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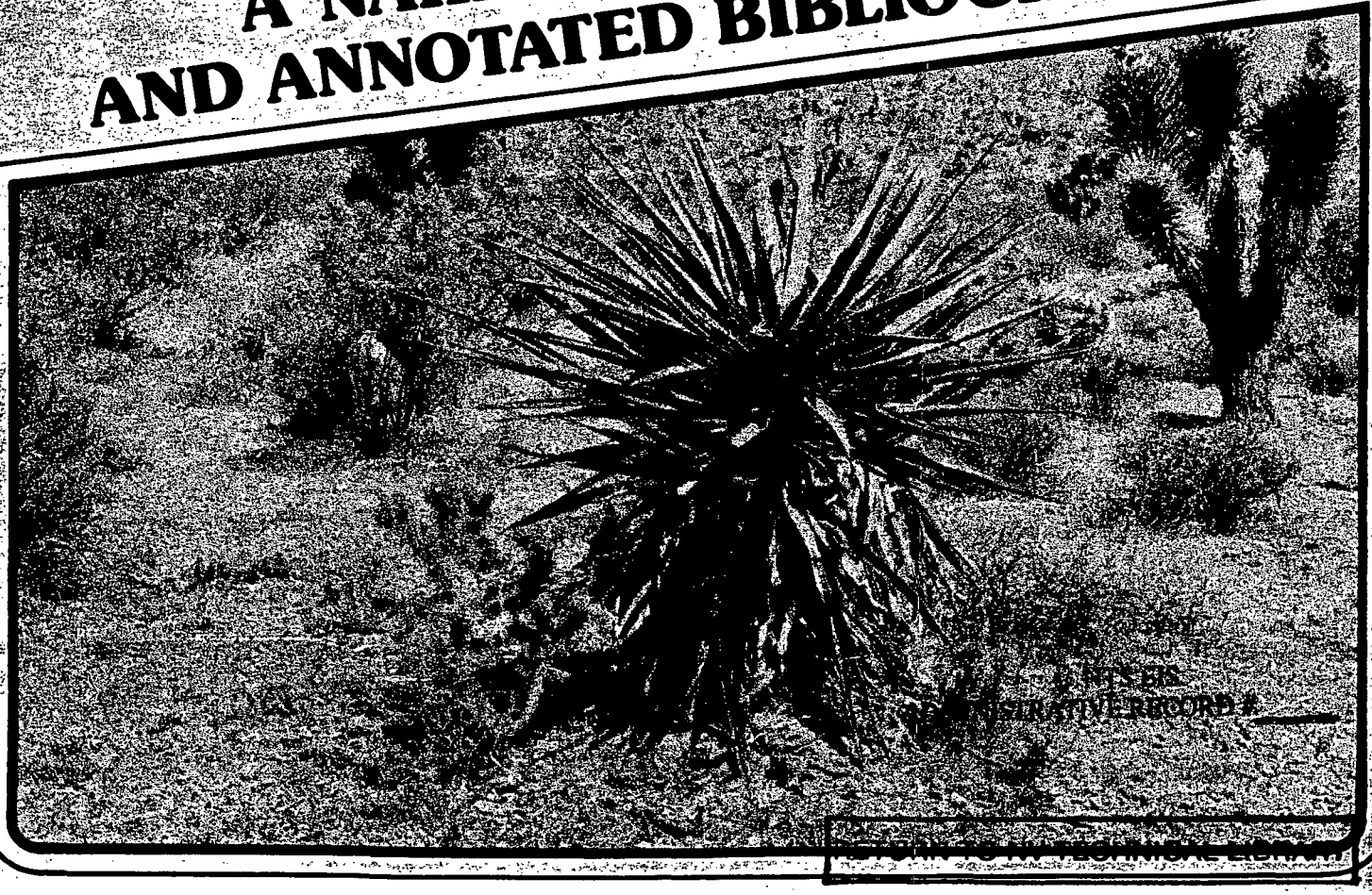

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NVO-167 Environmental and Earth Science

ECOLOGY OF THE NEVADA TEST SITE: A NARRATIVE SUMMARY AND ANNOTATED BIBLIOGRAPHY

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May, 1976

Prepared for the U. S. Energy Research and Development Administrati
Nevada Operations Office, under Contract AT(29-2)-1253, Modificatio

ABSTRACT

This document contains a summary of the ecology of the Nevada Test Site developed through existing scientific publications. It includes an annotated bibliography of 333 citations pertaining to ecological research conducted on NTS, a list of ERDA/NSF Desert Biome Research Memoranda, lists of Nevada Test Site flora and fauna, a list of citations concerning the fate and effects of nuclear and non-nuclear disturbances on the environment, and a compilation of references used to develop the document.

The U. S. Energy Research and Development Administration's Nevada Test Site (NTS) occupies 1,350 square miles (350,000 hectares) of desert terrain 70 miles (113 km) northwest of Las Vegas, Nevada. It is geologically complex and has deposits of igneous, sedimentary, and metamorphic rocks spilling downslope from mountains and hills into several large basins. Except for a few small springs, there is no permanent surface water. The climate exhibits extremes in temperature, precipitation, and wind velocity, as well as great variability in these parameters. At Yucca Flat temperature extremes are between 110°F and -14°F (43°C to -26°C). Average annual precipitation ranges from 4 to 12 inches (102 to 305 mm), increasing with increasing elevation, and is highly variable between sites and from year to year. Most soils have developed on alluvial deposits of mixed origins and characteristically have: coarse texture; an accumulation of carbonates within a few feet of the surface; low organic matter content; and low carbon/nitrogen ratios. Moisture reserves of the soil profiles seldom exceed field moisture capacity except during the period of winter precipitation. The site lies on the transition between the Mohave and Great Basin deserts; consequently, the flora and fauna consist of species characteristic of both deserts. A total of 711 taxa of vascular plants have been collected in the 6 to 7 major vegetation types. Distributions of the Mohave Desert, Great Basin Desert, and transitional vegetation associations are closely linked to temperature extremes, precipitation, and soil conditions. At least 1,028 taxa of invertebrates within the Phylum Arthropoda have been identified:

80% of the known arthropods are insects. Ants, termites, and ground-dwelling beetles are probably the most important groups of insects as regards distribution, abundance, and functional roles. Goldfish and golden shiners have been introduced on NTS. The reptilian fauna includes 1 species of tortoise, 14 species of lizards, and 17 species of snakes. The most abundant, widely distributed lizards include the side-blotched lizard, western whiptail, desert horned toad, and desert spiny lizard. Reproduction in side-blotched lizards is correlated with winter rainfall (and winter annual production). The western shovel-nosed snake is the most common snake on NTS, and there are at least four species of poisonous snake. There are records of 190 species of birds observed on the Nevada Test Site, 86% of which are transients. Only 27 species are permanent residents. A total of 42 terrestrial mammals and 4 species of bats have been recorded. Rodents account for half of the known species and are the most abundant and widespread group of mammals on NTS. There is an apparent correlation between production by winter annual plants and reproduction in desert rodents on NTS. Larger mammals on the site include: black-tailed jackrabbit, desert and Nuttall's cottontails, coyote, kit fox, badger, bobcat, and mountain lion. A herd of mule deer is located on the high mesas and surrounding bajadas. Wild horses and domestic cattle range over parts of the Nevada Test Site, and pronghorn antelope, bighorn sheep, and burros are thought to be rare visitors. None of the species of flora and fauna is presently listed in the *Federal Register* as being either threatened or endangered.

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INTRODUCTION

The U. S. Atomic Energy Commission, now the Energy Research and Development Administration, has sponsored ecological and life science research on the Nevada Test Site for over 20 years. Many of the programs represented pioneering efforts to determine the fate and effects of radiation in the environment following both surface and underground nuclear detonations. Since studies required comparisons between disturbed and control sites, a wealth of information was needed on the basic structure and function of the desert ecosystem. Prior to establishment of NTS there were no major scientific investigations in the immediate area, and little was known, even in descriptive terms, about the indigenous flora and fauna. Over the years an important task of investigators has been to gather baseline information on the ecology of NTS. Much significant information has been gathered and this has led the way to formulation of new ecological research objectives that are being pursued today.

Since passage of the National Environmental Policy Act of 1969 there has been a chronic need for a descriptive summary of the ecology of the Nevada Test Site that would meet the needs of management personnel preparing Environmental Impact Statements for proposed as well as continuing on-site operations. However, the important documentation for these management documents has been written by numerous authors over an extended period of time, and is scattered through a matrix of reports and journal articles, and lacks a focal point for collection and integration of the material.

The purpose of this report was to provide the necessary document by meeting the following specific objectives:

- Gather together all relevant literature concerning the ecology of the Nevada Test Site.
- Synthesize the essential elements necessary for understanding and describing the key biotic/abiotic interactions.
- Prepare a referenced narrative summary using only existing, readily available literature.
- Collate the narrative and bibliography with sufficient supportive information so that ERDA personnel can readily extract the necessary documentation to meet specific management goals.

Preparation of the narrative summary required establishment of certain guidelines to narrow the scope to meet the objectives. Since one of the specific goals was to summarize the basic ecology of NTS, information on the effects of ionizing radiation or the transport and uptake of radionuclides was not included in the summary. We felt that the synthesis of radiological information was too important to be treated as an adjunct to the ecological summary, and that it should be carefully reviewed and documented separately, as it usually is in Environmental Impact Statements. The appropriate citations to radioecological publications are gathered in the annotated bibliography, and a subject index is included to assist the reader in finding them.

We also limited our scope to exclude most of the information related to humans, domesticated livestock, and agricultural crops. These are more appropriately reviewed by contractors, such as the Environmental Protection Agency, who have the task of monitoring and investigating pollutant pathways involving human food chains.

Finally, we tried to include only those sources of information that are readily available to most readers. We established an arbitrary ranking system of decreasing availability based on our experiences,

and always sought to use the document with the highest ranking: 1) scientific journal articles and books, available in all large libraries and also as reprints from authors; 2) internal topical reports, with limited distribution of hard copies, often requiring special referencing information (especially document numbers that are not necessarily cross-referenced or interrelated) to assist librarian in obtaining copies; 3) prepublication series, very restricted distribution, rapidly outdated by final publications, leading to greatest number of referencing problems involving duplication of citations and information; 4) annual reports, limited distribution of preliminary material, but often containing essential background information on projects not subsequently documented in another format.

It was not our intent to prepare a critique or make value judgments concerning the validity or appropriateness of published information. Therefore, we refrained from making any judgments concerning the conclusions or findings presented by the authors. This was especially true in cases of divergent opinions, where we tried to present references to both views.

The narrative summary includes some reference information on the location, geology, hydrology, climatology, and soils of the Nevada Test Site. It was not intended that these chapters be definitive. Rather, they are necessary to give the reader sufficient baselines concerning abiotic elements so that a better understanding of the biotic associations can be drawn. This information has been summarized and synthesized by a number of specialists, and appropriate references are listed to suggest sources for more adequate descriptions.

Each section of the narration is prepared so that users can rapidly extract material to meet their needs for integrating the information into another document, say an Environmental Impact Statement. Paragraphs are written to include both generalized statements and specific

details. The user searching for general statements can easily eliminate the detail without losing the flow of the overall narration, while those requiring certain specific data should be able to find them. Negative information is only included in cases where we thought that the reader should know that certain programs were attempted. If a paragraph were written using material from one source the reference is cited only once. When specific additional material came from another author the citation immediately follows the appropriate phrase or sentence.

Scientific names are included for all plants and animals following the most recent taxonomic conventions. Except for important vertebrates, common names were used sparingly to avoid confusing the reader with colloquial names that are not necessarily accepted or even unique.

The narrative summary is followed by an annotated bibliography. The latter contains numbered citations to all the articles, reports, and documents gathered for the ecological narrative, whether they were used as references for the narration or not. A number of documents that were not specifically written for the AEC or about the Nevada Test Site were used to gain perspective for writing the narrative summary. A few of the most useful articles are also cited to assist the reader.

Citations are listed in alphabetical order by senior author, with a further breakdown according to the number and alphabetical ordering of the coauthors, and then by ascending chronological order within the multiple authorships. With few exceptions, the titles and pagination were checked against the original documents, not references, to minimize perpetuating errors. Volume numbers are followed by issue numbers only in the cases of journals that do not use consecutive pagination within a volume.

References to documents contain the document numbers necessary for obtaining copies, followed by the name and address of the appropriate institution where a copy might be obtained. We realize that all

documents may be otained from the National Technical Information Service, and that AEC-ERDA reports are now available through the Technical Information Center in Oak Ridge, Tennessee. However, in certain cases we found that some institutions or agencies could provide original hard copies of documents in a timely way, and their addresses are presented as an alternative source. The abstracts were drawn from a number of sources including the authors, abstracting services, and many were written by ourselves. When they are known, initials of the abstractors follow their work.

The Bibliography is followed by appendices containing supportive information that should provide the reader with useful additional specific facts or sources. Appendix 1 includes a description of the ERDA involvement in the National Science Foundation's International Biological Program (IBP), and a list of research memoranda written during projects conducted on the Nevada Test Site which represent part of the ERDA contribution to the Desert Biome portion of the IBP.

Appendix 2 contains indexes to citations within the Bibliography that contain information concerning: effects of radiation on biota of the Nevada Test Site; deposition, biological availability, and fate of radionuclides within native flora and fauna; and effects of non-nuclear disturbances on the ecology of NTS. It is followed by a listing of all source material used to prepare this document so that future amendments can be initiated from our completion benchmarks.

The final two appendices contain species lists of all the flora and fauna known to have been collected on the Nevada Test Site as well as depositories for reference collections. They are drawn only from published sources at the time of this writing, and have not been corrected or altered to reflect possible changes in nomenclature.

Preparation of the annotated bibliography was a much greater task than we had anticipated. Initially, there was no one source that listed the titles of publications concerning the Nevada Test Site.

Except for a few very helpful bibliographies, we found that the information was diffused through several journals, numerous internal reports, abstracts, and information retrieval systems.

The Nevada Operations Office of ERDA does not have a *complete* listing of titles, much less copies, of documents originating from environmental studies on NTS. Sponsorship and funds for these studies are provided through at least three other Operations Offices. It appears that authors have cleared and published several documents without necessarily involving or informing the "resident" Operations Office (i.e., Nevada), which has the primary ERDA field interest in the results of the studies.

A management procedure should be set up within ERDA to insure that NVOO, whether it is the funding Operations Office or not, is informed through its Bioenvironmental Division of all pending as well as published documents concerning the ecology of the Nevada Test Site. Arrangements should also be made to gather copies of the ERDA-sponsored environmental publications. To assist in meeting this objective, we have gathered reprints of most citations listed in the annotated bibliography of this document, and bound copies of the collected material will be deposited in the Special Collections Department of the University of Nevada, Las Vegas, Library.

ACKNOWLEDGEMENTS

We are indebted to a number of individuals, agencies, and institutions for making possible the acquisition of Nevada Test Site ecological research literature.

The following present and past Nevada Test Site investigators graciously supplied information on publications, including several that had eluded us because they were either very old or very recent; provided reprints of many articles for the bound volumes; and in some cases wrote to encourage our efforts: D. M. Allred, Brigham Young University; J. C. Beatley, University of Cincinnati; A. C. Cole, Jr., University of Tennessee; N. R. French, Colorado State University; C. D. Jorgensen, Brigham Young University; J. J. Koranda, Lawrence Livermore Laboratory; R. G. Lindberg, University of California, Los Angeles; W. E. Martin, Battelle, Columbus Laboratories; R. K. Mullen, Mission Research Corporation; W. A. Rhoads, EG&G; E. M. Romney, University of California, Los Angeles; V. M. Tanner, Brigham Young University; W. W. Tanner, Brigham Young University; F. B. Turner, University of California, Los Angeles; A. Wallace, University of California, Los Angeles.

E. D. Campbell and R. A. Brechbill, Life Sciences Branch, Nevada Operations Office, U. S. Energy Research and Development Administration, provided more than contract administration of this project. Both freely offered their sources of information, gained through years of work on NTS, to help us become oriented quickly so that we could concentrate on writing a more complete document. We also appreciate the many constructive criticisms offered by reviewers consulted by Mr. Campbell in the process of clearing this document.

Our special thanks to the University of Nevada Library System: At the University's Las Vegas Library, Robert Anderl, Assistant Director, Technical Services, and Susan Anderl, Special Collections Librarian, shepherded the entire research project through to completion. Maurica Osborne, Librarian, and Patricia Tissier, Senior Library Assistant, of the Life

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In addition we wish to thank Doreen Wickman, Librarian of the Environmental Monitoring and Support Laboratory, Environmental Protection Agency, Las Vegas, who functioned as a superb "detective" in our behalf, ferreting out documents no longer available through ordinary channels. Dorothy Nowack, Elaine Bickerstaff, and Kathy MacFarlane of the Energy Research and Development Agency (ERDA) Library in Las Vegas, afforded valuable assistance in locating government documents.

Other institutions and agencies assisting in search efforts were: Ecological Sciences Information Center, Oak Ridge National Laboratory; United States Geological Survey (USGS) Library, Denver; USGS Core Library, Mercury, Nevada; Report Library, Los Alamos Scientific Laboratory; Library of the Laboratory of Nuclear Medicine and Radiation Biology, University of California, Los Angeles; Chicago Operations Office, ERDA; and the Department of Wildlife and Fisheries Sciences, Texas A&M University.

Except where noted, all photographs were taken for the U. S. Energy Research and Development Administration, Nevada Operations Office, by Reynolds Electrical and Engineering Co., Pan American Airlines, and Lawrence Livermore Laboratory.

Finally we wish to thank Joan T. O'Farrell and Michael C. Worthington of Boulder City who assisted during preparation of several important portions of the manuscript.

Narrative Summary

ECOLOGY OF THE NEVADA TEST SITE: NARRATIVE SUMMARY

LOCATION

The U. S. Energy Research and Development Administration's Nevada Test Site (NTS) occupies 1,350 square miles (350,000 hectares) of arid, basin and range terrain in south-central Nevada (Fig. 1). The site was established to permit the safe testing of nuclear devices, both underground and in the atmosphere. Las Vegas, 70 miles (113 km) southeast, is the closest large community and has approximately 237,000 inhabitants. Exclusive of this metropolitan area, there are only about 20,000 residents within a 100-mile (160-kilometer) radius of NTS.[30] The site is further buffered on all but the south side by an additional 5,700 square miles (1,500,000 hectares) that were removed from public domain for the Nellis Air Force Range and the U. S. Fish and Wildlife Service Desert National Wildlife Range.

The site consists of basically three large valleys, Yucca, Frenchman, and Jackass flats, that are bordered by mountains, ridges, and hills of variable, but relatively rugged relief (Figs. 2 and 3). Yucca and Frenchman flats are closed basins with no outlets for surface runoff or gravitational flow of air at night. Each contains a large playa or dry lake bed (Figs. 4 and 5). Jackass Flats, and its associated Forty-Mile Canyon drainage (Fig. 6), has an outlet to the southwest at 2,688 ft (819 m), the lowest elevation on NTS. The smaller basins, Mercury Valley, Rock Valley, Mid Valley, and Topopah Valley, which are subunits of major drainages, are also "open."

The northern and northwestern portions of the test site are dominated by two high mesas, Rainier and Pahute, and the smaller Buckboard Mesa. The highest point within the test site, 7,679 ft (2,341 m) in elevation, is on Rainier Mesa (Fig. 7).

Figure 1. Location of the Nevada Test Site in relation to population centers of neighboring western states and the Nellis Air Force Bombing and Gunnery Range.

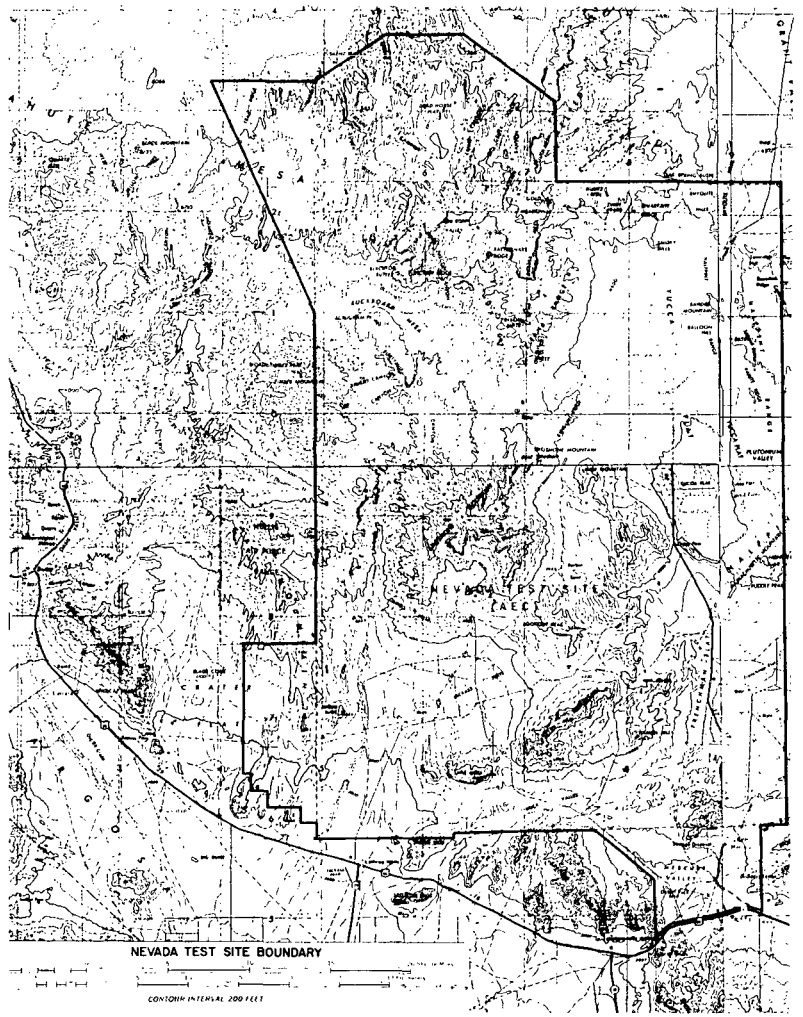


Figure 2. Major topographic features of the Nevada Test Site.

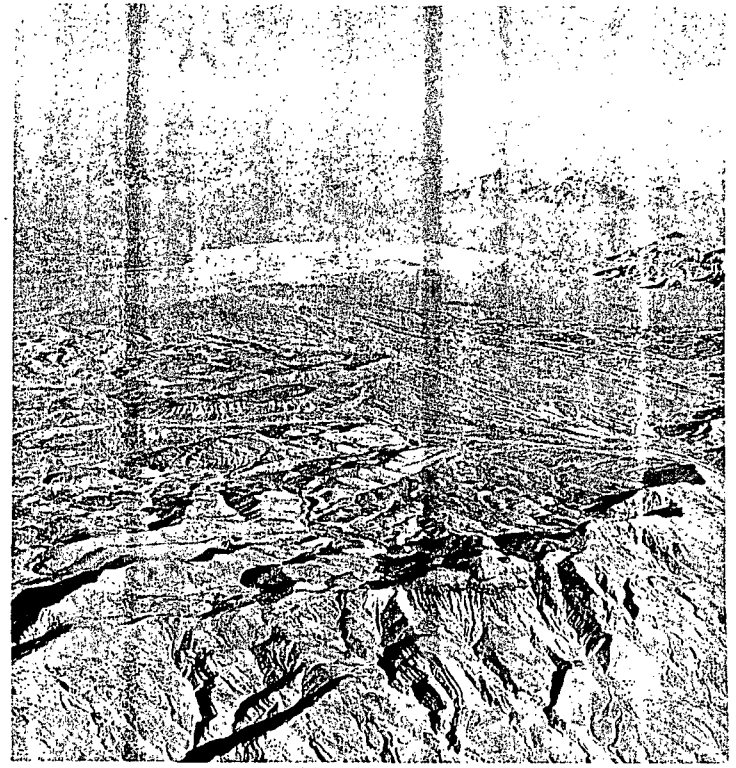


Figure 3. Aerial view of Frenchman Flat showing the surrounding mountainous terrain, alluvial deposits forming bajadas, and a playa at the lowest elevation.

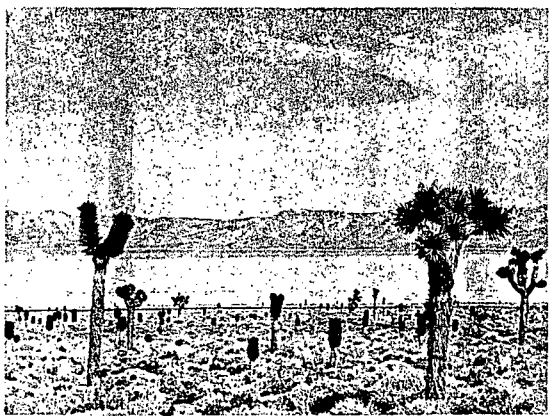


Figure 4. Yucca Flat is dominated by a large playa surrounded by rugged mountains and transitional vegetation types such as this blackbrush, *Coleogyne ramosissima*, association which has an overstory of Joshua trees, *Yucca brevifolia*.

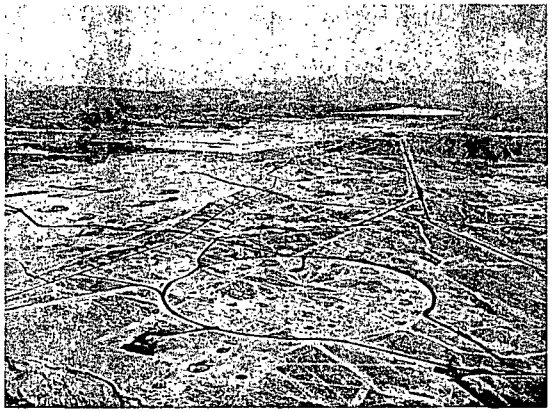


Figure 5. Subsidence craters formed during test shots dot the alluvial plain in Yucca Flat. Yucca Lake playa and the Spring Mountains are shown in the background.

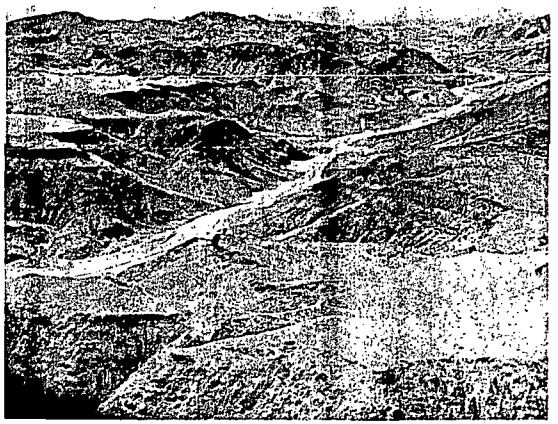


Figure 6. Forty-mile Canyon drains much of the northern and western portions of the Nevada Test Site through Jackass Flats, which is an open basin.

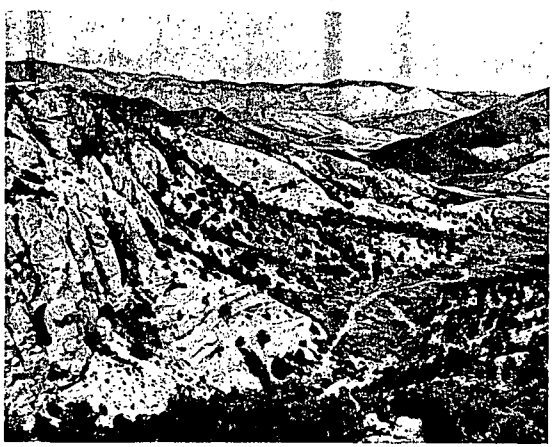


Figure 7. The highest point on the Nevada Test Site, 7,629 ft (2,341 m), is on Rainier Mesa which has vegetation types characteristic of the Great Basin Desert.

GEOLOGY

The geology of the test site is structurally complex due to intense crustal deformation, significant fold, two thrust fault systems, and abundant normal faults (Fig. 8).[67,90,130]

At least 17 Paleozoic formations and one of Tertiary age have been recognized. The former consist primarily of limestone, dolomite, quartzite, shale, and conglomerates, with a composite section approximately 40,000 feet (12,200 m) thick. About 30% of the outcrops on the site are sedimentary in origin. The remainder are predominantly volcanics of Tertiary age.[67,90,130]

During the Mesozoic Era there was uplift and folding, and thrust faulting of the region followed by volcanic deposition during the Tertiary. The central and western portions of the test site had numerous volcanic centers, of which five gave rise to calderas. The principal volcanic rocks are ash-flow tuffs of rhyolitic and quartz-latitic composition. These Tertiary formations have a composite section more than 30,000 feet (9,100 m) thick and represent the most widespread formation on NTS.[90,130]

Quarternary deposits are mainly mixtures of detrital material derived from bedrock areas and a fill of caliche, siltstone, and fanglomerates. They spill downslope from the mountains and hills into the basins as extensive bajadas (coalescent alluvial fans merging with the valley floor), leading often to a playa. Quarternary sediments in valleys are between 800 to 1,500 feet (244 to 457 m) thick, but in Yucca Flat they exceed 3,800 feet (1,158 m) in depth. The playas themselves consist almost entirely of impermeable fine silt and clay. These alluvium-filled basins occupy about 30% of the land area.[130]

HYDROLOGY

Groundwater is found at 300 to 500 feet (91 to 152 m) beneath the valleys of the southern part of the test site, and up to 2,000 feet (610 m) beneath the northern highlands. Movement of groundwater is

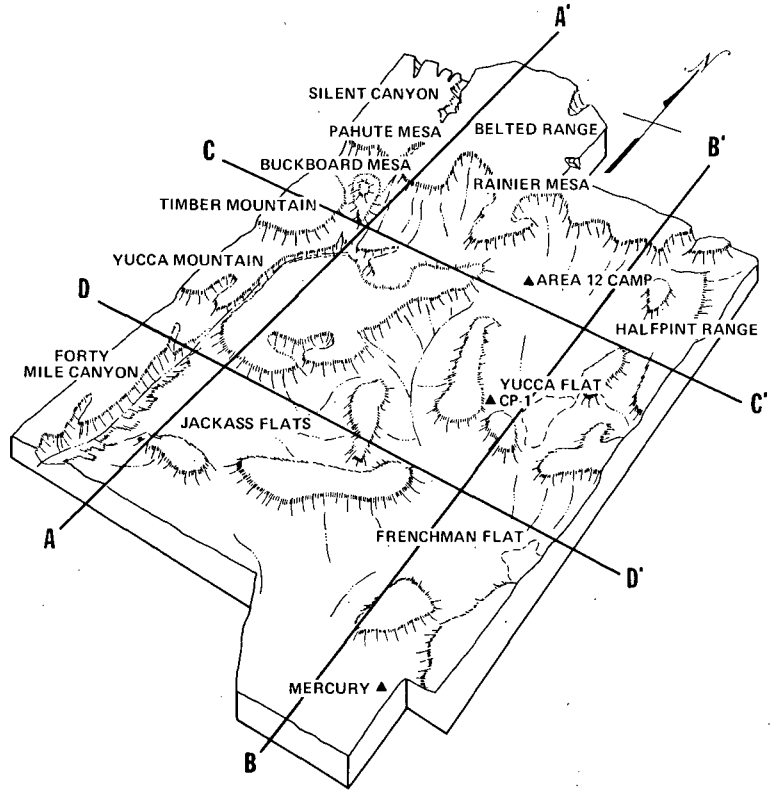
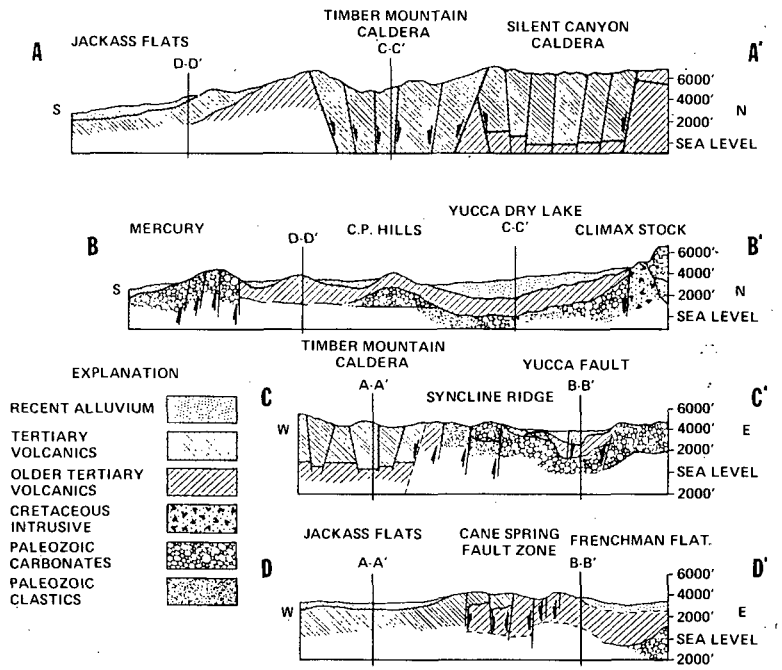


Figure 8. Major geologic features of the Nevada Test Site (Drawn from material in reference 90).



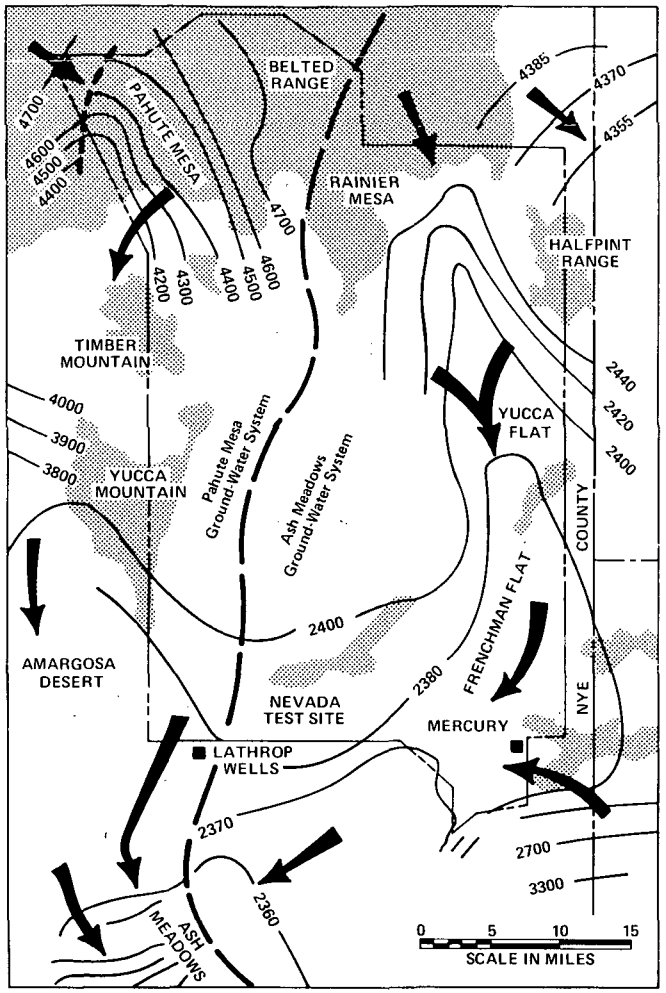


Figure 9. Altitude and direction of movement of ground water beneath and near the Nevada Test Site. Stippled areas indicate mountains, mesas, and hills (Drawn from material in reference 255).

from north to south in two major systems (Fig. 9). The Ash Meadows Groundwater System moves beneath the eastern two-thirds of the test site, collecting seepage water from Yucca and Frenchman Flats before discharging in the southeastern Amargosa Desert. The Pahute Mesa System receives water from the fractured volcanic rocks of Pahute Mesa and Timber Mountain as it flows south to southwest into the Amargosa Desert.[90,255]

Permanent surface water is limited to a few small springs. Following heavy precipitation some drainages carry intermittent streams. These often discharge into the playas where temporary lakes up to a few feet deep can form for a few days to a few months.

CLIMATE

The climate of the Nevada Test Site is characteristic of high deserts having rugged terrain. It experiences extremes in temperature, precipitation, and wind velocity, as well as great variability in these parameters from year to year, and between sites within years.[214] For simplification, the climatological summary for Yucca Flat has been used to provide a general description of the major features of the climate of NTS (Table 1). The summary is representative of the climate at the edge of a normally dry lake bed, and major climatic differences would be expected over short distances from the station due to the importance of orographic influences.

Temperatures fluctuate widely under conditions of predominantly clear skies and low relative humidities. Skies are clear (daytime average 0 to 3/10) an average of 50% of the days, and cloudy (more than 3/10) an average of 78 days. At Yucca Flat the average annual daily minimum is 37.4°F (3°C), and the average annual daily maximum is 72.5°F (22°C). Recorded extremes are 110°F (43°C) and -14°F (-26°C). Temperatures in excess of 100°F (38°C) can be expected between June and September, while temperatures at or near freezing have been recorded in all months except July and August.[214]

Table 1.

10-YEAR CLIMATOLOGICAL SUMMARY (1962-1971)

YUCCA FLAT, NEVADA – NEVADA TEST SITE

LATITUDE 36° 57' N
LONGITUDE 116° 03' W
ELEVATION 3,924 Feet 1196 m

NEVADA COORDINATE SYSTEM (Central)
E680,875
N803,600

	TEMPERATURE (°F) AVERAGES: DAILY MAXIMUM	DAILY MINIMUM	MONTHLY	EXTREMES: HIGHEST	YEAR	LOWEST	YEAR	DEGREE DAYS (Base 65°): HEATING	COOLING	PRECIPITATION (Inches): AVERAGE	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR	GREATEST DAILY	YEAR	SNOW: AVERAGE	GREATEST MONTHLY	YEAR	GREATEST DAILY	YEAR
A	52.1	20.8	36.5	73	1971	-2	1970	877	0	53	4.02	1969	T	1971*	1.25	1969	0.9	4.3	1962	4.3	1962
B	56.7	25.8	41.3	77	1963	5	1971*	662	0	84	3.55	1969	T	1967*	1.16	1969	1.9	17.4	1969	6.2	1969
R	60.9	27.7	44.3	87	1966	9	1962	634	0	29	.60	1969	0.2	1966	.38	1969	2.0	7.5	1969	4.5	1969
R	67.8	34.4	51.1	89	1962	13	1966	411	1	.45	2.57	1965	T	1962	1.08	1965	0.7	3.0	1964	3.0	1964
Y	78.9	43.5	61.2	97	1967	25	1967	147	38	.24	1.62	1971	T	1970*	.86	1971	0	T	1964	T	1964
N	87.6	49.9	68.8	107	1970	29	1971*	35	154	.21	1.13	1969	T	1971	.45	1969	0	0		0	
L	96.1	57.0	76.6	107	1967	40	1964*	0	366	.52	1.34	1966	0	1963	.77	1969	0	0		0	
G	95.0	58.1	76.6	107	1970	39	1968	1	368	.34	1.04	1965	0	1962	.35	1971*	0	0		0	
P	86.4	46.7	66.5	105	1971	25	1971	51	103	.68	2.38	1969	0	1968*	2.13	1969	0	0		0	
T	76.1	36.9	56.5	94	1964*	12	1971	266	9	.13	.45	1969	0	1967*	.42	1969	0	T	1971	T	1971
Y	61.8	27.6	44.7	82	1962	13	1966	602	0	.71	3.02	1965	0	1962	1.10	1970	0.5	4.8	1964	2.3	1964
C	50.7	19.9	35.3	70	1964	-14	1967	914	0	.79	2.66	1965	T	1969*	1.31	1965	2.3	9.9	1971	7.4	1971
Y	72.5	37.4	54.9	107	AUG 1970*	-14	DEC 1967	4600	1039	5.73	4.02	JAN 1969	0	SEP 1968*	2.13	SEP 1965	8.3	17.4	FEB 1969	7.4	DEC 1971

	RELATIVE HUMIDITY (%) HOUR (Pacific Standard Time): 04	10	16	22	WIND (Speeds in mph): AVERAGE SPEED	PEAK SPEED	YEAR	RESULTANT (Dir/Sp): 23-02 PST	11-14 PST	STATION PRESSURE (Inches): AVERAGES	HIGHEST	LOWEST	AVERAGE SKY COVER SUNRISE TO SUNSET	AVERAGE NUMBER OF DAYS: Sunrise to Sunset: CLEAR	PARTLY CLOUDY	CLOUDY	PRECIPITATION: .01 inch or more	.10 inch or more	.50 inch or more	1.00 inch or more	1.0 inch or more of Snow	THUNDERSTORMS	TEMPERATURE: Maximum 90°F or more	32°F or less	Minimum 32°F or less	0°F or less
A	67	49	35	60	6.6	58	1965	233/07	35/26	26.10	26.54	25.42	4.9	13	8	10	2	1	*	*	*	*	0	1	29	*
B	67	45	32	56	6.9	52	1967	275/11	18/27	26.05	26.42	25.56	5.0	11	8	9	3	2	*	*	1	0	0	*	23	0
R	58	31	23	44	8.4	55	1971	240/18	186/15	25.99	26.43	25.48	4.8	12	9	10	3	1	0	0	1	1	0	0	24	0
Y	52	27	21	38	9.1	60+	1970*	250/22	198/31	25.96	26.39	25.50	4.5	13	9	8	3	1	*	*	*	1	0	0	12	0
N	46	22	17	31	8.3	60+	1967	260/15	179/72	25.94	26.39	25.47	4.3	14	11	6	2	1	*	0	0	1	4	0	2	0
L	39	19	14	26	7.9	60+	1967	272/19	185/82	25.92	26.20	25.56	3.0	19	7	4	2	1	0	0	0	2	14	0	*	0
G	40	20	15	28	7.5	55	1971	278/09	185/20	26.00	26.19	25.68	3.0	19	9	3	3	2	*	0	0	4	29	0	0	0
P	44	23	16	30	6.7	60+	1968	222/25	182/22	26.00	26.22	25.71	3.0	20	8	3	3	1	0	0	0	4	27	0	0	0
T	43	21	17	32	7.0	52	1970	286/13	163/64	26.00	26.36	25.56	2.1	22	6	2	2	1	1	*	0	2	11	0	1	0
Y	46	24	19	36	6.6	60	1971	286/13	138/37	26.06	26.40	25.52	2.9	20	7	4	1	1	0	0	0	*	2	0	9	0
C	61	39	31	52	6.1	51	1970	234/12	052/41	26.08	26.58	25.64	4.8	13	7	10	3	2	*	*	*	*	0	0	23	0
Y	68	50	41	64	6.6	53	1970	288/19	109/10	26.07	26.59	25.49	4.6	14	8	9	3	1	1	*	1	*	0	1	29	1
Y	53	31	23	41	7.4	60+	APR 1970*	—	—	26.01	26.59	25.42	3.9	190	97	78	30	14	3	1	1	3	14	87	2	152	1

Temperatures on the site are primarily related to elevation and topography. Daytime temperatures are mainly a function of elevation with temperatures decreasing with increasing elevation. At night the influences of exposure and aspect tend to predominate over the influence of elevation. The influence is exerted mainly through the presence of wind at openly exposed locations and drainage flow on sloping terrain. The combined effect of elevation, exposure, and aspect is reflected in the average daily temperature range which is 10°F (6°C) in January and 19°F (11°C) in July at the Rainier Mesa station (7,480 ft:2,280 m) compared with 31°F (17°C) in January and 39°F (22°C) in July at Yucca Flat (3,924 ft:1,196 m). Being on the edge of a playa, the latter station is subject to air stagnation at night which maximizes the effect of radiational cooling.[214]

The average annual precipitation ranges from about 4 inches (102 mm) on an average of less than 30 days at 2,500 ft (762 m) to about 12 inches (305 mm) on an average of 50 or more days at 7,500 ft (2,286 m). The frequency and amount of precipitation vary directly as a function of elevation with elevation accounting for about 80% of the variance in the statistic. A curve of precipitation plotted against time is characteristically bimodal, with peaks in the winter and a secondary peak in summer. The site is in the rain shadow of the Sierra Nevada. However, winter precipitation, between October and April, results from storms coming in from the Pacific and accounts for about 65% of the average annual precipitation at Yucca Flat. Precipitation is at a minimum in May and June.[214]

In summer, precipitation results mainly from either convection of moist air brought on southeasterly winds from the Gulf of Mexico, or from cyclonic lows developing over the Great Basin.[129,214] Summer showers occur as isolated events with large variations in amounts of rain within the shower area. Occasionally storms move directly from the Gulf of California in a northeasterly direction, bringing widespread, heavy rains. There is a well defined[214] drop in the amount of precipitation during September or October.

Average annual snowfall at Yucca Flat is 8.3 inches (211 mm), and daily snowfalls of 1 inch (25 mm) or greater occur an average of 3 days per year. Snow does not ordinarily persist for more than a few days on the ground, but has persisted for as long as three weeks on occasion. At higher elevations snow will occur more frequently, accumulate to greater depths, and persist for longer periods of time.

At Yucca Flat average relative humidity ranges between 14% at 4:00 pm in June--July and 68% at 4:00 am in December.[214] Estimates of relative humidity at other locations can be keyed reasonably well to the daily and annual cycles of the average relative humidity at Yucca Flat, remembering that substantial differences can be expected between locations because of the inverse relationship between temperature and relative humidity.

Average annual wind speed at Yucca Flat is 7.4 mph (12 kph) and the prevailing direction is from the north, except in May through August, when the winds are primarily from the south-southwest. April is the windiest month, with speeds averaging 9.1 mph (15 kph); but gusts in excess of 50 mph (80 kph) have been recorded in every month. The predominant feature of the distributions of wind direction and speed at some point on the Nevada Test Site is the contribution by the mountain-valley wind system. This system follows the sun and is, therefore, most intense in summer and least active in winter and on cloudy days. Heating during the day causes the air to move upslope, while cooling at night causes a gravity flow downslope, producing a pronounced daily cycle in the direction and speed of the wind, which is highly dependent on the orography.[214]

SOILS

There has not been a definitive soil survey of the Nevada Test Site. Most information has been gathered to answer specific programmatic needs in widely separated areas. There have been soil surveys of: Area 15 surrounding the ERDA--EPA farm;[165] a large portion of Area 18 that is used for cattle grazing;[163] five sites containing plutonium contamination;[164] and

five drainages used by UCLA as part of their bioenvironmental research.[253] Information on soil characteristics is, therefore, only in the first stages of development, and the following summarization will be subject to much revision in the future.

Most of the soils on NTS have developed on alluvial deposits that contain unconsolidated parent materials of both sedimentary and volcanic origins.[253] They have developed under conditions of high temperatures and low rainfall, and display characteristics of desert soils: coarse texture; an accumulation of carbonates within a few feet of the surface contributing to the formation of a caliche layer; low organic matter content; and low carbon/nitrogen ratios. Most of the soils can be classified as belonging to the Thermic Families,[253] with those at higher elevations fitting into the Mesic Family classification.[163]

The soils are young as regards profile development and show little evidence of leached upper horizons. Much of the diversity in soil profiles reflects their mixed alluvial origin. Coarser fragments are found in soils developed nearer the base of mountains and hills, and finer textures are found towards the middle of valleys. If clay is present, it is usually found in B horizons in more level areas.[253]

Carbonate contents of soils can also be closely correlated with the origin of parent material, and it is highest in areas immediately adjacent to limestone mountain ranges. High carbonate concentrations are almost always correlated with the presence of a restrictive hardpan, usually at depths of 30-70 cm. Soils low in carbonate are most often those that have developed on alluvium of mixed igneous and sedimentary rocks.[253]

The particle size distribution of the soils also reflects formation on alluvial deposits. Variations in texture are largely due to differences in distributions of sand and silt particle size fractions. At low elevations there is characteristically a low clay content, but increased

clay concentrations have been found on alluvial sediments in closed drainage basins such as Frenchman Flat. Soils at higher elevations may have clay contents of as much as 50%.[163] The ratio of cation exchange capacity to percent clay is usually within 2 to 5, and occasionally can be greater than 10. In addition, the high soluble and exchangeable potassium content of some soils also indicates amorphous clays. Loess, consisting of variable-sized sandy material, blankets a major portion of the study areas. Much of it probably originated from volcanic ash falls that have been further eroded, mixed, and transported by the wind.[253]

Moisture retention characteristics of NTS soils are very poor and primarily reflect the low silt and clay content, as well as the relative lack of organic matter. Moisture reserves of the soil profiles seldom exceed field moisture capacity except during the period of winter precipitation. Vegetative growth and rising spring temperatures rapidly deplete soil water, and for 6 to 8 months soil moisture potential is below -30 bars, and it often falls below -90 bars in summer.[253]

The soils are usually nonsaline-nonalkali (electrical conductivity less than 4 mmhos/cm; exchangeable sodium percentage less than 15) in profiles within root zones of perennial vegetation, except for a few sites within closed basins. Saline conditions have been found in deeper horizons in Rock Valley and Jackass Flats, but most occur around playas in closed basins. The highest levels of soluble salts have been found in deeper soil horizons on Frenchman Flat. Soluble sulphates are low in all profiles. The percent free lime present is related primarily to contributions of limestone parent material to alluvium. Levels of micronutrients such as manganese, iron, copper, and zinc are low and variable between sites. The shrubs show no obvious signs of micronutrient deficiencies, and there is evidence that cycling of micronutrients takes place.[253]

Cation exchange capacities vary considerable between areas and sharply reflect particle size distributions of the soils. In Mercury Valley,

Rock Valley, and Yucca Flat, soils are low in exchangeable sodium and high in calcium and magnesium, while sandy soils from Jackass Flats are low in calcium, magnesium, and sodium. Soils from Frenchman Flat have the highest cation exchange capacity and exchangeable potassium; potassium concentrations sometimes exceed the exchangeable calcium and magnesium content.[253]

There is clear evidence of accelerated soil-forming processes under desert shrubs, which demonstrates an important role of shrubs in desert ecosystems. One of the most consistent characteristics of NTS soils is that the highest concentrations of organic carbon, organic nitrogen,[204] and available phosphorus occur in the upper horizons under shrubs.[253] Shrubs intercept the wind-borne, finely textured loess, adding it to the coarser alluvial material at their bases. Salts also accumulate under shrubs, probably because of recycling through leaf-fall and litter decompositon, as well as trapping of air-borne materials. Under shrubs there is often some decomposition of subsurface hardpans, and a better developed A horizon. Below the A horizon carbon/nitrogen ratios are around 10; in the A horizon they range from 5-30, although most are between 12-15. The A horizon is the only horizon in which the organic carbon content exceeds 1%. Low C/N ratios could be due to reduced organic matter content of desert soils, an increase in nitrogen fixation, or a combination of both.[253] In addition to the above, soil pH tends to be lower,[114] conductivity of saturation extracts is higher, nitrates and chlorides accumulate more,[204] and exchangeable cations, such as potassium, are greater under shrubs.[253]

Species of algae and fungi grow on and in the soils,[87,88] contributing to soil stabilization (Appendix 4). The algae are often enclosed in a colloidal sheath which binds particles of soil in a web-like matrix, consolidating a surface crust.[88,258] The water-holding capacity of the sheath improves moisture relations in the felted crusts. Recent data suggest that the algal crust in arid soils is an important link in the soil nitrogen cycle.

FLORA

The Nevada Test Site lies on the transition between the Mohave and Great Basin deserts. As a result, elements of both deserts are found in a diverse and complex flora that, to the casual observer, appears to be both sparse and rather monotonous. The species diversity is most evident when adequate precipitation, greater than 1 inch (>25 mm) mid-September to early December[56], stimulates blooming of a profusion of showy annual flowers which can almost cover the desert pavement, or bare soil between shrubs.

Extensive floral collections have thus far yielded 711 taxa of vascular plants within or near the boundaries of NTS[55] (Appendix 4). About 67 families are represented; however, one-third of the species belong to just three families: Compositae, Sunflower Family; Gramineae, Grass Family; and Polygonaceae, Buckwheat Family. There are many species of winter annuals, but only 7 species of summer annuals[49] in the flora. With the exception of grasses, perennial species are predominantly low, shrubby species.[235] Several species new to science have been described from material collected on the Nevada Test Site,[128,220-222] and a number of endemics have been identified.

The mosaic of vegetation types or associations has been described at various times as an aid to understanding the ecology of the major subdivisions (Fig. 10). The most satisfactory classification schemes have been based on descriptions of types according to the dominant or codominant species of perennial shrubs that are found.[24,57,235]

Associations of creosote bush, *Larrea tridentata,* which are characteristic of the Mohave Desert, dominate the vegetation mosaic on the bajadas of the southern Nevada Test Site, Jackass Flats, and Frenchman Flat (Fig. 11).. In Yucca Flat *Larrea* associations are restricted to the upper bajadas in the southwestern and northeastern parts of the drainage. *Larrea* associations reach elevations of 4,500 feet (1,372 m) in favorable locations.[57]

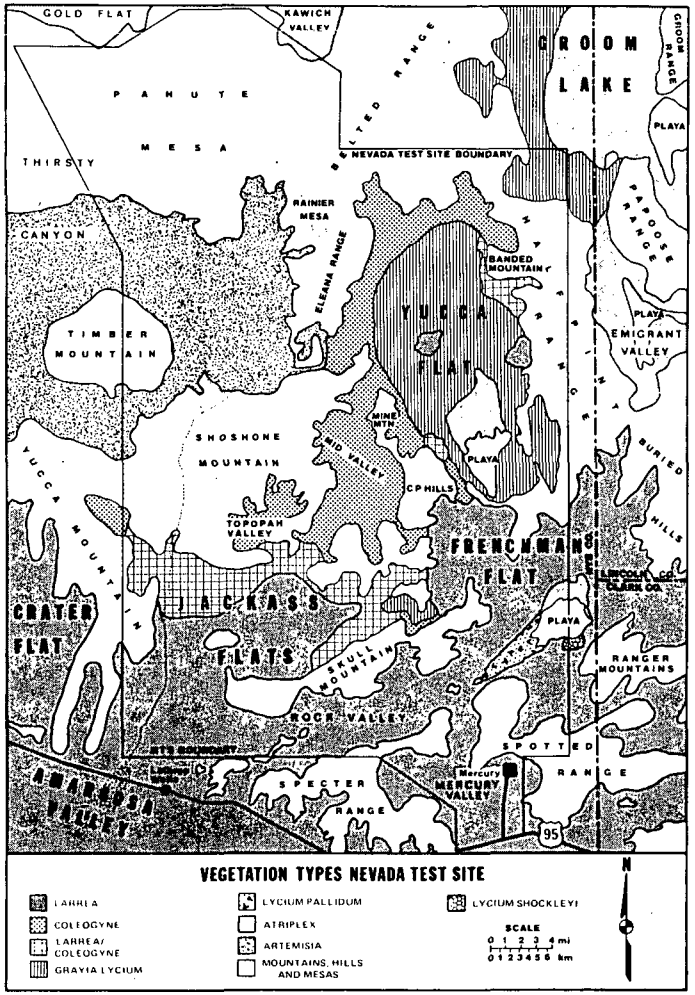


Figure 10. Major vegetation types of the Nevada Test Site (Redrawn from maps prepared by J. C. Beatley and printed with her permission).

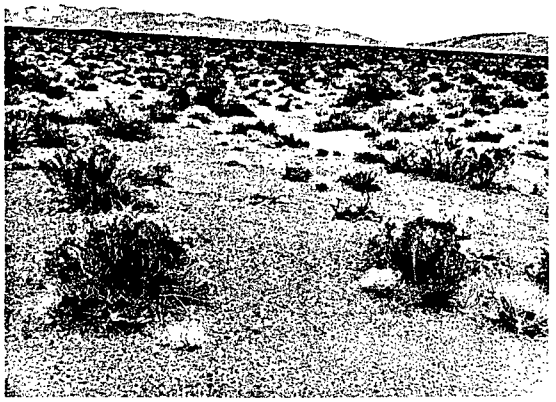


Figure 11. Mohave Desert vegetation types, principally *Larrea-Ambrosia (Franseria)*, dominate the flora of the southern portion of NTS.

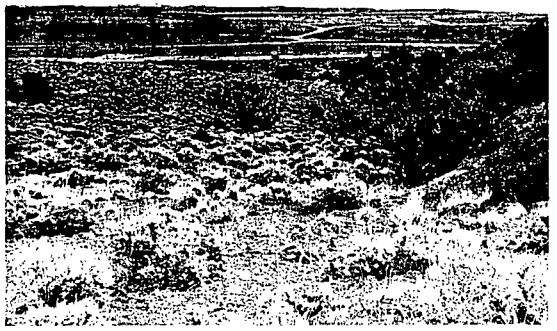


Figure 12. Above 5,000 ft (1,524 m) the vegetation mosaic is characteristic of the Great Basin Desert and is dominated by sagebrush associations of *Artemisia tridentata* and *Artemisia arbuscula* ssp. *nova*.

The altitudinal and northern distributions of *Larrea* are thought to be determined primarily by climatic conditions[57], although soil conditions have also been cited as limiting factors.[253] Creosote bush is excluded from basin floors of Frenchman and Yucca flats because of prevailing low minimum air temperatures resulting from drainage of cold air into these closed basins.[57,325] *Larrea* types are absent from habitats where the mean minimum air temperature is below 28.5°F (-2°C), or the extreme minimum is less than 1°F (-17°C). Increased precipitation probably limits the distribution of creosote bush on sites with temperature regimens favorable to the species. *Larrea* is limited to zones with an average rainfall of 7.2 inches (183 mm) or less.[57]

Transitional associations between the Mohave and Great Basin types exist between 4,000 and 5,000 feet (1,219 and 1,524 m) in elevation. In Jackass Flats *Coleogyne ramosissima*, blackbrush, replaces creosote bush as the dominant shrub. In Yucca Flat there are two major transitional associations above the basin floor. On the middle to lower portions of the bajadas transitional associations are dominated by *Grayia spinosa-Lycium andersonii*, hopsage-desert thorn, associations, while the upper bajadas support *Coleogyne* types. The former associations appear to occupy sites that have minimum temperatures that are below the tolerances of many Mohave Desert species found in the *Larrea* types, while the latter appear on sites with 7 to 8 inches (178 to 203 mm) of annual precipitation and stony, calcareous (especially limestone) soils.[58] Available soil moisture in spring is always highest in the transitional associations as compared with *Larrea* or *Atriplex* types.[236]

The floristic composition of the valleys has changed dramatically within the geologically recent past. Wood rat middens in the hills surrounding Frenchman Flat contain large quantities of juniper leaves and seeds. Radiocarbon dates suggest that the middens were deposited 7,800 to 40,000 years ago. The area which is presently dominated by creosote bush or blackbrush once had a Pleistocene woodland climate

more arid than the usual pinyon-juniper climate, but more temperate than now.[324]

Above 5,000 feet (1,524 m) the vegetation mosaic is characteristic of the Great Basin Desert and is dominated by sagebrush associations of *Artemisia tridentata* and *Artemisia arbuscula* ssp. *nova* (Fig. 12). The Distribution of Great Basin associations appears to be limited by mean maximum temperature and minimum rainfall tolerances of these "cold" desert species.[58] Pinyon pine, *Pinus monophylla,* and juniper, *Juniperus osteosperma,* are the usual dominants at elevations above 6,000 feet (1,829 m) and mix with the sagebrush associations on mountains and mesas of the northern and western protions of the Nevada Test Site where there is suitable moisture for these trees[58] (Fig. 13).

Adjacent to the playas in the closed basins of Frenchman and Yucca flats are associations dominated by either shadscale, *Atriplex confertifolia;* four-winged saltbush, *Atriplex canescens; Lycium pallidum-Grayia;* or *Lycium shockleyi.* The associations containing species of *Lycium* appear to be primarily controlled by low temperatures in these cold air drainages, but they are also related to the composition of the bedrock from which the soils were derived[58] and to salinity.[317] *Atriplex* vegetation types are correlated with highly calcareous soils and appear to be exceptional in that edaphic controls are probably more important than climatic conditions in limiting their distribution.[58]

Shrub coverage within the Mohave Desert types averages about 16% with a range of 7% to 23%. Transitional vegetation types average 29% with a range of 12% to 50%, while shrub coverage in Great Basin types averages 24% with a range of 15% to 37%. Shrub coverage within the various vegetation types is highly correlated with mean annual rainfall.[57] Standing crop of shrubs in Rock Valley is approximately 3,100 kg/hectare. Roots contribute about 45% by weight to the total.[312]

Winter annual forbs and grasses are the dominant species of ground cover, and they contribute most to the annual production of biomass. However,

Figure 13. Pinon-juniper *(Pinus monophylla-Juniperus osteosperma)* woodlands cloak the upper elevations. These trees on Rainier Mesa are backlit by a late-March snowfall.

the majority of winter annual seedlings do not survive to maturity. Studies have shown that following autumn germination approximately 38%, range 10% to 63%, reach maturity. After heavy rains and spring germination about 60%, 44% to 83%, survive. Inadequate soil moisture is the principal cause of mortality in germinated winter annuals.[47]

The contribution of winter annuals to biomass is highly variable between years, sites, and species, and can range between 0 and at least 616 kg/ha, on a dry weight basis, for undisturbed vegetation types. Biomass of winter annuals has been measured in: Mohave Desert vegetation types, 19 to 160 kg/ha; transitional vegetation types, 35 to 180 kg/ha; Great Basin Desert types, 25 to 62 kg/ha.[48] Burned sites consistently produce more winter annual biomass: 2 to 11 times more production than that on undisturbed sites was measured over a 3-year sampling period, due primarily to the presence of alien grasses, principally species of *Bromus*.[48]

Introduced species, especially *Bromus rubens* and *B. tectorum* which are winter annual grasses, and Russian thistle, *Salsola iberica* and *S. paulsenii*, which are summer annual forbs, have become important components within the vegetation mosaic. All rapidly invade disturbed sites, use the soil water effectively, and help delay revegetation of areas by native species. *Bromus tectorum*, cheatgrass, is found on disturbed sites at elevations above 5,000 feet (1,524 m) in the *Artemisia* or *Artemisia*-pinyon-juniper vegetation types. This species is increasing its distribution and abundance as higher elevations are disturbed for operational uses. *Bromus rubens*, downy chess, is found at middle elevations and is frequently the dominant winter annual in *Coleogyne* types. It can be found on undisturbed sites, but does not appear to be as aggressive as *B. tectorum*.[43]

Russian thistle is restricted to disturbed sites where the physical characteristics of the soil surface have been modified and the shrubs killed or inactivated.[40] Germinating *Salsola* cannot penetrate compacted

soils; therefore, it must have some scarification of the soil surface to be successful.[315] Russian thistle also requires warm soil temperatures, but only moderate soil moisture. Transpiration in *Salsola* is influenced more by soil temperature than soil moisture,[308] and these summer annuals appear to have 1/3 to 1/2 the moisture requirements of most crop plants.[315]

Knowledge of the physiological characteristics of Nevada Test Site flora has been developed in glass-house and laboratory studies. The information has been valuable in developing hypotheses concerning the mechanisms which might control the observed relationships between species distribution and the climatic and edaphic conditions of this arid region.

Field observations have pointed out the importance of air and soil temperatures to the distribution of vegetation types on NTS.[57,58] Controlled experiments have also shown that soil temperature is important for the growth of desert shrub seedlings,[316] and that temperatures might, under many conditions, help regulate the distribution of shrubs. Seedlings of shrubs characteristic of the Great Basin Desert show decreased growth with increasing soil temperatures in the range of 60 to 83°F (16 to 28°C). Seedlings of Mohave Desert species show increased growth with increasing soil temperatures, while species from transitional habitats usually grow best at intermediate temperatures.[316]

Growth rates of plants under variable temperature regimens are closely related to the pathways involved in the photosynthetic fixation of CO_2. In general, species adapted to cold habitats are associated with the Calvin cycle, while species adapted to hot temperatures are associated at least in part with the C_4 pathway. When 14 species from NTS were studied, only *Atriplex canescens* and *A. confertifolia* exhibited characteristics of the C_4 pathway only. The other species demonstrated characteristics of both pathways, suggesting that gradations between extremes of the two photosynthetic systems can occur in the same species.[321]

Another physiological adaptation involves the ability of some plants to respond to water vapor in the air as part of their moisture economy strategy. Species of *Atriplex* have the ability to absorb water from vapor through their leaves. *Larrea* absorbs only small amounts of water through its leaves, but there is evidence that if creosote bushes are preconditioned they are able to survive for periods with water from a vapor source only.[309] The contribution of water vapor to the water economy of desert species when soil moisture is limiting is still unclear, but with continuing study it may prove to be an important physiological adaptation to arid conditions.

Several species of plants demonstrate a physiological tolerance to high concentrations of minerals, especially salts, in the soil. The tolerance is often associated with the ability to concentrate both cations and anions in vegetative parts such as leaves, which can then be dropped with their concentrated minerals.[314,317,320] The anion and cation contents of plants are determined by the concentrations in the soils and the species of plant. Species of *Atriplex* accumulate up to 10% dry weight of sodium, chlorine, and potassium in their top leaves,[314] *Lycium andersonii* accumulates lithium,[317] *Grayia spinosa* concentrates potassium, and *Atriplex hymenelytra* accumulates cadmium.[320] Some species do not tolerate high levels of salts. *Larrea* fails to grow where the soil C horizon is highly saline and where the A horizon contains over 10 me/100 g exchangeable potassium.[317]

The ability to concentrate certain elements has also contributed to the toxic quality of certain species of plants on the Nevada Test Site. At least 30 species have been identified as being poisonous to animals, especially domestic livestock.[76] The majority of species are not poisonous in the colloquial sense, but must be consumed in large quantities to be lethal. Most poisonous plants will be avoided by livestock if suitable forage species have not been depleted by overgrazing. At least 9 species are potentially dangerous as they are lethal in small quantities.[76]

The complex interrelationships between plant physiology and the elemental composition of desert soils is still poorly known. Causal relationships

between plant responses to changing soil conditions involve subtle links that appear to tie important elements, such as phosphorus, to micronutrients such as zinc. The disturbance of one link concurrently alters other facets of the mineral cycle. In *Ambrosia dumosa*, an important shrub species within the Mohave Desert vegetation types, levels of phosphorus are linked to levels of micronutirents such as zinc, copper, iron, and manganese. When *Ambrosia* is grown on soils that contribute to high concentrations of phosphorus the plant demonstrates a a zinc deficiency; on soils effecting low levels of phosphorus the species shows signs of zinc toxicity.[318]

Soil fungi are considered to be important, even necessary, for the absorption of certain elements from the soil by plants. Symbiotic mycorrhizae, root fungi, associated with *Ambrosia* and the grass *Hilaria rigida* are necessary for phosphorus absorption in soils that are not well supplied with available phosphorus.[313] No doubt other examples of beneficial fungi/vascular plant associations will be identified with further study.

Other components within desert soils have a negative effect upon growth of plants. A degree of allelopathy has been demonstrated in soils taken from under existing or recently dead shrubs. Growth of new plants is decreased in such soils.[313] It has been suggested that substances from roots of the previous plants, or the accumulated litter, may be toxic to growth of new plants. Such a mechanism would act as an efficient method of maintaining adequate spacing of shrubs, thereby minimizing competition for water and nutrients.

Studies of mineral cycling within desert species must untangle a complex web of soil/mineral/plant relationships, few of which are simple causal links, many of which are presently unknown.

FAUNA

Invertebrates

Invertebrates comprise the majority of animals on the Nevada Test Site, both in terms of numbers of species and relative abundance.[24] At least 1,028 taxa have been identified within five classes of the Phylum Arthropoda: the joint-footed animals (Appendix 5). These probably represent a small fraction of the species that actually live in the diverse habitats on NTS. Most of the extensive and intensive sampling programs were designed to collect arthropods, and little is known about the species diversity, distribution, or roles of the soft-bodied invertebrates.

Eighty percent of the known arthropods are insects. The remaining taxa are divided between eight classes or orders; however, 84% of the taxa represent spiders and their close allies: mites and sunspiders.

A total of 94 species of spiders, representing 23 families, has been identified.[20] They are found in every vegetation association, but are most numerous in collections from *Coleogyne* associations. The greatest species diversity occurs in transitional vegetation types such as *Grayia-Lycium* and *Coleogyne*.[24]

Solpugids or sunspiders, 29 species,[9,201,202] and scorpions, 9 species,[115] are found principally in the Mohave Desert and transitional vegetation types. Both groups are most abundant in the *Larrea-Ambrosia* association, but most species are found to be in *Grayia-Lycium*.[24] Phalangids or harvestmen, 3 species, are found in all vegetation types,[4] but they are most abundant in *Coleogyne* associations.[24]

Other important spider relatives found on NTS include the mites and ticks. Both groups have been implicated as vectors for pathogens and parasites affecting plants and animals. Consequently, efforts have been made to describe host relationships as well as taxonomic status. Eleven species of ticks have been identified,[62,73,126] and 56 species of mites have been described along with their apparent hosts.[1-3,13,18,21,22,72,113,117,135,138,211]

Exclusive of insects, the remaining taxa of arthropods include: 2 species of isopods, pill bugs, which are small crustaceans;[23] 6 species of centipedes;[8,78] and 4 species of millipedes.[79-81] None of these groups appears to be either numerous or wide-spread.[24]

The 814 species of insects which are presently known from the Nevada Test Site represent 9 orders and 56 families.

One hundred eighty four species of Coleoptera, beetles, have been collected.[19,36,133,272-276] They belong to 17 families, but most species belong in the Family Tenebrionidae, the darkling beetles. These large, mostly black, ground-dwelling beetles are an important component of the fauna in arid and semi-arid regions of western North America. The greatest number of species are found in the *Larrea-Ambrosia* association, but they are most numerous in *Grayia-Lycium* associations. The most widespread species is *Eleodes obscura*, which is one of the largest darkling beetles. Beetles have been captured in all months of the year, but most are seasonally abundant depending on whether they are spring-emergent or fall-emergent species.[24]

There are 176 species within the Order Hymenoptera which includes the ants, bees, and wasps.[7,12,83-85,93,323] Members of 4 families have been identified, but most are either ants, 57 species, or bees, 71 species. Ants are most abundant in the *Grayia-Lycium* and pinyon-juniper associations, and the greatest number of species are also found in the latter vegetation type.[24] Ants are most active seasonally between spring and autumn, although some species are found in all months. Within seasons their activity aboveground is correlated closely with soil temperature, moisture, and availability of food.

Many species within the Order Hemiptera, true bugs, have been identified.[11,149] Five families are represented, but 159 of the 180 known species belong to the Family Miridae: plant bugs. This is a biased picture which reflects more closely the importance of taxonomic scrutiny rather

than the true species composition within the Order Hemiptera on NTS. A Miridae specialist reviewed material collected on the site and was able to describe 7 new genera and 97 new species.[149]

A similar situation occurs within the Order Diptera, flies, where only the members of the Family Bombyliidae have been reviewed by taxonomic authorities. They were able to identify and describe 111 species.[28] There are many other taxa within this large order which have been collected on NTS but are awaiting specific identifications.[61]

The remaining identified insects are classified as follows: Order Ephemoptera, May-flies, 1 family, 1 species; Order Trichoptera, caddice flies, 1 family, 1 species; Order Orthoptera, grasshoppers and crickets, 9 families, 58 species;[35] Order Lepidoptera, butterflies and moths, 13 families, 72 species;[6] Order Siphonoptera, fleas, 6 families, 31 species.[60] Special efforts have been made to identify both fleas and their hosts because fleas, like mites and ticks, can be important vectors for animal pathogens such as the one responsible for sylvatic plague.

The vast majority of insect species living on the Nevada Test Site, probably over 75%, are still unknown. Collecting techniques used over the years are all selective and give biased information on both species composition and relative abundance. Pit-fall traps were used to collect the bulk of arthropods on NTS, but this method yields few foliage-dwelling insects, soil microarthropods, or flying species. Many specimens have been collected and deposited in appropriate museums, but there are no authorities available to make taxonomic identifications for many major groups.[61] This is an important problem at NTS where so many insects are new to science and require species descriptions. As several other sampling schemes are used in major vegetation associations, and as more taxa are reviewed by specialists, important additions will be made to the species lists of insects.

The functional roles of most insects on the Nevada Test Site are still poorly known. Only recently programs have been initiated to extend the

earlier descriptive work into studies of niche fit, biomass, bioenergetics, structure and function of the insect component of desert ecosystems (Appendix 1). Present information indicates that ants and termites are probably the most important groups of insects on NTS, and many major desert habitats. Both groups contribute a large proportion to both the numbers and biomass of the fauna of arid lands. Ants harvest large quantities of the annual production of the vegetation, especially seeds and fruits. Termites aid in the reduction of woody materal that would otherwise decompose slowly in the arid, hot environment, and both groups are involved in the degradation of vegetative products and the recycling of important nutrients within the soil.

Fish

Goldfish, *Carassius auratus*, and golden shiners, *Notemigonus crysoleucas*, have been unofficially introduced into ponds associated with wells, and represent the only fish species known to occur on the test site. They breed successfully and the goldfish display the diversity of color patterns and sizes associated with the species.

Reptiles

The reptilian fauna of the Nevada Test Site includes 1 species of tortoise, 14 species of lizards, and 17 species of serpents[24,277,280] (Appendix 5).

The desert tortoise, *Gopherus agassizi*, is found throughout much of the Mohave Desert. On NTS it has been observed in the *Larrea-Ambrosia* association and the surrounding hillsides. It is presently protected by the game laws of the State of Nevada.

The rich lizard fauna is partly due to the overlapping ranges of species characteristic of the Mohave and Great Basin deserts. Several species show affinities with their place of origin by their patterns of distribution within the NTS vegetation types.[277,280] Species found mainly in Mohave Desert vegetation types include: banded gecko, *Coleonyx variegatus;* desert iguana, *Diposaurus dorsalis;* collared lizard, *Crotaphytus collaris;*

chuckwalla, *Sauromalus obesus;* and desert night lizard, *Xantusia vigilis.* The following lizards are found in both Mohave Desert and transitional vegetation associations: zebra-tailed lizard, *Callisaurus draconoides;* desert spiny lizard, *Sceloporus magister;* and western whiptail, *Cnemidophorus tigris.* Three species are confined to Great Basin Desert vegetation associations or pinyon-juniper woodlands: sagebrush lizard, *Sceloporus graciosus;* western fence lizard, *Sceloporus occidentalis;* and western skink, *Eumeces skiltonianus.* The side-blotched lizard, *Uta stansburiana,* is found in all vegetation types, and the leopard lizard, *Crotaphytus vislizenii,* and desert horned lizard, *Phrynosoma platyrhinos,* are found everywhere but in pinyon-juniper.

Based on their widespread distribution and relative abundance compared with other species, the most important lizards on the Nevada Test Site are reported to be the side-blotched lizard, western whiptail, desert horned lizard, and desert spiny lizard.[280]

Side-blotched lizards are abundant, and are found in all vegetation types and throughout the altitudinal gradient.[280] Estimated densities in Rock Valley range between 40-80 per hectare. Breeding is initiated early in the year and the first clutches of eggs are laid in mid-April. There are usually five clutches, averaging 3-4 eggs each, laid at intervals of 21.5 days.[301] Clutch size and frequency are thought to be correlated with production by winter annuals, since insects, the primary food of *Uta,* are thought to be dependent on production by annuals.[127]

Western whiptails are second only to *Uta* in abundance on NTS and are found in Mohave Desert and transitional vegetation associations (Fig. 14). Their estimated densities in Rock Valley and Yucca Flat are between 7-25 per hectare, and they attain a peak biomass of 106-282 g per hectare.[288,306] They usually produce one clutch of 2-4 eggs per year, and have an estimated maximum life span of about 7 years.[306]

Desert spiny lizards (Fig. 15) have been collected in all vegetation associations except *Coleogyne* and pinyon-juniper, and seem to be most

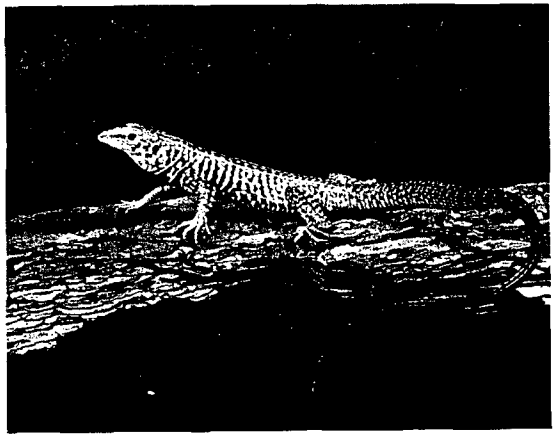


Figure 14. Western whiptails, *Cnemidophorus tigris,* are found in Mohave Desert and transitional vegetation types and are the second most abundant species of lizard.

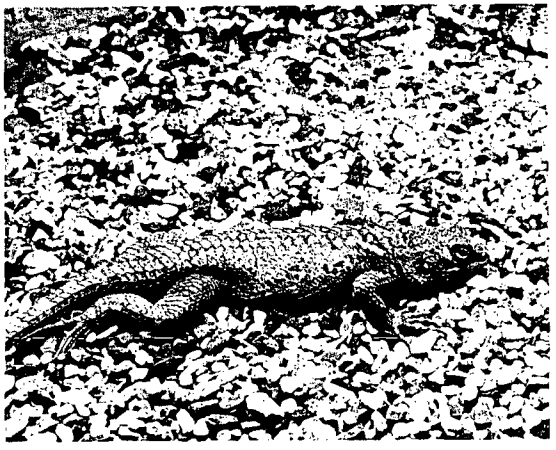


Figure 15. The desert spiny lizard, *Sceloporous magister,* is one of the more widely distributed lizards on NTS.

numerous in *Grayia-Lycium*.[280] Animals at least two years old begin to breed in May-June, and one clutch averaging 7 eggs is laid per year. Their food consists primarily of arthropods, especially ants. They are territorial and maintain fairly stable centers of activity between years. They are active between April and October.[281]

Horned lizards (Fig. 16) have been observed in all plant associations except pinyon-juniper, but are most numerous in *Larrea-Ambrosia* and *Grayia-Lycium*.[280] In the lowlands they are conspicuous during April and May, but are aboveground between March and September. Breeding takes place in May, and one clutch averaging 7 eggs is laid per year. They appear to be nomadic with no strong territorial behavior, and attain densities of about 5 per hectare.[282] Their maximum life span is at least 94 months.[193]

Another important species is the leopard lizard (Fig. 17). It is a husky lizard found in all vegetation types except pinyon-juniper. It is an opportunistic feeder whose diet includes insects, berries and blossoms, and smaller lizards.[283] Leopard lizards reach densities of 1-5 per hectare, and contribute approximately 44-119 g of biomass per hectare.[283,304]

There are 17 species of snakes on the Nevada Test Site. They are observed or collected very infrequently, which has made it difficult to describe their relative abundance, habitat preferences, or seasonal patterns of activity. Present information suggests that the western shovel-nosed snake (Fig. 18), *Chionactis occipitalis*, is the most common snake on NTS, especially over much of the bajadas.[280]

Only four snake species are poisonous: sidewinder (Fig. 19), *Crotalus cerastes;* speckled rattlesnake, *C. mitchelli;* night snake, *Hypsiglena torquata;* and the Sonora lyre snake, *Trimorphodon lambda*. The night snake and lyre snake are small snakes that inject venom with enlarged, grooved teeth toward the back of their upper jaws. They are seldom seen

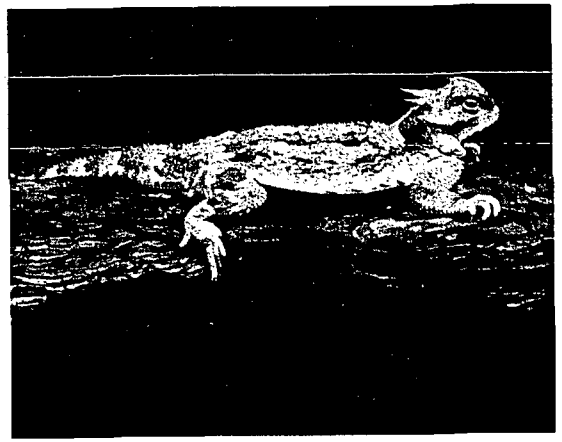


Figure 16. Desert horned lizards, *Phrynosoma platyrhinos*, are numerous and found to be in all vegetation types except pinon-juniper.

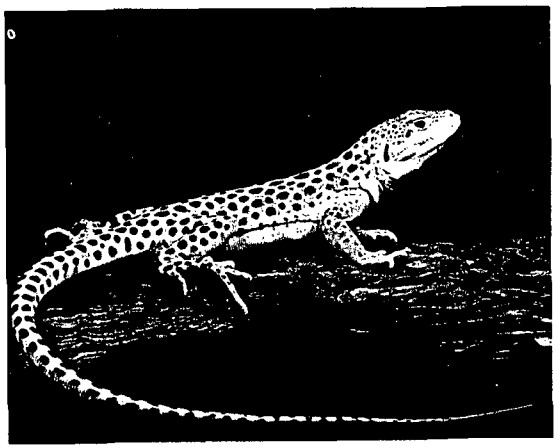


Figure 17. The leopard lizard, *Crotophytus wislizenii*, is a husky, opportunistic feeder that eats insects, berries and blossoms, as well as smaller lizards.

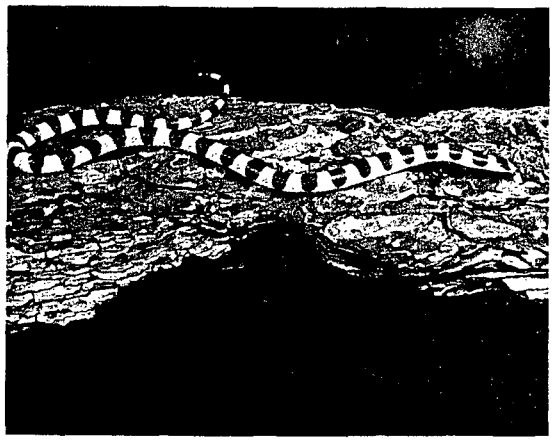


Figure 18. The western shovel-nosed snake, *Chionactis occipitalis*, is probably the most common species of snake on the Nevada Test Site.

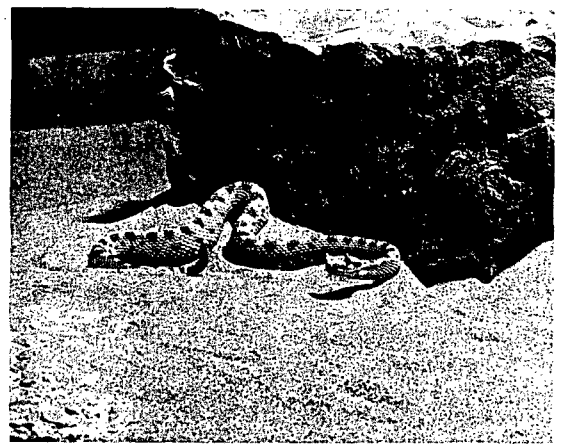


Figure 19. The sidewinder, *Crotalus cerastes*, is one of two species of rattlesnakes known to occur on NTS.

and pose no known threat to humans. The rattlesnakes are larger, more conspicuous, and must be avoided or treated with caution and respect owing to their potentially dangerous bite.

Amphibians

The range of the Great Basin spadefoot toad, *Scaphiopus intermontanus*, is thought to overlap the Nevada Test Site, but no amphibians have been located near the ponds or springs, or in the more mesic pinyon-juniper woodlands.

Birds

There are records of 190 species of birds observed on the Nevada Test Site (Appendix 5). They are widely distributed but appear to be most common in the *Grayia-Lycium* vegetation association. The greatest species diversity occurs in contrasting vegetation types: pinyon-juniper and *Larrea-Ambrosia*. The most widely distributed species are the Black-throated Sparrow, House Finch, Red-tailed Hawk, Common Raven, Loggerhead Shrike, Mockingbird, Ash-throated Flycatcher, and Mourning Dove.[24]

Approximately 86% of the bird species are either transients that migrate through the area during spring and fall, or are seasonal residents.[124] Only the following species are known to be full-time residents of NTS: Red-tailed Hawk, Marsh Hawk, Sparrow Hawk, Rough-legged Hawk, Prairie Falcon, Gambel's Quail, Chukar, Killdeer, Golden Eagle, Roadrunner, Burrowing Owl, Common Flicker, Hairy Woodpecker, Say's Phoebe, Horned Lark, Scrub Jay, Common Raven, Pinyon Jay, Mountain Chickadee, Common Bushtit, Rock Wren, Cactus Wren, Mockingbird, LeConte's Thrasher, Loggerhead Shrike, House Finch, and Rufous-sided Towhee.

During the spring and summer seasonal residents increase the species diversity in a number of habitats. These birds are important because presumably some of them breed on NTS: Snowy Egret, Turkey Vulture, Cooper's Hawk, Swainson's Hawk, Mourning Dove, Poor-will, Lesser Nighthawk, Costa's Hummingbird, Western Kingbird, Cassin's Kingbird, Ash-throated Flycatcher, Black Phoebe, Western Wood Peewee, Violet-green

Swallow, Blue-gray Gnatcatcher, Solitary Vireo, Warbling Vireo, Northern Oriole, Western Tanager, Lazula Bunting, Cassin's Finch, Black-throated Sparrow, Brewer's Sparrow, and Chipping Sparrow.[124]

For such an arid location there are a surprising number of transient waterfowl and shore birds. These include such species as: Mallard, Pintail, Green-winged Teal, Bufflehead, Ruddy Duck, Spotted Sandpiper, Greater Yellowlegs, Least Sandpiper, and Western Sandpiper. They find suitable habitats near the springs, well ponds, and the temporary lakes formed when surface runoff waters collect in Yucca and Frenchman playas.[124] In addition to waterfowl, the only game birds found on NTS are Gambel's Quail, Chukar, and Mourning Dove.

In winter the Nevada Test Site provides feeding grounds for thousands of small passerine birds, many of whom remain as winter residents, including the following: Sage Sparrow, House Finch, Gray-headed Junco, Mountain Bluebird, Starling, White-crowned Sparrow, Horned Lark.[230] Horned Larks and House Finches are present throughout the year, but they are found in much larger numbers during the winter. Horned Larks are the most common wintering species and often are seen in flocks of over 2,500 birds. House Finches are also seen in flocks numbering between 300 to over 2,500 birds. Prairie Falcons are the most common hawk in early winter, but after January Rough-legged Hawks are more numerous. Vegetation types disturbed by past nuclear testing seem to provide excellent supplies of winter food, especially seeds, particularly if large stands of Russian thistle and brome grasses are present.[230]

Mammals

A total of 42 terrestrial mammals and 4 species of bats have been recorded on the Nevada Test Site (Appendix 5).[15,24,140] Rodents account for almost half the known species, and are, in terms of distribution and relative abundance, the most important group of mammals on NTS. Most of the rodents belong to two important Families: Heteromyidae, which includes the kangaroo rats and pocket mice (Fig. 20); Cricetidae, the New World mice (Fig. 21).

Figure 20. Merriam's kangaroo rat, *Dipodomys merriami*, is an important small mammal in Mohave Desert vegetation associations (U. S. EPA, Las Vegas photo).

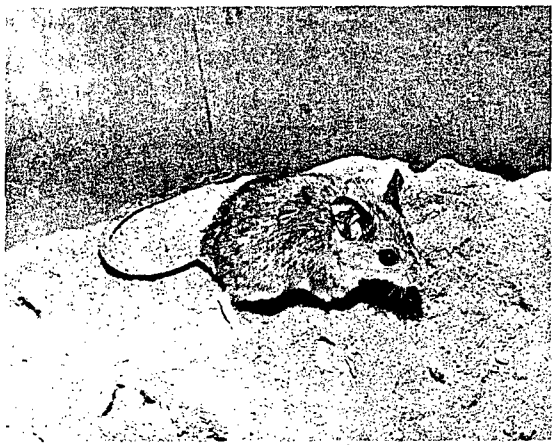


Figure 21. Four species of *Peromyscus* have been trapped on NTS. The cactus mouse, *Peromyscus eremicus*, shown here usually inhabits Mohave Desert vegetation associations (U. S. EPA, Las Vegas photo).

Several of the rodent species are typical of the Mohave Desert including: *Spermophilus tereticaudus*, round-tailed pocket gopher; *Dipodomys merriami*, Merriam's kangaroo rat; *Onychomys torridus*, southern grasshopper mouse; and *Peromyscus eremicus*, cactus mouse. They are generally observed or trapped in the Mohave vegetation types on NTS, and, to a lesser degree, in some of the transitional associations.[140] Other species are representative of the Great Basin Desert: *Spermophilus townsendii*, Townsend's ground squirrel; *Perognathus parvus*, Great Basin pocket mouse; *Dipodomys ordii*, Ord's kangaroo rat; *Dipodomys microps*, Great Basin kangaroo rat; and *Lagurus curtatus*, sagebrush vole. They have been sampled primarily in the transitional and Great Basin vegetation associations.

The greater number of rodent species are trapped in *Grayia-Lycium* and *Coleogyne* vegetation types, while the fewest species are captured in *Larrea-Ambrosia* and *Lycium pallidum* associations.[15] However, the transitional nature of the vegetation types, soils, altitudinal gradients, and microclimates presents enough permutations so that interactions between small mammals and preferred vegetation types cannot presently be described quantitatively. The relationships can be used in some cases as qualitative indicators. For example, there is a change from *Dipodomys ordii* and *D. microps* in the northern, Great Basin vegetation types, to *D. merriami* in *Larrea-Ambrosia* in the southern part of the Nevada Test Site.

The abundance of small mammals is quite variable between species, years, vegetation types, and locations. Populations respond quickly to periods of good vegetative growth, reproduce in a matter of weeks, and can increase their densities at least five-fold within one breeding season.[111] There is an apparent correlation between production of winter annual plants and reproduction in desert rodents on NTS,[50] although the causal mechanisms are still unclear.

During periods of poor food production few of the animals breed and some species of *Perognathus* enter periods of torpidity in their underground burrows. Studies in Rock Valley have shown that *Perognathus formosus* is

active aboveground only 30-40% of the time during summer, and is inactive for extended periods during midwinter.[107] It has been suggested that periods of torpor are an effective physiological mechanism for enhancing survival of the species during periods of stress due to adverse climatic conditions or scarcity of food. Periods of torpor may also contribute to the longevity of *Perognathus* compared with other small mammals. Although the average life spans of *Perognathus formosus* and *P. longimembris* are about 2 months, many individuals live up to 3-5 years.[108,111]

Kangaroo rats and pocket mice show a high degree of territoriality in their aboveground activities. Although some members of all species appear to have an instinct to disperse long distances from their natal site,[110] others maintain home ranges whose centers of activity are remarkably stable from year to year.[190] The estimated mean home ranges (2.45-sigma radius) for the most numerous small mammals are: *Perognathus formosus*, 0.44 hectare; *P. longimembris*, 0.68 ha; *Dipodomys microps*, 1.32 ha; *D. merriami*, 2.62 ha.[190] Kangaroo rats weigh more and have larger home ranges than pocket mice, but within genera, size of home ranges is not related to body size. The areas of home ranges are variable and differ between species, sexes, years, and population densities.[190]

Populations of small mammals, especially those in Rock Valley, have been sampled intensively over the years, and excellent information has been gathered on population dynamics, seasonal activities, food habits, movements and home ranges, and responses to chronic radiation exposure.[107,108,110,111,190] Comparatively little is known about the populations of medium-sized and large mammals of NTS.

The black-tailed jackrabbit, *Lepus californicus*, is the most conspicuous and widespread species of the larger mammals. It has been observed in all vegetation associations from the valley floors to the pinyon-juniper woodlands.[40] Little is known about their densities or population dynamics on NTS, and there is no evidence that they ever reach high densities,

which seems to be characteristic of species elsewhere in western North America. Two close relatives, *Sylvilagus audubonii,* desert cottontail, and *S. nuttallii,* Nuttall's cottontail, are also found on NTS. The former is more numerous, and is found in all vegetation types. Nuttall's cottontail is restricted to the higher elevations in the Great Basin vegetation associations.[140]

The most important carnivores include: coyote, *Canis latrans;* kit fox, *Vulpes macrotis;* badger, *Taxidea taxus;* bobcat, *Lynx rufus;* mountain lion *Felis concolor;* and long-tailed weasel, *Mustella frenata.* The coyote is the most widely distributed, conspicuous, and probably most numerous of the predatory mammals. The mountain lion is perhaps the most secretive, least numerous of the predators. It appears to be restricted to habitats on the northern mesas,[140] although a few sightings of lions have been made as far south as Mercury.

Mule deer, *Odocoileus hemionus,* are the most numerous large mammal, and can be found during all but the winter season on the high mesas in the *Artemisia* and pinyon-juniper vegetation associations.[140] No rigorous attempts have been made to estimate the size of the herd or determine its movements.

Pronghorn antelope, *Antilocapra americana,* and desert bighorn sheep, *Ovis canadensis,* are thought to be rare visitors on the site. There are a few sight records of antelope outside the northern boundary of NTS, but none of the animals moved onsite or remained nearby for any extended period. There are no authenticated sight records for bighorn sheep on NTS, but they are relatively abundant in mountain ranges to the east and they could easily wander onto NTS. Fecal droppings thought to be those of bighorn sheep have been recovered from mountains on the east side of Frenchman Flat.[140]

Wild horses, *Equus caballus,* and domestic cattle, *Bos taurus,* also range over parts of the test site. A band of about 20 mustangs is located in the vicinity of Rainier Mesa where they can obtain adequate food and

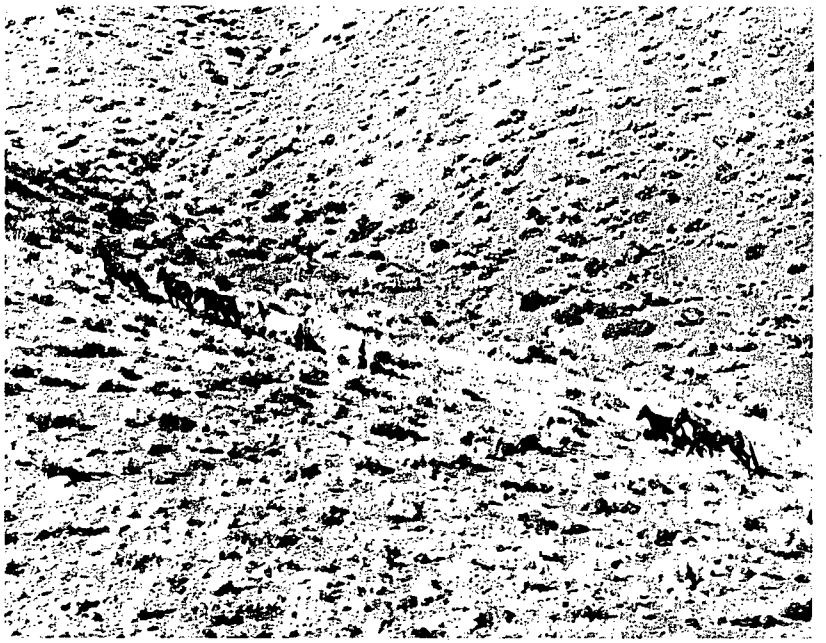


Figure 22. A small band of wild horses, *Equus caballus,* lives in the vicinity of the northern mesas and surrounding bajadas.

water (Fig. 22). Their numbers have not increased markedly over the last few years. A herd of cattle is maintained by the Environmental Protection Agency for ERDA on suitable ranges in the north-central portions of NTS. There are also occasional strays that wander across the northern boundaries. Although burros, *Equus asinus*, are common in several areas bordering on NTS, they have been sighted only rarely, near Cane, Topopah, and Captain Jack springs.

Only 4 species of bats, *Antrozous pallidus*, *Myotis californicus*, *Pipistrellus hesperus*, and *Plecotus townsendii*, have been observed, but special efforts have not been made to observe or capture them. There are several species having ranges overlapping NTS that will no doubt be found in the future.

ENDANGERED AND THREATENED SPECIES

No plants or animals occuring on the Nevada Test Site are presently on the Secretary of Interior's list of threatened and endangered wildlife (Part 17, Title 50, Code of Federal Regulations), as amended and republished in the *Federal Register*, September 26, 1975, Vol. 40(188): 44415-44429.

Recently a few sightings were made of American Peregrine Falcons flying over Yucca Flat. This species is on the Secretary of Interior's list of endangered and threatened wildlife. Because this species has been observed so rarely at NTS over a 25-year span, we assume that these recent sightings represent transient birds. The Prairie Falcon, which does occur on site, has been recommended periodically for listing as a threatened species, but it does not have that status presently.

The Smithsonian Institution has recommended to the Congress of the United States (House Document 94-51, 1975) that the following species of flora, known to exist on the Nevada Test Site, be given Federal protection under two categories:

Endangered	Threatened
Astragalus beatleyae	*Agave utahensis* var. *eborispina*
A. nyensis	*Arctomecon merriamii*
Camissonia megalantha	*Arabis shockleyi*
Frasera pahutensis	*Astragalus funereus*
Lathyrus hitchcockianus	*Coryphantha vivipara* var. *rosea*
Mirabilis pudica	*Ephedra funerea*
Penstemon pahutensis	*Eriogonum concinnum*
Phacelia beatleyae	*Gilia nyensis*
Trifolium andersonii ssp. *beatleyae*	*G. ripleyi*
	Haplopappus brickellioides
	Linanthus arenicola
	Phacelia mustelina

The State Board of Fish and Game Commissioners is empowered (Nevada Revised Statutes, Section 501:110, General Regulation 1, Amendment 5) to preserve, protect, manage, and restore wildlife, including non-game species, within the State of Nevada. Game animals, fur-bearing animals, game birds, migratory game birds, game fish, and game amphibians are managed through regulated hunting, trapping, and fishing. The State extends special protection to certain species considered to be endangered or rare within Nevada. Species on the Nevada Test Site that fall within the State's protected classifications include: kit fox; spotted bat; all eagles, falcons, hawks and owls; Osprey; Turkey Vulture; Belted Kingfisher; White Pelican; White-faced Ibis; Common Nighthawk; Lesser Nighthawk; Roadrunner; and desert tortoise.

RESUME

The U. S. Energy Research and Development Administration's Nevada Test Site (NTS) occupies 1,350 square miles of desert terrain 70 miles northwest of Las Vegas. Since its selection in 1950, NTS has provided a safe, secure area for testing of nuclear devices in the atmosphere (until July, 1962) and underground. The site lies in an area that is geologically complex and has deposits of igneous, sedimentary, and metamorphic

rocks spilling downslope from mountains into several large basins. Except for a few small springs, there is no permanent surface water.

The climate exhibits extremes in temperature, precipitation, and wind velocity, as well as great variability in these parameters. At Yucca Flat temperature extremes are between 110°F and -14°F. Average annual precipitation ranges from 4 to 12 inches, increasing with increasing elevation, and is highly variable between sites and from year to year.

Most soils have developed on alluvial deposits of mixed origins and characteristically have: coarse texture; an accumulation of carbonates within a few feet of the surface; low organic matter content; and low carbon/nitrogen ratios. Moisture reserves of the soil profiles seldom exceed field moisture capacity except during the period of winter precipitation.

The site lies on the transition between the Mohave and Great Basin deserts; consequently, the flora and fauna consist of species characteristic of both deserts. A total of 711 taxa of vascular plants have been collected in the 6 to 7 major vegetation types. Distributions of the Mohave Desert, Great Basin Desert, and transitional vegetation associations are closely linked to temperature extremes, precipitation, and soil conditions.

At least 1,028 taxa of invertebrates within the Phylum Arthropoda have been identified: 80% of the known arthropods are insects. Ants, termites, and ground-dwelling beetles are probably the most important groups of insects as regards distribution, abundance, and functional roles.

Goldfish and golden shiners have been introduced into ponds and springs on NTS.

The reptilian fauna includes 1 species of tortoise, 14 species of lizards, and 17 species of snakes. The most abundant, widely distributed lizards

include the side-blotched lizard, western whiptail, desert horned lizard, and desert spiny lizard. Reproduction in side-blotched lizards is correlated with winter rainfall (and production by winter annual plants). The western shovel-nosed snake is the most common snake on NTS, and there are at least four species of poisonous snakes. There are no known records of amphibians collected on NTS.

There are records of 190 species of birds observed on the Nevada Test Site, 86% of which are transients. Only 27 species are permanent residents. In winter the Nevada Test Site provides feeding grounds for thousands of small passerine birds, many of whom remain as winter residents. For such an arid location there are a surprising number of transient waterfowl and shore birds. In addition to waterfowl, the only known game birds are Gambel's Quail, Chukar, and Mourning Dove.

A total of 42 terrestrial mammals and 4 species of bats have been recorded. Rodents account for half of the known species and are the most abundant and widespread group of mammals on NTS. There is an apparent correlation between production by winter annual plants and reproduction in desert rodents on NTS. Larger mammals on the site include: black-tailed jackrabbit, desert and Nuttall's cottontails, coyote, kit fox, badger, bobcat, and mountain lion. A herd of mule deer is located on the high mesas. Wild horses and domestic cattle range over parts of the Nevada Test Site, and pronghorn antelope, bighorn sheep, and burros are thought to be rare visitors.

None of the species of flora and fauna is presently listed in the *Federal Register* as being either endangered or threatened.

Annotated Bibliography

GUIDE TO BIBLIOGRAPHY USAGE

Structure

A simple alphabetical order governs single authorships. Multiple authorships are listed 1) alphabetically by the senior author's name, 2) according to the *number* of coauthors, and 3) alphabetically by coauthors' names. Ascending chronological order is used within each group of alphabetically-ordered citations.

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Document Availability

Indicated parenthetically after each citation is the name of an agency of institution the reader may contact to obtain a copy of that document. Nearly all documents cited may be obtained from either the National Technical Information Service, Springfield, Virginia 22151, or the Technical Information Center, P. O. Box 62, Oak Ridge, Tennessee 37830.

Document Referencing

Citations contain the identification numbers necessary for document retrieval. In many instances, these numbers are preceded by a letter prefix which provides information concerning the document's origin. The prefix may indicate the author's affiliation with a private research institute, a government agency, or a specific government program. A key to letter prefixes, as well as general abbreviations, follows.

KEY TO ABBREVIATIONS

General

AEC	United States Atomic Energy Commission (now United States Energy Research and Development Administration)
EPA	United States Environmental Protection Agency
ERDA	United States Energy Research and Development Administration
NTIS	National Technical Information Service (formerly Clearinghouse for Scientific and Technical Information (CFSTI)), U. S. Dept. of Commerce
TIC	Technical Information Center (formerly Division of Technical Information Extension (DTIE)), U. S. Energy Research and Development Administration
USAEC	United States Atomic Energy Commission
USGS	United States Geological Survey, U. S. Dept. of Interior

Prefixes

BNWL	Battelle, Pacific Northwest Laboratories
CEX	Civil Effects Experiment (precedes number assigned by Civil Effects Test Operations, ERDA)
CONF	Conference (precedes number assigned to conference documents by the Technical Information Center)
COO	Chicago Operations Office, U. S. ERDA
EGG	Egerton, Germeshausen, and Grier, Inc.
ERLTM-ARL	Environmental Research Laboratories Technical Memorandum, Air Resources Laboratory - Las Vegas, U. S. Dept. of Commerce
HW	Hanford Works (formerly General Electric; now several contractors)
IAEA	International Atomic Energy Agency
LA	Los Alamos Scientific Laboratory, University of California
NERC-LV	National Environmental Research Center - Las Vegas (now Environmental Monitoring and Support Laboratory), U. S. EPA

NVO	Nevada Operations Office, U. S. ERDA
ORNL	Oak Ridge National Laboratory
PNE	Peaceful Uses for Nuclear Explosives (part of the U. S. ERDA's Plowshare program)
SAN	San Francisco Operations Office, U. S. ERDA
SC-M	Sandia Laboratories
SC-RR	Sandia Corporation
SM	Precedes document number assigned by International Atomic Energy Agency
SWRHL	Southwestern Radiological Health Laboratory (now Environmental Monitoring and Support Laboratory, U. S. EPA)
TID	Precedes document number assigned by Technical Information Center
UCLA	University of California, Los Angeles
UCRL	University of California Radiation Laboratory (now University of California Lawrence Livermore Laboratory)
USGS	United States Geological Survey, U. S. Dept. of Interior
WASH	ERDA Headquarters, Washington, D. C.
WT	Weapons Tests (joint project of the U. S. ERDA and the U. S. Dept. of Defense)

1 ALLRED, D. M. 1962. Mites on grasshopper mice at the Nevada atomic test site. Great Basin Nat. 22:101-104.

Grasshopper mice, *Onychomys torridus longicaudus* were examined for ectoparasites. Approximately the same percentage of mice was infested in one community as in another. Relatively more mice were infested during June and October than in other months, although the average number of mites found on the mice were highest in August and December. The peak in December was due to heavy infestation of chiggers and to mesostigmatids in August. Of the twelve mite species found on this mouse at the Nevada Test Site, *Haemolaelaps glasgowi* and *Ischyropoda armatus* were the most frequent in occurrence. Greatest numbers of individuals belonged to *Ischyropoda armatus*, *Odontacarus linsdalei*, *Euschöngastia criceticola*, and an undescribed species of chigger mites. (HP)

2 ALLRED, D. M. 1962. Mites on squirrels at the Nevada atomic test site. J. Parasitol. 48:817.

White-tailed antelope squirrels, *Ammospermophilus leucurus leucurus*, were examined for ectoparasites. Although they were commonly infested with lice, fleas, ticks, mites were found on only 10 percent of the squirrels. The predominant species of mite found was *Haemolaelaps glasgowi*. These mites were found in about equal numbers in the major plant communities of the test site. Other mites found were one specimen of a chigger, *Euschöngastia* sp. and nine of the family *Dermanyssidae*. There apparently are few mites on squirrels at the Nevada Test Site, although several species, especially the chiggers, are found abundantly on other rodent species living in close association with the squirrels. (HP)

3 ALLRED, D. M. 1963. Mites from pocket mice at the Nevada Test Site (Acarina). Proc. Entomol. Soc. Wash. 65:231-233.

Totals of 156 *Perognathus formosus*, 473 *Perognathus longimembris* and 23 *Perognathus parvus* were examined for mites from 1959-1962. They were collected from most of the major plant communities. Percentages of mice infested with representatives of 14 species of mites were 30 percent of the *P. formosus*, 16 percent of *P. longimembris* and 43 percent of *P. parvus*. The mites found most commonly on pocket mice at the NTS were mesostigmatids of the species *Haemolaelaps glasgowi* and *Hirstionyssus hilli*, and the chiggers *Euschöngastia criceticola* and *Trombicula arenicola*. (HP)

4 ALLRED, D. M. 1965. Note of phalangids at the Nevada Test Site. Great Basin Nat. 25:37-38.

Eurybunus riversi was found widely distributed geographically at the test site. They are present in all the plant communities.

Their seasonal activity is predominantly during the winter months. *Leiobunum townsendi* is a common species in the western United States, but at the test site only four specimens were found. These were taken in a Pinyon-Juniper community during July and August. This species is likely more typical of the higher and more northern communities than of the Lower Sonoran and Mohave areas. (HP)

5 ALLRED, D. M. 1967. Ecological consideration of nuclear detonations and Acarina related to zoonoses. In: Proc. Second International Congress of Acarology (CONF-670703-1), p. 627-629. (TIC, Oak Ridge, TN 37830)

Studies of the ecology of animals at the Nevada Test Site are reported. Ectoparasites were more numerous on rodents living adjacent to buried nuclear waste than on those living in areas of normal background radiation. Factors determining the maintenance and spread of zoonoses are discussed. It is pointed out that immunity of animals to infestation by ectoparasites may be affected either adversely or favorably by inhabitation of irradiated areas. (HLW)

6 ALLRED, D. M. 1969. Lepidoptera of the Nevada Test Site. Great Basin Nat. 29:42.

Moths and butterflies of the Nevada Test Site are identified both generally and specifically and alphabetically arranged for convenience. (HP)

7 ALLRED, D. M. 1969. Bees of the Nevada Test Site. Great Basin Nat. 29:20-24.

Between 1959 and 1965, bees representing 71 species of 35 genera were collected from plants of more than 40 species at the Nevada Test Site. Bees of nine of the species are new to science, and six others possibly are new. Most specimens were taken during June and July, but some were found as early as March and others as late as September. Bees of greatest abundance, as indicated by those collected, were *Dialictus albohirtus*, *Tetralonia* n. sp. "pr," *Anthophora urbana*, and *Centris rhodopus*. Those with the widest geographic distribution at the test site were *Dialictus hyalinus*, *D. albohirtus*, and *Anthophora urbana*. The species found on the greatest variety of plants was *Dialictus albohirtus*. A greater variety of bees was found on *Stanleya pinnata*, *Asclepias erosa*, and *Petradoria pumila* than on other plants. (Auth)

8 ALLRED, D. M. 1971. Ecological notes on recently described Myriapods from Nevada. Great Basin Nat. 31:161-163.

Chilopods of six species and millipeds of four species are known from the Nevada Test Site. Those of greatest abundance and most

widespread ecologically are *Scolopendra michelbacheri* and *Arinolus nevadae*, respectively. Myriapods were more abundant in the *Pinus-Juniperus*, *Grayia-Lycium*, *Lycium*, and mixed brush plant communities. Greatest numbers were found during November from 1959 to 1962. (HP)

9 ALLRED, D. M. 1972. Notes on Nevada solpugids. Great Basin Nat. 32:120.

Hemerotrecha branchi was taken at Cane Springs, Nevada Test Site, and *Hemerotrecha jacintoana* was collected in a *Coleogyne* plant community, extending its range to Nevada. (TPO)

10 ALLRED, D. M. 1973. Effects of a nuclear detonation on arthropods at the Nevada Test Site. Brigham Young Univ. Sci. Bull., Biol. Ser. 18(4), 20 p.

Fifty-three arthropod species were studied in an area affected by an underground nuclear detonation (Project Sedan). These were represented by 10 species of ants, 17 beetles, 5 orthopterans, 4 scorpions, 6 solpugids, and 11 spiders. Relative populations were determined prior to the detonation and at three periods after the detonation: 1) one and two months after (August and September 1962), 2) 11 months after (June 1963), and 3) 13 months after (August 1963). One and two months after the detonation, the number of species was reduced from the expected by 48%, by 52% after 11 months, and by 66% after 13 months. Greatest reduction of specimens occurred with spiders, followed by ants and beetles. Fewest changes occurred in the number of scorpions. Populations of each group changed significantly in each period. Reductions from 30% to 100% occurred in all groups in all periods after the detonation except for the scorpions one and two months after, when an increase of 160% was noted. After 11 months, spiders had increased 33%. Within specific sectors, populations did not vary significantly from the expected except in a few instances. In August and September 1962, immediately after the detonation, populations of arthropods in sectors 3, 4, and 5 were much higher than expected. This represented the area from approximately 65 m to 140 m from GZ. The increase may have been due primarily to the physical transport and initial survival of those arthropods living closer to GZ than 65 m. (Auth)

11 ALLRED, D. M. 1973. Records of Coreidae (Hemiptera) from the Nevada Test Site. Great Basin Nat. 33:123.

Arhyssus lateralis (Say), *Arhyssus* sp., *Harmostes angustatus* Van Duzee, *H. reflexulus* (Say) and *Liorhyssus hyalinus* (F.) were identified from approximately 240 coreids collected at the Nevada Test Site, USA. (JJB)

12 ALLRED, D. M. 1973. Additional records of mutillid wasps from the Nevada Test Site. Great Basin Nat. 33:156-162.

Ferguson (1967) listed 31 spp. of mutillids from the Nevada Test Site, USA. Three additional records are herein recorded: *Chyphotes melaniceps*, *C. petiolatus* and *Dasymutilla klugii*. Vegetational and ecological data are presented for each species. (JJB)

13 ALLRED, D. M., and D E. BECK. 1962. Ecological distribution of mites on lizards at the Nevada atomic test site. Herpetologica 18:47-51.

Ecological investigations at the Nevada Test Site included studies of reptiles and their ectoparasites. It was noted that an analysis of data shows that the areas of greatest infestation by two species of mites, *Odontacarus arizonensis* and *Eutrombicula belkini* were in the directions of fallout from atomic detonations. The data are presented in the following sequence for each species of mite: host, dates of collection with total number of mites collected, numbers of lizards from which taken. (HP)

14 ALLRED, D. M., and D E. BECK. 1963. Comparative ecological studies of animals at the Nevada Test Site. In: (Schultz, V., and A. W. Klement, Jr., eds.) *Radioecology*, Proc. First National Symp. on Radioecology, p. 327-331. (Reinhold Publ. Corp., New York, NY 10022)

Brigham Young University studied the comparative ecology of the native fauna of the Nevada Test Site beginning in 1959 to investigate the effects of nuclear detonations on animals. This was one of three separate projects operating in a coordinated manner. New Mexico Highlands University studied effects of nuclear testing on desert plants, and the University of California at Los Angeles studied biological availability of radionuclides to both plants and animals. The Brigham Young University group determined kinds, populations, geographical and seasonal distribution, migration, home range and other habits of native animals. Tissue changes of animals contaminated with radioactivity were compared with animals from noncontaminated areas. The greatest total number of animal species was found in areas disturbed by nuclear tests. The second greatest number of species was found in the *Larrea* community which may be typical of the Mohave. The greatest numbers of individuals of invertebrates were found in disturbed areas but this was not true of mammals. Kangaroo rats in disturbed areas ranged from three to ten times farther than those in undisturbed communities. (HP)

15 ALLRED, D. M., and D E. BECK. 1963. Ecological distribution of some rodents at the Nevada atomic test site. Ecology 44:211-214.

There were varied correlations between occurrence and relative abundance of rodents and total plant cover at the test site.

Plant height plus cover may be important, for animals of 7 or 8 species studied were most common in the 2 plant communities *Coleogyne* and *Grayia-Lycium*, where the product of total cover multiplied by average height of predominant plants was greatest. The texture of the soil is an important influencing factor, especially for burrowing animals. Antelope squirrels, grasshopper mice, little pocket mice, long-tailed pocket mice and Merriam's rats were most abundant at the test site where average penetrability of the soil was more than 50 cm and there were relatively few rocks larger than approximately 3 cm in diameter. (HP)

16 ALLRED, D. M., and D E. BECK. 1963. Range of movement and dispersal of some rodents at the Nevada atomic test site. J. Mammalogy 44:190-200.

Range of movement and dispersal of *Ammospermophilus leucurus*, *Dipodomys merriami*, *D. microps*, *Onychomys torridus*, *Peromyscus maniculatus*, *Perognathus formosus* and *P. longimembris* were studied for over a year at the Atomic Test Site, Mercury, Nevada. Traps were operated more than 25,000 trap nights in five different plant associations. Recapture data, range of movement distances, maximum dispersal distances and range of movement patterns are given. The influence of nuclear disturbance on range of movement of small mammals was noticeable. This is not unusual, for one may expect physical disturbance of any landscape caused by such factors as overgrazing, flooding, burning or erosion to result in ranges of different size from undisturbed areas. (Auth) (HP)

17 ALLRED, D. M., and D E. BECK. 1964. Arthropod associates of plants at the Nevada Test Site. Brigham Young Univ. Sci. Bull., Biol. Ser. 5(2), 16 p.

Plant-arthropod associations related to the predominant plants in several plant communities at the Nevada Test Site were determined. Special emphasis has been directed to the identification of kinds, relative numbers, seasonal incidence, and distribution relative to plant communities as well as plant species. Plants of eleven species were studied. (HP)

18 ALLRED, D. M., and D E. BECK. 1964. Mites on reptiles at the Nevada atomic test site. Trans. Amer. Microscopical Soc. 83: 266-268.

Additional records of mites found on reptiles at the Nevada Test Site included the host's name, the numbers examined and found infested, the number and stage of development of the mites, the date of collection and the plant community where known. The mites on snakes were found under the ventro-lateral scales. The predominant species at the Nevada Test Site was *Trombicula arenicola*. In these studies *Sauromalus obesus* seemed to be their preferred

host. The predominant mite on lizards at the Nevada Test Site was *Odontacarus arizonensis*. (HP)

19 ALLRED, D. M., and D E. BECK. 1965. A list of Scarabaeidae beetles of the Nevada Test Site. Great Basin Nat. 25:77-79.

Studies dealing with selected groups of arthropods yielded a number of beetles of the family Scarabaeidae. In sequence of greatest abundance, the most common species known to occur at the test site are *Paracotalpa granicollis*, *Aphodius fucosus*, *Diplotaxis subangulata* and *Aphodius nevadensis*, respectively. Seasonally, the greatest numbers of species in the adult stage were most active in July, June, August and May, respectively, although greatest numbers of individuals were found in January, July, April, August and December. (HP)

20 ALLRED, D. M., and D E. BECK. 1967. Spiders of the Nevada Test Site. Great Basin Nat. 27:11-25.

During 1959-1965 more than 5600 spiders were collected on the Nevada Test Site, and included 94 species of 65 genera in 22 families, not counting approximately 17 new species to be reported on later. The greatest number of spiders were collected in June-July although populations remained high between June-September. The greatest numbers of species were collected in the *Coleogyne* and mixed vegetation associations, while the largest populations were found to be in the *Coleogyne* and *Salsola* associations. Fewest species were found in the Pinyon-Juniper association, and the lowest populations were in the *Grayia-Lycium* association. (TPO)

21 ALLRED, D. M., and M. A. GOATES. 1964. Mites from mammals at the Nevada Test Site. Great Basin Nat. 24:71-73.

Additional collections of mites on vertebrate hosts represent eleven new mite-host associations, ten new distribution records for the test site and apparently for Nevada and an unusual record of erythraeid mites of the genus *Caeculisoma* crawling on bats. These larvae are normally parasitic on arthropods. (HP)

22 ALLRED, D. M., and M. A. GOATES. 1964. Mites from wood rats at the Nevada nuclear test site. J. Parasitol. 50:171.

Twenty-seven species of mites were taken from 56 wood rats, *Neotoma lepida*. The two most common species taken were *Erenisterna utahensis* and *Trombicula allredi*. Except for five species of chiggers, mites occurred on the rats in relatively small numbers. Mesostigmatid mites were found throughout the year with greatest numbers taken during spring and summer. Chiggers occurred most frequently in late summer and autumn. (HP)

23 ALLRED, D. M., and S. MULAIK. 1965. Two isopods of the Nevada Test Site. Great Basin Nat. 25:43-47.

At the Nevada Test Site, 490 isopods of two species were collected. *Armadillo arizonicus* were most commonly associated with *Lycium pallidum* and least with *Atriplex confertifolia-Kochia americana*. *A. arizonicus* was active only in May through October. Highest populations occurred during August for adults and July through September for immatures. All but one of the 109 specimens of *Porcellio laevis* were taken at Cane Springs in a mixed plant community. Highest populations of adult males appeared August through December and females August through October. (HP)

24 ALLRED, D. M., D E. BECK and C. D. JORGENSEN. 1963. Biotic communities of the Nevada Test Site. Brigham Young Univ. Sci. Bull., Biol. Ser. 2(2), 52 p.

Studies by Brigham Young University were designed to develop standards of measurement to determine past nuclear effects, so far as possible, as well as to measure the effects of future tests. Study sites were established in (1) test areas where visible effects of nuclear detonations were obvious, (2) contiguous areas where no physical effects were evident, and (3) areas several miles distant from centers of nuclear detonations. Objectives were to determine kinds, population, seasonal occurrence, geographic and ecological distribution, migration, home range, and related habits of native animals in these areas. This report identified, delineated and described the major plant communities of the Nevada Test Site, and included a listing of predominant animals occurring in these communities, with a designation of their relative abundance and seasonal occurrence and listed phylogenetically all the species of animals known from the test site and communities in which they are found. (HP)

25 ALLRED, D. M., D E. BECK and C. D. JORGENSEN. 1963. Nevada Test Site study areas and specimen depositories. Brigham Young Univ. Sci. Bull., Biol. Ser. 2(4), 15 p.

This paper supplements the publication, "Biotic Communities of the Nevada Test Site" (Allred, Beck and Jorgensen, 1963) by supplying additional information on the specific location and ecological peculiarities of the collection stations and listing the depositories of the specimens. (HP)

26 ALLRED, D. M., D E. BECK and C. D. JORGENSEN. 1964. Close-in effects of an underground nuclear detonation on small mammals and selected invertebrates. USAEC Report PNE-226F, 22 p. (NTIS, Springfield, VA 22151)

Sedan was detonated in the northern portion of Yucca Flat where the native vegetation was probably *Coleogyne ramosissima*, *Grayia*

spinosa and *Lycium andersonii*. When Sedan was detonated, ground zero was surrounded almost entirely by herbaceous vegetation dominated by *Salsola kali*. Small mammal populations varied between the two vegetative zones before the test. *Perognathus parvus*, *Dipodomys ordii*, and *Dipodomys merriami* were more abundant in the Herbaceous zone, *Dipodomys microps* was more abundant in the Shrub zone, and *Ammospermophilus leucurus*, *Onychomys torridus*, and *Perognathus longimembris* were equally abundant in each zone. The vegetation had not established itself sufficiently one year after detonation to allow small mammals to reinvade post-test zone 1. (HP)

27 ALLRED, D. M., D E. BECK and C. D. JORGENSEN. 1965. A summary of the ecological effects of nuclear testing on native animals at the Nevada Test Site. Proc. Utah Acad. Sciences, Arts and Letters 42:252-260.

Abnormalities which may be definitely attributed to the effects of radiation on the somatoplasm or the germ plasm of the native animals were not found during the studies. Some differences which were found, such as changes in fur color, have also been observed elsewhere in areas not associated with nuclear testing and fallout. On the basis of ecological distribution in nuclear disturbed areas, however, differences were found in the species composition in areas where the biota were disturbed but not completely destroyed. For the most part, these studies dealt with the fauna of the basins, playas and valleys of the test site. (HP)

28 ALLRED, D. M., D. E. JOHNSON and D E. BECK. 1965. A list of some beeflies of the Nevada Test Site. Great Basin Nat. 25:5-11.

Several thousand beeflies were identified representing 111 species of 24 genera. The species, number of individuals collected, months of occurrence, and ecological distribution are given. Species which were taken in the most abundant numbers at the test site are *Lordotus albidus*, *Lordotus nigriventris*, and *Poecilanthrax apache*. The beeflies most widely distributed ecologically are *Paracosmus morrisoni*, *Poecilanthrax apache* and *Villa aenea*. The greatest number of species and individuals were found in mixed and *Larrea-Franseria* communities. Seasonally the greatest number of species and individuals occurred in May, June, April, and September, respectively. (HP)

29 ANDERSON, A. O., and D. M. ALLRED. 1964. Kangaroo rat burrows at the Nevada Test Site. Great Basin Nat. 24:93-101.

The nature of burrows made by the kangaroo rat, *Dipodomys microps occidentalis*, was studied. Such information is important in evaluating the radiation dosage a rat may receive while in its burrow, and the effects of soil compaction from over-pressure of a nuclear detonation. Data and illustrations are presented for the pattern of burrows in five habitats. Included in the data are burrow depths, number of openings and side-burrows, site of food caches and type of food stored within. (FMM)

30 ANONYMOUS. 1973. Selected census information around the Nevada Test Site. NERC-LV-539-8, 11 p. (Environmental Monitoring and Support Laboratory, Environmental Protection Agency, Las Vegas, NV 89114)

The National Environmental Research Center-Las Vegas (NERC-LV), Environmental Protection Agency, conducts a comprehensive off-site radiological safety program in support of nuclear testing at the Nevada Test Site (NTS). To facilitate the planning and management of required surveillance and monitoring operations, and to assess potential and actual population exposures resulting from radioactive releases into the areas beyond the boundaries of the NTS, the NERC-LV collects and maintains census information in the area around the NTS. This report summarizes this census information which includes the number and distribution of resident adults and children, family milk cows, and Grade A dairy cows located by azimuth and distance within a radius of 450 miles of Control Point 1 at approximately the center of the NTS, 36° 15' N, 116° 04' W.

31 ANONYMOUS. 1973. Environmental Statement: Underground nuclear testing program, Nevada Test Site, April, 1973. USAEC Report WASH-1526, 130 p. (NTIS, Springfield, VA 22151)

The environmental impact of continuing underground nuclear tests and preparations for tests of one megaton or less at the Nevada Test Site (NTS) is reported. Information is included on the selection, geology, hydrology, environmental setting, and history of the NTS; the seismic and radiological impact of underground nuclear explosion testing; the commitment of resources; alternatives to testing; and review procedures. Two appendices of bio-environmental studies of the NTS and comments by the AEC and other agencies on the environmental impact report are included. It is concluded that the environmental impact due to continued testing at the NTS will be small. No observable or significant environmental effects are expected from radioactivity release. The explosions will create several nuclear subsidence craters, minor rock falls on cliffs in the area, and underground pockets of high radioactivity, but only minor property damage from ground motions

and no triggering of earthquakes. The benefits to nuclear weapons technology and Plowshare technology from continued underground testing are considered to exceed the environmental costs. (LCL)

32 ANONYMOUS. 1975. Underground nuclear testing program, Nevada Test Site: Final Supplement to Environmental Statement WASH-1526 (April 1973). WASH-1526 Supplement, 76 p. (NTIS, Springfield, VA 22151)

This document supplements Environmental Impact Statement WASH-1526 which assessed the environmental impact of underground nuclear tests and preparations for tests of one megaton or less at the Nevada Test Site. Significant new information on waste management and the Nevada Applied Ecology Group is included. (TPO)

33 ANSPAUGH, L. R., P. L. PHELPS, N. C. KENNEDY and H. G. BOOTH. 1973. Wind-driven redistribution of surface-deposited radioactivity. In: Proc. Symposium on Environmental Behaviour of Radionuclides Released in the Nuclear Industry, Aix-en-Provence, France, 1973 (CONF-730503), p. 167-184. (Available as STI/PUB-345 from Unipub, Inc., Box 433, Murray Hill Station, NY, NY 10016)

The deposition of radionuclides on a terrestrial surface can result in the delivery of dose to man through external radiation exposure, food chain contamination or inhalation of suspended particles. ^{239}Pu is one of the few radionuclides generally regarded as constituting an inhalation hazard through wind-driven resuspension. No adequate models of resuspension exist. Two major problem areas have been identified: the rate at which initially deposited debris weathers into a less erodible state as a function of time, and a source term factor in material removed per unit time per unit area, applicable to a source of any configuration. In experiments conducted at the US Atomic Energy Commission's Nevada Test Site, concentrations in air of particles moving in suspension were studied over a period of six weeks following the nuclear cratering event Project Schooner and over a 10-month period following accidental venting of an underground nuclear explosion. Suspended air activity was observed to decrease in time with half-times of from 35 to 80 days; this factor appears to be much more important than variations in meteorological parameters over these relatively short time periods. Movement of small particles in suspension accounts for only a minor fraction of the total mass movement. As much as 50% of the initially deposited debris was moved by saltation within a 24-hour period. Such movement can result in extensive micro-inhomogeneities with accumulation of debris under bushes or other places affording shelter from erosive forces. More detailed study of the resuspension process in an aged ^{239}Pu field is now in progress. Preliminary data are given on the particle size distribution of the total mass and the ^{239}Pu moving in suspension. (Auth)

34 ANSPAUGH, L. R., P. L. PHELPS, N. C. KENNEDY, H. G. BOOTH, R. W. GOLUBA, J. R. REICHMAN and J. S. KOVAL. 1974. Resuspension of plutonium: a progress report. USAEC Report UCRL-75484, Preprint, 111 p. (See also 86.) (NTIS, Springfield, VA 22151)

Progress is reported for a research program on the resuspension in the atmosphere of plutonium fallout deposited on the earth surface. The long-range goal of the resuspension studies is to produce a set of equations which can be used to predict the time-dependent average concentration of resuspended material downwind from a source of any geometrical configuration and soil surface characteristics. The experiments are conducted at the Nevada Test Site where plutonium-high explosive tests were performed from 1954 to early 1956. The investigations have included: monitoring of soil samples for PU; development of ultra-high volume air samplers, in-situ particle spectrometers, particle counters, and a micrometeorology field laboratory; determination of Pu redistribution due to the rolling of soil particles pushed by winds (creep), the bouncing of wind-pushed particles (saltation), and transport by dust devils; and measurements of meteorological parameters. Results from these experiments will be used to establish a data bank on radioisotope distribution and meteorological conditions at NTS and to provide information of the relation between the source and the dose to man from existing radioactivity. (LCL)

35 BARNUM, A. H. 1964. Orthoptera of the Nevada Test Site. Brigham Young Univ. Sci. Bull., Biol. Ser. 4(3), 134 p.

Orthoptera at the Nevada Test Site were studied in depth to classify species and provide taxonomic keys for differentiation, evaluate populations, and determine seasonal and geographic distribution in areas disturbed by atomic explosions as compared to undisturbed areas. Field observations were made from nine regular collection sites and four less frequently visited areas over a period of four years. All of the species are reported including environmental relationships of the Orthoptera. Each species represented was studied for variability, and measurements were made for representative specimens. Four of the recognized sub-orders, 9 families, 41 genera, and 60 species and subspecies were collected. An annotated listing is presented. No statistical data was given with reference to possible radiation effects. It was noted that in areas of complete destruction, few Orthopterans are found, perhaps due to the scarcity of vegetation. In geologically disturbed areas large numbers were found and in areas where no nuclear effects were noted, few Orthoptera were present. (BBM) (LE)

36 BARR, W. F. 1969. The Buprestidae and Cleridae of the Nevada Test Site (Coleoptera). Great Basin Nat. 24:11-19.

A preliminary listing of the species and descriptions are given of specimens of beetles belonging to the families Buprestidae and Cleridae. These specimens were collected at the Nevada Test Site between July 2nd and August 2nd in 1960, 1961 and 1962. (FMM)

37 BEATLEY, J. C. 1962. Vascular plants of the U. S. Atomic Energy Commission's Nevada Test Site, Nye County, Nevada. USAEC Report UCLA-508, 33 p. (UCLA, Los Angeles, CA 90024)

Taxa lists are given for vascular plants of the Nevada Test Site in Nye County, Nevada. Specimens were collected from 1958-1962 and are either included in the general herbarium or as voucher specimens in connection with field study plots. Distribution data given is based on specimens from drainage basins in the test site area. Geographic description of the area is given.(BBM)

38 BEATLEY, J. C. 1965. Effects of radioactive and nonradioactive dust upon *Larrea divaricata* Cav., Nevada Test Site. In: (Hungate, F. P., ed.) *Radiation and Terrestrial Ecosystems*, Health Physics 11:1621-1625.

Among populations of *Larrea divaricata* Cav., monitored for ionizing radiation exposure following nuclear detonations which occurred in July 1962 at the Nevada Test Site, two also sustained heavy coatings of fine-particle dust. All dust-covered plants eventually became defoliated during the following year; in those irradiated but not dust-coated, there was no defoliation. One of the dusted populations was exposed to 4000-6000 roentgens during this year, and the other to negligible dosages; defoliation and subsequent death of stems in the irradiated population was evidently the result, therefore, of dust effects and not the ionizing radiation. Defoliated plants have recovered or are recovering by basal and/or stem sprouts. (Auth)

39 BEATLEY, J. C. 1965. Ecology of the Nevada Test Site. I. Geographic and ecologic distributions of the vascular flora (annotated checklist). USAEC Report UCLA 12-553, 69 p. (UCLA, Los Angeles, CA 90024)

A checklist of vascular plants of the Nevada Test Site is presented for use in studies of plant ecology. Data on the occurrence and distribution of plant species are included. Collections were made from both undisturbed and disturbed sites. (CH)

40 BEATLEY, J. C. 1965. Ecology of the Nevada Test Site. II. Status of introduced species. USAEC Report UCLA 12-554, 39 p. (UCLA, Los Angeles, CA 90024)

Bromus rubens, *B. tectorum* and *Salsola kali* are the most successful introduced alien species of flora on the Nevada Test Site. *Bromus rubens* is now part of undisturbed shrub communities, especially *Coleogyne* at middle elevations, and is abundant on burned areas at middle elevations. *B. tectorum* occurs at higher elevations where it is essentially restricted to disturbed areas. It is actively increasing its areal distributions as an accompaniment of disturbances of the higher elevations. *Salsola kali* is restricted

to sites where the physical characteristics of the soil surface have been modified and shrubs killed or inactivated. (TPO)

41 BEATLEY, J. C. 1965. Ecology of the Nevada Test Site. III. Survival of winter annuals, 1963-64. USAEC Report UCLA 12-555, 21 p. (UCLA, Los Angeles, CA 90024)

Summarizes the survival of winter annuals on the Nevada Test Site in the growing season of 1963-64. Survival varied between 21-63% in Yucca Flat; 10-15% in Jackass Flats; and 40% in Rock Valley. Elimination of the majority of seedlings before reaching maturity was inferred as being a regular phenomenon. Soil moisture regimes following germination were largely responsible for the level of survival reached with species-specific differences noted. (TPO)

42 BEATLEY, J. C. 1965. Ecology of the Nevada Test Site. IV. Effects of the Sedan detonation on desert shrub vegetation in northeastern Yucca Flat, 1962-65. USAEC Report UCLA 12-571, 55 p. (UCLA, Los Angeles, CA 90024)

Vegetation and environmental parameters were measured on three sites over three years in the vicinity of the Sedan crater to evaluate the effects of the manipulation on the native flora. The first post-Sedan populations of winter annuals were large and vigorous, which was interpreted as being partly due to "stimulation" effects of ionizing radiation on winter annual embryos. The apparent effects were not seen in later years. Direct effects of radiation on flora were obscured by the multiplicity of environmental factors impinging on the vegetation coupled with non-nuclear sources of damage such as heavy loads of dust. (TPO)

43 BEATLEY, J. C. 1966. Ecological status of introduced brome grasses (*Bromus* spp.) in desert vegetation of southern Nevada. Ecology 47: 548-554.

Of the plant species introduced on the Nevada Test Site, Nye County, Nevada, *Bromus rubens* and *B. tectorum* are well established in the present vegetation mosaic. *B. rubens* is frequently the dominant winter annual species in *Coleogyne* (blackbrush) communities at 4000-5000 ft. Relative density (or absence) of populations is a site characteristic, as indicated by quantitative data from 18 study sites in Yucca Flat in the years 1963-1965. Like the native species, it occurs in higher densities on disturbed sites of areas where it is already established in the undisturbed vegetation. Its success is in part due to a growth regime and environmental requirements like those of the native winter annuals, and perhaps to higher percentage survival to maturity as in the 1963-1964 season. It is not aggressive in the region today. *B. tectorum* is confined to disturbed sites at the higher elevations (5000-7500 ft) where vegetation is *Artemisia* (sagebrush) or *Artemisia*-Pinyon-Juniper. It is numerically and areally increasing with

an increase in disturbed sites at these elevations. Fire is promoted by both species, but the contribution of *B. rubens* is much greater, either directly or indirectly because it is identified with *Coleogyne* vegetation, the shrub type in the region most susceptible to fire. (Auth)

44 BEATLEY, J. C. 1966. *Mirabilis pudica* populations in southern Nye County, Nevada. Leaflets of Western Botany 10:294-296.

Describes pubescent individuals of *Mirabilis pudica* collected on the Nevada Test Site, and also includes information on distribution and relative abundance. (TPO)

45 BEATLEY, J. C. 1966. Winter annual vegetation following a nuclear detonation in the northern Mojave Desert (Nevada Test Site). Radiation Botany 6:69-82.

Winter annual vegetation and environmental phenomena were observed and measured through the growing seasons of 1962-1965, on 3 sites in northeastern Yucca Flat within 2 miles of the Sedan underground thermonuclear detonation in July 1962. Cumulative gamma radiation recorded was of the magnitude of 4000-13,000 R. As a result of the regional precipitation regime in the autumn of 1962, there were no winter annuals present in the Sedan area, or in most other parts of the Test Site, during the growing season 1962-1963. Seedlings of the first post-Sedan populations, which appeared following September 1963 rains, were the largest and most vigorous of populations observed in any region of the Test Site. The exceptional size and vigor continued through the period of anthesis in May 1964, and were corroborated by measurements of average height, cover, biomass and survival of the spring populations, as compared with those on seven other sites in central and northern Yucca Flat. In the next generation, germinated in the spring of 1965 following record precipitation (4-5 in.), there was neither higher survival of the Sedan populations nor exceptional development at any stage during the several-week growing season. The unusual vigor of the winter annual populations in the 1963-1964 season is inferred to have been in part a "stimulatory" effect of the ionizing radiation to which the embryos in the seeds were exposed from July 1962 until time of germination in September 1963. Abnormal morphological development of frequent individuals of *Chaenactis stevioides*, the dominant winter annual on the Sedan sites, may also have been an effect of seed irradiation. (Auth)

46 BEATLEY, J. C. 1967. Ecology of the Nevada Test Site. V. Winter annual survival data. USAEC Report UCLA 12-650, 36 p. (UCLA, Los Angeles, CA 90024)

Data on survival of winter annual plants of the Nevada Test Site are presented in tabular form for the years 1963-64 and 1964-65. (TPO)

47 BEATLEY, J. C. 1967. Survival of winter annuals in the northern Mojave Desert. Ecology 48:745-750.

Following early autumn germination in Mojave Desert winter annual populations (53 taxa) sampled on 13 plots (total sample size, 16.4 m^2) in three drainage basins in southern Nevada, 1963-1964, there was 38 percent survival to maturity (plot range 10-63 percent). Death occurred in early spring, at the time of shift from the slow vegetative growth of winter to the beginning of stem elongation. Despite no marked precipitation deficiencies during the 7 to 8 month growing season, mortality apparently resulted from inadequate soil moisture to meet the demands of all seedlings at the point in the life cycle of a manyfold increase in plant volume. Mean percentage survival to maturity of seedlings (58 taxa), sampled on 62 plots (total sample size, 62 m^2) in seven drainage basins, following spring germination after rains of 3--5.5 inches in March-April 1965, was 60 percent (range by basin, 44-83 percent). Mortality in these populations, whose life cycles were completed in 6-10 weeks, could not be attributed to inadequate moisture levels. In most seasons, regardless of precipitation regimes, the majority of seedlings of desert annuals probably do not survive to maturity. (Auth)

48 BEATLEY, J. C. 1969. Biomass of desert winter annual plant populations in southern Nevada. Oikos 20:261-273.

Biomass of mature desert winter annual populations was measured during three growing seasons, which included the possible extremes in length, in 68 Mojave and Great Basin Desert communities. Precipitation was measured concurrently. Biomass was highly variable from site to site, and season to season. Its site variability was related primarily to local edaphic variables and was usually not correlated with the shrub dominants of the site; seasonal variations were related, directly or indirectly, to the rainfall regimes. Values ranged from 0 to 616 kg/ha on sites with undisturbed soils, and seasonally were 2 to 5 times higher on burned sites than on comparable unburned sites in the same area. Maximum site value was 753 kg/ha, obtained on a burned site where most of the weight was due to high density of *Bromus rubens* L., an introduced grass species. Although in two of the three years averaged site values were similar, the biomass was overall the greatest in the 38 Mojave Desert communities, least in the 10 Great Basin Desert communities, and intermediate (if large contributions of *Bromus* on about half the sites are excluded) in the 20 communities considered transitional between the two desert regions. (Auth)

49 BEATLEY, J. C. 1969. Vascular plants of the Nevada Test Site, Nellis Air Force Range, and Ash Meadows. USAEC Report UCLA 12-705, 122 p. (UCLA, Los Angeles, CA 90024)

A compilation is presented of the vascular plants of the Nevada Test Site, Nellis Air Force Range and Ash Meadows. The plants

are classified according to phyla, namely Pterophyta (ferns), Coniferophyta (cone-bearing plants), and Anthophyta (flowering plants. The Coniferophyta and Anthophyta are subclassified into families, genus and species. Details are given of the geographical and ecological distribution.

50 BEATLEY, J. C. 1969. Dependence of desert rodents on winter annuals and precipitation. Ecology 50:721-724.

Winter annual parameters, postreproduction rodent densities, and precipitation, were recorded over 5 consecutive years, 1963-1968, on 15 sites in Jackass Flats, southern Nevada. When the rain critical to autumn germination came, winter annuals were present during autumn-to-spring, and there was spring reproduction in the rodents (as indicated by summer densities). When the critical rain failed to come, winter annual populations were negligible and the rodents did not reproduce in the spring. One season, half of the study sites received autumn rainfall adequate for germination, and the other half did not; summer rodent densities increased on the former and markedly decreased on the latter. Following extraordinarily heavy early spring rains, following an autumn essentially without rain, there was partially successful germination in early spring, and rodent reproduction occurred in the summer. It is concluded that occurrence and failure of reproduction in desert rodents are correlated with the presence and absence of winter annuals in the environment. The data suggest that dietary water (and vitamins), available in winter annual vegetation prior to or at time of onset of the breeding season, are requirements in the physiology of reproduction of heteromyid species. (Auth)

51 BEATLEY, J. C. 1970. Perennation in *Astragalus lentiginosus* and *Tridens pulchellus* in relation to rainfall. Madroño 20:326-332.

Following large germinations related to heavy spring rains in 1965, numbers of plants of *Astragalus lentiginosus* Dougl. var. *fremontii* (Gray) Wats. (Leguminosae) and *Tridens pulchellus* (HBK.) Hitchc. (Gramineae) were recorded during 2 or more consecutive years on study sites in the northern Mojave Desert of southern Nevada (Nevada Test Site). Numbers of *Astragalus* plants surviving after the first year were correlated with increased rainfall with increase in elevation (from almost no plants at 3800 ft to nearly all at 4800 ft). The large reproducing populations of this species in southern Nevada appear to be biennials with origins related to exceptional spring rains, and the perennial habit is restricted to higher elevation populations and only certain individuals at the lower elevations. Most *Tridens* plants behaved as annuals, with only a few persisting as perennials. The facultative life cycle appears to contribute to the seasonal success of desert herbaceous species in which it occurs, and enables them to belong to a diversity of communities over a wide range in elevation. (NFG)

52 BEATLEY, J. C. 1971. Vascular plants of Ash Meadows, Nevada. USAEC Report UCLA 12-845, 59 p. (UCLA, Los Angeles, CA 90024)

Presents an annotated listing of 188 vascular plant taxa collected by Beatley and Reveal in 1968-1971 at Ash Meadows, southern Nye County, Nevada, and adjacent Inyo Country, California. Endemics and species with restricted distributions in the region are discussed, aiding future discussions of threatened and endangered species of plants. (TPO)

53 BEATLEY, J. C. 1971. Ecologic and geographic distributions of the vascular plants of southern Nye County, and adjacent parts of Clark, Lincoln, and Esmeralda Counties, Nevada (Supplement to UCLA 12-705). USAEC Report UCLA 12-800, 49 p. (UCLA, Los Angeles, CA 90024)

A compilation is presented of the vascular plants of southern Nye County and adjacent parts of Clark, Lincoln and Esmeralda Counties in Nevada. The plants were collected in the 1969 and 1970 seasons and are classified according to phyla viz: Calamophyta (horsetails), Lepidophyta (clubmosses), Pterophyta (ferns), *Coniferophyta (cone-bearing plants), and Anthophyta (flowering* plants). They are then subclassified into families, genus and species and the ecological and geographic distribution are noted. (FMM)

54 BEATLEY, J. C. 1973. Russian-thistle *(Salsola)* species in western United States. J. Range Management 26:225-226.

This paper poses the thesis that Russian thistle populations are either *Salsola iberica, S. paulsenii* or a combination of both rather than a single species *Salsola pestifer* A. Nels. (or *Salsola kali* L.). (TPO)

55 BEATLEY, J. C. 1973. Check list of vascular plants of the Nevada Test Site and central-southern Nevada. USAEC Report COO-2307-4, 42 p. (Univ. of Cincinnati, Cincinnati, OH 45221)

The compilation of taxa of vascular plants begun in 1959 in central-southern Nevada and the Nevada Test Site has been almost completed. A check list has been published, but a few taxa remain to be described, and a number of collections are yet to be critically reviewed. Species collected on the Test Site are indicated by an asterisk. Of a total of 1107 taxa, 706 occur within or near the boundaries of the Test Site. (BBM)

56 BEATLEY, J. C. 1974. Phenological events and their environmental triggers in Mojave Desert ecosystems. Ecology 55:856-863.

Phenological events in Mojave desert systems are triggered by heavy rains (greater than 25 mm (1 in)). The most predictable and

consequential of these is a regional rain between late Sept. and early Dec. This rainfall event is usually the precursor of successful vegetative and reproductive growth of shrubs the next spring, and is usually necessary for all growth phenomena of herbaceous perennials and winter annuals during the following winter and spring. For most plant components in most years, the growing season is synchronized within the autumn-winter-spring period, and the relative biological success each spring is dependent upon the occurrence or failure of occurrence of events of the preceding autumn. Under certain conditions rainfall during other seasons may trigger growth and reproduction of the primary producers and permit at least moderate or local successes every season. The relationships are stated in a flow diagram for the rainfall and phenological events, as documented for 13 years in the Mojave desert of southern Nevada. (Auth)

57 BEATLEY, J. C. 1974. Effects of rainfall and temperature on the distribution and behavior of *Larrea tridentata* (creosote-bush) in the Mojave Desert of Nevada. Ecology 55:245-261.

The effects of rainfall and temperature on the distribution and certain behavioral characteristics of *Larrea tridentata* (creosote-bush) at and near its northern limits in the northern Mojave desert of southern Nevada, were investigated at 30 sites with *Larrea* and 20 sites without *Larrea* in eight drainage basins at elevations of 915-1,770 m over a 2,600-km^3 area of the Nevada Test Site. Data used were (1) rainfall records for 9 years (1963-71) for each site; (2) maximum and minimum air temperature records for each site, Nov. 1962-Feb. 1972; (3) percentage cover by all shrub species and by *Larrea;* (4) height and density data for *Larrea;* and (5) percentage of germinable seeds from 29 of the *Larrea* populations for three seasons (1963-65) in relation to the seasonal rainfall for each site. Total percentage cover by all shrub species is highly correlated with mean annual rainfall, less well correlated with elevation. In general, in undisturbed communities, the taller the *Larrea* plants the fewer there are of them, but the relationship is not strictly linear. Using height as an index to plant volume, numbers of *Larrea* plants are highly correlated with total plant volume. Mean height is not strongly correlated with mean annual rainfall or temperature parameters, but is well correlated with the ratio of mean precipitation mean temperature. The prevailing low minimum air temperatures and their extremes in the lowlands of enclosed drainage basins are inferred to be the primary cause of the absence of *Larrea* in three discrete vegetation zones. Average extreme minimum air temperatures on all *Larrea* sites were above 1 degree F; the absolute minimum was -8 degrees F. Upper altitudinal limits of *Larrea* apparently are not determined by minimum temperatures. There is no pattern of relationship between maximum temperatures and the distribution of *Larrea* although the highest extreme maxima usually occur on non-*Larrea* sites in the lowlands of Frenchman

Flat. Mean annual rainfall on the *Larrea* sites ranged from 118 to 183 mm. Altitudinal and latitudinal limits of *Larrea* coincide with a maximum mean rainfall of 183 mm. Mean annual rainfall of 160-183 mm appears to be critical to the behavior of *Larrea*. Germination trials support the inference of a deleterious effect on high rainfall on *Larrea* populations through time: there were high correlation coefficients (negative or positive, depending on the year) between the rainfall of the effective rainfall season and the percentage of germinable seeds; highest mean germination percentages (20%-60%) occurred with 80-150 mm of seasonal rain, and either lower or higher seasonal rainfall resulted in lower percentages of germinable seeds (0%-20%). (Auth)

58 BEATLEY, J. C. 1975. Climates and vegetation pattern across the Mojave/Great Basin Desert transition of southern Nevada. Amer. Midland Nat. 93:53-70.

Plant communities of the transition between the Mojave and Great Basin desert of southern Nevada are under the primary control of climatic variables. Rainfall increases and temperature decreases according to large increments of increase in elevations of the drainage basins from S to N. Within the basins, the climates and vegetation patterns are primarily under the control of patterns of air circulation and nocturnal cold air accumulations and secondarily, of edaphic factors. Minimum temperature and maximum mean rainfall tolerances of Mojave Desert *Larrea* (creosote bush) communities are exceeded across this transition as, apparently, are the mean maximum temperature and minimum rainfall tolerances of the Great Basin *Artemisia* (sagebrush) communities. In those communities which characterize the transition *(Coleogyne, Grayia-Lycium andersonii, Lycium pallidum-Grayia, Lycium shockleyi)*, the Mojave and Great Basin temperature and rainfall regimes occur in various definable combinations. Only *Atriplex confertifolia* (shadscale) communities cannot be so defined; these occur along topographic gradients in both Mojave and Great Basin Desert climates. (Auth)

59 BECK, D E., and D. M. ALLRED. 1966. Tingidae, Neididae (Berytidae) and Pentatomidae of the Nevada Test Site. Great Basin Nat. 26: 9-16.

Collections of Tingidae, Pentatomidae, and Neididae were made at the Nevada Test Site as a continuation of the environmental survey of the area. Classification into genus and species was made and relationships to host plants were presented. (BBM)

60 BECK, D E., and D. M. ALLRED. 1966. Siphonaptera (fleas) of the Nevada Test Site. Brigham Young Univ. Sci. Bull., Biol. Ser. 7(2), 27 p.

For each of the 33 species of fleas collected at the Nevada Test Site, this sequence in presentation of information was followed:

(a) specific and subspecific identity and other pertinent taxonomic data; (b) ecological and geographical distribution with maps; (c) host association; and (d) seasonal occurrence accompanied by graphs where sufficient populations made such presentation worthwhile. Seasonal occurrence was interpreted on the basis that a collection of fleas from a single host constituted an encounter, regardless of the number of fleas taken. For those species for which data are minimal, the presentations are given as summary statements without headings. (Auth)

61 BECK, D E., and D. M. ALLRED. 1968. Faunistic inventory -- BYU ecological studies at the Nevada Test Site. Great Basin Nat. 28: 132-141.

Ecological studies of the Nevada Test Site were conducted by Brigham Young University from 1959 until termination of the project in 1966. The main objective of the studies was to make a faunistic inventory of the site, and an extensive collection of specimens was made. A taxonomic inventory of fauna collected at the site and location of specimens is presented for Insecta, Araneida, Reptilia, Aves, and Mammalia. Total number of specimens, completely or partly identified, the number of specimens unidentified and available, and specialists working with particular taxonomic groups are tabulated for each family. A list of depositories for Nevada Test Site specimens is given. (BBM)

62 BECK, D E., D. M. ALLRED and E. P. BRINTON. 1963. Ticks of the Nevada Test Site. Brigham Young Univ. Sci. Bull., Biol. Ser. 4(1), 11 p.

As part of a study to determine kinds, population, seasonal occurrence, and geographical and ecological distribution of ticks in areas where nuclear detonations have taken place compared with undisturbed areas, the tick fauna of the Nevada Test Site is reported. Twenty four species of animals (primarily rodents and leporids) were found infested with eleven species of ticks. Collections were confined to the valleys and lower elevations of the mesas and mountains. Each type of tick was discussed in relation to its host, seasonal incidence, and associated plant community type. Comments on abundance, presence on unusual hosts, and stage of development are included. Results indicated that the nature of the habitat was influential on survival of the ticks when not on a host. (ST)

63 BECK, D E., D. M. ALLRED, J. R. MURDOCK, C. D. JORGENSEN, C. L. HAYWARD and W. W. TANNER. 1964. Nevada Test Site desert ecology. Proc. Utah Acad. Sciences, Arts and Letters 41: 202-210.

The major plant communities in the Nevada Test Site and their predominant animal associates were defined. In each community, analyses of the plant, animal and soil relationships were made, with

special reference to mammal populations. A study of the structure and complex interactions of the biotic components within areas disturbed by nuclear detonations has begun and a summary is given of the bird, arthropod and herpetological studies. (FMM)

64 BEHNKE, J. J., and G. B. MAXEY. 1969. An empirical method for estimating monthly potential evapotranspiration in Nevada. J. Hydrol. 8:418-430.

Monthly potential evapotranspiration values were obtained for several stations throughout the State of Nevada using the Thornthwaite and Olivier equations. The Olivier equation correlated well with lysimeter and adjusted pan data as an estimate of ET. On an annual basis the Thornthwaite equation was approximately 50% too low. A technique was developed to estimate wet bulb depression from temperature data. This made it possible to solve the Olivier equation using only temperature data as input. Climatic conditions in Nevada were such that it was possible to apply the dry adiabatic lapse rate to a centrally located base station to obtain temperature values for other locations lacking climatic data. On a monthly basis, this 'modified' Olivier equation correlated satisfactorily with the original equation for Nevada locations ranging in elevation from 2171 to 5136 ft and in latitude from 36° to 41° N.

65 BERNSTEIN, R. A. 1971. The ecology of ants in the Mojave Desert: their interspecific relationships, resource utilization and diversity. Ph.D. Dissertation, University of California Los Angeles, 142 p.

The density of colonies of seed-eating ants was sampled for nine areas in the Mojave Desert, at altitudes ranging from 140 to 5888 feet (latitude 34 degrees N). Maximum density of colonies occurred at 4000 feet. Five seed-eating species were found in abundance, with separate but overlapping distribution ranges. *Veromessor pergandei* Mayr is found only at altitudes below 3000 feet. It is replaced at that altitude by *Pogonomyrmex rugosus* Emery which in turn reaches peak abundance between 4000 and 5000 feet. *Pogonomyrmex californicus* Buckley can be found at most altitudes, but reaches a definite peak abundance at 5000 feet. *Pheidole xerophila* Wheeler and *Pheidole gilvescens* Wheeler are abundant between 2500 and 4000 feet. The intraspecific spatial pattern of colony distribution was calculated for each species. The foraging method, foraging distance and diurnal activity of each species are highly adapted to the altitudinal range of the species. The distance from the nest that individuals of a colony travel in search of food was found to be a species-specific behavior, with low altitude species foraging the longest distances, high altitude the shortest. Species-specific temperature cues are used to initiate and terminate the daily foraging periods.

They serve to allow each species to maximize its foraging time during the season when seeds are most abundant. The effect of the altitudinal gradient on species diversity of desert ants was measured. Diversity, as estimated by the number of species and by the diversity index (H) increases with altitude. Increases in diversity are related to an increase in length of the food production season with altitude. (Auth) (FMM)

66 BLACKBURN, W. H., and P. T. TUELLER. 1970. Pinyon and juniper invasion in black sagebrush communities in east-central Nevada. Ecology 51:841-848.

As a means of studying inter- and intrazonal invasion in black sagebrush (*Artemisia nova* A. Nels) communities six maturity classes were established for pinyon (*Pinus monophylla* Torr. and Frem.) and juniper (*Juniperus osteosperma* (Torr.) Little) in east-central Nevada. Pinyon and juniper invade and increase in black sagebrush communities until the understory, except for a few hardy plants, is eliminated. Juniper invades first and tends to be eventually replaced by pinyon. Accelerated invasion by both species started about 1921 and is closely related to overgrazing, fire suppression, and climatic change. (Auth)

67 BLANKENNAGEL, R. K., and J. E. WEIR, Jr. 1973. Geohydrology of the eastern part of Pahute Mesa, Nevada Test Site, Nye County, Nevada. Geological Survey Professional Paper 712-B, 35 p. (Available as Stock Number 2401-00303 at U. S. Government Printing Office, Washington, D. C. 20402)

A deep structural depression, the Silent Canyon caldera, underlies the eastern part of Pahute Mesa, Nye County, Nev. The caldera is elliptical in plan and measures about 11 by 14 miles; the greater axis trends in a north-northeast direction. Exploratory drilling revealed a Tertiary volcanic section of ash-flow and ash-fall tuffs and rhyolitic lava flows which attained thicknesses in excess of 13,686 ft. Hydraulic tests made in deep drill holes indicated that these volcanic rocks are capable of transmitting water and that measurable permeability occurs at depths greater than 3,500 ft below the top of the saturated zone. Most movement of ground water beneath the mesa occurs through interconnecting fault and joint systems. Fractures are more common in rhyolitic lava flows and in densely welded ash-flow tuffs, and these fractures have a greater tendency to remain open than do those in ash-fall and nonwelded ash-flow tuffs. The yield of water to wells from intervals of ash-fall and nonwelded ash-flow tuffs, particularly those that are zeolitized or argillized, is low. Hence, these rocks are considered the best media for mining of underground chambers in the saturated zone. In the Silent Canyon caldera, depth to water ranges from about 1,952 ft (alt 4,164 ft) in the western part to 2,350 ft (alt 4,685 ft) in the eastern part. In the extreme northwestern part of the Nevada Test Site, outside the caldera, the depth to water is about 850 ft

(alt 4,700 ft). Stable and declining head potentials occur with depth in all but one of the holes drilled in the eastern part of the report area; variable heads in the upper 1,500 ft of the saturated zone and then increasing heads to toal drilled depth occur in holes drilled in the western part. Pumping tests indicate that transmissivities range from 1,400 to 140,000 gal per day per foot. The greatest transmissivities occur in holes drilled along the east margin of the caldera, where the principal rock type in the saturated zone is rhyolite. Water derived from drill holes at Pahute Mesa is sodium potassium type. These chemical constiuents comprised over 90 percent of the total cations in more than half the samples that were analyzed. Ground water beneath Pahute Mesa moves southwestward and southward toward the Amargosa Desert through Oasis Valley, Crater Flat, and western Jackass Flats. The flow, across a 15-mile underflow strip which extends from the hydraulic barrier on the west to the ground-water divide on the east, is estimated to be 8,000 acre-feet per year. Owing to the difficulty in obtaining accurate porosity data, estimates of ground-water velocity vary as much as two orders of magnitude -- 5 to 250 ft per year. Based on the assumption that most ground-water movement occurs along interconnected fractures and that some movement occurs through interstices, a reasonable estimate of velocity is less than 15 ft per year. (Auth)

68 BLISS, W., and L. DUNN. 1971. Measurement of plutonium in soil around the Nevada Test Site. In: (Fowler, E. B., R. W. Henderson and M. F. Milligan, CoChrs.) Proc. of Environmental Plutonium Symposium at Los Alamos, New Mexico, 1971 (LA-4756), p. 89-92. (Los Alamos Scientific Laboratory, Los Alamos, NM 87544)

Experiments conducted at the AEC's Nevada Test Site between 1951 and 1963, using plutonium in both critical and sub-critical configurations, resulted in distribution of plutonium beyond the boundaries of the Test Site. The Southwestern Radiological Health Laboratory of the Environmental Protection Agency is conducting a survey to assess the distribution and concentration of plutonium in the off-site environment. Special sampling methods were devised since desert soil is too coarse and dry for auger and cookie cutter sampling techniques. Soil sample analyses are performed by a dissolution, ion exchange, and electrodeposition procedure followed by alpha spectroscopy. Plutonium was detected in four locations around the Nevada Test Site. These locations correspond to fallout areas previously identified for the various test series. Plutonium concentrations in the top 3 cm of soil were 10 to 100 times greater than the concentration in soils from areas not subject to contamination by these series. (Auth)

69 BRADLEY, W. G., and J. E. DEACON. 1965. The biotic communities of southern Nevada. Univ. Nevada, Desert Research Inst. Preprint Ser. 9, 86 p. (Univ. Nevada, Reno, NV 89507)

Describes the biota of the Mohave Desert found in southern Nevada

exclusive of the southern portion of the Nevada Test Site. A total of 13 terrestrial and hydric communities are described showing the affinities of 887 species of vascular flora, 37 fish, 121 species of amphibians, reptiles and mammals, and approximately 290 species of birds. (TPO)

70 BRADY, D. N. (comp.) 1972. Environmental surveillance sampling results at the Nevada Test Site, July 1969 through June 1970. NVO-410-11, 58 p. (NTIS, Springfield, VA 22151)

Data derived from the environmental surveillance program at the Nevada Test Site (NTS) for fiscal year 1970 are presented. Gross beta radioactivity results for water and air samples collected throughout the NTS are listed and measurements of gamma radioactivity in soil and vegetation samples are also documented. Tabular data is supplemented by graphical presentations and sampling locations are shown in maps depicting the NTS. (Auth)

71 BRANDENBURG, M. K., H. L. MILLS, W. H. RICKARD and L. M. SHIELDS. 1962. Effects of acute gamma radiation on growth and morphology in *Pinus monophylla* Torr. and Frem. (pinyon pine). Radiation Botany 2:251-263.

A *Pinus monophylla* (pinyon pine) tree was irradiated from a position near the base for eight hours with a Multitron cobalt-60 unit in April, 1960. Shoot apices within fifteen inches (0.38 m, ca. 1300 r to 8000 r) showed almost immediate growth inhibition and were killed within four months. Between two and three feet from the source (0.61 to 0.92 m, ca. 500 r to 200 r) the terminal buds elongated, but by the end of the season had died, and one or two basal lateral buds had developed per shoot. At three to three and one-half feet (0.92 to 1.07 m, ca. 200 r to 150 r) stem elongation proceeded, but the 1961 bud primordia were dwarfed, and lateral buds elongated. Out to four feet (1.22 m, ca. 100 r) no needles developed on the 1960 stem length. From four to five feet from the source (1.22 to 1.53 m, ca. 100 r to 80 r) the number of needles was reduced to from one-half to one-third normal, and approximately one-half were dwarfed. Gnarled growth was common in these dwarf needles. Two vascular tissue anomalies occurred in a number of grossly abnormal as well as in normal appearing needles collected four to six feet from the source (1.2 to 1.8 m; dosages ca. 100 r to below 50 r). One, the double vascular strand probably is related to the naturally occurring fusion process. The other anomaly involved reduction of or lack of vascular tissue. Xylem radii measurements in transverse sections of young stems indicated a decrease in growth for 1960, ranging from 3 to 8 per cent, correlated with increasing exposure. Stem tip elongation in the experimental tree compared with that of the controls was inhibited at doses as low as 15 r. Lateral branching assumes a significant role in shoot recovery from radiation damage, particularly at exposures great enough to affect

the actively growing regions of the stem but not the other functional portions. (Auth)

72 BRENNAN, J. M. 1965. Five new chiggers from southwestern United States (Acarina: Trombiculidae). J. Parasitol. 51:108-113.

Described and figured are *Euschoengastoides sloomi* off *Neotoma lepida*, Nevada; *Pseudoschoengastia aeci* off *Neotoma lepida*, Nevada; *Trombicula sprocssi* off *Pipistrellus hesperus*, Arizona; *Trombicula univari* off *Pipistrellus hesperus*, Arizona; and *Trombicula veanda* off *Neotoma lepida*, Nevada. Other host and locality records from Arizona and California are included. (Auth)

73 BRINTON, E. P., D E. BECK and D. M. ALLRED. 1965. Identification of the adults, nymphs and larvae of ticks of the genus *Dermacentor* Koch (Ixodidae) in the western United States. Brigham Young Univ. Sci. Bull., Biol. Ser. 5(4), 44 p.

Contains illustrated keys to assist in the specific identification of the larval, nymphal, and adult stages of ticks belonging to the genus *Dermacentor* in the western United States including the Nevada Test Site. Information includes external anatomy and morphology, as well as geographic and ecological distributions, seasonal occurrence, and host relationships. (TPO)

74 BROWN, K. W., and B. J. MASON. 1968. Range survey, Area 18, Nevada Test Site. SWRHL-52, 42 p. (Environmental Monitoring and Support Laboratory, Environmental Protection Agency, Las Vegas, NV 89114)

The ocular reconnaissance method of surveying vegetation was used to survey 13,630 acres in Area 18, Nevada Test Site. A total of 233 line transects were established to obtain species distribution, composition and ground cover. There were six distinct plant communities identified: two sagebrush *(Artemisia arbuscula* subsp. *nova, A. tridentata)*, two annual *(Salsola kali* var. *tenuifolia, Eriogonum)*, one grass, and one Desert Shrub. These six communities contained a total of 36 families and 85 species. The *A. arbuscula* subsp. *nova* community occupied the largest area, 6,337 acres, and the *Eriogonum* sp. community the smallest, 17 acres. (Auth)

75 BROWN, K. W., and J. C. McFARLANE. 1973. Deposition and retention of ^{131}I on *Grayia spinosa* following Baneberry. Health Physics 24: 680-681.

A study is reported of the measurement of the deposition of radioactive fallout (^{131}I), following the underground nuclear weapons test Baneberry, on dormant rangeland vegetation 2 miles from the emplacement hole. By comparing the activity on samples of *Grayia spinosa* to that on planchets placed in the center of the stand of plants it was found that the effective collection surface of these plants is 235 cm^2/g. It is stated that the importance of this work

lies in the development of the concept that in the absence of man-made collection systems, plants (even dormant) can provide information about release of fallout materials. (UK)

76 BROWN, K. W., and D. D. SMITH. 1966. The poisonous plants of the U. S. Atomic Energy Commission's Nevada Test Site, Nye County, Nevada. SWRHL-33r, 65 p. (Environmental Monitoring and Support Laboratory, Environmental Protection Agency, Las Vegas, NV 89114)

This report provides a physical description, distribution, habitat, poisonous principle, symptomology, pathology, and treatment of affected animals, for 30 taxa of poisonous plants found on the Nevada Test Site. (TPO)

77 BURGE, J. R., and C. D. JORGENSEN. 1973. Home range of small mammals: a reliable estimate. J. Mammalogy 54:483-488.

A method of estimating the probability of an animal being in a particular region of the home range is discussed. Data for *Perognathus longimembris* (Coues) were used to illustrate the use of this method and were transformed with $r' = (r^{\lambda} - 1)/\lambda$. One-sided tolerance limits were used to assert degrees of confidence γ that given percentages of the recaptures will be within specified distances from the estimated activity center.

78 CHAMBERLIN, R. V. 1962. New records and species of chilopods from Nevada and Oregon. Entomol. News 73:134-138.

Ten spp. with collection data and other notes are listed as records: *Nyctunguis stenus*, Clark Co., Nevada; *Oabius wamus*, Saddleback Mt., Oregon; *O. mercurialis*, Clark Co., Nevada; *Pokabius utahensis tidus*, Saddleback Mt., Oregon. A tentative key distinguishing 15 spp. of *Nyctunguis* is given. (JLW)

79 CHAMBERLIN, R. V. 1962. Millipeds from the Nevada test area. Proc. Biol. Soc. Wash. 75:53-55.

Arinolus sequens, A. nevadae, Orthichelus michellbacheri (hitherto known from only 2 specimens), and *Titsona tida* were collected. (AKW)

80 CHAMBERLIN, R. V. 1963. A new genus in the chilopod family Tampiyidae. Proc. Biol. Soc. Wash. 76:33-35.

Eremorus with type *E. becki* from the Nevada test area is described, with key to distinguish 3 genera of Tampiyidae. (AKW)

81 CHAMBERLIN, R. V. 1965. A new genus and species in the chilopod family Tampiyidae. Great Basin Nat. 25:39-42.

Abatorus allredi, a new species in the chilopod family Tampiyidae

was described from material collected on the Nevada Test Site, Nye County, Nevada in December, 1961. (TPO)

82 CHRISTIANSEN, R. L., F. G. POOLE, H. BARNES, P. P. ORKILD, F. M. BYERS, Jr., W. J. CARR, F. A. McKEOWN, F. N. HOUSER, E. M. SHOEMAKER and W. L. EMERICK. 1969. Guidebook for past field trips to the Nevada Test Site. USGS Open File Report, 57 p. (USGS Libraries and Public Inquiries Offices) (Now in preparation: USGS Open File Report entitled Field Trip to Nevada Test Site)

Three topically oriented field trips are described. An examination of the thick miogeosynclinical section of Paleozoic rocks and some of the post-Paleozoic structural features were conducted on the first trip. The Timber Mountain caldera field trip is described. It is an assemblage of rocks of several thousand square miles in southern Nye County, Nevada. The last field trip guide features the observation of effects of explosions. Maps of all areas are included. (JCW)

83 COLE, A. C. 1963. A new species of *Veromessor* from the Nevada Test Site and notes on related species (Hymenoptera: Formicidae). Ann. Entomol. Soc. Amer. 56:678-682.

Four species of *Veromessor* are known from the Nevada test site, namely *pergandei* Emery, *lariversi* M. R. Smith, *lobognathus* (Andrews), and *smithi*, n. sp. The new species is described from all three castes, the sexual castes of *lariversi* and *lobognathus* are described, the four species are keyed, and essential features of the workers and males are figured. (Auth)

84 COLE, A. C. 1965. Discovery of the worker caste of *Pheidole (P.) inquilina*, new combination (Hymenoptera: Formicidae). Ann. Entomol. Soc. Amer. 58:173-175.

All castes of *Pheidole inquilina* (Wheeler) new combination, including the soldier which is reported for the first time, were found in nests of *Pheidole pilifera coloradensis* Emery, a host species, at the Nevada Test Site. The soldier is described and figured. The finding of the soldier, with its obvious *Pheidole* characteristics, has made it necessary to transfer *inquilina* to the genus *Pheidole* Westwood and to synonymize the monobasic genus *Epipheidole* Wheeler. (Auth)

85 COLE, A. C., Jr. 1966. Ants of the Nevada Test Site. Brigham Young Univ. Sci. Bull., Biol. Ser. 7(3), 27 p.

Description for 57 taxa of the family Formicidae is given as part of the ecological studies of the Nevada Test Site. Collection was made from can traps and field collections. Geographic areas and plant communities were described along with the inventory of ants. (BBM)

86 DUNAWAY, P. B., and M. G. WHITE (eds.). 1974. *The Dynamics of Plutonium in Desert Environments*, Nevada Applied Ecology Group Progress Report as of January 1974. NVO-142, 369 p. (ERDA, Las Vegas, NV 89114)

A status report of the Nevada Applied Ecology Group research activities is given. The twenty-six articles included have been abstracted separately for the data base. Investigations on the soils of Pu-contaminated areas at the Nevada Test Site were reported with statistical analyses included. Other papers dealt with the Pu content of vegetation of contaminated areas; Pu metabolism in dairy cattle; grazing studies on Pu-contaminated areas, giving the radionuclide levels in Area 18 cattle; ecological studies of vertebrates; digestion of ingested Pu in chickens and subsequent transfer to eggs; the role of soil microorganisms in the movement of Pu; resuspension studies, including the use of NTS Data to predict air concentrations of Pu due to resuspension on the Eniwetok Atoll; distribution and inventory element activities on NTS and off-NTS; the Pu transport and dose estimation model; a description of the information support for the NAEG by the Oak Ridge Data Base and the Library Services at AEC Nevada Operations Office. (FMM)

87 DURRELL, L. W., and L. M. SHIELDS. 1960. Fungi isolated in culture from soils of the Nevada Test Site. Mycologia 52:636-641.

Results of culturing 550 soil samples from the site of detonation of nuclear devices are reported, and the taxonomy and characteristics of the fungi isolated are described. Their resistance to uv radiation is also reported. By culture on Rose-Bengal agar containing streptomycin, 41 fungal taxa were isolated from surface and 3- to 6-in. samples of arid soils of the Nevada Test Site. Four taxa developed in from 40 to over 80% of the samples cultured: *Stemphylium ilicis*, *Fusarium* sp., *Phoma* sp., and *Penicillium oxalicum*. Certain of the species which produced black spores tended to predominate in cultures. Five of these species were also among the 14 isolated from Death Valley soils. The predominance of black-spored species in soils from the Nevada Test Site as well as from Death Valley suggests that in strongly insolated regions the melanin pigment affords a degree of protection. To determine relative resistance of fungal spores to uv light, cultures of a number of species were exposed to wavelength 2573 Å for different periods at 40 $\mu w/cm^2/min$. The time interval within which this exposure was 100% lethal is shown for seven representative species. Certain dark-spored species, as *S. ilicis*, *Stachybotrys atra*, and *Cladosporium herbarum*, survived prolonged exposures. *S. ilicis* spores were particularly resistant, germinating after 60 min in 95 to 100% of the exposed samples. Spores of *Aspergillus niger*, also black, were killed by two-min. exposure to uv light. The usual organic solvents did not extract the pigment from *S. ilicis* spores, while the spore

pigment of *A. niger* dissolved readily in methyl alcohol. When thin layers of these spores attached to a quartz slide were checked by a spectrograph and electrospectrometer for determining light transmission, no light within the range of 2000 to 20,000 Å was seen to pass through *Stemphylium* spores. In contrast, the extracted pigment from *A. niger* spores showed a wide transmission band with a peak maximum at 12,000 Å. Spore or nuclear volume also may modify the effect of uv light. Possibly energy absorption is less rapid by large spores, as in *Stemphylium* sp., than by the small spores of *A. niger* with about 1/50 the volume. The dark spores of *Coccosporium*, however, with an approximate volume of 13,000 μ^3 were killed in half the time required for *Stemphylium* with a spore volume of 8000 μ^3. (Auth)

88 DURRELL, L. W., and L. M. SHIELDS. 1961. Characteristics of soil algae relating to crust formation. Trans. Amer. Microscopical Soc. 80:73-79.

The algae *Microcoleus vaginatus* is enclosed in a colloidal sheath which binds particles of arid soil in a web-like matrix, consolidating a surface crust. The formation and accumulation of the sheath substance is favored by an alkaline reaction. Warping of the polygonal segments in drying results from greater shrinkage of the colloidal algal sheath material incorporated at the surface. The water holding capacity of the sheath contributes to the survival of algal cells and improves moisture relations in the felted crusts. In fluid, the trichomes of *Microcoleus vaginatus* grow beyond the enclosing sheath, assuming the appearance of *Phormidium* sp. The chemical composition of the sheath can be demonstrated by the action of hemicellulase, which digests it away, causing a rounding off of cross walls and resulting in fragmentation. Fragments revert to the filamentous habit when returned to culture. (Auth)

89 EBERHARDT, L. L., and R. O. GILBERT. 1972. Statistical analysis of soil plutonium studies, Nevada Test Site. USAEC Report BNWL-B-217, 60 pp. (Battelle, Pacific Northwest Laboratories, Richland, WA 99352)

A summary is presented of the results of plutonium environmental studies that are part of the work of the Nevada Applied Ecology Group. Many of the field studies are currently not completed, but it seems desirable to produce a summary analysis of the statistical aspects. The report will be useful in planning further studies at the Test Site. Much of the work has been directed towards the problems of estimating the inventory of plutonium in soil. The only extensive set of data available thus far is from the GMX area. That data suggests that it is quite feasible to proceed with an inventory for GMX with the tools at hand. The report provides some preliminary results on the use of the FIDLER instrument in Area 13, but is thought not profitable to

try to do too much interpretation of such comparisons without more crosschecking FIDLER counts against "wet" chemistry or similar analyses. Another section of the report provides a basis for decisions on the number of replicates for interlaboratory comparisons. It should be noted that this section serves for planning purposes -- once the study is completed, the results should be analyzed by other procedures (most likely an analysis of variance). (Auth) (FMM)

90 ECKEL, E. B. (ed.). 1968. *Nevada Test Site*. The Geological Society of America, Inc., Memoir 110, 290 p. (The Geological Society of America, Inc., 3300 Penrose Place, Boulder, CO 80301)

This book describes results of 12 years of geological research on the Nevada Test Site. The primary purpose of the studies was to aid and advise the USAEC in all phases of its testing of nuclear devices. An enormous amount of knowledge was gained about the complex geologic and hydrologic conditions that exist in and near NTS. The complex volcanic and sedimentary stratigraphy, structure, and geologic history of this part of the Basin and Range Province are described in detail. The deep fills in intermontane basins, and the groundwater in them, are known in three dimensions, and excellent geologic maps have been prepared and are described in the text. (TPO)

91 ENGEL, R. E., and R. A. BRECHBILL. 1967. Radiation surveillance in wildlife. CONF-670724-1, 5 p. From Conference of Western Association of Fish and Game Commissioners, Honolulu, Hawaii. (NTIS, Springfield, VA 22151)

A report on the wildlife surveillance activities in the Nevada Test Site environs is presented. The purpose of the study is fourfold, and includes: maintenance of veterinary public relations with the off-site population, investigation of alleged damage to domestic animals from AEC activities, determination of the tissue concentration of fission products in samples obtained from bovines on off-site ranches, University of Nevada Experimental Station and the Nevada Test Site, and development and conduction of wildlife studies on and near the Nevada Test Site to assess radionuclide content of edible wildlife species. In connection with this fourfold study, a study of the fission product accumulation of the Nevada Test Site mule deer was initiated. Background levels of radioisotopes in the desert bighorn sheep ranging in the Nevada Test Site were also determined. Beginning in July 1965 a survey of the ^{90}Sr content of the hock joints in wildlife ruminants was conducted under the assumption that these samples would serve as biological dosimeters from which fallout could be determined. A cooperative mule deer food habit analysis study is currently begin conducted with various agencies in the area. Hock joints and thyroids are analysed in this study, the former for ^{90}Sr, the latter for ^{131}I. Here again, the thyroid was used as a biological dosimeter for ^{131}I in that portion of the

state. The migration routes of the mourning dove are the object of intense investigation in the test site area. Trap mortalities are utilized to assess radioisotope content in these birds. (ERB)

92 ESSINGTON, E. H., H. NISHITA and A. J. STEEN. 1965. Release and movement of radionuclides in soils contaminated with fallout material from an underground thermonuclear detonation. Health Physics 11:689-698.

Fallout material from an underground thermonuclear detonation was analyzed to determine the presence of several longer lived radionuclides. The following radionuclides were identified: Zr-95: Nb-95, Ru-103:Ph-106, I-131, Cs-137:Ba-137, Ba-140:La-140, Ce-141, Ce-144:Pr-144, Sc-46, Mn-54, Y-88, Ph-102, W-181, W-185 and W-188: Re-188. Radiotungsten contributed the major fraction of the total activity. In suspension studies, chelating agents as compared to water generally increased the amount of soluble radionuclides but the effect was small. The effect of water and a chelating agent on the movement of radionuclides in soil columns were also studied. (Auth)

93 FERGUSON, W. E. 1967. Male sphaeropthalmine mutillid wasps of the Nevada Test Site. Brigham Young Univ. Sci. Bull., Biol. Ser. 8(4), 26 p.

As a part of the ecological studies of the Nevada Test Site, taxonomy and distribution of noctural mutillid wasps was detailed. It was shown that "ground zero" of nuclear detonations are reoccupied by mutillids within a few years of an explosion because of the attractive nesting sites for hymenoptera hosts of the parasitic mutillids. Genetic abnormalities for the wasps were not noted, possibly because abnormal genetic traits would prove fatal in the harsh desert environment. Specimens were collected in can pit-traps and light-traps. A description and discussion of taxonomic types is presented, including new species. (BBM)

94 FLAKE, L. D., and C. D. JORGENSEN. 1969. Invasion of a "trapped-out" southern Nevada habitat by *Perognathus longimembris*. Great Basin Nat. 29:143-149.

A 6.3 ha grid was established at the United States Atomic Energy Commission's Nevada Test Site and the small mammals trapped-out during the summers of 1964 and 1965 to study invasion by *Perognathus longimembris* Coues. Age analyses were made to determine the relationship between age and invasion. The mean age of invading animals was lowest in mid and late summer, but varied widely with reproductive success. There was no statistically significant difference in mean age between male and female invaders. Ratios of male to female invaders varied directly with that of the natural population. Invasion rates varied widely and were mainly influenced by population density outside the grid. (Auth)

95 FOUNTAIN, E. L., and M. S. SEAL. 1967. Strontium-90 in the bones of big game in the Western United States. Health Physics 13:1205-1209.

Bone samples from big game killed during hunting seasons were obtained for determination of the ^{90}Sr present. The observed content of ^{90}Sr rose slightly in 1959, decreased in 1961, and rose again in late 1964 and early 1965. Annual rainfall and the dietary habits of the observed animals appeared to influence the ^{90}Sr content more than the proximity to the Nevada Test Site. (Auth) (UK)

96 FOWLER, E. B., R. O. GILBERT and E. H. ESSINGTON. 1976. Sampling of soils for radioactivity: philosophy, experience, and results. In: (Engelmann, R. J., and G. A. Sehmel, Coordinators) *Atmosphere-Surface Exchange of Particulate and Gaseous Pollutants (1974)*, Proc. Symp. held at Richland, Washington, Sept., 1974 (CONF-740921), p. 709-726. (NTIS, Springfield, VA 22151)

This paper presents information on the philosophy and development of methods used in the Nevada Applied Ecology Group's program to define plutonium levels in soils. The program required interaction of experts in sampling, sample preparation, sample analyses, and data interpretation for successful implementation. (TPO)

97 FRENCH, N. R. 1963. Fallout and natural populations. In: Proc. First International Conf. on Widllife Disease, High View, New York, June, 1962, p. 152-156. (Wildlife Disease Association, P. O. Box 886, Ames, Iowa 50010)

Discusses the fate and effects of radioactive fallout in natural populations, focusing on both internal and external emitters. The reproductive system appears to be the most susceptible to radiation damage. 100 rads is estimated as the dose that might be the threshold between survival and extinction for a population of small mammals. (TPO)

98 FRENCH, N. R. 1964. Description of a study of ecological effects on a desert area from chronic exposure to low level ionizing radiation. USAEC Report UCLA 12-532, 27 p. (UCLA, Los Angeles, CA 90024)

A study of radiation effects on a desert ecological system is being conducted at the AEC Nevada Test Site. A circular 20-acre study area is fenced to confine the rodent population. The area is irradiated by a Cs-137 source which is partially shielded to reduce the dose rate at ground level close to the source. Small mammals are expected to receive about 1 r/day. Radiation dose to the kangaroo rats and pocket mice is being measured by small thermoluminescent dosimeters attached externally to the animals. Animals are individually marked. The populations of irradiated and control plots are censused at monthly intervals by live trapping. Mortality rates and production of young will be compared. Investigations of native vegetation, reptiles and arthropods are also being conducted. (Auth)

99 FRENCH, N. R. 1965. Radiation and animal populations: problems, progress and projections. In: (Hungate, F. P., ed.) *Radiation and Terrestrial Ecosystems*, Health Physics 11:1557-1568.

A review of recent literature suggests the importance of measuring the functional efficiency of irradiated populations. Population ecology provides methods suitable for evaluating the performance of populations. Dosimetry in radiation studies is simplified by new microthermoluminescent dosimeters. A population can be irradiated by administration of a single acute exposure of each individual animal, by chronic exposure of a large study area with an established population, or by administration of an isotope for internal exposure of the animals. Irradiation may impair a population primarily through reduction in fertility, and to some extent by reduction of life-span. In mammalian populations, reduced fertility would not under ordinary conditions be hazardous to survival, except when other environmental stress causes a shift in the age structure of the populations to the point where reproduction by older individuals is important to maintenance of the population. (Auth)

100 FRENCH, N. R. 1966. Irradiated desert rodent populations. In: (Sacher, G. A., ed.) *Radiation Effects on Natural Populations*, p. 22. (Argonne National Laboratory, Lemont, IL 60439)

This paper describes briefly the radiation facility being used at the Nevada Test Site to test the effects of chronic, low level radiation on wild species of rodents. (TPO)

101 FRENCH, N. R. 1967. Comparison of radioisotope assimilation by granivorous and herbivorous mammals. In: (Åberg, B., and F. P. Hungate, eds.) *Radioecological Concentration Processes*, Proc. International Symp., Stockholm, April, 1966 (CONF-660405), p. 665-673. (Pergamon Press, New York City, NY 10523)

Fractional uptake and effective half-life of ingested I-131 in a granivore (kangaroo rat), a herbivore (rabbit), and a rodent of intermediate dietary habits (deer mouse) were compared. The granivore showed the greatest thyroidal uptake and the longest effective half-life. Both uptake and effective half-life were much reduced in kangaroo rats on a high protein diet. This is attributed to increased urinary loss of iodine. The uptake was slightly increased, but effective half-life was much reduced in rabbits on a diet of alfalfa hay. This is attributed to the bulk of the diet, which decreased efficiency of absorption. Absorption of radioiodine from isolated intestinal loops was similar in animals on different diets, and was essentially similar in herbivores and granivores. Absorption from the duodenum appeared to be greater in the granivore than in the herbivore. The stable iodine content of the diet and renal loss of iodide are probably the most important factors influencing

thyroidal assimilation of ingested radioiodine. The amount of radioiodine ingested in a contaminated environment by an herbivore was estimated to be 48 times greater than by a granivore, and as a result the thyroid radioiodine is 8 times greater in the herbivore. Radiation dose to the thyroid would be similar in both types of animals, because the small size of the gland in the granivore reduces absorption of energy of the β radiation. (Auth)

102 FRENCH, N. R. 1969. Radiation sensitivity of rodent species. Nature 222:1003-1004.

A laboratory colony of *Peromyscus maniculatus* was exposed to chronic radiation at a rate of approximately 1.23 R/day. The intrinsic rate of natural increase was 0.1897 in the irradiated mice and 0.3134 in the controls. Within controls, males had a significantly greater life expectancy at birth. Chronic radiation reduced the average life span in both sexes. Computer simulations were used to investigate the significance of the radiation damage to a natural population of *Peromyscus*. Simulations suggested that wild populations were closely balanced and small additional stresses, such as chronic radiation damage, would be detrimental to the population, even perhaps causing extinction of the population. (TPO)

103 FRENCH, N. R. 1970. Chronic low-level gamma irradiation of a desert ecosystem for five years. In: (Grauby, A., ed.) Proc. Symp. International de Radioecologie, Cadarache, France, September, 1969 (CONF-690918, Volume 2), p. 1151-1167. (TIC, Oak Ridge, TN 37830)

Populations of vertebrate animals, certain insects, and plants were studied in three enclosed 8-hectare areas located in the Mojave desert. They were enclosed by a fence to prevent rodents from entering or leaving the study areas. One area was irradiated almost continuously at a dose rate of 80 to 500 mr/hr. Animal populations were examined by capturing, marking and releasing individuals. Plants were examined for growth and for production of leaves, flowers, fruit, and seeds. The life span of the population of pocket mice, *Perognathus formosus*, in the irradiated area was shorter than in the other areas. No difference was detected in the numbers of a small lizard, *Uta stansburiana*, that survived from year to year. Females of a larger but less numerous species of lizard have become sterile in the irradiated area. All vertebrate animals in the irradiated area have received exposures of 1 to 2r/day. Certain species of plants have produced fewer flowers and fruits in the irradiated area. Plants have received exposures of 4 to 7r/day. Although wild populations of small mammals are surprisingly sensitive to damage from chronic low-level radiation exposure, they are evidently able to persist under these conditions. There may be certain compensating mechanisms that become operative when the population is subjected to radiation stress. (Auth)

104 FRENCH, N. R., and H. W. KAAZ. 1968. The intrinsic rate of natural increase of irradiated *Peromyscus* in the laboratory. Ecology 49:1172-1179.

The effect of continous low-level exposure to γ radiation on a population of deer mice *(Peromyscus maniculatus sonoriensis)* in the laboratory was studied. The average dose rate was slightly greater than 1 R/day. One groups was exposed as adults, with irradiation beginning when they were weaned (age 3 to 4 weeks); another group was the offspring of the irradiated adults, hence these animals were irradiated since conception. Descendants from three separate field populations were present in each group. The intrinsic rate of natural increase was increased in animals irradiated as adults as a result of an elevation of the instantaneous rate of birth and a reduction of the instantaneous death rate. Animals irradiated since conception showed a lower intrinsic rate of natural increase than the controls. Life span was shortened by irradiation and age specific natality was reduced by radiation, both by lowering the maximum number of young per female and by shortening the reproductive life spans of females. Reduction was greatest in the animals irradiated since conception. There was evidence of hyperovulation in the group irradiated as adults. There was variation among the three field populations represented, both in reproductive capacity of control animals and in sensitivity to radiation. Among controls, the population from the lowest field elevation had the greatest intrinsic rate of natural increase. This population showed the least sensitivity to radiation. The greatest sensitivity to radiation was in the population from intermediate elevations. It was concluded that field populations of *Peromyscus* living in favorable environments might withstand the degree of reduction induced by this level of radiation exposure. Field populations living under less favorable conditions possibly could not. (CH)

105 FRENCH, N.R., and K. H. LARSON. 1963. Environmental pathways of radioactive iodine from nuclear tests in arid regions. In: (Schultz, V., and A. W. Klement, Jr., eds.) *Radioecology*, Proc. First National Symp. on Radioecology, p. 77-81. (Reinhold Publ. Corp., New York, NY 10022)

Varying quantities of radioiodine are liberated to the environment by nuclear detonations, reactor tests and accidents, and chemical processing of spent fuel elements. The amount released depends upon the physical and chemical characteristics of the reactions at the time of release of the fission products. Radioiodine is probably adsorbed on surfaces that are available. Whether incorporated in particles, as an aerosol, or as a gas, the radioiodine collects on the leaves of desert plants which expose considerable area to the passing air stream. It appears that this is the biologically important means of retention of radioiodine released to the environment. Ingestion is considered the only

important route of entry of radioiodine into the animals living in the contaminated environment. Animals exposed to radioiodine produced by nuclear reactions, but prevented from ingesting contaminated material, showed little or no radioiodine in their thyroids; animals that ingested the contaminated material showed great increases in thyroid radioiodine. Further, thyroid radioiodine of animals in a contaminated environment continues to increase for several days after contamination. This indicates that radioiodine was deposited in the environment rather than being inhaled during the single passage of the contamination. The contaminated food supply is the major source of ingested radioiodine. The contaminated soil surface also makes an important contribution to ingested radioiodine in native animals. This soil may be taken in with the food by accidental ingestion as the animal digs or moves about on the soil surface, or may be ingested by licking and cleaning the fur. Each of these routes of ingestion has been demonstrated with kangaroo rats in laboratory experiments. The abundance of radioiodine in radioactive contamination provides material that is widely distributed in detectable quantities. Its deposition on forage plants and the rapid assimilation and concentration in the animal thyroid gland provides a convenient tracer of released fission products. The same properties of assimilation and concentration make radioiodine one of the major potential hazards to vertebrate animals. Considerable effort is being and has been devoted to study of the physiology of iodine in the animal body. At present, very little is known of the mechanism of distribution, retention, and circulation of radioiodine in the environment. There is urgent need for concentrated study of the environmental pathways of radioiodine prior to the time it is incorporated in the animal. (Auth)

106 FRENCH, N. R., P. HAYDEN and T. TAGAMI. 1965. The source of ingested radioactivity in desert rodents. Health Physics 11:637-645.

Using ^{131}I as a tracer, comparisons were made of the radioactivity ingested by kangaroo rats when eating contaminated food and when living on contaminated sand. Different methods of exposure served to differentiate the sand consumed with the food, the sand consumed accidentally while digging or searching for food, and the sand consumed by licking the fur. Results indicated that all routes of entry are important. On the basis of further tests, the data were extrapolated from the laboratory tests to field conditions. Deposition of airborne ^{131}I was proportional to the surface areas of materials under consideration; 1 g of sand therefore contained nine times the radioactivity of 1 g of pearl barley seeds. When hulls were removed from the contaminated grain by the rodents, only 16 percent of the radioactivity on the food was consumed. It is estimated that under field conditions kangaroo rats obtain 70 to 80 percent of their internal emitters directly or indirectly from the sand. (Auth)

107 FRENCH, N. R., B. G. MAZA and A. P. ASCHWANDEN. 1966. Periodicity of desert rodent activity. Science 154:1194-1195.

The radiation dose detected by microthermoluminescent dosimeters attached to pocket mice, *Perognathus formosus* indicated the amount of time these animals were active on the surface of the ground. Radiation was from an elevated, partially shielded source in the center of the 8-hectare enclosure. The rodents are almost entirely inactive in midwinter but spend 30 to 40% of their time above ground in the summer months. Periods of activity increase gradually through the spring. These results support laboratory findings that members of this genus undergo periods of torpor in response to low ambient temperatures or food shortage. That this adaptation may enhance survival is indicated by the longevity of marked individuals of a related species. (Auth)

108 FRENCH, N. R., B. G. MAZA and A. P. ASCHWANDEN. 1967. Life spans of *Dipodomys* and *Perognathus* in the Mojave Desert. J. Mammalogy 48:537-548.

Rodent populations in four 20-acre plots were studied: three of the plots were fenced to prevent dispersal, and one of these plots was subjected to ionizing radiation; the fourth plot was unfenced. Mean life spans (defined as the time between the first and last appearance in the trapping records) in the fenced, unirradiated plots were between 3.7 and 5.0 months for *Perognathus formosus*, *P. longimembris*, *Dipodomys merriami* and *D. microps*. Mean life spans were shorter in the irradiated plot and shortest in the unfenced plot. Greatest mortality occurred in the few months following first capture. Some *P. longimembris* survived 3-4 years. (TPO)

109 FRENCH, N. R., B. G. MAZA and H. W. KAAZ. 1969. Mortality rates in irradiated rodent populations. In: (Nelson, D. J., and F. C. Evans, eds.) *Symposium on Radioecology*, Proc. Second National Symp. on Radioecology (CONF-670503), p. 46-52. (NTIS, Springfield, VA 22151)

Survival curves were computed for the pocket mouse, *Perognathus formosus*, populations of three fenced 20-acre plots. The animals of one plot were irradiated at a rate of approximately 1 R/day. The data are suggestive of a shorter life span induced by radiation, but are not conclusive. Survival curves for irradiated (1 R/day) and control *Peromyscus maniculatus* in the laboratory show significant differences between the two groups and between sexes in each group. Extrapolation of comparable shortening of life spans by radiation to survival rates of field populations of the same species indicates the importance of chronic radiation exposure from widespread radioactive contamination in a natural situation. The magnitude of the effect is related to the natural life spans in the field, and varies with the environment. A relatively long-lived species may suffer from such exposure, while

a naturally short-lived species will be unaffected. There was no indication of increased survival rates of the wild species under chronic low level exposure as has been indicated in similarly exposed laboratory rats and mice. (Auth)

110 FRENCH, N. R., T. Y. TAGAMI and P. HAYDEN. 1968. Dispersal in a population of desert rodents. J. Mammalogy 49:272-280.

Dispersal of 2 species of kangaroo rats and 2 species of pocket mice in the Mojave Desert was examined by live-trapping intensively an 8-ha (20-acre) area, and by setting rows of live-traps at 152-m (500 ft) intervals out to 914 m (3000 ft) from the area. Dispersal distances of *Perognathus formosus* were arranged in a frequency distribution. Dispersal appears to be nonrandom. There were too many moves to great distances and too few to intermediate distances for dispersal to be considered random. The results support the hypothesis that some members of the population have an instinct to disperse, and that their moves are long distance ones. Both young and old animals made dispersal movements, some more than once. We estimate 25 to 30% of the *P. formosus* made dispersal movements during the period of 1 year. Kangaroo rats wander during the nonbreeding season, but our sampling was not adequate to evaluate dispersal of these rodents. (Auth)

111 FRENCH, N. R., B. G. MAZA, H. O. HILL, A. P. ASCHWANDEN and H. W. KAAZ. 1974. A population study of irradiated desert rodents. Ecological Monographs 44:45-72.

Describes results of experiments initiated in 1963 to examine the effects of long-term low-level radiation exposure on desert populations of plants and animals. In years of adequate food *Perognathus formosus* populations could increase by a factor of 5 or more; in poor years there may have been no reproduction. Radiation exposures averaging 211-360 r/yr reduced survival, particularly before the age of 6 months. The instantaneous rate of death was increased, future life expectancy was reduced, and the intrinsic rate of increase was reduced in irradiated populations compared with controls. There was evidence indicating an increased birth rate in the irradiated population. Only in the most unfavorable periods, when reproduction is curtailed by natural forces, will the threshold levels of artificial radiation insult on the natural population be discernible. A rapid turnover of generations prevents a population from accumulating damaging effects of low-level exposure. Estimates of food requirements suggested that food supply may be an important limiting factor. (TPO)

112 FULLER, R. G., and W. E. MARTIN. 1969. Bioenvironmental safety. In: Technical Discussions of Offsite Safety Programs for Underground Nuclear Detonations (NVO-40, Rev. 2), p. 301-311. (ERDA, Las Vegas, NV 89114)

The Bioenvironmental Safety program sponsored by the AEC-NVOO is concerned with the more subtle and indirect consequences of nuclear

testing: the potential exposure of people to internal radiation via food chains, direct or indirect damage to wildlife populations, and environmental disturbances that may lead to undesirable ecosystem changes. Objectives include preshot prediction of effects, recommendation of courses of action to mitigate significant adverse effects, and post-shot documentation of ecological consequences. The methods used to achieve these objectives are the usual techniques of applied ecology: mission-oriented ecological surveys, analysis of ecosystem dynamics, experimentation when required, and application of relevant ecosystem models for predictive purposes. These concepts are equally applicable to any type of nuclear detonation, but bioenvironmental safety problems encountered will vary with the location and with the type of event. In general, the safety standards and the basic approaches to ensure that detonations meet those standards will remain the same. As the use of nuclear explosives advances from the testing phase into practical utilization in engineering projects, mining, and related uses, the same type of bioenvironmental safety efforts will be required, and the methods now being developed and used will be adaptable to future needs. (Auth)

113 FURMAN, D. P., and F. J. RADOVSKY. 1963. A new species of *Ornithonyssus* from the white-tailed antelope squirrel, with a re-diagnosis of the genus *Ornithonyssus* (Acarina: Dermanyssidae). Pan-Pacific Entomologist 39:89-98.

Ornithonyssus aridus, is described from *Ammospermophilus leucurus* from deserts of California, Nevada and Utah. *Ornithonyssus* is redefined and 15 spp. are included. *Neoichoronyssus* is synonymized with *Ornithonyssus*. (Auth)

114 GARCIA, P. L. 1960. The influence of *Larrea divaricata* and *Atriplex canescens* on soil pH, electrical conductivity and soluble sodium content. Master's Thesis, New Mexico Highlands Univ., Las Vegas, New Mexico, 63 p.

Samples were collected from the Tularosa Basin, New Mexico, and Frenchman Flat, Nevada, to determine the influence of desert shrubs on the soils beneath them. Measurements included mean pH, mean electrical conductivity, and amount of soluble sodium. The most significant observation was the lowering of soil pH from samples collected beneath *Larrea divaricata*. (TPO)

115 GERTSCH, W. J., and D. M. ALLRED. 1965. Scorpions of the Nevada Test Site. Brigham Young Univ. Sci. Bull., Biol. Ser. 6(4), 15 p.

The scorpion fauna of the Nevada Test Site was investigated from 1959-1964 as a part of the ecological study of the area and the effects of nuclear weapons. Nine species of scorpions live in the area, but only two species, *Vejovis confusus* and *Hadrurus spadix* may be considered abundant. Data given for each species

includes distribution and abundance, description and taxonomy, sex ratio and seasonal occurrence. (BBM)

116 GIST, C. S. 1967. Problems of sampling desert arthropods before and after a thermonuclear cratering test. Great Basin Nat. 27: 26-35.

An analysis of selected arthropods near ground zero was made before and after a large thermonuclear device at the Nevada Test Site (Project Sedan) was detonated. The study was restricted to species that could be sampled readily with sunken can traps and that were known to be well represented in the test area. Possible changes in species composition or in relative abundance of species as a result of the test were sought. It was concluded that the only significant lesson that emerged from the above experience was that deducing real changes in arthropod populations on the basis of captures in traps was difficult and required a considerable sampling effort in order to avoid ascribing significance to differences that occurred simply due to chance. Species captured in the study were scorpions: *Vejovis confusus* Stahnke, *Hadrurus hirsutus* Wood; insects: *Areniva apacha* (Saussure), *Stenopelmatus fuscus* Thomas, *Ceuthophilus* spp., *Trogloderus costatus* LeConte, *Eleodes hispilabris* (Say), *Pelecyphorus pantex* Casey, and *Eleodes* spp. (mostly *E. armata* (LeConte)). (BSL)

117 GOATES, M. A. 1963. Mites on kangaroo rats at the Nevada Test Site. Brigham Young Univ. Sci. Bull., Biol. Ser. 3(4), 12 p.

A systematic study of parasitic mites on kangaroo rats of two species at the Nevada Test Site was conducted from August 1959 to December 1961. The intent was to determine the kinds, numbers, seasonal occurrences and ecological relationships of mites in nuclear disturbed and contiguous undisturbed areas. A total of 1,256 rats from nine plant communities was examined. The 6,208 mites collected represented 16 species including four undescribed. Fourteen were found on both kinds of rats. Considerably more rats were infested with chiggers than with mesostigmatids. Seasonal peaks in numbers of mites occurred during the three periods of February-March, July, and October-November. Forty percent fewer rats in the nuclear disturbed areas were infested than in undisturbed areas, and only one-third as many mites were found on rats in the disturbed as in the undisturbed areas. (Auth)

118 GONZALEZ, D. D., C. T. WARREN and C. L. WASHINGTON. 1973. Water levels and spring discharges for selected wells and springs in Nevada, 1966-69. USGS-474-171, 69 p. (NTIS, Springfield, VA 22151)

Surface-water and ground-water data are collected from selected wells and springs in Nevada. Data presented are for the period 1966-69 and were collected from ground-water wells, gaging stations, miscellaneous sites, and four hot spring sites. A brief description of location of measurement sites is given. The data collection

network is to evaluate possible effects of nuclear explosions on the hydrology of springs and wells. (Auth)

119 GRABSKE, R. J., and J. M. DAWSON. 1969. Ecological studies at far-out locations. In: Bio-Medical Division Preliminary Report for Project Schooner (USAEC Report UCRL-50718), p. 70-71. (Univ. California Lawrence Livermore Laboratory, Livermore, CA 94550)

The Schooner Event was a 31-kiloton nuclear cratering detonation executed on 8 December 1968 at the Nevada Test Site. The Bio-Medical Division participated in this event in a variety of ways concerned with prediction, transport, and interaction with the biosphere. The predictive effort considered those radionuclides created within the device and its environment with the aim of identifying those with the greatest biological hazard. During and immediately following the event a variety of field experiments were conducted. Aircraft samples of the cloud were analyzed to determine radionuclide and mass partitioning as a function of particle size and class. Fourteen sequential air-sampling stations were fielded to study the distribution and redistribution of airborne particulates up to 6 weeks following the event. Considerable redistribution of debris was found, with the stations initially upwind recording very high activity four days after detonation. Pigs were stationed at four sites in the field for studies of the fate of radionuclides inhaled and ingested under field conditions. Fallout trays and tritium sniffers were fielded to document the mass deposition and radionuclide specific activity of fallout material and the tritium content of the base-surge cloud. In a joint project with Plowshare Division, more than 300 parachute-borne air samplers were dropped through the cloud to determine the total cloud burden. Two high-volume debris separators and collectors were fielded to collect large amounts of debris from the base-surge cloud for laboratory experiments on the biological availability of radionuclides in fallout debris. Several additional field and laboratory experiments were begun after detonation. With debris collected from the base-surge cloud as well as with crater-lip material, experimenters are determining the biological availability of radionuclides to pigs, cows, and various aquatic organisms. The leachability of debris radionuclides is being determined in a variety of solvents, and the biological availability of the nuclides to aquatic animals is being assessed. An ecology program was begun in the immediate vicinity to study the half-residence-times of radionuclides in soils, plants, and animal life. Surveys of the residual soil contamination and in situ biological availability of radionuclides are also being conducted at distances 50 miles from ground zero. Many of these experiments are continuing projects. This report summarizes preliminary findings and indicates the direction of continuing efforts. (Auth)

120 HALEY, T. J. 1964. Experimental usefulness of the kangaroo rat. Laboratory Animal Care 14:95-102.

Specialized research problems have resulted in the introduction of new and often exotic species of animals into the research laboratory. The kangaroo rat is one example of such an introduction. This readily tamed and useful animal has certain characteristics which make it unique and of interest in highly specialized research programs. Studies have been conducted on its ability to exist on a dried diet with only a bare minimum of water and that obtained from succulent plants. Hematological studies indicate that the kangaroo rat exhibits a different hematological distribution of cells than the mouse or rat. The lymphocyte constitutes 81.4% of the total leukocytes. The hematocrit has a value of 46 to 48 in spite of the high degree of water conservation practiced by the animal. The response to ionizing radiation of this species does not differ from that reported for the mouse or rat. Behavior studies indicate that digging characteristics of the kangaroo rat are similar to those of the gerbil. Furthermore, the animal shows definite psychotic tendencies under the influence of psychotomimetics like LSD-25 and psilocybin. At present an evaluation of the physiological responses of isolated tissues from this animal as well as its responses to anesthetics is being undertaken to evaluate its further usefulness in the laboratory.

121 HALEY, T. J., R. G. LINDBERG, A. M. FLESHER, K. RAYMOND, W. McKIBBEN and P. HAYDEN. 1960. Response of the kangaroo rat *(Dipodomys merriami* Mearns) to single wholebody x-irradiation. Radiation Research 12:103-111.

The responses of the kangaroo rat *(Dipodomys merriami* Mearns) to single whole-body x-irradiation in the dosage range 25 to 550 r have been studied. The ST_{50} of this species at 550 r was 10.3 (9.7 to 10.9) days, which is almost identical with that of the CF-1 mouse. Observations were made of the following: total erythrocytes, total leukocytes, differential cell count, platelets, hemoglobin, hematocrit, bone marrow, and adrenal, kidney, spleen, and body weights. The responses of the kangaroo rat were essentially the same as those observed in the albino rat, but the general symptomatology was different, reflecting, in part, the difference in intestinal flora. In the nonirradiated kangaroo rat, the lymphocyte comprises 81.4% of the total leukocytes, and the spleen has an average weight of only 33 ± 2.88 mg. (Auth)

122 HATCH, F. T., E. J. RIDLEY and J. A. MAZRIMAS. 1971. Some *Dipodomys* species: ecologic and taxonomic features, estrous cycle, and breeding attempts. USAEC Report UCRL-51140, 25 p. (Univ. California Lawrence Livermore Laboratory, Livermore, CA 94550)

A colony of various species of kangaroo rats *(Dipodomys)* was

maintained to gain practical experience concerning their maintenance needs, especially nutrition and reproduction. Information is included on trapping experience, species identification, habitats on the Nevada Test Site, and breeding phenology. (TPO)

123 HATCH, F. T., J. A. MAZRIMAS, J. J. KORANDA and J. R. MARTIN. 1970. Ecology and radiation exposure of kangaroo rats living in a tritiated environment. Radiation Research 44:97-107.

Kangaroo rats *(Dipodomys ordii)* living near a crater resulting from a nuclear detonation were found to be generally tritiated. The tritium activity of body water and tissues ranged from 0.1 to 0.4 μCi per gram. Organically bound tissue tritium had approximately the same specific activity as body water (6 - 8 x 10^6 dpm per gram hydrogen). The animals appeared to be in equilibrium with their food supply and the soil, in terms of tritium concentrations. The lifetime chronic radiation dose to adult animals was estimated to be 10 rad from internal ^3H. About 10 rad was also received from persistent external β- and γ-emitting radionuclides in the soil. There was no significant concentration of other internal radionuclides. The generalized tritium labeling and chronic low-level radiation exposure are of special interest in these animals. There was no macroscopic evidence of harmful radiation effects. (Auth)

124 HAYWARD, C. L., M. L. KILLPACK and G. L. RICHARDS. 1963. Birds of the Nevada Test Site. Brigham Young Univ. Sci. Bull., Biol. Ser. 3(1), 27 p.

Water sources, small as they are, are responsible for the presence of many species of birds at the Nevada Test Site. When natural vegetation was destroyed by atomic testing or construction, it was typically replaced within a short time by Russian thistle *(Salsola kali)*. This weed serves as a source of food and cover for many small birds. (HP)

125 HELVIE, J. B., and D. D. SMITH. 1971. Summary of necropsy findings in desert bighorn sheep. SWRHL-62r, 10 p. (Environmental Monitoring and Support Laboratory, Environmental Protection Agency, Las Vegas, NV 89114)

Necropsies were performed on 49 desert bighorn sheep. Incidence of pulmonary pathology was high for all age classes. The major cause of death, when determined, was pneumonia. (TPO)

126 HERRIN, C. S., and D E. BECK. 1965. Observations on the biology, anatomy, and morphology of *Otobius lagophilus* Cooley and Kohls. Brigham Young Univ. Sci. Bull., Biol. Ser. 6(2), 19 p.

Summarizes present knowledge about the geographic distribution, seasonal occurrence, and host-parasite relationships of the soft-bodied tick *Otobius lagophilus* Cooley and Kohls in western

North America, including the Nevada Test Site. The preferred host is *Lepus californicus*, the black-tailed jackrabbit, although collections have been made on *Lepus townsendii* and *Sylvilagus* spp. The tick has been found to be naturally infected with Rocky Mountain spotted fever, Colorado tick fever, and tularemia. It is capable of harboring *Pasteurella tularensis* for as long as 676 days. *Otobius lagophilus* may be a potential reservoir of some diseases in nature, but not a direct vector in transmission from host to host. (TPO)

127 HODDENBACH, G. A., and F. B. TURNER. 1968. Clutch size of the lizard *Uta stansburiana* in southern Nevada. Amer. Midland Nat. 80:262-265.

Clutch size of *Uta stansburiana* varies from year to year, with observed differences of as much as one egg per clutch. Fertility is correlated with production of winter annuals. The largest clutches were recorded in 1966, following unusually good growth of winter annuals. It is likely that the abundance of insects available to *Uta* is also related to production of annuals. (Auth)

128 HOLMGREN, N. H. 1971. A new species of *Penstemon* from Nye County, Nevada. Aliso 7:351-356. (New York Botanical Garden, Bronx, NY 10458)

Penstemon pahutensis, a new species, was described from material collected by Reveal on Pahute Mesa and Rainier Mesa, Nevada Test Site. (TPO)

129 HOUGHTON, J. G. 1969. Characteristics of rainfall in the Great Basin. Univ. Nevada, Desert Research Inst., 205 p. (Univ. Nevada, Reno, NV 89507)

The major objectives of this report were to: (1) explain the characteristics of rainfall in the Great Basin in terms of climatic controls; (2) develop statistical methods for estimating the long-term rainfall regime at stations with imcomplete records. The solution to the problem involved statistical techniques based on synoptic rainfall-triggering mechanisms. Analyses showed that rainfall components could be defined by standard curves expressing the associated annual march of rainfall. The Pacific component approximated a sine curve with a January peak and a July-August minimum. The Gulf component occurred only in summer with an August maximum. The Continental component, associated with closed lows developing over the Great Basin itself, varied in shape but generally peaked in the spring and fall. Given the standard curve, the estimated long-term annual march of rainfall could be computed for any station by fitting curves to the station data and combining them into a total curve. The parameter, precipitation effectiveness, is defined in terms of the annual mean rainfall and the deficiency index. The latter two terms are classified in terms of

vegetation types, including five categories of annual rainfall and seven categories of deficiency. Finally, the precipitation effectiveness is expressed in terms of climatic types representing the two factors combined. (TPO)

130 JOHNSON, M. S., and D. E. HIBBARD. 1957. Geology of the Atomic Energy Commission Nevada proving grounds area, Nevada. USGS Bull. 1021-K, 55 p. (U. S. Geological Survey, Denver, CO 80225)

The Nevada proving grounds area in Nye and Clark Counties, Nev., is about 700 square miles in size and lies about 70 miles northwest of Las Vegas in southern Nevada. It consists essentially of two large valleys, Yucca and Frenchman Flats, both surrounded and separated from one another by hills and mountains of variable relief. Seventeen Paleozoic formations and one of Tertiary age have been recognized in the Nevada proving grounds area. The Paleozoic formations are Early Cambrian to probable early Permian in age and consist of 22,000 feet of limestone, dolomite, quartzite, shale, and conglomerate beds. The predominantly volcanic Oak Springs formation of Tertiary age is at least 2,000 feet thick and is the most widespread formation in the area. A granitic intrusion of probable Late Cretaceous to early Tertiary age has metamorphosed and mineralized some of the Paleozoic rocks, and dikes of middle Tertiary or later age occupy normal faults along the northeastern margin of the area. Quaternary deposits reaching a maximum thickness of more than 800 feet are mostly a heterogeneous mixture of detritus derived from bedrock areas. This fill contains some caliche and fanglomerates. Playas made up wholly of impermeable fine silt and clay are present. During the Mesozoic era uplift and attendant folding and contemporaneous thrust faulting occurred, probably in Cretaceous time. Normal faulting began in early Tertiary time, followed by volcanic deposition and later by continued normal fault displacement. (Auth)

131 JOHNSON, R. F., C. S. COOK, L. A. WEBB and R. L. MATHER. 1958. Neutron-induced radioactive isotopes in soils (Operation Teapot, Project 2.3a). WT-1117, 53 p. (TIC, Oak Ridge, TN 37830)

A report is given on the part of Project 2.3 that studied the activities induced in the surface of the earth near Ground Zero (GZ) by neutrons released from a nuclear detonation. Gamma ray spectral measurements of Nevada Test Site soil obtained from the vicinity of GZ following Shots 1, 4 and 7 were studied. From these it is concluded that the relative quantities of observed neutron-induced activity to fission fallout activity are functions of height, yield, and type of detonation. Ten different soil samples were exposed to the neutrons from Shot 5. While only Na-24 and Mn-56 activities could be definitely found in significant quantities in all soils, the relative amounts of these two radioisotopes varied over a considerable range and, within reasonable accuracy, can be said to have been activated in proportion

to the amount of sodium and manganese atoms present in the soil at the time of irradiation. (Auth)

132 JORGENSEN, C. D. 1962. Disturbance of mammal traps by jack rabbits. Great Basin Nat. 22:83-86.

When the disturbance of Young-type mammal traps by hares became a serious threat to the collection of rodent data, the trapping pattern was altered to determine their reactions and behavior as a prerequisite to their removal from the study area. Following this sequence of experiments, the following theories are presented: (1) the hares responded to the bait inside the trap rather than the trap itself, (2) their visual senses enabled them to detect traps with accessible bait and avoid traps with inaccessible bait, (3) they followed trails to search which was suggestive of a learning process. (BBM)

133 JORGENSEN, C. D. 1963. Notes on the biology and distribution of *Paracotalpa granicollis* Haldeman (Coleoptera: Scarabaeidae). Pan-Pacific Entomologist 39:154-156.

Certain aspects of the biology and distribution of *Paracotalpa granicollis* were observed at the Nevada Test Site. Adult males were observed flying in all the plant communities except Pinyon-Juniper. They were most numerous in the *Grayia-Lycium* and *Lycium* communities and least numerous in the *Coleogyne* and *Artemisia* communities. They preferred sandy bajada soils, but not sandy washes or gullies. Males were observed from January to April. Mating behavior was discussed. (HP)

134 JORGENSEN, C. D. 1963. Spatial and time distribution of *Dipodomys microps occidentalis* within distinct plant communities. Ecology 44:183-187.

Two factors in animal distribution were evident: (1) a distinct border effect resulting from the trapping technique, (2) variations in distribution resulting from a continuous death rate opposing a seasonal birth rate. (HP)

135 JORGENSEN, C. D. 1967. A new species of Tuckerella (Acarina: Tuckerellidae) from Nevada. Entomol. News 78:141-146.

Females, males, and nymphs of a new species of Tuckerella were collected from *Coleogyne ramosissima*, *Atriplex canescens*, and *Atriplex confertifolia* at the Nevada Test Site. This is the only species known to be native to North America. (HP)

136 JORGENSEN, C. D. 1968. Spatial relationships of *Perognathus longimembris* (Coues) in southern Nevada. Proc. Utah Acad. Sciences, Arts and Letters 45:118-125.

The spatial relationships of least pocket mice were evaluated at

Nevada Test Site using the home range and distance between nearest neighbors. Generally, there was a clear ranking of classes within the population, some being much more tolerant of other classes than others, although there was considerable overlap. This ranking behavior could effect such parameters as sex ratios, relative survival rates, etc. which are vital in understanding population growth. (HP)

137 JORGENSEN, C. D. 1968. Home range as a measure of probable interactions among populations of small mammals. J. Mammalogy 49:104-112.

A technique for estimating the probability of interaction in space using the home range as a basis of measurement is presented. The overlap area between adjacent home ranges and the relative use of home range area are used to obtain the estimate. The methods were demonstrated with data for *Perognathus longimembris* for the USAEC (US Atomic Energy Commission) Nevada Test Site. Probable interaction between females ranged from .6301 for individuals with recapture centers only 11.43 m apart to .0000 for animals 88.53 m apart. In this case the recapture radius was 44.45 m. Probable interaction between males and females ranged from .6289 to .0000 with distances from recapture centers of 11.43 m to 85.53 m, respectively. Assumptions required by this technique and limitations of interpretation are discussed. (Auth)

138 JORGENSEN, C. D. 1970. Free living mites of the Nevada Test Site. (Final Report) USAEC Report COO-1731-4, 46 p. (NTIS, Springfield, VA 22151)

The effects of nuclear weapons testing on the species composition and distribution of mites in the Nevada Test Site area were studied. Sampling sites are described and a map is presented to show the location. A table is presented to show average beta and gamma radiation levels at various locations within the sampling sites. Methods of collecting mites from vegetation are described and mathematical formulas for determining ratios of predaceous, phytophagous, and scavenger mites are presented. Seventeen phenotypically distinct groups of mites were identified and a table is presented to show numbers of mites in each group for all samples taken. Graphs are presented to show species diversity indices at various sites; the effect of radiation stress, primarily beta, was to increase the species diversity. The effects of radiation stress on trophic level organization are indicated by means of graphs that show ratios of predaceous mites to phytophagous and scavenger forms. A list is presented of 111 plant species from which mites were collected and a list of approximately 400 species of mites collected is presented. (HLW)

139 JORGENSEN, C. D., and C. L. HAYWARD. 1963. Notes on shrews from southern Nevada. J. Mammalogy 44:582.

Three species of shrews were collected at the Nevada Test Site.

All collections were made with sunken can traps. (HP)

140 JORGENSEN, C. D., and C. L. HAYWARD. 1965. Mammals of the Nevada Test Site. Brigham Young Univ. Sci. Bull., Biol. Ser. 6(3), 81 p.

Two primary aspects of small mammal distribution at the Nevada Test Site are particularly evident. The occurrence of species in relation to elevation changes and the changing fauna as the ecotone is transected between the Mohave Desert and Great Basin Desert. A transect between the Mohave Desert and the Great Basin Desert crosses several valleys where any one species may occupy several functional or spatial niches. Examples of this are *Grayia spinosa* and *Lycium andersonii*, which are identified as a distinct biotic community in Yucca Flat, but are scattered among communities typified by other species in Frenchman Flat. *Dipodomys* may be used to interpret the ecotone between the Great Basin desert, and the Mohave Desert, and *Perognathus* may be used to interpret the physiognomy within the valleys resulting from habitat changes. (HP)

141 JORGENSEN, C. D., and A. M. ORTON. 1962. Note of lizards feeding on oatmeal bait. Herpetologica 17:278.

The animals caught in Young-type live traps are named. Stomach analysis revealed lizards ate oatmeal bait while confined inside. (HP)

142 JORGENSEN, C. D., and W. W. TANNER. 1963. The application of the density probability function to determine the home ranges of *Uta stansburiana stansburiana* and *Cnemidophorus tigris tigris*. Herpetologica 19:105-115.

Purposes of this paper are to estimate the home range of *Uta stansburiana stansburiana* Baird and Girard and *Cnemidophorus tigris tigris* Baird and Girard and to discuss the application of two methods for determining home range. The minimum polygon and density probability function methods were applied, and the latter gave results closer to those expected from field observations. The home ranges were: *Uta stansburiana* juveniles 16.82 ares (.42 acres), adult females 27.36 ares (.68 acres), and adult males 39.30 ares (.98 acres); *Cnemidophorus tigris* juveniles 21.7 ares (.54 acres), adult females 51.15 ares (1.28 acres), and adult males 28.65 ares (.71 acres). Trapping space, collection methods, trapping period, animal behavior, and methods of estimation must be considered in the interpretation of home range. In this study, normal distribution gave an estimate which more closely approximated the observed distribution than did Pearson's incomplete gamma distribution. (BBM)

143 JORGENSEN, C. D., D. M. ALLRED and D E. BECK. 1963. Some effects of an underground nuclear detonation on biotic communities at the Nevada Test Site. Proc. Utah Acad. Sciences, Arts and Letters 40:49-61.

The Brigham Young University study group found two major vegetation zones which extended from Sedan ground zero to about 3,250 feet. It was characterized by *Salsola kali, Sitanion hansenii, Oryzopsis hymenoides* and *Mentzella albicaulis*. The second shrub zone was mde up primarily of *Coleogyne ramosissima, Grayia spinosa,* and *Lycium andersonii*. These are the plants which originally covered the entire area before nuclear testing began in 1951. After the test, vegetation from ground zero to 3,000 feet was destroyed and more than a foot of throw-out was deposited. From 3,000 to 5,000 feet the vegetation was damaged by flying missiles. No visible blast damage occurred to plants beyond 5,000 feet except for a dust layer. The area where drastic changes of populations of small mammal survivors was noted was between 4,000 and 5,000 feet. Beyond 5,000 feet the populations were not reduced by the blast or throw-out effects. The disturbance did not cause an immediate movement of small mammals away from the area of destruction. (HP)

144 JORGENSEN, C. D., A. M. ORTON and W. W. TANNER. 1963. Voice of the leopard lizard, *Crotaphytus wislizenii* Baird and Girard. Proc. Utah Acad. Sciences, Arts and Letters 40:115-116.

Buried can traps have been used frequently to study invertebrates and lizards at the U. S. Atomic Energy Commission Nevada Test Site. While operating the traps in a *Grayia spinosa-Lycium andersonii* plant community in Sept. 1961, a leopard lizard was discovered with a high pitched voice. This distinct squeal-like voice replaces the usual hissing sound which is characteristic of the species after it has been excited. The lizard (a female) was returned to the laboratory where its voice was recorded on tape to be presented during this discussion. Particular note was made of all leopard lizards collected from the test site during the next year and only rarely was one found that would not squeal when excited. The nature of the voice is difficult to characterize, although it sounded similar to that of the western banded geckos *(Coleonyx variegatus)* Baird which have been collected from the test site. Some leopard lizards responded with no apparent period of agitation necessary, but most required a period of excitement before the characteristic hissing was replaced by squealing. After they had squealed for one to three minutes, a vicious attack on the object of agitation usually resulted, and a rest period was necessary before the voice was again discernible. The lizards were more easily induced to squeal in the early morning than later in the day. To our knowledge, this is the first record of a distinct voice for this species. Stebbins (Amphibians and Reptiles of Western North

America: 201, 1954) stated that only a few lizards have a voice. He does not include the leopard lizard as one of these. Since the majority of the individuals collected at the Nevada test site after the first voice was discovered, squealed, it was concluded to be a characteristic of the species in this area. (Complete article)

145 KAAZ, H. W., A. WALLACE and E. M. ROMNEY. 1971. Effect of a chronic exposure to gamma radiation on the shrub *Ephedra nevadensis* in the northern Mojave Desert. Radiation Botany 11: 33-37.

A 33,600 Ci ^{137}Cs source which was differentially shielded to increase the uniformity of the distribution of radiation was set up on a 15-m tower in the center of a 9-ha plot in Jan. 1964 in the Rock Valley areas of the northern Mojave Desert. In the spring of 1969 the large majority of 5000 *Ephedra nevadensis* Wats. shrubs (Mormon tea) within the plot failed to produce flowers and very little vegetative growth occurred on the species in contrast to a control plot and to other nonirradiated areas. The 5-yr cumulative radiation exposure throughout about 85% of the plot ranged from 3.9 to 9.8 kR. Radiation effects on other species were nonexistent or doubtful. *E. nevadensis* has a higher interphase chromosome volume than do the other shrub species.

146 KANTZ, A. D. 1971. Measurement of beta dose to vegetation from close-in fallout. In: (Bensen, D. W., and A. H. Sparrow, eds.) *Survival of Food Crops and Livestock in the Event of Nuclear War*, AEC Symp. Series 24 (CONF-700909), p. 56-70. (NTIS, Springfield, VA)

Dosimetry experiments are described in which both beta and gamma ray doses to the environment and to vegetation were measured with thermoluminescent dosimetric techniques in the close-in fallout fields from the Plowshare cratering events Cabriolet and Schooner. The beta doses measured were found to be an order of magnitude greater than the gamma-ray doses at the same location. This work was performed in support of ecological- and environmental- effects studies sponsored by the Environmental Sciences Branch of the Atomic Energy Commission's Division of Biology and Medicine. (Auth)

147 KILLPACK, M. L., and M. A. GOATES. 1963. Bat captured in snap trap. J. Mammalogy 44:125-126.

A female pallid bat, *Antrozous pallidus pallidus* (LeConte) was caught 8 July 1961 in a Museum Special snap trap at the Nevada Atomic Test Site, Mercury, Nye County, Nevada. The trap was one of 50 in a line established to collect small rodents. Traps were spaced 30 ft apart and baited with a combination of wet and dry rolled oats. The bat was trapped in the open near a sagebrush, *Artemisia tridentata* Nutt., on the floor of a small canyon near the base of Rainier Mesa. Here sandstone cliffs make up part of the slopes where pinyon pine and junipers extend down to the edge of the sagebrush community. Shrubs of this latter community

range from 6 to 15 inches in height with an average spacing of 2 to 3 feet. The bat apparently had alighted before being caught. Its wings were folded in a resting position, and it was secured across the center of the body with its head facing away from the treadle of the trap. Apparently it had sighted an insect on or near the trap, and was caught when attempting to secure it. Such a collection of the pallid bat is not unlikely when the habits of this species are considered. Hall (Mammals of Nevada, Univ. Calif. Press, p. 165, 1946) noted that this bat flies low over vegetation while searching for food, occasionally alighting on the bole of trees. Burt (San Diego Soc. Nat. Hist., 7:397, 1934) listed it as being a low flyer, even alighting on the ground to capture June beetles. Grinnell (Univ. Calif. Publ. Zool., 1918) found remains of Jerusalem crickets on the floor of a cave where pallid bats had been roosting. Our observation lends additional evidence that this species seeks some of its food on the ground. This observation was made as part of a study under AEC Contract AT (11-1)786. (Complete article)

148 KLEIN, W. L., and R. A. BRECHBILL. 1972. Preliminary radiation surveillance of an aquatic system near the Nevada Test Site, June-July, 1967. SWRHL-65r, 23 p. (NTIS, Springfield, VA 22151)

Results of a three-month preliminary radiation surveillance study of an aquatic system in Upper Pahranagat Lake near the Nevada Test Site are presented. The study was conducted to determine the concentrations of fission products in selected samples and to establish the necessary methodology for radiation surveillance in an aquatic ecosystem. Radionuclide concentrations were found to be insignificant in water, aquatic plant, and fish samples. Sediment samples had detectable levels of ^{137}Cs, ^{40}K, ^{90}Sr, and U. Strontium-90 levels in fishbone were low (2.38 pCi/g bone ash) compared with those found in bovine femur samples (6.9 pCi/g bone ash) collected during the same period. (Auth)

149 KNIGHT, H. H. 1968. Taxonomic review: Miridae of the Nevada Test Site and the Western United States. Brigham Young Univ. Sci. Bull., Biol. Ser. 9(3), 282 p.

Approximately 5,000 specimens of plant bugs were collected at the Nevada Test Site between 1959 and 1965. A total of 160 species representing 50 genera was taken at the site. Of these, 7 genera and 96 species were new to science. Comparative data for these and other western species were included. Taxonomic keys to subfamilies, genera, and species, distribution data and host plant relationships are provided. (HP)

150 KORANDA, J. J. 1969. Residual tritium at Sedan Crater. In: (Nelson, D. J., and F. C. Evans, eds.) *Symposium on Radioecology*, Proc. Second National Symp. on Radioecology (CONF-670503), p. 696-708. (NTIS, Springfield, VA 22151)

Residual tritium from the Sedan thermonuclear detonation, 6 July 1962, was scavenged by or entrained in the 5-6 million tons of earth materials moved by the detonation. As a result, the Sedan post-shot environment contained a most significant biological tracer in the form of THO. Residual tritium (THO) is found in μCi concentrations in the interstitial water of the Sedan throwout soil, and in the loose tissue water of plants which have re-invaded the new substratum deposited on the landscape adjacent to the crater. Tritium is present not only in the loose tissue water of vascular plants growing on the Sedan throwout, but a comparable level is also found in the tissue-bound hydrogen of these plants. Herbivores, mainly heteromyid rodents, which have re-invaded the Sedan post-shot environment and reside there, also have tritium concentrations in their body water between 1 and 3 μCi/ml. These body-water tritium concentrations are closely related to the levels of tritium in the plant tissue-bound hydrogen. Soil-water tritium concentrations in the soil air at the rodent burrow depth are several orders of magnitude lower than the observed body-water level. The inspirational route of entry of tritium into the animal is therefore assumed to be a secondary one, with the primary source being the plant organic matter synthesized in the Sedan post-shot environment which is used as the animal's food base. The internal dose to the resident mammal at Sedan crater from residual tritium is estimated to be between 18 and 268 rads, or about 10 times that from external radiation sources resulting from the detonation. (Auth)

151 KORANDA, J. J., and J. R. MARTIN. 1969. The persistence of radionuclides at sites of nuclear detonations. In: (Shore, B., and Hatch, F., CoChrs.) *Biological Implications of the Nuclear Age*, Proc. Symp. held at Livermore, Calif., March, 1969 (CONF-690303), p. 159-187. (TIC, Oak Ridge, TN 37830)

A study of the persistence of radioisotopes at nuclear detonation sites is extremely important for evaluating future peaceful engineering uses of nuclear explosions such as the excavation of canals and harbors. Information on the distribution of radioisotopes at test detonation sites (Pacific Proving Ground and Nevada Test Site), where earth has been moved to create craters or trenches, was studied and the uptake of certain radioisotopes by plants and animals in the areas was examined. Sedan Event data on tritium concentrations in crater fallback, crater soil water, tissue water of plants growing on ejecta, and kangaroo rats living in the Sedan area are presented. Five years after the shot, tritium was found to be the most abundant radioisotope in ejecta or in any biological system in the area. (LCL)

152 KORANDA, J. J., J. R. MARTIN and R. WIKKERINK. 1967. Residual tritium at Sedan crater. Part 2. Soil and Ejecta Studies. USAEC Report UCRL-50360, 42 p. (Univ. California Lawrence Livermore Laboratory, Livermore, CA 94550)

Continuing studies of residual tritium in soil or ejecta deposited

on the landscape around the Sedan crater, Nevada Test Site, are concerned with the spatial and temporal distribution of THO in the area from the crater lip to 5000 ft from ground zero. Seasonal variations in the concentrations of tritium in soil water occur mainly during the winter rainfall period. Dilution effects were observed to a depth of 3 ft during an unusually high rainfall period (1965-1966). Diluted tritium concentrations in the surface strata of soil (6 in. to 3 ft) increase to almost the predilution levels during the summer as a result of soil moisture movements. When Sedan ejecta occurs as a shallow layer overlying the preshot soil, maximum tritium concentrations are found in this soil, usually at the maximum depth of rainfall penetration, or approximately 3 ft. Maximum concentration of tritium in ejecta on the Sedan crater lip is found at a depth of 4 to 5 ft and is correlated with the depth of ejecta materials found around the crater lip. An inventory of tritium in the Sedan ejecta field was calculated, based upon collections of soil samples along transects of the ejecta-covered area, and to a depth of 6 ft at each site. The tritium inventory measurements are essentially of biologically available water in the soil system. When data are corrected to total soil-water tritium values, the current inventory of tritium outside the Sedan crater in 1967, five years postshot, is 5 to 6% of the estimated inventory of the residual tritium in the ejecta at shot time. (Auth)

153 KORANDA, J. J., J. R. MARTIN and R. W. WIKKERINK. 1970. Leaching of radionuclides at Sedan Crater. In: *Radionuclides in the Environment*, Advances in Chemistry Series, Number 93, p. 97-117. (American Chemical Society, 1155 16th St., NW, Wash., D.C. 20036)

The distribution of tritium and long-lived gamma radioactivity was studied in crater ejecta from the Sedan detonation (July 1962). Tritium concentrations were determined in soil water extracted from crater ejecta samples collected from the surface to 6 feet, and at distances of 3000 feet from the crater from 1966-1968. Tritium distribution was very obviously modified by postshot environmental effects, especially rainfall leaching. Tritium maximum concentrations were found below the strata in which they were deposited. Gamma radionuclides exhibited limited movement in the crater ejecta strata or in preshot soil covered by Sedan ejecta. A subtle leaching of Cs-137 was demonstrated by considering the Cs-137/Mn-54 ratios in the ejecta strata. (Auth)

154 KORANDA, J. J., J. R. MARTIN, R. W. WIKKERINK and M. L. STUART. 1969. Radioecological studies. In: Bio-Medical Division Preliminary Report for Project Schooner (USAEC Report UCRL-50718), p. 43-56. (Univ. California Lawrence Livermore Laboratory, Livermore, CA 94550)

See abstract under GRABSKE, R. J., and J. M. DAWSON. 1969. (119)

155 KORANDA, J. J., J. R. MARTIN, R. WIKKERINK and M. STUART. 1970. Postshot distribution and movement of radionuclides in nuclear crater ejecta. In: Proc. American Nuclear Society Symp. on Engineering with Nuclear Explosives held in Las Vegas, Nevada, January, 1970 (CONF-700101, Volume 1), p. 400-421. (Univ. California Lawrence Livermore Laborary, Livermore, CA 94550)

The distribution and postshot movement of radionuclides in nuclear crater ejecta are discussed. Continuing studies of tritium movement in ejecta at Sedan crater demonstrate that variations in tritium concentration are correlated with seasonal rainfall and soil water movements. Loss of 27 mCi $^3H/ft^2$ are evident on Sedan crater lip at the end of a three year period of measurements in which an unusually large flux of rain was received. The distribution of gamma emitting radionuclides and tritium is described in the recently created Schooner crater ejecta field. The specific activity of radionuclides in the Schooner ejecta continuum is shown for ejecta collected from the crater lip to 17 miles from Ground Zero (GZ). The movement of W-181 and tritium into the subejecta preshot soil is described at a site 3000 feet from GZ. (Auth)

156 KORANDA, J. J., P. L. PHELPS, L. R. ANSPAUGH and G. HOLLADAY. 1971. Sampling and analytical systems for measuring environmental radioactivity. In: *Rapid Methods for Measuring Radioactivity in the Environment* (IAEA-SM-148/36), p. 587-614. (Unipub, Inc., Box 433, Murray Hill Station, NY, NY 10016)

Rapid methods of sampling and quantitating airborne tritiated water, radioactive particulates and a wide range of environmental samples have been developed to document the releases of radioactivity associated with uses of nuclear explosives, reactor operation and basic radioecological studies. Two types of atmospheric water samplers have been used in environmental studies conducted in remote field operations. A simple cold-pipe sampler of several designs employing either LN or CO_2 has been used in laboratory studies and field studies. A more complex sampler which may eventually be actuated using a column of magnesium perchlorate or molecular sieve has also been used. A sampling and analytical system for determining air concentrations of radioactive particulates has been used successfully in several types of radioecological studies associated with nuclear cratering experiments, monitoring of worldwide and close-in fallout deposition, and reactor studies. A series of automatically sequenced air pumps which draw air through an efficient fiberglass filter is the basic component of this flexible air sampling system. The system may be turned on by radiation levels or by other means. Filters are prepared in a standard geometry and sealed in containers which retain gaseous radioactivity. Air flow data are obtained by calibration of the air pump before and after sample collection. Automatic particle collection trays are also described. Micrometeorological instrumentation is placed in the field with the sequential air sampler and provides supplemental data on the movement of radioactive particulates in the environment. The

sample is assayed with a sold-state detector and a 4096-channel pulse height analyser. The high resolution of this spectrometer permits quantitating 10-20 radionuclides simultaneously. The use of this solid state spectrometer has been extended to in situ field measurements of deposited radioactivity. The mobile system is mounted in a small van with a portable power supply and transported to remote field sites for measurement of environmental radioactivity. Sample preparation techniques for a wide range of environmental samples including animal organs, vegetation, and soil are discussed. (Auth)

157 KRIEGER, H. L. 1965. The measurement of long-lived activation products in soil by gamma spectroscopy. Health Physics 11: 653-658.

Soil samples collected at the site of the 1957 balloon-type nuclear detonation in Nevada have been periodically analyzed to determine specific nuclides and to observe changes in spectrum configurations resulting from decay of the shorter lived gamma activities. In 1963, Cs-134, Co-60, Pu-152 and Pu-154 were separated by radiochemical analysis and identified by gamma spectrometry. Both manual stripping of the identified nuclides and matrix calculations, in which identical geometric configurations were used, corroborated the presence of these nuclides in the soil sample. Photopeaks of the induced short-lived Sc-46, which were evident in the 1957 spectrum, were not evident in the new gamma scan. No Sr-90, Cs-137 or other fission products were detected; all the nuclides present evidently were produced by neutron activation of their stable precursors. Repeated acid leaching removed only about 70 percent of the activities of the nuclides present, indicating a very strong attachment of these nuclides to the soil. Estimations of the relative individual activities were calculated by use of computer matrix solutions developed from calibrated standards. (Auth)

158 LARSON, K. H. 1959. Summary of observations of distribution, characteristics and biological availability of fallout originating from continental detonations. In: Biological and Environmental Effects of Nuclear War, Hearings before the Special Subcommittee on Radiation of the Joint Committee on Atomic Energy, U. S. 86th Congress, 1st session, June, 1959, p. 803-830.

Describes progress made by the Environmental Radiation Division between 1949-1959 to: delineate fallout patterns and their characteristics as a result of nuclear testing; study the chemical, physical, and radiological characteristics of fallout debris; and to determine the biological availability, rate of accumulation, and retention of the fallout debris in various native and domestic plants and animals, as well as the persistence and redistribution of residual contamination in the total environment. (TPO)

159 LARSON, K. H. 1963. Continental close-in fallout: its history, measurement and characteristics. In: (Schultz, V., and A. W. Klement, Jr., eds.) *Radioecology*, Proc. First National Symp. on Radioecology, p. 19-26. (Reinhold Publ. Corp., New York, NY 10022)

Biological and radiological studies were made of the Trinity site. Vegetation appeared to be the most important influence in decreasing wind-borne radioactivity. The levels of beta activity in the surface in. of soil ranged from 60 to 380 disintegrations/min/gm or one μCi per sq ft 1 in. deep. Five years after the detonation there was evidence of downward migration of radioactivity into the second in. in Chupadera Mesa, but not in the crater. The radioactivity of plant material was 3.85 percent of soil radioactivity in 1949 and 5.6 percent in 1950. Tissue deposition was first detected in *Neotoma* sp. in the fourth year after detonation. Plutonium was found in amounts up to 0.07 μg/per sq ft, one-half in. deep, at a distance 88 miles northeast of the Trinity site and 1.47 μg per sq ft was found 28 miles northeast of the site in Chupadera Mesa. (HP)

160 LARSON, K. H., H. A. HAWTHORNE and J. H. OLAFSON. 1962. Nevada Test Site fallout: some characteristics, its apparent environmental equilibrium and biological availability. In: (Klement, A. W., Jr., ed.) *Radioactive Fallout from Nuclear Weapons Tests* (USAEC Report TID-7632, Book 1), p. 4-24.

Fallout from the detonation of test devices at the Nevada Test Site is governed by many complex variables such as energy yield and type of device, wind structure, support used for the device, nature of the ground surface, contact of the fireball with ground surface, and mass of inert material surrounding the device. Findings are summarized on the distribution and characteristics of fallout from detonations of tower-mounted devices and from balloon-mounted or air-dropped devices having less than 75 kt yield. The environmental equilibrium and biological availability of fission products are considered with emphasis on Sr-90. Results of biological studies indicate that biological availability of Sr-90 is much greater at some early time after fallout and that mechanisms for the reduction of potentially available Sr-90 exist in the environment, regardless of apparently persistent Sr-90 soil levels. (CH)

161 LARSON, K. H., J. H. OLAFSON, H. M. MORK and D. R. HOWTON. 1952. Field observations and preliminary field data obtained by the U.C.L.A. survey group on Operation Jangle, November, 1951. USAEC Report UCLA-182, 29 p. (NTIS, Springfield, VA 22151)

Observations on each of the Operation Jangle detonations and preliminary data on the area contaminated by the fallout material are summarized. Estimated fallout patterns are suggested for each detonation based on counting at various sites. The

first crop of radishes grown on contaminated soil absorbed a significant percentage of radioactivity. (WDM)

162 LARSON, K. H., J. W. NEEL, H. A. HAWTHORNE, H. M. MORK, R. H. ROWLAND, L. BAURMASH, R. G. LINDBERG, J. H. OLAFSON and B. W. KOWALEWSKY. 1966. The behavior of fallout in the environment; Biotic availability of fallout debris to indigenous animals and plants. In: Distribution, Characteristics, and Biotic Availability of Fallout, Operation Plumbbob (WT-1488), p. 118-181. (UCLA, Los Angeles, CA 90024)

Four persistence study stations were maintained on the midline of Priscilla fallout and two on the midline of Smoky fallout pattern. Maximum air temperature, minimum relative humidity, and maximum air movement occurred at about 1300 hours each day. Opposite measurements occurred at about 0300 hours. Wind speed was negligible at 6 inches above the soil surface as compared with speeds 36 inches above the soil surface in areas with normal to dense vegetation cover; wind speeds were approximately equal at the two measurement heights in areas having sparse vegetation. Radioactive decay measured in the field was similar to the decay of comparable fallout samples measured in the laboratory. Attenuation of gamma radiation was measured as 15.7 percent at 18 inches and 27.2 percent at 36 inches, of the radiation at one inch, using film badge type dosimeters. Beta attenuation similarly was measured as 28.6 percent at 18 inches and 44.2 percent at .36 inches, of the beta radiation measured at 1 inch above the soil surface. Fallout debris deposited on the soil surface tended to become mechanically trapped, the amount redistributed declining with time. Strong winds, however, caused material to be redistributed at concentrations equal to the initial contamination especially in areas having a sparse vegetative cover. The concentration of fallout debris in the surface inch of soil at two stations contaminated by Smoky Shot did not significantly change between D + 3 days and D + 300 days. Particles 44-88 microns in diameter contributed an average of 9.7 percent of the total redistributed fallout following Priscilla as compared to 21.0 percent following Smoky. Particles less than 44 microns in diameter contributed an average of 85.8 percent following Shot Priscilla compared to 68.3 percent following Shot Smoky. Aerosol concentrations were similar following both Shots Priscilla and Smoky despite significant differences in initial contamination. The original fallout contamination of native plant material persisted through the 18 day period following Shots Priscilla and Smoky. (Auth)

163 LEAVITT, V. D. 1970. Soil survey of Area 18, Nevada Test Site. SWRHL-74r, 119 p. (Environmental Monitoring and Support Laboratory, Environmental Protection Agency, Las Vegas, NV 89114)

A soil survey of Area 18, which lies in the northwestern portion of the Nevada Test Site, was undertaken to obtain information on

the soil and vegetation being grazed by the USAEC beef herd. Twenty soil series descriptions, including both physical and chemical analyses, were written and included on soil maps of the area. (TPO)

164 LEAVITT, V. D. 1974. Soil surveys of five plutonium contaminated areas on the test range complex in Nevada. NERC-LV-539-28, 84 p. (Environmental Monitoring and Support Laboratory, Environmental Protection Agency, Las Vegas, NV 89114)

Soils in five areas located on the Test Range Complex, Nye County, Nevada are described. All of the areas have at one time been sites of above-ground nuclear safety tests. The areas are contaminated with plutonium and are, therefore, the object of investigations regarding the movement of plutonium in the environment. Most of the surface soils in the five areas have a gravelly texture and are typically classified as gravelly sandy loam. The majority of the surveyed land is either flood-plain or alluvial fan with deep soils having well-developed profiles and platy structure. All of the soils are alkaline ranging in pH from 7.0 to 9.0. The vegetation is classified in two general categories, low and high desert shrub. The low desert shrubs are predominantly creosote-bush *(Larrea divaricata)* and white bursage *(Franseria dumosa)*. The high desert shrubs are mostly fourwing saltbush *(Atriplex canescens)*, winterfat *(Eurotia lanata)*, and bud sagebrush *(Artemisia spinescens)*. (Auth)

165 LEAVITT, V. D., and B. J. MASON. 1971. Soil survey of Area 15, Nevada Test Site. SWRHL-106r, 46 p. (Environmental Monitoring and Support Laboratory, Environmental Protection Agency, Las Vegas, NV 89114)

The results of a soil survey of the area around the Environmental Protection Agency Experimental Dairy Farm located in Area 15 of the U. S. Atomic Energy Commission's Nevada Test Site are reported. Four soil series were identified. Descriptions of these series are included along with physical and chemical analyses of representative samples of the soils. (Auth)

166 LINDBERG, R. G. 1959. Factors influencing the biological consequences of environmental contamination by nuclear debris. In: Proc. of the Second Plowshare Symp., San Francisco, Calif., May, 1959. Part II. Excavation (USAEC Report UCRL-5676), p. 42-59. (Univ. California Lawrence Livermore Laboratory, Livermore, CA 94550)

The physical and chemical properties of fall-out debris are discussed. It is pointed out that the biological consequences of environmental contamination by radioactive debris are largely a function of the physical characteristics of the contaminants and the utilization of the contaminants by plants or animals is

dependent upon the material being in a soluble or digestible form. Until this occurs the effect of radioactive debris is limited to the production of an external radiation field of rapidly declining intensity. A review of data on fall-out from previous detonations suggests that whatever the conditions of surface or above-ground detonation may be, a complete spectrum of kinds of fall-out particles are produced but with the proportion of those bearing a specific set of characteristics dependent upon the nature of the detonation. The conditions of detonation, therefore, strongly influence the physical properties of the particles produced. The biological effects of fall-out are largely dependent upon particle size, physical and chemical properties, and the specific radioisotopes that are present. It is anticipated that in the case of excavation detonations neutron-induced activity may make the most significant contribution to the fall-out field during the acute periods of contamination if significant amounts of radioactive debris should escape during excavation events. The biological problems resulting are probably of a short-term nature. Data are tabulated on isotopic fractionation and fall-out pattern during Operation Plumbbob. In its general characteristics, it is representative of fall-out patterns produced by shallow underground, tower-, or balloon-supported detonations. If venting should occur during excavation activities of the Plowshare Program, it would be expected that escaping radioactive debris would be deposited in a similar pattern. The radiation intensity will depend upon the energy yield, the specific design of the device, the location of the device with regard to the ground surface, and meteorological conditions. Ecological concepts which must be considered in evaluating the biological consequences of radioactive contamination are discussed. (CH)

167 LINDBERG, R. G., and K. H. LARSON. 1956. The short term biological fate and persistence of radioactive fallout as measured at various locations within fallout patterns. In: (Dunning, G. M., and J. A. Hilcken, eds.) Proc. Symp. on the Shorter-Term Biological Hazards of a Fallout Field, Washington, D.C., December, 1956, p. 197-204. (UCLA, Los Angeles, CA 90024)

Data was collected during weapons testing programs and up to one year following fallout contamination of an environment. The particular components studied were air, soil, plants, native rodents, and fallout, and the kinds of environment varied from the semiarid desert valleys to juniper and pinon covered slopes to relatively rich agricultural areas. The kangaroo rat, genus *Dipodomys*, and the jackrabbit, genus *Lepus* were used as indicators of the biological availability of radioactive fallout to other mammals. The persistence of fission products in various tissues from a natural population of kangaroo rats over a period of 90 days following a single fallout contamination in the spring of 1953 is presented graphically, as is the buildup of radioiodine in the thyroid of kangaroo rats and jack rabbits sampled from a

fallout area located 12 miles from Ground Zero (GZ) during the spring of 1955. The occurrence of radiostrontium in the bones of jackrabbits from the midline of residual fallout contamination was compared to distance of the sampling site from the Nevada Test Site and to the degree of residual environmental contamination. The ^{90}Sr activity in the bones along the midline of residual fallout increased out to 130 miles and then decreased slightly and leveled off. During the weapons testing program the predominant size of fallout particles greater than 100 μ in diameter decreased with distance from GZ while the less than 100 μ material did not decrease but remained the same or increased with distance up to 200 miles from GZ. The majority of particles retained by foliage was below 44 μ in diameter having an average size of approximately 20 μ. The smaller size material tended to be more soluble and therefore potentially more available to the biological cycle. (FMM)

168 LINDBERG, R. G., E. M. ROMNEY, J. H. OLAFSON and K. H. LARSON. 1959. Factors influencing the biological fate and persistence of radioactive fall-out (Operation Teapot). WT-1177, 78 p. (UCLA, Los Angeles, CA 90024)

During Operation Teapot the biological accumulation of fission products derived from nuclear detonations was studied as functions of the distance of the sampling site from Ground Zero (GZ), radioactive particle size distribution, and fractionation of fallout material as it may vary with distance from GZ. This included studies on the persistence of fission products in plants and animals living in contaminated environments, the availability of fallout material to plants under various conditions of contamination, evaluation of inhalation as a significant phenomenon in the uptake of fission products in actual fallout areas, and the determination of the percentage distribution of the total body burden of certain isotopes in the tissues of animals exposed to fallout. Preliminary data indicate that the activity measured in plant samples collected from fallout areas is the result of external contamination by radioactive fallout particles less than 44 microns in diameter. The degree of plant contamination is a function of the mechanical distribution of the less than 44 micron size particles within a distance of 100 miles from GZ, which is in turn influenced by such conditions of weapon detonation as tower height and meteorology. The radioactive fallout material on plant foliage is persistent as evidenced by the activity remaining on leaves even after washing in Versene and 0.1 N HCl solutions, or by the mechanical shaking brought about by severe wind storms. The tissue burdens of fission products in animals sampled from fallout contaminated environments tend to decrease with distance from GZ similarly to the degree of plant contamination. The activity per unit weight of femur, however, tends to remain fairly constant to a distance of 140 miles from GZ. The thyroid shows a greater tissue burden of radioiodine at 60 miles than at 12 miles from GZ. The tissue burden then declines similarly to other tissues. The

relative decrease in tissue burdens of fission products in native animals serially sampled from the same fallout contaminated environment in most cases did not markedly deviate from the radioactive decay rate of mixed fission products (t (E-1.2)). The activity per unit weight of femur, however, gradually increased until 3 days post-shot and then decreased. The thyroid activity continued to rise throughout the 15 day sampling period. Iodine 133 is believed to contribute largely to the thyroid burden during the first 3 days following the detonation. The close correlation in most cases between the relative tissue activity and the activity of the digestive tract contents suggests that ingestion is the principal source of tissue activity. The data indicate that a rapid equilibrium between the absorbed activity and that passing through the gut may have been established within the first 2 days following fallout. Data suggest that inhalation is a negligible path of uptake of fission products during and after fallout contamination. (Auth) (FMM)

169 LINDBERG, R. G., J. T. SCANLAN, J. C. WATSON, W. A. RHOADS and K. H. LARSON. 1954. Environmental and biological fate of fallout from nuclear detonations in areas adjacent to the Nevada Proving Grounds (Operation Upshot-Knothole). WT-812, 54 p. (NTIS, Springfield, VA 22151)

A radio-ecological survey of the area adjacent to the Nevada Proving Grounds in progress intermittently from Sept. 1951 to July 1953 is summarized. Samples have been taken periodically of soils, plants, and animals before, during, and after various test series at distances up to 30 miles from ground zero. Conclusions are drawn on the fission product burden in animal tissue. (WDM)

170 LUCAS, A.C., and N. R. FRENCH. 1967. A miniature thermoluminescent dosimeter and its application in radioecology. In: (Attix, F. H., ed.) *Luminescence Dosimetry*, AEC Symp. Series 8, p. 402-411. (EG&G, Goleta, CA 93017)

Glass capillary dosimeters containing CaF_2:Mn or LiF were constructed to measure radiation exposures of free-ranging small animals. In the 1-1000-R range they had a precision of ± 0.1 R or ± 3%, whichever was greater. Reading of exposures was facilitated by an externally heated coil of Nichrome wire. (TPO)

171 LYNN, R. L., D. G. CRANDALL, R. K. MULLEN and W. A. RHOADS. 1970. Gamma radiation spectra in the vicinities of Projects Shoal and Faultless. USAEC Report EGG-1183-2255, 15 p. (EG&G, Goleta, CA 93017)

The scintillator array used in the Aerial Radiological Measurement Survey (ARMS) System was employed in ground-based gamma radiation surveys of the Project Shoal and Project Faultless sites. Measurements were made at nine locations at the Project Shoal site and at

four locations at the Project Faultless site. On the basis of an unconfirmed report of possible low-level radioactive contamination at the Project Shoal site, six rodents were trapped and removed from that site for whole-body gamma spectral analysis. Computerized analysis of the gamma spectra obtained at the Project Shoal site revealed a radiation peak in the 0.650-0.670 MeV region at some, but not all, of the locations where measurements were made. The origin of this radiation, which has tentatively been identified as Cs-137, is unknown. Similar analysis of the gamma spectra obtained at the Project Faultless site revealed no radiation peaks not attributable to normal background. Whole-body counts made on the rodents secured from the Project Shoal site revealed no radiation burden other than normally occurring K-40. The lack of any discernable peak in the 0.650-0.670 meV region would suggest that the radioactive contaminant present at the Project Shoal site is not involved in the food-chain kinetics of the resident rodent population. (Auth)

172 MARTIN, J. R., and J. J. KORANDA. 1971. Distribution, residence time, and inventory of tritium in Sedan crater ejecta. Nuclear Technology 11:459-465.

Radioecological studies were conducted over a five-year period to characterize the distribution and residence time of tritium in soil samples from ejecta of the Sedan crater. Extracted water was assayed by liquid scintillation counting. Kangaroo rats were trapped and monthly body-water tritium concentrations were plotted as a function of time. Residence half-time for tritium in the rats was determined to be 14.5 plus or minus 1.4 months. The agreement of tritium residence time in the body water of the rat with that obtained from the soil data suggests that the surface-to-six-foot interval is the biologically significant zone for tritium in the desert ecosystem at Sedan crater. The tritium inventory in the ejecta at T sub 0 is reported as (1.5 plus or minus 0.2) x 10(E+6) μCi. (BBM)

173 MARTIN, J. R., and J. J. KORANDA. 1972. Biological half-life studies of tritium in chronically exposed kangaroo rats. Radiation Research 50:426-440.

The biological half-life of tritium was measured in the body water and in brain, liver, lung, kidney, heart and muscle tissues of two groups of kangaroo rats captured in the tritiated environment at Sedan crater in the Nevada Test Site. These animals had been exposed to tritium in their natural food for their entire lifetime. The rodents were maintained on tritium-free food in the laboratory during the two study periods of five and nine months. At regular intervals, several animals from each group were killed, dissected and lyophilized. Tritium in the body water was determined by liquid scintillation counting. Dried tissue residues were assayed by sealed-flask combustion and

liquid scintillation counting. The biological half-life of tritium in the tissue compartment of these uniquely exposed animals was 1.5 to 4 times that of the body water. At the time of trapping, a slight enrichment of tritium in tissue was indicated by the initial ratio of tissue to body water tritium which ranged from 1.2 to 1.6 with an average value of 1.40 ± 0.14. (Auth)

174 MARTIN, W. E. 1962. Applications of fundamental biology to the needs of man. 4. Radioecology and the study of environmental radiation. USAEC Report TID-16060, 71 p. (UCLA, Los Angeles, CA 90024)

A review is given of some of the ecological aspects of the problems of the atomic age which deal with the collection of data and the development of concepts to be used in making realistic, quantitative evaluations of the biological hazards, if any, resulting from increased environmental radiation due to fall-out. The major topics considered are: the kinds and amounts of natural and man-made sources of ionizing radiation in the biosphere; the formation and dispersal of fallout, including a comparison of local, tropospheric and stratospheric fall-out patterns; the redistribution of fall-out materials by environmental processes, their accumulation by plants and animals, and their cycling in terrestrial foodchains; and the evaluation of potential biological hazards arising from small increases in external and internal exposure of organisms to ionizing radiation. (Auth)

175 MARTIN, W. E. 1963. Loss of I^{131} from fallout-contaminated vegetation. Health Physics 9:1141-1148.

While the radioactive half-life of ^{131}I is 8.04 days, its effective half life on fallout-contaminated vegetation was found to be only 5.5 days. Experimental evidence indicated that the difference may have been due to the mechanical removal of particles from vegetation and/or to the vaporization of ^{131}I from particles retained by vegetation. These findings imply that ^{131}I and other radionuclides contained in fallout may be lost from the diets of herbivores at rates significantly greater than could be predicted on the basis of radioactive decay alone. (Auth)

176 MARTIN, W. E. 1963. Close-in effects of an underground nuclear detonation on vegetation. I. Immediate effects of cratering, throw-out, and blast (Project Sedan). USAEC Report PNE-228P, 41 p. (UCLA, Los Angeles, CA 90024)

Operation Sedan involved the detonation of a nuclear device at a depth of almost 650 ft in the alluvium of Yucca Flat, Nevada. Preliminary results are reported for studies dealing with the immediate close-in effects of this detonation on vegetation. (Auth)

177 MARTIN, W. E. 1963. Notes on the deposition of fallout in relation to topography and local meteorological conditions. USAEC Report UCLA-513, 17 p. (NTIS, Springfield, VA 22151)

Activities in a program to collect radioactive effluents released during the test operation of a Kiwi reactor (Kiwi B-1a) on December 7, 1961, are reported. Granular fallout collectors and cheesecloth aerosol collectors were prelocated along roads approximating arcs of 5, 16, and 37 miles from the reactor test cell at the Nevada Test Site. Each of these arcs crossed successively lower and wider parts of a gently sloping valley. A last-minute shift in wind direction carried the effluent cloud away from the prelocated sampling devices. Apparently, the cloud was trapped until nightfall in an inversion layer from 2000 to 3500 feet above the surface. During the night following the reactor test, tropospheric or stratospheric fallout probably derived from nuclear detonations in the U. S. S. R. (but no short-lived fission products) were deposited on the above-mentioned sampling devices. The shallow-valley inversion and cold air drainage caused the pattern of this deposition to be closely related to the local topography. The beta-gamma activity deposited on samplers at low elevation (presumably below the valley inversion layer) was less than that deposited on samplers at higher elevations. The highest levels of beta-gamma activity were detected on samplers which had been located directly in the most probable pathway of nocturnal cold-air drainage. Further studies are recommended. (Auth)

178 MARTIN, W. E. 1964. Radioecology and the study of environmental radiation. Bull. Torrey Bot. Club 91:283-323.

A review is given of some of the ecological aspects of the problems of the atomic age which deal with the collection of data and the development of concepts to be used in making realistic, quantitative evaluations of the biological hazards, if any, resulting from increased environmental radiation due to fall-out. The major topics considered are: the kinds and amounts of natural and man-made sources of ionizing radiation in the biosphere; the formation and dispersal of fall-out, including a comparison of local, tropospheric and stratospheric fall-out patterns; the redistribution of fall-out materials by environmental processes, the accumulation by plants and animals, and their cycling in terrestrial food chains; and the evaluation of potential biological hazards arising from small increases in external and internal exposure of organisms to ionizing radiation. (Auth)

179 MARTIN, W. E. 1964. Losses of Sr^{90}, Sr^{89}, and I^{131} from fallout-contaminated plants. Radiation Botany 4:275-284.

During the early period following local fallout, and during periods of maximal worldwide fallout, the entry of radionuclides into

terrestrial food chains is due primarily to the external contamination of plants and secondarily to the uptake of radionuclides from contaminated soil. The following studies were undertaken to estimate the rates of radionuclide loss from fallout-contaminated vegetation and hence from the diets of herbivores, living in a fallout field. On the fifth, fifteenth, thirtieth, and sixtieth days after an underground nuclear explosion (Operation Sedan) at the Nevada Test Site, plant samples were collected from twenty representative locations in the fallout field and analyzed to determine the concentrations (pc/g dry wt) of ^{90}Sr, ^{89}Sr, and ^{131}I at the times of collection. While the radioactive half-lives of ^{90}Sr, ^{89}Sr, and ^{131}I are approximately 27.7 years, 53 days, and 8.04 days respectively, their average effective half-lives on fallout contaminated plants, during the period from 5 to 30 days after the detonation, were 27.8 days, 17.8 days and 5.0 days respectively. Losses of ^{90}Sr and ^{89}Sr were attributed to radioactive decay and to the removal of fallout particles and foliage by wind and/or other mechanical disturbances. Losses of ^{131}I were attributed to radioactive decay, to mechanical disturbance, and to the vaporization of ^{131}I from the fallout particles retained on foliage. (Auth)

180 MARTIN, W. E. 1965. *Early food-chain kinetics of radionuclides following close-in fallout from a single nuclear detonation.* In: (Klement, A. W., Jr., ed.) *Radioactive Fallout from Nuclear Weapons Tests,* AEC Symp. Series 5 (CONF-765), p. 758-782. (TIC, Oak Ridge, TN 37830)

Plant samples and rabbits were collected from representative locations in the Sedan fallout field before and at various times after the detonation. Radiochemical and statistical analyses indiated highly significant correlations between estimates of gamma dose rates and maximum concentrations of Sr-89 or I-131 in plant samples and in the stomach contents, bone ash, or thyroids of rabbits collected between 15 and 100 miles from ground zero. The effective half-lives of Sr-89 and I-131 on fallout-contaminated plants were approximately 18 and 5.0 to 5.5 days, respectively. Maximum concentrations of Sr-89 in rabbit bone ash occurred about 30 days after the detonation and remained high for at least 60 days; but maximum concentrations of I-131 in rabbit thyroids occurred by or before five days and then declined to pre-Sedan levels in less than 60 days after the detonation. Deterministic exponential models were formulated and found to function satisfactorily, with parameter values derived from the data, in providing a partial explanation of the quantitative kinetic relations between initial concentrations of Sr-89 and I-131 on plants and subsequent concentrations in the bone ash or thyroids of rabbits collected in the Sedan fallout field. Major sources of error in the estimation of input-parameter values and in the use of such models to make predictions are described and discussed. Similar models were proposed for the study of radionuclide kinetics in human food chains (i.e., pasture plants, cow milk, and

human tissues or organs) following environmental contamination by a single fallout event. The results of hypothetical calculations were compared with radiation protection guides recommended by the Federal Radiation Council. (Auth)

181 MARTIN, W. E. 1965. Interception and retention of fallout by desert shrubs. In: (Hungate, F. P., ed.) *Radiation and Terrestrial Ecosystems*, Health Physics 11:1341-1354.

Concentrations of I-131 and Sr-89 on plants contaminated by fallout from Project Sedan tended to decrease with increasing distance from ground zero and increasing time after the detonation. Microscopic and radiometric examinations of foliage indicated that most of the activity deposited on leaves was probably due to particles <5 μ in diameter, and virtually none of it was due to particles >44 μ in diameter. A comparison between the theoretical and observed interrelations of gamma dose rates, I-131 and Sr-89 deposition rates, and I-131 and Sr-89 interception by desert shrubs indicated a deficiency of I-131 relative to Sr-89 in areas more than 40 miles from ground zero and an excess of both I-131 and Sr-89 relative to dose rates in areas about 100 miles from ground zero. The effective half-lives of I-131 and Sr-89 on plants were shorter than their radioactive half-lives and a comparison of environmental half-lives suggested that I-131 may have been lost from plants by some process, such as vaporization, which had no effect on the retention of Sr-89. Statistical analyses indicated that the frequency distributions of variates representing maximum concentrations of I-131 and Sr-89 on plants, and in the tissues of rabbits collected at the same times and locations in the fallout field, were not normal but lognormal. Similar analyses indicated that the frequency distributions of effective half-life estimates could be treated as either normal or lognormal. (Auth)

182 MARTIN, W. E. 1966. Close-in effects of nuclear excavation and radiation on desert vegetation. In: (Sacher, G. A., ed.) *Radiation Effects on Natural Populations,* p. 7-9. (Argonne National Laboratory, Lemont, IL 60439)

Detonation of the Sedan device subjected native vegetation to high levels of radiation and dust. The plants exhibited various degrees of damage, but these effects may have been due to exposure to dust alone rather than radioactivity. (TPO)

183 MARTIN, W. E., and F. B. TURNER. 1963. Increased environmental radiation in southern Nevada, October-December, 1961. USAEC Report UCLA-518, 45 p. (UCLA, Los Angeles, CA 90024)

Soils, plants, and animals were collected in October and early November 1961 from areas at and near the Nevada Test Site. Similar samples were collected after the Kiwi B-1a reactor test of

December 7, 1961. Radiochemical and statistical analyses provided evidence for the following conclusions: 1) The gross beta activity of soils in southern Nevada tended to decrease with increasing distance from the Nevada Test Site and appeared to be related to the general pattern of fallout from nuclear detonations during the 1950's, 2) the gross beta activity of plant samples also tended to decrease with increasing distance from the Nevada Test Site, but the differences between geographically comparable areas were not statistically significant, 3) there was, during late November and early December, a significant and geographically uniform increase in the beta activity of plants and rabbit stomach contents both at and to the south of the Nevada Test Site, 4) similarly, there were increases in the radiostrontium content of rabbit bones and in the Cs-137 content of rabbit muscle, 5) most of the observed increase of environmental radiation in southern Nevada was due to radioisotopes such as Sr-89, Y-91, Ce-141, and Ce-144 having intermediate half-lives, 6) evidence of marked increases in plant and animal contamination by short-lived radioisotopes such as I-131, I-133 and by Sr-91:Y-91 was restricted to areas in the immediate, downwind vicinity of the reactor test cell, 7) the major increase of environmental radiation, in southern Nevada during November 1961, was due to fallout from nuclear detonations in the U. S. S. R., and 8) increases of environmental radiation attributable to the deposition of radioactive effluents from the Kiwi reactor were minor and highly localized. (Auth)

184 MARTIN, W. E., and F. B. TURNER. 1965. Food-chain relationships of radiostrontium in the Sedan fallout field. USAEC Report PNE-237F, 61 p. (NTIS, Springfield, VA 22151)

Plant samples and rabbits were collected before and at various times up to 33 days after the detonation from 20 representative locations in the Sedan fallout field. Radiochemical analyses were made to determine the concentrations of Sr-89 and Sr-90 in dry plant samples and in the bone ash of rabbits at the times of collection. Estimates of initial gamma dose rates (R_0= mr/hr, 3 ft above ground, 24 hr after the detonation) were obtained from aerial survey data. The average concentrations, build-up, and later decline of radiostrontium in the bone ash of rabbits collected in the Sedan fallout field were apparently due to the initial concentrations of radiostrontium on the fallout-contaminated plants consumed by the rabbits; the weight of contaminated plant material consumed per rabbit per day; the weight of bone ash per rabbit; the fraction of ingested radiostrontium which was assimilated and deposited in bone; the effective half-life of radiostrontium on fallout-contaminated plants; and the effective half-life of radiostrontium in the skeleton. A mathematical model incorporating these parameters was formulated and found to function satisfactorily with parameter values derived from the radiochemical data. Estimates of the total doses (rad) delivered by

Sr-89 to rabbit bone were based on the model. The estimated doses to individual rabbits ranged from 0.11 to 9.48 rad, and the average was 1.12 ± 0.36 rad. While the model seems to provide an adequate explanation of the quantitative-kinetic relationship between average initial concentrations of radiostrontium on plants and subsequent average concentrations in rabbit bone ash, the parameter values used in fitting the hypothetical curves to the observed data points could be inaccurate; and even if the derived parameter values are accurate, they might not be applicable to other fallout fields. Some of the factors which influence the parameters considered in the model, and the major sources of error in estimating specific parameter values were discussed at length. A mathematical model was proposed to provide at least a partial explanation of the quantitative-kinetics of Sr-89 or I-131 on pasture plants, in cow's milk, and in human tissues (bone and thyroid) following fallout from a single nuclear detonation. The potential value of the proposed model as an aid in the study of human food-chain kinetics or for the interpretation of radiochemical data was illustrated by means of hypothetical calculations. (Auth)

185 MARTIN, W. E., and F. B. TURNER. 1966. Transfer of ^{89}Sr from plants to rabbits in a fallout field. Health Physics 12:621-631.

A study was conducted in the fallout field produced on July 6, 1962 by Project Sedan to formulate a mathematical model to represent the relationship between gamma dose rates and initial Sr-89 concentrations on fallout-contaminated plants and the time-specific relationship between Sr-89 concentrations on plants and in the bone ash of rabbits collected at the same times and locations in the fallout field. Estimates of gamma dose rates 24 hr after the detonation were based on the results of aerial radiometric surveys. Estimates of the time-specific concentrations of Sr-89 on plants and in rabbit bone ash were based on analyses of samples collected before and 5, 15, 30, and 60 days after the detonation at twenty representative locations in the Sedan fallout field. Correlation and regression coefficients based on estimated gamma dose rates and observed Sr-89 concentrations in plant and bone ash samples were highly significant, and analyses of variance indicated no significant deviations from linear regression. The average initial concentrations of Sr-89 on desert shrubs in the Sedan fallout field were approximately 103 pc/g per mR/hr. The average concentrations of Sr-89 in plant samples collected 5, 15, 30, and 60 days after the detonation were 1436, 909, 544, and 313 pc/g respectively. The average concentrations of Sr-89 in rabbit bone ash samples collected 5, 15, 30, and 60 days after the detonation were 863, 1680, 2097, and 1389 pc/g respectively. Estimates based on the 18-day effective half-life of Sr-89 on plants indicated an effective half-life of about 20 days for Sr-89 in rabbit skeletons. Estimates suggested that only 5.75 per cent

of the Sr-89 ingested was assimilated and deposited in rabbit bone. An exponential model based on the parameters described above was tested and found to provide a reasonable representation of the time-specific relationship between Sr-89 concentrations on fallout-contaminated plants and in rabbit bone ash. Using the same model to estimate the infinity doses delivered by Sr-89 to rabbit bone, indicated a range from about 0.1 to 9.5 rad and an average of 1.12 ± 0.36 rad in areas 12 to 110 miles from ground zero. Estimates of integrated doses indicated that 93 per cent of the infinity dose was delivered during the first 120 days after the detonation. (Auth)

186 MARTIN, W. E., G. E. RAINES, S. G. BLOOM and A. A. LEVIN. nd. Ecological transfer mechanisms - terrestrial. In: Proc. Symp. on Public Health Aspects of Peaceful Uses of Nuclear Explosives held at Las Vegas, Nevada, April, 1969 (SWRHL-82), p. 401-435. (Available as PB 187349 at NTIS, Springfield, VA 22151)

Radionuclides produced by nuclear excavation detonations and released to the environment may enter a variety of biogeochemical cycles and follow essentially the same transfer pathways as their stable-element counterparts. Estimation of potential internal radiation doses to individuals and/or populations living in or near fallout-contaminated areas requires analysis of the food-chain and other ecological pathways by which radionuclides released to the environment may be returned to man. A generalized materials transfer diagram, applicable to the forest, agricultural, and freshwater and marine ecosystems providing food and water to the indigenous populations of Panama and Colombia in regions that could be affected by nuclear excavation of a sea-level canal between the Atlantic and Pacific Oceans, is presented. Transfer mechanisms effecting the movement of stable elements and radionuclides in terrestrial ecosystems are discussed, and methods used to simulate these processes by means of mathematical models are described to show how intake values are calculated for different radionuclides in the major ecological pathways leading to man. These data provide a basis for estimating potential internal radiation doses for comparison with the radiation -protection criteria established by recognized authorities; and this, in turn, provides a basis for recommending measures to ensure the radiological safety of the nuclear operation plan. (Auth)

187 MASON, B. J., W. J. WIPPER and V. C. LEAVITT. 1969. Tritium uptake following a thermonuclear test. In: *Environmental Contamination by Radioactive Materials* (SM-177/73), p. 167-174. (Unipub, Inc., Box 433, Murray Hill Station, NY, NY 10016)

The mission of the Agrology Section of the US Public Health Service's Southwestern Radiological Health Laboratory is to develop radiation dose prediction models for components of man's food web that are

likely to be affected by radioactivity resulting from the peaceful uses of nuclear explosives. At the Nevada Test Site this section has developed a farming facility which is located approximately two miles downwind from the nuclear crater resulting from the July 1962 detonation of the 100 kiloton thermonuclear device, Project Sedan. This report presents results of a study to evaluate the uptake of tritium by selected crops which are important to Nevada's agricultural economy. To determine the distribution of tritium from this detonation, a four-station transect was located along the axis from the Sedan crater to the farm facility. A graph of the 1968 tritium profile in the soil indicates a maximum concentration at a depth of approximately 70 cm. This depth is closely correlated with the depth of the maximum desert rainfall penetration for this area. Prior to cultivation, the tritium concentration in the soil surface plow layer of the farm ranged from 11.4 to 26.5 pCi/ml of soil water or 0.21 to 0.42 pCi/g of dry soil. Comparisons made between radishes *(Raphanus sativus)*, potatoes *(Solanum tuberosum)*, sweet corn *(Zea mays)*, bush beans *(Phaseolus vulgaris)*, watermelons *(Citrullus vulgaris)*, and onions *(Allium cepa)* grown on the Nevada Test Site farm and similar produce purchased in the local markets indicated a significant difference between the tritium concentrations at the 99½ confidence level. Many of the items purchased in the local markets were below the minimum sensitivity of the analytical system used in this study. The levels in the Nevada Test Site crops ranged from 2.0 to 3.0 pCi/g of dry tissue, or 3.00 to 4.87 pCi/m of tissue water. Although the concentrations found are of little significance as far as total dose to humans is concerned, this study has indicated that tritium is available over considerable periods of time and does not leave the environment via evaporation as has been suggested.

188 MASON, B. J., K. W. BROWN, H. W. HOP and C. L. MILLER. 1973. Desert vegetation uptake of tritium from Project Gasbuggy effluent. In: (Nelson, D. J., ed.) *Radionuclides in Ecosystems*, Proc. Third National Symp. on Radioecology (CONF-710501), p. 177-182. (NTIS, Springfield, VA 22151)

Tritiated water vapor released to the atmosphere by flaring of the natural gas taken from the Project Gasbuggy cavity provided a unique tracer for evaluating atmospheric distribution of the activity and its subsequent uptake by native desert plants. Maximum uptake in plants was related to the effects of major terrain features on wind flow patterns. The maximum concentration of tritium was found to be in plants collected in the drainage wind pattern at 10 miles from the release points, and activity was from 5-10 times background levels found in vegetation collected elsewhere in the Southwest. (TPO)

189 MAXEY, G. B. 1968. Hydrogeology of desert basins. Ground Water 6: 10-22.

Hydrologic systems in arid lands normally include a recharge area in mountains and a discharge area in lowlands often with an intermediate area of lateral flow between recharge and discharge areas. This system is often modified by local geologic, climatic, and physiographic factors. Most water-supply, contamination and disposal problems arise from a combination of features superimposed on this system by concentration of population and agricultural activity in the discharge areas. Also most of our data on the system comes from the lowlands and little data is available from the recharge areas. In the Great Basin two general categories of groundwater flow systems are recognized: (1) local flow systems where drainage areas are usually small, flow paths are relatively short, interbasin flow is uncommon, springs have large fluctuations in discharge, water temperature is low, and concentration of Na, K, Cl, and SO is low, and (2) regional flow systems, where drainage areas are large, flow paths long, interbasin flow common, springs have large discharge, and the water is characteristically of higher temperature and contains higher concentratons of K, Na, CL, and SO^4. Hydrologic approaches used, in addition to conventional methods, include hydrologic budget, water-potential, and water-chemistry studies. Although detailed delineation of most flow systems in Nevada has not been accomplished, integration of hydrologic, geologic, and chemical methods allow approximate portrayal of many systems, both local and regional. Adequate methods upon which to base planning for optimum development of water resources in desert basins are now available. A conceptual model of optimal groundwater reservoir development illustrates how to determine optimum use of storage and perennial yield provided the use to which the water is to be put and the time of withdrawal are known. (Auth)

190 MAZA, B. G., N. R. FRENCH and A. P. ASCHWANDEN. 1973. Home range dynamics in a population of heteromyid rodents. J. Mammalogy 54: 405-425.

Seasonal, sexual and temporal aspects of home range for pocket mice *(Perognathus formosus* and *P. longimembris)* and kangaroo rats *(Dipodomys merriami* and *D. microps)* were analyzed from records accumulated over 7 yr of monthly censuses of the rodents in 3 9-ha enclosures and one similar area not enclosed in the Mojave Desert (California, USA). The density function was used as a standard expression (in terms of sigma) to compare home ranges of different individuals, groups or species, or over time. Detailed analysis of 340 *P. formosus* in one enclosure showed that 16 shifted locations of their home range during the course of this study, and 99 were detected to make one or more long-distance excursions beyond their home range. Compilation of all data gives an average representation of home range for this

species in this environment to be a circle of radius 31 m, which will encompass 86% of the animals' activity. This radius is the 2-sigma value computed from the data. Size of home range differs between sexes and among years, with significant year by sex interaction. There is an inverse relationship between population density and size of home range. Home range size is not related to body size in the 4 species studied, which presumably occupy the same trophic level of the system. Shifts in home range and excursions outside the established home range occurred most frequently in males and most frequently in the reproductive season.

191 McKINNEY, C. O., and F. B. TURNER. 1971. Genetic variation in irradiated and nonirradiated populations of the lizard *Uta stansburiana*. Radiation Research 47:530-536.

Analysis of allelic variation in continuously irradiated and nonirradiated populations of the lizard, *Uta stansburiana*, in Rock Valley, Nevada, revealed no significant differences in relative allele frequencies at 19 loci controlling selected proteins. The irradiated population did not differ significantly from control populations in 3 conventional measures of genetic variability. (Auth)

192 MEDICA, P. A., G. A. HODDENBACH and J. R. LANNOM, Jr. 1971. Lizard sampling techniques. Rock Valley Miscellaneous Publications, No. 1, 55 p. (Civil Effects Test Organization, Mercury, NV 89023)

Describes lizard sampling techniques used successfully by UCLA on the Nevada Test Site. Includes methods for estimating density and assessing reproduction and includes an appendix of sampling equipment and computer techniques. (TPO)

193 MEDICA, P. A., F. B. TURNER and D. D. SMITH. 1973. Effects of radiation on a fenced population of horned lizards *(Phrynosoma platyrhinos)* in southern Nevada. J. Herpetol. 7:79-85.

Between 1964 and 1966 minimum spring densities of horned lizards ranged from 1.0-2.5/hectare (ha) in three 8 ha enclosures in Rock Valley, Nevada. Minimal survival of hatchling horned lizards to the age of 8 months was about 26-38 per cent. Annual minimal survival of older lizards was 50-60 per cent. Female horned lizards usually laid one clutch of eggs per year, but multiple clutches were observed in 1969. Conversely, no reproduction was observed in 1970. The maximum life span of horned lizards is at least 94 months. One of the enclosures was subjected to continuous gamma irradiation from a centrally located source of Cs-137. Between 1964 and 1966 numbers of horned lizards declined in all 3 plots. Between 1967 and 1970 numbers of horned lizards increased in the two control areas, but continued to decline in the irradiated plot. Female sterility owing to regression of ovaries

is judged to be the cause of the population decline. Similar radiation effects have previously been observed among leopard lizards *(Crotaphytus wislizenii)*, whiptail lizards *(Cnemidophorus tigris)*, and side-blotched lizards *(Uta stansburiana)*.

194 MEDICA, P. A., F. B. TURNER and D. D. SMITH. 1973. Hormonal induction of color change in female leopard lizards, *Crotaphytus wislizenii*. Copeia, 1973, No. 4, p. 658-661.

Follicle stimulating hormone will induce red-orange pigmentation in nonovariectomized female leopard lizards in 7-21 days depending upon the season. Progesterone is judged to be an important hormone in the process of color change, and will bring about pigmentation in the absence of ovarian tissue. Estrogen alone has no apparent effect on color change, but when administered before progesterone it appears to have a priming effect.

195 MILLS, H. L., and L. M. SHIELDS. 1961. Root absorption of fission products by *Bromus rubens* L. from the AEC Nevada Test Site soil contaminated by an underground nuclear explosion. Radiation Botany 1:84-91.

The extent of accumulation in the above-ground plant parts resulting from fission products was assessed. The experimental plant chosen, *Bromus rubens*, was a grass with a fibrous root system which characteristically was located in soil retaining most of the fallout materials. The soil was from the crater of the underground nuclear detonation, Blanca Event, October 30, 1958. It does not seem appropriate in the case of shallow-rooted plants to make predictions of plant uptake on the basis of any distinction between soluble and exchangeable portions in soils. (HP)

196 MORK, H. M. 1970. Redistribution of plutonium in the environs of the Nevada Test Site. USAEC Report UCLA 12-590, 29 p. (UCLA, Los Angeles, CA 90024)

Data is presented on redistribution of plutonium as indicated by changes in the concentrations of gummed papers, air filters, soil and animal samples collected in 1956 and 1958. The airborne concentrations were significantly higher in one area than they were two years previous. The plutonium content of the soil ranged from less than one microgram to 2000 micrograms per square meter in the two areas studied. Some redistribution was occurring. Plutonium was associated with the liver, the lungs, and the bone of animals in the study areas. The maximum values observed in 1958 were 0.16 and 57.5 disintegrations per minute per animal for the liver and the lungs, respectively, and 2.62 disintegrations per minute per gram of bone ash. (Auth)

197 MULLEN, R. K. 1970. Respiratory metabolism and body water turnover rates of *Perognathus formosus* in its natural environment. Comp. Biochem. Physiol. 32:259-265.

Gravimetric and isotopic determinations of the respiratory and water metabolism of *Perognathus formosus* in the laboratory are in substantial agreement with values which are known from other heteromyid species obtained under similar conditions. Isotopic determinations in the field of these parameters in *P. formosus* yield respiratory metabolic values reflective of an active animal in a non-post-absorptive state. Body water turnover rates range from 2.4 to 4.0 times greater than those previously measured in heteromyid rodents. With the ability to measure metabolism in natural environments, continued reliance upon values obtained from laboratory experiments would seem limiting when insights into the physiological ecology of a species are sought. (Auth)

198 MULLEN, R. K. 1971. Energy metabolism and body water turnover rates of two species of free-living kangaroo rats, *Dipodomys merriami* and *Dipodomys microps*. Comp. Biochem. Physiol. 39: 379-390.

The energy metabolism and comparative body water turnover rates of two species of kangaroo rats, *Dipodomys merriami* and *Dipodomys microps* were measured in the natural environment over a 1-yr period with the $D_2{}^{18}O$ method. In addition to yielding energy metabolism data indicative of active, non-postabsorbtive animals, the results suggest that both species undergo diurnal torpor during periods of cold stress. Comparative water metabolism data indicate that *D. merriami* possesses a more conservative body water turnover rate than does *D. microps*. The $D_2{}^{18}O$ method of studying animal energy metabolism in the natural environment yields data not obtainable through conventional laboratory methods. It is preferable, therefore, that where practicable this method be employed in investigations of animal physiological ecology unless there is reasonable assurance that laboratory methods are adequate. (Auth)

199 MULLEN, R. K. 1971. Energy metabolism of *Peromyscus crinitus* in its natural environment. J. Mammalogy 52:633-635.

The energy metabolism of free-ranging canyon mice, *Peromyscus crinitus*, was measured using the $D_2{}^{18}O$ method. Estimates of oxygen consumption in January and February showed more variation between them than would have been predicted based on small differences in ambient temperature. The data suggest that some canyon mice may have undergone diurnal torpor or a period of reduced body temperature in response to either cold stress or shortage of food, or both. This technique does not provide data that would help define which of the two physiologic states the animals were in during the period of measurement. (TPO)

200 MULLEN, R. K., and R. M. CHEW. 1973. Estimating the energy metabolism of free-living *Perognathus formosus:* a comparison of direct and indirect methods. Ecology 54:633:637.

The results of an energy metabolism study of free-living *Perognathus formosus*, performed with the $D_2{}^{18}O$ method, are compared with data derived from metabolism chamber studies of the same species. Adding an activity correction factor to the metabolism chamber data results in oxygen consumption values essentially no different from those obtained from free-living *P. formosus*. This agreement was not unexpected, since the two methods share a large common component, i.e., the energy expended for thermoregulation. The agreement was partly fortuitous, however, in that *P. formosus* happens to behave similarly in nature and in the laboratory. Other species do not so behave. Thus, if prior knowledge is lacking concerning the metabolic behavior of a species in its natural environment, any indirect method of estimating that behavior would have to be validated by a direct method. (Auth)

201 MUMA, M. H. 1962. The arachnid order Solpugida in the United States, Supplement 1. Amer. Mus. Novitates 2091:1-44.

Twenty-one new spp. and new genus, *Horribates*, (type sp. *H. spinigerus)* are described. The allotypes of 4 previously known spp. are described. New distribution records and several new or expanded keys to males are included. (Auth)

202 MUMA, M. H. 1963. Solpugida of the Nevada Test Site. Brigham Young Univ. Sci. Bull., Biol. Ser. 3(2), 13 p.

As part of the ecological study of the Nevada Test Site, nearly 1000 specimens of solpugids were collected and identified as representing 28 species. Eight new species are described. A study is presented of the seasonal distribution and relative abundance of the sexes of 12 common species. Systematic collection data furnished ecological information about these species. (BBM)

203 NEEL, J. W., and K. H. LARSON. 1963. Biological availability of Strontium-90 to small native animals in fallout patterns from the Nevada Test Site. In: (Schultz, V., and A. W. Klement, Jr., eds.) *Radioecology*, Proc. First National Symp. on Radioecology, p. 45-49. (Reinhold Publ. Corp., New York, NY 10022)

The levels of Sr-90 soil contamination originating from Nevada Test Site activities and the Sr-90 bone levels of native jack rabbits and, in some cases, kangaroo rats, were determined in areas at different distances from the test site. Detailed studies showed Sr-90 to be persistent in the surface soil over a period of one year, and other observations indicated persistence for at least several years. Jack rabbits collected in 1958, one year after contamination by the fallout from the Plumbbob Series in an area 99 miles from ground zero had Sr-90 levels averaging 19.4 Sr units at all ages. A similar collection in 1961 revealed a

much reduced level of Sr-90 in the population (10.0 Sr units average) with the few higher values restricted to the older animals. It is postulated that the biological availability of Sr-90 in fallout is at its maximum at an early time after contamination; at later time the biological availability tends to be reduced by natural mechanisms in the environment. (Auth)

204 NISHITA, H., and R. M. HAUG. 1973. Distribution of different forms of nitrogen in some desert soils. Soil Science 116:51-58.

The distribution of different forms of N in desert soils collected at Nevada Test Site, USA, was examined. Soil profiles were sampled in 7.6-cm increments to various depths of which the maximum was 91.4 cm. Among the soil profiles examined, the different forms of N in the surface layer (0.0-7.6 cm) was always NO_2^- -N (not detectable) <extractable NH_4^+-N <NO_3^- -N <fixed NH_4^+ -N <organic N. In the sublayers, some variations from this order of N forms occurred in that the extractable NH_4^+ -N was greater than NO_3^- -N with the presence of trace amount of NO_2^- -N and/or the fixed NH_4^+ -N was greater than organic N. The amount of total N was the greatest in the surface layer and usually decreased very sharply in the 2nd layer (7.6-15.2 cm). Below the 2nd layer, the total -N contents generally varied slightly. In the surface layers, the total N was always accounted for primarily by organic N. Depending on the soil and the profile layer, the concentration of the total extractable inorganic N ranged 0.0004 - 0.00586% by weight of oven-dry soil. Expressed as percentage of total N, the range was 0.33 - 16.17. The amount of fixed NH_4^+ -N varied somewhat with different soils, but within any given soil profile, it generally varied slightly. The fixed NH_4^+ -N in the profiles collected in different areas and under different plant species ranged 0.0028 - 0.0079% by weight. Expressed as percentage of total N, the range was 3.4 - 74.4. The exchangeable K concentration under the plant was 41 - 240% greater than in the bare soil. The higher exchangeable K plus the higher organic matter content was considered to cause the lower NH_4^+ -N fixation under the plant compared to its fixation in the bare soil. (EMD)

205 NISHITA, H., and W. A. RHOADS. 1970. Ecological and environmental effects from local fallout from Schooner. 1. Soil thermoluminescence in relation to radiation exposure under field conditions. USAEC Report PNE-526, 21 p. (NTIS, Springfield, VA 22151)

A study was conducted to determine whether or not soil thermoluminescence could be related to radiation exposure in the field under conditions of actual nuclear detonation. The correlation coefficients between TLD-100 LiF dosimeter determinations and soil thermoluminescence for noncalcareous and slightly calcareous soils were 0.93 and 0.89, respectively. These results suggest that soils might be used to estimate the radiation exposure

received by a given area. With highly calcareous soil studied, the correlation coefficient (0.78) was poorer, indicating the lower suitability of this type of soil. Since soils exhibit variable amounts of "natural thermoluminescence," pre-irradiation soil sample collection appeared to be necessary. This pre-irradiation sample might then be used to determine the amount of "natural" thermoluminescence and the "equivalent" exposure level by irradiating it with a known radiation source. The applicability of these procedures, however, remains to be tested. (Auth)

206 NISHITA, H., E. M. ROMNEY and K. H. LARSON. 1965. Uptake of radioactive fission products by plants. In: (Fowler, E. B., ed.) *Radioactive Fallout, Soils, Plants, Foods, Man*, p. 55-81. (Elsevier Publ. Co., Amsterdam)

Root uptake largely depends upon the solubility of fallout debris, the chemical reactions of individual radionuclides in soils, and the absorptive power of radionuclides by plants. The relative order of magnitude of plant uptake of fission products and plutonium appeared to be Sr-89, Sr-90 >> I-131 > Ba-140 > Cs-137, Ru-106 > Ce-144, Y-91, Pm-147, Zr-Nb-95 > Pu-239. Although the relative order of magnitude varied little, the absolute magnitude of uptake may be varied by certain soil management practices such as cultivation, fertilization and organic matter application. Aside from differential uptake, there was differential distribution of absorbed radionuclides among different plant parts. The soil-plant step greatly reduces the amount of radionuclides transferred along the food chain to man. (HP)

207 NISHITA, H., R. H. MOORE, R. J. BECKMAN and M. HAMILTON. 1975. Decay characteristics of soil thermoluminescence. Soil Science 119:259-268.

Thermoluminescent decay of five different soils were examined after exposure to Co-60 photons or a neutron flux. In general, the shape of decay curves were similar: The most rapid decay occurred within 24-hr postirradiation, after which an apparent isothermal equilibrium state was approached. Curves were fitted to the decay data by the use of a computer program which obtains a weighted least squares fit of a function to the data by means of stepwise Gauss-Newton iterations on the parameters. Results indicated that the thermoluminescent decay curves of soils were hyberbolic in form. (Auth) (TPO)

208 OLAFSON, J. H., and K. H. LARSON. 1963. Plutonium, its biology and environmental persistence. In: (Schultz, V., and A. W. Klement, Jr., eds.) *Radioecology*, Proc. First National Symp. on Radioecology, p. 633-639. (Reinhold Publ. Corp., New York, NY 10022)

A brief review is presented of the metabolism and distribution of plutonium in animal tissues, plants, food and the environment.

Plutonium as an environmental contaminant does not appear to be a serious problem because of its biological and physical properties which do not favor high accumulation in the environment, plants, animals or man. Hasty conclusions should not be drawn since little can be predicted about future levels of accumulation. (KM)

209 OLAFSON, J. H., J. W. NEEL, C. J. SPIEGL, R. H. WILSON, F. G. LOWMEN and K. H. LARSON. 1953. Preliminary study of off-site, airborne radioactive materials, Nevada proving grounds. I. Fallout originating from Snapper 6, 7, and 8 at distances of ten to fifty miles from ground zero. USAEC Report UCLA-243, 123 p. (NTIS, Springfield, VA 22151)

The operations of the intermediate zone fall-out program (10 to 50 miles) conducted in connection with Operation Snapper 6, 7, and 8 during May and June 1952 are reviewed. The maximum concentrations of airborne fission products in this area as determined by means of Hi-Volume samplers were 1.0 to 2.7 $\mu c/m^3$. Particle size distribution of the airborne material was determined by modified Casella Cascade impactors. Fall-out patterns were determined by gummed papers. Decay data are presented on a number of selected typical samples from each detonation. (WDM)

210 PAGLIA, D. E. 1968. Hematopathologic surveys of kangaroo rats *(Dipodomys microps)* populating plutonium contaminated regions of the Nevada Test Site. Health Physics 15:493-498.

Hematologic characteristics were assessed in 765 kangaroo rats *(Dipodomys microps)* indigenous to five Pu-239 contaminated regions and two control areas within the Nevada Test Site. Bone and lung specimens, gastrointestinal contents, and environmental air and soil samples from all but one of these populations were assayed for Pu-239 content. Gross pathologic changes appeared minimal and nonspecific. Mean platelet levels in two exposed groups were slightly lower than control values. One of these groups, for which Pu-239 data were unavailable, also exhibited lower mean levels of peripheral lymphocytes. While significant statistically, all blood-cell depressions were physiologically inconsequential. Statistical evaluations disclosed no correlation between available Pu-239 burdens and any measured biological parameter. Reported values may serve additionally as useful baseline data in the event of resumption of atmospheric nuclear weapons testing or accidental venting of underground detonations. (Auth)

211 PARAN, T. P. 1966. A new fur mite, *Lavoimyobia hughesi* n.g., n. sp. (Acarina: Myobiidae) from a North American rodent. J. Med. Entomol. 3:172-178.

A description is given of a myobiid, *Lavoimyobia hughesi* n.g.,

n.sp., taken from Merriam's Kangaroo Rat, *Dipodomys merriami* Mearns, in Nevada, U. S. A. The new myobiid is interesting in that it shows both advanced and primitive features, and appears to be the first myobiid to be described from Kangaroo Rats. (Auth)

212 PENDLETON, R. C., and R. D. LLOYD. 1970. Environmental levels of radioactivity in Utah following Operation Pinstripe. Radiol. Health Data Report 11:65-67.

Samples of green vegetation, tansy mustard *(Sophia pinnata)* and Kentucky bluegrass *(Poa pratensis)*, collected in Utah along the fallout trajectory on the fourth day following the venting of an underground nuclear detonation at the Nevada Test Site on April 25, 1966, were analyzed for γ-emitting radionuclides at periods of three days, two months, and six months following collection. The radionuclides found included Cs-137, I-131, Mn-54, Ru-103, Ru-106, and Zr-95. These represented the spectrum of fresh fission products. Levels of radionuclides found in samples of desert shrubs collected just prior to the detonation represented the spectrum of characteristic of old fallout. The width of the fallout track was surveyed using a scintillation detector and a β-γ survey meter. Dairy cattle in the selected sampling area were not grazing during this period of time and no increase in Cs-137, I-131, or Sr-90 in milk was noted. (CH)

213 PENDLETON, R. C., J. J. KORANDA, W. WAGNER, P. PHELPS, R. D. LLOYD, L. ANSPAUGH and W. CHAPMAN. 1973. Radioecological studies in Utah subsequent to the Baneberry event. In: (Nelson, D. J., ed.) *Radionuclides in Ecosystems*, Proc. Third National Symp. on Radioecology (CONF-710501), p. 150-169. (NTIS, Springfield, VA 22151)

The Baneberry event was an underground weapons test conducted at the Nevada Test Site on the morning of December 8, 1970. Accidental venting occurred, producing a cloud of radioactivity which moved over central and northern Nevada into Utah. At the time of the Baneberry venting, the University of Utah's Department of Radiological Health and the Biomedical Division of the Lawrence Radiation Laboratory were conducting cooperative radioecological studies throughout the state of Utah. These studies were designed to document the distribution and movement of radionuclides in agricultural and natural environments in the state of Utah. As part of a program of environmental sampling, an air sampling network had been activated on 30 October 1970, and filter samples were obtained through 11 December 1970. These samples, when compared with those obtained during passage of the Baneberry cloud, enable a precise description of the radioactivity present in the state of Utah. Radioanalyses were made on air filters, water, vegetation, and animal organs obtained subsequent to the passage of the Baneberry cloud. Analyses were made by conventional NaI scintillation crystal and Ge (Li) solid-state gamma spectroscopy. Pre- and post-Baneberry air radioactivity levels will be compared.

Radioisotope data for nine radionuclides will be given for air filters exposed during passage of the Baneberry cloud, which contained a highly fractionated nuclear debris. The concentration of I-131 in thyroid glands of deer, sheep, and rabbits was also measured subsequent to the Baneberry event. The buildup and decay of I-131 in various environments in Utah will be described. A large sample of sheep thyroid glands obtained near Garrison, Utah, in mid-January 1971 was found to contain low but quantitatable levels of I-131. An analysis of the human hazard as the result of the Baneberry venting based on actual measurements and conditions during cloud passage, and on predictive models, will be made. Dose calculations for various radioisotopes have been made for a child living in northern Utah. (Auth)

214 QUIRING, R. F. 1968. Climatological data Nevada Test Site and Nuclear Rocket Development Station. U.S. Dept. of Commerce Environmental Science Services Administration Report ERLTM-ARL 7, 177 p. (NTIS, Springfield, VA 22151)

Climatological data for the Nevada Test Site and Nuclear Rocket Development Station were compiled. The data and analyses are presented as samples from substantially different topographic environments to show the salient features of the seasonal and diurnal variations of wind and temperature near ground level and aloft. An evaluation of precipitation data for a 20-station network on the test site and a 5-yr climatological summary for the continuously manned Yucca weather station are included. (Auth)

215 RAGSDALE, H. L., and W. A. RHOADS. 1974. Four-year post-exposure assay of vegetation surrounding Project Pinstripe: demonstration of the utility of delayed damage appraisals. Radiation Botany 14: 229-236.

This report illustrates the feasibility of using temporally-delayed vegetation assays to determine radiation damage, by documenting the radiation damage resulting from the accidental venting of radioactive materials during Project Pinstripe, Frenchman's Flat, Nevada Test Site, in April, 1966. Evidence of desert shrub radiation damage was first observed and photographed in April, 1968. Systematic study of the vegetation was initiated in October, 1970, and evidence of radiation damage documented over 72.9 hectares adjacent to the vent. Beta doses were estimated at 15-21 krads based on gamma exposure dose measurements. The minimum beta dose estimate was substantially greater than the theoretical lethal dose for the shrub, *Larrea divaricata*. Radiation damage to the shrubs, *Larrea divaricata, Ephedra funerea,* and *Atriplex confertifolia* was expressed as differential bud mortality, partial death of shrub crowns with and without crown regrowth, and total shrub crown death without crown regrowth. Each of the shrub populations was statistically different from its control population with respect to the distribution of individuals among damage classes.

Generally, damage patterns were similar to those observed at two previously-studied Plowshare events. (Auth)

216 RAMSPOTT, L. D., R. L. BRAUN and W. F. WADLEIGH. 1970. Mineral composition, CO_2 content, and grain density of drill hole samples from Yucca Flat, Nevada Test Site. USAEC Report UCRL-50915, 15 p. (NTIS, Springfield, VA 22151)

Mineral composition, CO_2 content, and grain density have been determined for 148 samples from 108 drill holes in Yucca Flat, Nevada Test Site. The amounts of calcite, dolomite, and quartz were quantitatively determined by x-ray diffractometry using an internal standard. All other minerals were identified, and qualitative estimates of the x-ray intensities of zeolite, feldspar, and illite are given. The mean weight-percent values for 119 alluvium samples are: calcite 5.9, dolomite 4.5, and CO_2 4.77. The median values for the same samples are: calcite 2.5, dolomite 1.5, and CO_2 3.60. The modal classes are: calcite 1-2 (wt%), dolomite 0-1, and CO_2 0-1. Although two-thirds of the holes had only cuttings samples for the alluvium interval, analysis of size fractions of suitable samples indicates that cuttings samples provide a usable indicator of the carbonate content of the original rock. In general, grain density does not correlate quantitatively with any one mineral, but in a suite of samples from one drill hole the correlation coefficient between dolomite and grain density was 0.933. (Auth)

217 RAVEN, P. H. 1964. *Polypogon australis* Brongn. in Nevada. Leaflets of Western Botany 10:117.

This close relative of *P. interruptus* Kunth, reported from a wide range of localities in California and from Cedros Island, Baja California, by Rubtzoff (Leafl. West. Bot. 9:166-169, -- 1961), may now be reported from Nevada: margin of Cane Springs, drainage of French Flat, Nye Co., elev. 4000 ft., 13 May 1959, J. C. Beatley & W. H. Rickard 556 (herb. Nevada Test Site). (Complete article)

218 REED, J. W. 1969. Climatology of airblast propagations from Nevada Test Site nuclear airbursts. USAEC Report SC-RR-69-572, 123 p. (NTIS, Springfield, VA 22151)

Microbarograph data from Nevada atmospheric nuclear tests of 1951 to 1962 have been assembled to show climatological patterns for long range propagations. Amplitudes have been normalized to 1-kiloton yield, free-airburst, after actual height-of-burst effects were removed. On-site propagations under early morning inversions often showed double the amplitudes expected for standard hemispherical wave expansion. These enhanced blasts were blocked by mountains and did not penetrate off-site. Strong winds at higher altitudes gave as much as 5x blast magnifications at Indian Springs and Las Vegas. Ducting at very high altitude, to 30 miles or 150,000 feet, is seasonally directed eastward in winter, westward in summer. Resulting amplitudes in the sound ring near 135 miles range show as large as 3x magnification downwind and 0.006x reduction upwind. On the average the annual cycling in east and west directions ranges from near standard, 1x downwind amplitudes to 0.016x upwind amplitudes. The seasonal reversal periods when upper winds are nearly calm, occur about May 5 and September 20. At that time amplitudes in all directions show an average 0.28x reduction below standard. (Auth)

219 REVEAL, J. L. 1968. A new variety of *Eriogonum umbellatum* from southern Nevada. Great Basin Nat. 28:157-159.

Erigonum umbellatum Torrey var. *vernum* Reveal, new variety, is described from the Nevada Test Site, southern Nevada, USA. The new variety, as the name implies, flowers in the spring of the year from May to early June. Likewise, none of the southern Nevada varieties has flowers as long as those found in var. *vernum*. Morphologically, it is compared with varieties *umbellatum*, *subaridum*, *polyanthum*, and *speciosum*. Of the various taxa in the species, the var. *vernum* is probably most closely related to var. *dichrocephalum*. (RS)

220 REVEAL, J. L. 1969. New species in *Eriogonum* and *Gilia* from southern Nevada. Bull. Torrey Bot. Club 96:476-484.

A new species of *Eriogonum* (Polygonaceae) is described as *E. concinnum* from the Nevada Test Site and the adjacent Las Vegas Bombing and Gunnery Range in Nye County. A member of the subgenus *Ganysma*, the new species is most closely related to *E. esmeraldense* and *E. rubricaule*. The new *Gilia* is a member of the subgenus *Giliandra*, and most closely related to *G. hutchinsiifolia*. Named *G. nyensis*, the new species ranges from central Nye County southward to the Nevada Test Site.

221 REVEAL, J. L. 1971. A new *Frasera* from southern Nevada (Gentianaceae). Bull. Torrey Bot. Club 98:197-108.

Frasera pahutensis sp. nov. is described from Pahute Mesa, Nye Co., Nevada on the Nevada Test Site. It is easily distinguished from all other species in the genus, and in particular from *F. puberulenta*, by its numerous stems, short inflorescences, greenish-white corollas, narrowly oblong glands with a cover only at the very base, and small crown scales.

222 REVEAL, J. L., and J. C. BEATLEY. 1974. A new variety of *Penstemon thurberi* (Scrophulariaceae). Great Basin Nat. 34:230.

Penstemon thurberi Torr. var. *anestius* Reveal & Beatley, a new variety of *Penstemon* is described from material collected east

of Frenchman Flat dry lake. It differs from var. *thurberi* in the smaller and less obvious flowers. (TPO)

223 RHOADS, W. A. 1975. Effects of fallout radiation on vegetation from venting of an underground nuclear detonation. USAEC Report EGG 565-117, 30 p. (EG&G, Goleta, CA 93017)

The accidental venting of radioactive material from Project Baneberry, an underground nuclear explosion, resulted in the irradiation of the native shrubs about 1.5 km to the north with doses estimated to reach 6248 rads beta plus gamma irradiation exposure. At the highest doses 35 percent of the dominant shrub in the area, *Coleogyne* (black brush), were killed and 65 percent severely damaged. At doses of 400 to 800 rads there was moderate damage. Other species of shrubs were also affected. *Grayia* showed a low frequency of stem fasciation at the higher doses as well as other manifestations of radiation damage. Although no firm conclusion as to causality could be made about effects on annual species which were seeds or very small seedlings when irradiated, there were more areas without annual species at the higher radiation levels than at the lower. At the same time there was a greater frequency of higher dry weights produced by the annual species at the higher radiation exposures. These conditions were attributed to the probability of greater lethality from radiation doses to seeds to seedlings of the annual species in the open; that is, away from the protection of the shrub clumps. At the same time the annuals, which were under shrub clumps where the shrubs themselves often were killed, had greater moisture and nutrients available to them, and this resulted in greater productivity and greater frequency of dry weights of annual plant material in areas with higher exposure doses. (Auth)

224 RHOADS, W. A., and R. B. PLATT. 1971. Beta radiation damage to vegetation from close-in fallout from two nuclear detonations. BioScience 21:1121-1125.

The report recounts first field experiments associated with nuclear events and concerned with vegetation damage attributed primarily to beta radiation. It is supported by the first extensive field dosimetry for measuring both beta and gamma radiation doses simultaneously. Two small nuclear cratering experiments; Palanquin on April 14, 1965 and Cabriolet on January 26, 1968 occurred at the Nevada Test Site. Vegetation studies were made on two species of sagebrush, *Artemisia arbuscula* and *Artemisia tridentata*. Downwind to Palanquin, shrubs and trees were killed over an area of more than 3 km^2, and in Cabriolet they were killed over a few hundred square meters beyond the area covered by material thrown from the crater. At Palanquin, the killed and damaged areas coincided with areas of elevated radiation backgrounds. Doses at Cabriolet were documented with special dosimetry to measure the field of beta doses in the presence of gamma radiation. Conclusions were drawn that damage and death of

Artemisia downwind to Palanquin and Cabriolet were attributable to fallout radiation, and beta radiation, with its large potential doses, was primarily responsible. (BBM)

225 RHOADS, W. A., and H. L. RAGSDALE. 1973. *Artemisia* shrub size and radiation damage to *Artemisia* from local fallout from Project Schooner. In: (Nelson, D. J., ed.) *Radionuclides in Ecosystems*, Proc. Third National Symp. on Radioecology (CONF-710501), p. 953-960. (NTIS, Springfield, VA 22151)

Project Schooner was a nuclear cratering experiment in the Plowshare Program for peaceful applications of nuclear explosives. The 31 kt device produced a crater about 260 meters across and 63 meters deep on Pahute Mesa in the northest corner of the Nevada Test Site. At distances of 1.7 kilometers the accumulated γ doses on dosimeters removed from the field 12 days post-event ranged from background to more than 900 rads; the β doses reached maximums of 10,650 rads. At these highest doses all *Artemisia* shrubs were killed. At dosimeter stations with less than total mortality, samples of 100 shrubs were measured, and estimates were made of the extent of their damage. Analysis of these data showed that shrubs with smaller volumes were more likely to be killed or severely damaged than were larger shrubs. The results are in accord with conclusions that shrub damage in local fallout patterns is primarily attributable to β radiation. The diminution of β doses by air shielding and shrub self-shielding protects larger shrubs more than the smaller ones. (Auth)

226 RHOADS, W. A., A. D. KANTZ and H. L. RAGSDALE. 1972. Ecological and environmental effects from local fallout from Schooner. 2. The beta and gamma radiation effects from close-in fallout. USAEC Report PNE-529, 41 p. (NTIS, Springfield, VA 21151)

Project Schooner, a nuclear cratering event with approximately eight to ten times the yield of two previous Nevada Test Site cratering events, Palanquin and Cabriolet, offered the opportunity to further investigate radiation dose and short-term effects to vegetation and the environment, where a larger affected area was anticipated and where topography might be expected to further influence the results of close-in fallout. Specially constructed dosimeters were placed at 92 locations, forming an arc with a radius of approximately 1.7 to 2.0 km. Dosimeters were positioned in vertical arrays at 25 cm, 1 meter, and 3 meters above the surface away from shrubs, as well as on the soil surface, and on shrubs. To determine whether preventing direct fallout from reaching the shrubs would protect them, polyethylene sheets were placed over shrubs at alternate stations. Twelve days after detonation the dosimeters were removed from the field and the protective sheets were removed. No effects were observed on the vegetation except a dusty covering on the unprotected shrubs. In April (D plus 4 months) the first effects attributable to radiation were noted.

During the following months at the center of the fallout pattern all *Artemisia* shrubs lost their leaves and died except those which had been covered with plastic sheets. Elsewhere along the arc there was a "skirting effect" in which the lower parts of larger shrubs were defoliated while the tops remained near normal. Small shrubs were completely killed. Increasingly larger shrubs were killed with higher doses. Beyond the dosimetry arc, a helicopter survey allowed an assessment of the extent of vegetation damage. South of the crater, study sites were established in the most diverse environments resulting from the crater formation. Vegetation analysis at these sites showed successional changes which might be expected to return the area to conditions approximating undisturbed conditions. (Auth)

227 RHOADS, W. A., R. B. PLATT and R. A. HARVEY. 1969. Radiosensitivity of certain perennial shrub species based on a study of the nuclear excavation experiment, Palanquin, with other observations of effects on the vegetation. USAEC Report CEX-68.4, 42 p. (NTIS, Springfield, VA 22151)

Comparison was made between the sensitivites of certain species of plants from the higher elevations of the Nevada Test Site to gamma radiation from a ^{60}Co source and from conditions in the fallout pattern of the nuclear excavation experiment Palanquin. *Artemisia,* sage brush, appeared much more sensitive to fallout, based on the infinite dose it received, than the radiation dose from pure gamma from ^{60}Co indicated it ought. The proposal was made that beta radiation contributed a greater dose to *Artemisia* than to certain other species because of its particular foliar retentive capacity for fallout particles. This suggested that beta radiation may be an important component in considering damage to vegetation from fallout, since other factors known to have damaged vegetation in nuclear experiments could, for the most part, be eliminated. (Auth)

228 RHOADS, W. A., R. B. PLATT, R. A. HARVEY and E. M. ROMNEY. 1969. Ecological and environmental effects from local fallout from Cabriolet. 1. Radiation doses and short-term effects on the vegetation from close-in fallout. USAEC Report PNE-956, 65 p. (NTIS, Springfield, VA 22151)

An intensive dosimetry experiment was undertaken on the vegetation in the vicinity of the proposed ground zero for the underground Cabriolet detonation. The midline of the fallout pattern occurred near the western edge of an arc of dosimeters placed 610 meters from ground zero: the highest measured gamma dose was 800 rad. The highest beta dose was about 8,000 rad yielding a beta-to-gamma ratio of 10, but the ratio varied around 4 to more than 12. Four months postdetonation the vegetation demonstrated changes previously associated with radiation damage, and some species eventually died. It was concluded that beta

radiation was primarily responsible for the observed damage as the total doses were near the previously established doses required to damage and kill the vegetation being considered. (TPO)

229 RHOADS, W. A., H. L. RAGSDALE, R. B. PLATT and E. M. ROMNEY. 1971. Radiation doses to vegetation from close-in fallout at Project Schooner. In: (Bensen, D. W., and A. H. Sparrow, eds.) *Survival of Food Crops and Livestock in the Event of Nuclear War,* AEC Symp. Series 24 (CONF-700909), p. 352-369. (NTIS, Springfield, VA 22151)

Project Schooner was a nuclear cratering experiment in the Plowshare Program for peaceful application of nuclear explosives. On the basis of information from two earlier experiments, Palanquin and Cabriolet, special dosimeters for measuring both beta and gamma radiation were placed in the open environment and on shrubs in the downwind area where fallout was anticipated. In addition, polyethylene sheets were placed over some shrubs to determine whether the shrubs could thus be protected against radiation damage. The gamma radiation doses for shrubs not covered were found to be essentially the same as the doses measured in the open and away from shrubs, but there was a 15 percent reduction in dose under the sheets. The beta doses to unsheltered vegetation were, however, reduced by almost 50 percent compared with doses at 25 cm in the open. This reduction was attributed to self-shielding. Beta doses to the shrubs were reduced still further, to 11 percent of the 25-cm beta dose in the open, by shielding the shrubs from direct fallout contamination. The estimated LD50 for *Artemisia* was 4449 rads, but the reduction in doses by the shelters was nearly sufficient to prevent damage to the shrubs, even though all other *Artemisia* shrubs in the center of the fallout pattern were killed. It was concluded that beta doses must be considered in protecting growing food crops and livestock and that even minimal shelter to prevent direct surface contamination would be of great importance. (Auth)

230 RICHARDS, G. 1962. Wintering habits of some birds at the Nevada atomic test site. Great Basin Nat. 22:30-31.

Describes species composition and relative abundance of birds observed wintering in undisturbed habitats of the Nevada Test Site, as well as other locations that were drastically altered by nuclear weapons testing. The alien winter annual forb, *Salsola kali,* invaded disturbed sites and appeared to provide winter feed for birds that was in excess of that provided by undisturbed vegetation associations. (TPO)

231 RICHARDS, G. L. 1965. Prairie falcon imitates flight pattern of the loggerhead shrike. Great Basin Nat. 25:48.

Prairie falcons were observed imitating the undulating flight patterns of loggerhead shrikes to approach unsuspecting white-tailed antelope ground squirrels. (TPO)

232 RICKARD, W. H. 1961. Notes on bird nests found in a desert shrub community following nuclear detonations. Condor 63:265-266.

The occurrences of bird nests in relation to the gross influences of nuclear detonations, which occurred prior to September 2, 1957, on the vegetation of a desert shrub community are reported. (MCG)

233 RICKARD, W. H. 1962. Phytosociological analyses in a desert shrub community following atomic explosions. USAEC Report HW-SA-2546, 7 p. (Battelle, Pacific Northwest Laboratories, Richland, WA 99352)

Quantitative and qualitative changes were recorded in the annual vegetation when phytosociological comparisons were conducted between adjacent disturbed and undisturbed plant communities two and three years after the last occurrence of atomic explosions in target area 4, Yucca Flat, Nevada. (Auth)

234 RICKARD, W. H. 1963. Vegetational analyses in a creosote bush community and their radioecologic implications. In: (Schultz, V., and A. W. Klement, Jr., eds.) *Radioecology*, Proc. First National Symp. on Radioecology, p. 39-44. (Reinhold Publ. Corp., New York, NY 10022)

Detailed vegetation analyses were conducted on fifteen permanent plots in a creosote bush *(Larrea divaricata)* community surrounding the nuclear reactor facilities. Creosote bush dominated the canopy-coverage provided by 11 shrub species and two species of bunch grasses by contributing 6.1 percent of the total 13.7 percent ground cover. *Chaenactis stevioides* dominated the herbaceous understory vegetation. The amount of ground covered by vegetative canopies, the contribution of each species to ground cover, and development and seasonal persistence of understory layers and the phenological sequence of leaf development and abscission are believed directly related to vegetative retention of radioactive fallout by desert shrub communities. (HP)

235 RICKARD, W. H., and J. C. BEATLEY. 1965. Canopy-coverage of the desert shrub vegetation mosaic of the Nevada Test Site. Ecology 46: 524-529.

Canopy-coverage of shrubs and perennial herbs was determined by 44 relatively undisturbed sites scattered throughout the vegetation mosaic covering several valleys in southcentral Nevada. The dominant shrubs were *Larrea divaricata, Grayia spinosa, Lycium andersonii, Coleogyne ramosissima, Atriplex confertifolia, Artemisia tridentata,* and *A. arbuscula* subsp. *nova*. Perennial herbs contributed little to canopy-coverage. The perennial herbs most frequently encountered were *Oryzopsis hymenoides* and *Stipa speciosa*. In the spring of 1960, on 34 of the same sites, the canopy-cover of annual herbs was also determined. Sites dominated by *Larrea* shrubs had more annual species and also the greatest amount of annual cover. *Chaenactis stevioides* was ubiquitous and often the dominant annual encountered throughout the vegetation mosaic. Other important

annuals were *Mentzelia veatchiana, Eriogonum maculatum, Eriophyllum pringelei, Bromus rubens, Cryptantha nevadensis, C. circumscissa,* and *Amsinckia tesselata*. (Auth)

236 RICKARD, W. H., and J. R. MURDOCK. 1963. Soil moisture and temperature survey of a desert vegetation mosaic. Ecology 44:821-824.

From March 4 to May 9, 1960 soil temperature and moisture measurements were made in 7 plant habitats on the Nevada Test Site, Nye County, Nevada. Soil moisture was determined by gravimetric sampling, and temperatures were measured using the sucrose inversion technique. Cooler soil temperatures were not always associated with an increase in elevation. In some cases topographic positions and soil properties influenced soil temperatures and available soil moisture more strongly than did elevational changes. (Auth)

237 RICKARD, W. H., and L. M. SHIELDS. 1963. An early stage in the plant recolonization of a nuclear target area. Radiation Botany 3: 41-44.

Vegetational analyses were conducted three years post-detonation in a nuclear target area in a *Grayia spinosa-Lycium andersonii* community in Yucca Flat, Nevada. Annual plants dominated the early stage of recolonization and were quantitatively more abundant in the disturbed areas than in an adjacent undisturbed shrub community. *Mentzelia albicaulis* and *Chaenactis stevioides* occurred in both disturbed and undisturbed areas; however, *Mentzelia* was more abundant in disturbed areas while *Chaenactis* was more abundant in the undisturbed community. *Salsola kali* was confined to disturbed areas while *Phacelia vallismortae* was more often encountered in the undisturbed community. The plant recolonization of a mechanically disturbed area was quantitatively and qualitatively more like that of the interior zone of the nuclear target area than less disturbed habitats. These data support a conclusion that soil displacement presents a more rigorous habitat for plant recolonization than disturbances created by the wider ranging destructive components of a nuclear detonation. (Auth)

238 ROMNEY, E. M., and J. J. DAVIS. 1972. Ecological aspects of plutonium dissemination in terrestrial environments. Health Physics 22: 551-557.

The potential benefits to be derived for mankind from continued development of peaceful applications for plutonium cannot be denied. The technology of plutonium production and processing is already established, but the realization of its peaceful applications depends largely upon the development of methods for preventing its distribution in the environment. Because of safeguards and effective control measures, no accidental plutonium contamination of the public domain has imposed serious risks to a population group. Trace amounts of plutonium from above-ground

nuclear detonations are contained in world-wide fallout; however, the levels of plutonium in foodstuffs and other components of the environment are insignificant compared to the amounts known to be hazardous. There has thus been very little interest in the study of ecological aspects of plutonium contamination. The result is a paucity of information on the behavior of plutonium in ecosystems and its radiological effects on natural fauna and flora. The Nevada Applied Ecology Group is embarked upon a program at the Nevada Test Site to investigate the long-range effects of plutonium disseminated into the desert ecosystem. Emphasis has been placed upon standardization of analytical methods, delineation of contaminated areas, problems of resuspension and redistribution, food chain transport, and ecological effects. (Auth)

239 ROMNEY, E. M., and W. A. RHOADS. 1966. Neutron activation products from Project Sedan in plants and soils. Soil Sci. Soc. Amer. Proc. 30:770-773.

Neutron activation products of tungsten, scandium, and antimony were among those radionuclides concentrated through roots of plants grown on ejecta from the Sedan thermonuclear cratering detonation. Nuclear reactor-produced isotopes were used in corroborative experiments to investigate, in greater detail, their behavior in plants and soils. Radiotantalum was also included as a matter of academic interest. Plants concentrated more Sc-46, Sb-124, and W-185 in leaves than in stems, whereas Ta-182 was concentrated more in stems. Plant uptake of Sc-46, Sb-124, and W-185 was influenced by different types of soil. Scandium-46 and Ta-182 were virtually immobile in columns of soil leached with 76 cm of water while Sb-124 and W-186 moved readily in neutral and alkaline soil, but not in acidic soil. Their behavior was influenced by the kind of clay mineral present, the sodium and potassium content, and the soil pH. (Auth)

240 ROMNEY, E. M., H. M. MORK and K. H. LARSON. 1970. Persistence of plutonium in soil, plants and small mammals. Health Physics 19: 487-491.

Periodic surveys during a 10-yr period were made of the persistence of residual Pu-239 in soil, plants and small mammals indigenous to fallout areas contaminated with Pu-239 dispersed by high explosive detonations. Downward migration of fallout particles occurred in undisturbed soil profiles, and wind and water erosion accounted for some redistribution of the initial Pu-239 contamination. Long-term cropping experiments showed a relatively low degree of Pu-239 transfer from soil to plants, but there was a consistent increase in its accumulation in plant tissue during a 5 yr cropping sequence. Plant uptake of Pu-239 from soil was enhanced by DTPA chelating agent. Qualitative trends from these surveys indicate that the accumulation of residual Pu-239 in kangaroo rats

and jackrabbits was highest in bone tissue; considerable amounts also were found in lung tissue. Inhalation is known to be the major pathway for plutonium deposition in lung and bone, but the high levels found in the gastrointestinal tracts indicate that ingestion is also an important route through which these small mammals maintained contact with the residual Pu-239 contamination in the environment. (Auth)

241 ROMNEY, E. M., H. NISHITA and A. WALLACE. 1960. Transfer of radioactive fallout debris. Calif. Agriculture 14(3):6, 14, 15.

Describes the uptake of Sr-90 and Cs-137 by agricultural crops growing on different soils, and methods for reducing accumulation. (TPO)

242 ROMNEY, E. M., A. WALLACE and J. D. CHILDRESS. 1973. Revegetation problems following nuclear testing activities at the Nevada Test Site. In: (Nelson, D. J., ed.) *Radionuclides in Ecosystems,* Proc. Third National Symp. on Radioecology (CONF-710501), p. 1015-1022. (NTIS, Springfield, VA 22151)

Areas of disturbed native vegetation on the Nevada Test Site are rapidly invaded by both indigenous and introduced species of winter annual plants. Decades are required for revegetation of perennial shrubs to their former state. On Pahute Mesa adequate germination and survival of native shrubs have returned disturbed areas to nearly original Great Basin Desert conditions. During severe drought browsing animals reduced seedling densities. In Mohave Desert portions of NTS germination and survival of native shrubs is much slower. If seedlings are protected from browsing animals, transplanting can be a practical method for accelerating revegetation of disturbed areas. (TPO)

243 ROMNEY, E. M., G. V. ALEXANDER, G. M. le ROY and K. H. LARSON. 1959. Influence of stable Sr on plant uptake of Sr 90 from soils. Soil Science 87:42-45.

Varied treatments of $Sr(NO_3)_2$ and $SrSO_4$ were applied to three different types of Sr-90-contaminated soil to determine to what extent stable Sr might reduce plant uptake of radiostrontium by the effect of carrier dilution. Applications of stable Sr at levels ranging from 0.1 to 5.0 me. Sr per 100 g. of air-dry soil increased the uptake of Sr-90 by beans and Ladino clover. Stable Sr displaced Sr-90 adsorbed on the soil exchange complex into the soil solution where it was more readily available to the plant. This effect was most apparent in an acidic soil containing a very low level of native Sr. Stable Sr uptake was linear with respect to the level of exchangeable Sr in the soil; however, the total amount of Sr accumulated by the plant was dependent upon the available soil calcium. Plants obtained more stable Sr from $Sr(NO_3)_2$-treated soils than from $SrSO_4$-treated soils. The levels

of stable Sr required to effectively reduce plant uptake of Sr-90 from soils by carrier dilution were greater than 5.0 me. Sr per 100 g. of soil, that is, equivalent to more than about 5 tons of Sr amendments an acre. (Auth)

244 ROMNEY, E. M., G. V. ALEXANDER, H. NISHITA and K. H. LARSON. 1961. Influence of Ca and Sr amendments on Sr^{90} uptake by Ladino clover upon prolonged cropping. Soil Sci. Soc. Amer. Proc. 25:299-301.

Prolonged cropping experiments showed that a single application of $CaCO_3$ in the amount recommended to produce better crop growth (2 to 5 tons an acre) continued to suppress Sr-90 uptake from an acidic soil that initially was deficient in plant-available Ca. This effect of treatment is attributable to the complementary ion influence of Ca on Sr. The cumulative amount of Sr-90 removed by 15 successive cuttings of Ladino clover was 29.38, 15.71, and 11.61% of the dose from Sassafras sandy loam treated with $CaCO_3$ at levels of 1, 5, and 10 mc Ca per 100 g soil (equivalent to 0.5, 2.5 and 10 tons $CaCO_3$ an acre, respectively). The greatest amount of the Sr-90 dose removed from the soil by a single clover cutting was 0.38% at the 1 mc Ca treatment. A single application of $Sr(NO_3)_2$ amendment at levels of 0.05, 1, and 2 mc Sr per 100 g soil (equivalent to 0.05, 1 and 2 tons $Sr(NO_3)_2$ an acre) initially increased plant uptake of Sr-90 from Hanford sandy loam as a result of the displacement of Sr-90 from the exchange complex by stable Sr into the soil solution where it was more readily available to the plant. This enhancing effect of low levels of Sr amendment of Sr-90 uptake became less apparent as time progressed. The carrier-dilution effect of reducing plant uptake of Sr-90 from Hanford sandy loam was achieved by applying $Sr(NO_3)_2$ at a level of 10 mc Sr per 100 g soil (equivalent to 10 tons $Sr(NO_3)_2$ an acre). (Auth)

245 ROMNEY, E. M., G. V. ALEXANDER, W. A. RHOADS and K. H. LARSON. 1959. Influence of calcium on plant uptake of Sr 90 and stable strontium. Soil Science 87:160-165.

The effects of applied Ca on uptake of Sr-90 by beans from nutrient solutions independent of soil factors was studied. In general Ca inhibited Sr uptake when applied in amounts equivalent to 2 to 5 t/acre. (TRH)

246 ROMNEY, E. M., W. L. EHRLER, A. H. LANGE and K. H. LARSON. 1960. Some environmental factors influencing radiostrontium uptake by plants. Plant and Soil 12:41-48.

Uptake of Sr-90 from Vina soil was measured in several agricultural crop plants, and varied by a factor of 10 within the species tested. In cereals the amount of Sr-90 was 20% less than that in the forage. Tubers of potatoes contained only 2% of what was found

in their tops, and uptake was inversely correlated with the level of plant-available calcium in three soils. Lowering root temperatures from 17° to 7° significantly reduced uptake by barley and beans. Decreased light intensity or duration of light exposure reduced uptake by barley and beans. (TPO)

247 ROMNEY, E. M., H. NISHITA, J. H. OLAFSON and K. H. LARSON. 1963. Root transfer of fission products from contaminated soil. Soil Sci. Soc. Amer. Proc. 27:383-385.

Dry yield of wheat grown for 117 days was not affected by solutions of nuclear reactor-produced mixed fission products (MFP) applied to the soil surface or mixed with equal amounts of potted soil at contamination level ranging from 0.1 to 1.0 μC beta activity per g of soil. Concentrations of beta and gamma activity in the above-ground parts of plants were increased as the soil contamination levels increased. Wheat removed from 0.07 to 0.09% of the total beta activity that had been mixed with the soil and from 0.10 to 0.15% of that which had been applied to the soil surface. Concentrations of radioactivity in above-ground plant parts were highest in leaves, intermediate in stems and lowest in fruiting heads. Radiostrontium accounted for 50 to 80% of the beta activity transferred to above-ground plant parts; <10% was attributable to root transfer of Y-91, Ru-106, Cs-137, and Ce-144 from soil. (Auth)

248 ROMNEY, E. M., W. A. RHOADS, A. WALLACE and R. A. WOOD. 1973. Persistence of radionuclides in soil, plants, and small mammals in areas contaminated with radioactive fallout. In: (Nelson, D. J., ed.) *Radionuclides in Ecosystems*, Proc. Third National Symp. on Radioecology (CONF-710501), p. 170-176. (NTIS, Springfield, VA 22151)

The persistence of radionuclides in soil, plants, and small mammals was investigated periodically in areas contaminated with fallout from aboveground nuclear detonations at the Nevada Test Site. Study sites were established at various locations out to about 225 km from ground zero. Emphasis was placed upon the movement of Sr-90 and Cs-137 from abiotic to biotic components. Several neutron activation products also were studied in fallout areas located within 5 km of nuclear excavation tests. Radionuclides continued to be taken up through plant roots in small amounts, as time progressed, and some continued to be deposited on foliage as resuspended dust particles. The inhalation route of entry became less important with passing time, whereas ingestion continued to be the most important route through which radionuclides entered small mammals living in old fallout areas. Long-lived Sr-90 accumulated primarily in bone tissue, while Cs-137 accumulated in muscle and soft tissue. Most of the neutron activation products are short-lived but among those found in animal tissues were isotopes of Co, Mn, and W. Findings indicate that Sr-90 and Cs-137 will

continue to move in small amounts from abiotic to biotic components in fallout-contaminated areas with passing time. (Auth)

249 ROMNEY, E. M., A. J. STEEN, R. A. WOOD and W. A. RHOADS. 1967. Concentration of radionuclides by plants grown on ejecta from the Sedan thermonuclear cratering detonation. In: (Åberg, B., and Hungate, F. P., eds.) *Radioecological Concentration Processes*, Proc. International Symp., Stockholm, April, 1966 (CONF-660405), p. 391-398. (Pergamon Press, New York City, NY 10523)

Native and domestic plants grown on ejecta from the Sedan thermonuclear cratering detonation concentrated high levels of radiotungsten, and smaller amounts of Sc-46, Mn-54, Co-60, Y-88, Sr-89, Sr-90, Zr-95, Ru-106, Sb-125, Cs-134, Cs-137, and Ce-144 through their roots. Uptake of these radionuclides persisted through the 3-year cropping period postdetonation. Plant foliage contaminated by Sedan fallout contained Rb-86, Y-91, Ru-102, Ru-103, I-131, Cs-156, Ba-140, Ce-141, Eu-152 and Eu-154; but these radionuclides were not concentrated through roots in later cropping experiments. Radioactive dust continued to be deposited on the foliage of plants re-established on Sedan ejecta. (Auth) (TPO)

250 ROMNEY, E. M., R. G. LINDBERG, H. A. HAWTHORNE, B. G. BYSTROM and K. H. LARSON. 1963. Contamination of plant foliage with radioactive fallout. Ecology 44:343-350.

Fallout particles less than 44 μ diameter were selectively trapped in the hairs and crevices and on resinous glands of the leaf surfaces of foliage contaminated with fallout from nuclear detonations. Beta activity on plant foliage was correlated with the beta activity from fallout particles less than 44 μ diameter. Decontamination treatments using washing with mild detergents and chelating agents reduced levels of radioactivity by half. Fallout on plant foliage that originated from tower-supported detonations was 5 to 35 percent soluble in 0.1 N HCL; fallout from balloon-supported detonations was 60 to 90 percent soluble. Radioisotopes of cerium, yttrium and zirconium contributed about 60 percent of the beta activity found in smaller than 44 micron-diameter fallout particles (90 days after detonation); radiostrontium accounted for nearly 5 percent and radiocesium contributed less than 1 percent. (Auth) (TPO)

251 ROMNEY, E. M., J. W. NEEL, H. NISHITA, J. H. OLAFSON and K. H. LARSON. 1957. Plant uptake of Sr90, Y91, Ru106, Cs137, and Ce144 from soils. Soil Science 83:369-376.

Soil pot experiments conducted in 1952 and 1953 showed virtually no Y-91, Ru-106, Cs-137, or Ce-144 were taken up from different soils by barley, bean, carrot, lettuce, and radish plants. Sr-90 was readily taken up and was concentrated in greatest amounts in leaf tissue. Radish tops accumulated the greatest amounts of Sr-90 per unit weight, followed by beans, carrots, lettuce, and

barley, in decreasing order. Soil types influenced Sr-90 uptake. Highest Sr-90 levels were found in plants grown on acidic soils low in Ca and lowest levels on alkaline calcareous soils. Intensive cropping is apparently not effective for the removal of fission products from soils within a short cropping period. (Auth)

252 ROMNEY, E. M., A. WALLACE, R. O. GILBERT, S. A. BAMBERG, J. D. CHILDRESS, J. E. KINNEAR and T. L. ACKERMAN. 1973. Some ecological attributes and plutonium contents of perennial vegetation in Area 13. USAEC Report UCLA 12-937, 17 p. (UCLA, Los Angeles, CA 90024)

Preliminary data are presented on levels of Pu-239,240 and Am-241 in samples of vegetation collected in the Project 57 fallout pattern, Area 13. Some data on floral ecology of the site are also included. Estimates of ground cover ranged from 12.8 to 28.3 percent. Shrub densities ranged between 11.2 x 10^3 and 17.9 x 10^3 plants per hectare, and standing shrub biomass ranged from 1592 to 4285 kilograms per hectare (0.7 to 1.9 tons per acre). Within intensive study plots there was a uniform distribution of Pu-239,240 and Am-241 among individual samples of the same plant species. However, there was considerable variation in contamination levels between different species. Concentrations in *Eurotia lanata* were three to five times higher than in other species sampled. Levels of Pu-239,240 and Am-241 in vegetation samples generally decreased with increasing distances from ground zero, but there were poor correlations between vegetation and soil concentrations in isopleth strata within a grazed site. Lower Pu/Am ratios in vegetation indicate that preferential uptake of Am-241 may have occurred. (TPO)

253 ROMNEY, E. M., V. Q. HALE, A. WALLACE, O. R. LUNT, J. D. CHILDRESS, H. KAAZ, G. V. ALEXANDER, J. E. KINNEAR and T. L. ACKERMAN. 1973. Some characteristics of soil and perennial vegetation in northern Mojave Desert areas of the Nevada Test Site. USAEC Report UCLA 12-916, 340 p. (NTIS, Springfield, VA 22151)

Data were compiled from several interrelated projects conducted at the Nevada Test Site as part of a team effort to obtain more information on soil and plant relationships in the desert ecosystem in order to better understand the impact of nuclear testing on the environment. It ties together the masses of acquired data into one convenient volume for use by the funding agency and also to serve as a basis for the continuing systems analysis work involved with these projects. Included are results from the chemical and physical characterization of soil profiles at 79 study sites located in some northern Mojave Desert areas of the Nevada Test Site. These profiles were characterized under clumps of perennial vegetation and under bare desert pavement in order to determine the modifying influence of shrubs on desert

soil. Ecological attributes of perennial vegetation determined by nondestructive, dimensional analysis are reported in terms of density, area, volume, and biomass according to the existence of shrubs as solitary plants or as members of a shrub clump. Mineral element compositions of leaves and stems are reported for the most common plant species at each study site. Also included are the concentratons of Cs-137 and the natural K-40 (as total K), uranium and thorium found in the surface fractions of the soil profile. Abiotic data compiled during a 5-year period from 9 sampling stations are reported for rainfall, air temperature, soil temperature and soil moisture. (Auth)

254 ROWLAND, R. H., and F. B. TURNER. 1964. Correlation of the local distributions of *Dipodomys microps* and *D. merriami* and of the annual grass *Bromus rubens*. Southwestern Nat. 9:56-61.

The occurrences of *Dipodomys microps* and *D. merriami* in a small area of the Nevada Test Site were examined. The abundance of *D. microps* varies inversely with the abundance of *Bromus rubens*. Reynold's hypothesis that dense grass interferes with escape from predators is reconsidered in terms of grass density and size of rodent. (Auth)

255 RUSH, F. E. 1971. Regional ground-water systems in the Nevada Test Site area, Nye, Lincoln, and Clark Counties, Nevada. Water Resources - Reconnaissance Series Report 54, 25 p. (U. S. Geological Survey, Denver, CO 80225)

The area covered by this report includes 16 hydrographic areas between Tonopah and Las Vegas, NV, and centers about the USAEC's Nevada Test Site. The area has an average annual precipitation of about 5 inches on the valley floors to 20 inches in the mountains. Consolidated rocks are mostly volcanic; however, some extensive areas of carbonate rocks have been mapped. Three types of ground-water reservoirs are identified: Valley-fill, volcanic-rock, and carbonate-rock aquifers. Alluvium beneath valley floors is commonly saturated only at great depth. Water in the valley-fill reservoirs generally leaks downward to volcanic or carbonate rocks. In the eastern part of the study area, volcanic-rock aquifers locally transmit water downward to carbonate-rock aquifers. In the western part, the volcanic-rock aquifers transmit a regional flow of water, as do the carbonate-rock aquifers of the eastern part. Transmissivity of volcanic-rock aquifers of the western part averages about 10,000 gal per day per ft. Transmissivity of the carbonate-rock aquifer generally is much higher, resulting in low flow gradients. Three regional interbasin ground-water flow systems have been identified: Ash Meadows, in the eastern two-thirds of the area; Pahute Mesa, in the western third; and Sarcobatus Flat, west of the study area and including Cactus Flat. Ground water in the Ash Meadows system flows generally southward to Ash Meadows to discharge at springs, by evapotranspiration, and possibly by subsurface outflow across a fault barrier to the south end of the Pahute Mesa system in Amargosa Desert. The Pahute Mesa

system flows generally southward to discharge largely by evapotranspiration in Amargosa Desert. Ground water is believed to flow southwestward from Cactus Flat to Sarcobatus Flat where it is largely discharged by evapotranspiration. Some of the water in the first two systems may move southwestward as underflow to Death Valley through the carbonate rocks of the Funeral Range. The estimated average annual recharge and discharge for the Ash Meadows system are 33,000 and at least 17,000 acre-feet, respectively; for the Pahute Mesa system these estimates are 11,000 and 9,000 acre-feet, respectively; and for the Sarcobatus Flat system, 3,500 acre-feet. For the Ash Meadows and Pahute Mesa systems, which join in Amargosa Desert, the computed excess of recharge over discharge of some 18.000 acre-feet per year may flow southwestward to Death Valley, assuming that substantial errors in the estimates do not exist. Because virtually all the ground-water discharge is by subsurface outflow at considerable depth, most ground-water development probably will be from ground water in storage. One exception is the western part of Groom Lake Valley where an estimated 2,500 acre-feet per year could be salvaged. Beneath valley floors, an estimated 10 million acre-feet of ground water is in transient storage in the uppermost 100 feet of saturation. (Auth) (LE)

256 SANBORN, S. R. 1972. Food habits of *Sauromalus obesus obesus* on the Nevada Test Site. J. Herpetol. 6:142-144.

A list of identifiable plant materials from the stomachs of 26 *S. obesus* from Nye County, Nevada is given. (ABM)

257 SCHAEFFER, J. R. 1968. Climatology of Tonopah Test Range, 1967. USAEC Report SC-M-68-522, 74 p. (NTIS, Springfield, VA 22151)

The climatology of the Tonopah Test Range is described by climatic summaries of temperature, relative humidity, station pressure, precipitation, and surface winds during 1967; summaries of the same elements based on 7-year averages covering the years 1961 to 1967; and summaries of upper winds based on the years 1961 to 1967. (Auth)

258 SHIELDS, L. M., and F. DROUET. 1962. Distribution of terrestrial algae within the Nevada Test Site. Amer. J. Botany 49: 547-554.

The incidence of terrestrial algal species in natural soil growths at the Nevada Test Site was considered in relation to the major shrub zones and to atomic target areas. Observations are based upon samples collected in three successive years (1957 to 1959) from control sites in the various shrub types, at 0.1-mile intervals within 1.0 mile from five tower ground zeros, and from the vicinity of the one perennial body of water, Cane Springs. Twelve terrestrial algal species, other than diatoms, were identified by microscopic examination of natural soil growths. Four soil species appeared in culture only. Fifteen taxa occurred only

in the vicinity of the one aquatic habitat. Colloidal sheaths of *Microcoleus vaginatus*, *Schizothrix californica* and *Schizothrix acutissima* stabilize soil particles, forming a surface crust. *Nostoc commune*, *Scytonema hofmannii* and *Protosiphon cinnamomeus* are commonly associated with lichens. Algal species cultured from the vicinity of nuclear detonation sites are reported. Seed plants showed a gradient of decreasing evidence of damage between 0.6 mile and the 1.0 mile interval at which vascular vegetation appeared relatively unaffected. The abundant stand of annuals the following spring between 0.3 and 0.6 mile, interpreted as evidence of seed survival in the soil, indicates that the surface crust within this radius tended to remain in position. Algae occurring as natural soil growths within 0.6 mile of ground zero the year following detonation appeared to represent survivors of nuclear effects. Algae developing only in culture may be windblown contaminants. For detonations at the five tower target areas during the 1957 nuclear test series at the Nevada Test Site, energy yields in roentgen equivalents for mammals one min after burst were approximated as ranging from 60,000 for the smallest to 700,000 for the largest shot at 0.25 mile from ground zero, 3000-30,000 at 0.5 mile and 700-6000 at 0.75 mile. While algae within 0.5 mile may have been removed with the soil or subjected to thermal injury, none at this distance were exposed to significant radiation levels. *Microcoleus vaginatus* was one of three algal species isolated from Nevada Test Site soils following acute γ exposures of 1280 kR from Co-60. *M. vaginatus* has also grown on sterile and in cultures of test-site soil following acute experimental Co-60 exposures amounting to 2560 kR. This species is the first alga to colonize construction sites and roadsides in this area. The extreme aridity of the growing seasons of 1959 to 1961 may account for failure of this and other species to become re-established on bladed control plots and at ground zeros within three yr following denuding. Failure to invade cannot be explained on the basis of radiation levels since the outer margin of the 100 mR/hr zone typically receded to within 0.5 mile of ground zero within 1 week. The effects of soil removal, denuding and the presence of debris from fission products are reflected temporarily within the 0.4-mile radius of ground zero by a slightly higher pH and electrical conductivity and a lower Kjeldahl nitrogen than in the surrounding 0.5-1.0 mile. (BBB)

259 SHIELDS, L. M., and W. H. RICKARD. 1961. A preliminary evaluation of radiation effects at the Nevada Test Site. In: *Recent Advances in Botany*, p. 1387-1390. (University of Toronto Press, Toronto, Canada.)

Field studies were conducted between 1957-1959 to determine the effects of nuclear detonations on native plant communities of the Nevada Test Site. In vegetation surviving in the vicinity of above-ground target areas, there was no unequivocal evidence of

radiation damage. Radiation did not seem to damage or kill shrubs at two initial detonation sites, but it may have selectively affected germination in winter annual species. Conifers near an underground shot chamber that vented were probably killed by root damage rather than by radiation insult. (TPO)

260 SHIELDS, L. M., and P. V. WELLS. 1962. Effects of nuclear testing on desert vegetation. Science 135:38-40.

Detonation of fission-type nuclear devices results in an inner circle of complete denudation of desert shrub vegetation, often about 0.5 mi in radius, surrounded by a zone of partial and selective destruction which is variable in width. The gross injury to vegetation appears to be attributable to mechanical and thermal effects. Successional change in the composition of the vegetation, due to invasion by plants of pioneer character, is taking place in all disturbed areas. (Auth)

261 SHIELDS, L. M., and P. V. WELLS. 1963. Recovery of vegetation on atomic target areas at the Nevada Test Site. In: (Schultz, V., and A. W. Klement, Jr., eds.) *Radioecology*, Proc. First National Symp. on Radioecology, p. 307-310. (Reinhold Publ. Corp., New York, NY 10022)

The typical nuclear detonation at the Nevada Test Site, an airburst of a 20 to 40-kiloton yield, denuded a zone of desert shrub vegetation about 0.5 mile in radius. Asymmetric blast damage to shrubs extended a greater distance, in some cases to beyond one mile, varying with species and stability of the substratum. Gross injury to vegetation appears to be largely from blast and thermal effects. The spring following denudation, ground cover by annuals between 0.4 and 0.8 mile from different ground zeros exceeded total cover in the control vegetation. Beyond the perimeter of denudation, recovery is evident in the crown sprouting of several shrub species, in the appearance of weedy perennials, and in the prominence of bunchgrasses. During a four-year study period (1957 through 1961) it has not been possible to establish an unequivocal relation between killing, injury, or morphological aberration in vegetation and ionizing radiation from nuclear detonations. (Auth)

262 SHIELDS, L. M., L. W. DURRELL and A. H. SPARROW. 1961. Preliminary observations on radiosensitivity of algae and fungi from soils of the Nevada Test Site. Ecology 42:440-441.

To evaluate relative radiosensitivity of soil algae and fungi from the Nevada Test Site, 89 soil samples were exposed to different levels of γ radiation from a Co-60 source. Total doses ranged from 2.5 to 2560 kR administered at dose rates varying from 190 to 245 kR/hr. The max exposure was 320kR for the first series, 1280 kR for the second, and 2560 kR for the third. The soils were taken from the surface and 3- to 6-in. depth within

one mile of four ground zeros and in undisturbed control areas. In both controls and treated samples, no difference in radiation injury could be observed between those from ground zeros of two years previously and those from undisturbed vegetation zones. Some soil algae were less susceptible to radiation injury than common fungi of arid soils. Three algal species survived acute exposures of 1280 kR, but the upper range of tolerance for fungi in the same samples was 640 kR. *Microcoleus vaginatus* the algal species consistently showing the highest radioresistance, is the most abundant and widely distributed alga in semi-desert soils. Two other algal species *(Phormidium tenue* and *Synechococcus cedrorum)* survived a max of 1280 kR. The higher soil moisture level in the control series is relected in the isolation of a greater number of fungal taxa and the relatively low radioresistence of all species. In the 3rd series, five species grew in culture following soil dosages of 640 kR: *(Stemphylium ilicis, Fusarium* sp., *Phoma* sp., *Alternaria tenuis* and *Streptomyces* sp.). (BBB)

263 SHIELDS, L. M., P. V. WELLS and W. H. RICKARD. 1963. Vegetational recovery on atomic target areas in Nevada. Ecology 44:697-705.

The effects of fission-type nuclear detonations on perennial plant cover at the Nevada Test Site were studied. An account is given of denuding and recolonization, by annual species in particular, in the vicinity of seven ground zeros. Observations were made from the close of Operation Plumbbob. An airburst of a 20-kt yield denuded a concentric zone of desert shrub vegetation about 0.5 mi in radius. Selective shock and blast damage to perennials extended asymmetrically to beyond 1 miles in certain cases. During the first recovery year the area within 0.1 to 0.3 mile of ground zeros remained essentially barren until *Salsola kali* formed a widely spaced summer stand. Cover by spring annuals between 0.4 and 0.8 mile from different tower detonation points exceeded total cover in the control vegetation. One species, *Mentzelia albicaulis,* contributed the greater part of the cover within 1.0 mile of five tower sites. In the surrounding vegetation *Chaenactis stevioides* was the predominant annual. A marked decrease in the second-, third-, and fourth-year cover at target areas was associated with a less favorable climatic regime. *Chaenactis* spp. and *Bromus rubens* invaded progressively in the direction of ground zeros. Marginal to the denuded areas, certain perennials are recovering by crown sprouting, and weedy shrubs are appearing. Gross damage to vegetation beyond the perimeter of complete denudation, however, appears to be attributable to mechanical and thermal injury. Radiosensitivity of various plant species is discussed. (BBB)

264 SMITH, D. D. 1972. Radiation surveillance of ruminants on and about the Nevada Test Site. NERC-LV-539-18, 10 p. (Environmental Monitoring and Support Laboratory, Environmental Protection Agency, Las Vegas, NV 89114)

The metabolism and tissue burdens of radionuclides in domestic and wild ruminants were studied. The Sr-90 levels in bones from three species of ruminants namely deer, cattle and sheep grazing on or near the Nevada Test Site showed a steady decline since the cessation of atmospheric testing in 1962. Levels of Sr-90 observed in desert bighorn sheep *(Ovis canadensis nelsoni)* ranged from 3.9-13.4 pCi/g of ash in 1964 (average of 9.7 pCi/g of ash) and from 1.0-12.0 pCi/g of ash in 1971 (average of 5.8 pCi/g of ash). Levels of gamma emitting radionuclides found in the Nevada Test Site beef herd remain low, with the liver as the edible organ containing the highest levels of radioactivity. In addition, the operation of an experimental dairy farm, the maintenance of an experimental beef herd, and the use of the dairy herd in controlled metabolism studies are discussed. (Auth)

265 SMITH, D. D. 1973. Observations on wildlife and domestic animals exposed to the ground motion effects of underground nuclear detonations. NERC-LV-539-24, 11 p. (Environmental Monitoring and Support Laboratory, Environmental Protection Agency, Las Vegas, NV 89114)

Domestic animals and wildlife were frequently observed or intentionally stationed in close proximity to surface ground zero at the time of underground nuclear detonations at the Nevada Test Site and at other test locations within the contiguous United States. Subjective summaries are given of large animal involvement with specific nuclear events. It is noted that physical damage from ground motion has not been reported. Recommendations are made for experimental verification of these subjective observations. (Auth)

266 SMITH, D. D. and K. R. GILES. 1970. Animal Investigation Program, 1969 annual report. SWRHL-102r, 20 p. (NTIS, Springfield, VA 22151)

The radionuclide contents of selected bovine, deer, and Bighorn sheep tissues which were collected during 1969 from animals grazing on or near the Nevada Test Site are reported. The radionuclide burden remains low, with the highest levels and widest range reported from animals collected in May. The strontium content of bones collected from all three species continues the downward trend of recent years. Other activities of the Animal Investigation Program during 1969 are also mentioned. Tables are presented to show contents of Ce-144, Cs-137, I-131, K-40, Mn-54 Ru-106, Sr-89, and Sr-90. (Auth)

267 SMITH, D. D., and K. R. GILES. 1974. Animal Investigation Program, 1970 annual report. NERC-LV-539-16, 53 p. (Environmental Monitoring and Support Laboratory, Environmental Protection Agency, Las Vegas, NV 89114)

This report presents the radionuclide contents of tissues collected during 1970 from cattle, deer, desert bighorn sheep, and other wildlife on or near the Nevada Test Site (NTS). Gamma emitting radionuclides were infrequently detected in the tissues of animals living on or around the NTS. However, I-131 was detected in the thyroids of all beef animals sampled during October. The probable source of the I-131 was a non-U. S. atmospheric test conducted on October 14, 1970. Elevated levels of I-131, Ru-106, H-3 were detected in the tissues of wildlife that drank from drainage ponds that collect runoff waters from the mines used for testting activities. A man, eating 311 g of the flesh on one chukar sampled, would ingest 34.2 nCi of I-131 and 53 μCi of H-3. The average Sr-90 levels detected in the bones of three ruminant species sampled on and around the NTS ranged from 2.4 to 5.6 pCi/g of ash. These levels are lower than those reported during 1969 and reflect the downward trend observed since the cessation of atmospheric testing. No gross or microscopic lesions were detected that could be directly attributed to the effects of ionizing radiation. Details of special studies of wildlife utilizing the contaminated runoff waters, of cattle grazing in the Schooner fallout area, and surveillance activities associated with Project Rulison are also presented. Other activities of the Animal Investigation Program including claim investigation, public information displays, etc., during 1970 are described. (Auth)

268 SMITH, D. D., K. W. BROWN, R. A. BRECHBILL, K. R. GILES and A. L. LESPERANCE. 1972. The radionuclide concentrations and botanical composition of the diet of cattle grazing the Area 18 range of the Nevada Test Site, 1966-1970. SWRHL-110r, 31 p. (NTIS, Springfield, VA 22151)

The radionuclide content and botanical composition of the diet of the cattle grazing on Area 18 range of the Nevada Test Site was determined by analyzing rumen samples collected from fistulated steers. A value for November 26, 1969 of 22 nCi/g was found that could be the result of ingestion of a single particle by the grazing animal. The radionuclide concentrations of the rumen samples both from world-wide fallout and from NTS events were either below the minimum detectable amount or are of very low magnitude. No pathology has been found that can be attributed to radiation. Detectable levels of Zr-95, Ru-106, Ba-140 and Ce-144 were usually found in samples collected during the late spring and early summer. Levels of Ru-106 and Zr-95 persisted into the fall. Samples collected following a contaminating event usually showed I-131 and Ba-140. Grass was a major portion of the diet. Squirreltail grass and Indian rice grass were predominant. Galleta grass, the dominant grass in Area 18 appeared in large amounts in

June 1966, July 1967, July, August, September 1968 and in September 1969. Desert bitterbush and gambel oak were the principal browse species during most months. (HP)

269 SMITH, H. D., C. D. JORGENSEN and H. D. TOLLEY. 1972. Estimation of small mammal using recapture methods: partitioning of estimator variables (sic). Acta Theriologica 17:57-66.

A model was designed to estimate small mammal densities using capture-recapture data. It includes a grid design with dense perimeter traps to detect movements off and on the grid. If movement is detected, dispersal behavior, death rate, trap avoidance, and animal-trap relationships are determined and partitioned to provide reliable density estimates. If movement is undetectable, the density estimates are less reliable. Reliable estimates of density are provided without home range data. This model seems to be most useful in studies where permanent or semi-permanent grids are established in populations that cannot be disturbed by removal or kill-trapping. (TPO)

270 SMITH, T. M., A. L. LESPERANCE, V. R. BOHMAN, R. A. BRECHBILL and K. W. BROWN. 1968. Intake and digestibility of forages grazed by cattle on a southern Nevada range. Proc., Western Section, Amer. Soc. of Animal Science 19:277-282.

Rumen fistulated steers were used to sample forage on a northern desert shrub range in southern Nevada during the winter, early summer and late summer. Grass made up 98 and 100 percent of the diet during the winter and early summer periods, respectively. During the late summer period Russian Thistle *(Salsola kali)* accounted for 78 percent of the selected diet. Percentages of the fibrous portions of the selected diet either were not significantly (P less than .01) different between periods or decreased with each succeeding period. Conversely, crude protein was highest during the two summer periods. Digestibility of dry matter, crude protein, gross energy, crude fiber and NFE was significantly (P less than .05) higher in either the late summer or both summer periods. Total digestible nutrient content was significantly (P less than .05) higher only in the late summer period. Percent digestible protein was (P less than .01) lowest in the winter period while percent digestible energy showed no significant (P greater than .05) difference between periods. Intake of digestible protein increased significantly (P less than .01) with each period. Dry matter and TDN intake was highest (P less than .05) in the late summer period. Digestible energy intake was significantly (P less than .05) different between the winter and late summer periods. (Auth)

271 TAGAMI, T., and P. HAYDEN. 1963. An albinistic pocket mouse from Nevada. J. Mammalogy 44:415.

A female pocket mouse, *Perognathus formosus*, trapped in Rock Valley,

Nevada Test Site had white pelage except for a few black-tipped spines over the rump and scattered black hairs on the head. Eyes were black. The authors estimated that this pelage anomaly occurred with a frequency of less than 1 in 3500. (TPO)

272 TANNER, V. M. 1963. A new species of *Craniotus* (Coleoptera: Tenebrionidae). Great Basin Nat. 23:167-170.

A new species of beetle was described from material collected on the Nevada Test Site. *Craniotus blaisdelli* was taken 12.5 miles NNE of Mercury, NV in *Larrea-Franseria*; 9.3 miles west of Mercury in *Larrea-Franseria*; 32.5 miles north of Mercury in *Coleogyne* associations. (TPO)

273 TANNER, V. M. 1966. Rhynchophora beetles of the Nevada Test Site. Brigham Young Univ. Sci. Bull., Biol. Ser. 8(2), 35 p.

As part of the ecological studies of the Nevada Test Site, collections of rhynchophora beetles were made of 310 specimens including 28 genera and 44 species. Morphological characteristics were listed but very little life history was obtained. The plant relationships, number of specimens collected, month and year of collection, and plant hosts or plant communities are given. (BBM)

274 TANNER, V. M., and W. A. PACKHAM. 1962. *Pelecyphorus semilaevis* (Horn) (Coleoptera: Tenebrionidae). Great Basin Nat. 22:110-113.

Many specimens of the ground-dwelling beetle, *Pelecyphorus semilaevis* (Horn) were collected near Mercury, Nevada Test Site. Representatives of this species have not been reported on since 1870, and the current authors were able to correctly assign the species to the genus *Pelecyphorus* rather than *Trichiasida* as previously reported by Casey. (TPO)

275 TANNER, V. M., and W. A. PACKHAM. 1965. Tenebrionidae beetles of the Nevada Test Site. Brigham Young Univ. Sci. Bull., Biol. Ser. 6(1), 44 p.

The intent of this study conducted over a period of three years was to (1) provide descriptions of the species of tenebrionids found at the Nevada Test Site, (2) determine their relative abundance, (3) determine their seasonal activity, and (4) ascertain their plant community relationships. A total of 14,650 beetles representing 46 kinds of tenebrionids was collected with sunken can traps, by hand, and ultra-violet light. Collections were made at regular intervals in the following plant communities: *Larrea-Franseria, Lycium, Atriplex-Kochia, Grayia-Lycium* (disturbed and undisturbed areas), *Salsola, Coleogyne,* Pinyon-Juniper, and Mixed. The data obtained from this study indicate that (1) more species were present in some plant communities than in others; (2) in nuclear disturbed areas a larger number of species was

present than in undisturbed areas; (3) some species were more closely associated with some plant associations than with others; (4) those species that were not widely distributed ecologically were fewer in number of individuals, whereas those that were widespread occurred in larger numbers, relatively speaking; (5) the species demonstrated variation in seasonal activity in that some were active for short periods whereas others were active during the whole year; and (6) the two seasonal peaks in population are indicative that some species over-winter as adults whereas others over-winter as larvae. (Auth)

276 TANNER, V. M., and W. W. TANNER. 1974. Additional records of Coleoptera collected at the Nevada Test Site, Mercury, Nevada, Great Basin Nat. 34:218-220.

Thirty-nine species of Coleoptera not previously reported for the Nevada Test Site are listed.

277 TANNER, W. W. 1969. New records and distributional notes for reptiles of the Nevada Test Site. Great Basin Nat. 29:31-34.

In a previous publication, Reptiles of the Nevada Test Site, the author listed 28 species of reptiles. Since then, three additional species have been added and increased understanding of other species has been noted. Discussion is given for 9 taxa including distribution of the species. (BBM)

278 TANNER, W. W., and B. H. BANTA. 1962. The distribution of *Tantilla utahensis* Blanchard. Great Basin Nat. 22:116-118.

Documents the presence of *Tantilla utahensis* in southern Nevada from the western edge of Yucca Flat, NTS. As *T. utahensis* was previously found only in Utah and east-central California, these records eliminate the hiatus in distribution. (TPO)

279 TANNER, W. W., and J. M. HOPKIN. 1972. Ecology of *Sceloporus occidentalis longipes* Baird and *Uta stansburiana stansburiana* Baird and Girard on Rainier Mesa, Nevada Test Site, Nye County, Nevada. Brigham Young Univ. Sci. Bull., Biol. Ser. 15(4), 39 p.

This paper constitutes the first in a series of terminal reports to the United States Atomic Energy Commission for contract AT (11-1) 1496. It includes a major study on the ecology of the western fence lizard, *Sceloprorus occidentalis longipes*, on Rainier Mesa. Also presented is a comparative study of three populations of *Uta stansburiana stansburiana* Baird and Girard, with special emphasis given to the Uta population on Rainier Mesa. Extensive data for the *S. o. longipes* study were gathered during periods of lizard activity in the years 1965 through 1968; limited observations and samplings continued through 1971. The study plot covered an area of 6.2 acres in a pinyon-juniper community situated at 7,480 ft elevation. Studies include descriptions of the

physical environment, biotic environment, behavior, parasites, temperature requirements, reproduction, food habits and home range. A maximum estimate for the home range size of 95 percent of the adult male lizards of this population is given as 1.67 acres. It was noted that nearly all individuals consistently remained in a given area for three or more years without changing their center of activity. Those few who did effect a change appeared to do so early in the spring before advent of the mating period. *S. o. longipes* does not move about foraging for food, but ingests, apparently with little discrimination, any suitably-sized prey discernible in its immediate vinicity. Utilization of available arthropods (particularly ants) is of considerable importance in the lizard's ability to survive in high altitudes. *S. o. longipes* basks, increasing its rate of metabolism to permit extension of its feeding periods. This extension promotes an earlier laying of eggs to insure reproduction. Conclusions derived from the comparative study of *Uta stansburiana* are that: (1) *Uta* live longer at high altitudes and population structure is different from that at lower elevations, (2) *Uta* from higher elevations attain a larger size, and (3) with a larger average size for adults in higher elevations, there are more eggs per clutch. (BBM) (LE)

280 TANNER, W. W., and C. D. JORGENSEN. 1963. Reptiles of the Nevada Test Site. Brigham Young Univ. Sci. Bull., Biol. Ser. 3(3), 31 p.

Ecological studies have been conducted at the Nevada Test Site to determine how animal populations are affected by nuclear weapons. In the present study twenty-nine species of reptiles have been taken including one tortoise, thirteen lizards, and fifteen snakes. Data presented includes a description and, where feasible, a discussion of the geographic and ecological distribution, external morphology as related to taxonomic identification, systematic position of each subspecies, and seasonal occurrence. The biology of some species, especially *Uta s. stansburiana* and *Cnemidophorus t. tigris*, is summarized for seasonal fluctations, population densities, survival, and growth rate. Vegetation was analyzed in all cases where detailed vegetation analysis was considered important. (BBM)

281 TANNER, W. W., and J. E. KROGH. 1973. Ecology of *Sceloporus magister* at the Nevada Test Site, Nye County, Nevada. Great Basin Nat. 33:133-146.

The natural history of *Sceloporus magister* was studied in populations at the Nevada Test Site, Mercury (USA). Individuals were marked and kept under surveillance from 1965 through 1970. Reproductive cycles were examined by field observation and by autopsy. Hatchlings appear in the population in July and August. Growth is rapid for the 1st year. Sexual maturity is reached before the 2nd hibernation or soon after emergence from it. Territoriality is a pronounced behaviorism; individuals have been observed to remain in a small area for several years. Food consists of

arthropods, with ants the predominant item. Reproduction occurs during May and/or June with only 1 clutch/yr. Density is variable and depends on the appropriateness of the habitat.

282 TANNER, W. W., and J. E. KROGH. 1973. Ecology of *Phrynosoma platyrhinos* at the Nevada Test Site, Nye County, Nevada. Herpetologica 29:327-342.

The natural history of *Phrynosoma platyrhinos p.* was studied in populations at the Nevada Test Site, Mercury, Nevada (USA). Individuals were marked and kept under surveillance from 1965 through 1971. Reproductive cycles were examined by field observations and autopsy. Hatchlings appear in July and Aug. Growth is rapid for the 1st year and sexual maturity is reached before the 2nd hibernation or soon after emergence from it. Territoriality is limited to broad general areas and is not a pronounced behaviorism as in most sceloporines. Food consists of arthropods, with ants the predominant item. Twenty-four females were producing 160 eggs with a range and average of 3-9 (6.66) eggs. Density was approximately 5/ha with the greatest activity occurring during spring and early summer months.

283 TANNER, W. W., and J. E. KROGH. 1974. Ecology of the leopard lizard, *Crotaphytus wislizeni* at the Nevada Test Site, Nye County, Nevada. Herpetologica 30:63-72.

The natural history of the leopard lizard *C. wislizenii* was studied at the Nevada Test Site, Mercury, Nevada (USA). Individuals were marked and examined from June 1956 through Sept. 1971. Reproduction cycles were examined by field observations and by autopsy. Sexual maturity is reached at or soon after emergence from the 2nd hibernation. Growth is rapid while they are hatchlings and juveniles. Data indicate some territoriality at least for a few years in some individuals. Territories are large and widely dispersed. Food consists of arthropods, lizards and vegetation (mainly blossoms and berries). One clutch of eggs is laid, usually in June, with greater reproductive activity occurring in some years. Density is approximately 5/ha at the study plot in Frenchman Flat.

284 TANNER, W. W., and J. E. KROGH. 1974. Variations in activity as seen in four sympatric lizard species of southern Nevada. Herpetologica 30:303-308.

Records were kept on the number of individuals observed and captured /h of each day over 2 summers at the Nevada Test Site (USA). The 4 spp. of lizards studied were *Callisaurus draconoides*, *Cnemidophorus tigris*, *Crotaphytus wislizenii* and *Phrynosoma platyrhinos*. On an hourly basis *Callisaurus* was always the more abundant species ranging from 67-100 % of the total of all species observed. *Cnemidophorus* was usually the 2nd most abundant species followed by *Crotaphytus* and *Phrynosoma* in that order. The same

trend was observed on a seasonal basis. *Callisaurus* and *Cnemidophorus* escape capture best at the time of day when they were most abundant.

285 TOWNER, J. W. 1965. The effect of radioactive fallout at the Nevada Test Site on the chromosomes of the pocket mouse. In: (Hungate, F. P., ed.) *Radiation and Terrestrial Ecosystems*, Health Physics 11:1569-1571.

Native populations of the long-tailed pocket mouse, *Perognathus formosus* were trapped at the Nevada Test Site from an area with a history of heavy contamination by radioactive fallout, but uncontaminated for 3 yr previous to trapping; and from an unexposed control area. With one possible exception, no unequivocal evidence has been obtained for the presence of a persistent, inherited chromosome aberration in either population. (Auth)

286 TOWNER, J. W., and R. G. LINDBERG. 1966. Persistent radiation induced chromosomal changes in native pocket mouse populations of the Nevada Test Site. USAEC Report SAN-510-2, 81 p. (Northrop Space Laboratories, Hawthorne, CA 90250)

A study was made of the persistence of chromosome damage in wild populations of the long-tailed pocket mouse, *Perognathus formosus* at the Nevada Test Site (NTS). Animals were collected in 1963 and 1964 from the previously contaminated hills east of the old Ground Zeros at Yucca Flat (YF) and from an essentially uncontaminated area north of Jackass Flats (JF). The infinite environmental dose to the YF study area was about 200 R from weapons tests between 1951 and 1958 and perhaps as much as 4000-6000 R total cumulative gamma dose from Project Sedan in 1962. The karyotype (2n = 36) consisted of 8 pairs of large metacentrics, 1 pair of small metacentrics, 8 pairs of small acrocentrics and the two sex chromosomes. Chromosomes 5, 6, 7, 8, 10, 18, X, and Y and three groups of autosomes were identifiable. Somatic chromosomes were generally studied in two tissues, mostly uncultured marrow and cultured kidney cells. Analyses were made under the microscope or from karyotypes. Meiosis was also examined in some males. No inherited aberrations were detected in the sex chromosomes, the acrocentrics, or the metacentrics Nos. 5, 6, 7 or 10. No inherited numerical aberrations were found. No animal had unequivocal cytogenetic or somatic symptoms of radiation exposure. One of the most important findings was that two animals from the contaminated area (2.4%) and one from the control area (2.2%) had a consistent, presumably inherited, karyotype aberration. All 3 cases seemed to involve nonreciprocal gain or loss of chromatin from the short arm of a metacentric autosome. All 3 animals were phenotypically normal and survived for a year or more in captivity. It was concluded that inherited chromosome aberrations were no more frequent in

pocket mice from an area at Yucca Flat that had been chronically contaminated by radioactive fallout than in animals from the essentially unexposed habitat at Jackass Flats. (Auth) (FMM)

287 TUELLER, P. T., A. D. BRUNER, R. EVERETT and J. B. DAVIS. 1974. The ecology of Hot Creek Valley, Nevada and nonradiation effects of an underground nuclear detonation. NVO-409-2, 55 p. (ERDA, Las Vegas, NV 89114)

Vegetation on approximately 70 square miles of the north portion of Hot Creek Valley were mapped using aerial photographs in conjunction with data from 108 ground macroplots. Soils and vegetation were described at each plot. Remote sensing data suggested that the vegetation was not subjected to any harmful physiological effect from ground shock from Faultless (UC-1). Areas have been disturbed by AEC contractors and recommendations for revegetating them are included. (TPO)

288 TURNER, F. B. 1963. Influence of a cratering device on close-in populations of lizards. (Project Sedan) USAEC Report PNE-224F, 39 p. (UCLA, Los Angeles, CA 90024)

Prior to the Sedan test on July 6, 1962, the density of adult lizards northeast of the prospective ground zero was estimated on the basis of repeated sampling of selected areas. Samples were taken by hand collecting and by means of buried cans, which served as traps for both lizards and various species of arthropods. Measurements of cumulative gross gamma dosages in the study areas were also made at 2" and 36" above the ground, 2" below the ground, and in the tissues of lizards by means of small implanted glass microdosimeters. In shrubby areas northeast of ground zero, the pre-test density of *Cnemidophorus tigris* in June was estimated at 5 to 10 per acre, the density of *Crotaphytus wislizenii* at 1 to 2 per acre. No juveniles of either species were observed. Densities of *Uta stansburiana* and *Phrynosoma platyrhinos* could not be estimated from the data acquired. After the test, during August and again in November, no adult lizards were observed closer to ground zero than 5500 ft. (Auth)

289 TURNER, F. B. 1963. Quantitative relationships between fallout radioiodine on native vegetation and in the thyroids of herbivores. Health Physics 9:1241-1246.

Following the Sedan test of July 6, 1962, the time-specific relationships between I-131 on vegetation and in jackrabbit thyroids were measured and compared to predictions derived from a deterministic model. The accord is considered good enough to encourage further application of this approach to environmental problems involving food-chain transfers of radioisotopes. Disparities between predicted and observed levels are reviewed in terms of possible sources of error in estimating input parameters. The value of considering this type of problem probabilistically is emphasized and a stochastic revision of the model is derived. (Auth)

290 TURNER, F. B. 1963. Biotic communitites of the Nevada Test Site. (A review) Ecology 44:633-634.

This review of "Biotic Communities of the Nevada Test Site" (Allred, C. M., D E. Beck and C. D. Jorgensen, 1963) critiques the merits and shortcomings of the first attempt at describing the biota of the Nevada Test Site. After a few caveats, the author states, "Investigators planning ecological research at the Nevada Test Site will find careful study of this bulletin and indispensable prelude to further endeavor." (TPO)

291 TURNER, F. B. 1965. Uptake of fallout radionuclides by mammals and a stochastic simulation of the process. In: (Klement, A. W., Jr., ed.) *Radioactive Fallout from Nuclear Weapons Tests*, AEC Symp. Series 5 (CONF-765), p. 800-820. (TIC, Oak Ridge, TN 37830)

A deterministic model, designed to predict time-specific levels of I-131 on vegetation, was revised as a probabilistic simulation of the experience of a consumer in a fallout field. The stochastic model was used to generate synthetic populations of up to 1000 individuals. The frequency distributions of thyroidal I-131 in 24 of these hypothetical populations were analyzed in terms of the recommended assumptions of the Federal Radiation Council, namely that the majority of individuals in a population does not vary from the average by a factor greater than 3. In only two of the distributions did more than 2% of the population exceed three times the mean. The frequency distributions predicted by the model were all skewed to the high side and approximated lognormal distributions. A number of frequency distributions of radionuclides recorded in the literature were reviewed, and X^2-tests indicated that most of them were not normal. All the non-Gaussian distributions were skewed to the high side, and some of them were apparently lognormal. It is concluded that the general form of the synthetic distributions produced by the model is in agreement with most past observations. It is further suggested that such asymmetrical distributions may be more likely than normal ones. Consideration was also given to the possible relation between the frequency distribution of a radionuclide in diets and the frequency distribution of the substance in the tissues of animals consuming these diets. (Auth)

292 TURNER, F. B. 1966. Growth rate of lizards *(Uta stansburiana)* exposed to chronic gamma radiation. In: (Sacher, G. A., ed.) *Radiation Effects on Natural Populations*, p. 46-52. (Argonne National Laboratory, Lemont, IL 60438)

A population of chronically irradiated *Uta stansburiana* exhibited reduced growth compared to control populations. However, the population density was greater in the irradiated population as well so it was not possible to eliminate a density dependent phenomenon rather than radiation as a causative factor. (TPO)

293 TURNER, F. B. 1968. Life history of a lizard. (A review) Evolution 22:841-842.

A critique of the book *The Life and Demography of the Side-blotched Lizard*, UTA STANSBURIANA. (Tinkle, D. W., 1967, Misc. Publ., Mus. of Zool., Univ. Mich., No. 132, 182 p.). Judged to be one of the most significant population studies of a lizard in several years. Chapter on demography of *Uta stansburiana* considered the most interesting and important portion of the book by the reviewer. Also demonstrates the enormous field effort required to evaluate demographic problems under natural conditions. (TPO)

294 TURNER, F. B., and C. S. GIST. 1965. Influences of a thermonuclear cratering test on close-in populations of lizards. Ecology 46:845-852.

On July 6, 1962, a large thermonuclear device was detonated at the Nevada Test Site (Project Sedan). It was buried 635 ft underground and had a total yield of 10 kt. The explosion ejected about 7.5 million yd^3 of alluvium and produced a crater 320 ft deep and 1200 ft in diameter. As a part of an investigation of the ecological influences of underground detonations, a study was made of lizard populations within 10,000 ft of ground zero. Adult *Cnemidophorus tigris*, *Crotaphytus wislizenii*, and *Uta stansburiana* were exterminated within 4000 ft from ground zero. Very few adult lizards of any species were observed within 6000 ft. No changes attributable to the test were detected at 8500 to 9000 ft. Eggs of the three species hatched following the test in areas where adults did not survive. Young *Uta stansburiana* were numerous in August from 2600 to 9000 ft from ground zero. By October, the young lizards at 2600 ft were gone, and mortality at 3800 ft was extremely heavy. At 9000 ft the apparent density of young *Uta* was only slightly reduced as compared to that in August. In June, 1963, adults of the three species were observed between 4500 and 5000 ft from ground zero, and *Uta* was apparently most abundant. It is possible that *Cnemidophorus* was more sensitive than *Uta* to the deleterious influences. The immediate mortality within 4000 ft is attributed to the gross physical effects of the detonation (dirt fall and blast) which destroyed all of the vegetation out to 2000 ft and caused partial damage to 5000 ft. Delayed mortality, as that exhibited by juveniles which hatched after the test, is attributed to destruction of habitat. Neither the depletion of food resources nor the residual radiation is likely to have been lethal. Absorbed tissue doses, as registered by three microdosimeters implanted in lizards before the test and recovered July 28, were probably significantly less than the free-air dose registered in the same area. (BBB)

295 TURNER, F. B., and R. I. JENNRICH. 1967. The concentration of ^{131}I in the thyroids of herbivores and a theoretical consideration of the expected frequency distribution of thyroidal ^{131}I in a large consumer population. In: Åberg, B., and F. P. Hungate, eds.) *Radioecological Concentration Processes*, Proc. International Symp., Stockholm, April, 1966 (CONF-660405), p. 175-182. (Pergamon Press, New York City, NY 10523)

A probabilistic version of a mathematical simulation model was used to generate frequency distributions of the amount of I-131 at varying times in the thyroids of individuals making up artificial "populations" of consumers. Positive skewness of output distributions arose not only because of positively skewed distributions of I-131 per gram of food, but also because of multiplicative combinations of random errors. If true, the expected frequency distribution would be lognormal, or at least positively skewed rather than normal. Earlier field data were reexamined in light of the results of the simulation modeling. The data suggested that within 25 miles of the Sedan detonation, the asymmetrical distribution of I-131 on plants was largely responsible for determining thyroidal I-131 in herbivores, but at greater distances multiplicative interaction of variables may have been more important. (TPO)

296 TURNER, F. B., and J. R. LANNOM, Jr. 1968. Radiation doses sustained by lizards in a continuously irradiated natural enclosure. Ecology 49:548-551.

Desert lizards occupying a 20-acre experimental facility continuously exposed to gamma radiation sustained tissue doses that were less than the cumulative free-air dose. Vegetation and terrain afforded some shielding, but time spent below ground was the major source of protection. It was estimated that, in the course of a year, tissue doses sustained by *Uta stansburiana* were from 0.3 to 0.6 of the cumulative free-air dose, and that about 1/3 of the total dose was experienced between June and August. *Cnemidophorus tigris* spent less time above ground, and sustained annual doses representing only about 0.1 to 0.2 of total incident γ radiation. The dose experience of *Crotaphytus wislizenii* was intermediate to the other two species. Dose regimes experienced by *Uta stansburiana* in the experimental area are not acutely lethal. (Auth)

297 TURNER, F. B., and W. E. MARTIN. 1964. Food-chain relationships of Iodine-131 in Nevada following the Sedan test of July 1962. USAEC Report PNE-236F, 60 p. (NTIS, Springfield, VA 22151)

Following the Sedan test of July 6, 1962, in Nevada, the applicability of mathematical models to food-chain transfers of iodine-131 in natural environments was examined. The amounts of radioiodine measured in the thyroids of jackrabbits collected at 5-day intervals between July 5 and August 5 were compared to levels

predicted by models on the basis of estimated levels of radioiodine on vegetation as of July 6. Four areas, from 20 to 110 miles from ground zero, were studied between 5 and 30 days after the test. The basic model was deterministic, but a probabilistic model predicated on the same assumptions was also developed and tested. The performance of the models was good enough to encourage further work of this nature. Analyses of vegetation samples suggest that the distribution of radioiodine on vegetation after the test was lognormal, not normal. When distributions of radioiodine on vegetation are defined as lognormal, and frequency distributions of thyroid radioiodine in large synthetic populations are generated by the computer, these distributions are also lognormal. Whether such distributions reflect the situation in nature depends on the validity of the assumptions built into the model. We believe that the model assumptions are qualitatively sound, and that lognormal distributions of radioisotope concentrations in organs are probably characteristic of populations consuming vegetation contaminated by local fallout. This conclusion is supported both by measurements of radioiodine on vegetation at various times between July 11 and August 5, and by analyses of observed distributions of radioiodine in the thyroid of herbivores consuming this vegetation. The assumption of the Federal Radiation Council that the majority of individuals do not vary from the average by a factor greater than three, appears reasonable, both on the basis of actual observations and analyses of synthetic distributions of 1000 individuals. If measurements of radioiodine on sagebrush *(Artemisia tridentata)* in the vicinity of Currant, Nevada (110 miles from ground zero) were even close to levels of radioiodine on cattle forage (i.e., no more than 10 times higher), it is an unavoidable conclusion that had milk been produced in this area during July of 1962, it would have contained radioiodine (2000-3000 $\mu\mu c/l$) temporarily far in excess of the limit of Range II recommended by the Federal Radiation Council (100 $\mu\mu c/l$). Levels would have been higher in areas closer to ground zero. Fortunately, there is little dairying in this part of Nevada. (Auth)

298 TURNER, F. B., G. A. HODDENBACH and J. R. LANNOM, Jr. 1965. Growth of lizards in natural populations exposed to gamma irradiation. In: (Hungate, F. P., ed.) *Radiation and Terrestrial Ecosystems*, Health Physics 11:1585-1593.

Growth of the iquanid lizard, *Uta stansburiana* was analyzed in four 20-acre areas in Nevada between July and November 1964. One plot was irradiated continuously during this interval (except for sampling time). Growth of lizards in all areas appeared the same until October and November, when growth in the irradiated plot fell behind that occurring in the control areas. Analyses of variance involving both body lengths and weights showed highly significant differences between areas which are primarily attributable to the retardation of growth in the irradiated plot. The difference

between plots is not, at this time, attributed to irradiation. Some alternative interpretations of the situation are discussed. (Auth)

299 TURNER, F. B., R. I. JENNRICH and J. D. WEINTRAUB. 1969. Home ranges and body size of lizards. Ecology 50:1076-1081.

The relationship between home range, A (m^2) and body weight, W (g) among adults of 13 spp. of terrestrial lizards was estimated as: $A = 171.4W^{0.95}$. The slope of the logarithmic regression is steeper than that relating standard metabolic rate, M (cm^3O_2/hr) at 30°C and body weight: $M = 0.82W^{0.62}$. These functions are compared with similar regressions relating the home ranges and basal metabolic rates of birds and mammals to body size. Two major difficulties in the interpretation of such data are discussed.

300 TURNER, F. B., R. H. ROWLAND and R. A. WOOD. 1966. Nuclear engineering and wildlife: radioactivity in jackrabbits after the Sedan test. J. Wildlife Management 30:433-443.

After the Sedan thermonuclear test of July, 1962, at the Nevada Test Site, black-tailed jackrabbits *(Lepus californicus)* were collected from two areas within the local fallout pattern. The maximal tissue burdens measured were 9,700 nc of iodine-131 per gram of thyroid, 3.6 nc of cesium-137 per gram of muscle ash, 25.3 nc of strontium-89 per gram of bone ash, and 0.3 nc of strontium-90 per gram of bone ash. Estimated infinite doses to thyroids from iodine-131 were as high as 4,000 rems. The muscle of jackrabbits did not contain enough cesium-137 to render the meat unsafe; a person consuming one of the most highly contaminated rabbits might have incorporated 5 to 10 nc of cesium-137. Possible biological effects of the Sedan test in areas beyond the zone of close-in destruction are considered, and some problems in evaluating the ecological impact of nuclear engineering on wildlife resources are discussed. (Auth)

301 TURNER, F. B., G. A. HODDENBACH, P. A. MEDICA and J. R. LANNOM. 1970. The demography of the lizard, *Uta stansburiana* Baird and Girard, in southern Nevada. J. Animal Ecology 39:505-519.

Between 1966 and 1967 populations of *U. stansburiana* in southern Nevada increased about 40%. Over the next year they declined by about 50%. These changes are explained in terms of annual differences in fecundity and survival. Most females laid 5 clutches of eggs in 1966, but only 2 or 3 clutches in 1967. Adult survivial between 1966 and 1967 was better than during the following year. The capacity for increase r_c was estimated as 0.0327/mo., and cohort generation time, T_c as 15.32 mo. from the 1966-67 data. Data from other natural populations of lizards are reviewed and the inferred net reproductive rates (R_0) compared with the history of the populations. Problems in the study of lizard populations

are discussed, particularly the difficulty in assessing egg production by species laying several clutches of eggs each season.

302 TURNER, F. B., B. KOWALEWSKY, R. H. ROWLAND and K. H. LARSON. 1964. Uptake of radioactive material from a nuclear reactor by small mammals at the Nevada Test Site. Health Physics 10: 65-68.

Studies were made on the degree to which radioactive isotopes released from a nuclear reactor (Kiwi-A) test contributed to the tissue burdens of rabbits and rats. Gross beta activities in tissues of rabbits collected within the fallout pattern after the test (July) were consistently greater than activities in rabbits analyzed before the test (February). However, muscles from rabbits collected outside the pattern in July showed significantly greater radioactivity than February samples. This suggests that the increases in gross beta activity can be ascribed to stratospheric fallout. The gross beta activities of the muscle, bones, skins, and gastrointestinal tracts (and contents) of the July rodents were higher than in the specimens collected in February. Gross beta activities of thyroids collected in July ranged from 18 to 3280 disintegrations per minute for rodents and 133 to 1740 disintegrations per minute for rabbits. (PCH)

303 TURNER, F. B., J. R. LANNON, H. J. KANIA and B. W. KOWALEWSKY. 1967. Acute gamma irradiation experiments with the lizard *Uta stansburiana*. Radiation Research 31:27-35.

Five experiments with young and adult *Uta stansburiana* indicate that, when this species is exposed to acute Co-60 radiations, the $LD_{50(30)}$ ranges from about 1700 to 2200 R (with standard deviations of the order of 300 to 400 R). Adult males were shown to be more radiosensitive than adult females, but no sex differences were observed in an experiment with animals 3 to 40 months of age. Doses were administered at 100R/min and 200 R/min; the latter dose rate resulted in shorter survival times and (among adult males) a lower $LD_{50(30)}$. (Auth)

304 TURNER, F. B., J. R. LANNON, Jr., P. A. MEDICA and G. A. HODDENBACH. 1969. Density and composition of fenced populations of leopard lizards *(Crotaphytus wislizenii)* in southern Nevada. Herpetologica 25:247-257.

Leopard lizards exist in Rock Valley, Nevada, at low densities (1-2/acre) sustained by good adult survival (roughly 50% per annum) and maximal life-spans of at least 7-8 years. Among individuals more than 8 months of age, male survivorship appears to be superior to that of females. Thus, although the sex ratio among hatchlings is about even, there appear to be more adult

males than females in our area. Biomass estimates over a period of 5 years in three 20-acre areas ranged from 17.6 g/acre to 47.8 g/acre. Females do not ordinarily reproduce until 21-23 months of age, but in 1966 a few females reproduced when 9-11 months old. One clutch of eggs per year is typical, but occasionally two clutches may be laid (1965), and in 1964 there was no reproduction. (Auth)

305 TURNER, F. B., P. A. MEDICA, J. R. LANNOM, Jr. and G. A. HODDENBACH. 1969. A demographic analysis of continuously irradiated and nonirradiated populations of the lizard, *Uta stansburiana*. Radiation Research 38:349-356.

A natural population of the lizard *Uta stansburiana* occupying a fenced 20-acre area in southern Nevada has been exposed to essentially continuous gamma irradiation since February 1964. Tissue doses averaged about 2 rads/day. Nonirradiated populations occupying three adjoining 20-acre areas have also been investigated. Five years of sampling data drawn from the experimental and control populations showed no statistically significant differences in the sex ratios. Comparisons of maximal life span (44 months) and χ^2 tests of age distributions did not indicate a statistically significant difference between the experimental and untreated populations, but the tests were not sensitive to small changes in the proportions of individuals living to the age of 44 months. Both the 59% increase of the irradiated population between 1966 and 1967 and the 43% decline between 1967 and 1968 were generally matched by corresponding changes in the three untreated areas. (Auth)

306 TURNER, F. B., P. A. MEDICA, J. R. LANNOM, Jr. and G. A. HODDENBACH. 1969. A demographic analysis of fenced populations of the whiptail lizard, *Cnemidophorus tigris*, in southern Nevada. Southwestern Nat. 14:189-202.

Between 1964 and 1967, spring densities of *Cnemidophorus tigris* in four study areas in southern Nevada ranged from 3-8 per acre. Estimated biomass ranged from around 43 to 114 g/acre. The sex ratio was 1:1. Minimal annual survival of adults was 54-60%, and life-spans of at least 7 years are postulated. An undetermined proportion of mature females laid two clutches of eggs in 1965, but the general pattern was one clutch of 2-4 eggs per year. Large females produced more eggs than small ones. Occasionally females 9-10 months of age laid eggs, but sexual maturity normally was attained at about 21 months. By assuming that all mature females laid two egg clutches in 1965 our fecundity estimates could be approximately reconciled with the observed size and age composition of populations in the spring of 1966. Possible compensatory errors in this analysis are discussed. (Auth)

307 TURNER, F. B., P. LICHT, J. D. THRASHER, P. A. MEDICA and J. R. LANNOM, Jr. 1973. Radiation-induced sterility in natural populations of lizards *(Crotaphytus wislizenii* and *Cnemidophorus tigris)*. In: (Nelson, D. J., ed.) *Radionuclides in Ecosystems*, Proc. Third National Symp. on Radioecology (CONF-710501), p. 1131-1143. (NTIS, Springfield, VA 22151)

Leopard lizards *(Crotaphytus wislizenii)* and whip-tail lizards *(Cnemidophorus tigris)* have been exposed to gamma radiation in a fenced 20 acre area since January 1964. Free-air exposure rates over most of the area were around 4-6 R/day. Average annual tissue doses have been estimated with implanted lithium fluoride microdosimeters at 400-500 rads/year for *Crotaphytus* and about half this for *Cnemidophorus*. Demographic data and failure of mature female *Crotaphytus* in the irradiated area to assume typical reproductive coloration indicated absence of reproduction by this species in 1967 and 1968. Three female leopard lizards taken from the irradiated plot in May and June 1969 exhibited complete regression of ovaries, undeveloped oviducal walls, and hypertrophied fat bodies. One of three irradiated males collected at the same time was sterile. All of 20 control individuals taken in 1969 exhibited ovaries, oviducts, testes, and epididymides normal for the season. The first sterile female *Cnemidophorus* was collected in June 1969. Of four more females taken from the irradiated area in June 1970, three lacked ovaries; one had ovaries and had recently laid eggs. Three males from the irradiated area in 1970 did not differ in sexual condition from three control males. Experimental administration of follicle-stimulating hormone to the three apparently sterile *Cnemidophorus* females collected in 1970 had no effect on oviducal growth. The sterility observed in both species is attributed to long-term exposure to gamma radiation. Reproduction by another lizard, *Uta stansburiana* occupying the irradiated area has apparently been normal since the beginning of the experiment. The difference in response of *Uta* and the other two species is attributed to their markedly different life-spans and demographic regimes. (Auth)

308 WALLACE, A. 1970. Water use in a glasshouse by *Salsola kali* grown at different soil temperatures and at limiting soil moisture. Soil Science 110:146-149.

Salsola kali (Russian thistle) plants were grown in soil in tanks used to control root temperatures. Moisture levels were varied and maintained for most plants at predetermined levels. Yields, water evaporated, and water transpired were measured and from these values transpiration and evapotranspiration values were calculated per unit of plant dry weight and also per unit of new plant growth. Transpiration and evapotranspiration were influenced more by soil temperature than by soil moisture. There was a tendency for increased transpirational efficiency at low

soil moisture. At 10, 12, and 13% soil moisture, transpiration increased with increasing soil temperature but at 7% soil moisture it did not, indicating a physiological resistance to water movement across roots when water was limiting. (MK)

309 WALLACE, A., and R. T. ASHCROFT. 1970. Significance of vapor in plant water economy. Advancing Frontiers of Plant Sciences 26: 153-159.

Atriplex lentiformus leaves absorbed considerable water vapor from a saturated water atmosphere and *Atriplex canescens* also absorbed a significant but smaller amount. *Larrea divaricata* absorbed a small amount only. *Lycium andersonii, Kalanchoe* sp., and *Pelargonium hortorum* neither gained nor lost water under this system. The last three species lost water more slowly when exposed to a dry atmosphere than other species. When leaves were partially desiccated before placing in 100% relative humidity, *Atriplex canescens* and *Larrea divaricata* regained much of the lost water from a saturated atmosphere. *Larrea divaricata* plants after preconditioning appeared to be able to survive for a period with water from the vapor source only. The critical answers about vapor and fog use by plants are not yet known.

310 WALLACE, A., and R. T. MUELLER. 1968. Effect of chelating agents on the availability of ^{54}Mn following its addition as carrier-free ^{54}Mn to three different soils. Soil Sci. Soc. Amer. Proc. 32:828-830.

Carrier-free Mn-54 was mixed into samples of three different soils and allowed to equilibrate for several days. The soils were Yolo loam (slightly acid), Hacienda loam (calcareous), and Dinuba fine sandy loam (neutral). Bush bean (*Phaseolus vulgaris* var. 'Improved Tendergreen') and corn (*Zea mays* var. 'Golden Cross Bantam') were grown in the soils with the presence and absence of various chelating agents. Yields and Mn-54 and total Mn were determined in the leaves and specific activities were calculated. After cropping, the control soils were assayed first for water soluble, then exchangeable Mn-54 and Mn, and then easily reducible or 10^{-3}M EDDHA, EDTA, DTPA, and NTA soluble Mn-54 and Mn. The Mn-54 appeared to differentially label various forms of Mn in the soil. Bush bean leaves contained more Mn-54 and Mn per plant than did corn. The specific activities of the Mn-54 in bush bean leaves were more like those for the easily reducible Mn than for other Mn forms for the three different soils but the specific activities in the corn, in contrast, were more nearly like those in the exchangeable Mn in the soils. DTPA tended to increase the amounts of both Mn-54 and Mn in plants with the Yolo and Dinuba soils with concommitant decreasing specific activity of Mn. With corn DTPA apparently added easily reducible Mn to the pool of available Mn. EDTA tended to increase uptake of the soluble and exchangeable Mn by the plants. NTA and EDDHA had little effect. (Auth)

311 WALLACE, A., and E. M. ROMNEY. 1974. Feasibility and alternate procedures for decontamination and post treatment management of Pu-contaminated areas in Nevada. USAEC Report UCLA 12-973, 90 p. (See also 328.) (NTIS, Springfield, VA 22151)

The feasibility and environmental impact of cleaning up Pu-contaminated areas in Nevada are discussed. The total area where the surface contamination level is above 1000 pCi/cm^2 is about 300 acres. Only a few acres are above 7000 pCi/cm^2. Instead of considering all aspects of radioactive decontamination, the report deals primarily with findings from pertinent land area decontamination and post-management experiences which can be applied to solving Pu problems at the Nevada Test Site and the Tonopah Test Range. Previous experiences from accidental and planned releases of Pu in the environment are discussed along with those gained from nuclear fallout decontamination studies. Considerable attention is given to problems concerning revegetation of arid lands. The fragile nature of the desert is such that any drastic alteration will result in a seriously damaged ecosystem. Revegetation by natural means is difficult, if not impossible, from a practical point of view. Post-treatment management of disturbed areas is almost always necessary to insure recovery. An ideal cleanup and post-treatment procedure would be to remove the contamination, retain some of the native vegetation with sufficient soil fertility for its maintenance, and stabilize the distributed soil to protect it from wind and water erosion. Correction of the damage may require greater efforts than the decontamination, and may have more far-reaching consequences than those concerned with the present status of the land. Alternate procedures are discussed such as deep plowing of the soil, a fencing program, and application of road oil to decrease resuspension which may be useful in Nevada, providing the necessary experimental work is done to test the validity of the assumptions made. Many answers to pertinent questions can be obtained from investigations conducted outside of the Pu areas. Recommendations are made for experimental work that should be done to determine the best course of action before cleanup begins. (Auth) (FMM)

312 WALLACE, A., S. A. BAMBERG and J. W. CHA. 1974. Quantitative studies of roots of perennial plants in the Mojave desert. Ecology 55:1160-1162.

Root and stem weights were obtained for 113 field samples of 10 species of perennial plants in the northern Mojave Desert in order to develop methods for determining belowground biomass under the given conditions. Root and stem weights for all were highly correlated, and linear regression in most cases adequately expressed the relationship between root weight and stem weight. Root weight for the total of all plants considered was about 45% of the sum of stem and root weights. There were species differences. The proportion that was root was generally independent

of plant size. Root biomass can be estimated from stem weights for a population, for some species at least, within a possible error of ±10% to 20%. The data were combined with stem weights by dimension analysis to calculate the belowground biomass per ha in the Rock Valley area of the Mojave Desert. (Auth)

313 WALLACE, A., E. F. FROLICH and G. V. ALEXANDER. 1973. Effect of steam sterilization of soil on two desert plant species. Plant and Soil 39:453-456.

Franseria dumosa Gray and *Hilaria rigida* (Thurb.) Benth. ex Scribn. seedlings were grown in a glasshouse in potted soil which was collected from the Mojave Desert near Mercury, Nevada. The soil represented areas under living shrubs and also areas between shrubs. Soil was either steam sterilized or not steam sterilized. The sterilization resulted in greatly decreased yields of plants possibly because of induced P deficiency. It was suggested that symbiotic mycorrhizae necessary for P absorption for the species involved might have been eliminated by the sterilization. The effect did not hold for a noncalcareous soil well supplied with available P. Soil sterilization increased both Mn and Zn in plants. There was an interaction in that plants did not grow well in soil from under shrubs regardless of steaming indicating possible allelopathic effects. (Auth)

314 WALLACE, A., R. T. MUELLER and E. M. ROMNEY. 1973. Sodium relations in desert plants: 2. Distribution of cations in plant parts of three different species of *Atriplex*. Soil Science 115:390-394.

A. hymenelytra cuttings were grown in Yolo loam soil for 35 days after addition of 3 levels of NaCl (0, 1, 5 g NaCl each applied 3 separate times to 3-kg lots of soil). Plants were not injured by any of the salt treatment. Highest concentrations of Na were in shoots with a steep gradient from top leaves to roots. Cl and K behaved similarly. At the highest salt level, top leaves contained nearly 10% on the dry weight basis of each of Na, Cl and K. Yields of *A. hymenelytra* grown in solution culture responded some to Na and root to leaf gradients for Na and K were similar to the plants grown in soil. Growth of *A. confertifolia* in the presence of a relatively high level of K in solution culture appeared to respond to Na when other nutrients were not limiting. A sharp gradient of Na content existed with leaves higher than stems and stems higher than roots. Yields were also increased by Na for *A. canescens* but Na and K contents were much lower than for *A. confertifolia* and the leaf-stem-root gradient for Na was poorly pronounced. *A. canescens* seemed to be resistant to absorption of large quantities of Na even though it tolerates high levels of it. (NFG)

315 WALLACE, A., W. A. RHOADS and E. F. FROLICH. 1968. Germination behavior of *Salsola* as influenced by temperature, moisture, depth of planting, and gamma irradiation. Agronomy J. 60:76-78.

Salsola kali, a troublesome weed, invaded the areas used for aboveground thermonuclear testing at the Nevada Test Site and persisted for a few years thereafter before disappearing from those specific sites. Its germination behavior was studied to clarify its peculiar ecological behavior. Germination and growth of Co-60 γ-irradiated seed were examined. Germination was slightly impaired by exposures of seed to doses up to 500,000 R. At 1,000,000 R no seed germinated. Seedlings slowly died when irradiated at ≈100,000 R. Cell division of germinating seeds was impaired at levels of irradiation much above 50,000 R, and elongation of root and shoot was almost equal above 100,000 R to about 400,000 R. Evidently no new cell division occurs at irradiation levels above about 100,000 R. Apparent seedling growth from such plants would then be from cell elongation only. The embryo, therefore, probably contains the complete seedling with cells all divided and differentiated. Seedlings emerged when the seeds had been covered with 7.5 cm of soil, but not at a depth of 13 cm. The amount of elongation of the seedlings which did not emerge approximated that of seedlings irradiated with Co-60 at levels high enough to stop all new cell division. (BBB)

316 WALLACE, A., E. M. ROMNEY and R. T. ASHCROFT. 1970. Soil temperature effects on growth of seedlings of some shrub species which grow in the transitional area between the Mojave and Great Basin Deserts. BioScience 20:1158-1159.

Thirteen species of shrubs from the Nevada Test Site were subjected to different soil temperatures to investigate the influence of this parameter on growth (as indicated by weights of roots and shoots). Data indicated that soil temperatures are probably an important regulating factor in the growth of different desert shrubs, but the effects are species-specific. The authors postulate that soil temperature is, under many conditions, a primary factor regulating distribution of desert shrubs in western North America. They further speculated that their results are related to photosynthetic pathways: hot desert shrubs being at least partly associated with the C_4-dicarboxylic pathway; cold desert shrubs with the Calvin cycle. (TPO)

317 WALLACE, A., E. M. ROMNEY and V. Q. HALE. 1973. Sodium relations in desert plants: 1. Cation contents of some plant species from the Mojave and Great Basin Deserts. Soil Science 115:284-287.

Leaves of 23 plant species native to the Mojave or Great Basin Deserts (USA) were analyzed for mineral cations by an emission spectrographic technique. Some of these species tend to accumulate Na in leaves, particularly species that grow in areas where

salts have accumulated. Distribution in the field of 3 *Lycium* species may be related to salinity. Na contents of the *Lycium* species were inversely related to those of Ca. *Grayia spinosa* is an accumulator of large amounts of K in areas where other species accumulate Na. Several members of the Chenopodiaceae accumulated Na in leaves. Plant species and soils both seemed to determine the cation contents of plants. *Larrea divaricata* failed to grow where C horizons were highly saline and where A horizons contained over 10 me/100 g exchangeable K. (EMD)

318 WALLACE, A., E. M. ROMNEY and R. T. MUELLER. 1969. Effect of the phosphorus level on the micronutrient content of *Franseria dumosa*. Phyton 26:151-154.

Franseria dumosa plants were grown in solution culture at 4 phosphorus levels and growth and mineral composition were measured. A low level of phosphorus seemed sufficient for maximum yield but phosphorus content at this level was similar to that of other species. A lower level of phosphorus resulted in apparent deficiency without reduced phosphorus content. Micronutrient levels in leaves, notably those of zinc, copper, iron, and manganese, were, however, increased for this treatment. The tendency for high phosphorus levels to induce zinc deficiency can, therefore, perhaps be generalized to include the concept that low phosphorus levels may induce zinc toxicity.

319 WALLACE, A., E. M. ROMNEY and R. A. WOOD. 1973. Cycling of stable cesium in a desert ecosystem. In: (Nelson, D. J., ed.) *Radionuclides in Ecosystems*, Proc. Third National Symp. on Radioecology (CONF-710501), p. 183-186. (NTIS, Springfield, VA 22151)

Contents of stable cesium and potassium in several compartments of desert ecosystems represented at the Nevada Test Site have been determined by neutron activation, and Cs:K discrimination under natural conditions was evaluated. Stable cesium was circulating but at a low rate. Ratios appeared to narrow going from plants to reptiles and mammals. Stable cesium was freely circulated in desert ecosystems, but at levels lower than that of K by at least 6 orders of magnitude. Stable cesium will influence the cycling of Cs-137. (TPO)

320 WALLACE, A., E. M. ROMNEY, J. W. CHA and G. V. ALEXANDER. 1974. Sodium relations in desert plants: 3. Cation-anion relationships in three species which accumulate high levels of cations in leaves. Soil Science 118:397-401.

Three desert perennial plant species (*Lycium andersonii* Gray, *Atriplex confertifolia* (Torr. & Frem.) Wats., and *Atriplex hymenelytra* (Torr.) Wats.) were grown in soil in a glasshouse with different sources of Na (NO_3, Cl^-, $H_2PO_4^-$) to evaluate their effects upon cation-anion balance in the plants. Each anion

greatly increased leaf content of itself with only minor if any interactions with other anions. The milliequivalent sum of anions measured (N, P, Cl), therefore, increased in each plant part with the soil applications. Simultaneously there were usually modest increases in the milliequivalent sum of cations. The cation-anion ratio was decreased markedly when $NaNo_3$ was added. The ratio was usually over one which means that considerable bicarbonate absorption and organic acid synthesis must occur in all three species. Maximum content of Cl and N in leaves was with *L. andersonii*, 13.51, and 6.37 percent, respectively, when each was added. There were some compensations among other cations as Na was increased so that a somewhat constant sum of cations was maintained although there were significant differences. *L andersonii* appeared to be an accumulator of Li and *A. hymenelytra* of Cd.

321 WALLACE, A., V. Q. HALE, G. E. KLEINKOPF and R. C. HUFFAKER. 1971. Carboxydismutase and phosphoenolpyruvate carboxylase activities from leaves of some plant species from the northern Mojave and southern Great Basin Deserts. Ecology 52:1093-1095.

Of 14 xerophytic plant species studied, only two (members of the Chenopodiaceae) exhibited high phosphoenolpyruvate (PEP) carboxylase and low carboxydismutase activities. Three other members of the Chenopodiaceae exhibited carboxylase activities characteristic of both the C_4-dicarboxylic acid pathway and the Calvin cycle in the same species. Activities range from high PEP carboxylase and moderately high carboxydismutase to, conversely, high carboxydismutase and moderately high PEP carboxylase activity, including moderately high levels of nearly equal activities of each enzyme. Hence, gradations between extremes of the two photosynthetic systems can occur in the same species. Members of three other families (Ephedraceae, Zygophyllaceae, and Liliaceae) had carboxylase activities characteristic of both photosynthetic systems in the same species. The enzymatic activity of plants which continue to grow during hot summers was characteristic of either the C_4-dicarboxylic acid pathway or of both photosynthetic pathways.

322 WALLACE, A., E.M. ROMNEY and Collaborators. 1972. *Radioecology and Ecophysiology of Desert Plants at the Nevada Test Site.* USAEC Report TID-25954, 439 p. (TIC, Oak Ridge, TN 37830)

The present work has been assembled as a base of future studies regarding radiation effects and radionuclide and mineral cycling problems which are of interest to the Atomic Energy Commission and manipulation experiments such as those of interest to the International Biological Program. This volume also serves as a partial review of literature of topics of importance in meeting the needs of the programs listed. (BBM)

323 WASBAUER, M. S. 1973. The male brachycistidine wasps of the Nevada Test Site (Hymenoptera: Tiphiidae). Great Basin Nat. 33:109-112.

Wasps of genera *Acanthetropis*, *Brachycistis*, *Brachycistina*, *Colocistis* and *Quemaya* were identified from 111 specimens collected from the Nevada Test Site, USA. (JJB)

324 WELLS, P. V., and C. D. JORGENSEN. 1964. Pleistocene wood rat middens and climatic change in Mohave Desert: a record of juniper woodlands. Science 143:1171-1174.

Leafy twigs and seeds of juniper are abundant in nine ancient *Neotoma* middens discovered in low, arid, desert ranges devoid of junipers, near Frenchman Flat, Nevada. Existing vegetation is creosote bush and other desert shrubs. Twelve radiocarbon dates suggest that the middens were deposited between 7800 to more than 40,000 years ago. Dominance of Utah juniper and absence of pinyon pine in most deposits indicates a local Pleistocene woodland climate more arid than the usual pinyon-juniper climate. (Auth)

325 WELLS, P. V., and L. M. SHIELDS. 1964. Distribution of *Larrea divaricata* in relation to a temperature inversion at Yucca Flat, southern Nevada. Southwestern Nat. 9:51-55.

Larrea divaricata Cav. is at a northern limit of its range in Yucca Flat, and occurs here in local aggregations chiefly on the middle slopes of the basin. Measurement of temperature along a gradient of elevation during a 7-month period from December to July recorded the repeated presence of a nocturnal temperature inversion due to cold air drainage into the basin. *Larrea* is essentially lacking in the cold-air "lake," but also fails to occupy completely some sectors of the gradient where the temperature regime appears to be favorable. (Auth)

326 WHITE, L. D. 1962. Concrete molds of rodent burrows. J. Mammalogy 43:265.

A grout mixture was used to help define the underground burrow systems of kangaroo rats, *Dipodomys merriami* and *D. microps*, on the Nevada Test Site. Mix ratios were determined empirically: in dry, loosely packed soils more water was needed to allow for loss to the soil. Grout hardened sufficiently in about one week and burrows could be excavated without losing the pattern of the burrow due to crumbling earth. (TPO)

327 WHITE, L. D., and D. M. ALLRED. 1961. Range of kangaroo rats in areas affected by atomic detonations. Proc. Utah Acad. Sciences, Arts and Letters 38:101-110.

Studies of the range of movement for kangaroo rats were conducted

in plant communities both disturbed and undisturbed by the nuclear tests conducted at the Nevada Test Site. Seven hundred and ninety rats were captured, marked, and recaptured. Findings indicated that animals living in areas disturbed by atomic detonations ranged almost three times as far as animals living in the undisturbed areas. Most of the animals of each of the two species studied ranged between 75 ft and 300 ft. The greatest distance recorded for *Dipodomys merriami* was 10,296 ft, and for *D. microps*, 5,280 ft. Ranges for *D. merriami* varied from 0.90 acres to 6.53 acres, and those of *D. microps* from 0.69 acres to 7.80 acres. (BBM)

328 WHITE, M. G., and P. B. DUNAWAY (eds.). 1975. *The Radioecology of Plutonium and Other Transuranics in Desert Environments*, Nevada Applied Ecology Group Progress Report as of January 1975. NVO-153, 504 p. (ERDA, Las Vegas, NV 89114)

This document provides a status report of the Nevada Applied Ecology Group (NAEG) whose mission is to determine the distribution and amounts of transuranics in the environment of the Nevada Test Site. Summaries of 21 studies are provided in 10 chapters that include: Distribution and Inventory; Resuspension; Soils; Microorganisms; Vegetation; Small Vertebrates; Large Vertebrates; Statistics; Decontamination Procedures; and Support Activities. Significant progress has been made in describing the distribution of plutonium and other radionuclides for NTS safety-shot areas, but results of inventory efforts for the entire NTS have been modest. Concentrations within components of the desert ecosystem are described and should provide useful quantification for modeling efforts that are also progressing well. A satisfactory evaluation of the radiological hazards of plutonium on NTS has not been formulated, which necessarily limited efforts to identify areas for possible cleanup. Existing decontamination techniques are being evaluated for possible application on NTS. Future efforts will be directed towards initiating experimental cleanup and treatment trials, studies of nuclear event sites containing plutonium, and completion of the inventory and distribution measurements for all contaminated areas on the NTS. (TPO)

329 WIELAND, P. A. T., E. F. FROLICH and A. WALLACE. 1971. Vegetative propagation of woody shrub species from the northern Mojave and southern Great Basin Deserts. Madroño 21:149-152.

Stem cuttings of 16 desert (USA) perennial shrub species were successfully rooted although juvenile material was needed in many cases. At least one of these (*Larrea divaricata* (Cav.)) is a species for which earlier attempts to root had been unsuccessful. Conditions for successful rooting varied with species. *L. divaricata*, *Atriplex hymenelytra* (Torr.) Wats., *Atriplex confertifolia* (Torr. and Frem.) Wats., and *Coleogyne ramosissima* Torr. rooted more readily in soil than in vermiculite. IBA was

not needed for *Atriplex* species (all *Atriplex* rooted) nor for *Kochia americana* Wats. *L. divaricata, Lycium andersonii* Gray, *Lycium pallidum* Miers, *Lycium shockleyi* Gray, *Franseria dumosa* Gray, *Artemisia tridentata* Nutt. and *Grayia spinosa* (Hook) Moq. required mist or responded satisfactorily to mist rooting while other species disintegrated rapidly under the same circumstances. Other species rooted equally or better under dry conditions or even in a lathhouse where temperatures were lower. These include *G. spinosa, Eurotia lanata* (Pursh) Moq., *Ephedra viridis* Cov., and *Thamnosma montana* Torr. and Frem. *Ephedra viridis* responded to bottom heat. The species studied for which stem cuttings have failed to root include *Krameria parvifolia* Benth. and *Juniperus osteosperma* (Torr.) Little. (HR)

330 WILSON, R. H., R. G. THOMAS and J. N. STANNARD. 1961. Biomedical and aerosol studies associated with a field release of plutonium. WT-1511, 70 p. (TIC, Oak Ridge, TN 37830)

On April 24, 1957, a high-explosive detonation was employed at the Nevada Test Site to release plutonium for field study of this fissionable material as a contaminant. One of four major measurements programs was a biomedical experiment which comprised exposure of animals to first deposition of plutonium oxide from the detonation cloud (acute subjects) and to the wind-induced resuspension of contamination (chronic subjects) as long as six months after original deposition. Acute subjects (26 dogs and 40 rats) were arrayed 500, 1000, and 2000 feet downwind from ground zero, and nine rats were flown on balloon cables positioned to intercept the cloud 500 feet from ground zero. Chronic subjects (three groups of 24 dogs and 3 burros) were placed, after a rough ground-activity survey, at climatologically probable downwind segments of isopleths marking nominal contaminations of 1000, 100 and 10 μgm of plutonium per square meter. Serial sacrifices of dogs were made at 4, 5, 16, 32, 64, 128, and 161 days after detonation. Ten tissues per animal were assayed by radiochemistry and autoradiography for plutonium content. All burros received the full 161-day exposure. Ten sheep were distributed among the three field positions on the 32nd day, at which time four additional dogs were placed at the middle position (100-line). All late animals stayed until the end of the maximum exposure period. Air samplers at each chronic field position documented daily mean air concentrations. The pattern of plutonium uptake was surprising in that statistically important numbers of acute and chronic animals showed signigicant bone burdens in an exposure situation for which lung alone was to have been the critical organ. This outcome was most unusual for acute animals sacrificed less than four hours post-detonation. In general, however, all uptakes were less than the forecast amounts. The factor of 100 difference between ground-level contamination at near and far chronic stations brought uptake differences of less than a factor of ten to indicate that airborne material accumulates along the upwind path. Air

centrations bear small if any relation to the "at foot" contamination for natural resuspension forces (wind). An explanation is advanced for the fact that, in an experiment designed to find time dependence in plutonium uptake, no tissues measured exhibited a correlation with exposure time, save GI tract and contents. The plutonium found in bone suggests some deviation from the pure oxide form (extremely insoluble in body fluids) and the presence of solubilizing influences either in early particulate formation or in animal lung. As yet no believable mechanism has been proposed. All autoradiography gave negative results. (Auth)

331 WORMAN, F.C. 1965. Anatomy of the Nevada Test Site. Los Alamos Scientific Laboratory Pamphlet, 32 p. (Los Alamos Scientific Laboratory, Los Alamos, NM 87544)

The human history and salvage archeology as well as geology and climatology of the Nevada Test Site are reviewed. The biology section separates the flora into perennials and annuals and elevations at which they grow. Animals of the Nevada Test Site included are centipedes, arachnids, scorpions, reptiles, birds and mammals. (HP)

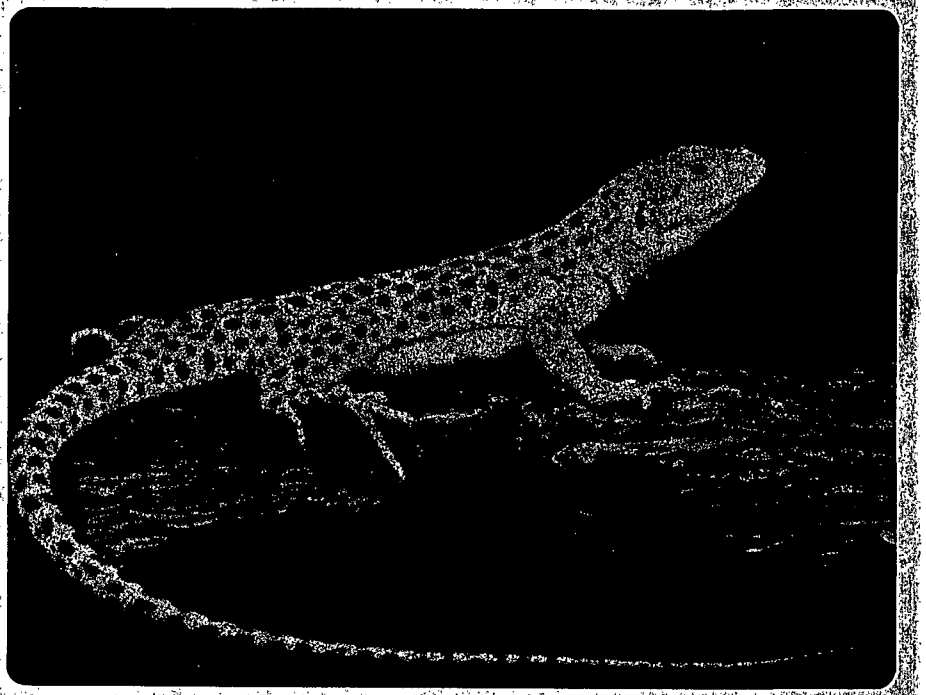
332 WORMAN, F. C. V. 1969. Archeological investigations at the U. S. Atomic Energy Commission's Nevada Test Site and Nuclear Rocket Development Station. LA-4125, 201 p. (NTIS, Springfield, VA 22151)

The archeology of southeastern Nye County, Nevada, which contains both the Nevada Test Site and the Nuclear Rocket Development Station was investigated. The biology, geology, and history of the NTS are discussed briefly. Then each of 17 archeological sites is described as to location, formation, and contents of archeological interest. These descriptions are illustrated with numerous photographs of the sites and the artifacts found therein. (LCL)

333 YOUNG, R. A. 1972. Water supply for the Nuclear Rocket Development Station, at the U. S. Atomic Energy Commission's Nevada Test Site. USGS Water-Supply Paper No. 1938, 19 p. (U. S. Geological Survey, Denver, CO 80225)

The Nuclear Rocket Development Station, in Jackass Flats, occupies about 123 square miles in the southwestern part of the U. S. Atomic Energy Commission's Nevada Test Site. Jackass Flats, an intermontane valley bordered by highlands on all sides except for a drainage outlet in the southwestern corner, has an average annual rainfall of 4 inches. Jackass Flats is underlain by alluvium, colluvium, and volcanic rocks of Cenozoic age and, at greater depth, by sedimentary rocks of Paleozoic age. The alluvium and the colluvium lie above the saturated zone throughout nearly

all of Jackass Flats. The Paleozoic sedimentary rocks contain limestone and dolomite units that are excellent water producers elsewhere; however, these units are too deep in Jackass Flats to be economic sources of water. The only important water-producing unit known in the vicinity of the Nuclear Rocket Development Station is a welded-tuff aquifer, the Tonopah Spring Member of the Paintbrush Tuff, which receives no significant recharge. This member contains about 500 feet of highly fractured rock underlying an area 11 miles long and 3 miles wide in western Jackass Flats. Permeability of the aquifer is derived mostly from joints and fractures; however, some permeability may be derived from gas bubbles in the upper part of the unit. Transmissivity, obtained from pumping tests, ranges from 68,000 to 488,000 gallons per day per foot. Volume of the saturated part of the aquifer is about 3.5 cubic miles, and the average specific yield probably ranges from 1 to 5 percent. The volume of groundwater in storage is probably within the range of 37-187 billion gallons. This large amount of water should be sufficient to supply the needs of the Nuclear Rocket Development Station for many years. Water at the Nuclear Rocket Development Station is used for public supply, construction, test-cell coolant, exhaust cooling, and thermal shielding during nuclear reactor and engine testing, and washdown. Present (1967) average consumption of water is 520,000 gallons per day -- all supplied by one well. This supply well and a standby well have a production capability of 1.6 million gallons per day -- adequate for present needs. Water in the welded-tuff aquifer is of the sodium bicarbonate type. Dissolved-solids content of the water in Jackass Flats is in the general range 230 milligrams per liter in the western part to 890 milligrams per liter in the eastern part. Personal communication from the author dated March 16, 1973, relates the following: As the report was written in 1968, the data is not quite up-to-date. Well J-12 was deepened in August 1968 to 1,000 ft and will now produce 1,000 gallons per minute with less than 20 ft of drawdown. Further, when the pump was pulled in 1968, it was found that the water level was the same as in 1952 when the well was drilled; therefore, there is no decrease in storage as indicated in the report. Because the wells have been on standby since the National Rocket Development Station has been deactivated, a maximum amount of storage should be anticipated at this time. (Auth)



Appendix 1.
National Science Foundation research efforts

APPENDIX 1
NATIONAL SCIENCE FOUNDATION
U. S. INTERNATIONAL BIOLOGICAL PROGRAM
DESERT BIOME
RESEARCH MEMORANDA

Between 1967 and 1974 the United States and 57 other nations of the world participated in an International Biological Program. The major goal of the IBP was to examine productivity of natural ecosystems throughout the world, and to determine their responses to man's increased activities related to providing more food and fibre for a growing world population. Specific scientific objectives included: formulation of a basis for understanding the interactions of components of representative biological systems; use of knowledge about biological systems to increase biological productivity; formulation of predictive models of the consequences of environmental stresses, both natural and man-made; development of new resource management protocols; and advancement of basic knowledge concerning man's genetic, physiological, and behaviorial adaptations.

The National Science Foundation administered the U. S. programs, and funded most of the research. However, the U. S. Energy Research and Development Administration made substantial contributions by funding IBP-oriented studies through their laboratories and contractors, and by direct transfers of funds to NSF in support of the national effort. On the Nevada Test Site ERDA and NSF jointly sponsored projects to fulfill the goals of the Desert Biome program within the IBP.

These research projects have been documented in preliminary stages as IBP-Desert Biome Research Memoranda. The following is a list of those memoranda concerning studies conducted on NTS. Copies may be obtained by writing to The Desert Biome, Utah State University, Logan, Utah 84322.

BAMBERG, S. A., and A. WALLACE. 1972. Gaseous exchange in Mohave Desert shrubs. RM 72-21, 8 p.

BAMBERG, S. A., A. WALLACE, G. E. KLEINKOPF and A. VOLLMER. 1973. Plant productivity and nutrient interrelationships of perennials in the Mohave Desert. RM 73-10, 52 p.

BAMBERG, S. A., A. WALLACE, G. E. KLEINKOPF and A. VOLLMER. 1974. Plant productivity and nutrient interrelationships of perennials in the Mohave Desert. RM 74-8, 16 p.

CHEW, R. M., and F. B. TURNER. 1974. Effect of density on the population dynamics of *Perognathus formosus* and its relationships within a desert ecosystem. RM 74-20, 9 p.

CHEW, R. M., F. B. TURNER, P. AUGUST, B. MAZA and J. NELSON. 1973. Effect of density on the population dynamics of *Perognathus formosus* and its relationships within a desert ecosystem. RM 73-18, 32 p.

DINGMAN, R. E., and J. BANDOLI. 1973. Density and dietary habits of pocket gophers *(Thomomys bottae centralis)* in Rock Valley. RM 73-21, 12 p.

DINGMAN, R. E., and L. BYERS. 1974. Interaction between a fossorial rodent (the pocket gopher, *Thomomys bottae*) and a desert plant community. RM 74-22, 6 p.

EDNEY, E. B., J. F. McBRAYER, P. J. FRANCO and A. W. PHILLIPS. 1974. Distribution of soil arthropods in Rock Valley, Nevada. RM 74-32, 5 p.

FRECKMAN, D. W., S. A. SHER and R. MANKAU. 1974. Biology of nematodes in desert ecosystems. RM 74-35, 10 p.

ROMNEY, E. M., A. WALLACE, J. D. CHILDRESS, J. E. KINNEAR, H. KAAZ, P. A. T. WIELAND, M. LEE and T. L. ACKERMAN. 1974. Responses and interactions in desert plants as influenced by irrigation and nitrogen applications. RM 74-17, 12 p.

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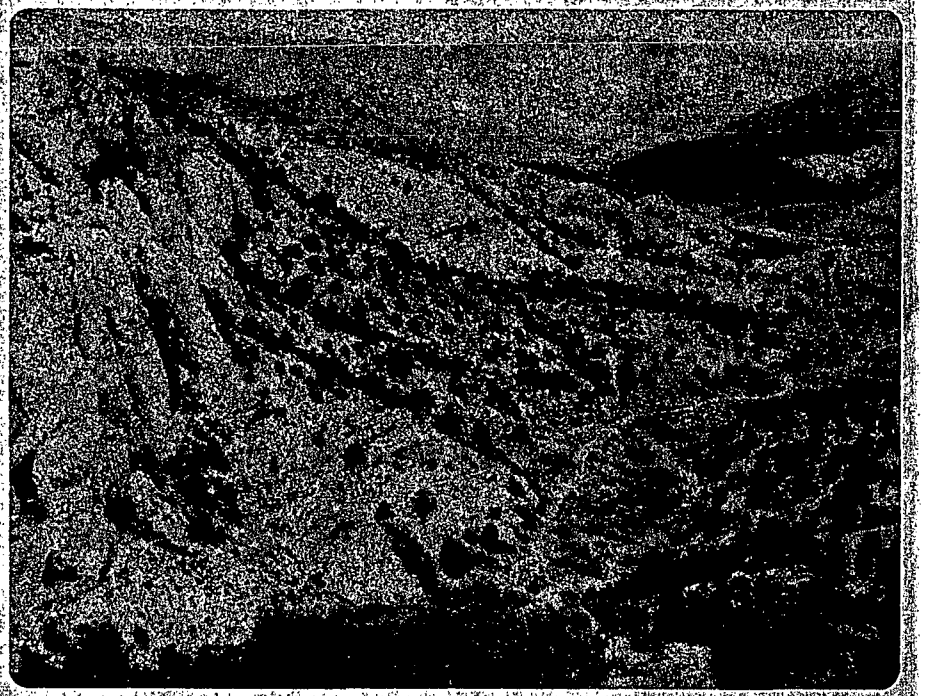

Appendix 2.
Fate and effects of radiation in the environment

APPENDIX 2

BIBLIOGRAPHIC CITATIONS CONCERNING THE FATE AND EFFECTS OF NUCLEAR AND NON-NUCLEAR DISTURBANCES ON THE NEVADA TEST SITE

The following citations include information on the distribution, uptake and biological transfer of radionuclides in components of the ecosystem:

SOIL	*VEGETATION*	*ANIMALS*		*MULTIPLE COMPONENTS*	
68	75	91	266-268	70	171
92	175	95	289	86	178
96	179	101	291	105	180
131	181	106	295	148	183-186
152	188	123	300	151	196
153	195	173	302	154	208
155	206	203	310	158	212
157	241	264	330	160	213
172	243-247			161	238-240
	249-252			162	248
				166-169	297
					322
					328

The following citations include information on the effects of environmental stresses associated with nuclear activities on NTS including:

NUCLEAR DETONATIONS				*RADIATION*				
				CHRONIC GAMMA		*GAMMA*	*BETA*	*PLUTONIUM*
5	42	176	263	98	191	69	224	210
10	45	182	285	100	193	102		328
14	62	205	286	103	292	121		
16	63	223	288	104	296	262		*NUCLEAR VENTING*
26	87	225-229	294	108	298	315		
27	116	234	327	109	303			215
31	124	237		111	305			
35	138	242		145	307			
38	143	258-261						

These citations contain information on the effects of non-nuclear disturbances such as:

DUST	*GROUND MOTION*	*MECHANICAL DISTURBANCES*
38	265	287
182		

Appendix 3.
References used to obtain information

APPENDIX 3

REFERENCES FOR BIBLIOGRAPHIC SURVEY

Appendix 3 includes lists of the information sources used to develop the Annotated Bibliography and Narrative Summary of this document. The material is presented so that authors of future supplements or related material will know the limits of our searches.

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1. Nevada
2. Nevada Proving Grounds
3. Nevada Test Site
4. Great Basin
5. Environmental Studies
6. Mohave Desert
7. Terrestrial Ecology
8. Names of past and present authors publishing on NTS ecological research

AGENCIES AND INSTITUTIONS

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- Los Alamos Scientific Laboratory, Los Alamos, NM

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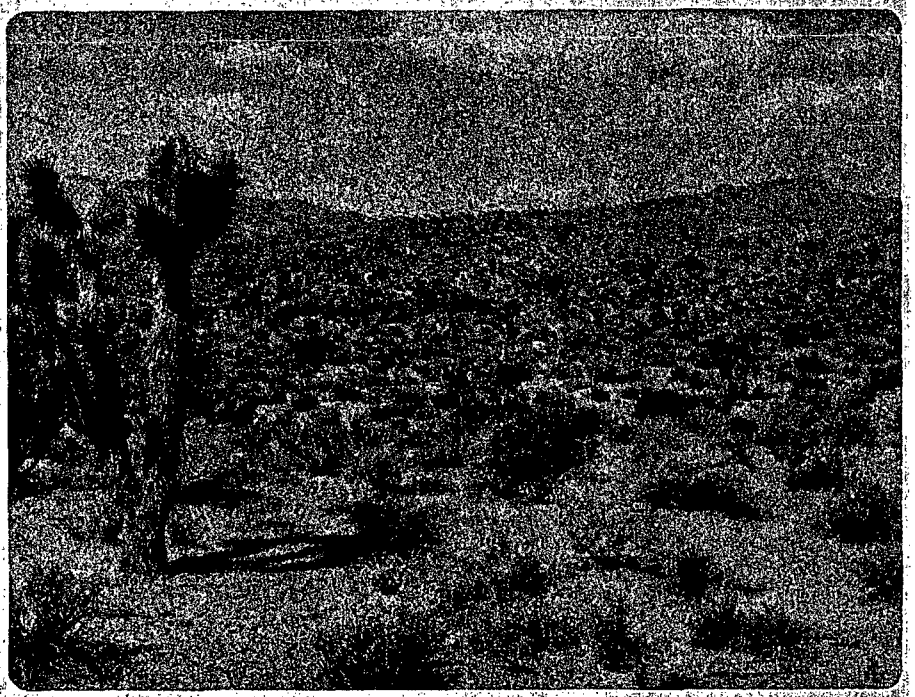

Appendix 4. Flora of the Nevada Test Site

APPENDIX 4

SPECIES LIST OF FLORA COLLECTED ON THE NEVADA TEST SITE

This appendix was compiled from citations 55, 87 and 258. The species are arranged in alphabetical rather than taxonomic order to help the lay reader locate names more readily. Names of taxonomic authorities were deleted, but they can be found in the original source material cited above. Common names were not included because many species from NTS do not have any, and because several common names are not unique, which might confuse readers unfamiliar with regional colloquial names.

Voucher specimens of the vascular plants have been deposited in a number of herbaria including those at the University of Cincinnati, Stanford University, New York Botanical Garden, and the University of Nevada, Reno.[55]

FLORA OF THE NEVADA TEST SITE

ALGAE

Chlorophyta
- *Bulbochaete* sp.
- *Chara* sp.
- *Franceia droescheri*
- *Oedogonium* sp.
- *Oocystis crassa*
- *Pandorina morum*
- *Protococcus grevillei*
- *Protosiphon cinnamomeus*
- *Scenedesmus bijuga*
- *Stigeoclonium* sp.

Chrysophyta
- Numerous species of diatoms on playas, rainpools, and ponds

Cyanophyta
- *Amphithrix janthina*
- *Anacystis montana*
- *Coccochloris elabens*
- *C. stagnina*
- *Microcoleus paludosus*
- *M. vaginatus*
- *Nodularia sphaerocarpa*
- *Nostoc commune*
- *N. entophytum*
- *N. humifusum*
- *N.* sp.
- *Oscillatoria brevis*
- *Phormidium autumnale*
- *P. tenue*
- *Plectonema boryanum*
- *P. nostocorum*
- *Schizothrix acutissima*
- *S. californica*
- *S. macbridei*
- *Scytonema hofmannii*
- *Symploca kieneri*

FUNGI

- *Alternaria tenuis*
- *Aspergillus flavipes*
- *A. fumigatus*
- *A. niveum*
- *A. ochraceus*
- *A. restrictus*
- *A. sulfureus*
- *A. ustus*
- *A. versicolor*
- *A. wentii*
- *Botrytis bassiana*
- *Cephalosporium* sp.
- *Chaetomium aureum*
- *C. spirale*
- *Choanephora* sp.
- *Circinella muscae*
- *Cladosporium herbarum*
- *Coccosporium* sp.
- *Cunninghamella bainieri*
- *C. microspora*
- *Fusarium roseum*
- *Gliocladium penicilloides*
- *G. roseum*
- *Mucor corticolus*
- *M. spinescens*
- *M. varians*
- *Myrothecium verrucaria*
- *Penicillium granulatum*
- *P. oxalicum*
- *P. urtica*
- *Phoma* sp.
- *Pullularia pullulans*
- *Pythium mammillatum*
- *Rhizopus nigricans*
- *Stachybotrys atra*
- *Stemphylium ilicis*
- *Streptomyces* sp.
- *Stysanus medicus*
- *Syncephalastrum racemosum*
- *Tetracoccosporium paxianum*
- *Trichoderma viride*

VASCULAR FLORA

PTEROPHYTA (FERNS)

Pteridaceae - Fern Family
- *Cheilanthes covillei*
- *C. jonesii*
- *C. parryi*
- *Pellaea longimucronata*
- *Pityrogramma triangularis* var. *maxoni*

CONIFEROPHYTA (CONE-BEARING PLANTS)

Cupressaceae - Cypress Family
- *Juniperus osteosperma*

Ephedraceae - Ephedra Family
- *Ephedra funerea*
- *E. nevadensis*
- *E. torreyana*
- *E. viridis*

Pinaceae - Pine Family
- *Pinus monophylla*

ANTHOPHYTA (FLOWERING PLANTS)

Monocotyledoneae

Agavaceae - Agave Family
- *Agave utahensis* var. *eborispina*
- *Yucca baccata* var. *vespertina*
- *Y. brevifolia*
- *Y. schidigera*

Amaryllidaceae - Amaryllis Family
- *Allium nevadense*
- *A. scorodeprasum*
- *Androstephium breviflorum*
- *Brodiaea pulchella* var. *pauciflora*

Cyperaceae - Sedge Family
- *Carex alma*
- *C. douglasii*
- *C. occidentalis*
- *C. praegracilis*
- *Eleocharis macrostachya*
- *E. montevidensis* var. *parishii*
- *Scirpus acutus*

Cyperaceae - Sedge Family (Cont'd)
Scirpus robustus

Gramineae - Grass Family
Agropyron desertorum
A. smithii
Agrostis semiverticillata
Aristida adscensionis
A. fendleriana
A. glauca
A. longiseta
A. purpurea
A. wrightii
Avena sativa
Blepharidachne kingii
Bouteloua barbata
B. gracilis
B. trifida
Bromus anomalus
B. catharticus
B. japonicus
B. marginatus
B. ridigus (B. diandrus)
B. rubens
B. tectorum var. *tectorum*
B. tectorum var. *glabratus*
B. trinii
Chloris virgata
Cynodon dactylon
Deschampsia danthonioides
Digitaria sanguinalis
Distichlis spicata var. *stricta*
Echinochloa crusgalli
Elymus cinereus
E. macounii
E. triticoides
Eragrostis barrelieri
Festuca arundinacea
F. megalura
F. octoflora
F. reflexa
Hilaria jamesii
H. rigida
Hordeum glaucum (H. stebbinsii)
H. jubatum
H. vulgare
Koeleria cristata
Leptochloa univervia
Lolium multiflorum
L. perenne
Muhlenbergia porteri
M. richardsonis

Gramineae - Grass Family (Cont'd)
Munroa squarrosa
Oryzopsis hymenoides
X *Stipa pinetorum*
X *S. speciosa*
X *S. thurberiana*
O. micrantha
Poa annua
P. fendleriana
P. nevadensis
P. sandbergii
P. scabrella
Polypogon australis
P. monspeliensis
Schismus arabicus
Setaria lutescens (S. glauca)
Sitanion hystrix
S. hansenii
S. jubatum
Sorghum halepense
Sporobolus cryptandrus
S. flexuosus
Stipa arida
S. comata
S. coronata var. *depauperata*
S. pinetorum
S. speciosa
S. thurberiana
Tridens muticus
T. pilosus
T. pulchellus

Juncaceae - Rush Family
Juncus balticus

Liliaceae - Lily Family
Calochortus flexuosus
C. nuttallii var. *bruneaunis*
Fritillaria atropurpurea
Zigadenus paniculatus

Potamogetonaceae - Pondweed Family
Potamogeton pectinatus

Typhaceae - Cat-tail Family
Typha latifolia
T. domingensis

Zannichelliaceae - Horned Pondweed Family
Zannichellia palustris

Dicotyledoneae

Aizoaceae - Carpet-weed Family
Mollugo cerviana

Amaranthaceae - Amaranth Family
Amaranthus albus
A. fimbriatus
A. graecizans
Tidestromia oblongifolia

Anacardiaceae - Sumac Family
Rhus trilobata var. *anisophylla*

Apocynaceae - Dogbane Family
Amsonia tomentosa (incl. *A. brevifolia*)
Apocynum sibericum var. *salignum*

Asclepiadaceae - Milkweed Family
Asclepias erosa
Cynanchium utahense
Sarcostemma hirtellum

Boraginaceae - Borage Family
Amsinckia tessellata
Coldenia canescens
C. nuttallii
C. plicata
Cryptantha ambigua
C. angustifolia
C. barbigera
C. circumscissa
C. confertiflora
C. decipiens
C. dumetorum
C. echinella
C. flaveculata
C. gracilis
C. humilis var. *ovina*
C. maritima var. *pilosa*
C. micrantha
C. nevadensis
C. pterocarya
C. racemosa
C. recurvata
C. scoparia
C. utahensis
C. virginensis
C. watsonii
Lappula redowskii var. *desertorum*
Lithospermum ruderale
Pectocarya heterocarpa
P. platycarpa

Boraginaceae - Borage Family (Cont'd)
Pectocarya recurvata
P. setosa
Plagiobothrys arizonicus
P. jonesii
P. kingii

Cactaceae - Cactus Family
Coryphantha vivipara var. *deserti*
C. vivipara var. *rosea*
Echinocactus polycephalus
Echinocereus engelmannii var. *engelmannii*
E. engelmannii var. *armatus*
E. engelmannii var. *chrysocentrus*
E. triglochidiatus var. *melanacanthus*
Mammillaria tetrancistra
Opuntia basilaris
O. echinocarpa
O. erinacea var. *erinacea*
O. erinacea var. *ursina*
O. polyacantha var. *rufispina*
O. pulchella
O. ramosissima
Sclerocactus polyancistrus

Campanulaceae - Bellflower Family
Nemacladus glanduliferus var. *orientalis*
N. rubescens
N. sigmoideus

Capparidaceae - Caper Family
Cleome lutea

Caprifoliaceae - Honeysuckle Family
Symphoricarpos longiflorus
S. parishii

Caryophyllaceae - Pink Family
Arenaria congesta var. *subcongesta*
A. kingii var. *glabrescens*
A. macradenia var. *ferrisiae*
A. macradenia var. *parishiorum*
Scopulophila rixfordii
Silene verecunda subsp. *andersonii*

Celastraceae - Staff-tree Family
Forsellesia nevadensis
Mortonia utahensis

Chenopodiaceae - Goosefoot Family
Atriplex argentea
A. canescens
A. confertifolia

Chenopodiaceae - Goosefoot Family (Cont'd)

Atriplex hymenelytra
A. lentiformis
A. polycarpa
Bassia hyssopifolia
Ceratoides lanata (Eurotia lanata)
Chenopodium atrovirens
C. berlandieri var. *sinuatum*
C. berlandieri var. *zschackei*
C. dessicatum var. *leptophylloides*
C. fremontii
C. gigantospermum
C. incanum
C. leptophyllum
C. missouriense
C. strictum var. *glaucophyllum*
Grayia spinosa
Halogeton glomeratus
Kochia americana var. *vestita*
K. iranica (K. scoparia)
Monolepsis spathulata
Salsola iberica (S. pestifer) } *(S. kali)*
S. paulsenii }
Suaeda torreyana var. *torreyana*

Compositae - Sunflower Family

Acamptopappus schockleyi
Achillea lanulosa
Agoseris glauca var. *monticola*
Ambrosia acanthicarpa (Franseria acanthicarpa)
A. dumosa (Franseria dumosa)
A. eriocentra (Franseria eriocentra)
Amphipappus fremontii
Anisocoma acaulis
Antennaria dimorpha
A. rosea
Artemisia arbuscula subsp. *nova*
A. bigelovii
A. dracunculus
A. ludoviciana subsp. *mexicana*
A. spinescens
A. tridentata
Atrichoseris platyphylla
Baccharis emoryi
Baileya multiradiata
B. pleniradiata
Balsamorhiza hookeri var. *neglecta*
Bebbia juncea
Brickellia arguta
B. californica
B. desertorum
B. incana
B. longifolia

Compositae - Sunflower Family (Cont'd)

Brickellia microphylla var. *scabra*
B. oblongifolia var. *linifolia*
B. watsonii
Calycoseris parryi
C. wrightii
Chaenactis carphoclinia
C. douglasii
C. fremontii
C. macrantha
C. stevioides
C. xantiana
Chaetadelpha wheeleri
Chrysopsis villosa var. *hispida*
Chrysothamnus greenei subsp. *filifolius*
C. nauseosus subsp. *hololeucus*
C. nauseosus subsp. *leiospermus*
C. paniculatus
C. parryi subsp. *nevadensis*
C. teretifolius
C. viscidiflorus subsp. *viscidiflorus*
C. viscidiflorus subsp. *puberulus*
C. viscidiflorus subsp. *stenophyllus*
Cirsium neomexicanum
Conyza canadensis
C. coulteri
Crepis intermedia
C. occidentalis
Dyssodia cooperi
D. thurberi
Encelia frutescens
E. virginensis var. *virginensis*
Enceliopsis nudicaulis
Erigeron aphanactis
E. divergens
E. pumilus subsp. *concinnoides*
Eriophyllum pringlei
Geraea canescens
Glyptopleura marginata
Gnaphalium palustre
Grindelia squarrosa var. *serrulata*
Gutierrezia microcephala
G. sarothrae
Haplopappus brickellioides
H. cooperi
H. cuneatus
H. gooddingii
H. gracilis
H. linearifolius
H. nanus
H. watsonii
Hecastocleis shockleyi

Compositae - Sunflower Family (Cont'd)

Helianthus annuus subsp. *lenticularis*
H. petiolaris subsp. *petiolaris*
H. petiolaris subsp. *fallax*
Hulsea vestita subsp. *inyoensis*
Hymenoclea salsola
Hymenopappus filifolius var. *megacephalus*
Hymenoxys cooperi
Iva nevadensis
Lactuca serriola var. *serriola*
Laphamia megalocephala subsp. *megalocephala*
L. megalocephala subsp. *intricata*
Leucelene eriocoides
Lygodesmia exigua
L. grandiflora
L. spinosa
Machaeranthera canescens
M. tortifolia var. *tortifolia*
M. tortifolia var. *imberbis*
Malacothrix coulteri
M. glabrata
M. sonchoides
Microseris lindleyi
Monoptilon bellidiforme
M. bellioides
Pectis papposa
Petradoria discoidea
P. pumila
Peucephyllum schottii
Porophyllum gracile
Psathyrotes annua
Psilostrophe cooperi
Rafinesquia neomexicana
Senecio douglasii
S. integerrimus var. *exaltatus*
S. multilobatus (incl.*S. stygius* and *S. lynceus)*
S. spartioides
Sonchus asper
S. oleraceus
Stephanomeria exigua var. *pentachaeta*
S. parryi
S. pauciflora incl. var. *parishii)*
Stylocline micropoides
Syntrichopappus fremontii
Tetradymia axillaris
T. canescens
T. glabrata
Viguiera multiflora var. *nevadensis*
Xanthium strumarium var. *canadense*

Cruciferae - Mustard Family
Arabis dispar
A. glaucovalvula
A. holboellii var. *pinetorum*
A. inyoensis
A. pendulina
A. perennans
A. pulchra var. *gracilis*
A. pulchra var. *munciensis*
A. shockleyi
Brassica geniculata
Caulanthus cooperi
C. glaber
C. pilosus
Descurainia pinnata subsp. *glabra*
D. pinnata subsp. *halictorum*
D. sophia
Draba cuneifolia var. *cuneifolia*
D. cuneifolia var. *integrifolia*
Lepidium flavum
L. fremontii
L. lasiocarpum
L. perfoliatum
Lesquerella latifolia
L. ludoviciana
Malcolmia africana
Physaria chambersii
Sibara deserti
Sisymbrium altissimum
S. irio
Stanleyi elata
S. pinnata subsp. *pinnata*
Streptanthella longirostris
Streptanthus cordatus
Thelypodium lasiophyllum (Caulanthus lasiophyllus, includes var. *utahense)*
T. wrightii
Thysanocarpus curvipes
T. laciniatus var. *lacinatus*
T. laciniatus var. *hitchcockii*

Cucurbitaceae - Gourd Family
Citrullus vulgaris var. *citroides*

Cuscutaceae - Dodder Family
Cuscuta denticulata
C. nevadensis

Euphorbiaceae - Spurge Family
Euphorbia albomarginata
E. fendleri
E. maculata (Chamaesyce maculata)
E. micromera

Euphorbiaceae - Spurge Family (Cont'd)
Euphorbia serpyllifolia
E. setiloba
Stillingia spinulosa

Fagaceae - Beech Family
Quercus gambelii

Gentianaceae - Gentian Family
Frasera pahutensis

Gerianiaceae - Geranium Family
Erodium cicutarium

Hydrophyllaceae - Water-leaf Family
Eucrypta chrysanthemifolia
E. micrantha
Nama aretioides
N. demissum
N. densum
N. depressum
N. pusillum
Phacelia affinis var. *affinis*
P. beatleyae
P. bicolor
P. crenulata var. *crenulata*
P. crenulata var. *funerea*
P. curvipes
P. fremontii
P. mustelina
P. pedicillata
P. peirsoniana
P. rotundifolia
P. saxicola
P. tetramera (Miltitzia pusilla)
P. vallis-mortae
Tricardia watsonii

Krameriaceae - Krameria Family
Krameria parvifolia

Labiatae - Mint Family
Hedeoma nana subsp. *californica*
Marrubium vulgare
Salazaria mexicana
Salvia columbariae
S. dorrii subsp. *gilmanii*

Leguminosae - Legume Family
Astragalus acutirostris
A. beatleyae
A. calycosus
A. casei

Leguminosae - Legume Family (Cont'd)
Astragalus didymocarpus var. *dispermus*
A. funereus
A. layneae
A. lentiginosus var. *fremontii*
A. lentiginosus var. *micans*
A. minthorniae var. *villosus*
A. mohavensis
A. newberryi
A. nyensis
A. oophorus var. *oophorus*
A. purshii var. *tinctus*
A. tidestromii
Dalea fremontii var. *minutifolia*
D. mollissima
D. polyadenia
Lathyrus hitchcockianus
Lotus humistratus
Lupinus argenteus var. *stenophyllus*
L. argenteus var. *tenellus*
L. aridus
L. brevicaulis
L. concinnus var. *orcuttii*
L. flavoculatus
L. palmeri
L. shockleyi
L. uncialis
Medicago sativa
Melilotus indicus
M. officinalis
Petalostemum searlsiae
Peteria thompsonae
Trifolium andersonii subsp. *beatleyae*

Linaceae - Flax Family
Linum perenne subsp. *lewisii*

Loasaceae - Loasa Family
Eucnide urens
Mentzelia albicaulis
M. congesta
M. montana
M. nitens
M. obscura
M. oreophila
M. reflexa
M. veatchiana
M. sp.
Petalonyx nitidus

Loganiaceae - Logania Family
Buddleja utahensis

Loranthaceae - Mistletoe Family
Arceuthobium campylopodum f. *divaricatum*
Phoradendron juniperinum

Malvaceae - Mallow Family
Eremalche exilis
E. rotundifolia
Malva parviflora
Sphaeralcea ambigua subsp. *ambigua*
S. ambigua subsp. *monticola*
S. emoryi var. *arida*
S. emoryi var. *variabilis*
S. grossulariaefolia var. *pedata*
S. parvifolia

Nyctaginaceae - Four O'Clock Family
Abronia elliptica
A. turbinata
Allionia incarnata
Mirabilis bigelovii var. *bigelovii* (incl. var. *retrorsa)*
M. froebelii
M. pudica
Oxybaphus comatus
O. pumilus
Selinocarpus diffusus

Oleaceae - Olive Family
Forestiera neomexicana
Menodora spinescens

Onagraceae - Evening-Primrose Family
Camissonia boothii subsp. *condensata*
C. boothii subsp. *intermedia*
C. brevipes subsp. *brevipes*
C. brevipes subsp. *pallidula*
C. chamaenerioides
C. claviformis subsp. *integrior*
C. heterochroma
C. kernensis subsp. *gilmanii*
C. megalantha
C. munzii
C. parvula
C. pterosperma
C. pusilla
C. refracta
C. walkeri subsp. *tortilis*
Epilobium adenocaulon var. *parishii*
Gaura coccinea
Gayophytum decipiens
G. diffusum subsp. *parviflorum*
G. racemosum

Onagraceae - Evening-Primrose Family (Cont'd)
Gayophytum ramosissimum
Oenothera avita
O. caespitosa subsp. *marginata*
O. deltoides
O. pallida
O. primaveris subsp. *primaveris*
O. primaveris subsp. *bufonis*

Orobanchaceae - Broom-rape Family
Orobanche corymbosa
O. fasciculata
O. ludoviciana var. *cooperi*

Papaveraceae - Poppy Family
Arctomecon merriamii
Argemone corymbosa
A. munita
Eschscholzia covillei (E. minutiflora var. *darwinensis)*
E. glyptosperma
E. minutiflora

Plantaginaceae - Plantain Family
Plantago insularis var. *fastigiata*
P. purshii

Polemoniaceae - Phlox Family
Eriastrum eremicum
E. sparsiflorum
E. wilcoxii
Gilia aliquanta
G. brecciarum
G. campanulata
G. cana subsp. *speciformis*
G. cana subsp. *triceps*
G. clokeyi
G. filiformis
G. hutchinsifolia
G. latifolia
G. leptomeria
G. malior
G. modocensis
G. nyensis
G. ophthalmoides
G. ripleyi
G. scopulorum
G. sinuata
G. stellata
G. transmontana
Ipomopsis congesta
I. depressa
I. polycladon

Polemoniaceae - Phlox Family (Cont'd)
Langloisia punctata
L. schottii
L. setosissima
Leptodactylon pungens subsp. *hallii*
L. pungens subsp. *pulchriflorum*
Linanthus arenicola
L. bigelovii
L. demissus
L. dichotomus
L. jonesii
L. nuttallii
L. septentrionalis
Microsteris gracilis subsp. *humilis*
Navarretia breweri
Phlox lanata
P. stansburyi

Polygalaceae - Milkwort Family
Polygala subspinosa var. *subspinosa*
P. subspinosa var. *heterorhyncha*

Polygonaceae - Buckwheat Family
Chorizanthe brevicornu var. *brevicornu*
C. brevicornu var. *spathulata*
C. rigida
C. thurberi
C. watsonii
Eriogonum baileyi
E. brachyanthum
E. brachypodum
E. caespitosum
E. carneum
E. cernuum var. *cernuum*
E. cernuum var. *viminale*
E. concinnum
E. deflexum var. *deflexum*
E. deflexum var. *baratum*
E. esmeraldense
E. fasciculatum var. *poliofolium*
E. glandulosum
E. heermannii var. *heermannii*
E. heermannii var. *argense*
E. heermannii var. *sulcatum*
E. hookeri
E. inflatum
E. insigne
E. kearneyi
E. maculatum
E. microthecum var. *foliosum*
E. microthecum var. *lapidicola*

Polygonaceae - Buckwheat Family (Cont'd)
Eriogonum nidularium
E. nutans
E. ovalifolium var. *ovalifolium*
E. palmerianum
E. pusillum
E. racemosum
E. reniforme
E. saxatile
E. thomasii
E. trichopes
E. umbellatum var. *dichrocephalum*
E. umbellatum var. *subaridum*
E. umbellatum var. *vernum*
Oxytheca perfoliata
Polygonum argyrocoleon
P. aviculare
P. douglasii var. *johnstonii*
P. pensylvanicum
Rumex crispus
R. salicifolius

Portulacaceae - Purslane Family
Calyptridium parryi var. *nevadense*
Lewisia rediviva var. *minor*
Montia perfoliata
Portulaca oleracea

Ranunculaceae - Crowfoot Family
Anemone tuberosa
Aquilegia shockleyi
Delphinium andersonii
D. parishii
Ranunculus andersonii

Rhamnaceae - Buckthorn Family
Ceanothus greggii var. *vestitus*

Rosaceae - Rose Family
Amelanchier utahensis
Cercocarpus intricatus
C. ledifolius
Coleogyne ramosissima
Cowania mexicana var. *stansburiana*
Fallugia paradoxa
Holodiscus microphyllus
Ivesia sabulosa
Peraphyllum ramosissimum
Petrophytum caespitosum
Potentilla biennis
Prunus fasciculata
Purpusia saxosa

Rosaceae - Rose Family (Cont'd)
Purshia glandulosa
P. tridentata
Rosa woodsii

Rubiaceae - Madder Family
Galium aparine
G. bifolium
G. hilendae subsp. *hilendae*
G. hilendae subsp. *kingstonense*
G. stellatum subsp. *eremicum*

Rutaceae - Rue Family
Thamnosma montana

Salicaceae - Willow Family
Salix exigua
S. gooddingii

Saxifragaceae - Saxifrage Family
Fendlerella utahensis
Lithophragma tenellum
Ribes cereum
R. velutinum

Scrophulariaceae - Figwort Family
Antirrhinum filipes
A. kingii
Castilleja chromosa
C. linariaefolia
C. martinii var. *clokeyi*
Collinsia parviflora
Keckiella rothrockii
Mimulus bigelovii
M. densus
M. guttatus
M. montioides
M. pilosus
M. spissus
M. suksdorfii
M. sp.
Mohavea breviflora
Penstemon angustifolius subsp. *venosus*
P. bridgesii
P. floridus subsp. *austinii*
P. fruticiformis subsp. *amargosae*
P. humilis
P. pahutensis
P. palmeri
P. petiolatus
Scrophularia desertorum

Scrophulariaceae - Figwort Family (Cont'd)
Veronica americana
V. anagallis-aquatica
V. peregrina subsp. *xalapensis*

Solanaceae - Nightshade Family
Datura meteloides
Lycium andersonii
L. pallidum
L. shockleyi
Lycopersicon esculentum
Nicotiana attenuata
N. trigonophylla
Physalis crassifolia

Tamaricaceae - Tamarix Family
Tamarix ramosissima

Ulmaceae - Elm Family
Ulmus carpinifolia
U. parvifolia

Umbelliferae - Carrot Family
Berula erecta
Cymopterus aboriginum
C. gilmanii
C. globosus
C. purpurascens
C. ripleyi (incl. var. *saniculoides*)
Lomatium macdougallii
L. nevadense
L. parryi
L. scabrum

Verbenaceae - Vervain Family
Verbena bracteata

Zygophyllaceae - Caltrop Family
Kallstroemia californica
Larrea tridentata (L. divaricata)
Tribulus terrestris

Appendix 5: Fauna of the Nevada Test Site

APPENDIX 5

FAUNAL LIST FOR THE NEVADA TEST SITE

This list includes the names of all animal species presently known to occur on the Nevada Test Site. It was developed from the following sources:

INVERTEBRATES			*FISHES*	*REPTILES*	*BIRDS*	*MAMMALS*
1-4	62	126	Personal	24	24	24
6-9	72	133	Observations	277	124	140
11-13	73	135		280		
18-24	78-81	149				
28	83-85	201				
35	93	202				
36	113	211				
59	115	272-276				
60	117	323				

Species are arranged in alphabetical rather than taxonomic order to assist the lay reader in finding names.

Names of taxonomic authorities have been deleted but they can be found in the original reference sources.

Common names have been included for all the vertebrates since they are used so frequently and are generally unique. Common names for the birds were taken from the *Checklist of North American Birds*, published by the American Ornithologists' Union.

Specimens have been deposited in several museums, but the most complete collection is housed at Brigham Young University.[25]

INVERTEBRATES

SCORPIONS

Family Chactidae
Superstitionia donensis

Family Vejovidae
Anuroctonus phaeodactylus
Hadrurus arizonensis
H. spadix
Vejovis becki
V. boreus
V. confusus
V. hirsuticauda
V. wupatkiensis

SPIDERS

Family Agelenidae
Agelenopsis aperta
Calilena restricta
Circulina utahana

Family Argiopidae
Apollophanes texana
Metepeira gosoga
Tetragnatha laboriosa

Family Caponiidae
Orthonops gertschi
Tarsonops sp.

Family Clubionidae
Anyphaena sp.
Castianeira sp.
Corinna bicalcarata
Micaria gosiuta
Neoanagraphis chamberlini
N. pearcei
Phrurtimpus sp.
Piabuna nanna
Syspira eclectica

Family Dictynidae
Dictyna calcarata
D. personata
D. reticulata
D. tucsona
Mallos mians
M. pallidus

SPIDERS (Cont'd)

Family Diguetidae
Diguetia cantities
D. signata

Family Filistatidae
Filistata utahana

Family Gnaphosidae
Cesonia classica
Drassodes celes
Drassyllus fractus
D. irritans
D. moronius
Gnaphosa californica
G. hirsutipes
Haplodrassus eunis
Herpyllus hesperolus
Megamyrmecion naturalisticum
Nodocion utus
Zelotes monachus
Z. nannodes
Z. puritanus

Family Heteropodidae
Olios fasciculatus

Family Homalonychidae
Homalonychus theologus

Family Linyphiidae
Ceratinopsis sp.
Cochlembolus sanctus
Erigone dentosa
Meioneta fillmorana
M. formica
Meioneta sp. (near *fratrella*)
Spirembolus sp.
Tapinocyba sp.

Family Lycosidae
Alopecosa kochi
Geolycosa rafaelana
Pardosa ramulosa
Schizocosa sp.
Tarentula kochi

SPIDERS (Cont'd)

Family Mimetidae
Mimetus eutypus

Family Oxyopidae
Oxyopes tridens

Family Pholcidae
Physocyclus tanneri
Psilochorus papago
P. utahensis

Family Plectreuridae
Kibramoa paiuta
Plectreurys tristis

Family Salticidae
Metacyrba arizonensis
M. taeniola
Pellenes brunneus
P. hirsutus
P. limatus
P. oregonensis
Phidippus apacheanus
P. formosus
P. opifex
P. workmanni

Family Scytodidae
Loxosceles unicolor

Family Theraphosidae
Aphonopelma sp.

Family Theridiidae
Enophognatha joshua
Euryopis scriptipes
E. spinigera
Latrodectus mactans
Steatoda fulva
S. medialis
S. washona
Theridion sp.

Family Thomisidae
Ebo dispar
E. merkeli
E. mexicanus
Misumenops desertus
M. rothi
Philodromus infuscatus

SPIDERS (Cont'd)

Family Thomisidae (Cont'd)
Rhysodromus clarus
Thanatus lexanus
Xysticus californicus
X. iviei
X. lassanus

Family Uloboridae
Uloborus diversus

SOLPUGIDS

Family Eremobatidae
Chanbria sp.
Eremobates ctenidiellus
E. mormonus
E. scopulatus
E. similis
E. vicinus
E. zinni
Eremorhax pulcher
E. titania
Hemerotrecha branchi
H. californica
H. denticulata
H. fruitana
H. jacintoana
H. proxima
H. serrata
Horribates sp.
Therobates arcus
T. attritus
T. bidepressus
T. branchi
T. cameronensis
T. flexacus
T. nudus
T. plicatus

Family Ammotrechidae
Ammotrechula dolabra
A. lacuna
A. pilosa
Branchia potens

PHALANGIDS

Family Phalangiidae
Eurybunus riversi
Globipes spinulatus
Leiobunum townsendi

MITES

Family Ameroseiidae
Kleemania sp.

Family Dermanyssidae
Brevisterna utahensis
Dermanyssus becki
Hirstionyssus bisetosus
H. carnifix
H. hill
H. neotomae
H. triacanthus
Ornithonyssus aridus
Steatonyssus antrozoi

Family Erythraeidae
Caeculisoma sp.

Family Haemogamasidae
Haemogamasus pontiger
Ischyropoda armatus

Family Ixodorhynchidae
Ixocorhynchus sp.

Family Laelaptidae
Androlaelaps lericulus
Eubrachylaelaps circularis
E. debilis
E. hollisteri
Haemolaelaps casalis
H. glasgowi
H. sp.
Hypoaspis lericulus

Family Listrophoridae
Listrophorous dipodomys

Family Myobiidae
Lavoimyobia hughesi

MITES (Cont'd)

Family Pterygosomidae
Geckobiella texana
Hirstielia sp.

Family Trombiculidae
Euschöngastia cordiremus
E. cricetiocola
E. decipiens
E. fasolla
E. lanei
E. obesa
E. radfordi
E. utahensis
E. sp.
Leeuwenhoekia americana
Odontacarus arizonensis
O. chiapanensis
O. hirsutus
O. linsdalei
O. micheneri
Pseudoschöngastia sp.
Sasacarus sp.
Trombicula allredi
T. arenicola
T. belkini
T. jessimae
T. panamensis
T. sola
T. 4 spp.
Whartonia perplexa
W. whartonia

Family Tuckerellidae
Tuckerella coleogynis

TICKS

Argas persicus
Dermacentor albipictus
D. parumapertus
Haemaphysalis leporis-palustris
Ixodes angustus
I. kingi
I. ochotonae
I. pacificus
I. sculptus
I. spinipalpis
Otobius lagophilus

CHILOPODS

Family Gosibiidae
Gosibius arizonensis

Family Lithobiidae
Oabius mercurialis

Family Schendylidae
Nyctunguis stenus

Family Scolopendridae
Scolopendra michelbacheri

Family Tampiyidae
Abatorus allredi
Eremorus becki

MILLIPEDS

Family Atopetholidae
Arinolus nevadae
A. sequens
Orthichelus michelbacheri

Family Leioderidae
Titsona tida

ISOPODS

Family Armadillidae
Armadillo arizonicus

Family Porcellionidae
Porcellio laevis

INSECTS

COLEOPTERA - BEETLES

Family Alleculidae
Hymenorus prolixus

Family Buprestidae
Acmaeodera diffusa
A. immaculata
A. lanata
A. purshiae

Family Buprestidae (Cont'd)
A. sp.
Agrilus felix
A. pubifrons
Anthaxia deleta
Chrysobothris cuprascens
C. arizonica
C. platti
Hippomelas near *obliterata*
Melanophila consputa
M. pini-edulis

Family Carabidae
Rhadine jejuna
R. myrmecades

Family Cerambycidae
Moneilema gigas
Prionus californicus subsp.

Family Chrysomelidae
Chlamys memnonia

Family Cleridae
Cymatodera fuchsii
C. latefascia
C. oblita
C. uniformis
Phyllobaenus pygmaeus
P. quadrimaculatus
P. subfasciatus
Serriger reichei
Trichodes ornatus

Family Coccinellidae
Hippodamia ambigua
H. apicalis
H. convergens
H. convergens uteana
Hyperaspis pleuralis
H. quadrivittata
H. taeniata nevadica
H. taeniata taeniata
Scymnus aridus
S. pallens

Family Cucujidae
Oryzaephilus surinamensis

Family Curculionidae
- *Anthonomus cycliferus*
- *A. haematopus*
- *A. hirtus*
- *A. inermis*
- *A.* near *juniperilius*
- *A. ochreopilosus*
- *A. ornatulus*
- *A. peninsularis*
- *A. sphaeralceae*
- *A. tenuis*
- *Apion varicorne*
- *Aragnomus hispidulus*
- *Auletes* sp.
- *Auletobius humeralis*
- *Auletobius* sp.
- *Brachyogmus ornatus*
- *Ceutorhynchus adjunctus*
- *C. tescorum*
- *Cimbocera buchanani*
- *Cleonus denticollis*
- *C. lobigerinus*
- *C. quadrilineatus*
- *Crocidema californica*
- *Crytpolepidus aridus*
- *C. cazieri*
- *C. leechi*
- *C. nevadicus*
- *Dinocleus denticollis*
- *Dirothognathus sordidus*
- *Epimechus gracilis*
- *Eucyllus echinus*
- *E. unicolor*
- *E. vagans*
- *Eupagoderes geminatus*
- *E. varius*
- *Lepidophorus* sp.
- *Macrorhoptus hispidus*
- *Magdalis lecontei*
- *Miloderes mercuryensis*
- *Mimetes gracilior*
- *Myrmex lineata*
- *Onychobaris* near *depressa*
- *O. mystica*
- *Ophryastes geminatus*
- *O. varius*
- *Orimodema protracta*
- *Otidocephalus vittatus*
- *Paracimbocera artemisiae*
- *P. atra*
- *Promecotarsus densus*
- *Smicronyx imbricatus*
- *Smicronyx* sp.

Family Curculionidae (Cont'd)
- *Thinoxenus nevadensis*
- *Thricolepis inornata*
- *Tychius prolixus*
- *T. (Sibinia) setosus*
- *Yuccaborus frontalis*
- *Zascelis irrorata*

Family Meloidae
- *Cysteodemus armatus*

Family Melyridae
- *Attalus futilis*
- *Collops punctulatus utahensis*
- *Eutrichopleurus concinnus*
- *Trichochrous varius*

Family Phalacridae
- *Phalacrus* sp.

Family Scarabaeidae
- *Aphodius fucosus*
- *A. militaris*
- *A. nevadensis*
- *Aphodius* sp. (near *talpoidesi*)
- *Chnaunanthus flaripennis*
- *Cyclocephala longula*
- *Diplotaxis deserta*
- *D. haydeni*
- *D. incuria*
- *D. insignis*
- *D. moerens*
- *D. pacata*
- *D. subangulata*
- *Ochodaeus sparsus*
- *Paracotalpa granicollis*
- *Phyllophaga* sp.
- *Serica alternata*
- *S. perigonia*

Family Scolytidae
- *Ips confusus*

Family Tenebrionidae
- *Alaephus nevadensis*
- *Anemia californica*
- *Anepsius brunneus*
- *Araeoschizus sulcicollis*
- *Auchmobius subboreus*
- *Blapstinus pubescens*
- *B. vandykei*
- *Centrioptera muricata*
- *Chilometopon abnorme*

Family Tenebrionidae (Cont'd)
- *Coelocnemis punctata*
- *Conibiosoma elongatum*
- *Coniontellus argutus*
- *Coniontis nevadensis*
- *Craniotus blaisdelli*
- *Cryptoglossa verrucosa*
- *Discodemus* near *knausi*
- *Edrotes orbus*
- *E. ventricosus*
- *Eleodes armata*
- *E. brunnipes*
- *E. carbonaria*
- *E. cognata*
- *E. concinna*
- *E. dissimilis*
- *E. extricata*
- *E. grandicollis*
- *E. hispilabris*
- *E. longicollis*
- *E. longipilosa*
- *E. nevadensis*
- *E. nigrina*
- *E. obscura*
- *E. omissa*
- *E. pimeloides*
- *E. striatipennis*
- *E. tenebrosa*
- *E.* sp. (near *californica*)
- *Embaphion elongatum*
- *Eschatomoxys wagneri*
- *Eupsophulus castaneus*
- *Eusattus agnatus*
- *E. dubius*
- *E. oblongulus*
- *Euschides luctatus*
- *Helops attenuatus*
- *Hylocrinus laborans*
- *Lobometopon* sp.
- *Metopoloba bifossiceps*
- *Metoponium abnorme*
- *M. convexicollis*
- *Notibius substriatus*
- *Pelecyphorus actuosus*
- *P. pantex*
- *P. semilaevis*
- *Sphaeriontis dilata*
- *Steriphanus lubricans*
- *Trichiasida acerba*
- *Triorophus laevis*
- *Trogloderus costatus*
- *T. tuberculatus*
- *Zopherodes uteanus*

DIPTERA-TRUE FLIES

Family Bombyliidae
- *Anastoechus hessei*
- *A. melanohalteralis*
- *Anthrax albofasciatus*
- *A. limatulus*
- *A. nidicola*
- *A. oedipus*
- *A. seriepunctatus*
- *Aphoebantus abnormis*
- *A. altercinctus*
- *A. arenicola*
- *A. argentifrons*
- *A. borealis*
- *A. brevistylus*
- *A. desertus*
- *A. eremicola*
- *A. fumosus*
- *A. interruptus*
- *A. marcidus*
- *A. marginatus*
- *A. marmon*
- *A. mus*
- *A. pavidus*
- *A. parkeri*
- *A. peodes*
- *A. scalaris*
- *A. scriptus*
- *A. tardus*
- *A. timberlakei*
- *A. transitus*
- *A. ursula*
- *A. varius*
- *A. vasatus*
- *A. vittatus*
- *A. vulpecula*
- *Astrophanes adonis*
- *Bombylius lancifer*
- *Conophorus fenestratus*
- *Desmatoneura argentifrons*
- *Dipalta serpentina*
- *Empidideicus humeralis*
- *Epacmus connectens*
- *E. labiosus*
- *E. litus*
- *E. pulvereus*
- *Eucessia reubens*
- *Exepacmus johnsoni*
- *Exoprosopa arenicola*
- *E. caliptera*
- *E. divisa*
- *E. dorcadion*

Family Bombyliidae (Cont'd)
Exprosopa doris
E. sharonae
E. utahensis
Geminaria canalis
G. pellucida
Geron argutus
Heterostylum robustum
H. sackeni
H. vierecki
Lepidanthrax agrestis
L. angulus
L. hyalinipennis
Lordotus abdominalis
L. albidus
L. apicula
L. singulatus
L. gibbus
L. junceus
L. luteolus
L. melanosus
L. nigriventrus
L. perplexus
L. pulchrissimus
L. sororculus
L. striatus
Oligodranes ater
O. cinctura
O. distinctus
O. dolorosus
O. fasciola
O. mus
O. pulcher
O. pullatus
Pantarbes capita
P. pusio
P. willistoni
Paracosmus insolens
P. morrisoni
Poecilanthrax alpha
P. apache
P. californicus
P. moffitti
P. poecilagaster
P. willistoni
Toxophora pellucida
T. vasta
T. virgata
Villa aenea
V. arizonensis
V. atrata

Family Bombyliidae (Cont'd)
Villa cautor
V. crocina
V. cypris
V. junctura
V. lepidota
V. mira
V. morio
V. scitula
V. sinuosa
V. supina
V. utahensis

EPHEMEROPTERA - MAYFLIES

Family Baetidae
Callibaetis sp.

HEMIPTERA - BUGS

Family Coreidae
Arhyssus lateralis
A. sp.
Harmostes angustatus
H. reflexulus
Liorhyssus hyalinus

Family Miridae
Ankylotylus pallipes
Atomoscelis modestus
Atractotomus purshiae
Beckocoris laticephalus
Bifidungulus puberus
Bolteria juniperi
B. speciosa
Brachyceratocoris nevadensis
Ceratocapsus fusiformis
C. nevadensis
C. nigrocuneatus
Ceratopidea daleae
Chlamydatus associatus
C. becki
C. monilipes
Coquillettia albella
C. luteiclava
C. virescens
Daleapidea albescens
D. daleae
Deraeocoris (Camptobrochis) bakeri

Family Miridae (Cont'd)
Deraeocoris brevis
D. bullatus
D. schwarzii
Dichaetocoris brevirostris
D. juniperi
D. merinoi
D. nevadensis
D. peregrinus
D. pinicola
D. stanleyaea
D. symphoricarpi
Dichrooscytus apicalis
D. flavivenosus
D. irroratus
D. junipericola
D. pinicola
Dicyphus hesperus
D. ribesi
Europiella albipubescens
E. decolor
E. grayiae
E. lycii
E. nigricornis
E. nigrofemoratus
E. punctipes
E. sparsa
E. stigmosa
E. unipuncta
Hadronema picta
H. uhleri
Hesperocapsus davisi
H. plagiatus
Hoplomachidea consors
Largidea nevadensis
Larinocerus balius
Lepidopsallus pini
Lopidea becki
L. deserta
L. fuscosa
L. knowltoni
L. scutata
Lygus desertinus
L. elisus
L. hesperus
Macrotylus infuscatus
M. salviae
Melanotrichus albocostatus
M. atriplicis
M. chelifer
M. coagulatus

Family Miridae (Cont'd)
Melanotrichus nevadensis
M. pallens
Merinocapsus ephedrae
Microphylellus symphoricarpi
Microphylidea pallens
M. prosopidis
Nevadocoris becki
N. bullatus
N. pallidus
Ontocylus guttulatus
Parthenicus accumulus
P. atriplicis
P. becki
P. brevicornis
P. condensus
P. covilleae
P. cuneotinctus
P. desertus
P. furcatus
P. incurvus
P. merinoi
P. minipunctatus
P. nevadensis
P. nigripunctus
P. pictus
P. pilipes
P. pinicola
P. rubrosignatus
P. rufusculus
P. sabulosus
P. tenuis
P. trispinosus
P. utahensis
Phyllopidea hirta
P. picta
Phymatopsallus prosopidis
P. ribesi
Phytocoris albidopictus
P. albidosquamus
P. albiscutellatus
P. becki
P. breviatus
P. carnosulus
P. consors
P. contrastus
P. cuneotinctus
P. decurvatus
P. deserticola
P. ephedrae
P. flavellus

Family Miridae (Cont'd)
Phytocoris geniculatus
P. gracillatus
P. hesperellus
P. hirsuticus
P. juniperanus
P. lineatellus
P. longihirtus
P. mellarius
P. merinoi
P. minituberculatus
P. nigripubescens
P. nigrolineatus
P. plenus
P. pulchricollis
P. ramosus
P. reticulatus
P. rostratus
P. squamosus
P. tricinctipes
P. ventralis
P. vividus
Pilophorus merinoi
P. microsetosus
Plagiognathus salviae
Platylygus vanduzeii
Polymerus relativus
Psallus atriplicis
P. purshiae
Pseudatomoscelis seriatus
Rhinacloa forticornis
Semium subglaber
Sericophanes nevadensis
Slaterocoris croceipes
S. longipennis
S. rubrofemoratus
Spanagonicus albofasciatus
Stenodema virens
Trigonotylus americanus

Family Neididae
Jalysus wickhami
Neides muticus
Pronotacantha annulata

Family Pentatomidae
Banasa euchlora
Brochymena sulcata
Chlorochroa sayi
Dendrocoris contaminatus
D. sp.
Prionosome podopioides
Thyanta pallidovirens
T. rugulosa

Family Tingidae
Corythucha mollicula
C. sphaeralceae
Dictyla coloradensis
Gargaphia opacula
Teleonemia nigrina

HYMENOPTERA - WASPS, ANTS & BEES

Family Formidicae
Acanthomyops interjectus
A. latipes
Apaenogaster boulderensis
A. megommatus
Camponotus hyatti
C. maccooki
C. ocreatus
C. vicinus
Crematogaster coarctata
C. depilis
Dorymyrmex bicolor
D. pyramicus
Formica fusca
F. integroides
F. lasioides
F. limata
F. microgyna
F. moki
F. neogagates
F. neorufibarbis
F. obscuripes
F. obtusopilosa
F. subpolita
Iridomyrmex pruinosum
Lasius crypticus
L. sitiens
Leptothorax andrei
L. nevadensis
L. tricarinatus
Liometopum occidentale
Monomorium minimum
Myrmecocystus comatus
M. lugubris
M. mexicanus
M. mimicus
M. mohave
Myrmica emeryana
Neivamyrmex minor
Pheidole bicarinata
P. desertorum
P. inquilina
P. pilifera
Pogonomyrmex barbatus
P. californicus
P. imberbiculus
P. occidentalis
P. rugosus
P. salinus
Solenopsis aurea
S. molesta

Family Formicidae (Cont'd)
Solenopsis salina
S. xyloni
Stenamma smithi
Veromessor lariversi
V. lobgnathus
V. pergandei
V. smithi

Family Mutillidae
Acanthophotopsis falciformis
Acrophototopsis eurygnathus
Chyphotes melaniceps
C. petiolatus
Dasymutilla gloriosa
D. klugii
D. paenulata
D. satanas
Dilophotopsis concolor crassa
D. c. paron
Odontophotopsis armata
O. clypeata
O. cookii
O. inconspicua
O. mamata
O. microdonta
O. obliqua
O. quadrispinosa
O. serca
O. setifera
Sphaeropthalma acontia
S. amphion
S. angulifera
S. becki
S. blakeii
S. brachyptera
S. difficilis
S. ferruginea
S. helicaon
S. macswaini
S. pallida
S. parapenalis
S. sonora
S. unicolor
S. yumaella

Family Tiphiidae
Acanthetropis aequalis
A. noctivaga
Brachycistis glabrella
B. inaequalis
B. ioachinensis
B. linsleyi

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Family Tiphiidae (Cont'd)
Brachycistis triangularis
Brachycistina acuta
Colocistis brevis
C. castanea
C. crassa
C. eremi
Quemaya paupercula

BEES

Agapostemon cockerelli
A. texana
Andrena sp.
Anthidium dammersi
Anthophora californica
A. porterae
A. urbana
Anthophora sp.
Ashmeadiella aridula
A. australis
A. bigeloviae
A. inyoensis
A. opuntiae
Bombus morrisoni
Centris rhodopus
Ceratina nanula
Chelostomoides lobatifrons
Colletes eulophi
Colletes sp.
Dialictus albohirtus
D. hyalinus
D. incompletus
C. microlepoides
D. nevadensis
D. pruinosum
D. 3 spp.
Diadasia australis
D. diminuta
D. lutzi
Dianthidium pudicum
D. subparvum
D. ulkei
Dioxys productus
Dufourea 2 spp.
Epeolus minimus
Evylaeus ruficornis
Halictus hyalinus
H. tripartitus
Heriades timberlakei

BEES (Cont'd)
Hesperapis wilmattae
Hylaeus asininus
Hypomacrotera subalpinus
Lasioglossum sisymbrium
Lithurgus apicalis
Melectamorpha californica
Melissodes subagilis
M. tritis
Micranthophora hololeuca
M. phenax
Nomia tetrazonata
Osmia titusi
Osmia sp.
Perdita arcuata
P. callicerata
P. chloris
P. fallugia
P. nasuta
P. thermophila
Perdita sp.
Sphecodes eustictus
Stelis sp.
Tetralonia quadricincta
Tetralonia 4 spp.
Triepeolus helianthi
Xylocopa california

LEPIDOPTERA - MONTHS, BUTTERFLIES

Family Arctiidae
Arachnis picta
Pygaractia murina

Family Coleophoridae
Heliodines near *sexpunctella*
Scythris 12 spp.

Family Cosmopterygidae
Inga concolorella

Family Geometridae
Caripeta sp.
Glaucina sp.
Phaeoura sp.
Semiothisa near *colorata*
Stenaspilates sp.

Family Lasiocampidae
Gloveria arizonensis

Family Noctuidae
Agrotis ypsilon
Conochares near *arizonae*
C. near *hutsoni*
Grotella sp.
Oxycnemis near *gracillima*
Phobolosia anfracta
Synedoida sp.
Triocnemis sp.

Family Papilionidae
Cercyonis sp.
Pieris protodice

Family Plutellidae
Abebaea sp.
Cerostoma near *angelicella*
C. near *delicatella*
C. near *flavistrigella*
Plutella maculipennis

Family Pyralidae
Dichozoma parvipicta
Dioryctria near *gulosella*
Etiella zinckenella
Eumysia mysiella
Heterographis morrisonella
Hulstia undulatella
Jocara sp.
Loxostege albiceralis
Nephopteryx bifasciella
Ommatopteryx texana
Passadena flavidorsella
Salebriacus odiosellus
Sosipatra rileyella
Staudingeria albipenella

Family Sphingidae
Celerio lineata
Sphinx dollii

Family Tineidae
Acrolophus laticapitanus
A. variabilis
A. 4 spp.
Dystospasta yumaeella
Myrmecozela near *obliquella*
Tinea sp.

Family Tortricidae
Decodes fragarianus

Family Tortricidae (Cont'd)
Eucosma bobana
E. near *bolanderana*
E. rorana
Ofatulena duodecemstriata
Phaneta indagatricana
P. setonana
Platynota labiosana
P. near *yumana*

Family - Unplaced
Adela punctiferella

ORTHOPTERA - GRASSHOPPERS, CRICKETS

Family Acrididae
Aeoloplides minor
A. tenuipennis
Ageneotettix deorum
Amphitornus coloradus
Anconia integra
Arphia conspersa
Bootettix punctatus
Cibolacris parviceps
Cordillacris occipitalis
Derotmema delicatulum
Dracotettix plutonius
Eremiacris pallida
Hesperotettix viridis
Leprus glaucipennis
Ligurotettix coquilletti
Melanoplus aridus
M. complanatipes
Mestobregma impexum
Poecilotettix sanguineus
Psoloessa delicatula
Trimerotropis albescens
T. bilobata
T. cyaneipennis
T. fortana
T. inconspicua
T. pallidipennis
T. sparsa
T. strenua
Tytthotyle maculata
Xanthippus corallipes

Family Eumastacidae
Morsea californica

Family Gryllacrididae
Ceuthophilus fossor
C. hebardi
C. lamellipes
C. 2 spp.
Pristoceuthophilus pacificus
Stenopelmatus fuscus

Family Gryllidae
Acheta assimilis
Cycloptilum comprehendens
Myrmecophia manni
Oecanthus californicus
O. nigricornis

Family Mantidae
Litaneutria minor
Stagmomantis californicus

Family Phasmatidae
Parabacillus hesperus
Pseudosermyle straminea

Family Polyphagidae
Arenivaga apacha
A. erractica
Eremoblatta subdiaphana

Family Tanaoceridae
Tanaocerus koebelei

Family Tettigoniidae
Anoplodusa arizonensis
Arethaea brevicauda
Atelopus lutens
Capnobotes fuliginosus
C. occidentalis
Insara covilleae
I. elegans

FLEAS - SIPHONAPTERA

Family Amphipsyllidae
Amphipsyllidae neotomae
Odontopsyllus dentatus

Family Ceratophyllidae
Dactylopsylla bluei
Diamanus montanus
Foxella ignota
Malaraeus telchinum

Family Ceratophyllidae (Cont'd)
Monopsyllus eumolpi
M. wagneri
Orchopeas sexdentatus
Thrassis aridis
T. bacchi

Family Hystrichopsyllidae
Anomiopsyllus amphiobolus
Atyphloceras echis
Callistopsyllus deuterus
Carteretta carteri
Catallagia decipiens
Epitedia wenmanni
Jordanopsylla allredi
Megarthroglossus procus
Meringis dipodomys
Meringis hubbardi
M. parkeri
Rhadinopsylla heiseri
R. sectilis
Stenistomera alpina

Family Ischnopsyllicae
Nycteridopsylla vancouvernensis

Family Leptopsyllidae
Peromyscopsylla hesperomys

Family Pulicidae
Cediopsylla inaequalis
Echidnophaga gallinacea
Hoplopsyllus anomalus
Pulex irritans

TRICHOPTERA - CADDICE FLIES

Family Limnephilidae
Limnephilus sp.

VERTEBRATES

FISHES

Family Cyprinidae	
Carassius auratus	Goldfish
Notemigonus crysoleucas	Golden Shiner

TORTOISES

Family Testudinidae	
Gopherus agassizi	Desert Tortoise

LIZARDS

Family Geckonidae	
Coleonyx variegatus	Banded Gecko
Family Iguanidae	
Callisaurus draconoides	Zebra-tailed Lizard
Crotaphytus collaris	Collared Lizard
C. wislizenii	Leopard Lizard
Dipsosaurus dorsalis	Desert Iguana
Phrynosoma platyrhinos	Desert Horned Lizard
Sauromalus obesus	Chuckwalla
Sceloporus graciosus	Sagebrush Lizard
S. magister	Desert Spiny Lizard
S. occidentalis	Western Fence Lizard
Uta stansburiana	Side-blotched Lizard
Family Scincidae	
Eumeces skiltonianus	Western Skink
Family Teidae	
Cnemidophorus tigris	Western Whiptail
Family Xantusidae	
Xantusia vigilis	Desert Night Lizard

SNAKES

Family Colubridae	
Arizona elegans	Glossy Snake
Chionactis occipitalis	Western Shovel-nosed Snake
Diadophis punctatus	Ringneck Snake
Hypsiglena torquata	Night Snake
Lampropeltis getulus	Common Kingsnake
Leptotyphlops humilis	Western Blind Snake
Masticophis flagellum	Coachwhip

Family Colubridae (Cont'd)

Masticophis taeniatus	Striped Whipsnake
Phyllorhynchus decurtatus	Spotted Leaf-nosed Snake
Pituophis melanoleucus	Gopher Snake
Rhinocheilus lecontei	Long-nosed Snake
Salvadora hexalepis	Western Patch-nosed Snake
Sonora semiannulata	Western Ground Snake
Tantilla utahensis	Utah Black-headed Snake
Trimorphodon lambda	Sonora Lyre Snake

Family Crotalidae

Crotalus cerastes	Sidewinder
C. mitchelli	Speckled Rattlesnake

BIRDS

Family Accipitridae

Accipiter cooperii	Cooper's Hawk
A. striatus	Sharp-shinned Hawk
Aquila chrysaetos	Golden Eagle
Buteo jamaicensis	Red-tailed Hawk
B. lagopus	Rough-legged Hawk
B. regalis	Ferruginous Hawk
B. swainsoni	Swainson's Hawk
Circus cyaneus	Marsh Hawk

Family Alaudidae

Eremophila alpestris	Horned Lark

Family Alcedinidae

Megaceryle alcyon	Belted Kingfisher

Family Anatidae

Anas acuta	Pintail
A. americana	American Widgeon
A. clypeata	Shoveler
A. crecca	Green-Winged Teal
A. cyanoptera	Cinnamon Teal
A. discors	Blue-winged Teal
A. platyrhynchos	Mallard
Aythya affinis	Lesser Scaup
A. americana	Redhead
Branta canadensis	Canada Goose
Bucephala albeola	Bufflehead
B. clangula	Common Goldeneye
Melanitta perspicillata	Surf Scoter
Mergus serrator	Red-breaster Merganser
Olar columbianus	Whistling Swan
Oxyura jamaicensis	Ruddy Duck

Family Apodidae

Aeronautes saxatalis	White-throated Swift

Family Ardeidae

Ardea herodias	Great Blue Heron
Butorides virescens	Green Heron
Casmerodius albus	Common Egret
Egretta thula	Snowy Egret
Ixobrychus exilis	Least Bittern
Nycticorax nycticorax	Black-crowned Night Heron

Family Bombycillidae

Bombycilla cedrorum	Cedar Waxwing

Family Caprimulgidae

Chordeiles acutipennis	Lesser Nighthawk
C. minor	Common Nighthawk
Phalaenoptilus nuttallii	Poor-will

Family Cathartidae

Cathartes aura	Turkey Vulture

Family Charadriidae

Charadrius alexandrinus	Snowy Plover
C. semipalmatus	Semipalmated Plover
C. vociferus	Killdeer
C. montanus	Mountain Plover
Pluvialis dominica	American Golden Plover
P. squatarola	Black-bellied Plover

Family Columbidae

Zenaida macroura	Mourning Dove

Family Corvidae

Aphelocoma coerulescens	Scrub Jay
Corvus brachyrhynchos	Common Crow
C. corax	Common Raven
Cyanocitta stelleri	Steller's Jay
Gymnorhinus cyanocephala	Pinyon Jay
Nucifraga columbiana	Clark's Nutcracker
Pica pica	Black-billed Magpie

Family Cuculidae

Geococcyx californianus	Roadrunner

Family Falconidae

Falco mexicanus	Prairie Falcon
F. peregrinus	American Peregrine Falcon
F. sparverius	Sparrow Hawk

Family Fringillidae

Amphispiza belli	Sage Sparrow
A. bilineata	Black-throated Sparrow
Calcarius lapponicus	Lapland Longspur
Carpodacus cassinii	Cassin's Finch

Family Fringillidae (Cont'd)

Carpodacus mexicanus	House Finch
C. purpureus	Purple Finch
Chlorura chlorura	Green-tailed Towhee
Chondestes grammacus	Lark Sparrow
Guiraca caerula	Blue Grosbeak
Hesperiphona vespertina	Evening Grosbeak
Junco caniceps	Gray-headed Junco
J. hyemalis	Dark-eyed Junco
Melospiza lincolnii	Lincoln's Sparrow
M. melodia	Song Sparrow
Passerculus sandwichensis	Savannah Sparrow
Passerina amoena	Lazula Bunting
Pheucticus melanocephalus	Black-headed Grosbeak
Pipilo erythrophythalmus	Rufous-sided Towhee
Pooecetes gramineus	Vesper Sparrow
Spinus pinus	Pine Siskin
S. psaltria	Lesser Goldfinch
S. tristis	American Goldfinch
Spizella atrogularis	Black-chinned Sparrow
S. breweri	Brewer's Sparrow
S. passerina	Chipping Sparrow
Zonotrichia atricapilla	Golden-crowned Sparrow
Z. leucophrys	White-crowned Sparrow

Family Hirundinidae

Hirundo rustica	Barn Swallow
Iridoprocne bicolor	Tree Swallow
Petrochelidon pyrrhonota	Cliff Swallow
Riparia riparia	Bank Swallow
Stelgidopteryx ruficollis	Rough-winged Swallow
Tachycineta thalassina	Violet-green Swallow

Family Icteridae

Agelaius phoeniceus	Red-winged Blackbird
Euphagus cyanocephalus	Brewer's Blackbird
Icterus galbula	Northern Oriole
I. parisorum	Scott's Oriole
Molothrus ater	Black-headed Cowbird
Sturnella neglecta	Western Meadowlark
Xanthocephalus xanthocephalus	Yellow-headed Blackbird

Family Laridae

Larus californicus	California Gull
L. delawarensis	Ring-billed Gull
L. philadelphia	Bonaparte's Gull

Family Laniidae

Lanius ludovicianus	Loggerhead Shrike

Family Mimidae

Dumetella carolinensis	Catbird

Family Mimidae (Cont'd)

Mimus polyglottos	Mockingbird
Oreoscoptes montanus	Sage Thrasher
Toxostoma lecontei	LeConte's Thrasher

Family Motacillidae

Anthus spinoletta	Water Pipit

Family Pandionidae

Pandion haliaetus	Osprey

Family Paridae

Parus gambeli	Mountain Chickadee
P. inornatus	Plain Titmouse
Psaltriparus minimus	Common Bushtit

Family Parulidae

Dendroica coronata	Yellow-rumped Warbler
D. petechia	Yellow Warbler
D. nigrescens	Black-throated Gray Warbler
D. townsendi	Townsend's Warbler
Geothylpis trichas	Yellowthroat
Icteria virens	Long-tailed Chat
Oporonis tolmiei	MacGillivray's Warbler
Vermivora celata	Orange-crowned Warbler
V. virginiae	Virginia Warbler
V. ruficapilla	Nashville Warbler
Wilsonia pusilla	Wilson's Warbler

Family Pelecanidae

Pelecanus erythrorhynchos	White Pelican

Family Phalaropodidae

Lobipes lobatus	Northern Phalarope
Steganopus tricolor	Wilson's Phalarope

Family Phasianidae

Alectoris chukar	Chukar
Lophortyx gambelii	Gambel's Quail

Family Picidae

Asyndesmus lewis	Lewis's Woodpecker
Colaptes auratus	Common Flicker
Dendrocopos scalaris	Ladder-backed Woodpecker
D. villosus	Hairy Woodpecker
Sphyrapicus varius	Yellow-bellied Sapsucker

Family Ploceidae

Passer domesticus	House Sparrow

Family Podicipedidae

Aechmophorus occidentalis	Western Grebe

Family Podicipedidae (Cont'd)	
Podiceps nigricollis	Eared Grebe
P. podiceps	Pied-billed Grebe
Family Ptilogonatidae	
Phainopepla nitens	Phainopepla
Family Rallidae	
Fulica americana	American Coot
Family Recurvirostridae	
Himantopus mexicanus	Black-necked Stilt
Recurvirostra americana	American Avocet
Family Scolopacidae	
Actitis macularia	Spotted Sandpiper
Calidris alpina	Dunlin
C. bairdii	Baird's Sandpiper
C. mauri	Western Sandpiper
C. melanotos	Pectoral Sandpiper
C. minutilla	Least Sandpiper
Capella gallinago	Common Snipe
Catoptrophorus semipalmatus	Western Willet
Limnodromus scolopaceus	Long-billed Dowitcher
Limosa fedoa	Marbled Godwit
Micropalama himantopus	Stilt Sandpiper
Numenius americanus	Long-billed Curlew
Tringa flavipes	Lesser Yellowlegs
T. melanoleucus	Greater Yellowlegs
T. solitaria	Solitary Sandpiper
Family Sittidae	
Sitta carolinensis	White-breasted Nuthatch
Family Strigidae	
Asio flammeus	Short-eared Owl
A. otus	Long-eared Owl
Bubo virginianus	Great Horned Owl
Speotyto cunicularia	Burrowing Owl
Family Sturnidae	
Sturnus vulgaris	Starling
Family Sylviidae	
Polioptila caerulea	Blue-gray Gnatcatcher
Regulus calendula	Ruby-crowned Kinglet
Family Thraupidae	
Piranga ludoviciana	Western Tanager
Family Threskiornithidae	
Plegadis chihi	White-faced Ibis

Family Trochilidae	
Calypte costae	Costa's Hummingbird
Selasphorus platycercus	Broad-tailed Hummingbird
S. rufus	Rufous Hummingbird
Family Troglodytidae	
Campylorhynchus brunneicapillus	Cactus Wren
Salpinctes obsoletus	Rock Wren
Telmatodytes palustris	Long-billed Marsh Wren
Thryomanes bewickii	Bewick's Wren
Troglodytes aedon	House Wren
Family Turdidae	
Catharus guttatus	Hermit Thrush
C. ustulatus	Swainson's Thrush
Myadestes townsendi	Townsend's Solitaire
Sialia currucoides	Mountain Bluebird
S. mexicana	Western Bluebird
Turdus migratorius	American Robin
Family Tyrannidae	
Contopus sordidulus	Western Wood Peewee
Empidonax oberholseri	Dusky Flycatcher
E. wrightii	Gray Flycatcher
Myiarchus cinerascens	Ash-throated Flycatcher
Nuttalornis borealis	Olive-sided Flycatcher
Pyrocephalus rubinus	Vermillion Flycatcher
Sayornis nigricans	Black Phoebe
S. saya	Say's Phoebe
Tyrannus verticalis	Western Kingbird
T. vociferans	Cassin's Kingbird
Family Vireonidae	
Vireo gilvus	Warbling Vireo
V. solitarius	Solitary Vireo
V. vicinior	Gray Vireo

MAMMALS

Family Antilocapridae	
Antilocapra americana	Pronghorn
Family Bovidae	
Bos taurus	Cow
Ovis canadensis	Desert Bighorn Sheep
Family Canidae	
Canis latrans	Coyote
Vulpes macrotis	Kit Fox

Family Cervidae	
Odocoileus hemionus	Mule Deer
Family Cricetidae	
Lagurus curtatus	Sagebrush Vole
Neotoma lepida	Desert Wood Rat
Onychomys torridus	Southern Grasshopper Mouse
Peromyscus crinitus	Canyon Mouse
P. eremicus	Cactus Mouse
P. maniculatus	Deer Mouse
P. truei	Pinyon Mouse
Reithrodontomys megalotis	Western Harvest Mouse
Family Equidae	
Equus asinus	Burro
E. caballus	Horse
Family Erethizontidae	
Erethizon dorsatum	Porcupine
Family Felidae	
Felix concolor	Mountain Lion
Lynx rufus	Bobcat
Family Geomyidae	
Thomomys umbrinus	Southern Pocket Gopher
Family Heteromyidae	
Dipodomys deserti	Desert Kangaroo Rat
D. merriami	Merriam's Kangaroo Rat
D. microps	Great Basin Kangaroo Rat
D. ordii	Ord Kangaroo Rat
Perognathus formosus	Long-tailed Pocket Mouse
P. longimembris	Little Pocket Mouse
P. parvus	Great Basin Pocket Mouse
Family Leporidae	
Lepus californicus	Black-tailed Jackrabbit
Sylvilagus audubonii	Desert Cottontail
S. nuttallii	Nuttall's Cottontail
Family Mustelidae	
Mustela frenata	Long-tailed Weasel
Spilogale gracilis	Western Spotted Skunk
Taxidea taxus	Badger
Family Procyonidae	
Bassariscus astutus	Ringtail
Family Sciuridae	
Ammospermophilus leucurus	White-tailed Antelope Squirrel
Eutamias dorsalis	Cliff Chipmunk
Spermophilus tereticaudus	Round-tailed Ground Squirrel

Family Sciuridae (Cont'd)	
Spermophilus townsendii	Townsend's Ground Squirrel
S. variegatus	Rock Squirrel
Family Soricidae	
Notiosorex crawfordi	Desert Shrew
Sorex merriami	Merriam's Shrew
S. tenellus	Inyo Shrew
Vespertilionidae	
Antrozous pallidus	Pallid Bat
Myotis californicus	California Myotis
Pipistrellus hesperus	Western Pipistrelle
Plecotus townsendii	Lump-nosed Bat

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