477/77
2-28-77

Ri. 747

**LA-6503-MS**
Informal Report

UC-11 and UC-70

Issued: January 1977

# Biotic Survey of Los Alamos Radioactive Liquid-Effluent Receiving Areas

by


F. R. Miera, Jr.
K. V. Bostick
T. E. Hakonson
J. W. Nyhan



los alamos
scientific laboratory
of the University of California
LOS ALAMOS, NEW MEXICO 87545

An Affirmative Action/Equal Opportunity Employer

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

Printed in the United States of America. Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161
Price: Printed Copy $3.50 Microfiche $3.00

BIOTIC SURVEY OF LOS ALAMOS RADIOACTIVE LIQUID-EFFLUENT RECEIVING AREAS

by

F. R. Miera, Jr., K. V. Bostick
T. E. Hakonson, and J. W. Nyhan

ABSTRACT

A preliminary study was completed of the vegetation and small mammal communities and associated climatology in three canyon liquid waste receiving areas at the Los Alamos Scientific Laboratory. Data were gathered on plant and animal composition, distribution, and biomass, along with air temperature, humidity, and precipitation, as a function of elevation and where data was available with season. Initial studies of the understory vegetation in the spring of 1974 indicate grass species to be dominant at higher elevations, with forb species becoming dominant at lower elevations. Generally, the highest total mass estimates for standing green vegetation were obtained in the study sites located in the upper portions of the canyons where precipitation is greatest, and where the terrain and intermittent stream flow result in a wetter habitat.

Fourteen species of small mammals were trapped or observed in canyon study areas during two trapping sessions of May-June 1974 and December 1974-February 1975. A greater number of species and the highest rodent biomass estimates in the spring were generally associated with the ponderosa pine/piñon-juniper woodland in the upper reaches of the canyons, and were lowest in the piñon-juniper woodland at the lower portions of the canyons. This trend was observed in only one of the canyons during the winter season.

Climatological data gathered in the three canyons since 1973 are also presented to serve as a data base for future reference.



---

## I. INTRODUCTION

The radioecology program at the Los Alamos Scientific Laboratory (LASL) was begun in 1972 to supply information on the environmental implications of the

Laboratory's radioactive waste disposal practices. During 1972 and 1973, a radionuclide inventory was conducted in three canyon systems which have received low-level radioactive liquid wastes.[1-4] The results of these early studies were used for selecting several intensive study sites on the basis of relative radionuclide ($^{137}Cs$, $^{238}Pu$, and $^{239,240}Pu$) levels in soils. Some of the objectives of current intensive site studies are to characterize radionuclide concentration variability in ecosystem components and to observe seasonal changes in radionuclide concentrations in the soils and biota.

The scope of this study was to determine species composition and mass estimates for understory vegetation along the stream channels located in each of three canyon systems, and to quantify small mammal populations. Climatological data gathered in the canyons since 1973 are also presented to serve as a data base for future reference.

## II. DESCRIPTION OF LASL STUDY AREAS

A detailed description of the LASL environs has been given previously.[1] There exists a general east-west elevational gradient of 1500 m within 25 km by air, proceeding from 1650 m elevation above sea level at the Rio Grande to the 3170 m peak elevation in the Jemez Mountains. The three canyons which have received treated radioactive liquid wastes for varying lengths of time are Mortandad (M), DP-Los Alamos (DP), and Acid-Pueblo (AP) Canyons, located in Los Alamos and Santa Fe Counties, New Mexico. Waste outfalls for the three canyons are located at approximately 2200 m elevation, in a mixed ponderosa pine/pinon pine-juniper overstory. As the canyons extend eastward toward the Rio Grande, they encompass plant and animal communities more typical of the piñon pine-juniper woodland community. The upper reaches of the canyons generally have stream channel widths of 1 m or less and alluvium depths up to 0.15 m. The stream channels in the lower canyon areas are about 3 m wide, with the alluvium ranging from 0.15-30 m depths. Intermittent surface water in the canyons is a result of Laboratory effluents and/or domestic sewage, but these flows occur only in small segments of the canyons because of rapid infiltration of surface water into the alluvium.

The climate of the area is typical of semi-arid continental mountain regions, with precipitation averaging about 46 cm at the higher elevations (~2200 m) on the west and about 18 cm at the lower elevations (~1650 m) on the east. About 75% of the precipitation occurs as thundershowers during the period May through October. Relatively large flows occur in all three canyons during storm runoff events, with storm runoff reaching the Rio Grande only in the AP and DP Canyon system. Gently sloping mesas, sheer cliffs, and canyon bottoms emphasize the phenomena of "edge effect" with diversified habitats and many ecotones, or transition areas of overlapping plant and animal communities in all three canyon systems.

## III. SELECTION OF SMALL MAMMAL AND VEGETATION INTENSIVE STUDY SITES

Eleven sites in the canyons were live-trapped for small mammals in May and June 1974 (Fig. 1) and constituted the spring trapping session. All of the sites were selected on the basis of relative radionuclide concentrations; three of these sites, one in each canyon system, served as control areas (BKG) where radionuclide concentrations were near fallout levels.

Based on the similarity of results obtained during the May-June trapping session, the number of sites was further reduced (Fig. 1) for purposes of more

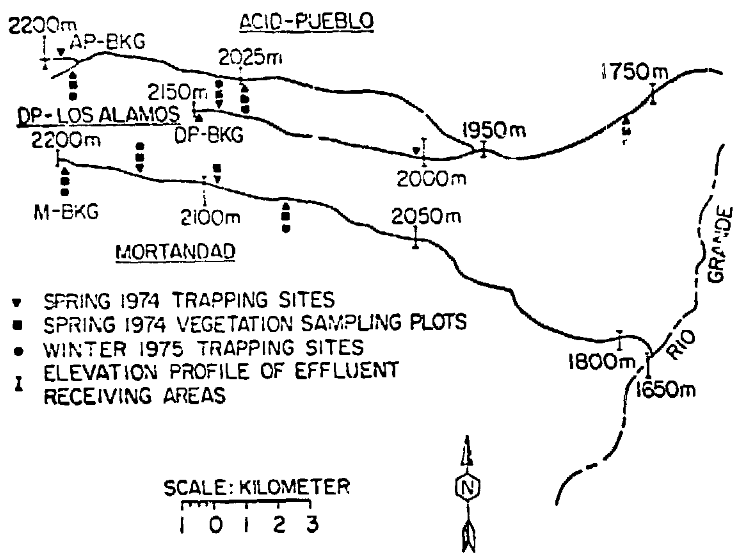


Fig. 1.
Elevational profiles of the liquid wastes disposal areas and locations of ecological study areas.

intensively studying small mammal populations during December through February 1975, constituting a winter trapping session. Mortandad Canyon, which does not link with any major canyon on its way to the Rio Grande, contains three sites, including the sole Control Site. The AP and DP Canyon systems join about 10 000 m below the DP Canyon waste outfall and continue as one canyon for an additional 6000 m before entering the Rio Grande. Two sites are located in AP Canyon and one in DP Canyon. An additional site is located east of the junction.

Nine vegetation plots coincident with the small mammal plots were sampled during May and June. A listing of the predominant overstory vegetation, as well as forbs and grasses to be found at the selected study sites, is provided in Table I.

## IV. METHODS

### A. Vegetation

At each of the nine intensive sites where vegetation was sampled (Fig. 1), a study area with dimensions of 25 m perpendicular to the stream channel by 100 m parallel to the stream channel was permanently marked. Ten randomly selected

TABLE I

SITE DESIGNATIONS AND VEGETATION OF RADIOACTIVE LIQUID EFFLUENT RECEIVING AREAS AT LOS ALAMOS

| Site Designation | | Elevation (m) | Dominant Overstory Vegetation | Dominant Forbs and Grasses |
|---|---|---|---|---|
| Mortandad Background | (M BKG) | 2190 | Ponderosa Pine-Fir Gambel's Oak | *Elymus* sp. (Wheatgrass) |
| Mortandad Site I | (M-I) | 2165 | Ponderosa Pine Fir Gambel's Oak, Chokecherry | *Poa* spp. (Bluegrass), *Clematis* sp. (Clematis) |
| Mortandad Site II | (M-II) | 2090 | Ponderosa Pine/ Piñon Juniper | *Poa* spp. (Bluegrass), *Chenopodium* sp. (Goose foot), *Galium* spp. (Bedstraw), *Fragaria americana* (Strawberry), *Taraxacum officinale* (Dandelion) |
| Mortandad Site III | (M-III) | 2085 | Ponderosa Pine/ Piñon Juniper/mixed shrubs | *Poa* spp. (Bluegrass) |
| DP-Los Alamos Background | (DP-BKG) | 2145 | Ponderosa Pine/ Piñon Juniper | -- -- |
| DP-Los Alamos Site I | (DP-I) | 2135 | Ponderosa Pine/ Piñon Juniper | *Poa* spp. (Bluegrass) |
| DP-Los Alamos Site II | (DP-II) | 2010 | Ponderosa Pine/Piñon Juniper, *Artemisia* | *Poa* spp. (Bluegrass), *Bromus* spp. (Bromegrass) |
| Acid-Pueblo Background | (AP-BKG) | 2165 | Ponderosa Pine-Fir | -- -- |
| Acid-Pueblo Site I | (AP-I) | 2165 | Ponderosa Pine Fir, Chokecherry | *Poa* spp. (Bluegrass), *Taraxacum officinale* (Dandelion) |
| Acid Pueblo Site II | (AP-II) | 2025 | Ponderosa Pine/ Piñon Juniper | *Poa* spp. (Bluegrass), *Sorghum helepensis* (Sorghum) |
| Acid-Pueblo-DP-Los Alamos Site III | (AP-DP-III) | 1755 | Juniper, Saltbrush, Sagebrush, Rabbit brush, Apache plume | *Bromus* spp. (Bromegrass), *Verbascum thapsus* (Mullein), *Gutierrezia sarothrae* (Snakeweed) |

sampling plots were located adjacent to the stream channel, and two sampling plots at both 0.5 m and 10 m from the stream channel. Each of the vegetation sampling plots was 0.25 m x 1.0 m, representing a total area of 0.25 $m^2$. Stems and leaf sheaths were clipped to within 3 cm of the soil surface to maintain the integrity of the leaf meristem, prior to harvesting the litter layer.

Taxonomic identifications[5,6] were made by Maureen Romine of New Mexico Highlands University. The major species of vegetation occurring within the clipped plots at each site are listed in Table I. Following identification, the samples were sorted into three categories: green grasses, green forbs and shrubs, and non-green dead vegetation and litter. Samples were oven-dried at 100° C for a period of 24 h and a dry-weight obtained for determination of biomass estimates.

B. Small Mammals

A live trapping grid with dimensions of 25 m perpendicular to the stream channel by 100 m parallel to the stream channel was permanently staked and marked at each study site. A rectangular trapping grid was chosen to accomodate the terrain and habitat in the canyons and the fact that high concentrations of radionuclides are confined primarily to the stream channels. Four rows of stations were located parallel to the stream channel, one row on each bank with the stations about 5 m apart, and one row 10 m from the bank on each side of the channel. Stations parallel to the stream channel were separated by a distance of 10 m. Each row consisted of 11 stations, giving a trapping grid of 4 by 11 stations. Two Sherman live traps were placed at each station, for a total of 88 traps per site. Extending each side of the grid by 5 meters, an effective trapping grid size of 0.39 hectares was assumed for deriving biomass estimates for all sites.

Trapping was conducted on a schedule of two days of prebaiting (traps closed) to accustom the animals to the traps and minimize "trap-shyness", followed by five consecutive days of trap-mark-release procedures. During the December-February trapping session, heavy snowfalls hampered attempts to obtain 5 consecutive days of trapping in some instances; however, a minimum of 3 consecutive days of trapping were conducted in all cases. The animals were marked by a standard system of toe amputation.[7] Data recorded on all captures included capture location, genus and species,[8-10] sex, age class, reproductive condition and weight. As one objective of this study was to determine radionuclide concentrations in the rodent component of the ecosystem, it was essential to remove specimens from the population for radiochemical analysis.

## C. Climatology

Temperature and relative humidity were measured from September 1973 at intensive sites I in Mortandad, Acid-Pueblo, and DP-Los Alamos Canyons and near Technical Area 8 (TA-8) located on the western perimeter of the Laboratory boundary. The TA-8 recording site is not depicted in Fig. 1. Weather Measure Model H311 hygrothermographs, using 7-day spring-wound clocks, were used to obtain daily temperature and relative humidity data. US Weather Bureau type maximum-and-minimum thermometers were used to provide supplemental data on the weekly temperature range. This equipment was located at each site in USWB "cotton-region type" instrument shelters. The hygrothermographs were calibrated periodically using an Assmann Psychrometer.

Precipitation measurements were recorded for the 11 canyon intensive sites and also at TA-8 as of May 1974. The rain gauge at the background site in AP Canyon was vandalized in July 1974 and was not replaced. Rain gauges fabricated of galvanized sheetmetal into cylinders 61 cm deep and 25.5 cm in diameter were placed in open areas as near the intensive sites as possible. One liter of antifreeze and 500 ml of mineral oil were placed in the gauges to prevent evaporation and freezing, and an initial depth was recorded. Net monthly precipitations were established from successive measurements. The gauges were drained twice yearly and the baseline reestablished.

# V. RESULTS

## A. Vegetation

Biomass estimates for the various plant groupings at each intensive study site are tabulated in Table II. Generally, highest mass estimates for standing green vegetation in May and June were obtained in the upper portions of the canyons where surface water commonly occurs. For plots clipped adjacent to the stream bank, mass estimates for grasses (Figs. 2 and 3) decreased with coincident decreases in sampling plot elevation and ranged from 110 g/m$^2$ at DP I to 3.8 g/m$^2$ at AP-DP III. Mass estimates for forbs increased as elevation decreased with a range of 0.3 g/m$^2$ at DP I to 240 g/m$^2$ at AP-DP III, however, these estimates were generally more variable than for both the grass and litter components. The largest portion of the total mass estimates for each site was attributable to the standing dead plus litter category. For sample plots clipped at 0.5 m

TABLE II

BIOMASS ESTIMATES FOR VEGETATION AT SELECTED LASL EFFLUENT RECEIVING AREAS, SPRING 1974, (g/m$^2$ dry)

| | Stream Bank Plots | | | | | | | Transect Plots (0.5 m) | | | | | | | Transect Plots (10 m) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Standing Green Grass | | | Standing Green Non Grass | | Standing Dead + Litter | | Standing Green Grass | | | Standing Green Non-Grass | | Standing Dead + Litter | | Standing Green Grass | | Standing Green Non-Grass | | Standing Dead + Litter | |
| | N[a] | Mean | CV[b] | Mean | CV | Mean | CV | N | Mean | CV | Mean | CV | Mean | CV | Mean | CV | Mean | CV | Mean | CV |
| M BKG | 7 | 33 | 0.22 | 3.6 | 2.60 | 460 | 2.37 | - | -- | -- | -- | - | -- | --- | - | ---- | -- | --- | -- | --- |
| M I | 10 | 7.8 | 0.83 | 9.5 | 1.60 | 935 | 0.48 | 2 | 5.2 | 0.65 | 2.6 | 1.40 | 1060 | 0.11 | 0.8 | 1.40 | 9.6 | 0.82 | 1180 | 0.53 |
| M II | 10 | 8.5 | 1.10 | 26 | 1.40 | 1080 | 50 | 2 | 17 | 0.82 | 34 | 1.40 | 840 | 0.37 | 8.5 | 1.40 | 0.8 | 1.40 | 1090 | 0.14 |
| M III | 10 | 9.0 | 1.10 | 39 | 1.80 | 1130 | 0.72 | 2 | 3.2 | 0.54 | 1.8 | 1.40 | 1530 | 0.08 | 2.4 | 0.96 | -0- | ---- | 1510 | 0.90 |
| DP I | 10 | 110 | 0.51 | 0.3 | 3.0 | 1460 | 0.28 | 2 | 90 | - | 2.4 | 0.46 | 1560 | 0.05 | 14 | 0.10 | 0.4 | 1.50 | 260 | 1.40 |
| DP II | 10 | 8.5 | 0.79 | 9.4 | 2.0 | 425 | 0.51 | 2 | 2.8 | 1.40 | 15 | 1.40 | 530 | 0.24 | -0- | - - | -0 | --- | 1210 | 0.23 |
| AP I | 5 | 19 | 0.87 | 5.5 | 0.98 | 625 | 0.32 | 2 | 28 | 1.40 | 6.4 | 1.80 | 630 | 0.03 | 4.4 | 1.40 | 1.8 | 1.40 | 670 | 1.40 |
| AP II | 10 | 72 | 0.85 | 73 | 1.90 | 745 | 0.91 | 2 | 90 | 0.33 | 34 | 1.40 | 740 | 0.29 | 12 | 1.40 | 320 | 1.40 | 3 | 1.10 |
| AP DP III | 10 | 3.8 | 1.70 | 240 | 0.65 | 340 | 1.40 | - | --- | ---- | --- | - - | --- | ---- | --- | ---- | --- | ---- | --- | ---- |

[a] N = Number of replicate samples

[b] CV = Coefficient of Variation = Standard Deviation/Mean

and at 10 m from the stream bank, such changes were not as consistent. Bluegrass (*Poa* sp.) appears to be the most widely distributed of the grass and forb species encountered, occurring in seven of the nine sites where vegetation was collected. Because mass estimates vary with season, data through a complete cycle are needed before the significance of site differences can be fully determined.

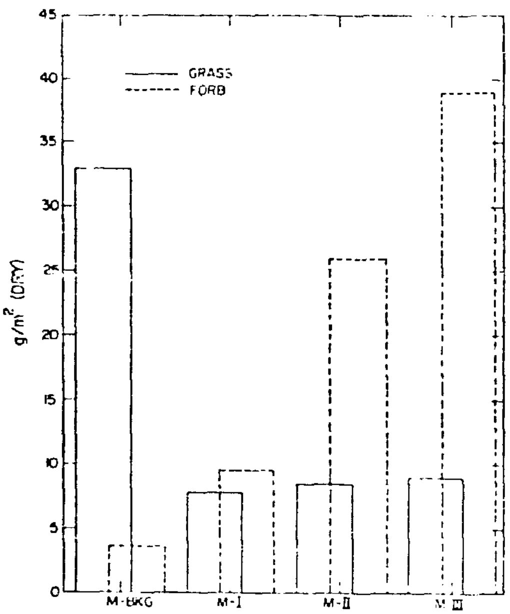


Fig. 2.
May-June 1974 grass species and forb species mass estimates along an elevational gradient in Mortandad Canyon.

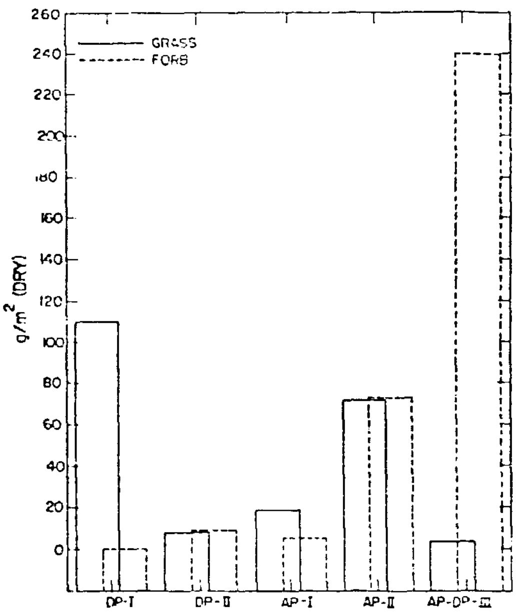


Fig. 3.
May-June 1974 grass species and forb species mass estimates along an elevational gradient for DP-Los Alamos and Acid Pueblo Canyons.

## B. Small Mammals

Approximately 8100 trap nights for the May-June and December-February trapping sessions at all sites yielded 1053 total captures of 547 different specimens. Representatives of five families (Sciuridae, Cricetidae, Geomyidae, Soricidae, and Leporidae) and nine genera were identified in the captures. In all, 10 species of mammals were captured, the most common being the piñon mouse (*Peromyscus truei*), deer mouse (*P. maniculatus*), western harvest mouse (*Reithrodontomys megalotis*), least chipmunk (*Eucamias minimus*), and the meadow vole (*Microtus pennsylvanicus*). Other species included the Mexican woodrat (*Neotoma mexicana*), dwarf shrew (*Sorex nanus*), valley pocket gopher (*Thomomys bottae*), rock squirrel (*Spermophilus variegatus*), and one immature cottontail rabbit (*Sylvilagus sp.*). A summary of trapping effort and total captures by site, for both trapping sessions is listed in Table III.

*Peromyscus truei* comprised about 38% of total captures for all sites, *P. maniculatus* 15%, *E. minimus* 30%, and *R. megalotis* 6%. The sex ratios, mean adult weights, and minimal biomass estimates for these four species appear in Tables IV and V. Sex ratios (M:F) observed for both species of *Peromyscus* favored females for the total trapping effort during the May-June trapping session; for *P. truei* the ratio was 0.87, and for *P. maniculatus* 0.94. Previous studies[11] have shown sex ratios to favor males for the genus *Peromyscus*. This was the case during the December-February session as *P. truei* and *P. maniculatus* males

TABLE III

SUMMARY OF SMALL MAMMAL TRAPPING DATA FROM LASL

(MAY-JUNE 1974 AND DECEMBER 1974 - FEBRUARY 1975)

| Location | Days | Trap Nights | Number species | First captures | Total Captures |
|---|---|---|---|---|---|
| M-BKG | 9 | 792 | 6 | 111 | 237 |
| M-I | 9 | 792 | 4 | 77 | 153 |
| M-II | 5 | 528 | 4 | 65 | 145 |
| M-III | 8 | 704 | 2 | 26 | 47 |
| DP-BKG | 7 | 616 | 4 | 36 | 81 |
| DP-I | 12 | 1056 | 6 | 31 | 46 |
| DP-II | 5 | 440 | 4 | 43 | 91 |
| AP-BKG | 6 | 528 | 3 | 23 | 34 |
| AP-I | 11 | 968 | 3 | 42 | 60 |
| AP-II | 11 | 968 | 6 | 36 | 62 |
| AP-DP-III | 8 | 704 | 4 | 57 | 97 |
| Totals | 91 | 8096 | | 547 | 1053 |

TABLE IV

SEX RATIOS, WEIGHTS, MOVEMENTS BETWEEN CAPTURES, AND MINIMAL BIOMASS ESTIMATES FOR FOUR SELECTED SMALL MAMMAL SPECIES AT INTENSIVE STUDY SITES DURING MAY-JUNE 1974

| Location | Sex Ratio M:F[a] | Mean Adult Weight (g) M | | | Mean Adult Weight (g) F | | | Average Distance between Captures (m) | | | Estimated Biomass[b] (g/m²) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Mean | CV[c] | N[d] | Mean | CV | N | Mean | CV | N | |
| *Peromyscus truei* | | | | | | | | | | | |
| M-BKG | 11:16 | 20.2 | 0.11 | 11 | 20.5 | 0.11 | 16 | 18.3 | 0.42 | 8 | 0.14[e] |
| M-I | 20:19 | 21.7 | 0.08 | 20 | 22.0 | 0.16 | 19 | 14.4 | 0.58 | 6 | 0.22 |
| M-II | 13:13 | 22.4 | 0.10 | 13 | 24.0 | 0.13 | 19 | 11.6 | 0.68 | 12 | 0.19 |
| M-III | - | -- | -- | - | -- | -- | - | -- | -- | -- | -- |
| DP-BKG | 7:7 | 22.9 | 0.14 | 7 | 23.1 | 0.17 | 7 | 10.3 | 0.38 | 4 | 0.08 |
| DP-I | 1:1 | -- | -- | -- | -- | -- | - | -- | -- | - | 0.01 |
| DP-II | 5:4 | 21.7 | 0.09 | 5 | 22.6 | 0.13 | 4 | -- | -- | - | 0.05 |
| AP-BKG | 5:4 | 21.1 | 0.10 | 5 | 26.6 | 0.06 | 4 | -- | -- | - | 0.07 |
| AP-I | 5:5 | 22.1 | 0.08 | 5 | 23.3 | 0.12 | 5 | -- | -- | - | 0.07 |
| AP-II | 5:6 | 22.4 | 0.02 | 5 | 22.5 | 0.08 | 6 | -- | -- | - | 0.08 |
| AP-DP-III | 3:5 | 25.6 | 0.18 | 3 | 25.5 | 0.07 | 5 | 71.0 | 0.60 | 4 | 0.06 |
| *Peromyscus maniculatus* | | | | | | | | | | | |
| M-BKG | 11:5 | 17.7 | 0.09 | 10 | 16.7 | 0.18 | 5 | 17.0 | 0.32 | 3 | 0.08 |
| M-I | 2:2 | -- | -- | -- | -- | - | - | -- | -- | - | 0.02 |
| M-II | 5:7 | 18.6 | 0.04 | 5 | 24.5 | 0.08 | 7 | -- | -- | - | 0.07 |
| M-III | 10:10 | 17.3 | 0.08 | 10 | 16.3 | 0.10 | 10 | -- | -- | - | 0.09 |
| DP-BKG | --- | -- | -- | -- | -- | -- | -- | -- | -- | - | -- |
| DP-I | 1:4 | -- | -- | -- | 16.2 | 0.02 | 4 | -- | -- | - | 0.02 |
| DP-II | 1:2 | -- | -- | -- | -- | -- | - | -- | -- | - | 0.01 |
| AP-BKG | 0:2 | -- | -- | -- | -- | -- | - | -- | -- | - | 0.01 |
| AP-I | --- | -- | -- | -- | -- | -- | - | -- | -- | - | -- |
| AP-II | --- | -- | -- | -- | -- | -- | - | -- | -- | - | -- |
| AP-DP-III | --- | -- | -- | -- | -- | -- | - | -- | -- | - | -- |
| *Eutamias minimus* | | | | | | | | | | | |
| M-BKG | 13:5 | 57.4 | 0.08 | 13 | 59.2 | 0.09 | 5 | 32.5 | 0.23 | 5 | 0.27 |
| M-I | 2:3 | -- | -- | -- | 51.6 | 0.01 | 3 | -- | -- | - | 0.07 |
| M-II | 5:6 | 55.2 | 0.10 | 5 | 57.6 | 0.14 | 6 | -- | -- | - | 0.16 |
| M-III | --- | -- | -- | - | -- | -- | - | -- | -- | - | -- |
| DP-BKG | 14:6 | 59.1 | 0.06 | 11 | 65.6 | 0.13 | 6 | -- | -- | - | 0.28 |
| DP-I | 0:2 | -- | -- | -- | -- | -- | - | -- | -- | - | 0.03 |
| DP-II | 8:12 | 58.2 | 0.04 | 3 | 54.2 | 0.07 | 6 | 25.0 | 0.42 | 3 | 0.24 |
| AP-BKG | 3:5 | -- | -- | - | 60.9 | 0.13 | 4 | -- | -- | - | 0.11 |
| AP-I | 11:10 | 53.5 | 0.04 | 5 | 66.9 | 0.13 | 6 | -- | -- | - | 0.28 |
| AP-II | 1:5 | -- | -- | - | 60.5 | 0.11 | 5 | -- | -- | - | 0.10 |
| AP-DP-III | 8:11 | 56.3 | 0.09 | 3 | 61.2 | 0.14 | 5 | -- | -- | - | 0.23 |
| *Reithrodontomys megalotis*[e] | | | | | | | | | | | |
| M-BKG | --- | -- | -- | - | -- | -- | - | -- | -- | - | --- |
| M-I | --- | -- | -- | - | -- | -- | - | -- | -- | - | --- |
| M-II | --- | -- | -- | - | -- | -- | - | -- | -- | - | --- |
| M-III | 3:2 | 10.7 | 0.14 | 3 | 9.9 | 0.26 | 2 | -- | -- | - | 0.01 |
| DP-BKG | --- | -- | -- | -- | -- | -- | - | -- | -- | - | --- |
| DP-I | 7:4 | 11.4 | 0.10 | 7 | 11.1 | 0.18 | 4 | -- | -- | - | 0.03 |
| DP-II | 2:1 | -- | -- | -- | -- | -- | - | -- | -- | - | 0.01 |
| AP-BKG | --- | -- | -- | -- | -- | -- | - | -- | -- | - | --- |
| AP-I | --- | -- | -- | -- | -- | -- | - | -- | -- | - | --- |
| AP-II | 5:2 | 12.4 | 0.09 | -- | -- | -- | - | -- | -- | - | 0.02 |
| AP-DP-III | --- | -- | -- | -- | -- | -- | - | -- | -- | - | --- |

[a] Sex ratio includes all age individuals captured.

[b] Minimal biomass estimate calculations are for all individuals of that species captured.

[c] CV = Coefficient of Variation = Standard Deviation/Mean.

[d] N = Sample number for which mean adult weights were calculated.

[e] Insufficient recapture data were available for computing $\bar{x}$ distances between captures.

TABLE V

SEX RATIOS, WEIGHTS, AND MINIMAL BIOMASS ESTIMATES FOR FOUR SELECTED SPECIES OF SMALL MAMMALS AT INTENSIVE STUDY SITES DURING DECEMBER 1974-FEBRUARY 1975

| Location | Sex Ratio M:F[a] | Mean Adult Weight (g) M Mean | M CV[c] | M N[d] | F Mean | F CV | F N | Estimated Biomass[b] ($g/m^2$) |
|---|---|---|---|---|---|---|---|---|
| *Peromyscus truei* | | | | | | | | |
| M-BKG | 4:3 | 21.8 | 0.08 | 4 | 19.7 | 0.11 | 3 | 0.04 |
| M-I | 13:4 | 21.4 | 0.12 | 12 | 19.5 | 0.10 | 4 | 0.09 |
| M-III | --- | -- | -- | - | -- | -- | - | -- |
| DP-I | --- | -- | -- | - | -- | -- | - | -- |
| AP-I | 0:1 | -- | -- | - | 19.5 | -- | 1 | -- |
| AP-II | 2:0 | 17.5 | 0.12 | 2 | -- | -- | - | 0.01 |
| AP-DP-III | 10:11 | 18.7 | 0.22 | 6 | 20.6 | 0.15 | 3 | 0.10 |
| *Peromyscus maniculatus* | | | | | | | | |
| M-BKG | 7:5 | 18.2 | 0.10 | 6 | 20.0 | 0.25 | 2 | 0.06 |
| M-I | 1:3 | 20.0 | -- | 1 | 23.3 | -- | 1 | 0.02 |
| M-III | 1:0 | -- | -- | - | -- | -- | - | -- |
| DP-I | --- | -- | -- | - | -- | -- | - | --- |
| AP-I | --- | -- | -- | - | -- | -- | - | --- |
| AP-II | --- | -- | -- | - | -- | -- | - | --- |
| AP-DP-III | 1:0 | 15.5 | -- | 1 | -- | -- | - | -- |
| *Eutamias minimus* | | | | | | | | |
| M-BKG | 9:7 | 49.7 | 0.06 | 9 | 62.0 | 0.09 | 7 | 0.23 |
| M-I | 0:3 | -- | -- | - | 52.3 | 0.11 | 3 | 0.24 |
| M-III | --- | -- | -- | - | -- | -- | - | -- |
| DP-I | --- | -- | -- | - | -- | -- | - | -- |
| AP-I | 6:0 | 48.9 | 0.03 | 6 | -- | -- | - | 0.06 |
| AP-II | --- | -- | -- | - | -- | -- | - | -- |
| AP-DP-III | --- | -- | -- | - | -- | -- | - | -- |
| *Reithrodontomys megalotis* | | | | | | | | |
| M-BKG | --- | -- | -- | - | -- | -- | - | -- |
| M-I | --- | -- | -- | - | -- | -- | - | -- |
| M-III | --- | -- | -- | - | -- | -- | - | -- |
| DP-I | 5:0 | 8.7 | 0.05 | 5 | -- | -- | - | 0.01 |
| AP-I | --- | -- | -- | - | -- | -- | - | -- |
| AP-II | 1:1 | 11.0 | -- | 1 | 9.5 | -- | 1 | 0.01 |
| AP-DP-III | --- | -- | -- | - | -- | -- | - | -- |

[a] Sex ratio includes all age individuals captured.

[b] Minimal biomass estimate calculations are for all individuals of that species captured.

[c] CV = Coefficient of Variation = Standard Deviation/Mean.

[d] N = Sample number for which mean adult weights were calculated.

comprised 60% and 56% of the captures, respectively. Sex ratios for *Reithrodontomys* favored males as was expected from previous studies.[12] Sex ratios of about 1:1 were measured for total *Eutamias* captures during the spring session. However, because snowfall hampered trapping efforts during the winter session, three of the sites were trapped in late February. These were the only sites where *Eutamias* captures were recorded, and probably represented the first individuals to come out of hibernation. Sex ratios were highly variable from site to site for all species.

Mean live weights for adult *Peromyscus* were usually greater for females than males during the spring trapping session, and were attributed to the presence of pregnant females. Approximately 43% of P. truei females and 22% of P. maniculatus were judged to be reproductively active and/or lactating at the time of capture, although the percentage of those actually pregnant was not determined. Additionally, for E. minimus, the presence of yearlings in the population contributed to larger variations in mean weights. Weight differences between sexes of the four species were not as apparent during the winter trapping session.

Adult physical measurements, excluding weight, are listed in Appendix A for the four dominant species captured during the spring trapping session. These measurements were obtained from specimens used for radionuclide analysis and are generally within the ranges reported for each of the species.[8]

Minimal biomass estimates ($g/m^2$, live weight) for the four major species are also listed in Tables IV and V. Total minimal biomass estimates for the seven sites trapped during both sessions are represented graphically in Fig. 4. Density estimators, such as number (density) per hectare derived from total captures, do not appear to be applicable with the grid system employed for this study due to the peculiar topography of the canyon systems.

Movement patterns were calculated for the spring 1974 session, where data were available, and are presented in Table IV. Data for both males and females

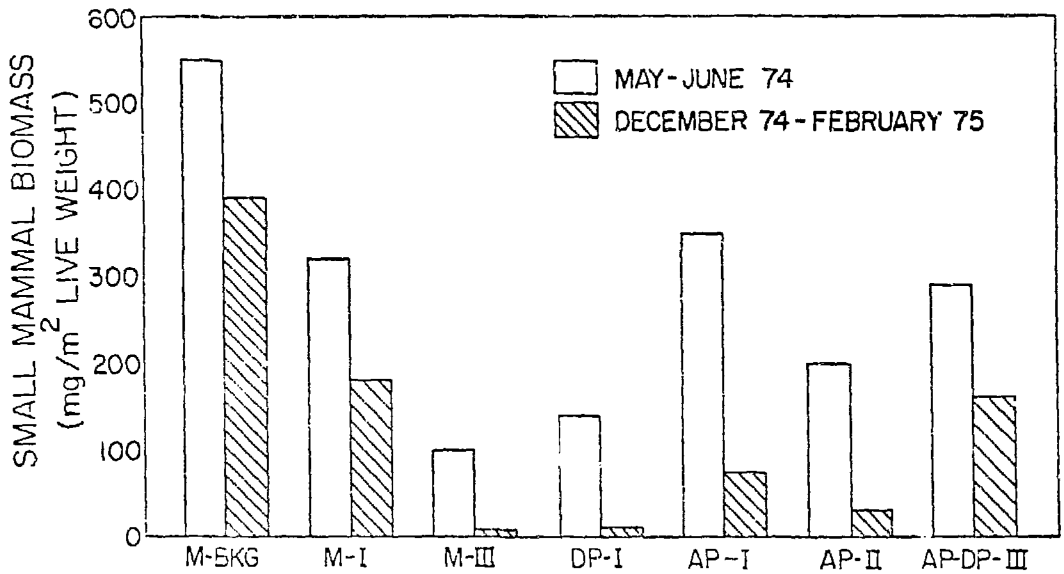


Fig. 4.
Small-mammal biomass estimates as a function of elevation and season at LASL liquid-effluent receiving areas.

were combined by species and were computed as mean distances between captures. The estimates were based on at least three adult individuals of each species that were captured a minimum of four times. Data from five sites for P. truei yielded 10 m between captures at DP-BKG compared to 21 m at AP-DP III. The maximum distance between successive points of capture recorded for a single P. truei was 65 m at M-BKG. Sufficient recapture data for P. maniculatus was available at only one site, M-BKG, with a mean of 17 m recorded between captures. The maximum distance between successive points of capture for an individual P. maniculatus was 52 m at Site DP-I. For E. minimus, mean distances of 25 m and 32.5 m between captures were recorded at Sites DP-II and M-BKG, respectively. The maximum distance between successive points of capture for an individual E. minimus was 74 m at Site M-BKG.

The maximum distance between successive points of capture of a single individual for each of these three species was more than double the length of the grid perpendicular to the stream channel (25 m). Therefore, mean distance movement calculations should logically represent a measure of movement parallel to the stream channel and should be interpreted as a minimal estimate of movement patterns perpendicular to the stream channel.

## C. Vegetation-Small Mammal Interrelationships

No significant correlations were found either between combined small mammal biomass per site for the spring session with understory vegetation biomass, or number of species of small mammals per site with total vegetation estimates. Both P. truei and E. minimus were captured at all sites but one, indicating that they are distributed throughout the canyon systems. However, P. maniculatus and R. megalotis captures were generally restricted to sites having dense stands of grasses and forbs. The spring 1974 data showed that the highest rodent densities and mass estimates were generally associated with the sites where the overstory vegetation was comprised of mixed ponderosa pine/piñon-juniper and were lowest in the piñon-juniper woodland. In Mortandad Canyon, an approximate 100-m decrease in elevation over a 4000-m distance corresponded to more than a fivefold decrease in combined rodent mass. However, such dramatic decreases were not as evident in the other two canyon systems. Low densities recorded at site locations DP-I and AP-BKG can be attributed, in part, to the large number of traps molested and/or sprung by predators.

The December-February mass estimates for Mortandad Canyon indicated a trend similar to the May-June results. However, results from the AP-DP Canyon systems were reversed: values obtained at AP-DP-III in the piñon-juniper woodland were greater by at least a factor of two than those obtained in the upper parts of the canyons.

## D. Incidental Occurrences of Small Mammals

An additional four species of rodents were noted during field observations or captured during other studies. These included the tassel-eared squirrel (Sciurus aberti), golden-mantled squirrel (Spermophilus lateralis), hispid cotton rat (Sigmodon hispidus), and the house mouse (Mus musculus). Field observations of S. aberti were at sites M-BKG, DP-BKG, DP-I, AP-BKG, and AP-I, in ponderosa pine overstory, with which this species is reported to be most commonly associated.[13] An individual S. lateralis was captured approximately 200 m east of M-BKG Site, in Mortandad Canyon. Specimens of S. hispidus and M. musculus were also captured in the upper portions of Mortandad Canyon.

## E. Climatology Data Base

Temperature and relative humidity data were calculated on a monthly basis for the Intensive Site I locations in Mortandad and DP-Los Alamos Canyons and for TA-8. Data from Acid-Pueblo canyon were omitted because of vandalism to equipment. Appendix B contains monthly extremes, average maximum and minimum temperature, relative humidity values, monthly mean temperature, and relative humidity for these three locations. Coefficient of variation values are also presented for the mean data. This mean represents the average daily temperature and relative humidity for the month.

Temperature ranges appeared to be fairly uniform for the entire area, although the mean temperature for DP Canyon was slightly lower. This station also appears to have a slightly higher mean relative humidity. The greatest daily temperature variations occurred in December, January, and February at all locations. Relative humidity variations were fairly uniform throughout the year with the largest variation occurring in May and June during a period of little rainfall. The maximum temperature encountered during this study period was 35.6° C recorded in Mortandad Canyon in July 1974 and again in June 1975. The minimum temperature recorded was -25.6° C in Mortandad Canyon during January 1975.

Seasonal variations and elevation influenced the precipitation distribution throughout the Intensive Site network, as illustrated for the Mortandad, DP-Los Alamos, and Acid-Pueblo Canyon systems in Figs. 5, 6, and 7, respectively. TA-8 is included in the Mortandad Canyon systems for purposes of comparison. Appendix C contains the monthly precipitation, in centimeters, for each of the 11 sampling locations, grouped by canyon system.

The elevation influences are best shown by the stations at the extremes, TA-8 at 2340 m and AP/DP Site III at 1755 m, which had 64 and 39 cm, respectively, of total precipitation during 1975. In general, precipitation decreased as elevation decreased. However, during the rainy season of July and August, the AP/DP Site III station received statistically the same rainfall as was recorded at the higher elevations. The variation in yearly precipitation results primarily from snowfall which is greater at higher elevations. This is shown by the data for TA-8 and by comparison of all stations for April 1975 when a record snowfall occurred above 2130 m, with very little precipitation recorded below that elevation.

The mean yearly precipitation totals by canyon system for 1975 were 52±7.4 cm for Mortandad Canyon, 43±3.5 cm for DP-Los Alamos Canyon, and 48±8.6 cm

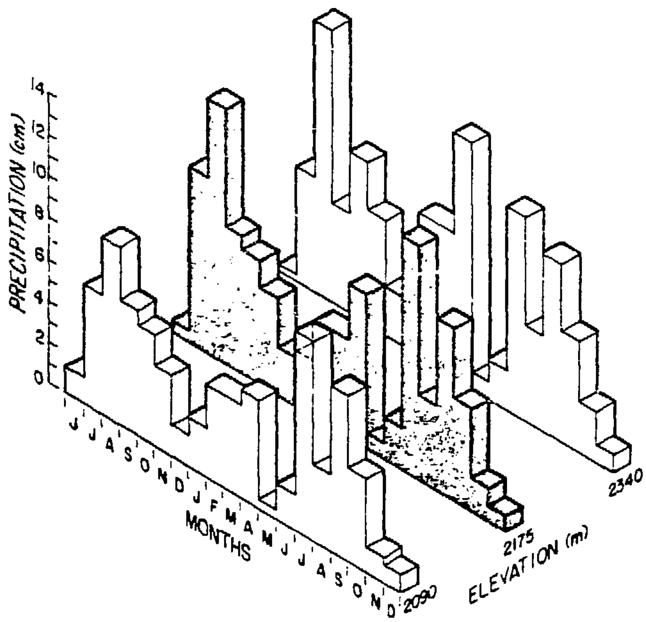


Fig. 5.
Monthly precipitation in centimeters for representative elevations in Mortandad Canyon.

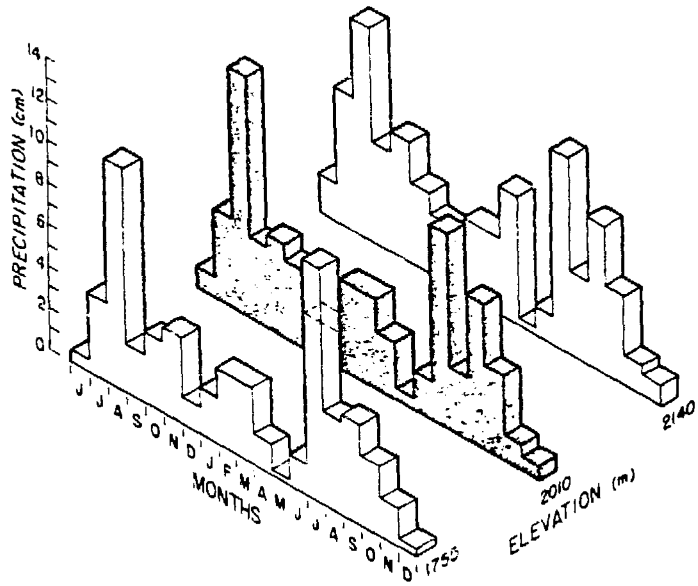


Fig. 6.
Monthly precipitation in centimeters for representative elevations in DP-Los Alamos Canyon.

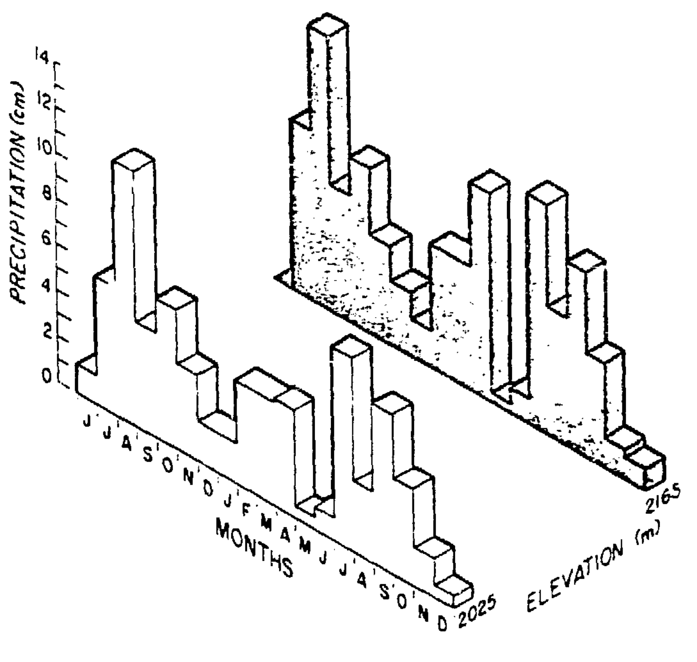


Fig. 7.
Monthly precipitation in centimeters for elevations of intensive sites in Acid-Pueblo Canyon.

for Acid-Pueblo Canyon. The mean yearly precipitation for the entire Intensive Site network was 48±7.2 cm (one standard deviation). Measurable precipitation fell at each of the 11 stations throughout the 19 months covered by this study.

## VI. SUMMARY AND CONCLUSIONS

Vegetation and small-mammal composition and distribution are described for three canyon systems which have served or are presently serving as receiving areas for treated low-level radioactive liquid wastes. The overstory vegetation may, for the most part, be categorized as mixed coniferous forests. Initial studies for the understory vegetation, performed in May 1974, indicated that the highest mass estimates for standing green vegetation were obtained in the study sites located in the upper portions of the canyons where the terrain and intermittent stream flow result in a generally wetter habitat. Mass estimates for understory vegetation generally decreased with distance down the canyon systems where stream flows are primarily intermittent and result from storm runoff. Vegetation study plots adjacent to the stream bank in all three canyon systems indicated mass estimates for grass species to decrease with coincident decreases in elevations, while the pattern was reversed for forbs. Although the greatest precipitation levels were in the upper portions of the canyons, the largest total mass estimates for grass and forb species combined were recorded at the lower elevations.

Ten species of small mammals were trapped at 11 study sites established within the three canyon systems during May and June 1974 and from December 1974 through February 1975. An additional four species were recorded through field observations and incidental trappings related to the canyon studies. Trapping results indicate four species of importance. Peromyscus truei (38% of total captures) and Eutamias minimus (30%) were captured at all sites but one, indicating that they are distributed through most canyon systems; Peromyscus maniculatus (15%) and Reithrodontomys megalotis (6%) were generally associated with sites having dense stands of grasses and forbs.

The spring 1974 data indicate that the highest rodent mass estimates were generally associated with the ponderosa pine/piñon-juniper woodland and were lowest in the piñon-juniper woodland. This was most evident in Mortandad Canyon where a 100-m decrease in elevation over a 4000-m distance corresponded to more than fivefold derease in combined rodent mass. However, such dramatic decreases were not recorded in the other two canyon systems. Winter trapping results showed a similar trend for Mortandad Canyon. The AP-DP Canyon systems indicated a reversal of this trend, with the study site located at the lowest elevation registering the higher mass estimates by factors of two and greater.

ACKNOWLEDGMENTS

Many individuals of LASL's Group H-8, whose important contributions and assistance have made this report possible, deserve credit and recognition. These include Leo Martinez, Gloria Martinez, Max Maes, Richard Romero, Laura Quintana, and Eliza Trujillo. Special recognition is due Wayne Hanson, also of H-8.

REFERENCES


1. T. E. Hakonson, J. W. Nyhan, L. J. Johnson, and K. V. Bostick, "Ecological Investigation of Radioactive Materials in Waste Discharge Areas at Los Alamos for the Period July 1, 1972, through March 31, 1973," Los Alamos Scientific Laboratory report LA-5282-MS (May 1973).

2. E. C. Anderson and E. M. Sullivan, Comps., "Annual Report of the Biomedical and Environmental Research Program of the LASL Health Division, January through December 1974," Los Alamos Scientific Laboratory report LA-5883-PR, (February 1975), pp. 46-62.

3. T. E. Hakonson and K. V. Bostick, "Cesium-137 and Plutonium in Liquid Waste Disposal Areas at Los Alamos," in Radioecology and Energy Resources, Proc. 4th Nat. Symp. Radioecology, C. E. Cushing, Jr., Ed. (Dowden, Hutchinson and Ross, Inc., Stroudsburg, PA., 1976), pp. 41-48.

4. J. W. Nyhan, F. R. Miera, Jr., and R. J. Peters, "The Distribution of Plutonium and Cesium in Alluvial Soils of the Los Alamos Environs," in Radioecology and Energy Resources, Proc. 4th Nat. Symp. Radioecology, C. E. Cushing, Jr., Ed. (Dowden, Hutchinson and Ross, Inc., Stroudsburg, PA, 1976), pp.49-57.

5. H. D. Harrington, Manual of the Plants of Colorado (Sage Books, Denver, CO, 1964).

6. W. A. Weber, Rocky Mountain Flora (University of Colorado Press, Boulder, CO 1967).

7. Technical Report No. 145, "Basic Field Data Collection Procedures for the Grassland Biome 1972 Season," US International Biological Program, Grassland Biome (1972).

8. E. Raymond Hall and Keith R. Kelson, The Mammals of North America, Vols. I and II (The Ronald Press Company, NY 1959).

9. James S. Findley, Arthur H. Harris, Don E. Wilson, and Clyde Jones, Mammals of New Mexico (University of New Mexico Press, Albuquerque, NM, 1975).

10. David M. Armstrong, Distribution of Mammals in Colorado (University of Kansas Printing Service, Lawrence, KS, 1972).

11. C. R. Terman and J. F. Sassaman, "Sex Ratio in Deer Mouse Populations," J. Mamm. 48 (4), 589-597 (1967).

12. G. H. Richins, H. D. Smith, and C. D. Jorgenson, "Growth and Development of the Western Harvest Mouse, Reithrodontomys megalotis," Great Basin Naturalist, 34, 105-120 (1974).

13. J. O. Keith, "The Abert Squirrel and Its Dependence on Ponderosa Pine," Ecology, 46, 150-163 (1965).

APPENDIX A

PHYSICAL MEASUREMENTS OF ADULT SMALL MAMMALS, ± 1 STD DEV, COLLECTED FROM LIQUID-EFFLUENT RECEIVING AREAS DURING MAY-JUNE 1974

| Location: | Total Length (mm) | | Tail Length (mm) | | Hind Foot Length (mm) | | Ear Height (mm) | |
|---|---|---|---|---|---|---|---|---|
| | M | F | M | F | M | F | M | F |
| Peromyscus maniculatus | | | | | | | | |
| M-BKG | 159±4 (4)[a] | 149±14 (5) | 66±3 (4) | 64±8 (5) | 20±1 (5) | 19±1 (5) | 17±1 (4) | 15±1 (5) |
| M-I | ---- | ---- | ----- | ---- | ---- | ---- | ----- | ---- |
| M-II | 172±0 (2) | 164±43 (2) | 83±6 (2) | 78±32 (2) | 22±1 (2) | 19±5 (2) | 19±1 (2) | 12±3 (2) |
| M III | 144±7 (3) | 148±1 (2) | 64±5 (3) | 66±1 (2) | 21±1 (3) | 21±1 (2) | 17±0 (3) | 16±1 (2) |
| DP-BKG | ---- | ---- | ----- | ---- | ---- | ---- | ----- | ---- |
| DP-I | ---- | 143±6 (3) | ----- | 64±4 (3) | ---- | 19±1 (4) | ----- | [illegible]±1 (4) |
| DP-II | ---- | ---- | ----- | ---- | ---- | ---- | ----- | ---- |
| AP-BKG | ---- | ---- | ----- | ---- | ---- | ---- | ----- | ---- |
| AP-I | ---- | ---- | ----- | ---- | ---- | ---- | ----- | ---- |
| AP-II | ---- | ---- | ----- | ---- | ---- | ---- | ----- | ---- |
| AP-DP-III | ---- | ---- | ----- | ---- | ---- | ---- | ----- | ---- |
| Peromyscus truei | | | | | | | | |
| M-BKG | 170±8 (6) | 184±6 (6) | 85±3 (6) | 94±6 (6) | 21±1 (6) | 21±1 (6) | 22±1 (6) | 20±1 (6) |
| M-I | 164±14 (7) | 174±14 (6) | 86±16 (7) | 88±5 (6) | 22±1 (7) | 22±1 (6) | 21±1 (6) | 20±1 (6) |
| M-II | 174±4 (8) | 183±6 (6) | 82±5 (8) | 92±5 (6) | 21±1 (8) | 22±1 (6) | 20±2 (8) | 22±1 (6) |
| M-III | ---- | ---- | ----- | ---- | ---- | ---- | ----- | ---- |
| DP-BKG | 176±7 (4) | 177±7 (4) | 91±2 (4) | 92±4 (4) | 23±1 (4) | 23±1 (4) | 23±1 (4) | 23±1 (4) |
| DP-I | ---- | ---- | --- | ---- | ---- | ---- | ----- | ---- |
| DP-II | 186±14 (4) | 192±17 (3) | 100±8 (4) | 100±11 (3) | 21±1 (4) | 21±1 (3) | 21±1 (4) | 20±1 (2) |
| AP-BKG | ---- | ---- | ---- | ---- | ---- | ---- | ----- | ----- |
| AP-I | 159±4 (5) | 171±5 (3) | 86±8 (5) | 86±4 (3) | 21±1 (5) | 23±1 (3) | 20±1 (5) | 21±2 (3) |
| AP-II | - -- | ---- | ---- | ---- | ---- | ---- | ----- | ----- |
| AP-DP-III | 177±9 (3) | 179±13 (3) | 86±8 (3) | 89±6 (3) | 23±1 (3) | 22±1 (3) | 24±0 (3) | 26±1 (3) |
| Eutamias minimus | | | | | | | | |
| M-BKG | 215±6 (5) | ---- | 94±7 (5) | ---- | 32±1 (5) | ---- | 18±1 (5) | ----- |
| M-I | ---- | 210 (1) | - | 93 (1) | ---- | 32 (1) | ---- | 16 (1) |
| M-II | ---- | ---- | -- -- | ---- | ---- | ---- | --- | ----- |
| M-III | ---- | ---- | ----- | ---- | ---- | ---- | ---- | ----- |
| DP-BKG | 203±6 (3) | 213±4 (2) | 92±3 (3) | 98±4 (2) | 32±1 (3) | 32±2 (2) | 18±1 (3) | 17±0 (2) |
| DP-I | ---- | ---- | -- - | --- | ---- | ---- | ---- | ----- |
| Eutamias minimus | | | | | | | | |
| DP-II | 223±1 (2) | 232±25 (2) | 100±1 (2) | 115±20 (2) | 32±0 (2) | 33±1 (2) | 20±1 (2) | 19±1 (2) |
| AP-BKG | 225±9 (3) | ----- | 102±6 (3) | ----- | 33±2 (3) | ----- | 18±1 (3) | ----- |
| AP-I | 233±31 (2) | 199±10 (3) | 98±3 (2) | 100±13 (3) | 34±3 (3) | 31±1 (3) | 16±3 (3) | 16±3 (3) |
| AP-II | ---- | ----- | ---- | ----- | ---- | ----- | ---- | ----- |
| AP-DP-III | 215 (1) | 232±18 (3) | 95 (1) | 97±3 (3) | 33 (1) | 34±2 (3) | 17 (1) | 14±1 (3) |
| Reithrodontomys megalotis | | | | | | | | |
| M-BKG | 126±8 (4) | 134±5 (4) | 66±7 (4) | 59±4 (4) | 18±1 (4) | 17±3 (4) | 12±1 (4) | 15±1 (4) |

[a]Number = number of individual measurements.

# APPENDIX B

## MORTANDAD CANYON

| | CELSIUS TEMPERATURES | | | | | | RELATIVE HUMIDITY | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DATE | MAX | AVG MX | MIN | AVG MN | MEAN | CV | MAX | AVG MX | MIN | AVG MN | MEAN | CV |
| 9/73 | 27 | 22 | -0.56 | 4.9 | 13 | 0.69 | 100 | 88 | 13 | 26 | 57 | 0.57 |
| 10/73 | 25 | 19 | - 5.6 | 0.61 | 9.7 | 1.0 | 94 | 78 | 10 | [illegible] | 51 | 0.56 |
| 11/73 | 21 | 12 | -12 | -4.2 | 4.0 | 2.5 | 93 | 82 | 12 | 27 | 54 | 0.54 |
| 12/73 | 12 | 4.8 | -12 | -9.0 | -2.1 | -3.7 | 97 | 80 | 12 | 33 | 58 | 0.48 |
| 1/74 | 13 | 3.9 | --- | ---- | ---- | ---- | 93 | 87 | 20 | 39 | 63 | 0.41 |
| 2/74 | 14 | 6.9 | -16 | -10 | -1.7 | -5.8 | 97 | 84 | 4 | 29 | 57 | 0.52 |
| 3/74 | 20 | 14 | -11 | -2.5 | 5.6 | 1.6 | 90 | 69 | 4 | 16 | 43 | 0.66 |
| 4/74 | 24 | 16 | - 7.8 | -1.3 | 7.1 | 1.4 | 90 | 67 | 0 | 13 | 40 | 0.76 |
| 5/74 | 33 | 26 | - 3.3 | 5.3 | 15 | 0.71 | 86 | 57 | 0 | 7.5 | 32 | 0.89 |
| 6/74 | 34 | 30 | - 1.1 | 8.8 | 19 | 0.58 | 86 | 63 | 0 | 9.1 | 36 | 0.83 |
| 7/74 | 36 | 29 | 6.7 | 10 | 19 | 0.49 | 89 | 73 | 3 | 17 | 45 | 0.66 |
| 8/74 | 31 | 26 | 6.1 | 9.8 | 18 | 0.49 | 89 | 83 | 12 | 26 | 55 | 0.56 |
| 9/74 | 31 | 21 | - 1.7 | 6.3 | 14 | 0.65 | 96 | 84 | 10 | 34 | 59 | 0.50 |
| 10/74 | 26 | 16 | - 4.4 | 2.4 | 9.2 | 0.89 | 99 | 91 | 18 | 43 | 67 | 0.41 |
| 11/74 | 13 | 9.2 | -15 | -5.0 | 2.1 | 3.8 | 100 | 93 | 18 | 36 | 65 | 0.46 |
| 12/74 | 8.9 | 1.9 | -20 | -13 | -5.5 | -1.6 | 84 | 79 | 9 | 33 | 56 | 0.44 |
| 1/75 | 14 | 2.8 | -26 | -12 | -4.7 | -2.1 | 87 | 80 | 11 | 33 | 57 | 0.44 |
| 2/75 | 14 | 7.4 | -20 | -8.1 | -0.36 | -24 | 80 | 76 | 15 | 30 | 53 | 0.47 |
| 3/75 | 16 | 9.4 | -11 | -3.5 | 2.9 | 2.5 | 81 | 73 | 5 | 24 | 48 | 0.53 |
| 4/75 | 24 | 14 | - 7.2 | -1.6 | 6.0 | 1.5 | 84 | 75 | 8 | 22 | 48 | 0.59 |
| 5/75 | 28 | 22 | - 5.0 | 2.0 | 12 | 0.89 | 85 | 71 | 0 | 11 | 41 | 0.77 |
| 6/75 | 36 | 29 | - 1.1 | 7.0 | 18 | 0.65 | 77 | 62 | 0 | 5.0 | 33 | 0.91 |
| 7/75 | 31 | 27 | 6.7 | 9.9 | 19 | 0.48 | 76 | 73 | 7 | 13 | 45 | 0.63 |
| 8/75 | 32 | 28 | 6.1 | 9.7 | 19 | 0.51 | 78 | 70 | 1 | 13 | 42 | 0.72 |

APPENDIX B (contd)

DP CANYON

| DATE | CELSIUS TEMPERATURES | | | | | | RELATIVE HUMIDITY | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MAX | AVG MX | MIN | AVG MN | MEAN | CV | MAX | AVG MX | MIN | AVG MN | MEAN | CV |
| 9/73 | 26 | 21 | -2.2 | 1.9 | 11 | 0.88 | 100 | 94 | 13 | 25 | 60 | 0.64 |
| 10/73 | 24 | 17 | -8.9 | -2.4 | 7.4 | 1.4 | 100 | 98 | 10 | 28 | 63 | 0.59 |
| 11/73 | 18 | 11 | -12 | -6.9 | 2.2 | 4.8 | 100 | 99 | 12 | 28 | 63 | 0.62 |
| 12/73 | 12 | 5.7 | ---- | ---- | ---- | ---- | 100 | 91 | 10 | 33 | 66 | 0.52 |
| 1/74 | 11 | 2.9 | -12 | -11 | -3.9 | -2.0 | 100 | 98 | 24 | 44 | 71 | 0.42 |
| 2/74 | 14 | 5.6 | -18 | -12 | -3.1 | -3.1 | 100 | 98 | 13 | 29 | 64 | 0.56 |
| 3/74 | 20 | 13 | -12 | -4.9 | 4.1 | 2.4 | 100 | 93 | 8 | 23 | 58 | 0.63 |
| 4/74 | 23 | 16 | -10 | -3.7 | 6.2 | 1.8 | 100 | 78 | 0 | 12 | 45 | 0.78 |
| 5/74 | 30 | 25 | -6.7 | 2.0 | 13 | 0.89 | 98 | 75 | 0 | 8.9 | 42 | 0.84 |
| 6/74 | 33 | 29 | -1.7 | 6.2 | 17 | 0.68 | 99 | 80 | 0 | 8.8 | 44 | 0.84 |
| 7/74 | 31 | 27 | 5.6 | 8.4 | 18 | 0.54 | 98 | 85 | 1 | 19 | 52 | 0.66 |
| 8/74 | 27 | 23 | 3.3 | 7.3 | 15 | 0.56 | 100 | 94 | 12 | 30 | 62 | 0.54 |
| 9/74 | 28 | 21 | -2.2 | 4.6 | 13 | 0.72 | 100 | 89 | 6 | 30 | 59 | 0.56 |
| 10/74 | 26 | 16 | -6.1 | 0.91 | 8.4 | 1.1 | 100 | 95 | 9 | 44 | 70 | 0.43 |
| 11/74 | 13 | 8.7 | -19 | -6.9 | 0.90 | 9.9 | ---- | ---- | 18 | 37 | ---- | --- |
| 12/74 | 5.6 | 0.50 | -23 | -16 | -7.7 | -1.2 | 97 | 94 | 11 | 38 | 66 | 0.44 |
| 1/75 | 13 | 2.4 | -23 | -13 | -5.4 | -1.8 | 98 | 94 | 20 | 41 | 67 | 0.41 |
| 2/75 | 12 | 4.9 | -23 | -10 | -2.7 | -3.2 | 97 | 91 | 18 | 37 | 64 | 0.46 |
| 3/75 | 15 | 9.0 | -12 | -4.9 | 2.1 | 3.9 | 97 | 89 | 8 | 29 | 59 | 0.54 |
| 4/75 | 22 | 12 | -9.4 | -3.8 | 4.3 | 2.2 | 100 | 91 | 2 | 23 | 57 | 0.64 |
| 5/75 | 31 | 19 | -9.4 | -1.5 | 8.8 | 1.3 | 99 | 87 | 1 | 14 | 51 | 0.75 |
| 6/75 | 30 | 25 | -3.3 | 3.6 | 15 | 0.80 | 92 | 80 | 0 | 9.6 | 45 | 0.82 |
| 7/75 | 29 | 26 | 6.7 | 8.7 | 17 | 0.51 | 100 | 95 | 13 | 28 | 62 | 0.56 |
| 8/75 | 30 | 26 | 2.2 | 7.9 | 17 | 0.56 | 100 | 97 | 9 | 24 | 61 | 0.62 |

APPENDIX B (contd)

TA-8

| | CELSIUS TEMPERATURES | | | | | | RELATIVE HUMIDITY | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DATE | MAX | AVG MX | MIN | AVG MN | MEAN | CV | MAX | AVG MX | MIN | AVG MN | MEAN | CV |
| 9/73 | 26 | 21 | -1.7 | 4.2 | 12 | 0.73 | 100 | 85 | 12 | 30 | 57 | 0.53 |
| 10/73 | 25 | 18 | -6.1 | 1.2 | 9.5 | 0.98 | 88 | 70 | 14 | 25 | 48 | 0.54 |
| 11/73 | 20 | 11 | -12 | -4.4 | 3.2 | 3.0 | 89 | 68 | 13 | 25 | 47 | 0.52 |
| 12/73 | 13 | 4.8 | -12 | -9.3 | -2.3 | -3.5 | 87 | 71 | 10 | 28 | 49 | 0.50 |
| 1/74 | 15 | ---- | ---- | ---- | ---- | ---- | 89 | 79 | 11 | 35 | 57 | 0.43 |
| 2/74 | 14 | ---- | ---- | ---- | ---- | ---- | 86 | 75 | 12 | 28 | 51 | 0.49 |
| 3/74 | 24 | 14 | -11 | -3.4 | 5.1 | 1.8 | 94 | 75 | 10 | 27 | 51 | 0.53 |
| 4/74 | 21 | 14 | -8.9 | -2.2 | 5.9 | 1.6 | 89 | 65 | 7 | 19 | 42 | 0.62 |
| 5/74 | 31 | 23 | -3.3 | 5.1 | 14 | 0.69 | 84 | 52 | 3 | 13 | 33 | 0.73 |
| 6/74 | 33 | 27 | -1.1 | 8.4 | 18 | 0.57 | 77 | 57 | 1 | 11 | 34 | 0.74 |
| 7/74 | 31 | 26 | 5.6 | 9.5 | 18 | 0.49 | 78 | 69 | 8 | 19 | 44 | 0.61 |
| 8/74 | 29 | 24 | 6.1 | 9.2 | 17 | 0.48 | 96 | 87 | 19 | 34 | 60 | 0.48 |
| 9/74 | 31 | 22 | 2.8 | 6.7 | 14 | 0.62 | 96 | 82 | 14 | 35 | 59 | 0.49 |
| 10/74 | 28 | 14 | -5.6 | 1.1 | 7.7 | 1.0 | 99 | 89 | 19 | 47 | 68 | 0.37 |
| 11/74 | 14 | 8.6 | -14 | -5.3 | 1.7 | 4.6 | 100 | 86 | 12 | 37 | 62 | 0.44 |
| 12/74 | 13 | 3.6 | -18 | -11 | -3.6 | -2.3 | 74 | 64 | 13 | 24 | 44 | 0.49 |
| 1/75 | 13 | 3.7 | -18 | -9.7 | -3.0 | -2.9 | 78 | 68 | 11 | 29 | 49 | 0.44 |
| 2/75 | 10 | 3.9 | -21 | -10 | -3.2 | -2.6 | 77 | 68 | 12 | 26 | 47 | 0.48 |
| 3/75 | 13 | 6.9 | -14 | -5.3 | 0.81 | 9.3 | 73 | 66 | 1 | 22 | 44 | 0.54 |
| 4/75 | 18 | 11 | -9.4 | -2.8 | 4.2 | 2.1 | 75 | 63 | 7 | 22 | 42 | 0.57 |
| 5/75 | 24 | 18 | -6.1 | 1.0 | 9.5 | 0.99 | 81 | 65 | 4 | 15 | 40 | 0.66 |
| 6/75 | 30 | 25 | -2.2 | 6.3 | 15 | 0.64 | 77 | 57 | 2 | 10 | 33 | 0.77 |
| 7/75 | 29 | 25 | 7.8 | 9.6 | 17 | 0.47 | 82 | 79 | 15 | 28 | 53 | 0.51 |
| 8/75 | 30 | 26 | 6.1 | 9.2 | 18 | 0.50 | 98 | 87 | 9 | 26 | 57 | 0.57 |

APPENDIX C

MONTHLY PRECIPITATION BY SITE FOR EACH CANYON SYSTEM

*(Units of measure are centimeters)*

| Month | MORTANDAD CANYON SYSTEM TA-8 (2340 m) | BKGD (2190 m) | Site I (2165 m) | Site II (2090 m) | Site III (2085 m) | DP-LOS ALAMOS CANYON SYSTEM BKGD (2145 m) | Site I (2135 m) | Site II (2010 m) | Site III[a] (1755 m) | ACID-PUEBLO CANYON SYSTEM Site I (2165 m) | Site II (2025 m) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| June, 1974 | 0.2 | 0.2 | 1.0 | 1.3 | 1.2 | 2.0 | 1.8 | 1.0 | 0.5 | -- | 1.3 |
| July | 5.6 | 8.4 | 8.5 | 6.8 | 4.7 | 6.7 | 6.1 | 4.3 | 3.7 | 7.4 | 5.6 |
| August | 13.2 | 11.8 | 13.0 | 9.4 | 7.8 | 10.2 | 10.1 | 11.5 | 10.7 | 12.0 | 11.1 |
| September | 4.9 | 6.6 | 6.8 | 6.2 | 5.7 | 4.9 | 4.6 | 3.9 | 2.3 | 5.6 | 4.6 |
| October | 7.9 | 5.9 | 6.0 | 5.9 | 4.9 | 6.0 | 5.6 | 4.5 | 3.5 | 7.3 | 6.2 |
| November | 5.6 | 5.2 | 4.4 | 4.1 | 3.7 | 4.1 | 3.6 | 3.8 | 4.1 | 4.4 | 3.8 |
| December | 2.4 | 2.0 | 3.0 | 1.1 | 1.8 | 3.5 | 2.3 | 1.8 | 1.2 | 2.9 | 1.8 |
| Total (1974) | 39.8 | 40.1 | 42.7 | 34.8 | 29.8 | 37.4 | 34.1 | 30.9 | 26.0 | 39.6 | 34.3 |
| | | | | | | | | | | | |
| January, 1975 | 3.5 | 2.0 | 1.5 | 2.9 | 1.8 | 3.5 | 3.2 | 1.8 | 2.1 | 1.7 | 1.8 |
| February[b] | 6.9 | 4.5 | 4.8 | 4.9 | 4.1 | 3.5 | 3.7 | 4.3 | 3.8 | 5.4 | 4.5 |
| March[b] | 6.9 | 4.5 | 4.8 | 4.9 | 4.1 | 3.5 | 3.7 | 4.3 | 3.8 | 5.4 | 4.5 |
| April | 11.9 | 7.4 | 7.4 | 6.3 | 4.0 | 6.2 | 6.0 | 2.8 | 1.5 | 9.1 | 4.7 |
| May | 0.9 | 0.8 | 0.8 | 0.6 | 0.1 | 0.6 | 0.2 | 0.5 | 0.2 | 0.4 | 0.5 |
| June | 1.9 | 2.1 | 1.9 | 1.9 | 1.6 | 1.4 | 1.4 | 1.9 | 1.5 | 1.3 | 1.0 |
| July | 9.8 | 11.1 | 11.4 | 9.7 | 9.7 | 10.3 | 8.6 | 9.4 | 11.3 | 10.1 | 8.6 |
| August | 4.7 | 3.8 | 4.3 | 4.2 | 3.1 | 4.2 | 3.8 | 3.0 | 4.5 | 5.7 | 3.1 |
| September | 8.6 | 8.2 | 8.3 | 7.6 | 8.4 | 7.5 | 6.8 | 7.0 | 4.9 | 8.7 | 7.0 |
| October | 5.4 | 5.1 | 4.8 | 4.6 | 4.5 | 4.4 | 4.1 | 4.1 | 3.4 | 4.7 | 4.3 |
| November | 2.4 | 2.1 | 1.3 | 1.7 | 0.9 | 1.3 | 1.6 | 1.3 | 1.9 | 1.4 | 1.7 |
| December | 0.9 | 0.8 | 0.8 | 0.8 | 0.9 | 0.8 | 1.1 | 0.7 | 0.4 | 1.0 | 0.6 |
| Total (1975) | 63.8 | 52.4 | 52.1 | 50.1 | 43.2 | 47.2 | 44.2 | 41.1 | 39.3 | 54.4 | 42.3 |

[a]This station is located below the confluence of the DP-Los Alamos and Acid-Pueblo Canyon systems.

[b]Averaged over a 2-month period.

☆ U S GOVERNMENT PRINTING OFFICE 1977—777-018/4