.0±0.9	YUF011	APR 24	108±77	0.5±0.3
ROV005SE	MAY 01	118±34	2.0±0.6	YUF012	APR 24	74±29	0.5±0.2
ROV006	APR 08	92±27	0.4±0.2	YUF016	APR 18	998±481	21±17
MER002	APR 08	148±33	0.8±0.2	YUF017	APR 30	110±30	5.4±2.4
MER003	APR 09	116±27	0.5±0.2	YUF018	APR 30	86±39	1.1±0.6
MER002E	MAY 02	82±17	5.3±1.4	YUF010	APR 22	38±20	0.4±0.2
MER002W	MAY 02	82±17	1.9±0.5	YUF009	APR 22	40±11	1.1±0.4
MER001W	APR 04	269±76	0.5±0.1	YUF013	APR 24	328±65	5.5±1.5
MER001E	APR 04	22±8	0.04±0.01	MID001C	MAY 13	100±16	6.4±2.2
FRF001	APR 11	18±11	0.08±0.05	MID001	MAY 13	142±29	14.7±3.3
FRF001SE	MAY 06	2±2	0.06±0.06	PAM006	JUN 10	2618±703	16.4±3.9
FRF001W	MAY 06	6±3	0.9±0.2	PAM007	JUN 10	11±2	0.4±0.2
FRF002	APR 17	0	0	RAM001	JUL 02	3±2	.023±.015
FRF002C	APR 17	8±8	0.06±0.06				

searched area, indicating a significant density below the 2/m² limit of detectability in quadrats. The median density on these 26 sites was 83 plants per m², which was low compared to the 1987 (732/m²) and 1988 (962/m²) medians.

As in 1990, the plot with the highest ephemeral density (2618±703/m²) was a drill pad on Pahute Mesa, U19ac (PAM006). The vast majority of ephemerals on the plot (98%) were *Salsola australis* seedlings which developed under the standing dead litter of a less-dense stand, probably from 1990. The high density did not indicate better germination on Pahute Mesa, but was due to the successional stage of this drill pad. It had been 10 to 12 years since the pad was scraped, and this weedy species had time to develop a dense population. The adjacent control plot, as in 1990, had a low density (11±2/m²) of ephemerals and herbaceous perennials, again indicating significant water use by the perennials, dominated again by *Pinus monophylla*.

Thus, contrast to 1989 and 1990, when germination occurred at higher altitudes and was nearly absent below 1500 m, germination occurred in low numbers throughout the NTS in 1991. Ephemeral biomass ranged from 0 to 21.2 g/m² in 1991, with a median of 0.85 g/m², which was low compared to 1987 (27 g/m²) and 1988 (14 g/m²), but high compared to the drought years of 1989 and 1990 (0). The low biomass produced was due largely to the late germination date. It would have been lower, but growth was extended into May by cool weather and light rains, and many plants flowered and fruited.

At four locations an assessment of late growth was made by sampling plots adjacent to previously sampled ones in early May (Table 6). *Bromus rubens* at the later sampling dates had grown significantly (t-test on medians, RS1) in Rock Valley and Mercury Valley, to an average of 19-58 mg/plant, which is sufficient to produce considerable seed.

Table 6. Total densities and biomasses and *Bromus rubens* weight per plant on nearby ephemeral plots sampled early and late in the 1991 season.

Plot	Early Sample				Late Sample			
	Date	n/m ²	g/m ²	mg	Date	n/m ²	g/m ²	mg
ROV005	APR 03	106±31	0.54±0.20	6±2	MAY 01	186±43	6.0±0.919	19±3
MER002	APR 08	148±33	0.82±0.19	6±0	MAY 02	82±17	5.3±1.4	58±12
FRF001	APR 11	18±11	0.08±0.05	12	MAY 06	2±2	0.06±0.06	-
YUF001	APR 17	78±35	0.51±0.26	7±2	MAY 06	30±13	1.1±0.5	16±3

With one exception, the plots which produced the most ephemeral biomass in 1991 were areas where perennial plants had been killed (Sedan blast area, U19ac drill pad, and Mid Valley burned area). The exception was Jackass Flats, which had higher precipitation than other valleys (see Figures 5 and 6 of the perennials section of this report).

Species Distributions

From 1989 through 1991, >134 species were sampled at study plots throughout the NTS. This approaches roughly half of the number of "annual" plant species recorded by Beatley (1976) for the NTS and southern Nevada. These species have widely varying growth habits and distributions. The plots they occurred on, their relative densities (within an order of magnitude), the years they appeared, and the altitudinal ranges of the plots where they were found are recorded in Table 7. It should be noted that these were drought years, and ranges will be greater in wetter years. Also, the 58 locations sampled since 1987 represent only approximately 0.02% of the area of the NTS.

There are some fairly clear patterns. For example, the altitudinal range of *Bromus rubens* and *Bromus tectorum* overlap, but *B. rubens* dominated below about 1300 m and *B. tectorum* dominated above that altitude. Some species had wide altitudinal ranges (e.g., *Astragalus lentiginosus fremontii* and *Salsola australis*), while others were only present at the lower extremes (e.g., *Astragalus didymocarpus*, *Schismus arabicus*) and others only at the upper extremes (e.g., *Chaenactis douglassii*, *Chenopodium leptophyllum*).

The two *Bromus* species are very similar in morphology and cannot be distinguished before they produce seeds. Because the 1991 season was late, many of the *Bromus* populations were dominated by vegetative material at the time of sampling. Those are called *Bromus* sp. in Appendix 1 and Table 7, referring to an indeterminate mixture of the two.

Table 7. Ephemeral Species sampled on the Nevada Test site, 1989-1991.

Entries are plot names-relative densities-years-altitude range (m), following each species name. Relative density codes are:

A = present in quadrats (usually 0.5m²); B = present in 100m²; C = present in 1000m²; D= seen nearby.

(*) = introduced species. "sp." indicates species could not be determined, usually due to absence of flowers.

SPECIES PLOTS, RELATIVE-DENSITIES, - YEARS, ALTITUDE RANGE.

Abronia elliptica PAM006-D-91. 2134.

Achillea sp. GOL001-B-89. 2060.

Allium nevadense ROV005-B-90; FRF007-B-90; ROV005-B-91; FRF002-B-91; YUF018-C-91. 945-1335.

Amsinckia tessellata MER002-C-90; YUF002-A-91; BREN73-B-91; ROV005-B-91; ROV006-B-91; MER002-A-91; YUF018-B-91; MID001C-B-91; MER003-B-91; FRF001-C-91; FRF002-B-91; YUF001-B-91; YUF017-A-91. 965-1448.

Androstephium breviflorum BREN70-B-91; ROV006-B-91; YUF011-C-91; YUF012-B-91; YUF010-B-91; YUF009-B-91; MID001-A-91; PAM007-A-91. 1049-2134.

Anisocoma acaulis MER002-B-91; FRF001-B-91. 965-1076

Astragalus calycosus GOL001-B-89; PAM005-A-90; PAM007-A-91; PAM006-B-91. 2060-2134.

A. didymocarpus JAF001-B-91; ROV006-A-91; MER001-B-91; FRF002-B-91; YUF001-B-91. 954-1237.

A. lentiginosus fremontii YUF023-C-89; ROV005-C-90; MER002-B-90,91; FOR003-C-90; PAM004-C-90; PAM005-C-90; YUF002-B-91; ROV006-A-91; MER002-A-91; MER003-C-91; FRF002-C-91; YUF001-A-91; YUF011-C-91; YUF012-B-91; YUF018-C-91; YUF010-A-91; YUF009-B-91; MID001C-B-91; MID001B-B-91; PAM006-C-91. 1036-2134.

A. purshii tinctus GOL001-B-89; MID001C-B-91; MID001-B-91. 1448-2060.

A. sp. MID004-C-89.

Baileya pleniradiata FOR003-C-90; JAF001-D-91. 954-1554

B. sp. JAF003-B-89; MER001-B-91.

Bromus rubens (*) YUF021-C-89; ROV005-A-90,91; MER002-A-90,91; MER003-A-90; MER001-A-90,91; YUF014-B-90; YUF002-C-91; JAF001-B-91; BREN70-A-91; BREN73-A-91; ROV006-A-91; MER003-A-91; MER001-A-91; FRF001-A-91; FRF002-B-91; YUF001-A-91; MID001C-A-91; MID001B-A-91. 965-1448.

B. tectorum (*) YUF019-D-89; GOL001-A-89; PAM004-A-90; PAM005-B-90; JAF001-D-91; FRF001-B-91; YUF017-C-91; YUF018-B-91; MID001C-B-91; MID001B-B-91; RAM001-C-91. 954-2283.

B. sp. (*) FOR003-A-90; YUF001-A-91; YUF011-A-91; YUF012-A-91; YUF016-A-91; YUF017-A-91; YUF018-A-91; YUF010-A-91; YUF009-A-91; YUF013-A-91; MID001C-A-91; MID001B-A-91.

Calochortus flexuosus PAM005-B-90; MID001B-C-91. 1448-2103.

C. parryi YUF001-C-91. 1237.
Calycoseris wrightii ROV006-C-91. 1049.
Camissonia boothii MER001-B-91. 1161.
C. claviformis integrrior ROV005-B-91; MER003-B-91; FRF001-D-91; YUF018-C-91; YUF010-B-91; YUF009-C091. 965-1335.
C. kernensis gilmanii BREN73-B-91; BREN70-B-91; MID001B-A-91. 1143-1448.
C. pterosperma BREN73-B-91; BREN70-A-91. 1143.
Castilleja chromosa MID001C-C-91; MID001B-C-91. 1448.
Caulanthus cooperi BREN73-B-91; BREN70-B-91; ROV005-B-91; ROV006-B-91; MER001-B-91. 1036-1161.
C. lasiophyllus BREN73-B-91; ROV005-A-91; MER002-B-91; MER003-A-91; MER001-B-91; FRF002-B-91; YUF001-B-91. 977-1237.
C. pilosus PAM004-B-90; MID001C-B-91; MID001B-B-91; PAM006-B-91. 1448-2134.
Chaenactis carphoclinia ROV005-A-91. 1036.
C. douglasii PAM007-B-91; RAM001-B-91. 2134-2283.
C. fremontii FRF003-C-90; JAF001-A-91; BREN73-B-91; ROV005-B-91; MER002-C-91; FRF001-B-91; FRF002-A-91; YUF001-A-91; YUF009-B-91; YUF013-B-91; RAM001-A-91. 954-2283.
C. macrantha MER001-A-91. 1161.
C. stevioides MER002-A-91; FRF002-B-91; YUF001-A-91; YUF002-A-91; YUF017-B-91; YUF018-A-91; YUF010-B-91; YUF009-A-91; MID001C-A-91. 977-1448.
Chenopodium fremontii PAM004-C-90; RAM001-B-91. 2103-2283.
C. incanum MER002-A-91; YUF001-C-91; YUF011-A-91; YUF012-B-91; YUF009-A-91; YUF013-B-91; MID001B-B-91; PAM006-B-91. 1076-2134.
C. leptophyllum PAM004-A-90; PAM005-B-90; PAM006-C-91. 2103-2134.
Chorizanthe brevicornu BREN73-B-91; BREN70-B-91; ROV005-B-91; ROV006-B-91; MER002-A-91; FRF002-C-91. 977-1143.
C. rigida FRF002-C-91. 977.
C. thurberi MID001C-A-91; MID001B-A-91. 1448.
C. watsonii MID001C-A-91. 1448.

Cleome lutea PAM006-B-91. 2134.

Crepis intermedia GOL001-A-89; PAM007-B-91. 2060-2134.

Cryptantha angustifolia JAF001-B-91. 954.

Cryptantha circumscissa PAM003-C-89; GOL001-A-89; MER001-B-90; YUF014-C-90; FOR003-C-90; MID001B-B-91; YUF002-B-91; JAF001-B-91; BREN73-B-91; BREN70-B-91; ROV005-B-91; ROV006-C-91; MER002-B-91; FRF001-C-91; YUF001-B-91; YUF011-B-91; YUF016-B-91; YUF017-B-91; YUF018-A-91; YUF010-A-91; YUF009-A-91; YUF013-A-91; MID001C-B-91. 954-2060.

C. dumetorum FRF001-A-91. 965.

C. gracilis JAF001-B-91; BREN73-B-91; BREN70-B-91; ROV005-B-91; MER002-D-91; FRF001-D-91; FRF002-C-91; YUF012-A-91; YUF017-B-91; YUF018-A-91; MID001C-B-91. 954-1448.

C. micrantha JAF001-A-91; BREN73-B-91; ROV006-A-91; FRF001-D-91; YUF012-C-91; YUF009-C-91; YUF013-A-91. 954-1279.

C. nevadensis FRF001-B-91; FRF002-A-91; ROV005-A-91; MER003-A-91; MER002-B-91; YUF001-B-91; YUF017-A-91; YUF010-B-91; YUF013-C-91. 965-1327.

C. pterocarya JAF001-A-91; BREN73-B-91; BREN70-B-91; ROV005-B-91; FRF001-B-91; FRF002-C-91; YUF001-A-91; YUF017-A-91; YUF018-B-91; MID001C-A-91. 954-1448.

C. recurvata YUF001-A-91; MID001B-A-91. 1237-1448.

Cryptantha virginensis MER001-B-91. 1161.

C. watsonii FOR003-B-90. 1554.

C. sp. BREN70-B-91; ROV005-A-91; ROV006-B-91; MER001-A-91; FRF001-A-91; FRF002-B-91; YUF001-B-91; YUF011-B-91; YUF012-A-91; YUF010-B-91; YUF009-B-91.

Cymopterus ripleyi ROV005-C-90; YUF012-D-90. 1036-1239.

Delphinium andersonii PAM005-B-90; PAM007-A-91. 2103-2134.

D. parishii ROV005-B-91; MER002-C-91; YUF001-C-91 (*Ssp parishii*); YUF010-C-91; MID001C-C-91; MID001B-C-91. 1036-1448.

Descurainia pinnata PAM004-C-90; FRF001-A-91; FRF002-A-91; BREN73-B-91; BREN70-B-91; ROV005-A-91; ROV006-C-91; MER002-B-91; MER001-A-91; YUF001-A-91; YUF002-A-91; YUF011-B-91; YUF012-B-91; YUF016-C-91; YUF017-C-91; YUF018-C-91; YUF009-B-91; YUF013-A-91; MID001C-A-91; MID001B-A-91. 965-2103.

D. sophia (*) PAM006-B-91. 2134.

Dichelostemma pulchellum MER002-A-90; JAF001-C-91; MER002-A-91; MER003-A-91; MID001C-A-91; MID001B-A-91. 954-1448.

Eriastrum eremicum JAF001-C-91; FRF001-B-91; ROV006-A-91; MER003-B-91; MER002-B-91; MID001C-B-91; MID001B-A-91. 954-1448.

Eriogonum deflexum YUF023-C-89; MER001-A-90,91; PAM004-A-90; YUF002-B-91; YUF016-A-91; YUF017-B-91; YUF010-B-91; YUF009-A-91; YUF013-A-91; PAM006-A-91. 1161-2134.

E. inflatum ROV005-C-89; ROV005-B-91; MER001-B-91. 1036-1161.

E. maculatum JAF001-C-91; BREN70-B-91; FRF001-B-91; FRF002-C-91; YUF001-A-91; YUF002-C-91; YUF011-A-91; YUF012-A-91; YUF018-B-91; YUF010-B-91; PAM006-A-91. 954-2134.

E. nidularium FRF002-C-91; YUF001-A-91; YUF017-B-91; YUF018-C-91; MID001C-B-91; MID001B-B-91. 977-1448.

E. reniforme BREN73-B-91; BREN70-B-91, ROV006-B-91. 1049-1143.

E. trichopes ROV005-A-91; MER001-B-91. 1036-1161.

Eriophyllum ambiguum MID001B-B-91. 1448.

E. pringlei BREN73-B-91; BREN70-B-91; FRF001-D-91; YUF001-A-91; YUF018-A-91; YUF010-B-91; MID001B-B-91. 965-1448.

Erodium cicutarium (*) MER001-A-90,91; YUF002-C-90; YUF014-B-90; YUF002-A-91; BREN73-B-91; ROV006-B-91; MER003-A-91; MER002-B-91; FRF002-B-91; YUF001-C-91; YUF017-B-91; YUF009-B-91; MID001C-B-91. 977-1448.

Eschscholzia glyptosperma BREN73-B-91; BREN70-B-91; ROV005-B-91; MER002-B-91; FRF001-A-91. 965-1143.

E. minutiflora MID001C-A-91; MID001B-B-91. 1448.

Euphorbia albomarginata JAF003-A-89; MER002-A-90,91; FRF003-A-90; YUF014-D-90; YUF011-B-91; YUF009-A-91; MID001C-C-91. 963-1448.

Fritillaria atropurpurea PAM007-B-91; RAM001-B-91. 2134-2283.

Gayophytum decipiens RAM001-A-91. 2283.

Gilia cana FOR003-B-90; PAM004-B-90; PAM005-A-90; MER002-B-91 (SSP. *speciformis*); FRF002-C-91; PAM006-B-91. 1067-2134.

G. filiforme PAM007-C-91. 2134.

G. sinuata FRF003-C-90; FRF001-C-91; PAM007-C-91. 965-2134.

G. transmontana JAF001-D-91; BREN73-A-91; BREN70-B-91; ROV005-B-91; MER002-A-91; MER003-A-91; YUF002-C-91; YUF012-B-91; YUF010-C-91; YUF013-A-B-91; MID001B-A-91; PAM002-A-91. 954-1911.

Glyptopleura marginata ROV006-D-91; YUF018-A-91; RAM001-B-91. 1049-2283.

Halogeton glomeratus YUF019-D-89; PAM002-A-89. 1213-1911.

Hymenoxys cooperi PAM007-A-91. 2134.

Ipomopsis congesta RAM001-A-91. 2283.

I. polycladon MER003-B-91; MER001-A-91; YUF001-B-91. 1103-1237.

Langloisia setosissima YUF001-B-91. 1237.

L. schottii FRF002-C-91; YUF012-C-91; YUF010-C-91; YUF009-B-91. 977-1279.

Lappula occidentalis GOL001-A-89; PAM004-B-90; PAM006-C-91. 2060-2134.

Lepidium lasiocarpum BREN73-B-91; ROV005-A-91; MER002-B-91; MER003-B-91; FRF001-C-91; FRF002-D-91; YUF001-B-91; YUF011-C-91; YUF012-B-91; YUF018-A-91; MID001C-B-91. 1036-1448.

Lesquerella kingii PAM007-B-91. 2134.

Lewisia rediviva GOL001-C-89. 2060.

Linanthus dichotomus MER002-D-91; MID001C-A-91. 1076-1448.

L. jonesii BREN73-B-91; BREN70-B-91; MID001C-A-91; MID001B-C-91. 1143-1448.

Linum sp. PAM006-C-91. 2134.

Lomatium nevadense GOL001-A-89; MID001C-C-91; MID001B-C-91. 1448-2060.

Lupinus brevicaulis PAM007-B-91; RAM001-A-91. 2134-2283.

L. shockleyi JAF001-B-91; FRF001-B-91; FRF002-C-91. 954-977.

L. sp. MER003-C-91.

Machaeranthera canescens JAF003-A-89; YUF019-C-89; YUF021-C-89; YUF023-B-89; YUF024-C-89; MID006-B-89; PAM003-C-89; MER002-B-90; YUF014-C-90; YUF028-D-90; PAM004-C-90; MER002-A-91; MER003-A-91; YUF001-B-91; YUF012-B-91; YUF017-A-91; YUF018-C-91; YUF010-B-91; YUF009-B-91; MID001C-C-91; MID001B-B-91. 963-2103.

Malacothrix coulteri BREN73-B-91. 1143.

M. glabrata YUF002-A-91; JAF001-C-91; BREN73-B-91; BREN70-A-91; ROV006-A-91; FRF001-B-91; YUF001-B-91; YUF012-C-91; YUF017-B-91; YUF018-B-91; YUF010-B-91; YUF009-C-91. 954-1335.

M. sonchoides JAF001-B-91. 954.

Mentzelia albicaulis YUF014-D-90; FOR003-A-90; PAM004-A-90; PAM005-A-90; YUF002-B-91; JAF001-B-91; BREN73-B-91; BREN70-B-91; ROV005-B-91; ROV006-B-91; FRF001-B-91; FRF002-B-91; YUF001-C-91; YUF012-B-91; YUF016-C-91; YUF017-A-91; YUF018-A-91; YUF010-B-91; YUF009-A-91; YUF013-A-91; MID001C-A-91; MID001B-A-91; PAM006-B-91. 954-2134.

M. obscura RAM001-B-91. 2283.

Mimulus rubellus MID001B-C-91. 1448.

Monoptilon bellidiforme BREN70-B-91; FRF001-A-91. 965-1143.

Muilla coronata MER001-B-91. 1161.

M. sp. YUF010-C-91.

Nama demissum JAF001-D-91; BREN73-B-91; FRF002-C-91. 954-1143.

N. densum densum RAM001-B-91. 2283.

Oenothera avita JAF001-B-91. 954.

O. caespitosa MER003-C-91; YUF016-B-91. 1103-1318.

O. deltoides PAM006-C-91. 2134.

Oxytheca perfoliata BREN70-B-91; YUF018-A-91; YUF010-B-91. 1143-1335.

Pectocarya heterocarpa ROV005-A-91; FRF002-B-91. 977-1036.

P. platycarpa BREN73-B-91; ROV005-A-91; MER002-B-91. 1036-1173.

P. setosa MID001C-B-91. 1448.

Penstemon petiolatus RAM001-B-91. 2283.

P. sp. GOL001-C-89; PAM007-A-91; RAM001-C-91.

Phacelia bicolor FOR003-A-90. 1554.

P. fremontii FOR003-B-90; PAM005-C-90; YUF002-B-91; BREN73-A-91; BREN70-A-91; ROV005-A-91; MER002-A-91; MER003-B-91; MER001-B-91; MID001C-A-91; MID001B-A-91; YUF001-A-91; YUF018-B-91; YUF010-B-91. 1036-2103.

P. vallis-mortae ROV006-B-90; ROV005-A-91; ROV006-B-91; MER003-C-91; YUF001-B-91; YUF010-B-91; MID001C-A-91; MID001B-B-91; PAM007-C-91. 1036-2134.

Phlox stansburyi MID001C-A-90 ; PAM004-C-90; PAM005-A-90; ; MID001B-A-91; PAM007-A-91. 1448-2134.

Plagiobothrys jonesii FRF001-B-91; ROV005-B-91; ROV006-B-91; MER002-C-91; MER003-B-91; ; YUF017-B-91; YUF013-B-91. 965-1337.

Prenantheella exigua ROV005-B-91; MER003-B-91; YUF001-B-91; FOR003-B-90. 1036-1237.

Psathyotes annua YUF016-A-91. 1318.

Rafinesquia neomexicana BREN73-B-91; ROV005-B-91; ROV006-C-91; MER001-B-91; FRF001-B-91; FRF002-B-91. 965-1143.

Salsola australis (*) YUF021-C-89; YUF023-B-89; PAM002-A-89; PAM004-A-90; YUF002-D-91; MER002-B-91; YUF001-B-91; YUF011-A-91; YUF012-B-91; YUF016-A-91; YUF017-B-91; YUF018-B-91; YUF010-B-91; YUF009-A-91; YUF013-A-91; MID001C-A-91; MID001B-A-91; PAM006-A-91. 1076-2134.

Schismus arabicus (*) JAF001-B-91; BREN73-B-91; BREN70-A-91. 954-1143.

Sisymbrium altissimum (*) YUF016-C-91; YUF017-B-91; YUF018-B-91; YUF009-B-91. 1279-1335.

Stephanomeria exigua JAF001-D-91; YUF011-C-91; YUF012-B-91; YUF010-C-91. 954-1267.

Streptanthella longirostris JAF001-A-91; FRF001-D-91; ROV005-B-91; ROV006-B-91; ; YUF001-B-91; YUF012-B-91; YUF018-B-91. 954-1335.

Streptanthus cordatus RAM001-B-91. 2283.

Stylocline micropoides MID001C-B-91. 1448.

Syntrichopappus fremontii ROV006-B-91. 1049.

Thysanocarpus curvipes MID001C-B-91. 1448.

T. laciniatus ROV006-A-90. 1049.

Tiquilia nutallii JAF001-B-91. 954.

Tiquilia plicata JAF003-A-89. 963.

Tricardia watsonii MID001C-C-91. 1448.

Unidentified PAM003-C-89; GOL001-A,C-89; FOR003-A-90; FRF001-C-91; FRF002-C-91; MER002-B-91; MER001-B-91; ; MID001B-C-91; PAM007-C-91.

Vulpia microstachys MID001C-A-91; MID001B-B-91. 1448.

V. octoflora JAF001-A-91; FRF001-B-91; BREN73-B-91; BREN70-A-91; ROV005-A-91; ROV006-D-91; MER002-A-91; MER003-A-91; MER001-A-91; ; YUF001-A-91; YUF017-C-91; MID001C-A-91; MID001B-B-91. 954-1448.

The 10 most frequently encountered species, which are adapted to a wide range of habitats, are listed in Table 8. Three of these are introduced weeds that are frequently dominant where they occur (*Bromus rubens*, *Salsola australis*, and *Erodium cicutarium*). The most frequently encountered native species varied. Some are generally sparse but widespread (*Cryptantha circumscissa*, *Machaeranthera canescens*, *Astragalus lentiginosus fremontii*, and *Phacelia fremontii*), while others are occasionally dominant in some locations (*Mentzelia albicaulis*, *Descurainia pinnata*, and *Vulpia octoflora*).

Table 8. The ten most frequently encountered ephemeral species on the Nevada Test Site, 1989-1991. Species with asterisks are introduced.

<u>Species</u>	<u># of Sites Occupied</u>	<u>Range (m)</u>	<u>1991 Median Density</u>
<i>Cryptantha circumscissa</i>	23	954-2060	0.01-2
<i>Mentzelia albicaulis</i>	23	954-2134	0.01-2
<i>Machaeranthera canescens</i>	21	963-2103	0.01-2
<i>Descurainia pinnata</i>	20	965-2103	0.01-2
<i>Astragalus lentiginosus</i> var. <i>fremontii</i>	19	1036-2134	0.01-2
<i>Salsola australis</i> *	18	1076-2134	2
<i>Bromus rubens</i> *	17	965-1448	24
<i>Phacelia fremontii</i>	14	1036-2103	2
<i>Vulpia octoflora</i>	13	954-1448	4
<i>Erodium cicutarium</i> *	13	977-1448	0.01-2

The majority of species (70) could be considered rare, occurring at only one or two sites, often on two nearby plots.

Considering the high densities and widespread distributions of the introduced brome grasses, they must easily make up more than half of the plant numbers on the NTS. Their small sizes, however, allow the dominant perennials to dominate total plant biomass.

Some species were observed or collected during work at other locations. Noteworthy species are listed in Table 9. The unknown *Gilia* species was previously collected by S. Cochrane (personal communication) and is distinguished from *Gilia nyensis* by having "hot pink" on the top side of the petals.

Table 9. Noteworthy ephemeral plant collections on the NTS, 1989-1991.

<u>Species</u>	<u>Location</u>	<u>Remarks</u>
<i>Camissonia megalantha</i>	Tweezer Roadsides	Candidate threatened species
<i>Chaetopappa lyonii</i>	Gold Meadow Pond	New species for NTS
<i>Coldenia nuttallii</i>	RED001 Burn	New location
<i>Eleocharis montevidensis</i>	Reitmann Seep	New location
<i>Eriogonum shockleyi</i>	Crossgrain Valley	New location
<i>Gilia</i> sp.	RED001 Burn	Possible new species
<i>Machaeranthera ammophila</i>	RED001 Burn	New location
<i>Muilla coronata</i>	Mercury	New species for NTS.
<i>Muilla</i> sp.	Yucca Flat	New species for NTS.

DISCUSSION

There are several long- and short-term trends in ephemeral plant populations on the NTS. The major on-going change is an adjustment of the native flora to certain aggressive weeds introduced by man from Europe, the Middle East, and Asia. The most significant invasion, that of two species of weedy annual grass (*Bromus rubens* and *B. tectorum*), has been discussed recently by Hunter (1990, 1991). It is briefly discussed here, along with summaries of the progress of invasions by other introduced species. Another long-term trend is for ephemeral populations to adjust to an increased level of disturbance, which here is considered to be removal of shrub cover. Over the period covered by this report, an adjustment to short-term drought is also occurring, and there are a number of interactions of ephemerals with several other environmental variables.

INTRODUCED SPECIES

Brome Grasses

Since the first botanical observations were made on the NTS (Shields and Rickard 1957), *Bromus rubens* and *Bromus tectorum* have been present. They apparently spread across the Mojave Desert between 1900 and 1930 (Hunter 1991). Their densities gradually increased from 1963 through 1988 to levels where they totally dominated the ephemeral flora in many areas on the NTS

(Hunter 1991). The primary invader was *B. rubens*, but *B. tectorum* extended its range to disturbed areas between 1200 and 1500 m during the early 1980s (Hunter 1990, 1991), being restricted to areas above 1524 m prior to that time (Beatley 1966).

The increase in *Bromus rubens* is illustrated for Rock Valley in Table 10, which is updated from Hunter (1990). The years 1989 and 1990, years of severe drought, can be considered a setback or stasis of the ongoing invasion. During 1989 there was virtually no germination at all of *B. rubens*, and *B. tectorum* was found only at higher altitudes (Gold Meadow, 2060 m). In 1990 *B. rubens* germinated, but only in low numbers with poor reproduction. In 1991, however, it was by far the densest species encountered (Table 8). Its altitudinal range was somewhat limited, but *Bromus tectorum* complements that range and perhaps can eventually be expected to dominate the higher altitudes. The data from Rock Valley (Table 10) show that in 1991 *B. rubens*, even though reduced in numbers by drought, still dominated the ephemeral populations. Was this dominance detrimental to the native ephemerals? A declining trend in native numbers is not apparent in Table 10, but an analysis of biomass data suggests that the competition is having a negative effect (Table 11). In the 1970s the production of native biomass was correlated significantly with rainfall (Pearson's $r^2 = 0.90$, $n = 6$, significant at $p < .05$, f test). The linear regression equation was Annual Net Production of natives = $(0.43 \times \text{precipitation}) - 25.4$. Between 1987 and 1991, however, even though rainfall varied dramatically, there was no significant correlation for native species ($r^2 = 0.114$; ANP = $(0.003 \times \text{precipitation}) + 0.3$). The years of highest rainfall (1987,88) had only 1.1 and 1.4% of the biomass predicted by the 1970s regression line.

Table 10. Densities (n/m^2) of *B. rubens* and native ephemerals at Beatley's Plot 3 in Rock Valley, 1963-1991. Rainfall data (mm, Sep.-Apr.) are from NOAA/USWB. Data sources are in Hunter 1990.

<u>Year</u>	<u><i>Bromus rubens</i></u>	<u>Natives</u>	<u>Precip.</u>
	5.0	10.0	-
1964	6.2	27.6	76.2
1965	2.2	2.4	90.7
1966	3.2	69.6	139.7
1967	3.6	7.0	73.9
1968	7.6	99.6	93.7
1969	14.0	109.8	212.3

Table 10, continued.

<u>Year</u>	<u><i>Bromus rubens</i></u>	<u>Natives</u>	<u>Precip.</u>
1970	19.8	14.0	68.1
1971	0.2	2.0	46.7
1972	0.0	3.0	43.1
1973	0.4	118	220.0
1974	11.2	101	70.1
1975	13.2	216	112.3
1976	90.0	327	125.7
~~~	~~~	~~~	~~~
1983	89	108	173.7
1984	167	19	50.3
1985	156	111	117.9
1986	-	-	98.6
1987	754 $\pm$ 298	100 $\pm$ 22	167.1
1988	2034 $\pm$ 632	86 $\pm$ 33	202.9
1989	0 $\pm$ 0	0 $\pm$ 0	17.8
1990	16 $\pm$ 16	0 $\pm$ 0	31.5
1991	60 $\pm$ 20	46 $\pm$ 19	83.3

Table 11. Biomass (g/m²) of *Bromus rubens* and native ephemeral species in Rock Valley. The 1971-76 data are from Turner et al., and the 1987-91 data are BECAMP's. Sept-Apr precipitation is from NOAA/USWB records for Rock Valley.

<u>Year</u>	<u><i>Bromus rubens</i></u> g/m ²	<u>Natives</u> g/m ²	<u>Precip.</u> mm
1971	0.10	0.54	46.7
1972	0.04	0.40	43.1
1973	1.29	78.9	220.0
1974	0.83	1.50	70.1
1975	2.13	22.5	112.3
1976	3.25	12.0	>125.7
1987	27.0	0.51	167.1
1988	34.0	0.9	202.9
1989	0.0	0.0	17.8
1990	0.0	0.0	31.5
1991	2.0	2.0	83.3

Using the IBP Desert Biome data, Turner and Randall (1989) published a regression line meant to predict production (g/m^2) of all winter annual species from September-March precipitation. That relationship ($\log \text{ANP} = 1.976 \log(\text{Sep-Mar precipitation}) - 2.746$) did hold up well in the late 1980s (Table 12). The actual production was somewhat higher than the predicted production in each of the four years where a prediction was possible. This suggests *B. rubens*, which dominated annual net production each year, may be somewhat more efficient at water use than the native species. The correlation coefficient between the predicted and actual production for all species combined was $r^2 = 0.988$, significant at $p < 0.05$.

Table 12. Annual net production of ephemeral plant biomass in Rock Valley as predicted by Turner and Randall (1989) and as measured by BECAMP, 1987-1991.

<u>Year</u>	<u>Precipitation</u>	<u>ANP (g/m^2)</u>	
		<u>predicted</u>	<u>actual</u>
1987	127.5	16.5	18 $\pm$ 5
1988	154.2	26.2	36 $\pm$ 8
1989	17.8	-	0 $\pm$ 0
1990	27.7	0.004	0.06 $\pm$ 0.06
1991	83.3	0.028	5.0 $\pm$ 1.7

Other Introduced Species

Two other introduced species were among the most frequently encountered ephemerals - *Salsoia australis* (Russian thistle, tumbleweed) and *Erodium cicutarium* (storksbill, filaree). *S. australis* invaded the United States in the late 1800s, and has spread worldwide (Young 1991). It presumably originated in Asia, but its original habitat has not been discovered. It is particularly adapted to germination and growth on loose, disturbed soil (Wallace and Romney 1972). It spreads seed by "tumbling", as the whole plant breaks off at ground level and blows in the wind. An intact perennial shrub community stops the seed dispersal, and this summer annual species does not compete well for water with perennial plants, so it is largely restricted to disturbed areas.

BECAMP data on ephemerals are collected in spring, a relatively poor time to assess *Salsoia* numbers and production. *Salsoia* is measured in mid-summer with

perennials to partially correct for that failing. The species spans essentially the whole altitudinal range of the NTS, and dies every fall with freezing weather. Maximum size is reached in late September or early October.

On the NTS *Salsola* was noted early for invading the areas blasted free of shrubs by above-ground nuclear weapons tests. A vegetation map produced by Allred et al. (1963) showed these blast areas as circles dominated by *Salsola*. Shields et al. (1963) noted it appeared within a year of the tests, and it persisted on the ground zeroes into the 1970s (Hunter et al. 1987a). Even in the late 1980s and early 1990s it was present in large numbers on some of the ground zeroes (GZs) (Table 13), 25 to 30 years after the tests. It was also present at relatively high densities on the drill pads BECAMP sampled on Pahute Mesa, but on burned areas and gopher-denuded sites it occurred only at low densities. On burned areas the absence of soil disturbance probably limits *Salsola* seed burial, but its absence from the gopher areas seems anomalous.

Table 13. Densities (n/m²) of *Salsola australis* in spring on disturbed and control areas.

<u>Disturbance</u>	<u>Year</u>	<u>Location</u>	<u>Density</u>	
			<u>Disturbed</u>	<u>Control</u>
GROUND ZEROES	1988	Sedan-305m	557±512	0
	1991		892±469	0
	1991	T3 GZ	14±5	0
	1988	T1 GZ	128±34	2±2
	1991		2±2	0
	1988	T2-1 GZ	44±14	2±2
DRILL PADS	1989	U20ao	44±13	0
	1990	U19e	904±242	0
	1991	U19ac	2562±694	0
SCRAPED AREAS	1988	3B	12±5	18±7
	1991		96±77	0
CRATERS	1989	U3cn	0-7.1	5.0
	1989	U7au	2.1-41.0	0
	1989	U10af	0.03-0.94	0.02
BURNED AREAS	1987	SW Yucca	0	0
	1988	S Mid Valley	2±2	0
	1991		28±10	4±4

Table 13. continued.

<u>Disturbance</u>	<u>Year</u>	<u>Location</u>	<u>Density</u>	
			<u>Disturbed</u>	<u>Control</u>
GOPHER AREAS	1988	W Mercury	0	-
	1990		0	0
	1991		0	0

Beatley (1965) reported *Salsola* was rare and in the early 1960s only recently present at altitudes below 1200 m. She then suggested it was poorly suited to the drier portions of the NTS, but its widespread presence in Las Vegas and Daggett, California (600 m) (Hunter et al., 1987b), suggests it can do well wherever soils are disturbed and perennial vegetation has been removed.

The last introduced species listed in Table 8 is *Erodium cicutarium*. It was apparently introduced by the Spaniards, as seeds have been found in mission adobes in California built as early as 1771 (Frenkel 1970, citing Hendry 1931). Fremont reported it covered the ground in southern California in 1844 (Robbins et al. 1941). Cole and Webb (1985) documented its presence in Death Valley packrat middens as early as 270±70 years before the present (about A.D. 1700). On the NTS it was reported as one of two species which rapidly invaded the GZs (Shields et al. 1963).

Erodium cicutarium is a small winter annual with fairly effective short-range dispersal and a good seed burial mechanism. Its well-developed tap root provides somewhat better drought-hardiness than the introduced grasses it often occurs with. From 1987 through 1991 it occurred on both disturbed and control plots, but usually only at low densities. It was most dense on T2 ground zero and on a plot in Mercury where shrubs were removed by hand in 1985.

One other introduced species of potential future importance on the NTS is *Schismus arabicus*. The earliest herbarium specimen in the southwestern deserts is from Phoenix, Arizona, in 1929 (California Academy of Sciences Herbarium, #12642). Most of the 1930s collections were also from Arizona. The oldest specimen in southern Nevada was from Mercury on the NTS in 1959 (Beatley, DOE herbarium #558). Ira Clokey, who collected plants in the Charleston Mountains in the late 1930s, did not report finding any *Schismus* (Clokey 1951). Although it is now a dominant ephemeral at lower elevations in the Mojave Desert (e.g., Hunter et al. 1987b), it has been found by BECAMP

only in Jackass Flats (Table 7) and Mercury. Irrigation experiments in Mercury in the 1970s showed it responded well to added summer moisture (Romney et al. 1978; Hunter, unpublished observation) but not to winter irrigation. It has the potential to invade the low, sandy areas of the NTS in Jackass Flats and Frenchman Flat, but has not yet appeared in significant numbers in those areas.

Of the plots sampled from 1989 through 1991 which had ephemerals at all, only one had no introduced species in the 1000 m² sampled. That was PAM007, a control plot in pinyon forest on Pahute Mesa at 2133 m altitude.

DISTURBANCE

The NTS has a very unusual land use pattern. Although situated on land suitable for grazing, mining, hunting, and recreation, all of those activities are prohibited. Most disturbance to the ecosystem is related to nuclear testing, primarily through support activities since underground testing began. An estimate of total disturbed area on the NTS was made by Hunter and Medica (1992), and added up to about 8% of the total area. The major disturbance is fire, which from 1978 through 1987 burned 4.3% of the NTS (records are unavailable prior to 1978). The next largest surface disturbance is the blast zones from atmospheric tests, estimated at 1.6% of the total area. The major continuing disturbance is almost undoubtedly roadside maintenance and construction of new bladed roads.

Productivity

In general, the numbers and sizes of ephemeral plants are greater on disturbed areas than where the shrub community is intact. Table 14 shows that for 31 paired plots with shrubs removed (by blast, fire, scraping, or gophers) on one and intact on the other, ephemeral density and biomass were significantly greater on the disturbed plots. This was true in 18 of the 22 pairs where ephemeral biomass was not zero. In other words, in years when germination occurred, both numbers of seeds germinated and total biomass production were greater in the absence of shrubs.

Table 14. A comparison of mean densities (n/m^2), biomass (g/m^2), and species richness ($n/0.5m^2$) for ephemerals sampled on paired disturbed/undisturbed plots below 1450m, 1986-1991.

	<u>Density</u>	<u>Biomass</u>	<u># of Species</u>
31 undisturbed plots	214 $\pm$ 75	4.5 $\pm$ 1.8	5.6 $\pm$ 1.2
31 disturbed plots	706 $\pm$ 210	14.5 $\pm$ 4.1	5.2 $\pm$ 0.9
(probability dist. = undist.) (t-test Minitab)	0.03	0.03	0.83

Species Distribution

Although we found the same number of species on disturbed and undisturbed plots (Table 14), they were not necessarily the same species. Disturbance certainly favors certain species, but determination of which species and how they are affected is made difficult by high spatial and temporal variability. If we look only at paired disturbed and undisturbed plots, and combine data from all years and plots with non-zero ephemeral numbers, it appears that the introduced species (*Bromus rubens*, *B. tectorum*, *Descurainia sophia*, *Erodium cicutarium*, *Salsola australis*, *Schismus arabicus*, and *Sisymbrium altissimum*) tended to grow better on disturbed areas, while native species benefitted to a lesser degree (Table 15). This generalization, however, is somewhat misleading. Species appeared to respond individually to disturbance, weather patterns, soil type, and competition with other species. Since BECAMP monitoring began there was an apparent decrease in the proportion of the ephemeral plant populations made up of introduced species (Table 16). The decline in the proportion of introduced plant numbers (but not biomass) was largely coincident with the severe drought of 1989 and 1990, which suggests seeds of the introduced species (*Bromus spp.* and *Salsola australis*) do not persist in the soil as long as natives.

Table 15. Mean densities ($n/m^2 \pm \text{sem}$) and biomasses ($g/m^2 \pm \text{sem}$) for native and introduced ephemeral species on disturbed and undisturbed sites, 1986-91. (The analysis includes only years and plots with densities > 0 .)

	<u>n/m^2</u>		<u>g/m^2</u>	
	<u>Introduced</u>	<u>Native</u>	<u>Introduced</u>	<u>Native</u>
18 undisturbed	330 $\pm$ 113	74 $\pm$ 23	7.3 $\pm$ 2.8	1.2 $\pm$ 0.6
18 disturbed	1050 $\pm$ 310	123 $\pm$ 34	19.2 $\pm$ 5.4	4.8 $\pm$ 2.2
p dist. = undist.	0.04	0.24	0.06	0.13

Table 16. Ratios of introduced to native densities ($n/m \pm \text{sem}$) and biomasses ($g/m^2 \pm \text{sem}$) on pooled disturbed and undisturbed paired plots, 1986-1991.

Year	Introduced/Native	
	n/m^2	g/m^2
1987	39 ± 13	3.8 ± 1.2
1988	14 ± 5	121 ± 72
1991	2.4 ± 0.6	12 ± 7
(probability all years are equal)	0.002	0.423

Only one disturbed plot has been sampled annually. That is a plot in Mercury where shrubs were removed by hand in September 1985. Ephemerals were measured on that plot and an adjacent control from 1986 through 1991. Of the six most numerous species, the three natives (*Descurainia pinnata*, *Eriogonum deflexum*, and *Vulpia octoflora*) ended the period with the largest populations, while the three introduced species expanded during the three "normal" years 1986-88, but were nearly absent in 1991, the third drought year (Table 17). Thus the natives appear to be better able to survive drought, while the introduced species seem better competitors in wetter years. The result is a shifting dominance by different species, depending on the amount and season of rainfall and the pattern of wet and dry years.

Table 17. Densities ($n/m \pm \text{sem}$) of the dominant ephemerals from 1986 through 1991 on a shrub removal and control plot in Mercury.

Species	1986	1987	1988	1989	1990	1991
(shrubs removed)						
<i>Bromus rubens</i>	790 ± 269	456 ± 192	1912 ± 475	0	2 ± 2	0
<i>Descurainia pinnata</i>	42 ± 13	16 ± 6	14 ± 7	0	0	74 ± 38
<i>Eriogonum deflexum</i>	0	3 ± 2	72 ± 17	0	2 ± 2	35 ± 11
<i>Erodium cicutarium</i>	5 ± 3	10 ± 5	278 ± 42	0	5 ± 3	6 ± 3
<i>Schismus arabicus</i>	10 ± 10	10 ± 5	294 ± 103	0	0	0
<i>Vulpia octoflora</i>	232 ± 52	92 ± 24	365 ± 78	0	0	134 ± 48
(control plot)						
<i>Bromus rubens</i>	168 ± 60	352 ± 120	443 ± 130	0	0	10 ± 4
<i>Descurainia pinnata</i>	2 ± 2	6 ± 6	3 ± 2	0	0	0
<i>Eriogonum deflexum</i>	0	0	2 ± 2	0	0	0

Table 17, continued.

<u>Species</u>	<u>1986</u>	<u>1987</u>	<u>1988</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>
		(shrubs removed)				
<i>Erodium cicutarium</i>	2±2	0	6±4	0	0	0
<i>Schismus arabicus</i>	0	3±2	0	0	0	0
<i>Vulpia octoflora</i>	172±64	21±6	85±32	0	0	11±5

Disturbance therefore clearly favors certain species over others. Examples are *Salsola australis* on drill pads and ground zeroes, and *Erodium cicutarium* and *Descurainia pinnata* on the shrub removal plot. Since much of the disturbance is caused by man, we must ask if these changes are detrimental. Will they increase the threat of extinction to native species? In general I would say no. On the NTS only about 8% of the land has been disturbed since 1951, and disturbance alone is unlikely to cause major changes in the flora, even though introduced species are favored by disturbance.

One final aspect of disturbance is important. Disturbed areas, particularly roadsides, may act as corridors for the spread of introduced species. This has been discussed recently by Tyser and Worley (1992), who measured patterns of alien species along roadsides in Glacier National Park. Although they implicated road construction and management in the invasion of alien species, they did not show that the alien species were displacing native species, nor did they show the roadsides were the only or major invasion path. It is my opinion that the really deleterious introduced species invade natural communities rapidly, even in the absence of disturbances, and would be only moderately, if at all, slowed by the absence of roads. The alien species on the NTS that apparently require disturbance (*Salsola australis*, *Erodium cicutarium*, and possibly *Bromus tectorum*) (Beatley 1966; Hunter 1991) do not compete strongly with natives in the absence of disturbance. *Bromus rubens*, a deleterious species now nearly ubiquitous on the NTS, has successfully invaded both disturbed and undisturbed areas (Hunter 1990, 1991).

The DOE is party to an agreement to avoid introducing exotic plant and animal species to the NTS. If roadway construction and management is shown to result in such introductions, it may in the future be necessary to modify those activities.

MISCELLANEOUS INFLUENCES

Ephemeral plants interact with many environmental factors. Research published over the last several years adds significantly to an understanding of the ecology of these species.

Drought

The obvious effect of the drought of 1989 through 1991 was to inhibit germination of ephemerals, so that lower altitudes had essentially no germination in 1989 or 1990. In 1991 germination was late and sparse. There was no good way to assess the effects of drought on soil seed reserves, because conditions were never ideal for germination. However, some theoretical and research work done off the NTS suggests that drought should favor native species and species with prolonged seed-life.

Meidan (1990) in Israel modelled soil wetting and seed germination for the winter of 1983-4. He found that only 2 of 21 rainfall events would have resulted in germination of four native species. This poor germination with light rains is probably characteristic of desert species (Went and Westergaard 1949). Vidiella and Armesto (1989) found that introduced species ("cosmopolitan weeds") tended to germinate with less than 10 mm of rain while species native to the Chilean-Peruvian coastal desert required more than 40 mm. Here in the Mojave Desert Beatley reported at least 25 mm is needed (Beatley 1974). The germinating rainfall in 1991 which fell February 27-March 2 totaled 26 mm in Rock Valley, 14 mm in Frenchman Flat, and 23 mm in Yucca Flat. It was therefore a marginal germination event that in theory would have favored the introduced species. That it did not (Table 17) suggests that during the drought a higher percentage of introduced than native seeds died.

Drought appeared to favor a subset of native herbaceous plants with below-ground dormancy. These included the rhizomatous *Euphorbia albomarginata*, the biennial *Machaeranthera canescens*, and the bulbs *Allium nevadense*, *Androstephium breviflorum*, and *Dichelostemma pulchellum*. Two new species collected on the NTS in 1991 were also bulbs, *Muilla coronata* and an apparently undescribed *Muilla* species (Table 9). (In the absence of flowers both these would have been mistaken for *Allium nevadense*.) These species appeared to be favored by drought because they grew, or survived, on less rainfall than was required to germinate the dominant ephemeral species.

The worst year of drought on the NTS was 1989. Records are available for locations in Rock Valley from 1963 through 1976 and 1983 through 1991 (Table 10). Only in 1972 were ephemerals too sparse to measure by J. Beatley, who sampled a total of 5 m² (50 0.1-m² quadrats.) In that year other studies (Turner 1973) in Rock Valley reported 4 to 17 plants/m² in six vegetation zones. Yet in many of our study sites we found zero live annuals in 1000 m².

Species presence/absence data were similarly extreme in 1989. In 1988 126 species were seen on 25 sites (Hunter 1992), while in 1989 26 species were seen on 20 sites. The average number of species per site was 20.5 ± 1.6 (sem) in 1988 and 1.8 ± 0.6 in 1989. The average ($\pm$ sem) number of species in 1989 on areas where shrubs were removed by disturbance was 2.3 ± 0.5 . Excluding the high altitude Gold Meadows plot, which had 12 species, the 12 control and pristine plots averaged 0.5 ± 0.3 species. The difference in numbers of species between control and disturbed plots in 1989 was significant at $p = 0.01$ (one way analysis of variance).

Nitrogen

Numerous studies of atmospheric nitrogen pollutant levels are available, but comparatively little is known about what effects these pollutants exert on plants. It is clear that plants can directly take up atmospheric ammonia and NO₂ into their leaves (Porter et al. 1972; Hutchinson et al. 1972; Rogers and Aneja 1980), but it isn't known whether such uptake improves plant growth. Nitrogen compounds also settle out with particulates and wash down with precipitation (see, e.g., Wallace et al. 1978).

Nitrogen fertilizer (100 kg N/ha) on plots without added water in Mercury apparently favored *Bromus rubens*. After three years it increased on those plots from 48% to 78% of the population, and from 58% to 80% of the biomass (Table 18). On these fertilized plots, while total ephemeral biomass increased, native species in the third year produced 1.5 g/m² without added N and 1.2 g/m² with N, suggesting they were not nutrient limited. The introduced species, however, produced 2.9 g/m² without and 6.9 g/m² with the fertilizer in 1976 (Hunter, 1977, unpublished observations).

Table 18. Percent of density and biomass of winter ephemeral populations made up by *Bromus rubens*, as affected by 100 kg Nitrogen per ha. (Hunter, 1990.)

	<u>N added</u>	<u>percent <i>Bromus</i></u>		
		<u>1974</u>	<u>1975</u>	<u>1976</u>
Density	0	22	25	48
	100	-	47	78
Biomass	0	46	55	58
	100	-	51	80

Does nitrogen pollution by man therefore increase dominance of these cosmopolitan introduced species? This question cannot be answered at the present time. Hobbs and Atkins (1988) found in western Australia that nitrogen fertilization increased growth of both native and introduced species, but the introduced species were favored by disturbance. They were working in an apparently nutrient-limited ecosystem, instead of a water-limited one. Goldberg and Miller (1990), working in Michigan, found nitrogen addition led to an increased productivity and decreased diversity, as found on the NTS (above, and Hunter 1990). Some pieces to this puzzle are present, but experimental work to determine effects of nitrogen pollutants on Mojave Desert ephemerals has not been done.

Interactions with Shrubs

Ephemeral plants in the Mojave Desert grow in close association with shrubs. Muller (1953) attributed the appearance of certain species only beneath shrub canopies to the presence of a soil mound ("fertile island") beneath the shrub. Long-lived species like *Ambrosia dumosa* which produced mounds had these annual species, while short-lived shrub species without mounds had none. Muller attributed the difference to improved fertility and soil tilth due to decay of wind-deposited organic matter under the canopy.

Recently Mun and Whitford (1990) reported similar features for kangaroo rat mounds in the Chihuahuan Desert. Mounds had more annual plant biomass (173 ± 7 g/m² versus 98 ± 2 g/m²) than intermounds, and generally more nitrogen, and different species of annuals. Their results generally support Muller's interpretations on mound/shrub interactions. However, Halvorson and Patten (1975) noted a weak negative correlation between shrub density and ephemeral

biomass. Other work by Cunliffe et al. (1990) showed that even though density of annual plants increased near shrubs, their size was smaller. Their interpretation was that though the shrubs and annuals compete for resources, germination and establishment were greater in the vicinity of the shrubs.

On the NTS it is apparent that this latter effect is operative. With shrub seedlings it has been shown that growth on a disturbed area was greater than in a mature community, but seed germination was much greater among the shrubs (Hunter 1989). Seeds and plant litter tend to collect under shrubs, where wind speed is reduced. Also, in the shaded area soil dries more slowly, allowing longer times for seedling root growth. In a forest environment Conard and Radosevich (1982) showed the need for shade outweighed the effects of resource competition on seedling establishment.

These observations help to explain some of the results on ephemerals obtained by BECAMP. The absence of *Bromus rubens* on the shrub removal plot following three years of drought (Table 17) suggests that *Bromus* required shade for germination or perhaps for long-term seed survival, while the resurgence of native species in 1991 suggests they had no such needs. At least in the first three years following shrub removal the *Bromus* appeared to do better without shrubs. Similarly, the many species differences between disturbed and undisturbed areas (Appendix 1) might be explained by combinations of species requirements for shade to germinate, protection from high midday soil temperatures for seed survival, protection by shrubs from seed predation, nutrient and light levels needed for growth, and adaptations to deposit seeds in low-wind environments.

BECAMP data include the percent of an ephemeral quadrat that is shaded, as well as species composition, plant size, and reproductive status. Due to time limitations the shade data have not been analyzed, but the potential exists to examine these shrub-ephemeral interactions with multi-year analyses on several different sites in undisturbed habitats (ROV005, YUF001, MER001E).

Interactions with Animals

There are many potential animal-ephemeral interactions, only a few of which have been investigated. Beatley (1969) showed a correlation between presence of winter annuals and reproduction in heteromyid rodents, and postulated that the dietary water and vitamins provided by the ephemerals were necessary for reproduction. Nagy and Medica (1986) showed that desert tortoises eat a

considerable amount of ephemerals, but suggested the high potassium content is deleterious. Karl (1981), noting a negative correlation between *Bromus rubens* success and desert tortoise abundance, postulated the introduced species are nutritionally inferior. Ohmart (1980) showed that *Bromus rubens* and *Erodium cicutarium* made up a significant part of the diet of desert tortoises on the Beaver Dam slope in Utah.

Seed predation by rodents may be significant to the ecology of some ephemeral species. Brown (1990) showed the larger-seeded native annual plants in the Sonoran Desert increased markedly when kangaroo rats were excluded for five years. Bowers, examining data from IBP Desert Biome studies in Rock Valley, found a higher proportion of large-seeded species under shrubs (M. A. Bowers, personal communication). That might be related to rodent foraging patterns, and perhaps also to the need for larger seeds to establish in shaded habitats.

BECAMP studies show considerable differences in ephemeral populations on gopher-denuded areas (plots JAF003,004; MER002,003). The presence of *Euphorbia albomarginata* and *Amsinckia tessellata* on the gopher areas, but not the undisturbed sites, can probably be attributed to gopher removal of the shrubs. Similarly the presence of *Caulanthus lasiophyllus* on the undisturbed plot (MER003), but not the gopher area, probably reflects that species' habit of growing largely under shrubs.

Finally, the decline of lizard populations in 1989-1990 (Medica, this report) may reflect low insect populations resulting from the absence of ephemeral plants during those drought years.

Fire Frequency

In the northern Great Basin wildfire frequency has increased dramatically over historical times. The presence of introduced annual grasses, primarily *Bromus tectorum*, is blamed for this change. The increased fire frequency results in conversion of shrub-dominated ecosystems to "annual grasslands" (Whisenant 1990). This decreases species diversity (Whisenant 1990) and reduces the grazing value and wildlife utilization of the land (Pellant 1990). The reduction in wildlife is also considered a possible cause for decline of raptor populations (Pellant 1990; Woffinden and Murphy 1989).

In Arizona Schmid and Rogers (1988) blamed an increasing fire frequency partly on fuel provided by exotic annual plants.

On the NTS range fires are normally quickly controlled. Records of fire size and frequency have been maintained since 1978, but ephemeral plant records during that time are only available since 1987. This is too short a time to correlate fire frequency with ephemeral production.

With five years of monitoring data, added to a significant history of measurement of ephemeral populations on the NTS, it is becoming possible to determine significant trends and interactions. The one major trend, towards dominance of the ephemeral flora by introduced weeds, is affecting many other facets of the ecosystem. The knowledge developed about these effects should help determine management practices for NTS land.

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APPENDIX K

This appendix contains tabular results of quadrat sampling for ephemerals during 1989, 1990, and 1991. Results are presented as densities (n/m^2), biomasses (g/m^2), and mean plant size (mg) of harvested, dried specimens, usually from $0.025m^2$ quadrats. The sample area was usually $0.5m^2$ per plot (20 quadrats). Errors are standard errors of the mean. Totals for density and biomass are calculated as means for the 20 quadrat totals, rather than sums of the species' means, and may be slightly different from those sums.

Plots listed in text Table 1, but not included here, had no ephemerals in the sampled quadrats.

"Exclusion" plots were untreated replicates set up to be treated in the future with grass-specific herbicides.

Species which were too rare to fall in a quadrat, but were sampled in the 100 or 1000- m^2 areas at a site, are listed in the text in Table 7.

The order of results presented in this appendix is by altitude, from lowest to highest, then by date. More exact locations of the plots are given in Appendix 1 of the reptile section.

By landform, the results are found in the following tables:

Forty Mile Canyon	39
Frenchman Flat	2-6
Gold Meadow	41
Jackass Flats	1,20,21
Mercury Valley	14-19, 22-24
Mid Valley	37,38
Pahute Mesa	40,42-45
Rainier Mesa	46
Rock Valley	7-13
Yucca Flat	25-36

Table 1. Ephemeral population characteristics on plot JAF001, a baseline plot in Jackass Flats, measured on May 7, 1991. Elevation 954 m.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Chaenactis fremontii</i>	8±8	2.3±2.3	288
<i>Cryptantha micrantha</i>	16±5	1.5±1.3	63±45
<i>Cryptantha pterocarya</i>	2±2	0.9±0.9	449
<i>Streptanthella longirostris</i>	6±3	2.6±1.9	425±246
<i>Vulpia octoflora</i>	132±33	2.4±1.0	15±3
TOTALS	164±38	9.7±5.1	

Table 2. Ephemeral population characteristics on plot FRF001, next to Beatley Plot 23 in Frenchman Flat, measured on April 11, 1991. Elevation 965 m.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Bromus rubens</i>	2±2	0.02±0.02	12
<i>Cryptantha</i> sp.	4±4	0.009±0.009	22
<i>Descurainia pinnata</i>	6±6	0.03±0.03	5
<i>Eschscholzia glyptosperma</i>	2±2	0.007±0.007	4
<i>Monoptilon bellidiforme</i>	4±4	0.007±0.007	2
TOTALS	18±11	0.08±0.05	

Table 3. Ephemeral population characteristics on plot FRF001, SE exclusion plot in Frenchman Flat, measured on May 6, 1991. Elevation 965 m.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Malacothrix glabrata</i>	2±2	0.06±0.06	32
TOTALS	2±2	0.06±0.06	

Table 4. Ephemeral population characteristics on plot FRF001, W exclusion plot in Frenchman Flat, measured on May 6, 1991. Elevation 965 m.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Chaenactis fremontii</i>	2±2	0.7±0.7	344
<i>Cryptantha dumetorum</i>	2±2	0.17±0.17	85
<i>Monoptilon bellidiforme</i>	2±2	0.02±0.02	8
TOTALS	6±3	0.9±0.2	

Table 5. Ephemeral population characteristics on plot FRF003, a roadside in Frenchman Flat, measured on April 4, 1990. This plot was sampled with 30 1.0-m² quadrats.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Euphorbia albomarginata</i>	0.10±0.07	0.006±0.005	92±35
TOTALS	0.10±0.07	0.006±0.005	

Table 6. Ephemeral population characteristics on plot FRF002, an abandoned roadside control in Frenchman Flat, measured on April 17, 1991.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Chaenactis fremontii</i>	2±2	0.02±0.02	10
<i>Cryptantha nevadensis</i>	2±2	0.02±0.02	9
<i>Descurainia pinnata</i>	4±4	0.02±0.02	6
TOTALS	8±8	0.06±0.06	

Table 7. Ephemeral population characteristics on plot ROV005A, Beatley Plot 3 in Rock Valley, measured on March 28, 1990. A replicate of ROV005B. Elevation 1036 m.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Bromus rubens</i>	16±16	0.056±0.056	3.5
TOTALS	16±16	0.056±0.056	

Table 8. Ephemeral population characteristics on plot ROV005B, Beatley Plot 3 in Rock Valley, measured on March 28, 1990. A replicate of ROV005A. Elevation 1036 m.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Bromus rubens</i>	2±2	0.001±0.001	0.7
TOTALS	2±2	0.001±0.001	

Table 9. Ephemeral population characteristics on plot ROV005, Beatley Plot 3 in Rock Valley, measured on April 3, 1991. Elevation 1036 m.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Bromus rubens</i>	60±20	0.28±0.11	6±2
<i>Caulanthus lasiophyllus</i>	6±6	0.04±0.04	7
<i>Cryptantha</i> sp.	2±2	0.01±0.01	5
<i>Eriogonum trichopes</i>	4±3	0.02±0.02	6±4
<i>Pectocarya</i> sp.	2±2	0.01±0.01	5
<i>Vulpia octoflora</i>	30±13	0.17±0.08	6±3
TOTALS	106±31	0.54±0.20	

Table 10. Ephemeral population characteristics on plot ROV005, SE exclusion plot in Rock Valley, measured on May 1, 1991. Elevation 1036 m.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Bromus rubens</i>	88±29	1.4±0.6	12±2
<i>Caulanthus lasiophyllus</i>	4±3	0.10±0.08	24±13
<i>Chaenactis carphoclinia</i>	2±2	0.07±0.07	36
<i>Lepidium lasiocarpum</i>	2±2	0.04±0.04	18
<i>Pectocarya heterocarpa</i>	6±4	0.23±0.19	36±10
<i>Phacelia fremontii</i>	2±2	0.13±0.13	63
<i>Vulpia octoflora</i>	14±11	0.11±0.09	7±2
TOTALS	118±34	2.0±0.6	

Table 11. Ephemeral population characteristics on plot ROV005, NW exclusion plot, in Rock Valley, measured on May 1, 1991. Elevation 1036 m.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Bromus rubens</i>	104±29	2.6±1.2	19±3
<i>Caulanthus lasiophyllus</i>	8±5	0.7±0.6	72±44
<i>Cryptantha nevadensis</i>	6±6	0.05±0.05	76
<i>Descurainia pinnata</i>	2±2	0.01±0.01	5
<i>Eriogonum trichopes</i>	2±2	0.4±0.4	221
<i>Pectocarya heterocarpa</i>	18±8	1.0±0.4	59±11
<i>Pectocarya platycarpa</i>	10±10	0.06±0.06	6
<i>Phacelia vallis-mortae</i>	2±2	0.3±0.3	156
<i>Vulpia octoflora</i>	34±12	0.4±0.2	11±2
TOTALS	186±43	6.0±0.9	

Table 12. Ephemeral population characteristics on plot ROV006, Beatley Plot 3 in Rock Valley, measured on March 26, 1990. Elevation 1049 m.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Bromus rubens</i>	10±10	0.032±0.032	3.1
<i>Thysanocarpus laciniatus</i>	2±2	0.004±0.004	1.8
TOTALS	12±12	0.036±0.036	

Table 13. Ephemeral population characteristics on plot ROV006, Beatley Plot 4 in Rock Valley, measured on April 8, 1991. Elevation 1049 m.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Astragalus didymocarpus</i>	10±4	0.04±0.02	5±1
<i>Astragalus lentiginosus</i>	2±2	0.02±0.02	8
<i>Bromus rubens</i>	38±15	0.16±0.08	4±1
<i>Cryptantha micrantha</i>	20±12	0.03±0.02	2±1
<i>Eriastrum eremicum</i>	2±2	0.006±0.006	3
<i>Malacothrix glabrata</i>	20±12	0.17±0.13	6±2
TOTALS	92±27	0.44±0.16	

Table 14. Ephemeral population characteristics on plot MER002, a rodent-denuded area in Mercury Valley, measured on April 23, 1990. Elevation 1076 m.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Bromus rubens</i>	4±2	0.04±0.02	8 ± 1
<i>Dichelostemma pulchellum</i>	0.5±0.5	0.004±0.004	9
<i>Euphorbia albomarginata</i>	122±24	4±1	30 ± 4
TOTALS	127±24	4±1	

Table 15. Ephemeral population characteristics on plot MER002, a rodent denuded area in Mercury Valley, measured on April 8, 1991. Elevation 1076 m.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Amsinckia tessellata</i>	2±2	0.08±0.08	42
<i>Dichelostemma pulchellum</i>	4±3	0.06±0.05	14±12
<i>Bromus rubens</i>	52±18	0.32±0.13	6±0
<i>Chenopodium incanum</i>	2±2	0.008±0.008	4
<i>Euphorbia albomarginata</i>	24±14	0.10±0.05	6±2
<i>Gilia transmontana</i>	50±22	0.18±0.06	5±1
<i>Machaeranthera canescens</i>	10±4	0.04±0.02	4±0
<i>Phacelia fremontii</i>	2±2	0.02±0.02	9
<i>Vulpia octoflora</i>	2±2	0.006±0.006	3
TOTALS	148±33	0.82±0.19	

Table 16. Ephemeral population characteristics on plot MER002, NW exclusion plot in Mercury Valley, measured on May 2, 1991. Elevation 1076 m.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Amsinckia tessellata</i>	2±2	0.2±0.2	95
<i>Astragalus lentiginosus</i>	2±2	0.1±0.1	52
<i>Bromus rubens</i>	8±5	0.13±0.09	17±9
<i>Euphorbia albomarginata</i>	58±15	1.2±0.4	33±18
<i>Machaeranthera canescens</i>	4±4	0.05±0.05	13
<i>Muilla coronata</i>	2±2	0.03±0.03	15
<i>Vulpia octoflora</i>	2±2	0.14±0.14	72
TOTALS	78±18	1.9±0.5	

Table 17. Ephemeral population characteristics on plot MER002, SE exclusion plot in Mercury Valley, measured on May 2, 1991. Elevation 1076 m.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Amsinckia tessellata</i>	2±2	0.4±0.4	206
<i>Astragalus lentiginosus</i>	2±2	0.04±0.04	18
<i>Bromus rubens</i>	16±6	0.9±0.4	58±12
<i>Chaenactis stevioides</i>	2±2	0.2±0.2	100
<i>Chenopodium incanum</i>	2±2	0.03±0.03	15
<i>Chorizanthe brevicornu</i>	2±2	0.3±0.3	143
<i>Euphorbia albomarginata</i>	40±13	2.9±1.2	68±20
<i>Machaeranthera canescens</i>	4±3	0.14±0.10	35±1
Unknown	4±3	0.20±0.16	51±29
<i>Vulpia octoflora</i>	8±4	0.21±0.13	26±12
TOTALS	82±17	5.3±1.4	

Table 18. Ephemeral population characteristics on plot MER003, a control plot in Mercury Valley, measured on April 25, 1990. Elevation 1103 m.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Bromus rubens</i>	10±8	0.12±0.09	14±5
TOTALS	10±8	0.12±0.09	

Table 19. Ephemeral population characteristics on plot MER003, a control plot in west Mercury Valley, measured on April 9, 1991. Elevation 1103 m.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Dichelostemma pulchellum</i>	8±6	0.18±0.15	20±5
<i>Bromus rubens</i>	42±11	0.12±0.03	3±1
<i>Caulanthus lasiophyllus</i>	14±7	0.04±0.02	3±1
<i>Cryptantha nevadensis</i>	2±2	0.02±0.02	9
<i>Erodium cicutarium</i>	2±2	0.02±0.02	10
<i>Gilia transmontana</i>	4±4	0.02±0.02	6
<i>Machaeranthera canescens</i>	4±3	0.01±0.01	2±2
<i>Vulpia octoflora</i>	38±18	0.07±0.03	3±1
Unknown	2±2	0.002±0.002	1
TOTALS	116±27	0.49±0.17	

Table 20. Ephemeral population characteristics on plot 70 at Bren Tower in Jackass Flats, measured on April 29, 1991. Elevation 1143 m.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Bromus rubens</i>	17±12	0.4±0.3	21±5
<i>Caulanthus lasiophyllus</i>	2±2	0.09±0.09	52
<i>Chaenactis fremontii</i>	7±5	0.4±0.3	59±12
<i>Cryptantha micrantha</i>	5±4	0.04±0.03	6±2
<i>Descurainia pinnata</i>	2±2	0.03±0.03	18
<i>Erodium cicutarium</i>	2±2	0.07±0.07	44
<i>Camissonia pterosperma</i>	2±2	0.003±0.003	2
<i>Malacothrix glabrata</i>	2±2	0.04±0.04	26
<i>Phacelia fremontii</i>	3±3	0.22±0.22	66
<i>Schismus arabicus</i>	2±2	0.02±0.02	12
<i>Vulpia octoflora</i>	3±2	0.02±0.02	7±5
TOTALS	45±17	1.4±0.7	

Table 21. Ephemeral population characteristics on plot 73 at Bren Tower in Jackass Flats, measured on April 29, 1991. Elevation 1143 m.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Bromus rubens</i>	25±14	0.5±0.4	19±5
<i>Gilia transmontana</i>	2±2	0.05±0.05	22
<i>Phacelia fremontii</i>	2±2	0.02±0.02	9
TOTALS	29±16	0.59±0.40	

Table 22. Ephemeral population characteristics on plot MER001W, a Mercury Valley plot with shrubs removed, measured on April 5, 1990. The control plot, MER001E, had no ephemerals in 1990.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Bromus rubens</i>	2±2	0.006±0.006	4
<i>Eriogonum deflexum</i>	2±2	0.007±0.007	4
<i>Erodium cicutarium</i>	5±3	0.060±0.035	13±2
TOTALS	8±3	0.09±0.04	

Table 23. Ephemeral population characteristics on plot MER001W, a shrub removal plot in Mercury Valley, measured on April 4, 1991. Elevation 1161 m.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Chaenactis macrantha</i>	10±5	0.05±0.02	5.0±0.4
<i>Cryptantha</i> sp.	2±2	0.005±0.005	3
<i>Descurainia pinnata</i>	74±38	0.16±0.08	2.4±0.5
<i>Erodium cicutarium</i>	6±3	0.03±0.01	4.2±0.2
<i>Eriogonum deflexum</i>	35±11	0.10±0.03	2.8±0.3
<i>Erioneuron pulchellum</i>	2±2	0.006±0.006	4.0
<i>Ipomopsis polycladon</i>	5±4	0.008±0.006	1.8±0.2
<i>Vulpia octoflora</i>	134±48	0.19±0.06	1.9±0.4
TOTALS	269±76	0.54±0.13	

Table 24. Ephemeral population characteristics on plot MER001E, a control plot in Mercury Valley, measured on April 4, 1991. Elevation 1161 m.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Bromus rubens</i>	10±4	0.02±0.01	2.1±0.2
<i>Ipomopsis polycladon</i>	2±2	0.003±0.003	2
<i>Vulpia octoflora</i>	11±5	0.02±0.01	1.6±0.2
TOTALS	22±8	0.04±0.01	

Table 25. Ephemeral population characteristics on plot YUF013, on the east edge of T3 GZ, measured on April 24, 1991. Elevation 1236 m.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Bromus</i> spp.	12±8	0.4±0.2	32±7
<i>Cryptantha circumscissa</i>	120±33	1.3±0.4	10±1
<i>Cryptantha micrantha</i>	2±2	0.03±0.03	15
<i>Descurainia pinnata</i>	6±3	0.17±0.12	29±13
<i>Eriogonum deflexum</i>	142±35	1.9±0.4	19±4
<i>Mentzelia albicaulis</i>	52±46	1.3±1.1	22±3
<i>Salsola australis</i>	14±5	0.6±0.3	45±15
TOTALS	328±65	5.5±1.5	

Table 26. Ephemeral population characteristics on plot YUF001A, next to Beatley Plot 46 on a Yucca Flat baseline plot, measured on April 17, 1991. This and YUF001B are replicates.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Bromus</i> spp.	64±35	0.4±0.3	7±2
<i>Chaenactis stevioides</i>	2±2	0.004±0.004	2
<i>Cryptantha pterocarya</i>	2±2	0.01±0.01	6
<i>Descurainia pinnata</i>	4±3	0.004±0.3	10±4
<i>Eriogonum maculatum</i>	2±2	0.006±0.006	3
<i>Eriogonum nidularium</i>	2±2	0.006±0.006	3
<i>Eriophyllum pringlei</i>	2±2	0.004±0.004	2
TOTALS	78±35	0.51±0.26	

Table 27. Ephemeral population characteristics on plot YUF001B, a baseline plot in Yucca Flat, measured on April 17, 1991. This is a replicate of YUF001A. Elevation 1238 m.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Bromus</i> spp.	70±44	0.4±0.2	6±1
<i>Chaenactis fremontii</i>	4±3	0.05±0.04	12±6
TOTALS	74±44	0.4±0.2	

Table 28. Ephemeral population characteristics on plot YUF001, west exclusion plot in Yucca Flat, measured on May 6, 1991. Elevation 1238 m.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Bromus rubens</i>	42±17	1.3±0.5	33±8
<i>Chaenactis stevioides</i>	2±2	0.1±0.1	71
<i>Cryptantha recurvata</i>	2±2	0.2±0.2	81
<i>Descurainia pinnata</i>	2±2	0.05±0.05	23
TOTALS	48±18	1.6±0.7	

Table 29. Ephemeral population characteristics on plot YUF001, East exclusion plot in Yucca Flat, measured on May 6, 1991. Elevation 1238 m.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Astragalus lentiginosus</i>	6±4	0.05±0.04	9±1
<i>Bromus</i> sp.	8±5	0.14±0.09	16±3
<i>Chaenactis stevioides</i>	2±2	0.03±0.03	17
<i>Cryptantha recurvata</i>	4±3	0.44±0.31	111±25
<i>Phacelia fremontii</i>	4±3	0.25±0.18	63±7
<i>Vulpia octoflora</i>	6±6	0.14±0.14	23
TOTALS	30±13	1.1±0.5	

Table 30. Ephemeral population characteristics on plot YUF012, next to consolidation site 3B in Yucca Flat, measured on April 24, 1991. Elevation 1239 m.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Bromus</i> sp.	44±22	0.3±0.1	9±3
<i>Cryptantha gracilis</i>	20±13	0.14±0.09	7±0
<i>Cryptantha</i> sp.	8±8	0.01±0.01	13
<i>Eriogonum maculatum</i>	2±2	0.008±0.008	4
TOTALS	74±29	0.5±0.2	

Table 31. Ephemeral population characteristics on plot YUF011, 3B waste consolidation site in Yucca Flat, measured on April 24, 1991. Elevation 1242 m.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Bromus</i> spp.	2±2	0.0004±0.0004	2
<i>Chenopodium incanum</i>	2±2	0.006±0.006	3
<i>Eriogonum maculatum</i>	4±3	0.03±0.02	6±4
<i>Salsola australis</i>	96±77	0.4±0.3	5±1
TOTALS	108±77	0.5±0.3	

Table 32. Ephemeral population characteristics on plot YUF010, a control near T1 GZ in Yucca Flat, measured on April 22, 1991. Elevation 1267 m.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Astragalus lentiginosus</i>	4±3	0.03±0.02	7±5
<i>Bromus</i> spp.	32±20	0.4±0.2	13±3
<i>Cryptantha circumscissa</i>	2±2	0.02±0.02	10
TOTALS	38±20	0.4±0.2	

Table 33. Ephemeral population characteristics on plot YUF009, T1 blast area in Yucca Flat, measured on April 22, 1991. Elevation 1279 m.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Bromus</i> sp.	12±7	0.28±0.26	17±13
<i>Chaenactis stevioides</i>	8±5	0.34±0.26	17±14
<i>Chenopodium incanum</i>	2±2	0.004±0.004	2
<i>Cryptantha circumscissa</i>	2±2	0.02±0.02	12
<i>Eriogonum deflexum</i>	4±3	0.07±0.05	17±2
<i>Euphorbia albomarginata</i>	2±2	0.006±0.006	3
<i>Mentzelia albicaulis</i>	8±6	0.26±0.21	31±4
<i>Salsola australis</i>	2±2	0.06±0.06	31
TOTALS	40±11	1.1±0.4	

Table 34. Ephemeral population characteristics on plot YUF016, 305 m north of Sedan GZ, measured on April 18, 1991. Elevation 1318 m.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Bromus</i> spp.	42±30	0.3±0.2	15±6
<i>Eriogonum deflexum</i>	58±16	0.2±0.1	4±2
<i>Psathyrotes annua</i>	6±4	0.03±0.03	7±6
<i>Salsola australis</i>	892±469	20.7±17.4	7±2
TOTALS	998±481	21.2±17.4	

Table 35. Ephemeral population characteristics on plot YUF017, 914 m north of Sedan GZ in Yucca Flat, measured on April 30, 1991. Elevation 1327 m.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Amsinckia tessellata</i>	2±2	0.2±0.2	95
<i>Bromus</i> spp.	86±27	4.1±2.3	60±32
<i>Cryptantha nevadensis</i>	6±6	0.2±0.2	35
<i>Cryptantha pterocarya</i>	2±2	0.02±0.02	9
<i>Machaeranthera canescens</i>	4±3	0.01±0.01	9±7
<i>Mentzelia albicaulis</i>	6±4	0.8±0.8	138±122
TOTALS	110±30	5.4±2.4	

Table 36. Ephemeral population characteristics on plot YUF018, 1524 m north of Sedan GZ, measured on April 30, 1991. Elevation 1335 m.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Bromus</i> spp.	60±34	0.8±0.5	8±2
<i>Chaenactis stevioides</i>	8±5	0.11±0.08	18±12
<i>Cryptantha circumscissa</i>	2±2	0.03±0.03	13
<i>Cryptantha gracilis</i>	2±2	0.03±0.03	15
<i>Glyptopleura marginata</i>	2±2	0.02±0.02	5
<i>Eriophyllum pringlei</i>	2±2	0.02±0.02	12
<i>Lepidium lasiocarpum</i>	4±4	0.04±0.04	21
<i>Mentzelia albicaulis</i>	2±2	0.02±0.02	11
<i>Oxytheca perfoliata</i>	2±2	0.03±0.03	17
TOTALS	86±39	1.1±0.6	

Table 37. Ephemeral population characteristics on plot MID001c, an undisturbed plot adjacent to a burned area in Mid Valley, measured on May 13, 1991. Elevation 1448 m.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Dichelostemma pulchellum</i>	2±2	0.02±0.02	12
<i>Bromus rubens</i>	20±8	0.8±0.3	43±13
<i>Bromus</i> sp.	6±3	0.05±0.03	10±1
<i>Chaenactis stevioides</i>	2±2	0.09±0.09	45
<i>Chorizanthe thurberi</i>	6±4	0.06±0.05	13±9
<i>Chorizanthe watsonii</i>	2±2	0.04±0.04	21
<i>Cryptantha pterocarya</i>	4±3	0.14±0.10	36±0
<i>Descurainia pinnata</i>	2±2	0.006±0.006	3
<i>Eschscholzia minutiflora</i>	2±2	0.5±0.5	26
<i>Gilia transmontana</i>	8±6	0.10±0.08	12±8
<i>Linanthus dichotomus</i>	2±2	0.006±0.006	3
<i>Linanthus jonesii</i>	2±2	0.008±0.008	4
<i>Mentzelia albicaulis</i>	2±2	0.02±0.02	10
<i>Phacelia fremontii</i>	2±2	0.05±0.05	26
<i>Phacelia vallis-mortae</i>	2±2	1.7±1.7	866
<i>Phlox stansburyi</i>	18±8	2.5±1.4	120±35
<i>Salsola australis</i>	4±4	0.05±0.05	13
<i>Vulpia microstachys</i>	8±6	0.12±0.08	90±57
<i>Vulpia octoflora</i>	6±6	0.01±0.01	2
TOTALS	100±16	6.4±2.2	

Table 38. Ephemeral population characteristics on plot MID001b, a burned area in Mid Valley, measured on May 13, 1991. Elevation 1448 m.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Amsinckia tessellata</i>	2±2	0.01±0.01	6
<i>Dichelostemma pulchellum</i>	4±3	0.12±0.11	31±22
<i>Bromus rubens</i>	24±15	2.5±1.6	89±37
<i>Bromus</i> spp	10±6	0.5±0.3	45±17
<i>Camissonia kernensis</i>	2±2	0.03±0.03	16
<i>Chorizanthe thurberi</i>	8±6	0.3±0.3	27±17
<i>Cryptantha recurvata</i>	10±5	0.7±0.4	64±36
<i>Descurainia pinnata</i>	2±2	0.2±0.2	79
<i>Eriastrum eremicum</i>	4±3	0.20±0.14	50±13
<i>Gilia transmontana</i>	14±7	1.6±1.1	87±46
<i>Mentzelia albicaulis</i>	6±3	9.9±8.3	1651±1255
<i>Phacelia fremontii</i>	6±3	0.4±0.4	71±54
<i>Phlox stansburyi</i>	24±11	4.0±2.3	176±80
<i>Salsola australis</i>	28±10	1.8±0.8	74±31
TOTAL	142±29	14.7±3.3	

Table 39. Ephemeral population characteristics on plot FOR003, near the junction of Pahute Mesa Road and Stockade Wash Road, measured on April 30, 1990.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Bromus</i> sp.	5±2	0.29±0.13	66±28
<i>Mentzelia albicaulis</i>	2±2	0.05±0.05	34
<i>Phacelia bicolor</i>	1±1	0.20±0.05	199±123
Unknown	1±1	0.007±0.006	7±5
TOTALS	8±2	0.55±0.23	

Table 40. Ephemeral plants on drill pad U20ao, BECAMP plot PAM002, measured April 17, 1989. The control plot (PAM003) had none. Elevation 1911 m.

<u>Species</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Halogeton glomeratus</i>	3396±947	3.7±1.1	1.1±0.2
<i>Salsola australis</i>	44±13	0.18±0.06	4.5±0.9
Totals	3440±948	3.9±1.1	

Table 41. Ephemeral on plot GOL001 in Gold Meadows, sampled on May 3, 1989. Elevation 2060 m. measured on May 15, 1990. Elevation 2103 m.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Bromus tectorum</i>	370±119	3.0±0.8	14+3
<i>Crepis intermedia</i>	2±2	1.1±1.1	570
<i>Cryptantha circumscissa</i>	4±4	.007±.007	1.7
<i>Lappula occidentalis</i>	2±2	.2±.2	9.8
<i>Lomatium nevadense</i>	4±4	.36±.36	90
Unknown	2±2	.01±.01	0.25
TOTALS	386±119	4.68±1.32	

Table 42. Ephemerals population characteristics on plot OAM004, drill pad U19e on Pahute Mesa, measured on May 15, 1990. Elevation 2103 m.

<u>Species</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Bromus tectorum</i>	276±51	7.5±1.5	34±6
<i>Chenopodium leptophyllum</i>	2±2	0.02±0.02	10
<i>Eriogonum deflexum</i>	2±2	0.06±0.06	28
<i>Mentzelia albicaulis</i>	10±6	0.12±0.07	13±1
<i>Salsola australis</i>	904±242	13.9±2.5	29±5
Totals	1194±256	21.1±2.7	

Table 43. Ephemeral population characteristics on plot PAM005, an undisturbed plot on Pahute Mesa, measures on May 15, 1990. Elevation 2103 m.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Astragalus calycosus</i>	4±3	0.04±0.03	11±4
<i>Gilia cana</i>	2±2	0.007±0.007	4
<i>Mentzelia albicaulis</i>	2±2	0.006±0.006	3
<i>Phlox stansburyi</i>	4±3	0.78±0.15	196±121
TOTALS	12±4	0.84±0.64	

Table 44. Ephemeral population characteristics on plot PAM006, drill pad U19ac on Pahute Mesa, measured on June 10, 1991. Elevation 2134 m.m.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Eriogonum deflexum</i>	6±4	0.02±0.02	3±1
<i>Eriogonum maculatum</i>	50±38	0.28±0.22	5±1
<i>Salsola australis</i>	2562±694	16.1±3.9	7±0
TOTALS	2618±703	16.4±3.9	

Table 45. Ephemeral population characteristics on plot PAM007, a control plot near U19 ac drill pad, measured on June 10, 1991. Elevation 2134 m.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Androstephium breviflorum</i>	2±2	0.02±0.02	20±18
<i>Astragalus calycosus</i>	4±1	0.05±0.02	15±3
<i>Delphinium andersonii</i>	1±1	0.02±0.02	23±12
<i>Gilia transmontana</i>	1±1	0.002±0.002	4
<i>Hymenoxys cooperi</i>	1±1	0.001±0.001	2
<i>Penstemon sp.</i>	1±1	0.12±0.09	122±41
<i>Phlox stansburyi</i>	2±2	0.17±0.15	17±5
TOTALS	11±2	0.4±0.2	

Table 46. Ephemeral population characteristics on plot RAM001, a baseline plot on Rainier Mesa, measured on July 2, 1991. Elevation 2282 m.

<u>SPECIES</u>	<u>n/m²</u>	<u>g/m²</u>	<u>mg/plant</u>
<i>Chenopodium fremontii</i>	1±1	0.09±0.09	171
<i>Gayophytum decipiens</i>	1±1	0.003±0.003	3±0
<i>Ipomopsis congesta</i>	1±1	0.007±0.007	7±5
<i>Lupinus brevicaulis</i>	1±1	0.012±0.012	12
TOTALS	3±2	0.023±0.015	

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