MOHAVE GROUND SQUIRREL STUDY IN WEST MOJAVE COORDINATED MANAGEMENT PLAN CORE RESERVES

KERN AND SAN BERNARDINO COUNTIES

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SUMMARY

The Mohave ground squirrel (*Spermophilus mohavensis*) has been designated as one of the primary target-species to be protected under the proposed West Mojave Coordinated Management Plan (WMCMP). In support of the WMCMP, field studies of the Mohave ground squirrel (MGS) were carried out at 12 locations in Kern and San Bernardino counties during May-June 1994 and April-May 1995. Field investigations were conducted at nine of these sites in 1994 and at three additional sites in 1995. These study sites were selected to represent major vegetation community-types within the proposed core reserves (A-zones) to be managed for the benefit of the MGS and other wildlife and plant species under the WMCMP.

The field effort included live-trapping to confirm the presence of MGS within the core reserves and to estimate relative abundance. The live-trapping procedure also sampled populations of the white-tailed antelope ground squirrel (*Ammospermophilus leucurus*). In order to obtain data on the food habits of the two species, fecal samples were collected and analyzed histologically. Vegetation surveys were conducted along 5 transect lines per grid to determine the frequencies of perennial and annual plant species and to gather data on the frequencies of bare ground, rock and litter. Complete lists of both perennial and annual plant species were compiled for each grid.

Mohave ground squirrels were caught at eight of the 12 study sites, while white-tailed antelope ground squirrels (AGS) were caught at all locations. A total of 26 MGS and 450 AGS were captured over all 12 trapping grids. AGS were more abundant than MGS at the eight sites where they occurred together. In 1994, a drought year, there were no captures of juvenile MGS and very few captures of juvenile AGS. In 1995, a year with above-average winter rainfall, both ground squirrel species reproduced.

Microhistological analysis of fecal samples of MGS showed that the diet was composed almost entirely of leaf material from forbs and shrubs. Important food items included the forbs *Gilia/Linanthus*, *Layia*, and *Astragalus*, and the shrubs *Atriplex and Larrea*. The relatively large proportion of the diet contributed by *Larrea* on two of the study sites is an interesting result, since this shrub has not been shown to be an important food item in similar studies in the Coso region of Inyo County.

The production of annual herbaceous vegetation in 1994 was very low, most likely as a result of low winter rainfall. The two northernmost grids, 1 and 2, supported the highest number of annual plant species and more herbaceous production in general. The other grids contained significantly fewer annual plant species than were observed on grids 1 and 2. In 1995, annual herbaceous production was much higher as a result of considerably above-average winter rainfall.

INTRODUCTION

This study was designed to support the West Mojave Coordinated Management Plan (WMCMP) by providing current data regarding Mohave ground squirrel (MGS) populations within areas designated as core reserves under the WMCMP.

The WMCMP is a multi-agency, multi-species planning effort being undertaken to protect sensitive biological resources of the western Mojave Desert. The primary focus of the WMCMP is to ensure the survival of the desert tortoise and the MGS by maintaining the long-term viability and genetic diversity of their populations. Consistent with these goals, management opportunities will be identified that allow human use of desert resources and economic growth.

The WMCMP divides the western Mojave Desert into three main management zones: core preserves, managed-use areas and development zones. Core reserves (Zone A's) are designated for protection of listed and candidate species of plants and animals as well as the associated plant communities. Managed-use areas (Zone B's) are designed to protect special status species in conjunction with certain resource uses, such as mining, livestock grazing, and OHV recreation. Development zones (Zone C's) are areas which will not be managed for perpetuation of target species or plant communities. The core reserves are linked to managed-use areas and are made up primarily of federal land. The development zones include mainly private land. Scattered throughout the managed-use areas and development zones are a number of small "specialty preserves" designed to protect rare or unique biological resources which are not included in the core reserves.

The present field study was carried out in the five southern WMCMP core reserves in Kern and San Bernardino counties. The five major objectives of this study are listed below:

1. Conduct live-trapping investigations to determine the presence of MGS in each major vegetation community-type within the core reserves.

2. Obtain data on relative abundance of adult MGS for each study site using sampling techniques patterned after the methods of the Coso Grazing Exclosure Study.

3. Obtain data on food habits by collection and analysis of fecal samples from captured MGS and AGS.

4. Select study sites that may be suitable for permanent monitoring under the WMCMP.

5. Sample vegetation to characterize the habitat of each study site.

NATURAL HISTORY OF MOHAVE GROUND SQUIRRELS AND WHITE-TAILED ANTELOPE GROUND SQUIRRELS

Mohave Ground Squirrel

The MGS is a small, diurnal ground squirrel with a relatively short tail. It has large almond-shaped eyes set high on the head. Its fur is gray above and whitish below. Juveniles have been described as having "a cinnamon-color, molting to gray as they mature" (Gustafson 1993).

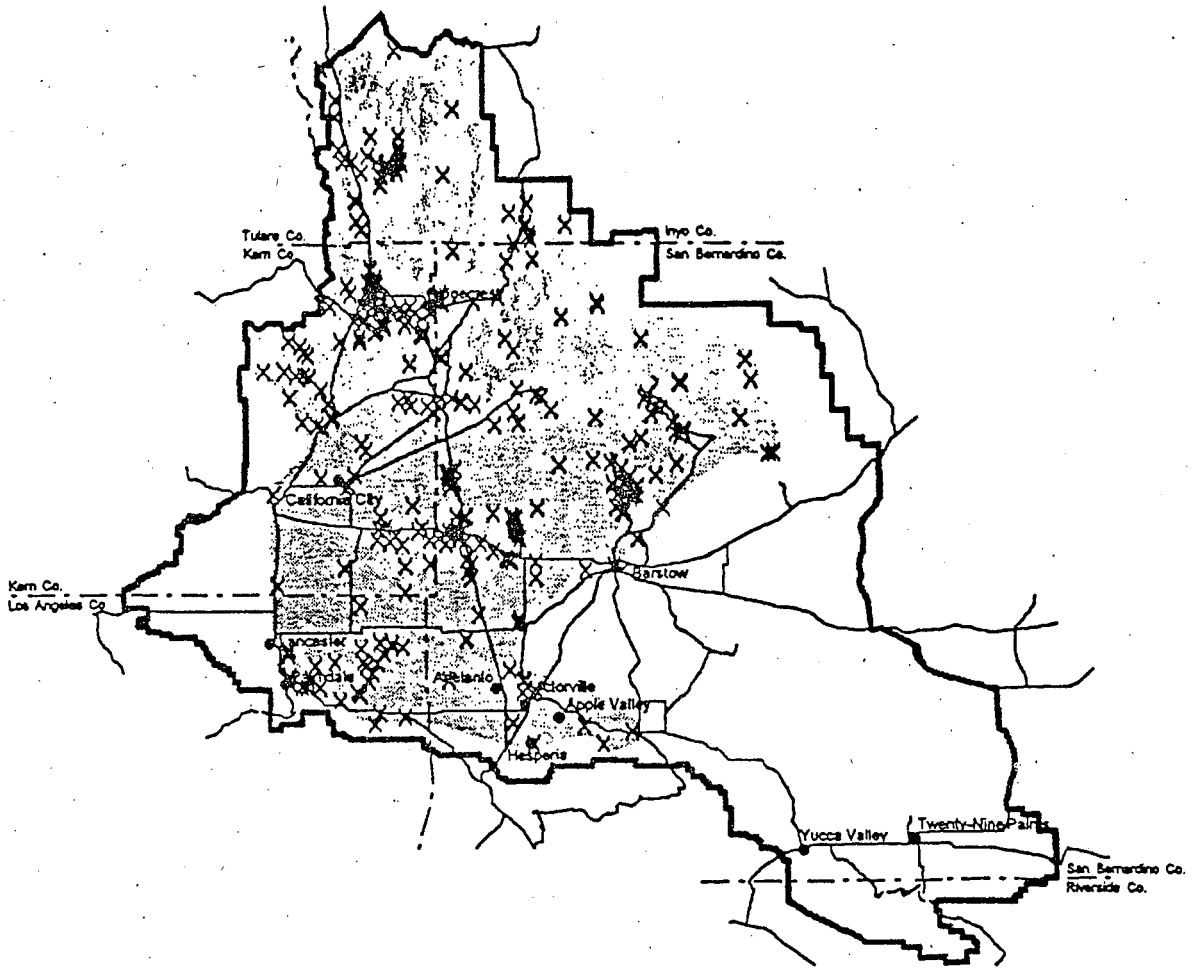
These ground squirrels are active above ground for only 6-7 months each year. The duration of their active period is dependent upon the abundance of food. It may extend from February through July or August. They spend the rest of the year underground in a state of physiological dormancy. MGS begin to enter estivation (summer dormancy) when the annual herbaceous vegetation has dried. Dormancy extends through a fall and winter hibernation period, ending when new growth begins on the shrubs and forbs.

Recht (unpubl.) has reported that MGS mate soon after emergence from hibernation. Litters average 4-6 young which are born after a gestation period of 28-30 days. In years with extremely low precipitation and poor growth of annual plants, MGS have been reported not to reproduce (Leitner et al. 1995).

The diet of the MGS is composed mainly of the leaves of shrubs and forbs, with some contribution from shrub and forb seeds, pollen and flower parts, and occasional arthropods (Leitner et al. 1993).

Figure 1 shows the geographic range of the MGS, based on a compilation of records by Debi Clark, formerly of BLM, Barstow (D. Clark, unpubl. data). The species is restricted to the western Mojave Desert, where it can be found at elevations between 600 m and 1700 m (2000-5600 ft). Its range extends from the southern edge Owens Lake in Inyo County, south along the eastern base of the Sierra Nevada to the vicinity of Lancaster and Palmdale. It is found as far east as Fort Irwin, Barstow, and Lucerne Valley. The California Department of Fish and Game reports the MGS to occur in all "broad plant-communities within its range. Also, there is reason to believe that the squirrel occurs in all of the specific plant-communities within its range" (Gustafson 1993).

Currently the MGS is listed as threatened by the California Fish and Game Commission and is a candidate for listing (Category 2) by the U.S Fish and Wildlife Service. In 1993, the California Fish and Game Commission made the decision to remove the MGS from the state list of threatened species. This decision is currently under litigation.



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Mohave Ground Squirrel Range

Sighting or Trap Location

WMCMP Boundary

occurrences?

Figure 1. Range of the Mohave ground squirrel.

White-tailed Antelope Ground Squirrel

The white-tailed antelope ground squirrel (AGS) is slightly smaller than the MGS. These animals are grayish-brown above, with one white stripe down each side, and white underneath including the underside of the tail. They usually hold the tail closely over the back while running (Ingles 1965).

The AGS exhibits diurnal activity throughout the year and is capable of being active during the hottest parts of the day, even in mid-summer. The reproductive season occurs between February and June and litter size ranges from 5-14, with an average of nine. Females may have two litters in one year, but one is more common (Zeiner et al. 1990). They are omnivores, feeding on seeds, fruits, green vegetation, arthropods, and carrion.

This species is distributed over the entire California desert region from Mono County south to Mexico and along the northeastern border of California in Lassen and Modoc counties. It is found in a variety of habitats including desert scrub, sagebrush, alkali desert scrub, Joshua tree woodland, bitterbrush scrub, and pinyon-juniper woodland as well as in desert riparian, desert succulent scrub, desert wash habitats, mixed chaparral, and annual grasslands (Zeiner *et al.* 1990).

It has been claimed that the Mohave and white-tailed antelope ground squirrels are able to exist sympatrically because the MGS are in dormancy for much of the year, minimizing interspecific competition (Bartholomew and Hudson 1961). The AGS, on the other hand, remains active in the hottest parts of the day, even during summer (Ingles 1965). Its adaptations to the desert include a higher thermal neutral zone (32-42 degrees C) than any other non-sweating mammal and emergency evaporative cooling by salivation.

TRAPPING GRID DESCRIPTIONS

Selection of Trapping Grids

The selection of suitable trapping locations began by reviewing GIS overlays of major vegetation community-types within the core reserves of the WMCMP. It was determined that two of the major vegetation community types in the core reserves were Mojave creosote bush scrub and Mojave desert saltbush scrub. After a general area within a core reserve was chosen as a potential study location, field reconnaissance was conducted to determine the precise location of each trapping grid.

Twelve trapping grids were selected, with either two or three trapping grids located in each core reserve. The El Paso, Kramer, and Superior core reserves had two grids each; there were three grids each in the Rand and Buckhorn core reserves. Each core

reserve contains both a creosote bush site and a saltbush site with the exception of the Rand Mountain core reserve which included three creosote bush sites but no saltbush sites, and the El Paso core reserve which included one creosote bush site and one Mojave mixed woody scrub site. Figure 2 shows the location of each grid within the WMCMP boundaries.

Trapping Grid Locations

The grid locations are as follows (see Appendix III for site maps shown on U.S. Geologic Survey 1:24,000 scale quads):

1.	Freeman Gulch	T27S	R38E,	Secs. 32 and 33 (MDM)
2.	Last Chance	T28S	R38E,	Secs. 29 and 32 (MDM)
3.	Red Buttes	T8N	R7W,	Secs. 11 and 14 (SBM)
4.	Buckthorn Wash	T8N	R5W,	Sec. 6 (SBM)
		T9N	R5W,	Sec. 31 (SBM)
5.	Boron NE	T32S	R41E,	Secs. 14 and 23 (MDM)
6.	Harper Lake	T11N	R43E,	Secs. 9, 10, 15 and 16 (SBM)
7.	Red Mountain	T30S	R39E,	Sec. 36 (MDM)
8.	Superior Lake	T31S	R46E,	Sec. 19 (MDM)
9.	Lane Mountain	T32S	R46E,	Secs. 26, 35 and 36 (MDM)
10.	Red Mountain II	T30S	R39E,	S1/2 Sec. 26 (MDM)
11.	Fremont Valley	T29S	R40E,	Secs. 28 and 29 (MDM)
12.	Red Buttes II	T8N	R7W,	Secs. 15 and 22 (SDM)

General Description of Trapping Grids

All of the grids with the exception of Grid 7 at Red Mountain are on public lands managed by the BLM. Grid 7 is owned by the California Department of Fish and Game. Elevation, topography and dominant vegetation will be described here.

Grid 1 - Freeman Gulch

This is the northernmost grid, located approximately 8.5 miles south of the town of Inyokern in Kern County. The study site is relatively flat with an elevation of 884 m (2900 ft). The grid is bisected by the access road. This Mojave mixed woody scrub area is dominated by spiny hopsage (*Grayia spinosa*) and burrobush (*Ambrosia dumosa*). Cooper's boxthorn (*Lycium cooperi*) and Cooper's goldenbush (*Ericameria cooperi*) are also common. Production of annual herbaceous plant species was low but with a fairly high species richness (37 species - second highest of all nine grids).

Grid 2 - Last Chance (Canyon)

This grid is located approximately 13.5 miles south of the town of Inyokern (five miles south of Grid 1). It is situated at an elevation of 1000 m (3300 ft) at the head of an alluvial fan that slopes upward to the east. There is a large wash at the southwestern edge of the grid and a rocky slope rises above the

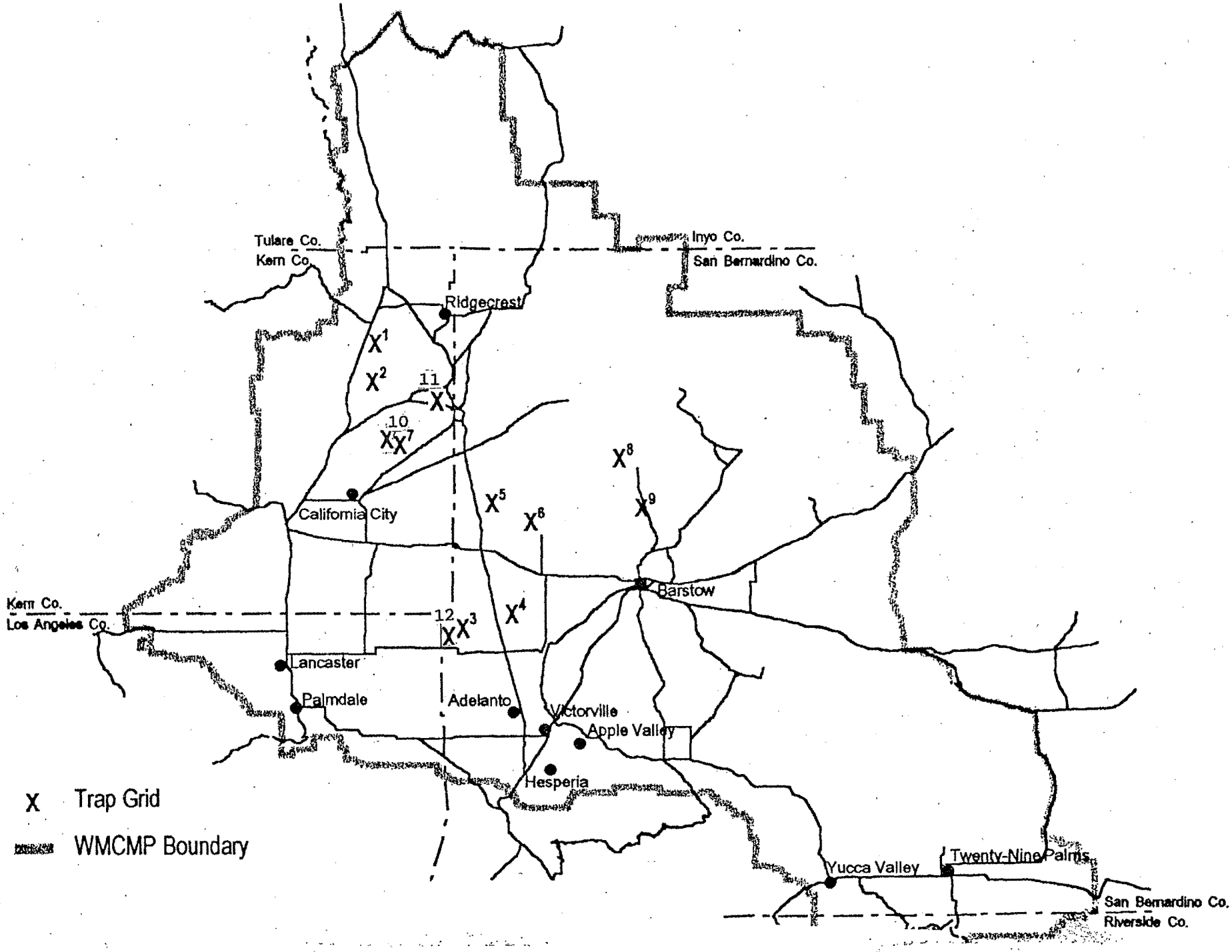


Figure 2. Mohave ground squirrel trapping grids, 1994 and 1995.

eastern edge. In this Mojave creosote bush scrub area, the dominant vegetation is creosote bush (*Larrea tridentata*), burrobush, winterfat (*Krascheninnikovia lanata*) and goldenhead (*Acamptopappus sphaerocephalus*). There is also a number of Joshua trees (*Yucca brevifolia*) on the grid. This site had 49 species of annual herbaceous plants, the highest number recorded on the nine sites studied in 1994.

Grid 3 - Red Buttes

Grid 3 is located approximately 15 miles south of Kramer Junction and 6 miles west of Highway 395 in San Bernardino County. It is at an elevation of 914 m (3000 ft.) and slopes upward from south to north. This Mojave creosote bush scrub site is dominated by burrobush and creosote bush with an occasional Joshua tree. There are a few small rocky knolls, although they do not significantly affect the overall topography. There was almost no annual herbaceous growth at this site in 1994.

Grid 4 - Buckthorn Wash

The fourth grid is located approximately 12 miles south of Kramer Junction and 2.3 miles east of Highway 395 at an elevation of 818 m (2685 ft). It is a flat Mojave saltbush scrub area dominated almost entirely by Mojave saltbush (*Atriplex spinifera*) with a small number of burrobush. There was a slightly higher production of annual herbaceous plants compared to grid 3, but still almost none.

Grid 5 - Boron NE

This grid is located approximately 11 miles north of Kramer Junction and almost 2 miles east of Highway 395. It is situated at an elevation of 832 m (2730 ft) in a relatively flat Mojave saltbush scrub expanse. Vegetation consists mainly of Mojave saltbush, and to a slightly lesser extent, shadscale (*Atriplex confertifolia*) and burrobush. Most of the site is characterized by hard-packed clay soil, although there are two raised areas, or hummocks, that appear to be stabilized dunes with a more sandy soil. These hummocks support a greater diversity of shrub species than the rest of the grid. Annuals were slightly more abundant here than on grids 3 and 4, but there was far less species richness and productivity than on grids 1 and 2.

Grid 6 - Harper Lake

The Harper Lake grid is 2 miles west and 1 mile north of the Harper Lake Luz sub-station, at an elevation of 693 m (2275 ft). It is generally flat, but a large wash runs through the middle of the site. The Mojave creosote bush scrub community here consists mainly of creosote bush, burrobush and allscale (*Atriplex polycarpa*). The wash supports a slightly more diverse assemblage

of shrubs than the rest of the grid, including a fair number of Mojave indigo bush (*Psorothamnus fremontii*). There was almost no annual growth in 1994.

Grid 7 - Red Mountain

The only grid not located on BLM land and without an access road through the middle, grid 7 is situated on property owned by the California Department of Fish and Game. It is approximately 9-10 miles west of the town of Red Mountain and 1 mile north of the Mojave-Randsburg Rd., at an elevation ranging from 1079 m (3540 ft) in the southwest corner to 1109 m (3640 ft) in the northeast corner. A wash runs across the extreme southwest corner of the grid and up along the western edge just outside the grid. Creosote bush and Cooper's goldenbush are the dominant shrubs in this Mojave creosote bush scrub community. Joshua trees are also present in fair numbers. Annual growth was similar to Grid 5 in 1994. This grid has been grazed heavily by sheep in past years.

Grid 8 - Superior Lake

Grid 8 is approximately 23 miles north of Barstow in Superior Valley, at an elevation of 921 m (3020 ft). The dominant shrubs in this Mojave saltbush scrub site are burrobush and Mojave saltbush. One Joshua tree is located on the grid. Only two annual plant species were recorded in 1994 and their abundance was very low.

Grid 9 - Lane Mountain

The last grid trapped in 1994 is located on Coolgardie Mesa approximately 15 miles north of Barstow at an elevation ranging from 1085 m to 1110 m (3560 ft to 3640 ft). The lowest point on the site is on the north side and it slopes upward to the east and south. Shrub species richness is somewhat higher than on grids 2, 6, and 7, the most common species being creosote bush, spiny hopsage and winterfat followed closely by Mormon-tea (*Ephedra nevadensis*) and turpentine bush (*Thamnosma montanum*). Annual plant growth here in 1994 was noticeably more abundant than on grids 3 through 8, but it was lower in species richness than grids 1 and 2.

Grid 10 - Red Mountain II

This grid is located about one-half mile west-northwest of Grid 7, on the south-facing upper slopes of the Rand Mountains. The elevation range for this site is about 1090 to 1110 m (3600 to 3670 ft). It is located just north of the California City corporate boundary in an area of Mojave creosote bush scrub dominated by Cooper's goldenbush, creosote bush, and goldenhead. This site has a greater shrub species richness than Grid 7. Annual plant growth was relatively abundant here in 1995, as would be expected for a year with much higher than average precipitation.

Grid 11 - Fremont Valley

Grid 11 is located on an unpaved road parallel to and 0.4 mi north of the Randsburg-Red Rock Road in Fremont Valley. The site is about 3 mi northwest of Randsburg and is located on a west-sloping bajada that extends up to the base of the Rand Mountains. The elevation range for the grid is 810 to 830 m (2660 to 2740 ft). This site was relatively low in shrub species diversity, as is typical for Mojave creosote bush scrub. The predominant shrub species, which together comprise 95 percent of shrub frequency, are burrobush, goldenhead, and creosote bush. As with the other two grids sampled in 1995, annual plants were abundant.

Grid 12 - Red Buttes II

This grid is about 1.5 miles southwest of Grid 3, west of Highway 395 and south of the southeastern portion of Edwards Air Force Base. The elevation range for the grid is from about 890 to 900 m (2950-2960 ft). The natural community is a Mojave saltbush scrub dominated by Mojave saltbush, with minor amounts of other shrubs, including burrobush and winterfat. Production of annual herbaceous plants was high here in 1995.

METHODS

Size and Configuration of Trapping Grids

Each of the trapping grids measured 500 by 500 m (1640 by 1640 ft) for a total area of 25 ha (61.8 ac). Traps were placed 50 m apart for a total of 121 trap stations (11 by 11 grid configuration). Pymatuning traps were used on the first 5 grids in 1994, while Tomahawk brand traps were used for the remaining 7 grids. Both types of traps are constructed primarily of wire mesh and their dimensions are approximately 12 x 12 x 40 cm (4.75 x 4.75 x 16 in).

Each trap station was given an alpha-numeric designation based upon a 21 by 21 grid configuration with traps at 25 m intervals. In a 21 by 21 grid, lettered lines run from A to U and numbered lines run from 1 to 21; trap station identifiers range from A-1 through U-21. Because traps were placed at 50 m intervals in this study, alternate letters and numbers were used. Thus, lettered lines were A, C, E, G, I, K, M, O, Q, S, and U, while odd numbers 1 through 21 were used for numbered lines. Typically the K-line ran along the access road. Wire flags were used to temporarily mark each of the trap stations and permanent orange plastic stakes were used to mark the K-1 and K-21 stations. Grid 7 is not bisected by an access road, but is bordered by roads on the north and west sides, one road being 25 m from the A line and the other 25 m from the 21 line. On grid 7, permanent plastic stakes were placed at the A-1 and A-21 stations, adjacent to one of the peripheral roads.

Daily Trapping Procedures

Traps were operated for five consecutive days at each grid. Each day, the traps were opened between 0630 and 0830 hours and baited with a commercially available horse feed containing various grains (Kruse's Perfection brand horse ration with molasses). The traps were checked on a regular schedule two to three times a day and closed each afternoon between 1600 and 1800 hours.

During each trap check, all ground squirrels captured were identified to species, sex, and age class (juvenile/adult). Body mass was determined at first capture using a 300 g Pesola spring scale. Reproductive condition was assessed, checking for signs of pregnancy, lactation, previous lactation or no lactation in females, and scrotal or non-scrotal testes in males. Each animal was individually marked on the ventral side with a blue Sharpee brand indelible pen using an alpha order lettering system. The animal was released at the capture location after all data were collected. All information was recorded on an individual animal data sheet upon first capture, as well as on a daily summary sheet (see Appendix VI for field survey forms). Upon subsequent recapture the species, age, sex and "identification letter" of the ground squirrel were recorded on the daily summary sheet for that particular day.

Special precautions were taken to protect captured ground squirrels from heat stress. When possible, traps were placed on the northeast side of shrubs for maximum shade during the hottest part of the day. Each trap was protected from the sun with a cover made from a sheet of white corrugated cardboard measuring 61 by 71 cm (24 by 28 in). These covers were folded to form an inverted V when placed over the traps and were held down with two 6-inch nails inserted through the cardboard into the soil on either side. Dirt was then placed over the edges of the covers for additional weight to guard against wind theft. Temperature inside a shaded test trap was monitored throughout the day. If internal trap temperature reached 39 degrees C (102 degrees F), all traps on the grid were closed until conditions returned to a safe level.

Ground Squirrel Food Habits

The diets of the Mohave ground squirrel (MGS) and white-tailed antelope ground squirrel (AGS) were documented by the microscopic examination of undigested food material found in fecal samples.

In 1994, fecal samples were taken from every MGS captured and from the first 10 adult AGS of each sex captured on each trapping grid. On the first occasion that each ground squirrel was captured, three fresh fecal pellets were removed from the trap. The pellets were placed in a small envelope which was sealed and labeled to indicate the species, sex, age class, identification code, date, study site and trap station. After each capture, all remaining

fecal pellets were cleared from the trap, thus ensuring that a subsequent sample could be accurately attributed to a known individual.

Fecal samples were analyzed for botanical composition at the Composition Analysis Laboratory, Fort Collins, Colorado. The microhistological technique used is described in detail in Hansen *et al.* (1974) and Foppe (in prep.). Each fecal sample was prepared and processed in the laboratory and transferred to a microscope slide for the identification of discernable food materials. Plant fragments were identified to genus and species where possible; seed and leaf from the same plant taxon could often be differentiated. Twenty fields containing at least three identifiable fragments were examined on each slide using a phase-contrast microscope at 100X power. The occurrence of discernable fragments was recorded for each field and was used to compute the percent frequency for all material present in the sample. Percent frequency was then converted to percent relative density for each plant species. Relative density for a food item is thus considered to be a reasonable estimate of its dry weight contribution to the diet.

Vegetation Surveys

Five transects of 500 m each were conducted using a variation of the step-point method of sampling (Evans and Love 1957). A mark was made on the inside of the observer's right shoe near the toe. A sample, or hit, was recorded every time a step was taken with the right foot. Whatever was touching the mark on the shoe was recorded on a data sheet (Appendix VI). Sample categories were perennial plant species, annual plant species (the current year's annual growth), and bare ground, litter and rock collectively. These transects followed the B, F, J, N, and R lines across the grid. Plant species lists for annual and perennial vegetation were also compiled for each grid, based upon transect sampling and general observations (Appendix I).

RESULTS

Ground Squirrel Abundance and Demography

Results of 1994 trapping. A total of 20 individual MGS and 373 individual AGS were captured at all nine grids between May 1 and June 17, 1994. Sampling effort totaled 5,445 trap days (121 traps x 5 days x 9 grids). Table 1 gives a summary of MGS and AGS captures by grid, sex and age class. Using the total number of individuals captured as an index of relative abundance, AGS were more abundant than MGS on all grids. No MGS were taken on grids 3 and 7. Grid 1 had by far the highest abundance of MGS, with 9 individuals, while number of individuals on the other grids ranged from 1 to 3. AGS numbers ranged from a minimum of 27 individuals on Grid 9 to a maximum of 68 individuals on Grid 4.

Table 1. Summary of 1994 trapping results, grids 1-9.

Grid 1 (Freeman Gulch) - May 1-5, 1994.

Mohave Ground Squirrels

	Male	Female	Total
Juvenile	0	0	0
Adult	6	3	9
Total	6	3	9

Antelope Ground Squirrels

	Male	Female	Total
Juvenile	0	0	0
Adult	34	24	58
Total	34	24	58

Grid 2 (Last Chance) - May 7-11, 1994.

Mohave Ground Squirrels

	Male	Female	Total
Juvenile	0	0	0
Adult	2	1	3
Total	2	1	3

Antelope Ground Squirrels

	Male	Female	Total
Juvenile	0	0	0
Adult	14	16	30
Total	14	16	30

Grid 3 (Red Butte) - May 14-18, 1994.

Mohave Ground Squirrels

	Male	Female	Total
Juvenile	0	0	0
Adult	0	0	0
Total	0	0	0

Antelope Ground Squirrels

	Male	Female	Total
Juvenile	0	0	0
Adult	21	17	38
Total	21	17	38

Table 1 (contd.)

Grid 4 (Buckthorn Wash) - May 16-20, 1994.

Mohave Ground Squirrels

	Male	Female	Total
Juvenile	0	0	0
Adult	0	1	1
Total	0	1	1

Antelope Ground Squirrels

	Male	Female	Total
Juvenile	1	1	2
Adult	33	33	66
Total	34	34	68

Grid 5 (Boron NE) - May 22-26, 1994.

Mohave Ground Squirrels

	Male	Female	Total
Juvenile	0	0	0
Adult	1	1	2
Total	1	1	2

Antelope Ground Squirrels

	Male	Female	Total
Juvenile	0	0	0
Adult	15	18	33
Total	15	18	33

Grid 6 (Harper Lake) - May 27-31, 1994.

Mohave Ground Squirrels

	Male	Female	Total
Juvenile	0	0	0
Adult	1	0	1
Total	1	0	1

Antelope Ground Squirrels

	Male	Female	Total
Juvenile	0	0	0
Adult	16	17	33
Total	16	17	33

Table 1 (contd.)

Grid 7 (Red Mountain) - June 4-8, 1994.

Mohave Ground Squirrels

	Male	Female	Total
Juvenile	0	0	0
Adult	0	0	0
Total	0	0	0

Antelope Ground Squirrels

	Male	Female	Total
Juvenile	4	2	6
Adult	12	14	26
Total	16	16	32

Grid 8 (Superior Lake) - June 7-11, 1994.

Mohave Ground Squirrels

	Male	Female	Total
Juvenile	0	0	0
Adult	0	2	2
Total	0	2	2

Antelope Ground Squirrels

	Male	Female	Total
Juvenile	0	0	0
Adult	19	36	54
Total	19	36	54

Grid 9 (Lane Mountain) - June 13-17, 1994.

Mohave Ground Squirrels

	Male	Female	Total
Juvenile	0	0	0
Adult	2	0	2
Total	2	0	2

Antelope Ground Squirrels

	Male	Female	Total
Juvenile	0	0	0
Adult	13	14	27
Total	13	14	27

Overall, 12 male MGS were taken as compared to 8 females, with more males than females recorded on all but two grids. The overall sex ratio for AGS was approximately 1:1, with a total of 182 males and 191 females captured on all nine grids. Numbers of male and female AGS on individual grids were roughly equal, except for Grid 1 with 34 males and 24 females and Grid 8 with 19 males and 36 females.

All MGS captured were adults and none of the females showed signs of reproductive activity such as pregnancy or lactation. Adult female AGS showed no evidence of reproduction on grids 1, 3, 5, 6, and 8, and no AGS juveniles were captured on these sites. On grids 2 and 9, female AGS showing signs of reproduction were recorded, but no juveniles were captured. Grids 4 and 7 had several female AGS showing signs of reproduction and a few juveniles were captured.

Body mass for the MGS ranged from 131 to 219 grams, while adult AGS ranged in body mass from 66 to 129 grams. In general, ground squirrels caught on grids with little annual growth and more bare ground tended to have lower body mass than ground squirrels on grids with more abundant annual growth. The body mass for juvenile AGS ranged from 59 to 75 grams. The heavier juveniles were not caught until early June on grid 7.

Results of 1995 trapping. Table 2 gives a summary of MGS and AGS captured by grid, sex and age class during the period from April 22 through May 31, 1995. The sampling effort during this period was 1,815 trap days (121 traps x 5 days x 3 grids). A total of six individual MGS and 77 individual AGS were captured at the three grids (grids 10 through 12).

MGS were captured only at Grid 12; no MGS were caught at grids 10 or 11. In contrast to 1994, there was clear evidence of reproduction in this species since all of the MGS captured at Grid 12 were juveniles. They were captured in diagonally opposite corners of the grid, suggesting that at least two litters had been produced at this site.

AGS were captured at all three grids, although their numbers were very low at grids 10 and 11, where six and four individual adults were taken, respectively. At Grid 12, the total number of individual AGS was much higher; over two-thirds of the 67 AGS taken there were juveniles. Although no juvenile AGS were captured at grids 10 and 11, lactating and pregnant adult females were taken at these sites in late April and early May, respectively. It is likely that juveniles were not trapped at grids 10 and 11 because they were not yet active outside their natal burrows. Since Grid 12 was trapped later in the season, juvenile AGS were probably more active above-ground and consequently more likely to be captured. At all grids, adult female AGS were more abundant than adult males.

Table 2. Summary of 1995 trapping results, grids 10-12.

Grid 10 (Red Mountain II) - April 22-26, 1995.

Mohave Ground Squirrels

	Male	Female	Total
Juvenile	0	0	0
Adult	0	0	0
Total	0	0	0

Antelope Ground Squirrels

	Male	Female	Total
Juvenile	0	0	0
Adult	2	4	6
Total	2	4	6

Grid 11 (Fremont Valley) - May 9-13, 1995.

Mohave Ground Squirrels

	Male	Female	Total
Juvenile	0	0	0
Adult	0	0	0
Total	0	0	0

Antelope Ground Squirrels

	Male	Female	Total
Juvenile	0	0	0
Adult	1	3	4
Total	1	3	4

Grid 12 (Red Buttes II) - May 26-31, 1995.

Mohave Ground Squirrels

	Male	Female	Total
Juvenile	0	6	6
Adult	0	0	0
Total	0	6	6

Antelope Ground Squirrels

	Male	Female	Total
Juvenile	21	26	47
Adult	8	12	20
Total	29	38	67

At Grid 10 there were 4 females and 2 males, at Grid 11, 3 females and 1 male, and at Grid 12 there were 12 females and 8 males.

Body mass of MGS captured at Grid 12 varied from 71 to 140 grams, a range that is typical for juveniles at the end of May. The body mass for adult AGS ranged from 69 to 123 grams, and for juveniles from 52 to 84 grams.

Ground Squirrel Food Habits

This section presents results of analysis of fecal samples by microhistological technique. Analysis was done only for samples collected in 1994; no samples from 1995 were analyzed.

Mohave ground squirrels. Table 3 presents a summary of the food habits analysis for MGS captured on the seven WMCMP core reserves in May and June 1994. Overall, the MGS diet in 1994 was dominated by shrub and forb leaf, with these two categories combined making up 90-100 percent of the diet at all seven trapping grids. However, the relative proportions of shrub and forb leaf were highly variable from site to site, with the diet strongly dominated by shrub leaf on three grids and by forb leaf on three grids.

Creosote bush (*Larrea tridentata*) leaf made up a substantial part of the diet on grids 2 and 9, while saltbush (*Atriplex* sp.) leaf was important on grids 4, 5, 6, and 8. Winterfat (*Krascheninnikovia lanata*) and spiny hopsage (*Grayia spinosa*) leaf made a minor contribution to the diet, mainly on grids 1 and 9.

Only three species of forbs appeared in significant amounts in the MGS samples analyzed. Rattleweed (*Astragalus* sp.) made up almost two-thirds of mean relative density of samples collected from Grid 8, while *Gilia/Linanthus* leaf was well-represented in the diet on grids 1 and 9. The only other forb contributing substantially was *Layia*, especially on grids 4, 5, and 8, where its relative density averaged from 14 to 66 percent in the samples analyzed.

There was considerable variation from site to site in the average number of food items represented in each sample. The mean number of food items ranged from a high of 5.5-5.8 in samples collected from grids 1 and 9 to a low of 1.5-2.0 in samples collected from grids 4, 5, and 6.

Antelope ground squirrels. Table 4 presents data on food habits of AGS on all nine trapping grids in 1994. Shrub and forb leaf made up most of the AGS diet during the May-June trapping period, although the proportion contributed by each of these categories varied substantially from site to site. Arthropod (insect) material was also of importance at five of the grids, where it ranged from 11 to 22 percent mean relative density.

Table 3. Food habits of Mohave ground squirrels at seven trapping grids, 1994.

Mean percent relative density of food items in fecal samples
(Frequency of food item occurrence in parentheses)

Food Item	Trapping Grid Number 1	2	4	5	6
GRASSES AND ALLIES					
Bromus leaf					
Hilaria leaf	5.2 (0.5)	1.7 (0.5)			
Poa leaf	0.9 (0.2)				
Schismus leaf	3.6 (0.4)	1.7 (0.5)			
Vulpia leaf	1.1 (0.2)				
Total	10.8	3.4	0.0	0.0	0.0
SHRUBS					
Atriplex leaf	0.8 (0.2)		53.5	33.0 (1.0)	96.5 (1.0)
Cactus stem	0.2 (0.1)				
Ephedra stem	4.3 (0.4)				
Grayia leaf	9.1 (0.8)			1.2 (0.5)	
Krascheninnikovia lf.		1.7 (0.5)			
Larrea leaf	0.8 (0.1)	87.9 (1.0)			
Larrea seed					
Tetradymia leaf					
Total	15.2	89.6	53.5	34.2	96.5
FORBS					
Astragalus leaf	1.6 (0.1)				
Camissonia leaf	1.2 (0.4)				
Composite seed		7.0 (1.0)			
Eremalche lf.					
Eremocarpus leaf					
Eriogonum leaf					
Erodium leaf					
Gilia/Linanthus lf.	67.2 (1.0)				3.5 (0.5)
Flower parts	1.6 (0.4)				
Layia leaf	0.5 (0.1)		46.5	65.8 (1.0)	
Legume pod	0.3 (0.1)				
Lupinus leaf					
Salvia sp. leaf	1.1 (0.2)				
Salvia columbariae	0.3 (0.1)				
Unknown forb	0.3 (0.1)				
Total	74.1 (1.0)	7.0 (1.0)	46.5	65.8 (1.0)	3.5 (0.5)
OTHER					
Arthropod	0.3 (0.1)	0.0	0.0	0.0	0.0
Total	100.4	100.0	100.0	100.0	100.0
No. samples	8	2	1	2	2
Items/sample: mean	5.8	3.5	2	1.5	1.5
range	(1-10)	(2-5)	2	(1-2)	(1-2)

Table 3 (contd.)

Mean percent relative density of food items in fecal samples
(Frequency of food item occurrence in parentheses)

Food Item	Trapping Grid Number 8	Trapping Grid Number 9
GRASSES		
Bromus leaf		3.4 (0.5)
Poa leaf		
Schismus leaf		
Vulpia leaf		
Total	0.0	3.4
SHRUBS		
Atriplex leaf	13.5 (0.5)	5.2 (0.5)
Cactus stem		
Ephedra stem		
Grayia leaf		7.2 (0.5)
Krascheninnikovia lf.		9.3 (0.5)
Larrea leaf		49.9 (1.0)
Larrea seed		0.9 (0.5)
Tetradymia leaf		
Total	13.5	72.5
FORBS		
Astragalus leaf	63.9 (1.0)	
Camissonia leaf		
Composite seed	3.2 (0.8)	
Gilia/Linanthus lf.		21.5 (1.0)
Flower parts	2.6 (0.2)	
Layia leaf	13.6 (1.0)	
Legume pod		
Lupinus leaf		1.7 (0.5)
Salvia sp.		
Salvia columbariae		
Unknown forb		
Total	83.3	23.2
OTHER		
Arthropod	3.2 (0.2)	0.9 (0.5)
Total	100.0	100.0
No. samples	4	2
Items/sample: mean	3.8	5.5
range	(3-4)	(4-7)

Table 4. Food habits of antelope ground squirrels at nine trapping grids, 1994.

Mean percent relative density of food items in fecal samples
(Frequency of food item occurrence in parentheses)

Food Item	Trapping Grid Number 1	2	3	4	5
GRASSES					
Bromus leaf					
Poa leaf					
Schismus leaf	1.7 (0.2)				
Vulpia leaf					
Unknown grass lf.	.	3.5 (0.5)	.	.	.
Total	1.7	3.5	0.0	0.0	0.0
SHRUBS					
Atriplex leaf	1.9 (0.3)	5.6 (0.8)	11.9 (0.8)	91.7 (1.0)	77.0 (1.0)
Cactus stem	0.3 (0.1)	0.8 (0.1)			1.5 (0.4)
Chrysothamnus leaf					
Ephedra stem		23.7 (0.5)			
Grayia leaf		2.6 (0.4)	0.3 (0.1)		0.2 (0.1)
Krascheninnikovia lf.	2.7 (0.5)	3.5 (0.6)	0.7 (0.1)		
Larrea leaf		7.3 (0.6)	84.9 (1.0)		17.4 (0.2)
Lycium seed					
Tetradymia leaf				0.5 (0.2)	0.2 (0.1)
Vigueria leaf	.	.	.	.	0.6 (0.1)
Total	4.9	43.5	97.8	92.2	96.9
FORBS					
Astragalus leaf					
Camissonia leaf				0.3 (0.1)	0.6 (0.1)
Composite seed	3.5 (0.5)	5.5 (0.6)			0.9 (0.2)
Eremalche lf.	5.1 (0.6)	0.7 (0.1)			
Eremocarpus leaf					
Eriogonum leaf		0.4 (0.1)			
Erodium leaf		0.9 (0.1)		2.9 (0.1)	0.6 (0.1)
Gilia/Linanthus lf.	76.1 (1.0)	12.2 (0.4)		0.2 (0.1)	
Flower parts	2.9 (0.6)	13.8 (0.7)		0.2 (0.1)	
Layia leaf			0.4 (0.1)	3.9 (0.2)	0.6 (0.1)
Legume pod	0.4 (0.1)				
Lomatium leaf					
Malvaceae leaf					
Mentzelia leaf					
Salvia sp. lf.	0.3 (0.1)	1.8 (0.3)			
Salvia columbariae					
Sphaeralcea leaf	2.3 (0.6)	2.9 (0.3)			
Unknown forb	.	.	.	.	.
Total	90.6	38.2	0.4	7.5	2.7
OTHER					
Arthropod	1.8 (0.5)	10.6 (0.9)	1.8 (0.5)	0.4 (0.1)	0.4 (0.2)
Pollen	0.3 (0.1)	2.2 (0.1)			
Unknown seed	0.6 (0.2)	2.1 (0.3)			
Yucca seed	.	.	.	.	.
Total	2.7	14.9	1.8	0.4	0.4
Total	99.9	100.1	100.0	100.1	100.0
No. samples	10	10	10	10	10
Items/sample: mean	5.4	7.4	2.6	1.9	2.6
range	(3-7)	(6-10)	(1-5)	(1-3)	(1-6)

Table 4. (contd.)

Mean percent relative density of food items in fecal samples
(Frequency of food item occurrence in parentheses)

Food Item	Trapping Grid Number 6	7	8	9
GRASSES				
Bromus leaf				
Poa leaf		0.4 (0.1)		
Schismus leaf		0.8 (0.1)		
Vulpia leaf		1.0 (0.1)		2.1 (0.1)
Unknown grass lf.				
Total	0.0	2.2	0.0	2.1
SHRUBS				
Atriplex leaf	5.8 (0.4)	0.4 (0.1)	33.4 (0.8)	5.9 (0.7)
Cactus stem	0.3 (0.1)	1.7 (0.1)	0.4 (0.1)	11.2 (0.5)
Chrysothamnus leaf		0.4 (0.1)		
Ephedra stem		23.9 (0.6)	0.4 (0.1)	4.0 (0.1)
Grayia leaf	0.4 (0.1)			0.4 (0.1)
Krascheninnikovia lf.	0.7 (0.1)			0.4 (0.1)
Larrea leaf	38.1 (1.0)	30.3 (0.7)		3.2 (0.3)
Lycium seed			1.0 (0.2)	
Tetradymia leaf				24.1 (0.7)
Vigueria leaf				
Total	45.3	56.7	35.2	49.2
FORBS				
Astragalus leaf	0.3 (0.1)			
Camissonia leaf				
Composite seed			6.3 (0.4)	
Eremalche lf.				
Eremocarpus leaf			2.3 (0.2)	
Eriogonum leaf				1.0 (0.2)
Erodium leaf		10.2 (0.4)	4.0 (0.3)	
Gilia/Linanthus	32.5 (0.8)	0.3 (0.1)		11.8 (0.4)
Flower parts		0.5 (0.1)	0.4 (0.1)	
Layia leaf	6.6 (0.5)		7.5 (0.4)	2.8 (0.2)
Legume pod			0.4 (0.1)	
Lomatium leaf			3.1 (0.1)	1.7 (0.3)
Malvaceae leaf			7.1 (0.2)	
Mentzelia leaf				
Salvia sp.				0.4 (0.1)
Salvia columbariae				
Sphaeralcea leaf			10.7 (0.4)	1.6 (0.1)
Unknown forb				
Total	39.4	11.0	41.8	19.3
OTHER				
Arthropod	14.9 (0.8)	20.9 (0.8)	21.5 (0.7)	21.5 (0.9)
Pollen	0.4 (0.1)	9.3 (0.4)		0.4 (0.1)
Unknown seed			1.5 (0.4)	7.2 (0.4)
Yucca seed				
Total	15.3	30.2	23.0	29.1
Total	100.0	100.1	100.0	99.7
No. samples	10	9	10	10
Items/sample: mean	4.0	3.8	4.5	5.3
range	(3-5)	(2-6)	(2-6)	(3-10)

The AGS diet was strongly dominated by shrub foliage on grids 3, 4, and 5, where *Atriplex* and/or *Larrea* leaf contributed over 90 percent mean relative density. Shrub material was also important on grids 2, 6, 7, 8, and 9, where mean relative density varied from 35-57 percent. *Atriplex* and *Larrea* were well-represented in the samples from these sites, but *Tetradymia* leaf, cactus stem, and *Ephedra* stem also made up substantial portions of the diet at various trapping grids.

Only at Grid 1 did forb leaf constitute the overwhelming majority of the diet, with *Gilia/Linanthus* accounting for 76 percent relative density. This food item was also important at grids 2, 6, and 9. *Erodium* leaf, *Sphaeralcea* leaf, and flower parts were also significant elements in the AGS samples analyzed.

Vegetation Surveys

Appendix I presents a list of annual and perennial plants observed on the study grids in 1994 and 1995, while Appendix II presents a summary of the data collected from the step-point transects.

Number of plant species observed and sampled. Figure 3 compares the total number of species of perennial and annual plants observed on each grid in 1994. Grids 1 and 2 supported 37 and 49 species of annual plants, respectively, far more than were recorded at grids 3-9 where the numbers of annuals ranged from 0-12. From 14 to 20 perennial species were observed at all grids except Grid 4, where only eight perennials were seen. At the three grids studied in 1995, Grid 10 had the highest richness of perennial species, with 24 species observed. Grids 11 and 12 had 13 and 17 perennial species, respectively. The number of annual species observed at the three grids studied in 1995 ranged from 30 to 45. Thus, annual species richness at grids 10-12 was comparable to that seen at grids 1 and 2 the preceding year, but much higher than that observed on the other grids sampled in 1994.

Figure 4 presents the numbers of annual and perennial species recorded in vegetation transects for each grid in 1994. The number of species detected in transect sampling must be equal to or less than the total number of species observed. In almost every case, the number of species recorded in the transects was substantially smaller, suggesting that some species were either uncommon on the grid or aggregated in such a way that they were unlikely to be sampled. The vegetation transects for grids 1 and 2 showed the highest species richness for annuals with 16 and 19 species, respectively. However, the difference in number of annual plant species between these grids and grids 3-9 was not as pronounced for the transect sampling data as for the number of species observed. In 1995, the number of annual species sampled ranged from 16 to 29 per grid, consistent with the higher overall annual species richness observed in that year (Appendix II).

TOTAL NUMBER OF PLANT SPECIES OBSERVED FOR EACH GRID

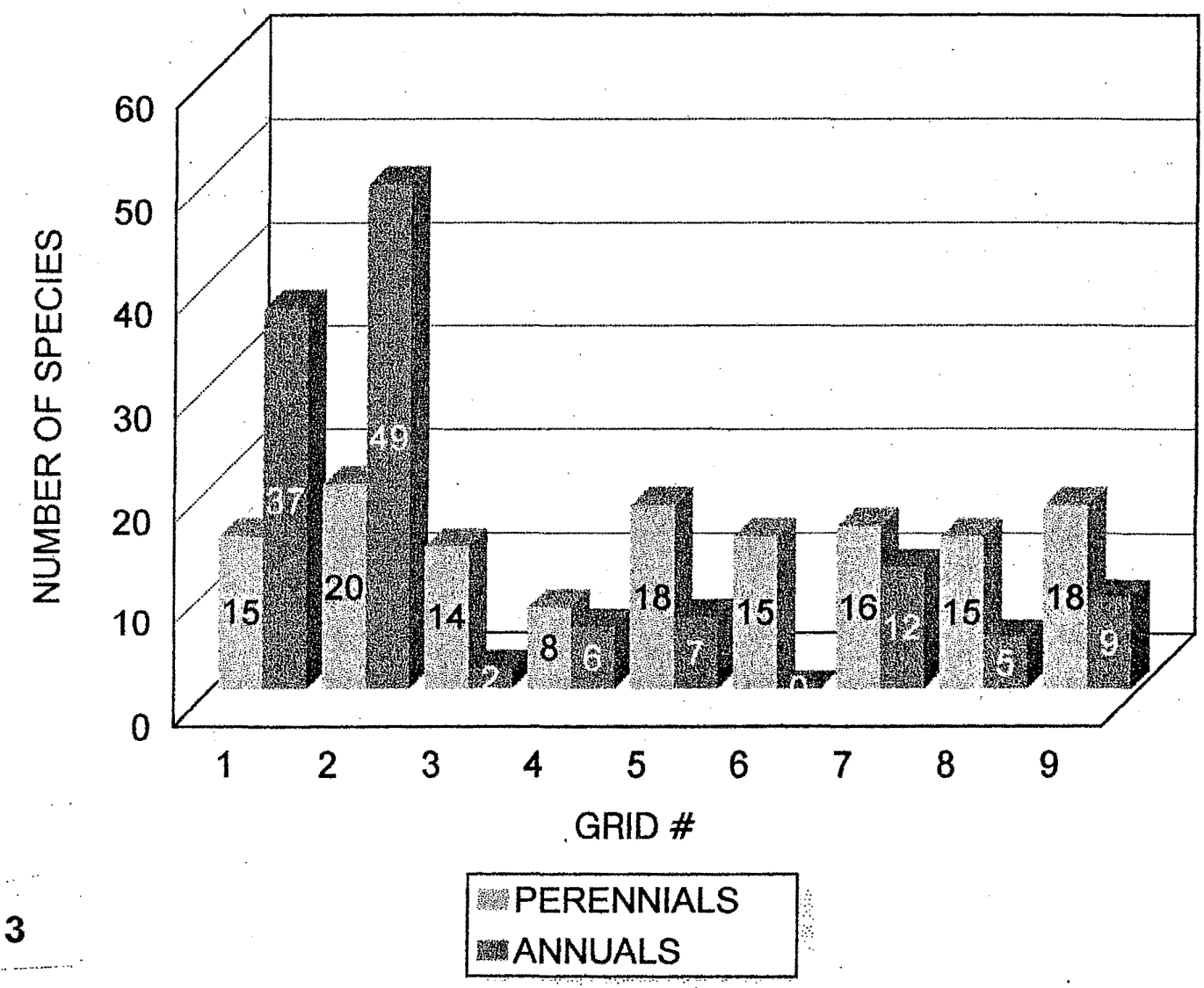


FIGURE 3

TOTAL NUMBER OF ANNUAL AND PERENNIAL SPECIES RECORDED IN VEGETATION TRANSECTS FOR EACH GRID

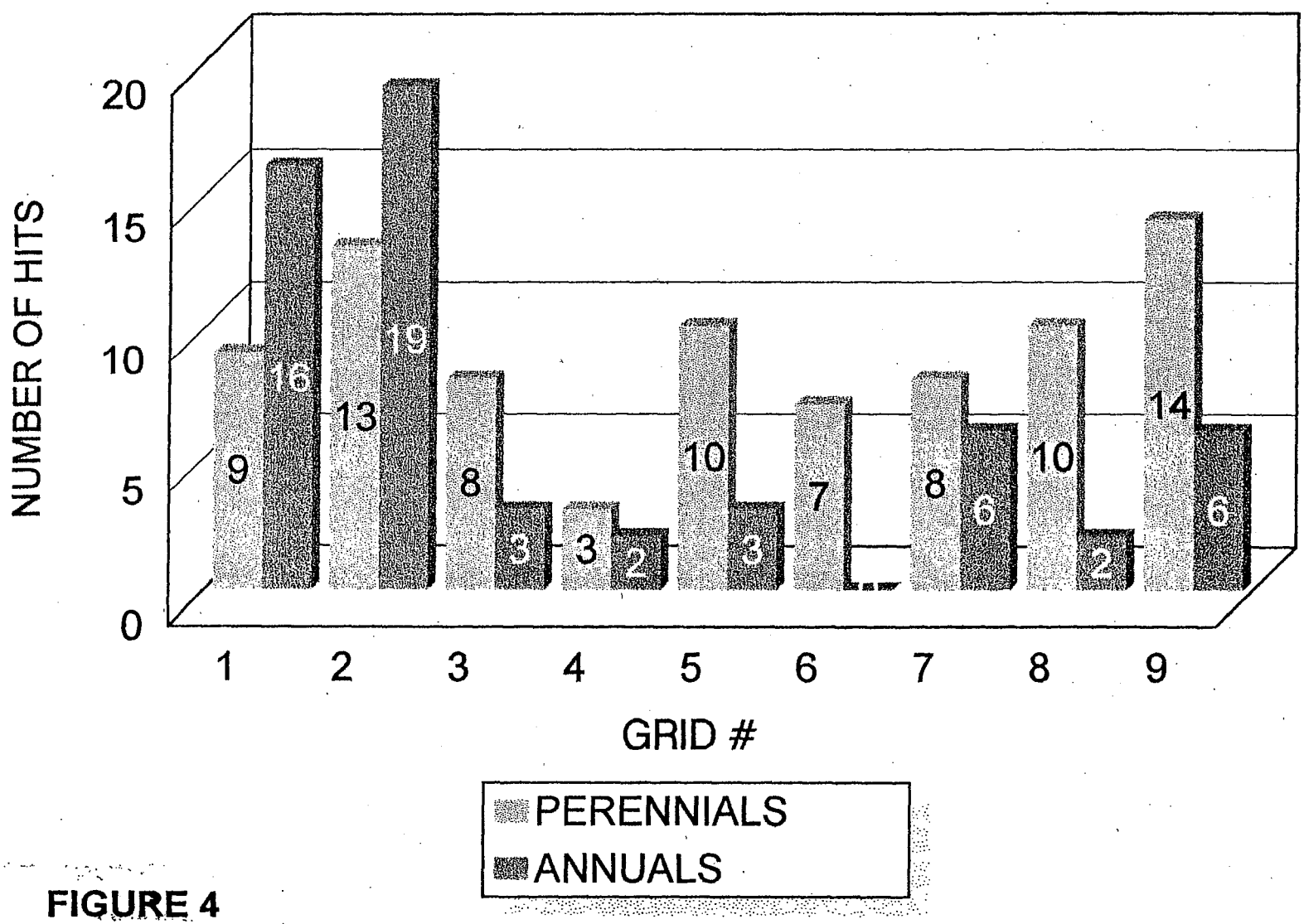


FIGURE 4

Ground cover. Figure 5 shows the percent frequency of annual and perennial hits recorded during vegetation transects on grids 1-9 in 1994. Annual cover was almost non-existent on most of the grids; only grids 1, 2, and 9 showed any significant cover by annual plants. A comparison with the 1995 results for grids 10-12 clearly illustrates how sparse the growth of annual plants was in 1994. The 1995 data show annual frequencies ranging from 40 percent at Grid 11 to 51 percent at Grid 10 (Appendix II). The range in percent frequency of perennial hits on the three grids sampled in 1995 (8 to 16 percent) was very similar to that recorded on grids 1-9 in 1994, suggesting that shrub cover did not differ greatly among the 12 sites.

Figure 6 illustrates the percent frequency of rocks, litter and bare ground for each grid as recorded in the vegetation transects on grids 1-9 in 1994. As expected from the higher frequency of annual plants, grids 1 and 2 had less bare ground than the other sites. In 1995, the much higher percent frequency of annuals on grids 10-12 was accompanied by a corresponding reduction in the percent frequency of bare ground as compared to the grids sampled the preceding year.

Shrub species composition. Figures 7-9 show the percent frequencies of the most common shrubs for each vegetation type represented in the nine grids sampled in 1994: Mojave mixed woody scrub (Grid 1; Figure 7), Mojave desert saltbush scrub (grids 4, 5, and 8; Figure 8) and Mojave creosote bush scrub (grids 2, 3, 6, 7, and 9; Figure 9). Figure 10 shows the percent frequencies for the most common shrubs sampled on grids 10-12 in 1995.

These four figures demonstrate the wide variation in shrub species composition between and within the three major desert vegetation community-types sampled in this study (see Holland 1986 for description and definition of these community-types). Grid 1, the single Mojave mixed woody scrub site, differed from all other grids in the absence of both saltbush and creosote bush. Common species on Grid 1 that were shared with other grids included burrobush, spiny hopsage, and Cooper's goldenbush (*Ericameria cooperi*). On the Mojave desert saltbush scrub sites, the dominant saltbush species varied from grid to grid. At grids 4, 5, and 12, the most frequently-occurring species was Mojave saltbush (*Atriplex spinifera*), while at Grid 8 the dominant species was allscale (*A. polycarpa*).

The Mojave creosote bush scrub sites were quite variable in shrub species composition. The common feature at all seven grids was the presence of creosote bush, which varied from 14 percent relative frequency (Grid 2) to 47 percent at Grid 7. Grids 3 and 6 were similar, being highly dominated by burrobush and creosote bush. They resemble the "classic" creosote bush community as expressed throughout much of the Mojave Desert, particularly on valley floors and gentle slopes with rather fine-textured soils.

PERCENT FREQUENCY OF ANNUAL AND PERENNIAL HITS RECORDED IN VEGETATION SURVEYS FOR EACH GRID

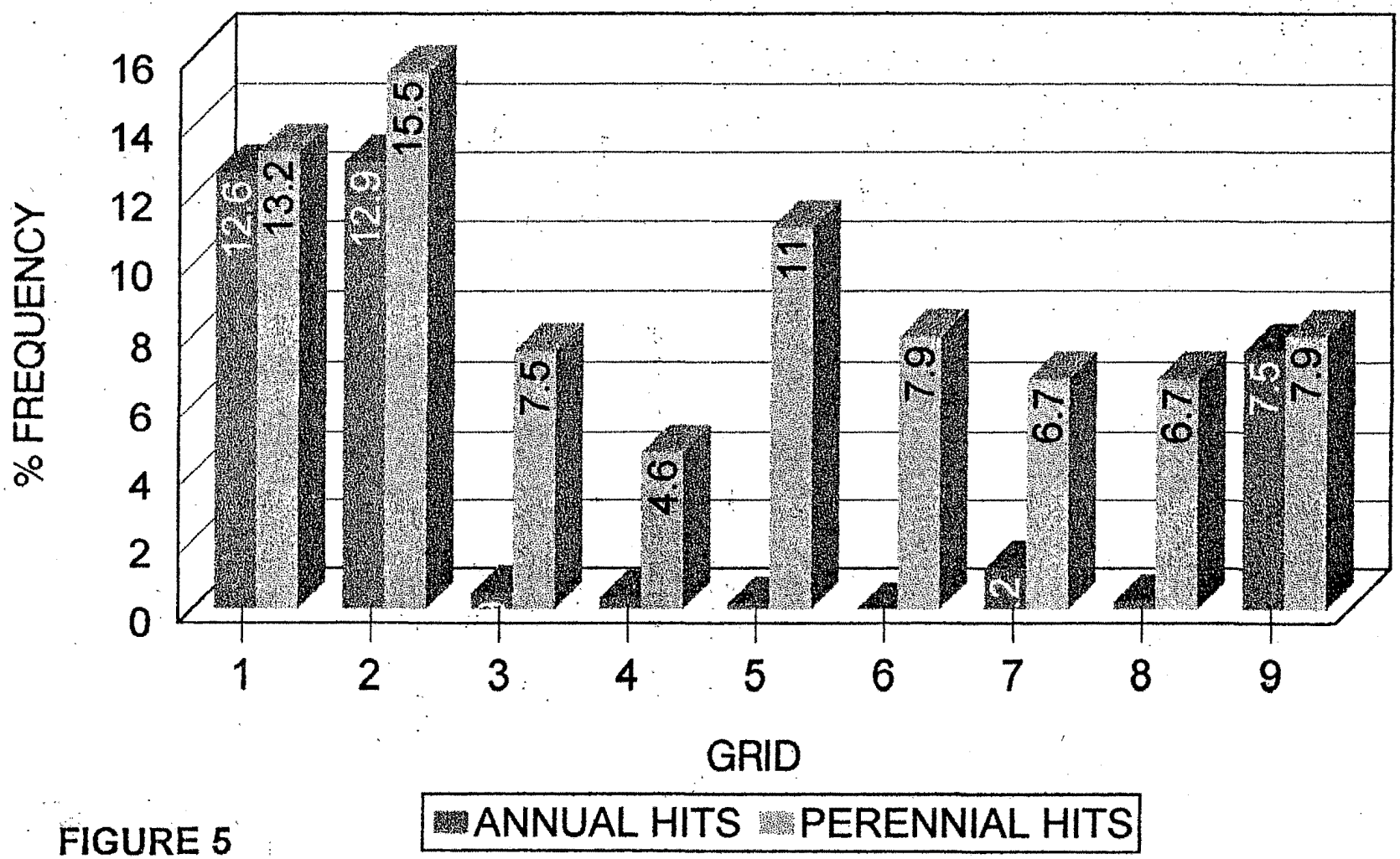


FIGURE 5

PERCENT FREQUENCY OF ROCKS/LITTER/BARE GROUND RECORDED IN VEGETATION TRANSECTS FOR EACH GRID

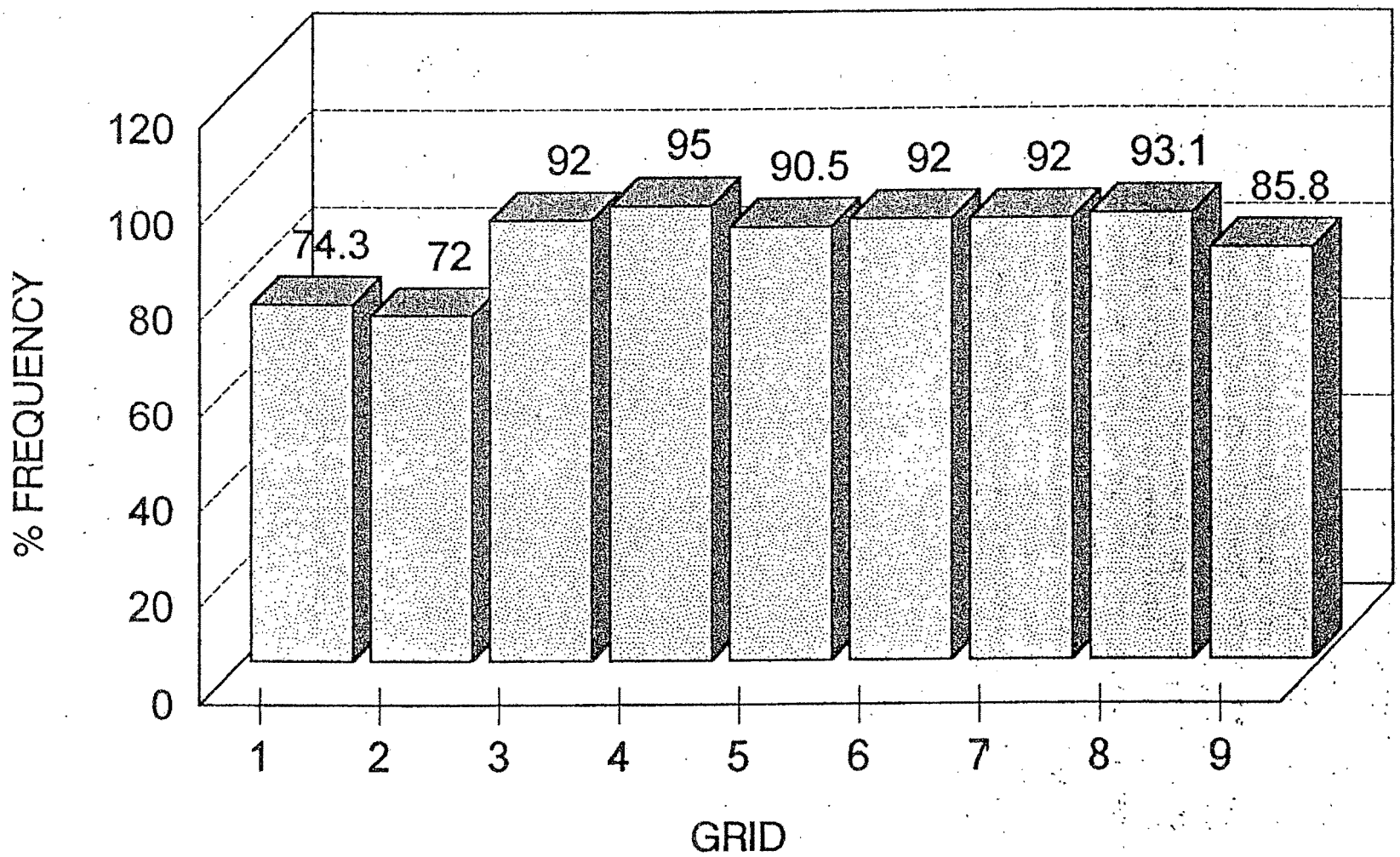


FIGURE 6

PERCENT FREQUENCY OF THE MOST COMMON SHRUBS RECORDED IN VEGETATION TRANSECTS FOR EACH GRID

MOJAVE DESERT SALTBUSH SCRUB

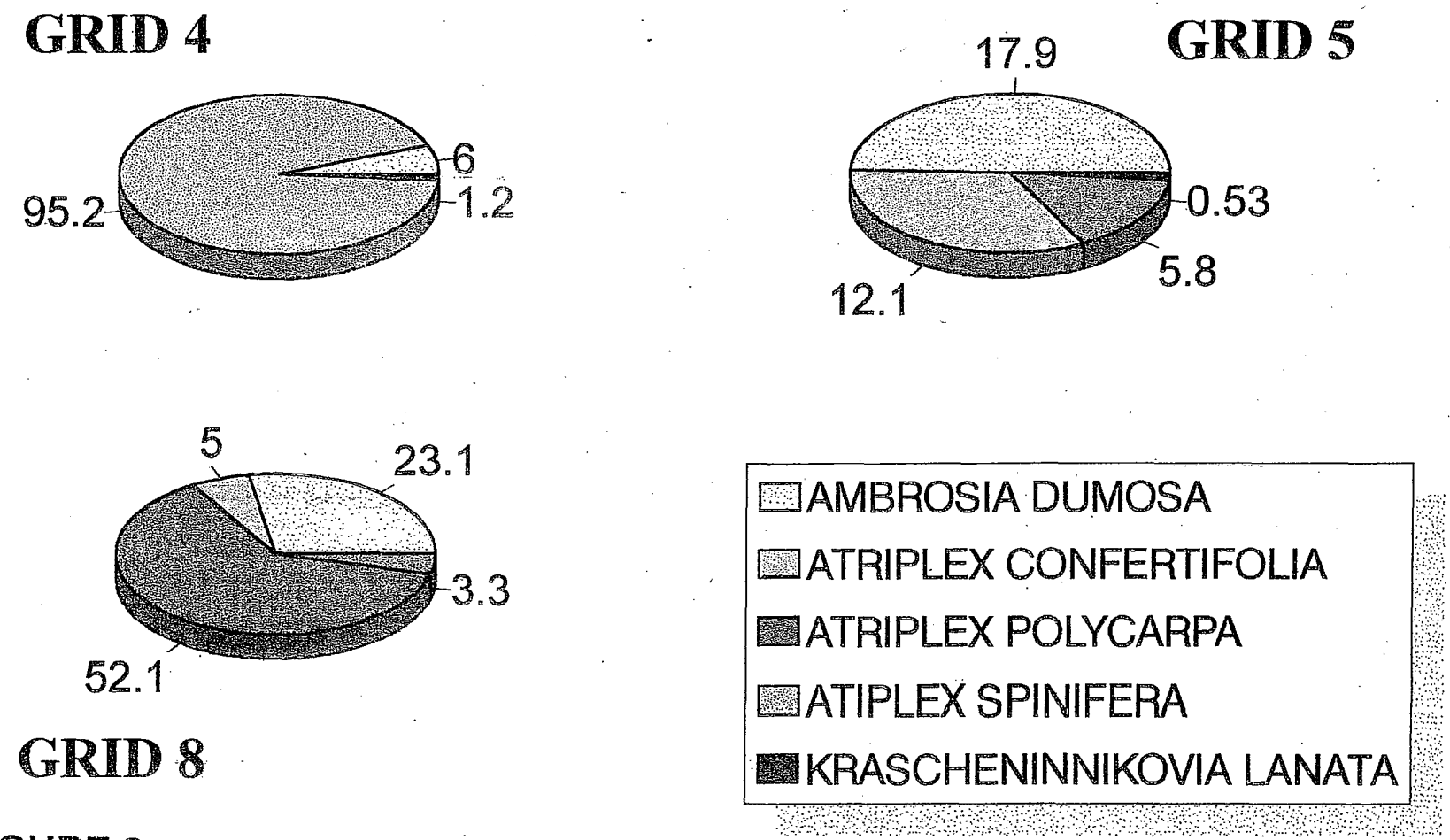


FIGURE 8

PERCENT FREQUENCY OF THE MOST COMMON SHRUBS RECORDED IN VEGETATION TRANSECTS FOR EACH GRID

MOJAVE CREOSOTE BUSH SCRUB

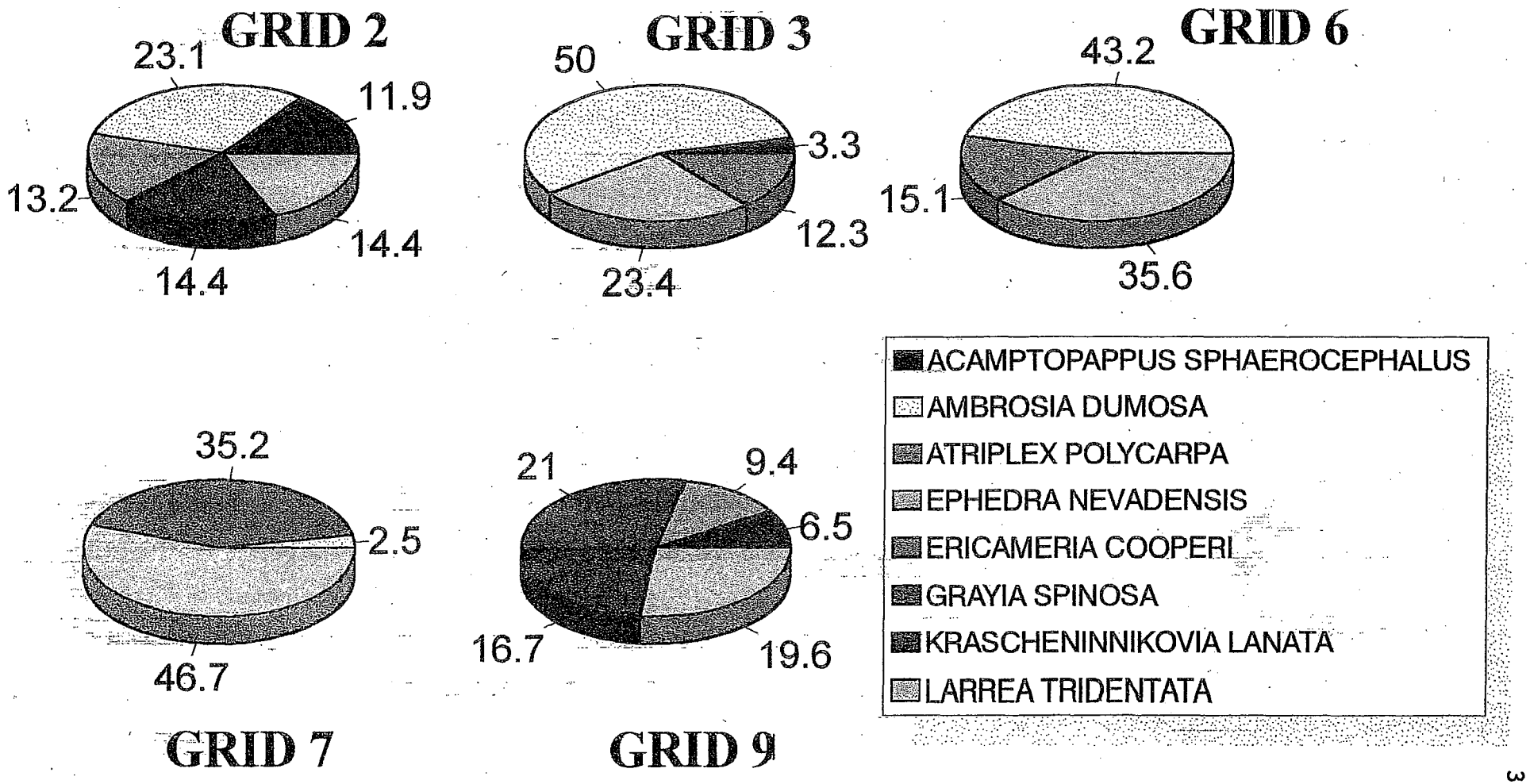


FIGURE 9

PERCENT FREQUENCY OF THE MOST COMMON SHRUBS RECORDED IN VEGETATION TRANSECTS FOR GRIDS 10-12, SAMPLED IN 1995.

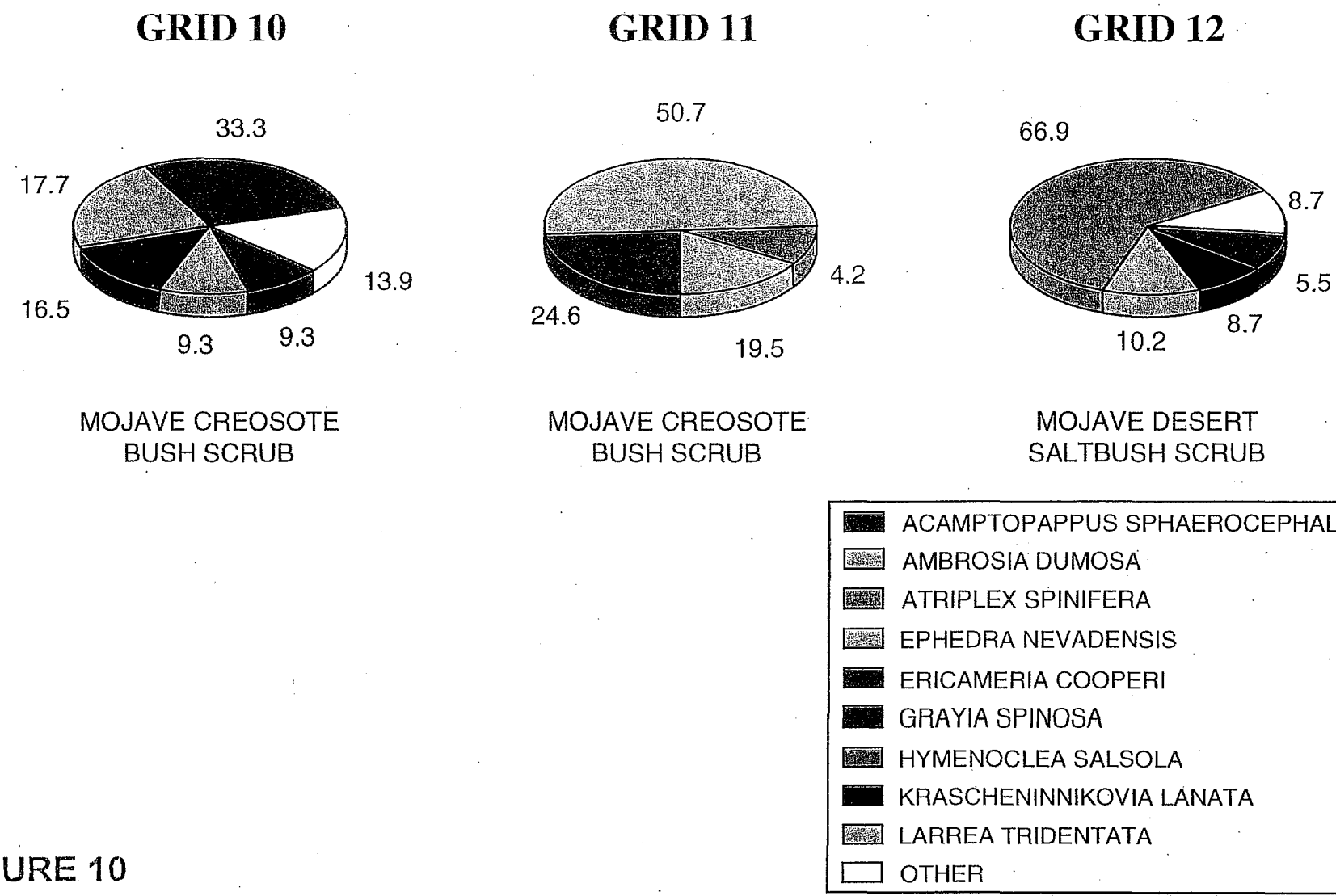


FIGURE 10

Grid 11 also resembled this burrobush-creosote bush phase of Mojave creosote bush scrub, but differed in having nearly 25 percent relative frequency of goldenhead (*Acamptopappus sphaerocephalus*).

Grid 7, being dominated largely by creosote bush (47 percent relative frequency) and Cooper's goldenbush (35 percent relative frequency), represents a phase of Mojave creosote bush scrub often found on sandy, south-facing slopes where shrub cover and diversity are rather low.

Grids 2, 9 and 10 had the greatest shrub species-richness within the Mojave creosote bush scrub vegetation-type. Each had creosote bush relative frequency ranging from 14 to 20 percent, which creates visual dominance by this species. Associated species included a variety of shrubs, the assemblage at each site being somewhat distinctive. This phase of Mojave creosote bush scrub is often found on upper bajadas or more rocky situations. It tends to occur on sites with higher actual or effective precipitation, and it often grades into Mojave mixed woody scrub.

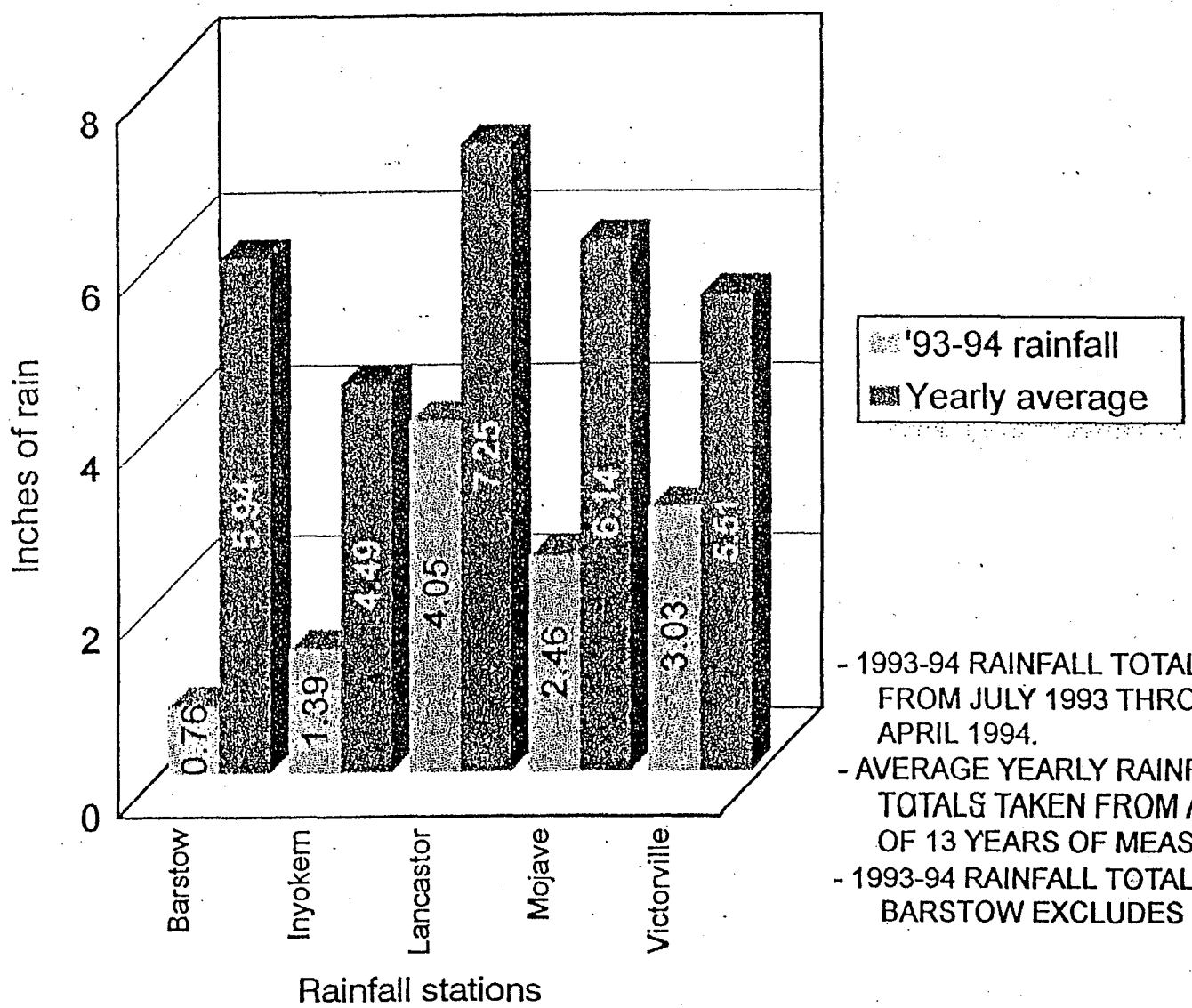
DISCUSSION

Reproduction of Mohave ground squirrels

Fall and winter precipitation is the most important control on biological productivity in the western Mojave Desert. In particular, the production of annual herbaceous growth in the spring is determined by the amount and timing of precipitation during the preceding fall and winter. The winter of 1993-94 was notable for low precipitation totals throughout the western Mojave Desert (Figure 11). As a result, the growth of herbaceous plants was minimal on the nine grids trapped during this study in 1994. Since no juvenile MGS were captured in 1994 and adult females showed no sign of pregnancy or lactation, it is reasonable to conclude that no MGS reproduction took place on any of the sites where the species was trapped. The long-term Coso Grazing Exclosure Monitoring Study has provided evidence that MGS are dependent upon adequate annual herbaceous growth as a food source for successful reproduction (Leitner et al. 1991). Data from the four Coso study sites confirmed that no MGS reproduction took place there in 1994 (Leitner et al. 1995) and additional MGS trapping studies at Edwards Air Force Base (David Laabs, pers. comm.) and Fort Irwin (Tony Recht, pers. comm.) provided further evidence of widespread reproductive failure in this species in 1994.

In contrast, fall and winter precipitation in the western Mojave Desert was roughly double the long-term average in 1994-95. Primary production of annual herbaceous plants was very high throughout the region in the spring of 1995. Six juvenile MGS were trapped at Grid 12, providing clear evidence of MGS reproduction. Because the juvenile captures were clustered at two diagonal

COMPARISON OF1993-94 RAINFALL YEAR AND AVERAGE YEARLY RAINFALL FOR SELECTED SITES IN THE WESTERN MOJAVE DESERT



- 1993-94 RAINFALL TOTALS FROM JULY 1993 THROUGH APRIL 1994.
- AVERAGE YEARLY RAINFALL TOTALS TAKEN FROM A MINIMUM OF 13 YEARS OF MEASURMENTS.
- 1993-94 RAINFALL TOTAL FOR BARSTOW EXCLUDES MARCH 1994

FIGURE 11

corners of the grid, it is likely that two litters were produced on this grid in 1995. Substantial numbers of juvenile MGS were also captured at the four Coso study sites in 1995, suggesting that above-average rainfall was associated with MGS reproduction in other parts of the western Mojave Desert as well.

Mohave ground squirrel abundance on trapping grids

The trapping data indicate that MGS were not abundant in 1994 and 1995 at the sites where sampling was carried out. It is noteworthy that no MGS were captured on four of the 12 sites and on five grids only one or two individuals were trapped. As has often been reported, the abundance of AGS was much greater than that of MGS on all study sites. In general, the levels of MGS abundance documented in this study were much lower than those reported in the long-term Coso investigation (Leitner et al., 1993 and 1995). Only on Grid 1, where nine individuals were captured, did MGS numbers approach those usually found on Coso study sites 2, 3, and 4. Since the basic methodology in this study was modeled on that used in the Coso study, especially in regard to grid size and length of trapping period, the low numbers of MGS captured probably reflect a significant difference in abundance.

Nevertheless, other factors may have played some role in reducing capture success in 1994. For example, inclement weather in the form of cold, windy days in late May may have been implicated in the almost complete lack of MGS captures on grids 3 and 4. Daily temperatures were quite cool with moderate winds for the middle three days on Grid 3 and the first three days on Grid 4. The single MGS captured on Grid 4 was not taken until the second full day of near normal temperatures.

It is also possible that some MGS resident on the grids trapped in late May-early June 1994 had already entered estivation. A radiotelemetry study in the Coso area indicated that six of 14 radiocollared adult MGS had already become dormant by late April 1994 (Leitner et al., 1995). An early entry into estivation in 1994 was also confirmed by the results of live-trapping in late May-early June 1994 on the four Coso study sites. The recapture data suggested that over 50 percent of the adult MGS population may have entered dormancy by that time. The same situation may have occurred on the grids sampled in this study since, due to unavoidable delays, trapping was not started until May and a majority of grids were not trapped until late May and early June.

Even when the possible effects of weather and early estivation on capture success are considered, the results of this study strongly support the conclusion that MGS are not abundant throughout much of their range and that the species often cannot be trapped in areas of apparently suitable habitat.

Habitat characteristics and abundance

The abundance of adult MGS in 1994 was highest on grids 1 and 2, with a total of 12 individuals, as compared to 8 on all other grids combined. In comparison with the other seven sites trapped during the same year, grids 1 and 2 clearly had the highest number of annual plant species (Figs. 3 and 4). These two grids also showed the highest annual plant productivity, as indicated by 12-13 percent frequency of hits in the vegetation transects (Fig. 5), with Grid 9 in third place with 7.5 percent frequency. As would be expected, grids 1 and 2 also had the lowest percent frequencies in the categories of rocks/litter/bare ground, with Grid 9 again in third place (Fig. 6). This suggests that sites with high species richness and high productivity of annual plants provide good MGS habitat.

There is also evidence that the nature of the shrub community may be correlated with MGS abundance. The three Coso study sites (sites 2, 3, and 4) that have consistently supported high density MGS populations are characterized by Mojave mixed woody scrub (Leitner et al. 1995). In this study, the single grid with similar vegetation (Grid 1/Freeman Gulch) was also the site with by far the greatest MGS abundance. The possible association of high MGS abundance with the Mojave mixed woody scrub vegetation-type should be investigated further. If this association is confirmed, it may help to identify high-priority habitat for future conservation efforts.

The Coso studies indicate that certain shrub species, particularly winterfat and spiny hopsage, are of special importance to MGS as food resources early in their active season before annuals are well developed and during drought years when the total production of annuals is limited (Leitner et al. 1995). If the carrying capacity for MGS is related to the abundance of winterfat and spiny hopsage, it should be possible to demonstrate a correlation between the percent shrub cover contributed by these two shrub species and the number of MGS captured. The percent of hits in the step-point method, which is presented as frequency, also provides a reasonable estimate of cover.

Table 5 compares the absolute frequencies of winterfat and spiny hopsage (combined number of hits on the two shrubs/total number of hits sampled) with the MGS capture data. Grid 1, with the greatest number of MGS captured, had the highest combined absolute frequency of winterfat and spiny hopsage (5.1 percent). Grids 2 and 9, where 3 and 2 MGS were captured, had the next highest combined absolute frequency of the two shrub species (2.5 and 3.0 percent). The relatively high frequency of these shrubs at Grid 9 may explain why MGS were still active above-ground there as late as mid-June 1994. On five of the seven grids where winterfat and spiny hopsage were essentially absent (grids 3-8 and 11), the number of MGS captured was very low (0 or 1). On three grids, the MGS capture

Table 5. Mohave ground squirrel trapping results compared with absolute frequency of spiny hopsage and winterfat at the 12 grids trapped in 1994 and 1995.

Grid No.	1	2	3	4	5	6	7	8	9	10	11	12
No. MGS trapped	9	3	0	1	2	1	0	1	2	0	0	6*
Absolute frequency												
Winterfat	0.4	2.2	0	0.1	0.1	0	0	0	1.3	0.4	0.1	0.7
Spiny hopsage	4.7	0.3	0	0	0	0	0	0	1.7	1.3	0	0
Total frequency, both species	5.1	2.5	0	0.1	0.1	0	0	0	3.0	1.7	0.1	0.7

*Grid 12 MGS were all juveniles, while all other results report adults only. For comparability, it may be assumed that these juveniles represent the litters of two adult female MGS.

results did not support a correlation: at both grids 5 and 8, with less than 0.1 combined frequency of the two shrub species, two MGS were captured, while no MGS were trapped at Grid 10, which had 1.7 percent frequency of winterfat and spiny hopsage.

The trapping results at the four Coso study sites during the period May 31-June 14, 1994 provide additional evidence that MGS abundance is correlated with the cover of winterfat and spiny hopsage. Only one MGS was captured at Coso Study Site 1, where the combined cover of the two shrubs is less than 0.1 percent. On study sites 2, 3, and 4, with combined cover of winterfat and spiny hopsage that totalled 1.8, 5.2, and 6.5 percent, the number of adult MGS captured was 16, 13, and 12, respectively.

This analysis suggests that habitat characteristics associated with high-quality MGS habitat may include (1) high species richness and productivity of forbs, (2) presence of the Mojave mixed woody scrub vegetation-type, and (3) relatively high levels of abundance of certain shrub species, especially winterfat and spiny hopsage.

Food habits of Mohave ground squirrels

The Coso study has shown that MGS take annual forbs whenever they are available (Leitner et al. 1995). In this study, annual forbs made up a substantial portion of the diet of MGS in 1994 at grids 1, 4, 5, and 8. Since the availability of annuals was relatively high at Grid 1, it was not surprising that almost three-fourths of the diet was composed of forbs. However, it is striking that annuals were taken in relatively high proportion at grids 4, 5, and 8, where annual growth was very sparse. There is evidence from the Coso study that MGS are extremely efficient foragers,

since they were successful in finding and consuming annual plants at Coso during the extreme drought of 1990 when virtually none were visible to human observers (Leitner et al. 1991).

At Grid 1, the most frequently-occurring shrub, spiny hopsage, was also the largest shrub component in the MGS diet. This shrub species has been shown to be an important part of the MGS diet at the Coso study sites as well, especially during low-rainfall years. The fact that spiny hopsage was so abundant at Grid 1, where MGS were most numerous, and was relatively infrequent on the other grids trapped is consistent with the hypothesis that spiny hopsage is an important habitat element for MGS.

Studies at Coso also show that saltbush can be an important, though not preferred, element in the MGS diet, especially when annuals are of limited availability (Leitner et al., 1995). This also seemed to be the case here, where saltbush contributed from 34 to 96 percent relative density in MGS samples collected from grids 4, 5 and 6.

One of the most surprising results of the diet analysis was the high relative density contributed by creosote bush foliage at grids 2 and 9, where more preferred shrubs, especially winterfat and spiny hopsage, were quite abundant. The resins present in creosote bush leaves might be expected to reduce its palatability and nutritional value for MGS. Because creosote bush is such a dominant perennial species across much of the range of the MGS, a better understanding of its role in the MGS diet may provide useful perspective on what constitutes suitable habitat.

Suggestions for future study

The results of the 1994-1995 trapping study in the core reserves of the WMCMP suggest that a few additional, carefully-focused investigations would be desirable:

1. Two to three other grids in Mojave mixed woody scrub habitat should be included in future trapping since the highest number of MGS were captured in such a vegetation-type on Grid 1. These sites should be located throughout the western Mojave Desert.

2. A more complete understanding of MGS habitat requirements can be obtained by conducting vegetation surveys to determine percent cover of annual and perennial growth as well as shrub densities and biomass of annual plants, in relation to MGS abundance.

3.The MGS diet should be studied in habitats dominated by creosote bush and by saltbush in order to determine the extent to which foliage from these shrub species can support MGS populations.

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APPENDIX I

ANNUAL AND PERENNIAL PLANTS OBSERVED ON THE STUDY GRIDS

APPENDIX I. ANNUAL AND PERENNIAL PLANTS OBSERVED ON THE STUDY GRIDS

Note: Sites 1-9 were studied in 1994; sites 10-12 in 1995. Plants identified only to genus in one year may or may not be one of the other species noted.

PLANT SPECIES	STUDY SITE WHERE OBSERVED											
	1	2	3	4	5	6	7	8	9	10	11	12
AGAVACEAE												
Yucca brevifolia		X	X	X			X		X	X		X
APIACEAE												
Lomatium mohavense	X									X		
ASTERACEAE												
Acamptopappus sphaerocephalus	X	X	X	X	X	X	X	X	X	X	X	X
Ambrosia acanthicarpa	X	X										
Ambrosia dumosa	X	X	X	X	X	X	X	X	X	X	X	X
Artemisia spinescens								X				
Chaenactis fremontii/stev.	X	X			X		X	X			X	X
Chrysothamnus nauseosus		X										
Coreopsis bigelovii		X								X	X	
Encelia sp.		X							X			
Ericameria cooperi var. cooperi	X	X	X		X	X	X	X		X		
Eriophyllum ambiguum											X	
Eriophyllum pringlei	X	X								X		
Eriophyllum wallacei	X	X									X	
Hymenoclea salsola var. salsola	X	X	X	X	X	X	X	X	X	X	X	X
Lasthenia californica										X	X	X
Layia glandulosa		X										
Layia sp.										X	X	
Lepidospartum squamatum						X						
Lessingia lemmonii var. ramulosissima	X	X									X	
Malacothrix coulteri										X		
Malacothrix glabrata		X								X	X	X
Stephanomeria exigua									X			
Stephanomeria sp.	X	X			X							
Stylocline gnaphaloides											X	
Syntrichopappus fremontii										X		
Tetradymia axillaris var. longispina?	X				X	X	X	X	X			
Tetradymia stenolepis										X	X	X
Xylorhiza tortifolia var. tortifolia		X							X	X		X
BORAGINACEAE												
Amsinckia tessellata		X					X		X	X	X	X
Cryptantha sp. 1										X		X
Cryptantha sp. 2										X		
Cryptantha circumscissa	X	X									X	
Cryptantha dumetorum		X										
Cryptantha micrantha	X	X										
Cryptantha nevadensis		X										
Cryptantha pterocarya		X										

PLANT SPECIES	STUDY SITE WHERE OBSERVED											
	1	2	3	4	5	6	7	8	9	10	11	12
BORAGINACEAE (contd.)												
Cryptantha utahensis											X	
Pectocarya penicillata	X									X		X
Pectocarya platycarpa											X	
Pectocarya setosa	X									X		X
Pectocarya sp.	X	X										
BRASSICACEAE												
Caulanthus cooperi	X	X										
Descurainia pinnata	X	X										
Descurainia sp.	X	X								X		X
Lepidium fremontii	X	X			X	X			X			
Sisymbrium sp.										X		X
Stanleya pinnata ssp. pinnata						X		X				
CACTACEAE												
Opuntia basilaris var. basilaris		X	X						X	X		
Opuntia bigelovii		X	X			X		X				
Opuntia echinocarpa var. echinocarpa					X		X		X	X		
CAMPANULACEAE												
Nemacladus sigmoideus											X	
Nemacladus sp.										X	X	
CHENOPODIACEAE												
Atriplex canescens						X						
Atriplex confertifolia					X			X				
Atriplex polycarpa					X	X		X				
Atriplex spinifera			X	X	X							X
Grayia spinosa	X	X	X		X		X	X	X	X		X
Krascheninnikovia lanata	X	X			X		X	X	X	X	X	X
Salsola tragus		X										
CONVOLVULACEAE												
Cuscuta california										X		X
EPHEDRACEAE												
Ephedra nevadensis	X	X					X		X	X		
EUPHORBIACEAE												
Chamaesyce albomarginata	X	X			X		X	X		X		X
Stillingia paucidentata	X				X							
FABACEAE												
Astragalus mohavensis	X											
Astragalus sp.		X			X			X		X		
Astragalus sp. 1										X		
Astragalus sp. 2												X
Lotus humistratus											X	
Lupinus sp. 1										X		

PLANT SPECIES	STUDY SITE WHERE OBSERVED											
	1	2	3	4	5	6	7	8	9	10	11	12
FABACEAE (contd.)												
Lupinus sp. 2										X		
Lupinus arizonicus											X	
Psorothamnus arborescens var. minutifolius			X			X						
GERANIACEAE												
Erodium cicutarium	X	X		X			X		X	X	X	X
HYDROPHYLLACEAE												
Emmenanthe penduliflora											X	
Nama demissum	X	X								X		
Phacelia distans/tanacetifolia										X	X	X
Phacelia fremontii		X								X	X	
Phacelia sp.	X											
LAMIACEAE												
Salazaria mexicana		X					X	X	X	X		
Salvia columbariae	X	X								X	X	
LILIACEAE												
Dichelostemma pulchella										X		
LOASACEAE												
Mentzelia albicaulis		X								X	X	X
Mentzelia veatchiana?										X		
Mentzelia sp.										X	X	
MALVACEAE												
Eremalche exilis		X										
Sphaeralcea ambigua ssp. ambigua	X			X	X			X				X
NYCTAGINACEAE												
Abronia pogonantha	X	X									X	
Mirabilis bigelovii				X			X			X	X	X
ONAGRACEAE												
Camissonia boothii		X									X	X
Camissonia campestris	X	X								X	X	X
Camissonia claviformis											X	
PAPAVERACEAE												
Eschscholzia minutiflora		X								X	X	
POACEAE												
Achnatherum hymenoides	X	X	X		X		X	X	X	X	X	X
Achnatherum speciosum	X				X		X	X	X	X	X	X
Bromus madritensis ssp. rubens	X	X					X		X	X	X	X
Bromus tectorum	X	X		X							X	
Elymus elymoides	X											

PLANT SPECIES	STUDY SITE WHERE OBSERVED											
	1	2	3	4	5	6	7	8	9	10	11	12
POACEAE (contd.)												
Schismus arabicus/barbatus	X	X	X	X	X		X		X	X	X	X
Vulpia octoflora	X	X					X		X	X	X	X
POLEMONIACEAE												
Eriastrum sp.		X					X					
Eriastrum eremicum												X
Gilia sp. 1										X		X
Gilia sp. 2										X		X
Gilia sp. 3										X		
Gilia latiflora											X	
Linanthus aureus	X											
Linanthus dichotomus		X								X		
Linanthus parryi										X		
Linanthus sp.										X		
Loeseliastrum matthewsii	X										X	X
POLYGONACEAE												
Centrostegia thurberi	X	X								X		X
Chorizanthe brevicornu											X	X
Chorizanthe watsonii		X										
Chorizanthe sp.											X	X
Eriogonum sp. 1				X						X		
Eriogonum sp. 2							X			X		X
Eriogonum sp. 3							X			X		
Eriogonum sp. 4								X		X		
Eriogonum sp. 5												X
Eriogonum baileyi	X	X			X							
Eriogonum brachyanthum	X	X										
Eriogonum fasciculatum var. polifolium		X					X					
Eriogonum gracillimum	X	X									X	X
Eriogonum inflatum		X	X						X	X	X	X
Eriogonum maculatum	X	X							X			
Eriogonum nidularium	X	X									X	
Eriogonum pusillum/reniforme											X	
Oxytheca perfoliata		X					X			X		X
RANUNCULACEAE												
Delphinium parishii										X	X	
ROSACEAE												
Coleogyne ramosissima		X										
RUTACEAE												
Thamnosma montana									X			
SCROPHULARIACEAE												
Castilleja exserta											X	

PLANT SPECIES	STUDY SITE WHERE OBSERVED											
	1	2	3	4	5	6	7	8	9	10	11	12
SOLANACEAE												
Lycium andersonii	X	X	X	X	X	X	X	X	X	X		X
Lycium cooperi	X	X		X	X	X	X		X	X	X	X
ZYGOPHYLLACEAE												
Larrea tridentata	X	X	X	X	X	X	X		X	X	X	

APPENDIX II

SUMMARY OF VEGETATION SURVEY RESULTS

SUMMARY OF VEGETATION TRANSECTS FOR GRID 1 AND 2

FREEMAN GULCH

GRID 1 MOJAVE MIXED WOODY SCRUB

PERENNIAL SPECIES	(B LINE) T1	(F LINE) T2	(J LINE) T3	(N LINE) T4	(R LINE) T5	TOTAL	% FREQUENCY
ACHNATHERUM SPECIOSUM	1	0	0	1	3	1	2.3
AMBROSIA DUMOSA	13	14	15	21	19	82	37
ERICAMERIA COOPERI	12	5	5	0	0	22	10
GRAYIA SPINOSA	27	9	21	10	14	81	36.7
HYMENOCLEA SALSOLA	0	0	1	0	1	2	0.9
KRASCHENINNIKOVIA LANATA	1	3	3	0	0	7	3.2
LYCIUM ANDERSONII	1	2	2	4	2	11	5
LYCIUM COOPERI	1	4	2	2	5	14	6.3
TETRADEMIA SPINOSA	0	1	1	0	0	2	0.9
TOTAL # OF ANNUAL HITS	71	38	45	32	31	217	12.6
ROCKS/LITTER/BARE GROUND	219	264	261	275	252	1271	74.3
TOTAL # OF HITS	344	340	359	344	324	1711	***
TOTAL # OF PERENNIAL SPECIES HIT	7	7	7	5	6	9	***
TOTAL # OF ANNUAL SPECIES HIT	11	6	7	7	8	16	***

LAST CHANCE CANYON

GRID 2 MOJAVE CREOSOTE BUSH SCRUB

PERENNIAL SPECIES	(B LINE) T1	(F LINE) T2	(J LINE) T3	(N LINE) T4	(R LINE) T5	TOTAL	% FREQUNCY
ACAMPTOPAPPUS SPHAEROCEPHALUS	2	3	6	9	9	29	11.9
ACHNATHERUM HYMENOIDES	1	1	0	0	1	3	1.2
AMBROSIA DUMOSA	10	7	9	14	16	56	23.1
COLEOGYNE RAMOSISSIMA	1	2	1	1	1	6	2.5
EPHEDRA NEVADENSIS	13	5	6	2	6	32	13.2
ERICAMERIA COOPERI	3	0	1	0	1	5	2.1
GRAYIA SPINOSA	0	1	0	3	1	5.	2.1
HYMENOCLEA SALSOLA	9	7	10	0	2	28	11.5
KRASCHENINNIKOVIA LANATA	6	3	7	13	6	35	14.4
LARREA TRIDENTATA	4	5	7	10	9	35	14.4
LYCIUM ANDERSONII	0	0	1	4	0	5	2.1
XYLORHIZA TORTIFOLIA	0	0	0	0	1	1	0.41
YUCCA BREVIFOLIA	1	2	0	0	0	3	1.2
TOTAL # OF ANNUAL HITS	50	51	41	34	27	203	12.9
ROCKS/LITTER/BARE GROUND	233	223	231	217	228	1132	72
TOTAL # OF HITS	328	316	318	294	317	1573	***
TOTAL # OF PERENNIAL SPECIES HIT	10	10	9	8	11	13	***
TOTAL # OF ANNUAL SPECIES HIT	11	9	7	8	7	19	***

RED BUTTES

GRID 3 MOJAVE CREOSOTE BUSH SCRUB

PERENNIAL SPECIES	(B LINE) T1	(F LINE) T2	(J LINE) T3	(N LINE) T4	(R LINE) T5	TOTAL	% FREQUENCY
ACAMPTOPAPPUS SPHAEROCEPHALUS	1	0	1	2	1	5	3.3
AMBROSIA DUMOSA	29	11	18	8	11	77	50
ATRIPLEX SPINIFERA	1	2	2	1	4	10	6.5
LARREA TRIDENTATA	8	5	10	6	7	36	23.4
LYCIUM ANDERSONII	2	1	1	0	0	4	2.6
PSOROTHAMNUS FREMONTII	7	6	4	0	2	19	12.3
XYLORHIZA TORTIFOLIA	1	0	0	0	1	2	1.3
YUCCA BREVIFOLIA	0	0	1	0	0	1	0.65
TOTAL # OF ANNUAL HITS	6	2	1	1	0	10	0.49
ROCKS/LITTER/BARE GROUND	425	375	369	345	371	1885	92
TOTAL # OF HITS	480	402	406	363	397	2048	***
TOTAL # OF PERENNIAL SPECIES HIT	7	5	7	4	6	8	***
TOTAL # OF ANNUAL SPECIES HIT	2	2	1	1	0	3	***

BUCKTHORN WASH

GRID 4 MOJAVE SALTBUSH SCRUB

PERENNIAL SPECIES	(B LINE) T1	(F LINE) T2	(J LINE) T3	(N LINE) T4	(R LINE) T5	TOTAL	% FREQUENCY
AMBROSIA DUMOSA	0	0	2	0	1	3	6
ATRIPLEX SPINIFERA	13	22	19	13	13	80	95.2
KRASCHENINNIKOVIA LANATA	0	0	0	1	0	1	1.2
TOTAL # OF ANNUAL HITS	1	0	2	3	0	6	0.33
ROCKS/LITTER/BARE GROUND	355	334	343	349	348	1729	95
TOTAL # OF HITS	369	356	366	366	362	1819	***
TOTAL # OF PERENNIAL SPECIES HIT	1	1	2	2	2	3	***
TOTAL # OF ANNUAL SPECIES HIT	1	0	1	1	0	2	***

SUMMARY OF VEGETATION TRANSECTS FOR GRIDS 5 AND 6

BORON NE

GRID 5 MOJAVE SALTBUSH SCRUB

PERENNIAL SPECIES	(B LINE) T1	(F LINE) T2	(J LINE) T3	(N LINE) T4	(R LINE) T5	TOTAL	% FREQUENCY
ACAMPTOPAPPUS SPHAEROCEPHALUS	0	1	0	0	0	1	0.53
ACHNATHERUM HYMENOIDES	0	1	1	0	0	2	1.1
ACHNATHERUM SPECIOSUM	1	0	1	4	0	6	3.2
AMBROSIA DUMOSA	6	6	5	11	6	34	17.9
ATRIPLEX CONFERTIFOLIA	0	5	1	9	8	23	12.1
ATRIPLEX SPINIFERA	35	15	19	20	21	110	5.8
HYMENOCLEA SALSOLA	0	2	0	4	3	9	4.7
KRASCHENINNIKOVIA LANATA	0	0	1	0	0	1	0.53
LYCIUM ANDERSONII	0	1	0	0	2	3	1.6
XYLORHIZA TORTIFOLIA	0	0	1	0	0	1	0.53
TOTAL # OF ANNUAL HITS	0	0	1	2	0	3	0.17
ROCKS/LITTER/BARE GROUND	329	349	328	321	317	1644	90.5
TOTAL # OF HITS	371	380	358	361	346	1816	***
TOTAL # OF PERENNIAL SPECIES HIT	3	7	6	5	6	10	***
TOTAL # OF ANNUAL SPECIES HIT	0	0	1	2	0	3	***

HARPER LAKE

GRID 6 MOJAVE CREOSOTE BUSH SCRUB

PERENNIAL SPECIES	(B LINE) T1	(F LINE) T2	(J LINE) T3	(N LINE) T4	(R LINE) T5	TOTAL	% FREQUENCY
AMBROSIA DUMOSA	14	15	7	5	22	63	43.2
ATRIPLEX POLYCARPA	5	1	7	3	6	22	15.1
HYMENOCLEA SALSOLA	2	2	0	0	0	4	2.7
LARREA TRIDENTATA	9	11	15	9	8	52	35.6
LEPIDOSPARTUM SQUAMATUM	0	0	1	2	0	3	2.1
LYCIUM ANDERSONII	0	0	0	1	0	1	0.69
PSOROTHAMNUS FREMONTII	1	0	1	0	0	2	0.69
TOTAL # OF ANNUAL HITS	0	0	0	0	0	0	0
ROCKS/LITTER/BARE GROUND	320	348	332	342	349	1691	
TOTAL # OF HITS	351	377	362	362	385	1837	***
TOTAL # OF PERENNIAL SPECIES HIT	5	4	4	5	3	7	***
TOTAL # OF ANNUAL SPECIES HIT	0	0	0	0	0	0	***

SUMMARY OF VEGETATION TRANSECTS FOR GRIDS 7 AND 8

RED MOUNTAIN

GRID 7 MOJAVE CREOSOTE BUSH SCRUB

PERENNIAL SPECIES	(B LINE) T1	(F LINE) T2	(J LINE) T3	(N LINE) T4	(R LINE) T5	TOTAL	% FREQUENCY
ACHNATHERUM SPECIOSUM	1	2	2	4	2	11	9.8
AMBROSIA DUMOSA	0	2	1	0	0	3	2.5
EPHEDRA NEVADENSIS	1	0	0	0	0	1	0.82
ERICAMERIA COOPERI	13	7	11	5	7	43	35.2
ERIOGONUM FASCICULATUM	1	0	0	1	0	2	1.6
HYMENOCLEA SALSOLA	3	0	0	0	0	3	2.5
LARREA TRIDENTATA	4	21	10	9	13	57	46.7
SALAZARIA MEXICANA	1	0	0	1	0	2	1.6
TOTAL # OF ANNUAL HITS	2	1	6	3	10	22	1.2
ROCKS/LITTER/BARE GROUND	349	325	335	314	342	1665	92
TOTAL # OF HITS	375	358	365	337	374	1809	***
TOTAL # OF PERENNIAL SPECIES HIT	7	4	4	5	3	8	***
TOTAL # OF ANNUAL SPECIES HIT	2	1	4	2	5	6	***

SUPERIOR VALLEY

GRID 8 MOJAVE SALTBUSH SCRUB

PERENNIAL SPECIES	(B LINE) T1	(F LINE) T2	(J LINE) T3	(N LINE) T4	(R LINE) T5	TOTAL	% FREQUENCY
ACAMPTOPAPPUS SPHAEROCEPHALUS	1	0	1	1	0	3	2.5
ACHNATHERUM HYMENOIDES	0	0	1	0	0	1	0.83
AMBROSIA DUMOSA	5	2	7	6	8	28	23.1
ARTEMESIA SPINESCENS	0	0	0	2	2	4	3.3
ATRIPLEX CONFERTIFOLIA	2	0	0	4	0	6	5
ATRIPLEX POLYCARPA	15	10	9	13	16	63	52.1
ERICAMERIA COOPERI	3	0	2	1	1	7	5.8
HYMENOCLEA SALSOLA	0	0	1	0	0	1	0.83
LYCIUM ANDERSONII	1	0	4	0	0	5	4.1
TETRADEMIA SPINOSA	0	2	1	0	0	3	2.5
TOTAL # OF ANNUAL HITS	1	1	1	1	0	4	0.22
ROCKS/LITTER/BARE GROUND	309	352	331	355	342	1689	93.1
TOTAL # OF HITS	337	367	358	383	369	1814	***
TOTAL # OF PERENNIAL SPECIES HIT	6	3	8	6	4	10	***
TOTAL # OF ANNUAL SPECIES HIT	1	1	1	1	0	2	***

SUMMARY OF VEGETATION TRANSECTS FOR GRID 9

LANE MOUNTAIN

GRID 9 MOJAVE CREOSOTE BUSH SCRUB

PERENNIAL SPECIES	(B LINE) T1	(F LINE) T2	(J LINE) T3	(N LINE) T4	(R LINE) T5	TOTAL	% FREQUENCY
ACAMPTOPAPPUS SPHAEROCEPHALUS	2	1	3	0	3	9	6.5
ACHNATHERUM SPECIOSUM	0	0	1	1	1	3	2.2
AMBROSIA DUMOSA	2	1	0	0	2	5	3.6
EPHEDRA NEVADENSIS	1	3	2	3	4	13	9.4
ERICAMERIA COOPERI	0	0	0	0	3	3	2.2
GRAYIA SPINOSA	6	4	3	7	9	29	21
HYMENOCLEA SALSOLA	0	1	0	2	0	3	2.2
KRASCHENINNIKOVIA LANATA	8	5	3	6	1	23	16.7
LARREA TRIDENTATA	7	5	5	6	4	27	19.6
LYCIUM ANDERSONII	1	0	4	1	0	6	4.3
SALAZARIA MEXICANA	0	0	1	3	1	5	3.6
TETRADEMIA SPINOSA	0	0	1	0	1	2	1.5
THAMNOSMA MONTANUM	2	1	0	2	2	7	5.1
XYLORHIZA TORTIFOLIA	1	0	1	1	0	3	2.2
TOTAL # OF ANNUAL HITS	14	29	38	22	28	131	7.5
ROCKS/LITTER/BARE GROUND	327	311	295	282	277	1492	85.8
TOTAL # OF HITS	368	359	340	336	335	1738	***
TOTAL # OF PERENNIAL SPECIES HIT	9	7	10	10	11	14	***
TOTAL # OF ANNUAL SPECIES HIT	3	4	5	4	3	6	***

SUMMARY OF VEGETATION TRANSECTS FOR GRIDS 10, 11 AND 12 (SAMPLED IN 1995)

RED MOUNTAIN II — GRID 10 — MOJAVE CREOSOTE BUSH SCRUB

Perennial Species	TRANSECT B	F	J	N	R	TOTAL	% FREQUENCY
Acamptopappus sphaerocephalus	19	7	3	7	3	39	16.46
Ambrosia dumosa	2					2	0.84
Ephedra nevadensis	3	3	13	1	2	22	9.28
Ericamaria cooperi	9	18	17	20	15	79	33.33
Grayia spinosa	10	4	3	5		22	9.28
Hymonoclea salsola	3	1	1	1	2	8	3.38
Krascheninnikovia lanata	3	3			1	7	2.95
Larrea tridentata	8	10	9	4	11	42	17.72
Lycium andersonii			1	3		4	1.69
Lycium cooperi		1		2	1	4	1.69
Salazaria mexicana					2	2	0.84
Tetradymia stenolepis		4	2			6	2.53
Total # perennial hits	57	51	49	43	37	237	14.06
Total # of annual hits	163	155	168	179	189	854	50.65
Rocks/litter/bare ground	125	115	131	120	104	595	35.29
Total # of hits	345	321	348	342	330	1686	***
Total # perennial species hit	8	9	8	8	8	12	***
Total # annual species hit	19	19	21	20	21	29	***

FREMONT VALLEY — GRID 11 — MOJAVE CREOSOTE BUSH SCRUB

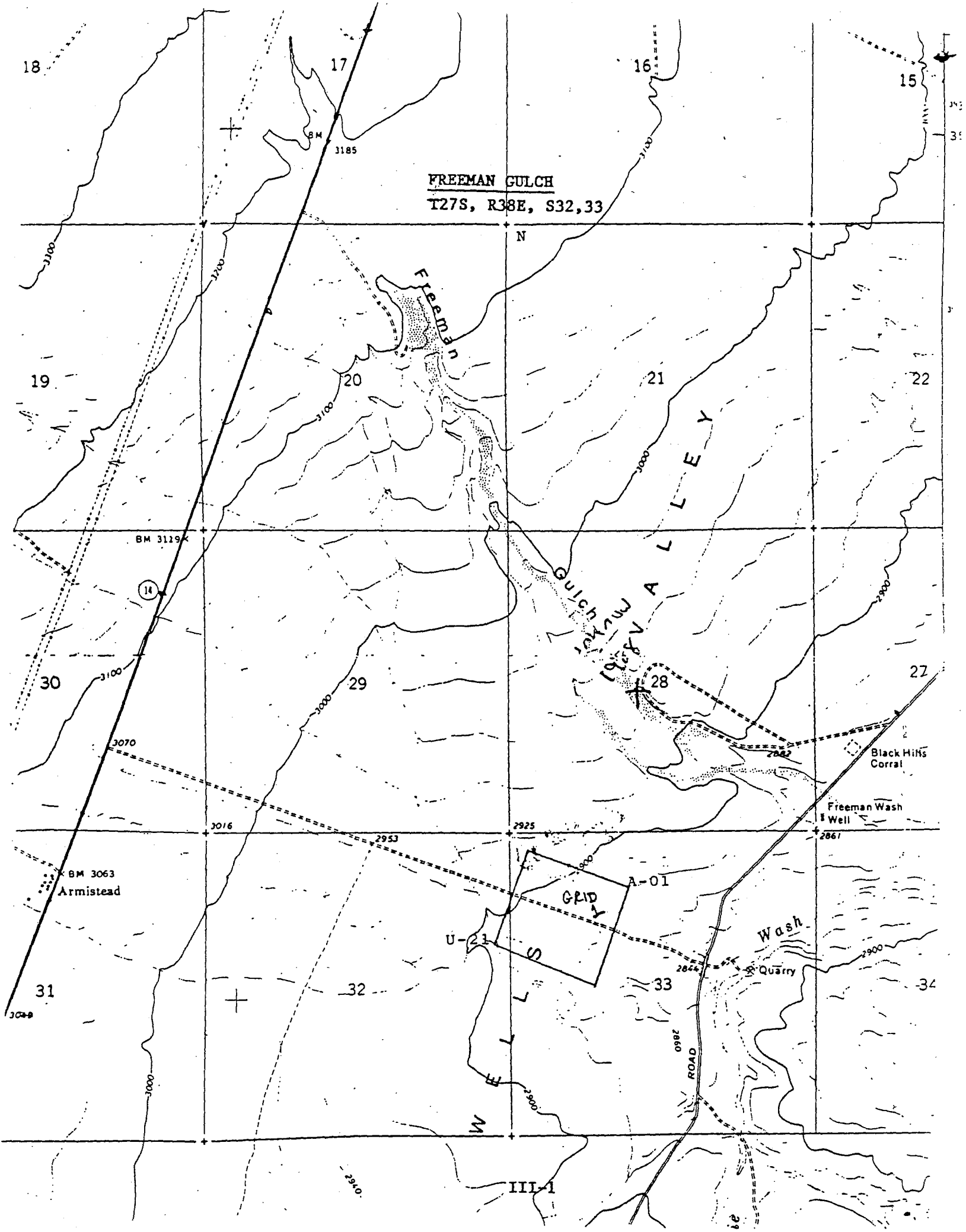
Perennial Species	TRANSECT B	F	J	N	R	TOTAL	% FREQUENCY
Acamptopappus sphaerocephalus	10	14	14	9	6	53	24.65
Ambrosia dumosa	17	20	21	20	31	109	50.70
Hymonoclea salsola	1	1	1	1	5	9	4.19
Krascheninnikovia lanata					1	1	0.47
Larrea tridentata	9	6	8	9	10	42	19.53
Tetradymia stenolepis			1			1	0.47
Total # perennial hits	37	41	45	39	53	215	15.74
Total # of annual hits	143	133	101	80	96	553	40.48
Rocks/litter/bare ground	99	93	116	159	131	598	43.78
Total # of hits	279	267	262	278	280	1366	***
Total # perennial species hit	4	4	5	4	5	6	***
Total # annual species hit	12	6	7	7	9	16	***

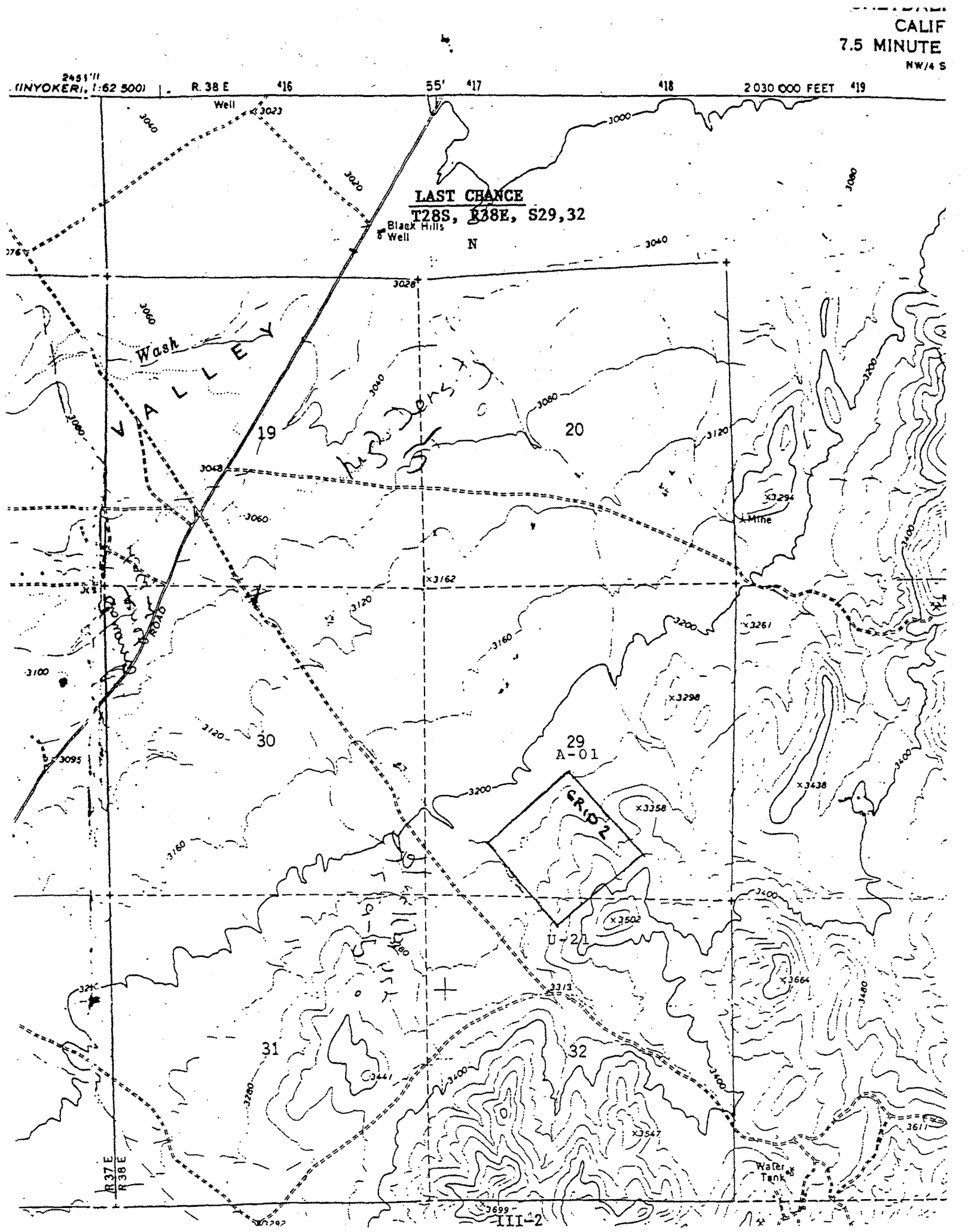
RED BUTTES II — GRID 12 — MOJAVE SALTBUSH SCRUB

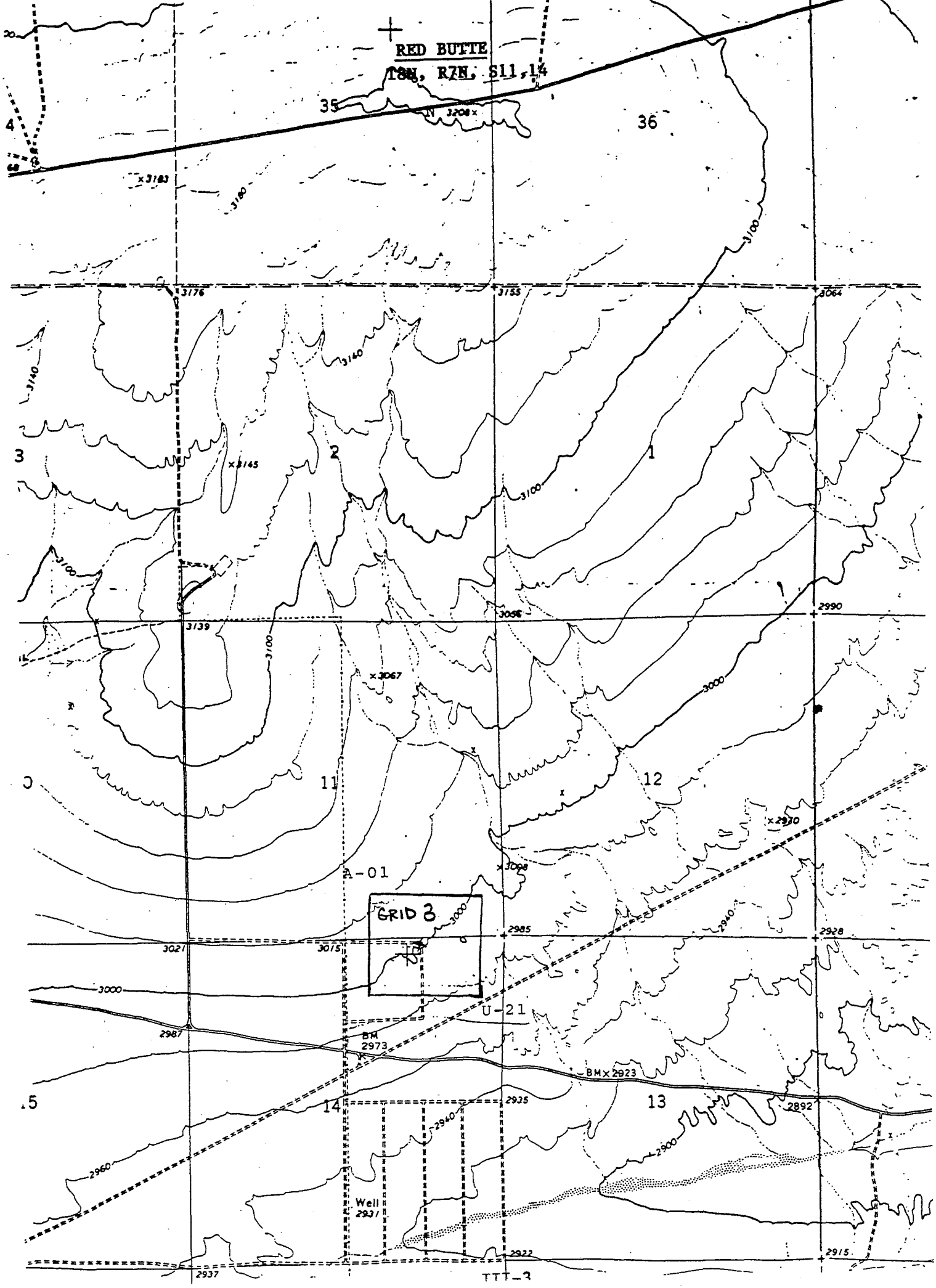
Perennial Species	TRANSECT B	F	J	N	R	TOTAL	% FREQUENCY
Acamptopappus sphaerocephalus	1	2	3	1		7	5.51
Ambrosia dumosa	1	2	4	2	4	13	10.24
Atriplex spinifera	6	19	19	23	18	85	66.93
Hymonoclea salsola		2	3			5	3.94
Krascheninnikovia lanata	3	5	2	1		11	8.66
Lycium andersonii	1		3		1	5	3.94
Tetradymia stenolepis		1				1	0.79
Total # perennial hits	12	31	34	27	23	127	7.96
Total # of annual hits	149	129	151	151	112	692	43.39
Rocks/litter/bare ground	115	169	163	116	213	776	48.65
Total # of hits	276	329	348	294	348	1595	***
Total # perennial species hit	5	6	6	4	3	7	***
Total # annual species hit	9	10	11	17	9	17	***

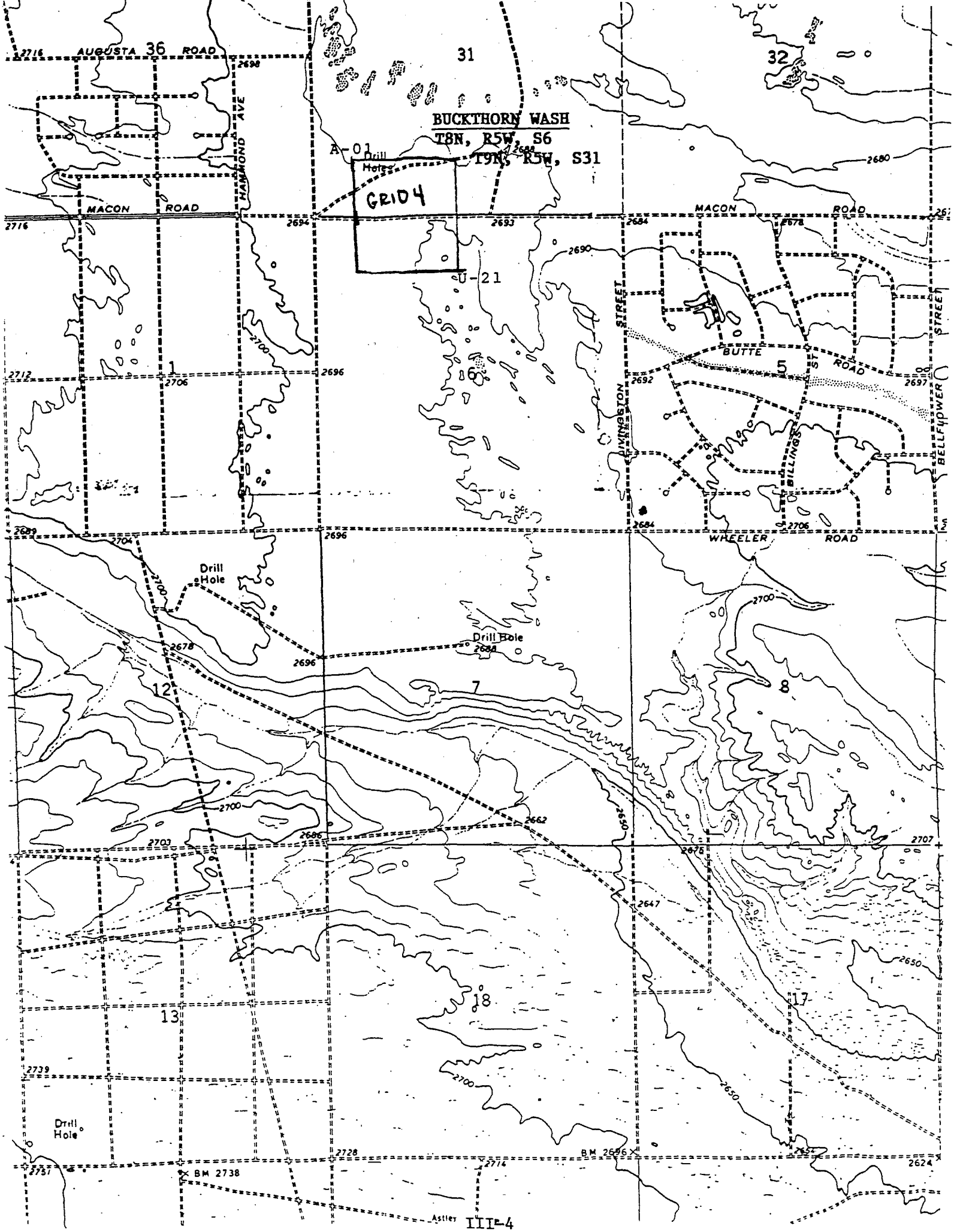
APPENDIX III

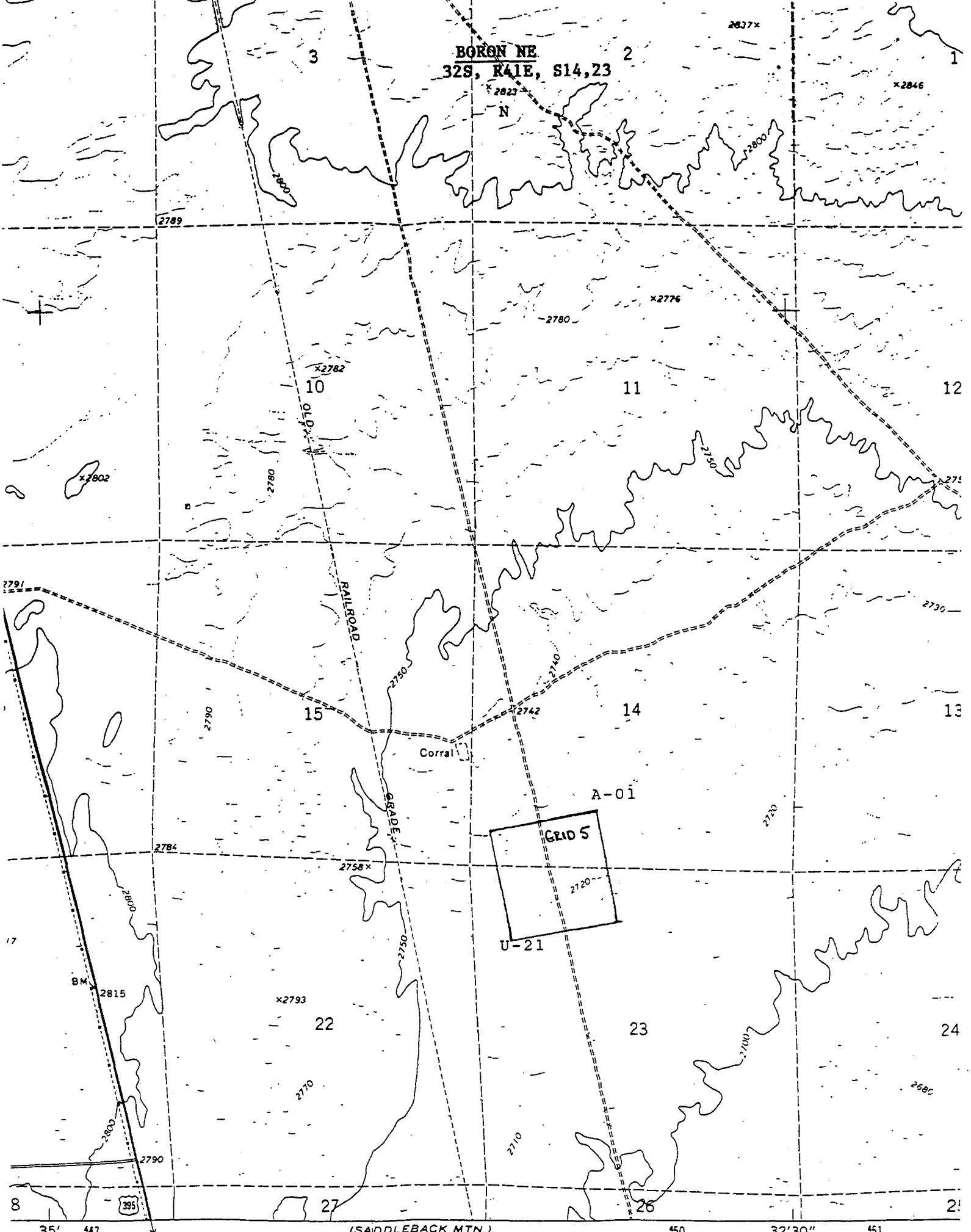
MAPS SHOWING GRID LOCATIONS


FREEMAN GULCH
T27S, R38E, S32,33
N
18
17
16
15
19
20
21
22
30
29
28
27
31
32
33
34
BM 3185
BM 3129
BM 3063
Armistead
Freeman
Gulch
MUSHUW
VALLEY
Black Hills Corral
Freeman Wash Well
Quarry
Wash
ROAD
WILLS
GRID
A-01
U-21
III-1
3100
3000
3070
3016
2953
2925
2882
2861
2844
2900
2940
2980

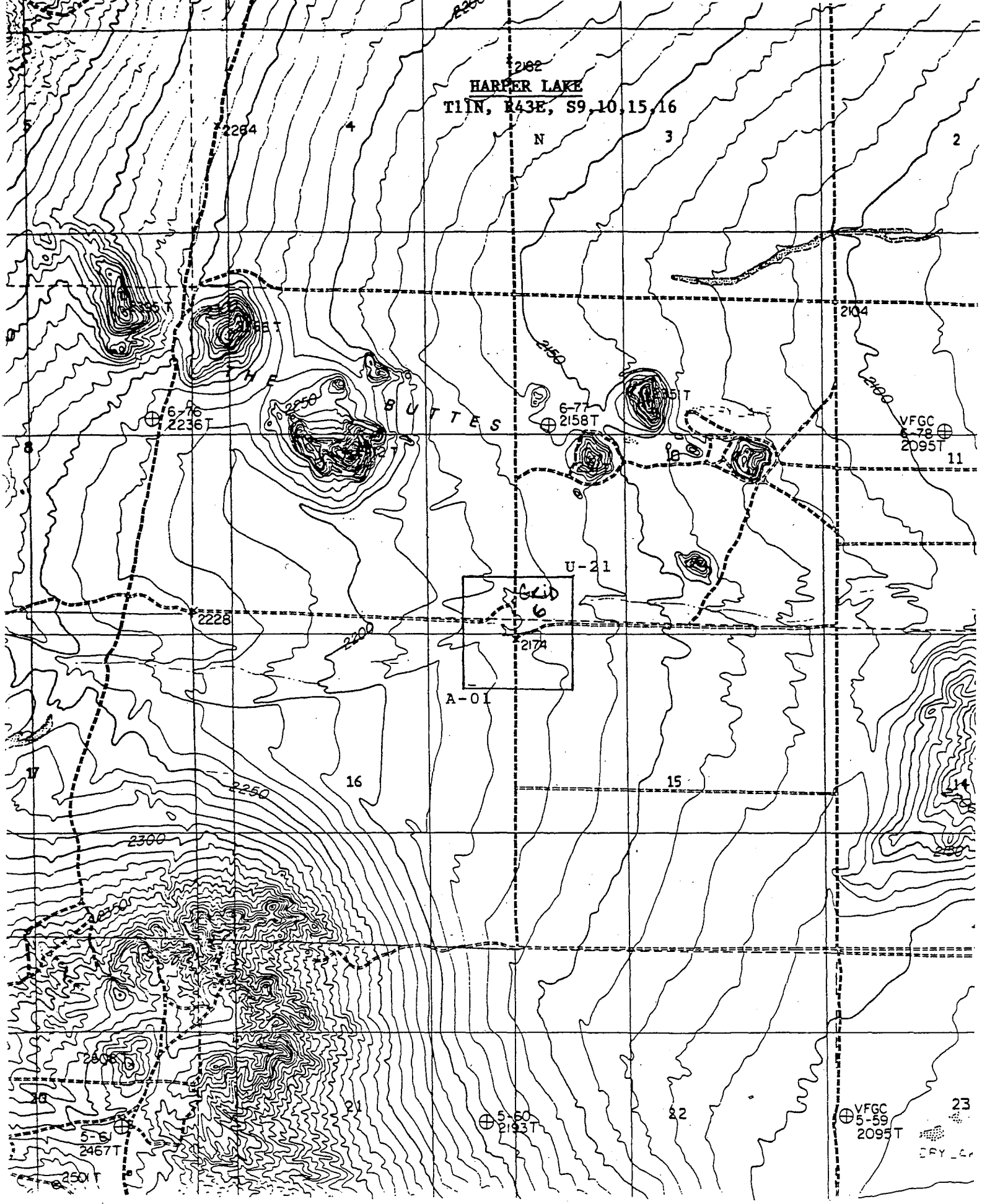

CALIF
7.5 MINUTE
NW/4 S
(INYOKERN, 1:62 500)
R. 38 E
55'
2 030 000 FEET
Well
LAST CHANCE
T28S, R38E, S29,32
Black Hills
Well
N
Wash
VALLEY
19
20
30
29
A-01
GRID 2
U-21
31
32
Mine
Water Tank
R37E
R38E
3023
3000
3020
3040
3060
3080
3100
3120
3160
3200
3280
3400
3480
3611
3699
3441
3547
3502
3313
3358
3298
3261
3294
3438
3664
3162
3095


RED BUTTE
T8N, R7N, S11,14
35
36
3
2
1
11
12
14
13
A-01
U-21
GRID 8
BM 2973
BM x 2923
Well 2931
3176
3155
3064
3139
3067
3098
2990
2985
2928
3021
3015
2987
2935
2892
2922
2915
2937
3100
3140
3145
3183
3208
3000
2940
2960
2900
TTT-3


BUCKTHORN WASH
T8N, R5W, S6
T9N, R5W, S31
A-01
Drill Hole
GRID 4
U-21
AUGUSTA ROAD
MACON ROAD
HAMMOND AVE
BUTTE ROAD
WHEELER ROAD
LIVINGSTON STREET
BILLINGS ST
BELLFLOWER STREET
Drill Hole
BM 2738
BM 2696
Astley



SCALE 1:24 000


HARPER LAKE
T11N, R43E, S9,10,15,16
N
THE BUTTES
6-76
2236T
6-77
2158T
VFGC
6-78
2095T
U-21
Grid 6
A-01
5-60
2193T
VFGC
5-59
2095T
5-61
2467T
2250T
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2174
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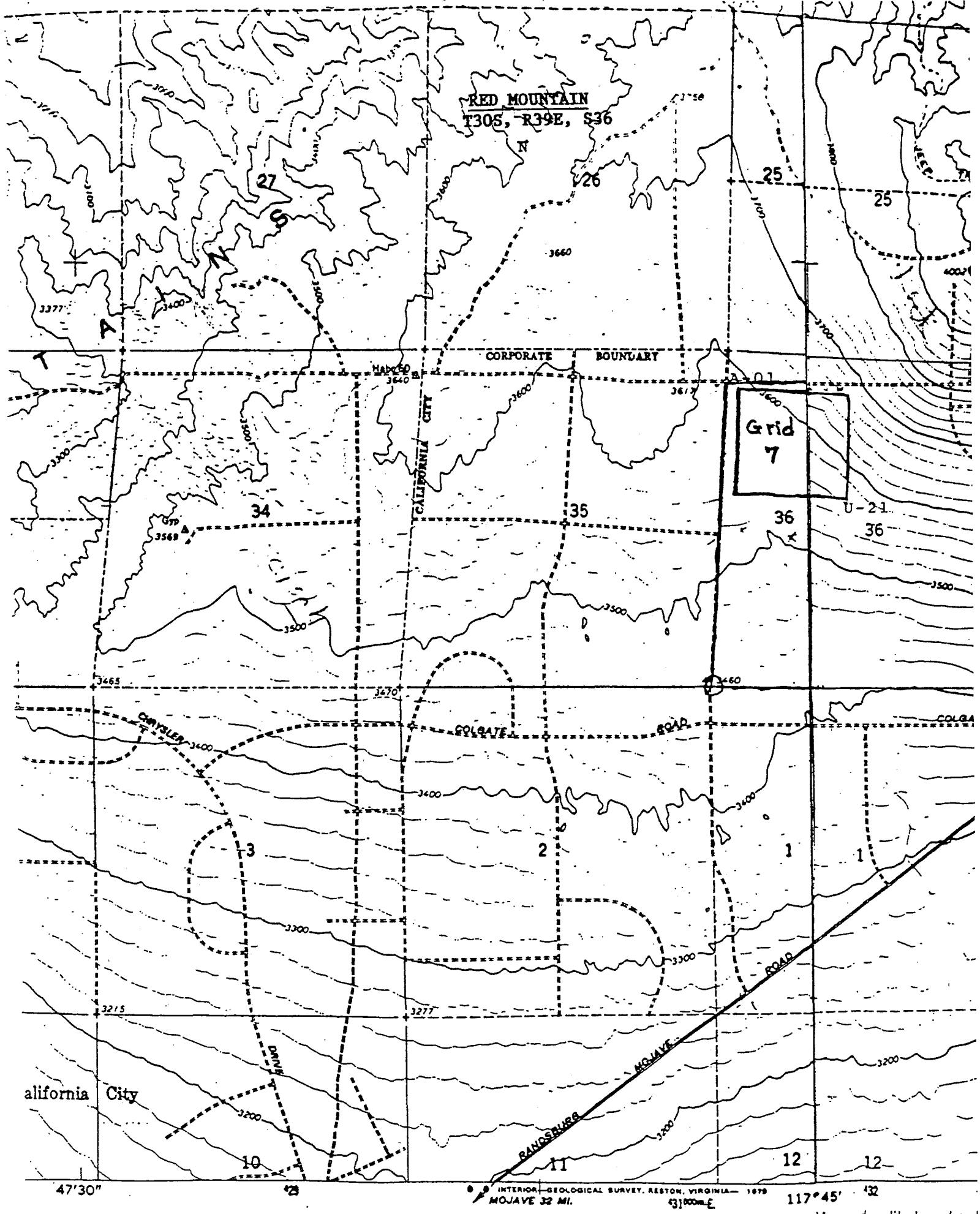
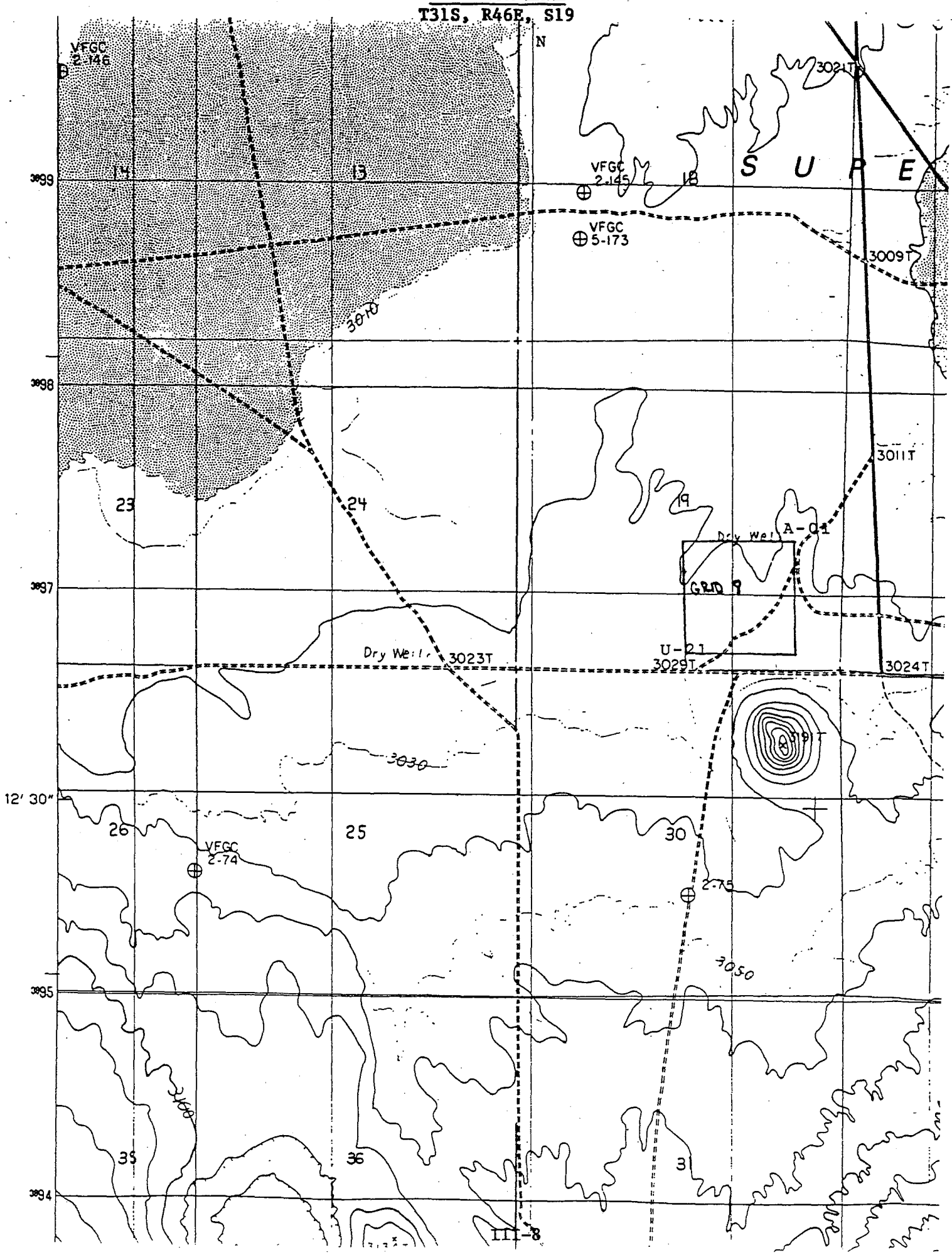
2450
2400
2350
2300
2250
2200
2806
DRY LAKE

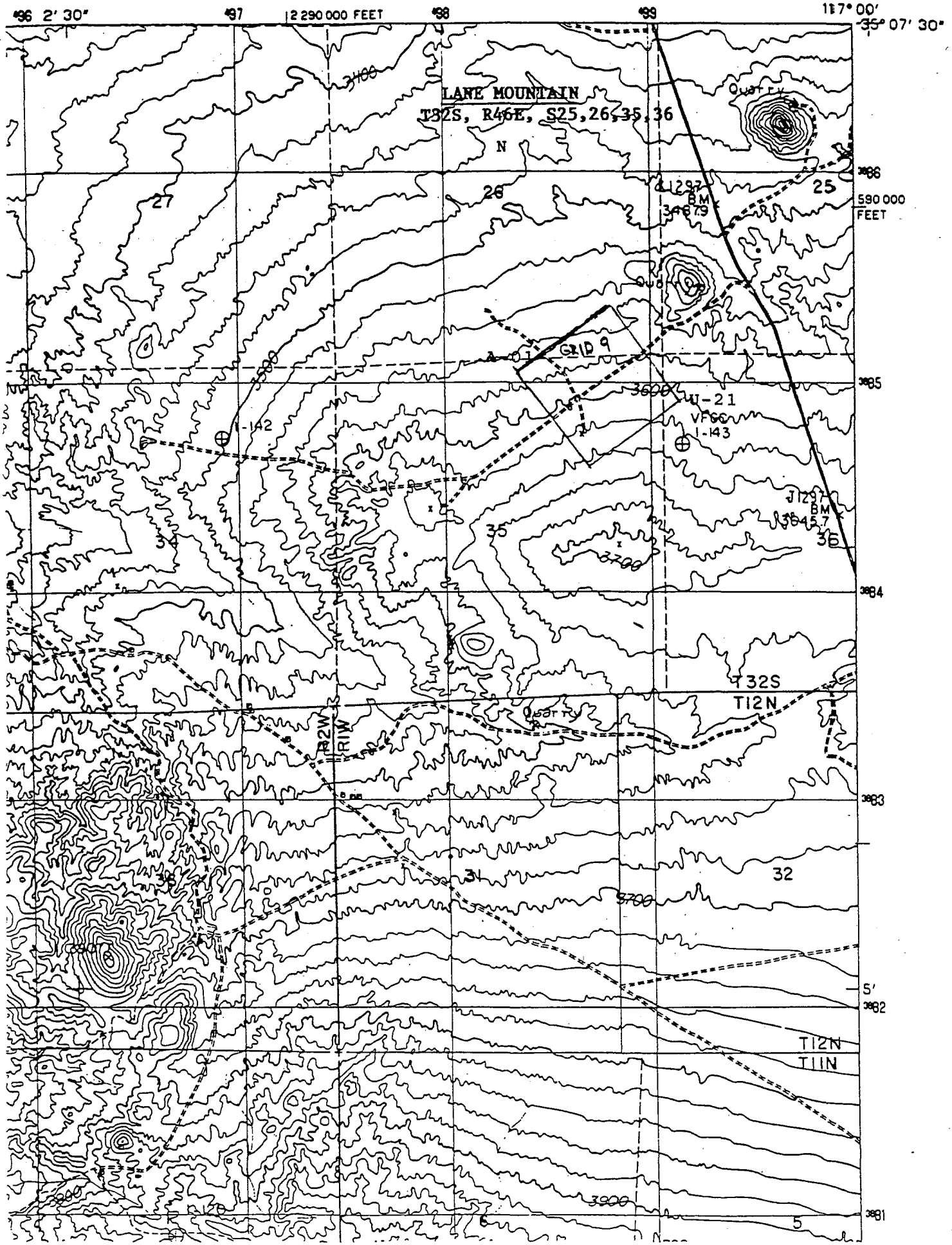


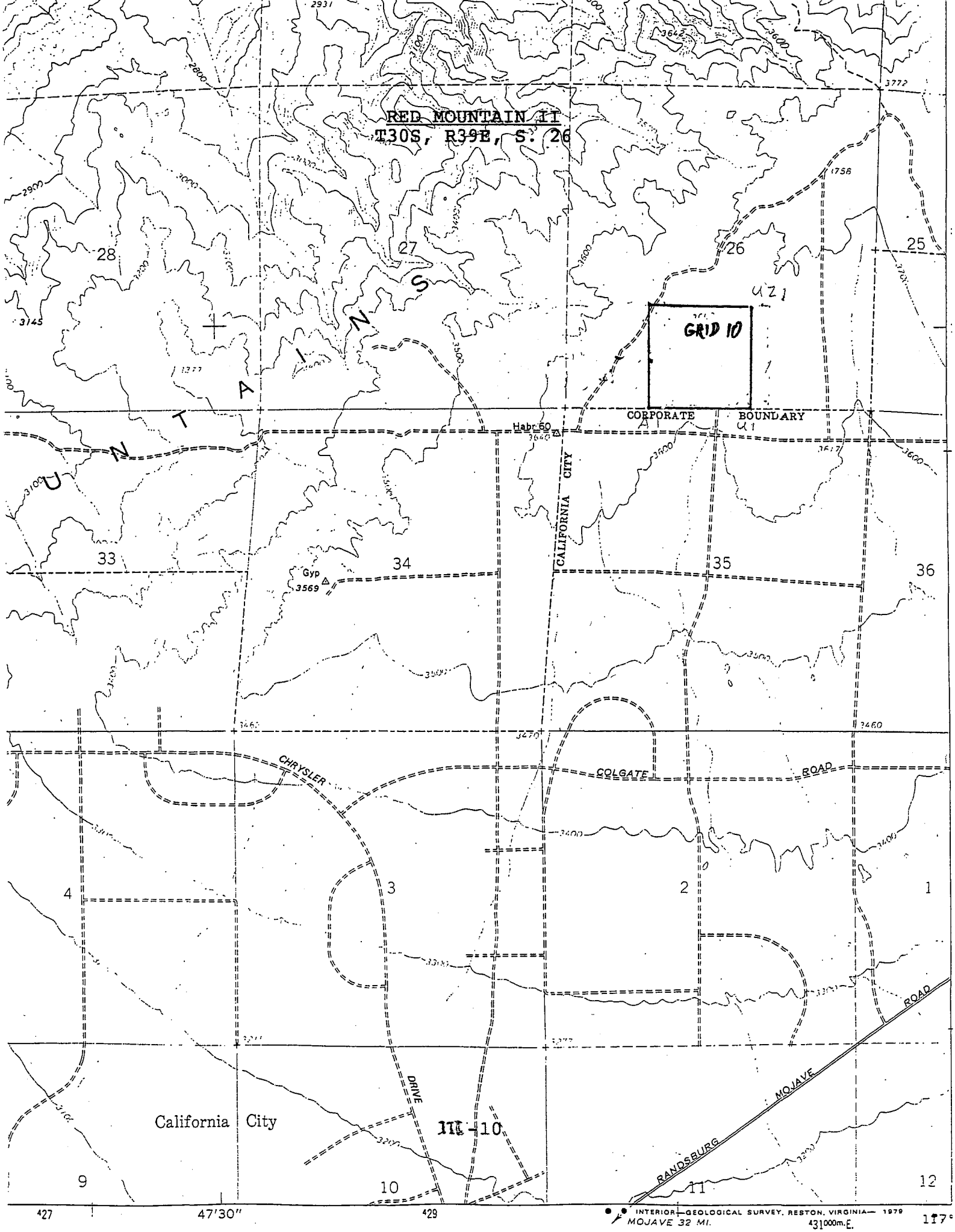
Mapped, edited, and pul

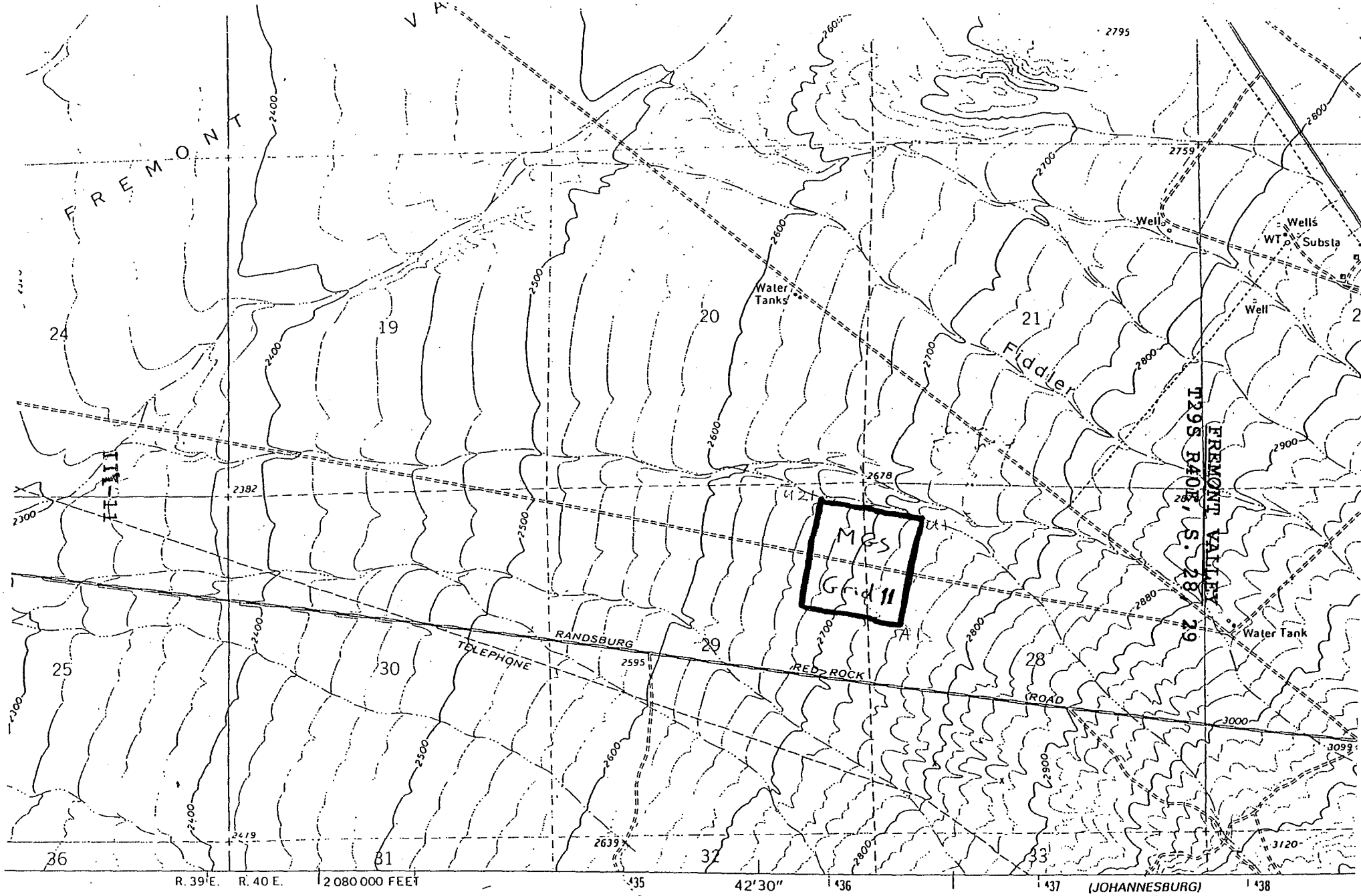
Control by USGS and USC

SUPERIOR LAKE
T31S, R46E, S19




LANE MOUNTAIN
T32S, R46E, S25,26,35,36
2 290 000 FEET
590 000 FEET
GRID 9
U-21
I-142
I-143
J1297
BM
T32S
T12N
T11N
R12W
R11W
25
26
27
28
31
32
34
35
36
5


RED MOUNTAIN II
T30S, R39E, S. 26
GRID 10
CORPORATE BOUNDARY
CALIFORNIA CITY
Habr 60
Gyp
3569
CHRYSLER
COLGATE
ROAD
DRIVE
MOJAVE
RANDSBURG
ROAD
California City
III-10
28
27
26
25
33
34
35
36
4
3
2
1
9
10
11
12
427
47'30"
429
INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA—1979
MOJAVE 32 MI.
431000m.E.
117°



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graphy by photogrammetric methods from aerial photographs
1965. Field checked 1967

onic projection. 1927 North American Datum

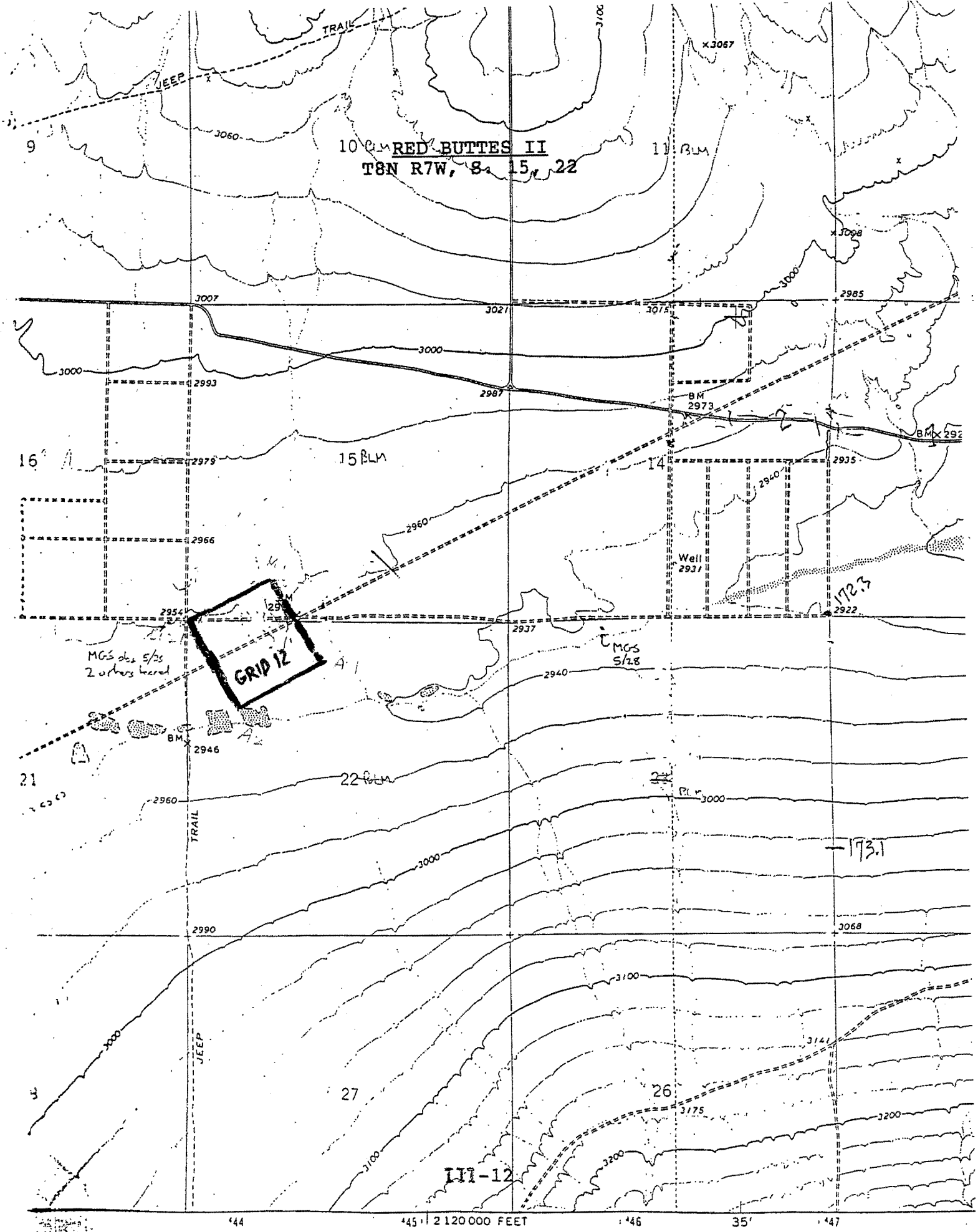
GN
0°24'
7 MILS
15½°
276 MILS

SCALE 1:24 000

1000 0 1000 2000 3000 4000 5000 6000

CONTOUR INTERVAL 20 FEET

NATIONAL GEODETIC VERTICAL DATUM OF 1929



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APPENDIX IV

CAPTURE LOCATIONS OF MGS ON EACH GRID

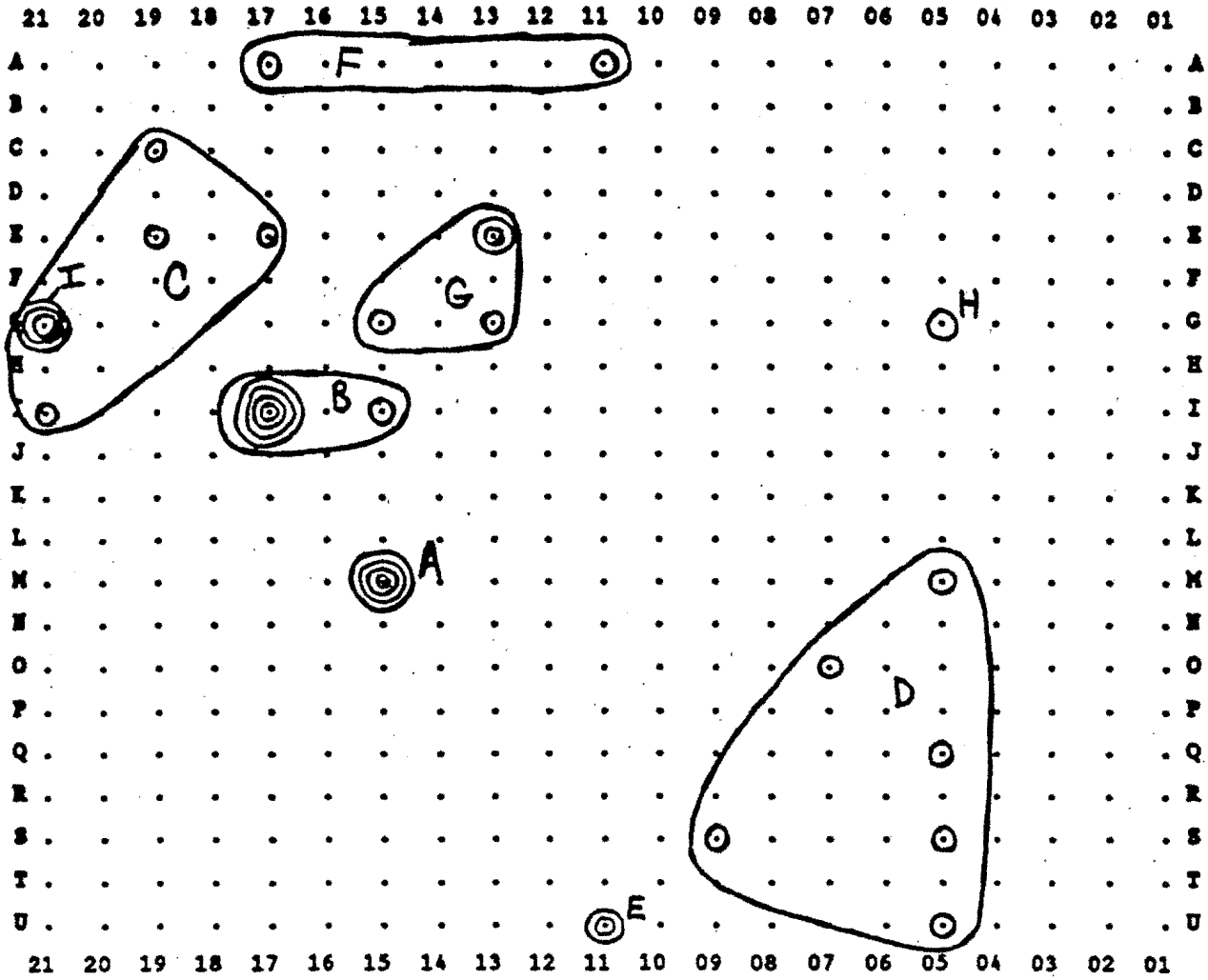
Notes:

1) Each circle surrounding a dot on the grid maps represents a single capture event at that station. If a dot is circled more than once, more than one capture occurred there. In some instances, more than one Mohave ground squirrel was captured at a station; this is noted by both alphabetic letters indicating individual animals marking the concentric circles. Larger enclosed areas represent a conservative approximation of home range for a single Mohave ground squirrel.

2) Trap stations are located only on alternate letters and numbers of the maps shown (e.g., stations are at 1, 3, 5 but not 2, 4, 6 and so on; also stations are at A, C, E but not B, D, F and so on).

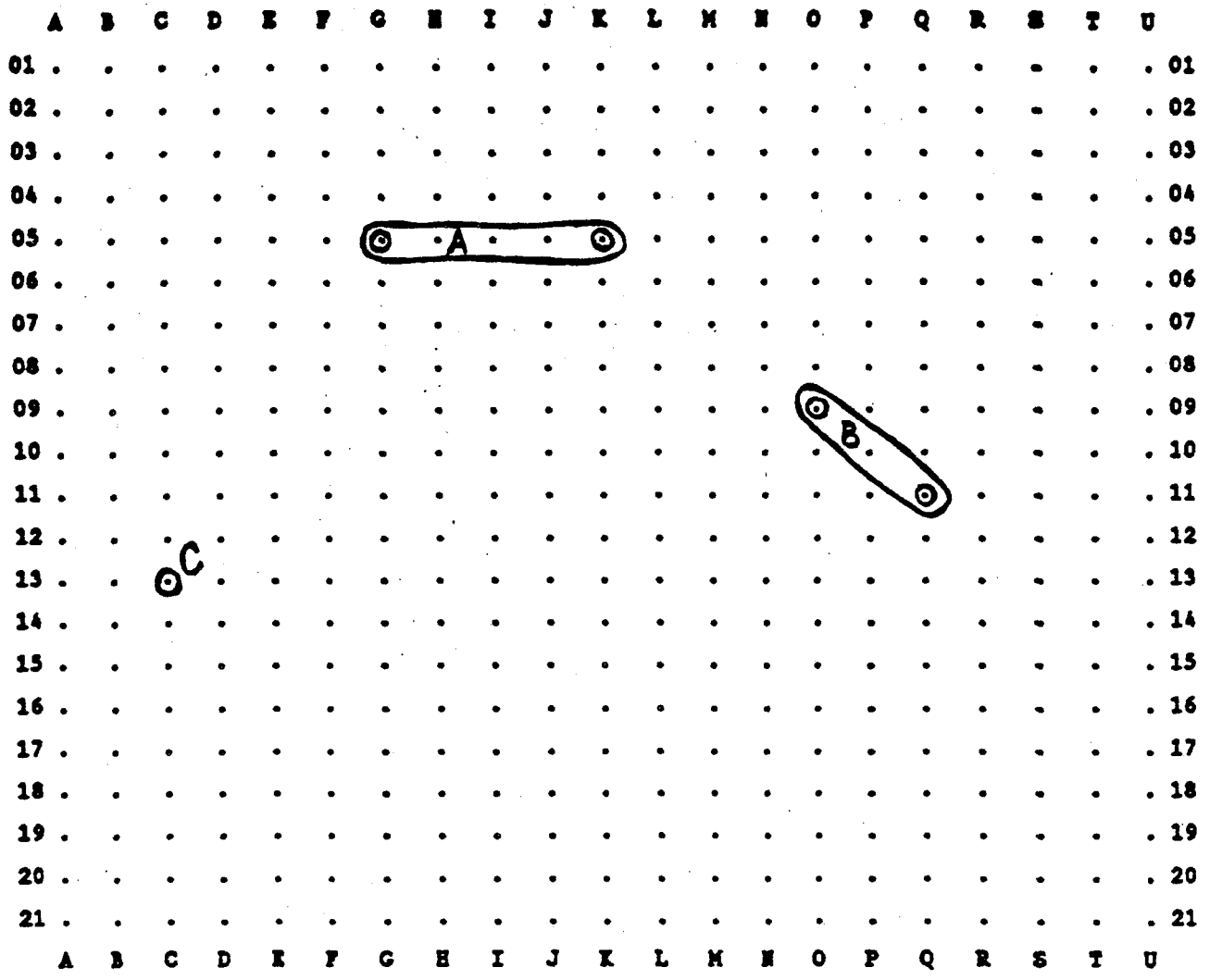
3) The arrangement of the numbering and lettering of grid stations is slightly different on grids studied in 1994 (grids 1-9) than those studied in 1995 (10-12). Specifically, while numbered lines run from 1 to 21 from left to right (west to east) on all grids, lettered lines begin with A in the northernmost position in grids 1-9 and in the southernmost position in grids 10-12.

CORE RESERVE MOHAVE GROUND SQUIRREL TRAPPING
GRID: 1 Freeman Gulch
DATES TRAPPED: May 1-5 1994



N

CORE RESERVE MOHAVE GROUND SQUIRREL TRAPPING
GRID: 2 Last Chance
DATES TRAPPED: May 7-11 1994



CORE RESERVE MOHAVE GROUND SQUIRREL TRAPPING
GRID: 3 Red Butte
DATES TRAPPED: May 14-18 1994

	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	
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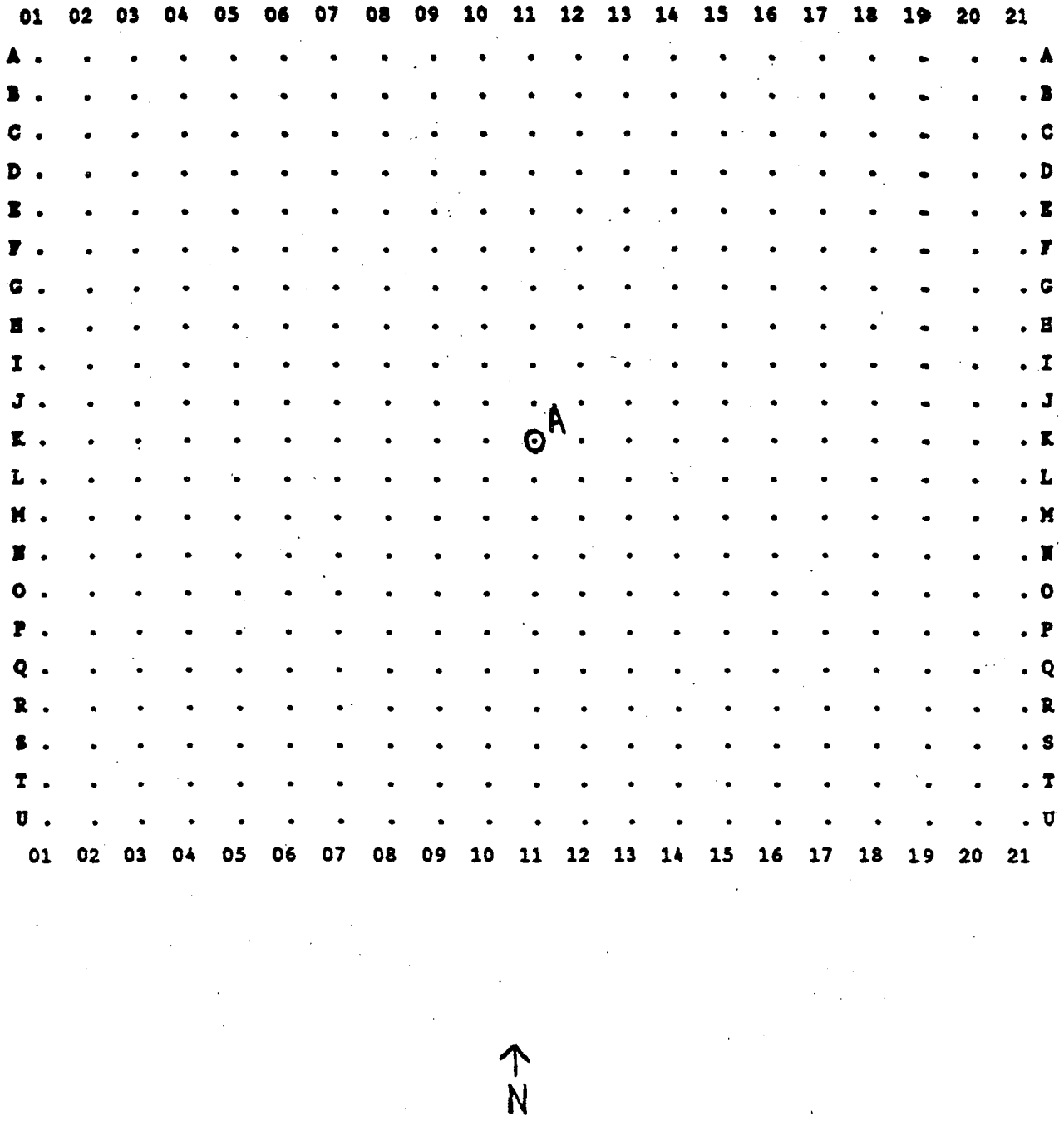
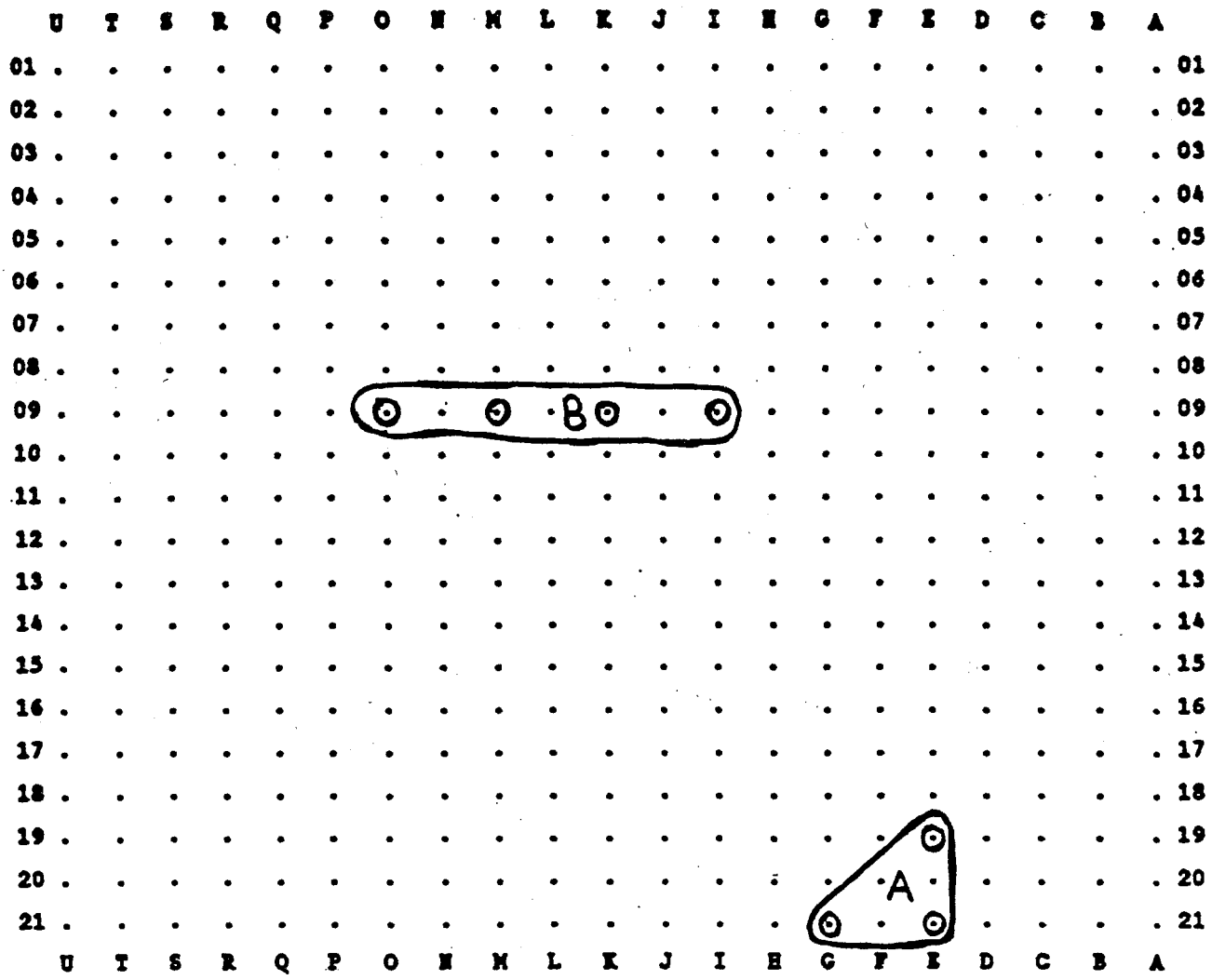
NO MGS CAPTURED

N

CORE RESERVE MOHAVE GROUND SQUIRREL TRAPPING
GRID: 4 Buckthorn Wash
DATES TRAPPED: May 16-20 1994

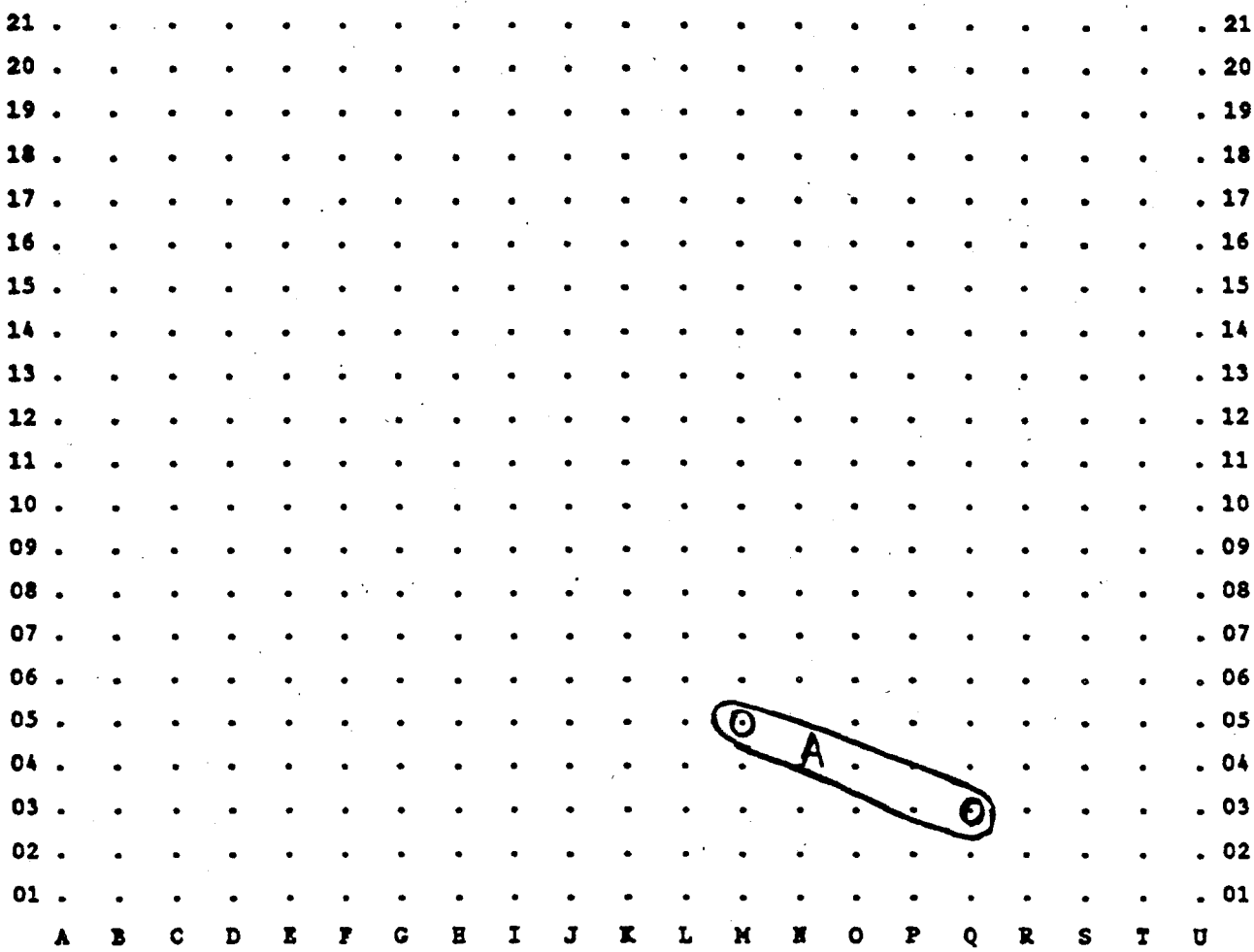


CORE RESERVE MOHAVE GROUND SQUIRREL TRAPPING
GRID: 5 Boron NE
DATES TRAPPED: May 22-26 1994



N

CORE RESERVE MOHAVE GROUND SQUIRREL TRAPPING
GRID: 6 Harper Lake
DATES TRAPPED: May 27-31 1994



N

CORE RESERVE MOHAVE GROUND SQUIRREL TRAPPING
GRID: 7 Red Mountain
DATES TRAPPED: June 4-8 1994

	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	
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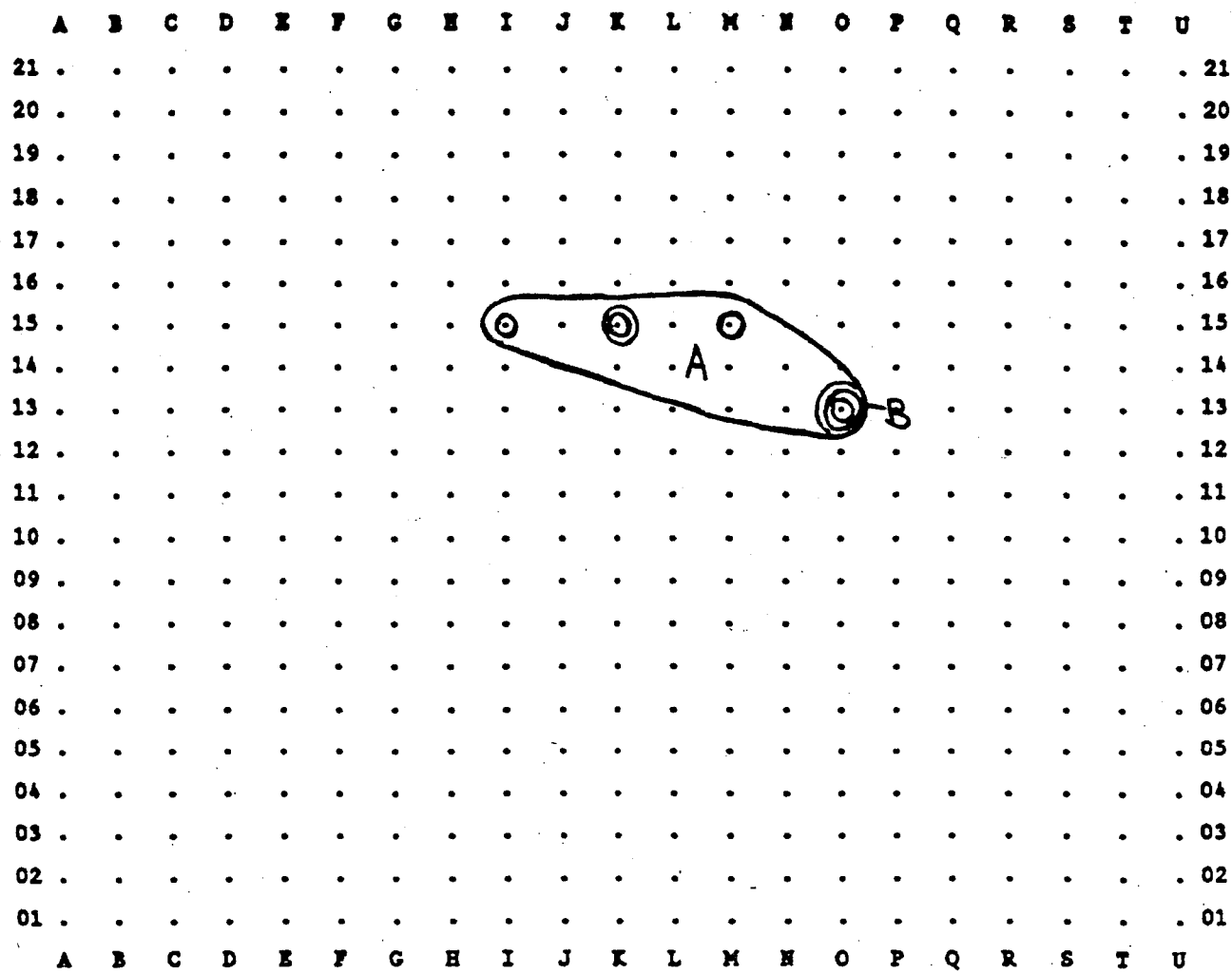
	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	

NO MGS CAPTURED

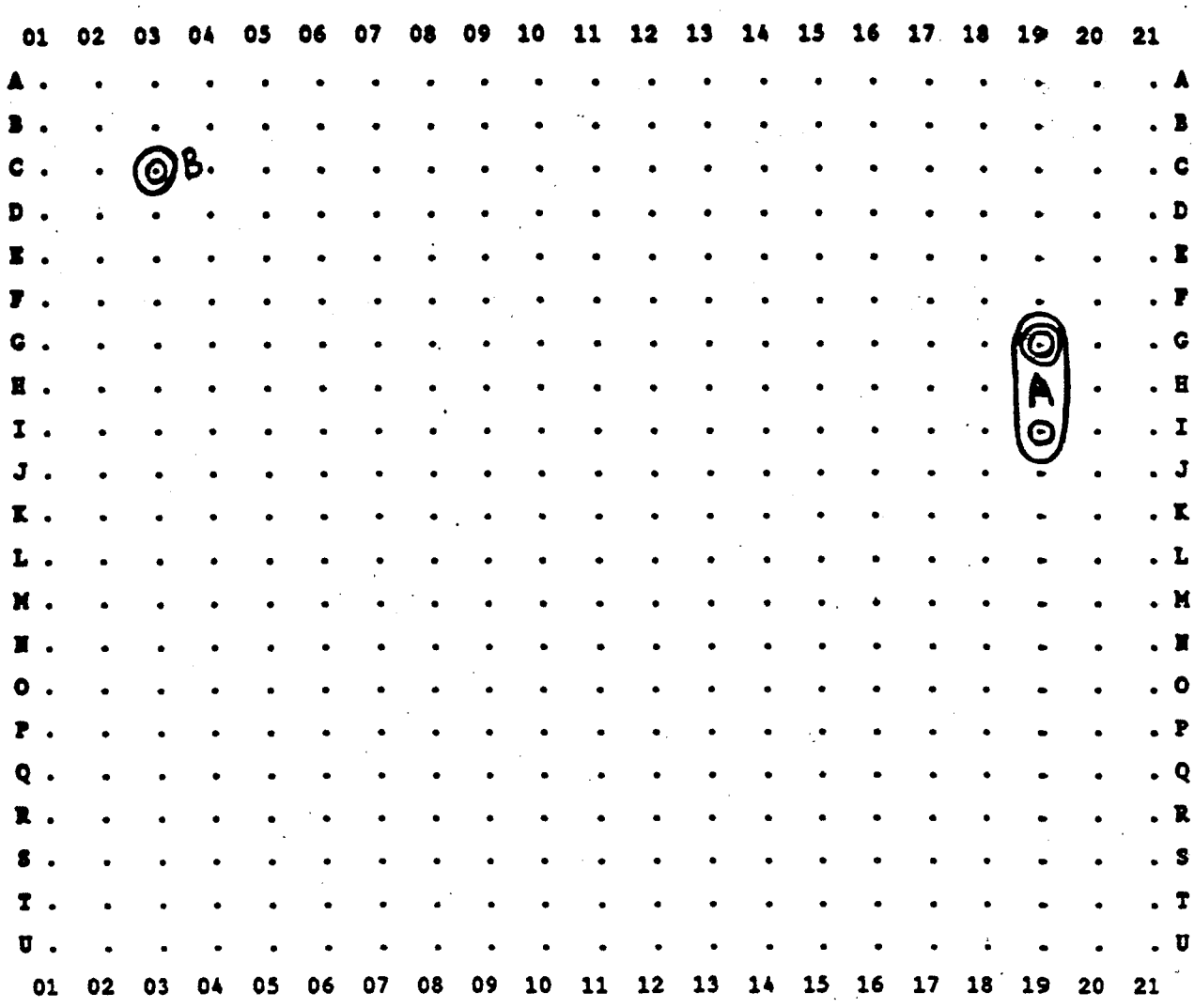
↑
N

CORE RESERVE MOHAVE GROUND SQUIRREL TRAPPING
GRID: 8 Superior Lake
DATES TRAPPED: June 7-11, 1994



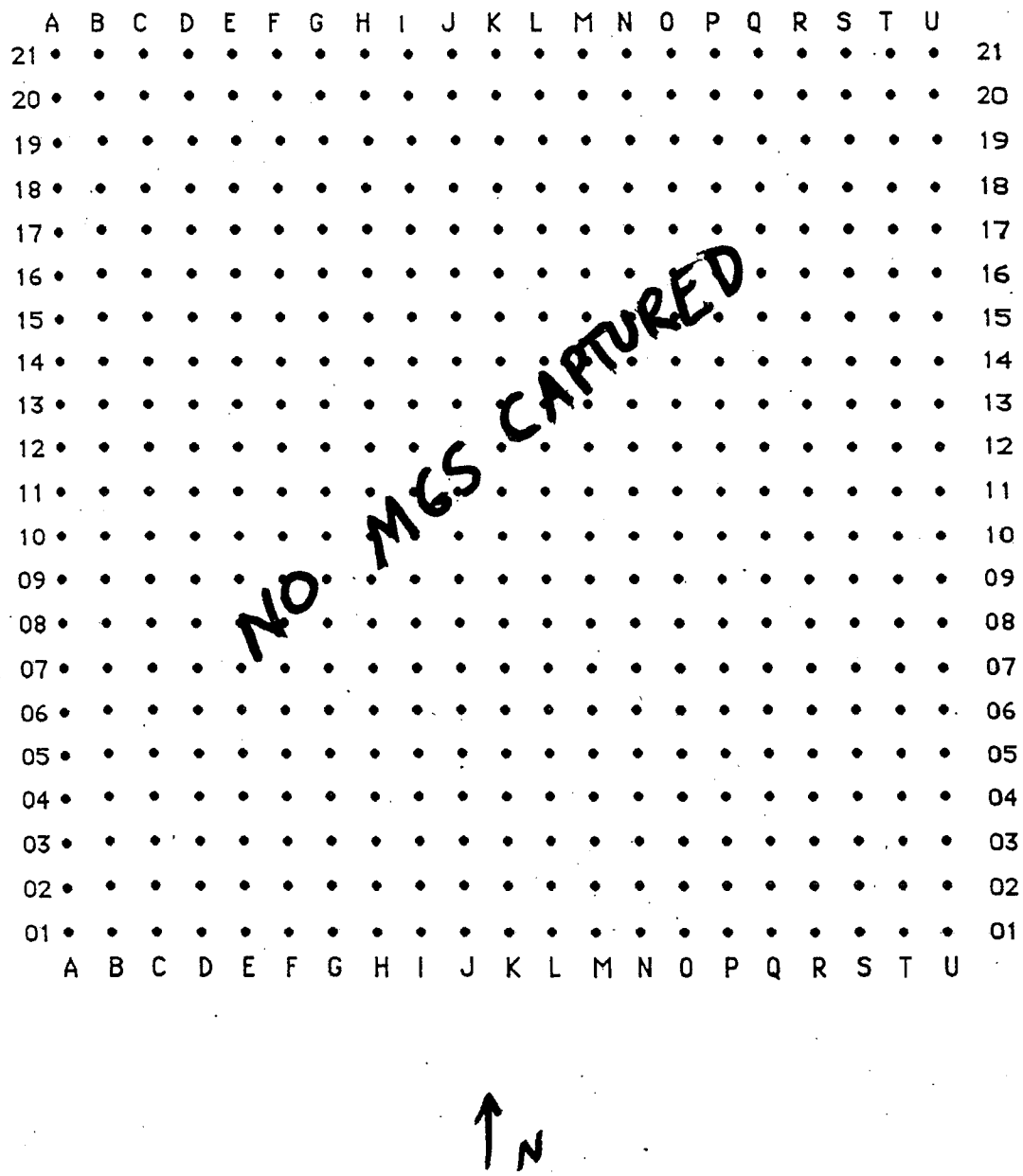
N

CORE RESERVE MOHAVE GROUND SQUIRREL TRAPPING
GRID: 9 Lane Mountain
DATES TRAPPED: June 13-17, 1994

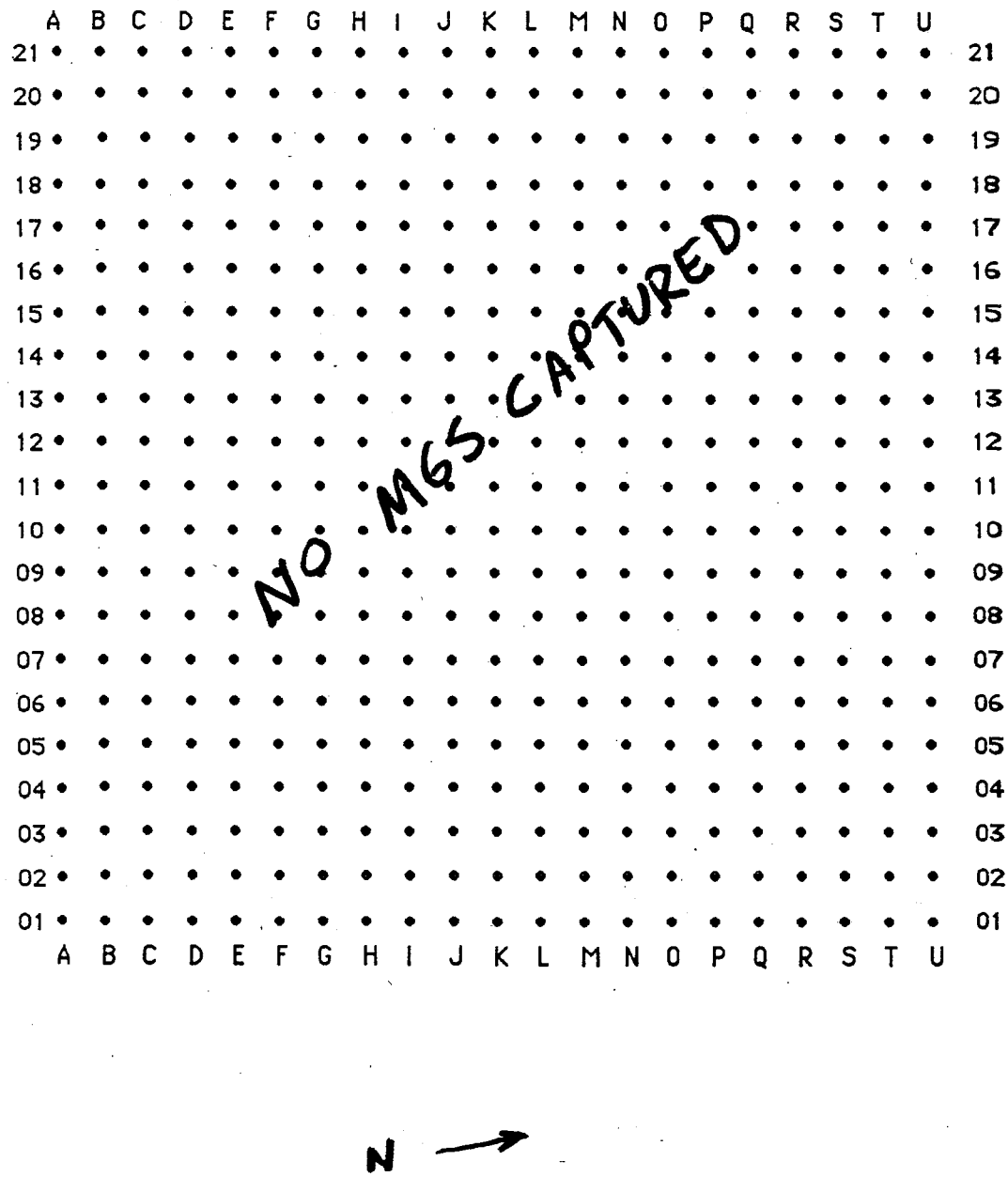


N

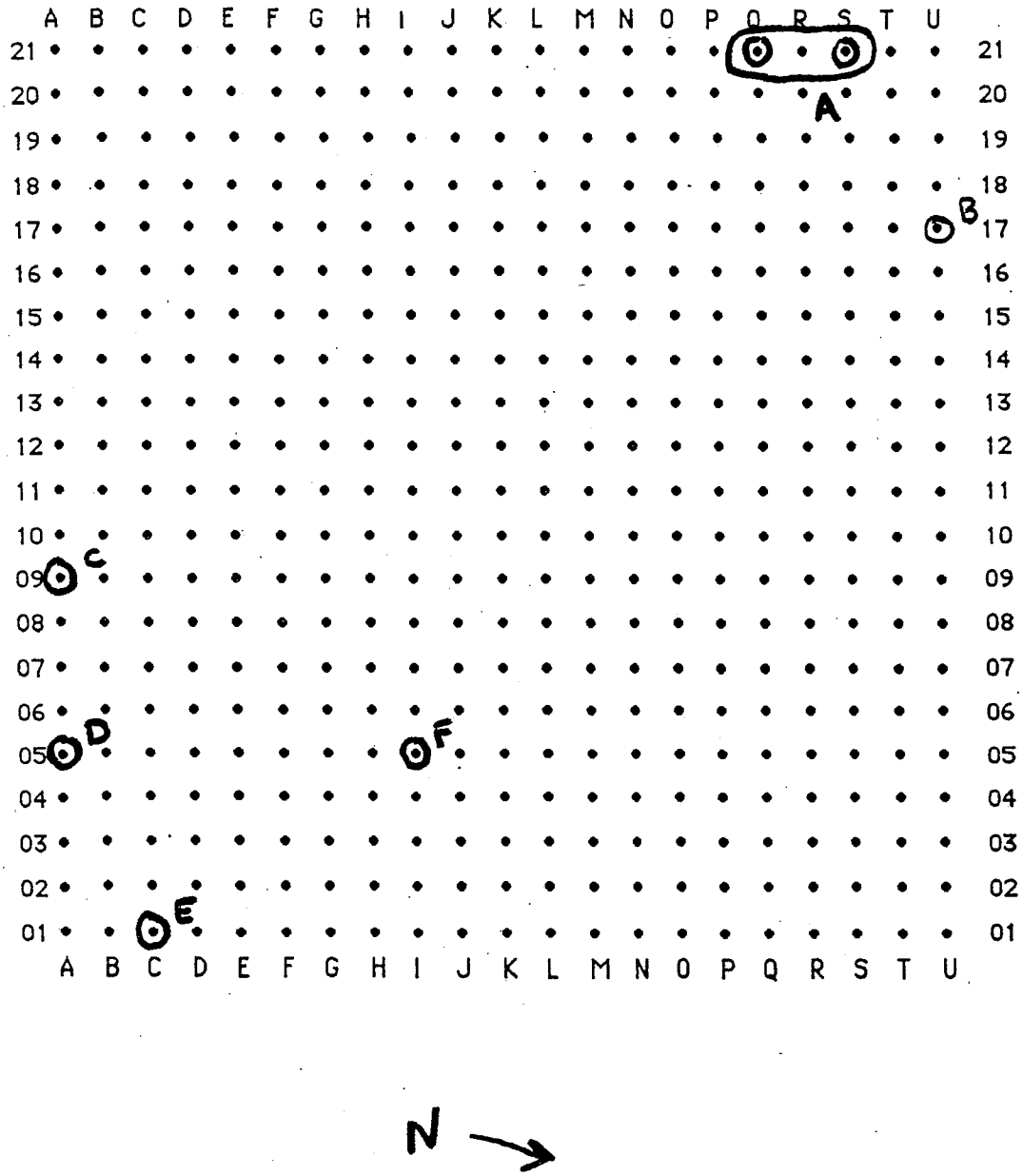
CORE RESERVE MOHAVE GROUND SQUIRREL TRAPPING
GRID: 10 Red Mountain
DATES TRAPPED: April 22-26, 1995



CORE RESERVE MOHAVE GROUND SQUIRREL TRAPPING
GRID: 11 Fremont Valley
DATES TRAPPED: May 9-13, 1995



CORE RESERVE MOHAVE GROUND SQUIRREL TRAPPING
GRID: 12 Red Buttes II
DATES TRAPPED: May 27-31, 1995



APPENDIX V

ANIMAL SPECIES SEEN OR SIGN OBSERVED ON EACH GRID

APPENDIX V. ANIMAL SPECIES SEEN OR SIGN OBSERVED ON EACH GRID

Note: Sites 1-9 were surveyed in 1994; sites 10-12 in 1995. Since nocturnal trapping was carried out in 1995 only, the number of species observed are larger due to this additional effort.

	STUDY SITE WHERE OBSERVED											
SCIENTIFIC AND COMMON NAME	1	2	3	4	5	6	7	8	9	10	11	12
REPTILES	1	2	3	4	5	6	7	8	9	10	11	12
TESTUDINIDAE												
Gopherus agassizii Desert tortoise	X		X	X		X		X			X	X
IGUANIDAE												
Callisaurus draconoides Zebra-tailed lizard	X				X	X						X
Gambelia wislizenii Long-nosed leopard lizard	X	X	X	X		X					X	X
Sceloporus magister Desert spiny lizard			X		X			X	X	X		X
Uta stansburiana Side-blotched lizard	X	X	X		X	X		X	X	X	X	X
Phrynosoma platyrhinos Desert horned lizard	X	X		X	X			X			X	X
XANTUSIDAE												
Xantusia vigilis Desert night lizard										X		X
TEIIDAE												
Cnemidophorus tigris Western whiptail	X	X	X		X	X		X	X	X	X	X
COLUBRIDAE												
Masticophis flagellum Coachwhip		X	X	X		X		X		X	X	
Salvadora hexalepis Western patch-nosed snake										X		X
Pituophis melanoleucus Gopher snake	X											X
Rhynocheilus lecontei Long-nosed snake											X	
Chionactis occipitalis Western shovel-nosed snake		X										
VIPERIDAE												
Crotalus scutulatus scutulatus Mohave green rattlesnake								X		X		
Crotalus cerastes Sidewinder			X					X			X	X

SCIENTIFIC AND COMMON NAME	STUDY SITE WHERE OBSERVED											
	1	2	3	4	5	6	7	8	9	10	11	12
BIRDS												
CATHARTIDAE												
Cathartes aura Turkey vulture						X		X		X		
ACCIPITRIDAE												
Buteo jamaicensis Red-tailed hawk	X							X		X		X
Aquila chrysaetos Golden eagle							X					
Circus cyaneus Northern harrier					X	X	X		X			X
FALCONIDAE												
Falco sparverius American kestrel										X		
COLUMBIDAE												
Columba livia Rock dove											X	
Zenaida macroura Mourning dove	X									X	X	
CAPRIMULGIDAE												
Phalaenoptilus nuttallii Common poor-will		X										
Chordeiles acutipennis Lesser nighthawk		X										
TROCHILIDAE												
Calypte costae Costa's hummingbird											X	X
Calypte sp. Hummingbird	X	X										
APODIDAE												
Aeronautes saxatilis White-throated swift										X	X	
Chaetura vauxi Vaux's swift										X		
PICIDAE												
Picoides scalaris Ladder-backed woodpecker							X			X		
TYRANNIDAE												
Tyrannus verticalis Western kingbird		X	X									
Sayornis saya Say's phoebe							X	X				

SCIENTIFIC AND COMMON NAME	STUDY SITE WHERE OBSERVED											
	1	2	3	4	5	6	7	8	9	10	11	12
TYRANNIDAE (contd.)												
Myiarchus cinerascens Ash-throated flycatcher										X	X	
Empidonax sp. Empidonax flycatcher		X										
ALAUDIDAE												
Eremophila alpestris Horned lark	X			X		X		X		X	X	X
HIRUNDIDAE												
Riparia rustica Barn swallow										X	X	
Hirundo pyrrhonota Cliff swallow											X	
CORVIDAE												
Corvus corax Common raven	X	X	X	X			X	X	X	X	X	X
TROGLODYTIDAE												
Campylorhynchus brunneicappilus Cactus wren										X		
MUSCICAPIDAE												
Regulus calendula Ruby-crowned kinglet										X		
Popliotila melanura Black-tailed gnatcatcher										X		
Turdus migratorius American robin										X		
MIMIDAE												
Mimus polyglottos Northern mockingbird										X		
Toxostoma lecontei Le Conte's thrasher										X		
Toxostoma redivivum California thrasher			X			X		X				
Toxostoma sp. Thrasher sp.	X				X							
PTILOGONATIDAE												
Phainopepla nitens Phainopepla										X	X	
LANIIDAE												
Lanius ludovicianus Loggerhead shrike		X								X		

SCIENTIFIC AND COMMON NAME	STUDY SITE WHERE OBSERVED											
	1	2	3	4	5	6	7	8	9	10	11	12
STURNIDAE												
Sturnus vulgaris European starling										X		X
EMBEREZIDAE												
Dendroica coronata Yellow-rumped warbler										X		
Dendroica townsendi Townsend's warbler		X										
Dendroica nigescens Black-throated gray warbler										X		
Vermivora celata Orange-crowned warbler										X		
Geothylpis trichas Common yellowthroat	X											
PASSERIDAE												
Passer domesticus House sparrow				X								
ICTERIDAE												
Sturnella neglecta Western meadowlark										X		
Icterus parisorum Scott's oriole		X										
Icterus cucullatus Hooded oriole			X									
Icterus galbula Northern oriole												X
FRINGILLIDAE												
Pheucticus melanocephalus Black-headed grosbeak										X		
Amphispiza bilineata Black-throated sparrow		X				X	X		X	X	X	
Amphispiza belli Sage sparrow	X	X	X	X	X	X	X	X	X	X	X	X
Junco hyemalis Dark-eyed junco										X		
Spizella breweri Brewer's sparrow										X	X	
Zonotrichia leucophrys White-crowned sparrow										X		

SCIENTIFIC AND COMMON NAME	STUDY SITE WHERE OBSERVED											
	1	2	3	4	5	6	7	8	9	10	11	12
MAMMALS												
MUSTELIDAE												
Taxidea taxus American badger											X	
CANIDAE												
Vulpes velox macrotis Desert kit fox	X	X				X		X	X	X	X	X
Canis latrans Coyote	X		X			X		X	X	X	X	X
HETEROMYIDAE												
Chaetodipus formosus Long-tailed pocket mouse											X	
Perognathus longimembris Little pocket mouse											X	
Perognathus sp. Undescribed pocket mouse										X		X
Dipodomys microps Great Basin kangaroo rat												X
Dipodomys panamintinus Panamint kangaroo rat										X	X	
Dipodomys merriami Merriam's kangaroo rat	X	X	X	X	X		X	X	X	X	X	X
CRICETIDAE												
Neotoma lepida Desert woodrat	X	X								X		X
SCIURIDAE												
Ammospermophilus leucurus White-tailed antelope ground squirrel	X	X	X	X	X	X	X	X	X	X	X	X
Spermophilus mohavensis Mohave ground squirrel	X	X		X	X	X		X	X			X
GEOMYIDAE												
Thomomys bottae Botta's pocket gopher											X	
LEPORIDAE												
Sylvilagus auduboni Desert cottontail						X						
Lepus californicus Black-tailed hare	X		X	X	X	X	X	X	X	X	X	X