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The Utah Prairie Dog: Abundance, Distribution, and Habitat Requirements

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THE UTAH PRAIRIE DOG: ABUNDANCE, DISTRIBUTION, AND HABITAT REQUIREMENTS

by

G. Donald Collier

A dissertation submitted in partial fulfillment
of the requirements for the degree

of

DOCTOR OF PHILOSOPHY

in

Wildlife Science

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G. Donald Collier

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ABSTRACT

The Utah Prairie Dog: Abundance, Distribution,
and Habitat Requirements

by

G. Donald Collier, Doctor of Philosophy

Utah State University, 1975

Major Professor: Dr. J. Juan Spillett
Department: Wildlife Science

Objectives of this study were: (1) to determine the status of the Utah prairie dog (Cynomys parvidens, Allen), a rare mammal endemic to south-central Utah, and (2) to identify habitat factors which limit densities of this species. Seven components of the habitat were studied: barriers, other animals, soil, temperature and precipitation, topography, vegetation, and water. Prior to collection of habitat data, virtually all populations of the species were found by extensive searching and interviewing; the number of animals and the area occupied were determined for each population.

Results justified the endangered status of the Utah prairie dog. Area occupied by this prairie dog was reduced by an estimated 87 percent during the past 50 years. During this time, the animals disappeared from 34 localities. Recently, total numbers also were reduced: between 1970 and 1971, the total population dropped from an estimated 8,600 animals to 5,700. Only 48 substantial populations existed in 1971. Six other populations were exterminated the preceeding year by rodent control.

Although the loss of prairie dogs between 1970 and 1971 resulted from rodent control, another loss between 1971 and 1972 resulted from drought. A drought decimated all populations in regions without water. Topographic region, which reflected water available to plants, was more strongly correlated to density of this prairie dog than any other parameter ($r^2 = .67$).

The crucial role of water was confirmed by analysis of vegetative parameters. Since grasses, forbs, and shrubs have distinctive water contents, they indicated prairie dog response to plant water. Forb cover, which contains the highest relative water content, was the only type of cover that was positively correlated to the density of these animals. Shrubs, with the lowest water content, were negatively correlated; and grasses, with an intermediate water content, were neutral relative to density.

Two other parameters also demonstrated the critical nature of water: the mean number of grasses, forbs, and shrubs, and heterogeneity among plant communities. No other parameters were significant ($p \geq .05$) in multiple regression. Together, these explained 75 percent of the variability in abundance of the Utah prairie dog. The mean number of grasses, forbs, and shrubs was negatively correlated with density; coefficients of this parameter probably reflected the time required for prairie dogs to select plant parts with adequate water. On the other hand, heterogeneity among plant communities was positively correlated to density, and indicated emergency sources of plant water. Such water probably allowed prairie dogs to avoid population reductions otherwise associated with drought.

The critical nature of plant water is especially meaningful in light of long-range drying trends. The Utah prairie dog's habitat has become progressively drier during the past several thousand years. If these trends continue, the animal may become extinct. However, their possible extinction can be delayed by transplanting animals to sites adjacent to streams or irrigated fields. Transplanting also can help solve the secondary problem of rodent control: since prairie dogs are often eradicated on private lands, transplant sites should be controlled by the public. Public lands in southern Utah usually contain little water; therefore, purchase of certain private lands with adequate water for the animals is a key to managing this unique prairie dog.

(108 pages)

INTRODUCTION

Species extinction often occurs in the development of ecological communities. However, modern man sometimes increases the rate at which it proceeds. Within historical times, 20 species of birds and mammals have disappeared within the United States alone (Bureau of Sport Fisheries and Wildlife, 1973). Several well-known species are presently on the verge of extinction: the whooping crane (*Grus americanus*), the California condor (*Gympnogyps californicus*) and the black-footed ferret (*Mustela nigripes*). There are now 120 vertebrate species and subspecies in the U.S. that have been designated as endangered or in danger of extinction (Bureau of Sport Fisheries and Wildlife, 1973). One of these species is the Utah prairie dog (*Cynomys parvidens*, Allen).

The status of the Utah prairie dog has been in question for several years (Collier and Spillett, 1972a). It was classified as endangered in 1968, non-endangered in 1972, and subsequently reinstated as endangered in 1973 (Bureau of Sport Fisheries and Wildlife, 1968a, 1972, 1973). According to Hardy (1937), this prairie dog occurred in 9 counties of south-central Utah in 1937. In 1968, the species occurred in only 5 counties and the estimated population was 8,000 animals (Bureau of Sport Fisheries and Wildlife, 1968b).

The intelligent management of any species requires a knowledge of its distribution, abundance, and habitat requirements. Such knowledge is critical in efforts to perpetuate an endangered species. Prior to this study, only sketchy information was available on the distribution and abundance of the Utah prairie dog and nothing was known about its habitat requirements. This study attempts to rectify this situation by relating prairie dogs to habitat characteristics. Specific objectives of the study were: (1) to determine the distribution and numbers of the Utah prairie dog, and (2) to relate habitat factors to the density and distribution of this prairie dog species.

METHODS

Methods are described in 4 sections: (1) distribution and numbers, (2) abundance index, (3) environmental variables, and (4) data analysis. The first section is concerned with the status of the Utah prairie dog. The 3 remaining sections are concerned with relating habitat parameters to the animal's density.

Distribution and Numbers

Present and past distribution of the Utah prairie dog was determined through interviews with people knowledgeable about areas within and near the known range of the species. Interviews were conducted with farmers, ranchers, sheepherders and with personnel of the U. S. Fish and Wildlife Service, the U. S. Bureau of Land Management, the Utah Division of Wildlife Resources, the U. S. Forest Service, and the Soil Conservation Service. A total of 325 interviews were conducted; 235 in person, 25 by phone, and 65 by mail.

In 1971, the numbers of prairie dogs were censused and the area inhabited was estimated. Census methods were modified from Koford (1958) and Tyler (1968). A maximum count was considered the minimum number of animals, and the minimum was adjusted upward to estimate the true population. Factors considered in this adjustment were: time of day, amount of cover, weather, season, and the degree of disturbance. Finally, the area occupied by each dog town was estimated with the use of aerial photographs.

Prairie dog numbers in 1970 were estimated in 2 steps. Approximate areas of dog towns that became extinct between 1970 and 1971 were determined from the interviews. Densities for these extinct dog towns then were extrapolated by using the density of a living dog town in a similar habitat.

Abundance Index and Habitat

Mounds were used as an index to relate density of the Utah prairie dog to habitat parameters. Mounds were used rather than direct counts, discussed previously, because mounds fluctuate much less than the actual population (King, 1955). This is a distinct advantage, since short-range fluctuations can be caused by catastrophies (such as shooting, flooding, or disease) and can mask adjustment of density to influences of the habitat.

The method of collecting data on mounds was modified from Catana (1963). Each dog town was mapped and a grid of 8 transects (4 north-south and 4 east-west) was sketched. Four of these transects (2 in each direction) were selected at random and about 25 mounds were sampled in each transect. Distance from the center of each mound was measured (in paces) to the center of the next mound, within a 90-degree arc of inclusion in the predetermined direction. Mounds were identified by excavated soil separated from other mounds by at least 306 cm (1 ft.). The active nature of a mount was determined by tracks, disturbed soil, feces, and flies near the mouth of burrows.

Several mathematical transformations were performed on the abundance index in an effort to determine which best related to the habitat parameters. An exponential transformation gave the best results: $e^{(\text{abundance index}/100)}$. Division by 100 was performed to prevent computer overflow.

Habitat Variables

A pilot study in 1970 and 1971 indicated that vegetative variables were of primary importance. They were, therefore, studied most intensively, but many other variables also were observed. Because of the number of variables, time requirements were a major consideration in the choice of methods. For convenience, variables were grouped into 7 categories: barriers, other animals, soil, temperature and precipitation, topography, vegetation, and water.

Barriers

Topographical. The presence of topographical barriers (such as a river or deep gulley) was recorded as a percentage (nearest 10%) of the total periphery of the dog town.

Habitat. The presence of habitat barriers, such as forests, highways, and shrubby areas, was recorded as a percentage of the total periphery of the dog town. Habitat barriers included topographical barriers.

Other animals

Townsend ground squirrel. Townsend ground squirrels (*Spermophilus townsendi*) were recorded if they were seen near a dog town.

Badger excavation. The percentage of mounds excavated by badgers was obtained for all mounds sampled with the abundance index. Badger excavations were obvious, since they were about twice the diameter of a prairie dog hole.

Shooting intensity. People familiar with dog towns were questioned regarding the degree and success of shooting. Dog towns were placed in 3 categories of estimated shooting intensity: heavy, intermediate, and light.

Type grazing. Direct observation was made on the occurrence of grazing and the kind of animals (cattle, sheep, horses) involved. Presence of feces and information from the interviews supplemented direct observations.

Grazing intensity. Grazing intensity was estimated by the height of grasses and forbs in each dog town. Three categories were used: substantial, intermediate, and none. Substantial grazing was assumed if non-shrubby vegetation was mostly less than 5 cm (2 in.) high. Grazing was assumed none if general height was above 20-25 cm (8-10 in.) and little evidence of grazing was observed.

Soil

Soil samples were taken in 1971 from upper soil horizons, as identified by color, in positions where prairie dog mounds had not altered the composition of the soil. Data given below, unless otherwise stated, are from the surface horizon.

Surface texture. Texture classes were determined by Dr. Alvin Southard, Department of Soils and Meteorology, at Utah State University (USU), using the "feel" method. Eleven classes were found: (1) clay, (2) silty clay, (3) clay loam, (4) gravelly clay loam, (5) silty clay loam, (6) silt loam, (7) gravelly silt loam, (8) loam, (9) gravelly loam, (10) sandy loam, and (11) gravelly-sandy loam.

Sand-clay texture. Textures 1-5 (clayey) and 10-11 (sandy) were analyzed relative to the remaining textures.

Percent coarse material. Soil samples from each dog town were sifted through a 2 mm (.08 in.) sieve to separate coarse material, which was then weighed and calculated as a percentage of the total weight of the sample.

Mound stones. Mound stones, a possible hindrance to digging, were considered common if 50% or more of the excavated volume appeared to consist of stones greater than 1 cm (0.5 in.) in diameter. Ten mounds were observed in each dog town.

Soil-prairie dog color. Color of the soil surface of each dog town was compared to the rump color of prairie dog skins to judge the value of cryptic coloration. Contrast of soil and prairie dog colors was designated as distinct, intermediate, and little.

Percent total soluble salts. This variable was analyzed by the USU Soils Laboratory by the Bureau of Soils Cup Method.

pH. pH was determined by the USU Soils Laboratory with a glass electrode.

Nitrogen. Percent total nitrogen was determined by the USU Soils Laboratory by the Kjeldah Method. The upper 31 cm (12 in.) of soil were analyzed by mixing horizon samples proportional to the percent each horizon occupied the upper 31 cm (12 in.).

Phosphorus content. Available phosphorus (ppm) was analyzed by the USU Soils Laboratory by sodium bicarbonate extract, Olsen Method. The upper 31 cm (12 in.) of soil were sampled as above.

Water table depth. Depth of the water table was recorded as: (1) less than 920 cm (3 ft.), (2) more than 920 cm (3 ft.), and (3) varied. The highest water table level during the year was utilized.

Temperature and precipitation

Climatic data from weather stations in the vicinity of dog towns were utilized upon the advice of Mr. Arlo Richardson, Utah State Climatologist. According to Mr. Richardson, weather stations were situated so that data were representative of the regions where dog towns occurred. The following weather stations supplied data for 26 dog towns: Cedar City, Bryce Canyon FFA, Koosharem, Loa, Panguitch, and Parowan. The Loa data were used for both the Fremont and Horse Valley dog towns. The remaining 5 dog towns were located on the Awapa Plateau. Data were collected there by Mr. Joseph Jarvis, 1970-1972. Long range estimates on the Awapa were made with adjusted Bryce Canyon data.

Temperatures. Mean temperatures (maximum and minimum) were compiled from monthly climatic summaries (State of Utah Climatologist's log, unpublished) for each locality for the 1972 growing season. In addition, a 5-year mean was calculated for the mean number of days/year with a maximum temperature of 0 C (32 F) or less.

Precipitation. Data for October, 1971, through July, 1972, were compiled from the U. S. Department of Commerce (1971, 1972).

Growing season. The growing season length for each locality was recorded as the number of days from the last 0 C minimum in the spring until the first 0 C minimum in the autumn (State Climatologist's log, unpublished).

Wind index. Mean annual number of accumulated wind miles/day for each locality was obtained from Mr. Arlo Richardson (unpublished data).

Elevation. Elevation was obtained from 1:250,000 scale topographic maps (U. S. Geological Survey) and recorded to the nearest 30.5 m (100 ft.).

Topography

Topographic region. Dog towns were located in 7 topographic regions in south-central Utah: (1) Horse Valley, (2) Fremont Valley, (3) Awapa Plateau, (4) Paunsaugunt Plateau, (5) Grass Valley, (6) Sevier Valley, and (7) Cedar Valley. Regions were identified by using a topographic map of Utah (U. S. Geological Survey).

Ridges. Ridges are hilltops characterized by rapid drainage and exposure to the wind. Occurrence of mounds in each dog town was judged relative to ridges as: (1) ridges, a substantial number of mounds; (2) ridges, some mounds; and (3) ridges, few or no mounds.

Swales. When mounds were located in topographic depressions or areas relatively protected from the wind, they were categorized similar to ridges: (1) swales, a substantial number of mounds; (2) swales, some mounds; and (3) swales, few or no mounds.

Slope. The degree of slope for each dog town was determined by visual estimate to the nearest 5 degrees and checked several times with a protractor and bubble level. A variable slope was so recorded.

Aspect. Aspect was recorded to the nearest 1/8 compass interval. Varied aspects and dog towns with no obvious aspect were so recorded.

Drainage. Three categories were used to subjectively classify this factor as good, fair, and poor.

Terrain homogeneity. The terrain within each dog town was subjectively classified as: (1) homogenous, (2) intermediate and (3) heterogeneous. A heterogeneous terrain was defined by substantial gulleys, ridges, or rocky eruptions.

Solar radiation. Annual solar radiation in Langleys was obtained from tables compiled by Frank and Lee (1966).

Vegetation

Vegetation cover. Vegetation cover was the most appropriate type of vegetative data relative to the objectives of this study. Cover was defined as the percent surface of the ground influenced by vegetative crowns. It was, therefore, a reflection of the relative amount of vegetation available to prairie dogs as food. Data were collected on species and on type, such as shrub, forb, or grass.

The canopy coverage method (Daubenmire, 1959) was used to collect data between July 23 and September 5, 1972. A 20 x 50 cm (8 x 20 in.) quadrat was the basic sampling unit. Quadrats were spaced along a transect at intervals of every other quadrat length (100 cm or 40 in.). Percent cover was measured as the outline of the periphery of each plant. The method was modified by assigning each species a specific percent cover, instead of using Daubenmire's class intervals. A voucher specimen was collected for each species, assigned a 3-digit identification number, and identified at the Intermountain Herbarium at USU. Data were recorded directly onto an IBM data sheet (No. 556) for transfer to computer cards by an electronic reader. An assistant recorded data, while I observed appropriate values for each variable. A separate data sheet was used for each quadrat (Appendix Table 1).

All vegetation within 91.5 cm (300 ft.) of the mound aggregation was considered within the "dog town unit" and was sampled to reflect a habitat value for the entire area. This area was visually stratified and sketched according to plant communities that differed visibly. If a community occurred more than once, separate portions of that community were assigned numbers, and a sample portion was chosen from a table of random numbers. Large communities were subdivided into areas of 30.5 m (100 ft.) diameter and the sample portion chosen at random. Each community within the "dog town unit" was sampled separately and the percent to which that community occupied the "dog town unit" was estimated. Two transects, each containing half of the quadrats, were placed at the center of each sample area. Direction of each transect was chosen at random from 8 possible compass directions. The number of samples/community was modified according to the complexity and importance of the community sampled. For example, a homogenous community with only 1 or 2 species merited 15 quadrats, but as many as 40 quadrats were taken on more heterogeneous communities. Communities which comprised less than 5% of the "dog town unit" merited 1 to 5 quadrats.

Data for each dog town were compiled by community and subsequently weighted by the percentage to which a community occupied the "dog town unit." Data from each community then were added to give a value for the entire dog town.

Heterogeneity among plant communities. This parameter expressed the visual difference of plant communities within dog towns relative to plant communities at the periphery of dog towns. Periphery was the area from the edge of the "dog town unit" to 91.5 m (300 ft.) outward.

Distance from cultivation. Cultivation included both irrigated and dry farm crops and was measured as the percent of the "dog town unit" within 91.5 m (300 ft.) of cultivated areas.

Percent seeding. The percent of the "dog town unit" which was seeded in wheat grasses (Agropyron spp.) was estimated.

Number of communities. This was the number of communities within the "dog town unit."

Mean number of grasses, forbs, and shrubs. Each plant was classified into one of the following types: shrub, forb, grass, suffrutescent, sedge, cactus, and lichen. The mean number of these types per quadrat was obtained by adding the weighted mean for each community.

Percent vegetation cover greater than 31 cm (12 in.) tall. These data were recorded along with the vegetation species data previously described. Six categories of height were utilized (see Appendix Table 1).

Water

Type of water. Each dog town was classified as having 1 of 5 types of surface water: (1) none, (2) wet weather, (3) year-around pond or stream, (4) irrigation, or (5) varied.

Distance to water. This parameter was estimated as a direct proportion (nearest 10%) of the "dog town unit" within 91.5 m (300 ft.) of water. Data included wet weather water, year-around water, irrigation water, and any kind of water.

Irrigation. Five cm (12 in.) of water were assumed for each 10 days of the growing season. The resulting statistic was reduced by the percentage of the "dog town unit" greater than 91.5 m (300 ft.) from the irrigated field.

Greeness of grass. This variable was used as an index of water available to plants. Grasses were classified as green, intermediate, and brown.

Data Analysis

Simple regression was used to obtain an r^2 or coefficient of determination (percent of variation of the Y variable explained by an X variable) for each habitat variable. The r^2 values were tested by the F-ratio, using model and error degrees of freedom (df). The cumulative F-distribution in Ostle (1963) was used to test significance. The tabular error df category, less than the actual error df of a variable, was utilized to favor conservative testing. A significant test indicated that the effect of the X on Y probably was not the result of chance. The null hypothesis was that a regression coefficient was 0.

Multiple regression was used to examine relationships among variables (overlaps). Since preliminary analysis of data indicated that environmental variables were strongly interrelated, stepwise multiple regression was performed on various pairs of significant variables ($p \leq .05$). Finally, a multiple regression model was constructed.

RESULTS

Results are given in 4 parts: distribution and numbers, study areas, abundance index, and habitat. The first part presents findings on the status of the Utah prairie dog; the remaining parts give habitat relationships.

Distribution and Numbers

The distribution of the Utah prairie dog has changed greatly since 1920 (Pizzimenti and Collier, in press). The species, at one time or another, occurred in 10 topographical regions of south-central Utah (Fig. 1). Within each of these regions, the area occupied declined sharply (Table 1). In fact, a decline of 87% in the total area occupied was extrapolated from the interviews. In 1920, the species occurred within approximately 713 sections (1846 km^2) as compared to 96 sections (249 km^2) in 1971. Magnitude of change also was illustrated by the species' disappearance from 34 specific localities (Appendix Table 2).

A sharp downward trend also was observed in numbers of the Utah prairie dog. A 1970 estimate of 8,600 animals fell to 5,400 in 1971 (Table 2); the last estimate was increased to 5,700 by the inclusion of populations with less than 25 animals each (see Appendix Table 3). The 1971 population was limited to a total area of 954 ha (2,357 acres). Population estimates for 1971 were based on a census of 48 dog towns (see Appendix Tables 4 and 5). The

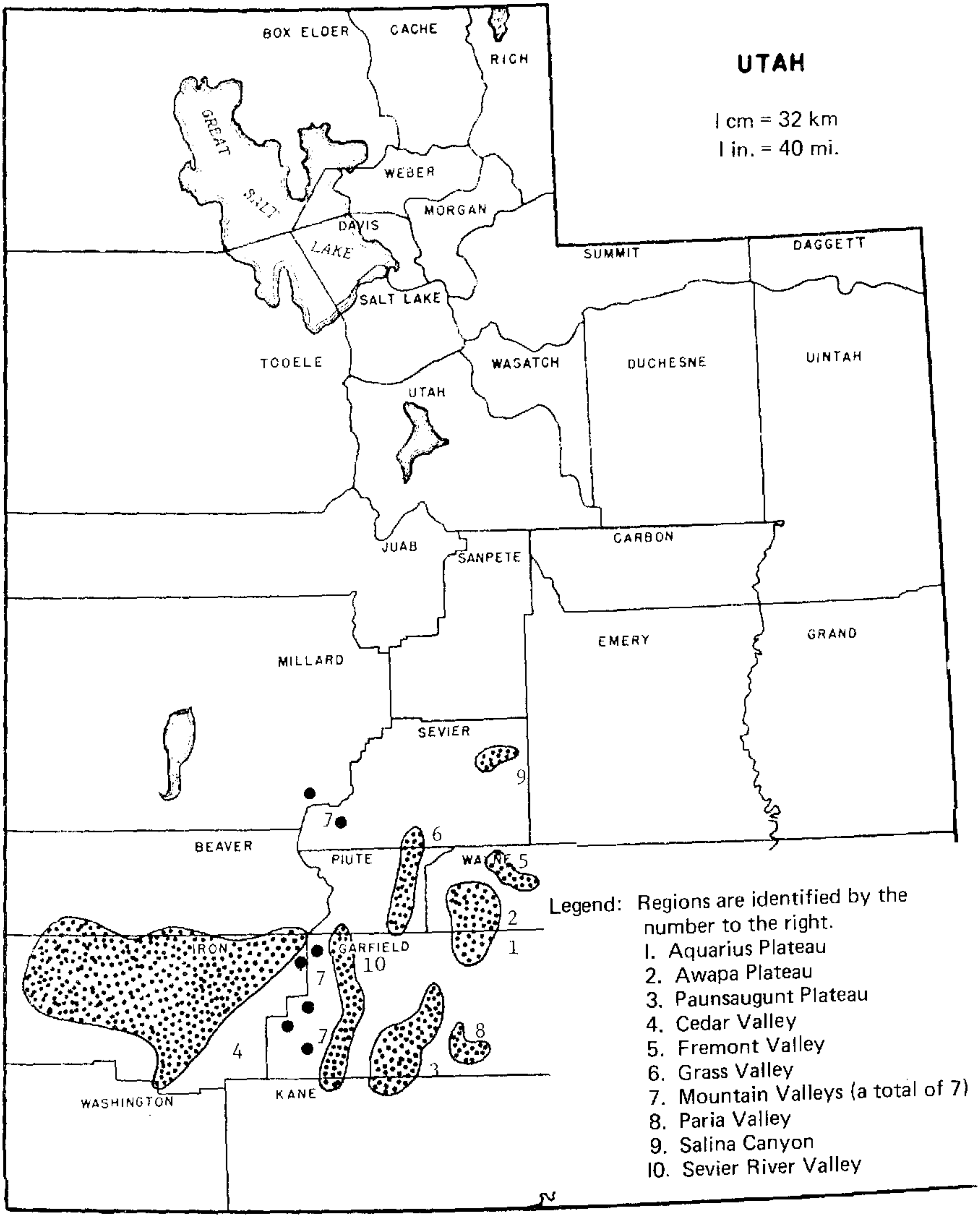

Fig. 1. Topographic regions where the Utah prairie dog occurred, 1920-1970.

Table 1. Present (1971) and recent (1920-1970) number of sections containing Utah prairie dog towns in 10 regions of southern Utah

	Distribution			
	1920-1970		1971	
Region[1]	Sections	Km^2	Sections	Km^2
1. Aquarius Plateau	95	246	1	0.3
2. Awapa Plateau	212	549	32	83.0
3. Paunsaugunt Plateau	103	267	20	52.0
4. Cedar Valley	65	168	16	41.0
5. Fremont Valley	35	91	4	10.0
6. Grass Valley	38	98	6	16.0
7. Mountain Valleys[2]	55	142	12	31.0
8. Paria Valley	15	39	1	3.0
9. Salina Canyon[3]	6	16	0	0.0
10. Sevier River Valley	89	230	4	10.0
Total	713	1846	96	249

[1] Regions are mapped in Fig. 1.

[2] Term used to describe location of dog towns in isolated mountain valleys.

[3] Presence of living prairie dogs reported but not observed.

Table 2. Numbers of Utah prairie dogs in 1970 and 1971

	1970		1971	
County	Dog towns (No.)	Prairie dogs (No.)	Dog towns (No.)	Prairie dogs (No.)
Wayne	16	2376	14	1495
Garfield	19	2237	15	1510
Iron	17	3645	13	2070
Piute	5	170	5	240
Sevier	2	150	1	70
Total	59	8578	48	5385

census showed only 3 counties with sizable populations: Wayne, Garfield, and Iron. Results (Table 3) are summarized by county.

Wayne County

An estimated 1,495 prairie dogs inhabited 457.7 ha (1,131 acres) in Wayne County. These totals accounted for 48% of the area occupied by the species, but only 28% of the total population. Most of the county's population was located on the Awapa Plateau, where 12 dog towns were recorded. Two other dog towns were located in the Fremont Valley area.

An additional 165 prairie dogs were observed in 15 populations of less than 25 animals each. Seven of these populations, all on the Awapa Plateau, were considered to have excellent potential for growth. These 7, of all

Table 3. Population of the Utah prairie dog by county (1971)

	Dog Towns		Area Inhabited			Prairie Dogs Populations				
County	No.	%	Ha	Acres	%	>25	%	< 25	%	Total No. of Animals
Wayne	14	29	457.7	1131	48	1495	28	165	50	1660
Garfield	15	31	246.9	610	25.5	1510	29	50	15	1560
Iron	13	27	224.7	555	23.5	2070	38	105	32	2175
Piute	5	11	17.8	44	2	240	4	0	0	240
Sevier	1	2	6.9	17	1	70	1	10	3	80
Totals	48		954.0	2357		5385		330		5715

populations for the species containing less than 25 animals each, were the only ones believed to have excellent potential for growth.

Garfield County

An estimated 1,510 prairie dogs inhabited 246.9 ha (610 acres) in Garfield County. Approximately 31% of the total population and 26% of the total area occupied by the species were found in the county. The population was distributed among 4 topographic regions: The Paunsaugunt Plateau [9 towns, 230.2 ha (568.5 acres), 1,085 dogs]; the Paria Valley [1 town, 2.47 ha (1 acre), 30 dogs]; the Sevier River Valley [3 towns, 7.4 ha (19.4 acres), 370 dogs]; and the Aquarius Plateau [1 town, 12.4 ha (5 acres), 25 dogs]. Another 50 prairie dogs occurred in 18 populations of less than 25 animals each. Five of these 18 populations were judged to have a fair potential for growth.

Iron County

An estimated 2,070 prairie dogs inhabited 224.7 ha (555 acres) in Iron County. This county had almost 40% of the total population for the species, but only 24% of the total area. All but 1 of the 13 dog towns were located in Cedar Valley, between Kanarraville and Paragonah. An additional 105 prairie dogs occurred in 13 populations of less than 25 animals each. Only 2 of these 13 populations were considered to have a good potential for growth.

Piute County

An estimated 240 prairie dogs inhabited 17.8 ha (44 acres) in Piute County. This accounted for only 2% of the total area and 4% of the total population for the species. All 5 dog towns in Piute County were located in Grass Valley near Greenwitch. There were 4 additional populations of less than 25 animals each. Each of these 4 populations were judged to have little potential for population growth.

Sevier County

One dog town occurred in Sevier County, just north of the populations in Piute County. This dog town contained an estimated 70 prairie dogs on 6.7 ha (17 acres); it accounted for approximately 1% of the total area and 2% of the total population for the species. In addition, 10 prairie dogs were recorded in 2 populations of less than 25 animals each. In 1 population, chances for growth were slight. The existence of prairie dogs in the other was uncertain.

Land Control

In 1971, private lands accounted for approximately 63% of the total population of the Utah prairie dog (Table 4). Private landowners generally felt that the prairie dog was a nuisance and should be eliminated. Accordingly, dog towns with hundreds of prairie dogs were exterminated between 1970 and 1971 (see Appendix Table 6). Additional rodent control was planned for 34% of the remaining population (Table 5). Rodent control was most extensive in Iron County; interviews indicated that landowners planned to exterminate almost half of the dog towns which contained about 64% of the county's population.

Table 4. Occurrence of Utah prairie dogs in relation to land status (1971)

Land Status	Area Ha	Acres	%	Prairie Dogs (Estimated)		Dog Towns		Mean Density/ Inhabited Area Ha	Acres
Public	482.8	1190	(50%)	1640	(30%)	18	(38%)	3.5	1.4
Private	411.5	1014	(44%)	3395	(63%)	28	(58%)	8.5	3.4
Combination	61.1	151	(6%)	350	(7%)	2	(4%)	5.8	2.3
Total	954.4	2355		5385		48			

Table 5. Plans for existing Utah prairie dog towns by those in control of land (1971)

Type Plans	Number of Dog Towns		Areas Ha	Acres		Number of Prairie Dogs	
Eliminate dogs	12	(25%)	149.7	370.0	(16%)	1815	(34%)
Manage dogs	3	(6%)	37.7	93.0	(4%)	370	(7%)
Undeveloped Plans (Public Lands)	18	(37%)	481.5	1189.5	(50%)	1640	(30%)
Uncertain (Private Lands)	8	(17%)	122.5	302.5	(13%)	765	(14%)
Other	7	(15%)	161.7	399.5	(17%)	795	(15%)
Total	48		953.1	2354.5		5385	

Public lands accounted for 30% of the total population of this prairie dog and 50% of the total area (see Table 4). Most of this area and population was on the Awapa and Paunsaugunt Plateaus. The Awapa Plateau was controlled by the Bureau of Land Management, Richfield District; and the Paunsaugunt Platuea by the Dixie National Forest, Powell Division. Sentiment of these agencies was favorable towards the species.

Study Areas and Habitat

To correlate habitat parameters with abundance, 31 Utah prairie dog towns were sampled in 1972. These 31 dog towns accounted for all but 2 of the populations with 25 or more animals in 1972 (see Appendix Table 5). Dog towns occurred in several topographic regions (Fig. 2) which had characteristic elevations, land use patterns, and land control (Table 6). Topographic regions also influenced the floral composition within dog towns (see Appendix Tables 7 and 8).

Abundance Index and Habitat

The abundance index, based on distances between prairie dog mounds, was distinct from the population counts given previously. This index was used to correlate density of the Utah prairie dog with habitat parameters and was determined only for the 31 dog towns of more than 25 animals each.

Mean distance between active prairie dog mounds (Table 7) was 11 m (36 ft.), with a range of 3 to 27 m (11-91 ft.). Mean distances among 31 dog towns were significantly different at $p < .005$ (Table 8). Of 961 possible

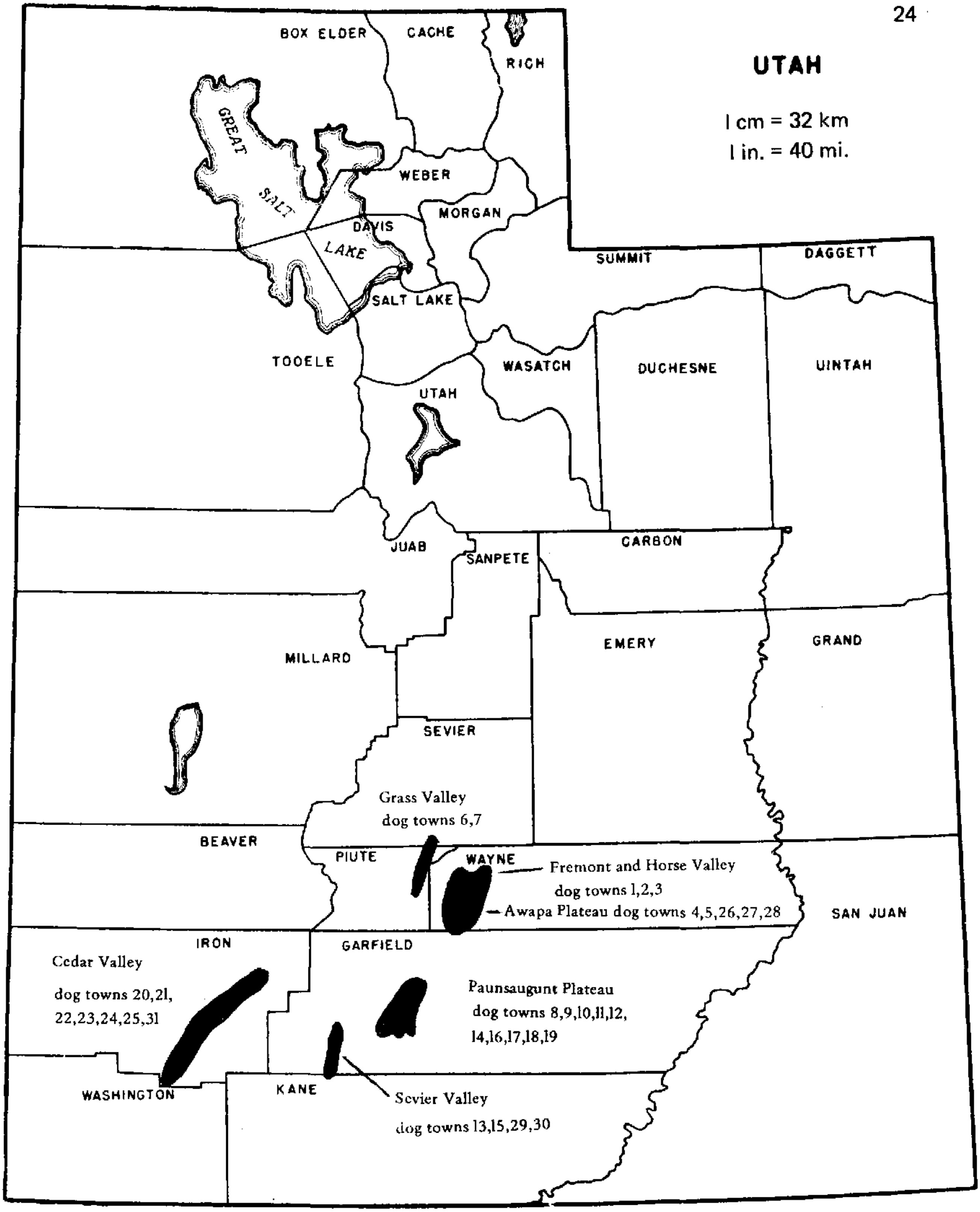

Fig. 2. Areas where the Utah prairie dog was studied in 1972. The numbers identify individual dog towns.

Table 6. Elevation, land control, and land use in the 7 topographic regions where the Utah prairie dog was studied in 1972

Region	Elevation	Land Control	Land Use
Awapa Plateau	2,593 - 2,837 m (8,500 - 9,300 ft.)	Public	Grazing
Cedar Valley	1,678 - 1,830 m (5,500 - 6,000 ft.)	Private	Cultivation
Fremont Valley	2,135 m (7,000 ft.)	Private	Cultivation
Grass Valley	2,135 m (7,000 ft.)	Private	Grazing and Cultivation
Horse Valley	2,379 m (7,800 ft.)	Private	Cultivation
Paunsaugunt Plateau	2,257 - 2,410 m (7,400 - 7,900 ft.)	Private and Public	Grazing
Sevier Valley	2,047 - 2,166 m (6,800 - 7,000 ft.)	Private	Grazing and Cultivation

Table 7. Mean mound distance, number of distances sampled, and variance for each Utah prairie dog town

Dog town Number	Number of Distances Sampled	Mean Distance Cm	Mean Distance Ft.	Variance
1	63	608	19.96	559.27
2	72	645	21.19	760.90
3	46	639	20.99	882.36
4	52	1170	38.41	2421.77
5	39	1676	54.99	4936.54
6	74	712	23.36	817.73
7	83	583	19.15	596.02
8	85	1207	39.62	2585.19
9	72	811	26.64	1104.48
10	95	1375	45.12	3230.97
11	110	1384	45.43	3412.17
12	93	778	25.55	1067.38
13	100	356	11.07	148.91
14	65	1951	64.04	7702.00
15	89	575	18.89	489.67
16	67	1627	53.41	5252.85
17	53	1933	63.45	7830.41
18	96	1259	41.31	2601.43
19	63	1407	46.19	3703.09
20	69	1050	34.47	1789.70
21	97	539	17.71	401.55
22	89	411	13.51	232.04
23	87	995	32.66	1641.13
24	77	979	32.15	1412.11
25	48	915	30.04	1657.52
26	42	2790	91.54	12722.48
27	58	1468	48.18	3965.61
28	69	2289	75.13	9945.43
29	94	670	22.00	631.55
30	97	725	23.81	864.86
31	47	417	13.71	230.40

Table 8. Analysis of variance of mound distances in 31 Utah prairie dog towns

	df	S.S.	M.S.	F	P<
Total	2290	2838536.40	1239.53		
Treat	30	2130385.78	71012.85	226.63	.0005
Error	2260	708150.61	313.34		

dog town combinations, only 123 were not significantly different in an LSD multiple mean comparison (see Appendix Table 9).

The abundance index was used instead of density in order to avoid a problem: computation of density inverted the relationship of mound distances among dog towns. An abundance index (Table 9) was devised by subtracting the mean mound distance of each dog town from 100. This index was used in all correlations with habitat parameters.

Habitat

Data on 54 habitat parameters are documented for each dog town (see Appendix Tables 10 and 11). An analysis of these data is presented in 4 parts: individual parameters, interrelations, prediction of abundance, and consistency. Each part emphasizes a separate type of analysis.

Individual parameters and abundance

Relating individual habitat parameters with the abundance index was the primary step in analyzing habitat requirements of the Utah prairie dog. Relations

Table 9. Mound density and abundance index for each Utah prairie dog town

Dog town Number	Mounds/Units of Area Ha	Acre	Abundance Index
1	269	109	80
2	240	97	79
3	245	99	79
4	74	30	62
5	35	14	45
6	198	80	77
7	294	119	81
8	69	28	60
9	151	61	73
10	52	21	55
11	52	21	55
12	166	67	74
13	877	355	89
14	27	11	36
15	301	122	81
16	37	15	47
17	27	11	37
18	64	26	59
19	49	20	54
20	91	37	66
21	343	139	82
22	590	239	86
23	101	41	67
24	103	42	68
25	119	48	70
26	12	5	8
27	47	19	52
28	20	8	25
29	222	90	78
30	190	77	76
31	798	323	86

were obtained by simple regression which gave the degree (r^2) and positive or negative direction of correlations. Twenty-nine of the 54 parameters and 5 interactions were significantly correlated ($p \leq .05$) with abundance (Table 10).

Five habitat parameters (3 climatic and 2 vegetative) were strongly associated ($r^2 > .50$) with this prairie dog's abundance. The climatic variables were: mean maximum temperature, number of days < 0 C, and topographic region. Two of the topographic regions, the Awapa and Paunsaugunt Plateaus, had highly variable abundance in contrast to the 4 remaining regions (Table 11). The 2 vegetative parameters strongly associated with abundance were: (1) heterogeneity among plant communities, and (2) mean number of grasses, forbs, and shrubs. The last parameter correlated negatively to abundance.

Fourteen parameters were intermediate in their association with abundance ($r^2 = .21 - .50$). Five of these parameters were climatic: wind, elevation, total precipitation, winter precipitation, and mean minimum temperature. Three parameters from the water category were intermediate in association with abundance: distance from irrigation water, amount of irrigation water, and greenness of grass (an index of available water). These 3 variables were each positively correlated to prairie dog numbers. Four vegetative parameters were intermediately associated: distance to cultivation, percent forb cover, percent shrub cover, and grass cover x shrub cover (interaction). Shrub cover and grass x shrub cover were negatively associated. Finally, habitat barriers and percent nitrogen, respectively, were positive and negative in association with abundance.

Table 10. Simple regression of environmental parameters with the abundance index of the Utah prairie dog

Variable	r^2	B Value	F	P<
Barriers				
Habitat	.23	.052[1]	8.83	.01
Topographic	.06	.044	1.81	N.S.
Statistical Interactions				
Grass Cover x Shrub Cover	.33	-.002	14.32	.001
Shooting Intensity x Badger Activity	.18	-.0029	6.15	.025
Grass Cover x Forb Cover	.12	.0003	4.11	.10
Grass x Forb x Shrub x Cover	.02	-.00005	.73	N.S.
Forb Cover x Shrub Cover	.01	-.0005	.15	N.S.
Other Animals				
Badger Excavation	.11	-.0059	3.58	.10
Hunting Intensity	.16	multiple[2]	2.66	.10
Townsend Ground Squirrel	.06	multiple	1.76	N.S.
Grazed or Not Grazed	.04	.279	1.26	N.S.
Intensity of Grazing	.06	multiple	.85	N.S.
Type of Grazing Animal	.13	multiple	.48	N.S.
Soil				
Nitrogen	.26	-.0599	10.06	.005
Soil and Prairie Dog Colors, Contrast	.18	multiple	3.17	.05
Phosphorus	.10	.0146	3.13	.10
pH	.00	.054	2.91	N.S.
Percent Coarse Matter	.09	.0037	2.87	N.S.
Texture	.53	multiple	2.21	.10
Mound Stone Abundance	.05	-.063	1.54	N.S.
Water Table Depth	.05	multiple	.77	N.S.
Sand-Clay, Textural Composition	.02	multiple	.68	N.S.
Total Soluble Salts	.00	-.022	.115	N.S.
Temperature-Precipitation				
Mean Max. Temp., Growing Season to August 15	.58	.0094	40.8	.0005
Number of Days with Max. Temp. less than 0 C, 5-yr. Total	.35	-.0056	33.0	.0005

Table 10. Continued

Variable	r^2	B Value	F	P<
Temperature-Precipitation Cont.				
Elevation	.38	-.019	17.46	.0005
Total Precipitation	.32	-.115	13.4	.005
Wind	.29	-.028	11.75	.005
Accumulated Winter Precipitation	.26	-.135	9.9	.005
Mean Minimum Temp., Growing Season to August 15	.22	.008	8.4	.01
Total Amount of Water	.17	.0186	5.7	.05
Annual Growing Season, 5-yr. Mean	.16	.0059	5.6	.05
Precipitation, Growing Season to August 15	.15	-.185	4.8	.05
Topography				
Topographic Region	.67	multiple	8.21	.0005
Solar Radiation	.11	-.0073	3.69	.10
Ridges	.10	.134	2.86	N.S.
Drainage	.06	-.110	1.87	N.S.
Aspect	.34	multiple	1.76	N.S.
Homogeneity of Terrain	.08	multiple	1.19	N.S.
Swales	.04	.080	1.08	N.S.
Slope	.01	.011	.336	N.S.
Vegetation				
Heterogeneity among Plant Communities	.56	.079	36.23	.0005
Mean Number of Grasses, Forbs, and Shrubs	.54	-.039	35.18	.0005
Percent of Dog Towns Less than 91.5 meters (100 yds.) from Cultivation	.33	.056	14.38	.001
Percent Shrub Cover	.29	-.023	11.865	.005
Percent Forb Cover	.25	.008	9.801	.005
Number of Communities Greater than 19% of Total Dog Town Size	.19	.675	6.91	.025
Percent Vegetative Cover 12 inches or Higher	.17	.011	5.95	.025

Table 10. Continued

Variable	r^2	B Value	F	P<
Vegetation Cont.				
Percent Sedge Cover	.16	-.052	5.67	.05
Percent Total Cover	.05	.003	1.60	N.S.
Percent of Dog Town Seeded in Wheat Grasses	.02	.013	.46	N.S.
Percent Lichen Cover	.01	-.033	.276	N.S.
Percent Grass Cover	.00	-.001	.059	N.S.
Water				
Irrigation, Percent of Dog Town Within 91.5 meters (100 yds.)	.36	.053	16.52	.0005
Irrigation, Inches Applied	.25	.022	9.74	.005
Greenness of Grass	.35	multiple	7.60	.001
Any Water, Percent of Dog Towns within 91.5 meters (100 yds.)	.10	.026	3.28	.10
Wet weather, Percent of Dog Town within 91.5 meters (100 yds.)	.08	-.028	2.38	N.S.
Permanent, Percent of Dog Town within 91.5 meters (100 yds.)	.04	.033	1.06	N.S.

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[1] Degrees of freedom (df) are 1/29 for continuous variables.

[2] Degrees of freedom for discrete variables (multiple B values) can be determined by referring to Appendix Table 10: the number of categories is equal to model df while the number of categories subtracted from 30 equals error df.

Table 11. Abundance index statistics of Utah prairie dog towns in 6 topographic regions of southern Utah

Abundance Index Statistics	Sevier Valley	Fremont[1] Valley	Grass Valley	Cedar Valley	Paunsaugunt Plateau	Awapa Plateau
N	4	3	2	7	10	5
Mean	81	79.3	79	75	54.9	38.4
S. D.	5.7	.59	2.8	9.2	13	21.7
Range	76-89	79-80	77-81	66-86	36-74	8-62

[1] Dog town in Horse Valley is included here.

Nine parameters were weakly associated with prairie dog abundance (r^2 = .11 - .20). Three of these were vegetative: number of communities, percent vegetative cover taller than 31 cm (12 in.), and percent sedge cover. The number of communities and the vegetation taller than 31 cm were positively correlated. However, vegetation taller than 31 cm (12 in.) was less than 5% of the total cover in 28 of 31 dog towns. Three climatic parameters were related weakly to abundance: total water, length of the growing season, and precipitation during the growing season. The last parameter was negatively related to abundance. Finally, shooting intensity x badger excavation and contrast of soil-prairie dog color were weakly correlated to abundance.

Interrelations of habitat parameters

Knowledge about interrelations was needed to make reliable generalizations about habitat requirements. Interrelations were observed in the overlaps of several pairs of parameters. These overlaps were given for 2 purposes: (1) to reveal relationships that were masked in multiple regression, and (2) as a reference for possible questions.

Four categories of overlaps between parameters were: temperature (Table 12), water (Table 13), vegetation (Table 14), and representative climatic and vegetative parameters (Table 15). Overlaps generally were high in all categories. In fact, most were overlapped greater than 50% and many greater than 80%. The largest of the 2 percentages given for each overlap facilitated quick reference, since it defined the overlap of the weaker variable within the stronger (stronger variable = larger r^2).

Table 12. Percentage of overlap between significant ($p \leq .05$) temperature-related variables and the abundance index for the Utah prairie dog

	% Elevation	% Length of Growing Season	% Days less than 32 F	% Minimum Temperature	% Maximum Temperature
Growing Season Length	23[1]				
	54[2]				
Days less than 32 F	100	67			
	70	20			
Minimum Temperature	82	99	56		
	99	52	95		
Maximum Temperature	88	97	94	93	
	63	30	95	56	
Wind	25	85	33	02	39
	33	47	61	02	71

[1] Overlap of the variable at the top of the table with the variable at the margin.

[2] Overlap of the variable at the margin of the table with the variable at the top.

Table 13. Percentage of overlap between significant ($p \leq .05$) water variables and the abundance index for the Utah prairie dog

	% Distance to Irrigation	% Greenness of Grass	% Winter Precipitation	% Growing Season Precipitation	% Total Precipitation	% Inches of Irrigation Water
Greenness of Grass	52[1]					
	54[2]					
Winter Precipitation	45	37				
	65	50				
Growing Season Precipitation	29	11	36			
	73	28	65			
Total Precipitation	56	40	100	100		
	64	44	80	45		
Inches or Irrigation Water	68	42	48	81	55	
	98	58	49	46	69	
Total Water	34	40	13	36	20	66
	75	87	19	31	38	100

[1] Overlap of the variable at the top of the table with the variable at the margin.

[2] Overlap of the variable at the margin of the table with the variable at the top.

Table 14. Percentage of overlap between significant ($p \leq .05$) vegetation variables and the abundance index for the Utah prairie dog

	% Habitat Barriers	% Forb Cover	% Shrub Cover	% Heterogeneity among Communities	% Number of Communities	% Mean number of grasses, forbs, and shrubs
Forb Cover	70[1]					
	65[2]					
Shrub Cover	75	75				
	60	66				
Heterogeneity among Communities	98	90	84			
	41	41	44			
Number of Communities	40	44	39	26		
	49	58	59	76		
Mean number of grasses, forbs, and shrubs	83	84	84	58	76	
	36	31	45	60	27	
Vegetation Height	35	39	22	17	47	17
	82	99	64	95	91	92

[1] Overlap of the variable at the top of the table with the variable at the margin.

[2] Overlap of the variable at the margin of the table with the variable at the top.

Table 15. Percentage of overlap between some significant ($p \leq .05$) climatic and vegetation variables and the abundance index for the Utah prairie dog

	% Distance to Irrigation	% Heterogeneity among Communities	% Mean number of grasses, forbs, and shrubs	% Total Precipitation
Heterogeniety among Communities	94[1]			
	62[2]			
Mean number of grasses, forbs, and shrubs	70	58		
	47	60		
Total Precipitation	56	42	57	
	64	73	97	
Maximum Temperature	78	72	77	91
	54	76	79	55

[1] Overlap of the variable at the top of the table with the variable at the margin.

[2] Overlap of the variable at the margin of the table with the variable at the top.

Prediction of abundance

Prediction of abundance was feasible when a small number of parameters were identified and used in multiple regression. Parameters were chosen which were both significantly correlated ($p \leq .05$) with the abundance index in simple regression and which feasibly could exert a direct influence upon prairie dogs.

Only 2 parameters were significant ($p \leq .01$) in multiple regression with prairie dog abundance: heterogeneity among plant communities and the mean number of grasses, forbs, and shrubs. In stepwise regression, these 2 variables explained 75% of the variability of the abundance, 56% and 19%, respectively.

Consistency of habitat parameters with abundance

The consistency with which particular habitat parameters are linked to animal abundance in different localities is indicative of causal relationships (Chitty, 1967). To aid in identification of such causal relationships, Table 16 was constructed in 3 steps: (1) representative parameters were chosen that were statistically significant ($p \leq .05$) in simple regression with prairie dog abundance, (2) each of these parameters was identified as positively or negatively correlated with abundance (see Table 10), (3) data for each dog town were treated so that only positive relationship were recorded in the table. In shrub cover, for example, a median point (15%) was selected; and only dog towns with cover values below 15% were denoted in the table. By contrast, in parameters positively related to abundance, dog towns with values above the median were denoted in the table.

Table 16. Habitat parameters and abundance of the Utah prairie dog: consistency of associations. Only positive associations are denoted. Dog towns are arranged in order of descending abundance, from left to right

Variables	13	22	31	21	15	7	1	3	2	29	6	30	12	9	25	24	23	20	4	8	18	10	11	19	27	16	5	17	14	28	26
Elevation (less than 2,196 meters--7,200 ft.)	x	x	x	x	x	x		x		x	x	x			x	x	x	x													
Greenness of Grass (green)	x	x	x	x	x	x											x								x						
Water in Addition to Precipitation	x	x	x	x		x		x	x								x	x													
Past Cultivation within Dog Town Unit	x	x	x	x	x	x	x		x	x	x				x			x													
Heterogeneity Among Plant Communities (less than 40%)	x	x	x	x	x	x	x	x	x	x	x	x	x	x				x	x									x			
Mean number of Grasses Forbs and Shrubs (More than 2.1)	x	x	x	x	x	x	x	x	x	x	x	x			x		x	x				x	x	x		x					
Shrub Cover (less than 15%)	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x		x	x		x				x	x	x	x	x
Forb Cover (greater than 30%)		x	x	x							x				x	x		x													
Badger Excavation (less than 33%)	x	x	x	x	x	x		x		x	x	x	x		x	x	x	x		x	x		x	x	x		x	x	x	x	
	← High Abundance → Index Range 11-19							← Medium Abundance → Index Range 20-37													← Low Abundance → Index Range = 38-92										

Overall, 4 habitat parameters were consistently associated with prairie dog abundance: elevation, past cultivation, water in addition to precipitation, and heterogeneity among plant communities. Of these 4 parameters, only elevation was negatively linked to abundance. Elevation was positively related to only 4 dog towns; 3 of these (1, 2, and 12) were adjacent to cultivated areas, while the other (9) was enclosed by habitat barriers.

To give perspective, dog towns were subjectively grouped into 3 categories: high abundance, medium abundance, and low abundance (see Table 16). The medium category provided distinction between high and low abundance. In the high abundance dog towns, only 1 parameter (forb cover) was not consistently linked to prairie dog abundance. In the low abundance dog towns, 3 parameters lacked consistency: the mean number of grasses, forbs, and shrubs; shrub cover; and badger excavation.

DISCUSSION

The discussion is presented in 3 sections. The first, "Factors Affecting Abundance," is based on direct evidence on the habitat requirements of the Utah prairie dog. The second section, "Factors Affecting Distribution of Prairie Dog Towns," is based mostly on implications of the data. A third section, "Recommendations," gives suggestions for managing the Utah prairie dog.

Factors Affecting Abundance

This section is presented in 6 parts: water, grasses-forbs-shrubs, heterogeneity among plant communities, climatic patterns, predation, and a synthesis. The first 4 are interrelated and should be read in order. The last part is a synthesis which gives general conclusions.

Water

The habitat of the Utah prairie dog is classified as a semi-arid steppe (Thornthwaite, 1931). Water available to plants in this climatic regime is deficient at all seasons relative to potential plant growth. Water available to animals also is critical, and yet prairie dogs (*Cynomys* spp.) do not have an effective system of conserving water. They probably resemble ground squirrels (*Spermophilus* spp.) in that moist food is necessary for survival (Vorhies, 1945; Schmidt-Nielsen and Schmidt-Nielsen, 1952; and others). Dew often is available to prairie dogs, but if commonly utilized, prairie dogs would drink water more frequently than observed by Young (1944) and Anthony (1955) in captive animals. I observed that captive Utah prairie dogs also drank free water only rarely.

Utah prairie dog densities were high only where adequate water was available to plants. Precipitation did not supply adequate water. The negative correlation of precipitation with prairie dog abundance reflected inadequate water available to plants without irrigation. Irrigation, on the other hand, was positively associated with abundance and, of the type of water investigated, best indicated moisture available to plants. Either irrigation water and/or the greenest category of grass were present in each of the high abundance dog towns, and were absent in all but one of the low abundance dog towns (see Table 16).

Grasses, forbs, and shrubs

Grasses, forbs, and shrubs are distinctive in water content: grasses contain more water than shrubs, and forbs contain more water than either grasses or shrubs (Sharif, 1969). Since prairie dogs obtain most of their water from plants, the relative availability of grasses, forbs, and shrubs could be a key factor in determining the abundance of the Utah prairie dog.

Grasses, low to intermediate in relative water content, showed no correlation with prairie dog abundance. Since this relationship was neutral, instead of negative, an explanation is appropriate. Water is concentrated in the stem base of grasses. This allows prairie dogs to offset the relatively low moisture content of the whole grass plant by selecting stem bases. Even larger mammals, such as ungulates, select an increased proportion of grass stems during dry periods (Gwynne and Bell, 1968).

Shrubs, lowest in relative water content, were negatively correlated with abundance. The low water content of shrubs provided an adequate explanation for the negative correlation. However, shrubs also can present a nutritional problem to prairie dogs. Although highly nutritious (Cook and Harris, 1950a), shrubs are partly woody. To the degree that woody tissue is eaten by prairie dogs, other more nutritious material is neglected.

Forbs, highest in relative water content, were positively correlated with abundance. If forbs are plentiful, prairie dogs can select them and increase their water intake. In addition, nutritional value, concomitant with water content, is relatively high in forbs (Cook and Harris, 1950a). A positive relationship of forbs to prairie dogs also was noted by Clements and Clements (1940), Longhurst (1944), King (1955), and Koford (1958).

Grasses, forbs, and shrubs were individually useful in reflecting the availability of water. In addition, their mean frequency was indicative of the time required for prairie dogs to obtain adequate water. The mean number of grasses, forbs, and shrubs was negatively related to abundance ($r^2 = .54$). This association was interpreted relative to differential concentration of water in the various parts of grasses, forbs, and shrubs (see Cook and Harris, 1950b). When water is critical, the searching time required to obtain adequate water would be greater in dog towns with a high variety of grasses, forbs, and shrubs. Obtaining less water per unit of time could negatively influence both fitness and reproduction.

Heterogeneity among plant communities

Heterogeneity among plant communities indicated the magnitude of difference in plant communities at the periphery of a dog town relative to plant communities within the dog town. Heterogeneity was positively correlated to abundance (r^2 = .56) and was greater than 40% in the 14 highest abundance dog towns (see Table 16).

Since droughts are frequent in the habitat of the Utah prairie dog, means of adapting to drought are vital. One means of adapting to drought is provided by plant heterogeneity. With increased heterogeneity, the likelihood increases that some plant community at the periphery of a dog town can serve as a good source of moisture during drought. Yet, prairie dogs rarely use the peripheral portion of a colony; travel away from the burrow system involves energy expenditure and risk. But during a drought, presence of emergency water might easily outweigh disadvantages normally associated with use of the periphery.

Heterogeneity among plant communities is linked to density of prairie dogs in a second way; the rate dispersal is affected. Dispersal is the major regulating mechanism of density in the whitetail prairie dog (C. leucurus, Tileston and Lechleitner, 1966). In the Utah prairie dog, evidence indicated that dispersal was important and that increased heterogeneity among plant communities interfered with dispersal. Two Utah prairie dog towns (13 and 31) had exceptionally high densities and both were surrounded almost completely by habitat barriers. Habitat barriers, positively associated with the Utah prairie dog's abundance, were 98% overlapped with heterogeneity among communities (see Table 14). Habitat barriers also restricted dispersal in blacktail prairie dogs (*C. ludovicianus*; Schaffner, 1928; Osborn and Allan, 1949; and Koford, 1958).

Climatic patterns

All climatic parameters were significantly correlated ($p < .05$) with the abundance of the Utah prairie dog (see Table 10). An additional parameter, topography, markedly influenced climate. Topographic regions where dog towns occurred were associated with abundance more strongly than any other parameter in the study (r^2 .67). Within each topographic region, climatic regimes and concomitant precipitation patterns were consistent and distinctive (Arlo Richardson, personal communication). I believe that precipitation patterns were responsible for this strong correlation.

Climatic regimes, especially precipitation-related components, may serve as a shortcut to predicting density of various species of prairie dogs. To illustrate, precipitation appears to affect the relative value to prairie dogs of grasses, forbs, and shrubs. If so, density also might be affected by precipitation. Data on the food habits of 3 species of prairie dogs (Kelso, 1939) allow a comparison of the use of grasses, forbs, and shrubs by prairie dogs in areas with different amounts and patterns of precipitation (Table 17). To help draw inferences, annual precipitation patterns and amounts are given for the general range of each species of prairie dog (Table 18). Although more data are needed,

Table 17. Proportion of food items by volume in the stomachs of 3 species of prairie dogs[a]

	March	April	May	June	July	Aug.	Sept.	Oct.
Blacktail								
Grass	.55	.64	.65	.88	.72	.78	.78	.52
Shrub	.07	.01	.11	0	0	.01	0	.05
Forb	.17	.15	.16	.02	.21	.03	.10	.40
Whitetail								
Grass	.16	.48	.22	.25	.62	.43	.30	.49
Shrub	.73	.46	.49	.42	.01	.01	.01	.38
Forb	.11	.05	.10	.04	.16	.36	.50	.13
Gunnison								
Grass		.58	.42	.33	.92	.33	.27	
Shrub		0	0	trace	0	0	0	
Forb		.41	.49	.57	0	.28	.39	

[a] Data adapted from Kelso, 1939.

Table 18. Distribution of 4 prairie dog species in relation to amounts and seasonal patterns of precipitation[a]

Species	General Range	$\overline{X}$ Annual Precipitation (Inches)	Peak Period of Precipitation
Blacktail	Great Plains	12-32	Spring-Summer
Whitetail	Wyoming	8-16	Spring
Utah	South-Central Utah	8-16	Summer
Gunnison	Southwestern Colorado to Northwestern Arizona	8-16	Summer

[a] Data adapted from the Superintendent of Documents, 1968.

since Kelso's study does not include availability of vegetation, the following discussion can serve as a source of ideas.

The blacktail prairie dog had a diet of mostly grasses. This species' habitat is characterized by the highest precipitation available to any of the prairie dogs. By contrast, the diet of the whitetail prairie dog consisted of both shrubs and grasses. The whitetail's habitat has less moisture and is distinguished by an obscure precipitation peak in the spring.

The divergent feeding patterns of the blacktail and whitetail prairie dogs provide a clue to water relationships. The feeding pattern of the blacktail prairie dog is characterized by aimless wandering, while that of the whitetail is distinguished by systematic movements (Tileston and Lechleitner, 1966). This divergence may be an adaptation to lower precipitation and, consequently, reduced vegetative moisture and quality within the whitetail's range.

The Utah and Gunnison (_C. gunnisoni_) species seem more positively associated with forbs than either the blacktail or whitetail. Since precipitation in the range of these species is concentrated in the late summer, moisture is more likely to be deficient during the reproductive period. Selection of plants, such as forbs, that are high in moisture content could be an effective adaptation to late summer precipitation. In contrast to these species, the whitetail prairie dog may be positively related to shrubs (see Table 17). In the range of the whitetail, a spring precipitation peak may render water less critical during the reproductive period. Thus, shrubs might not have the negative relation to whitetail abundance that they do to Utah prairie dog abundance.

In conclusion, climatic regimes appear useful in predicting density and population trends in prairie dogs; water appears to be the key factor. In the Utah prairie dog, precipitation patterns were strongly linked to relative abundance. In other species of prairie dogs, indirect evidence indicated that available moisture influenced the value of grasses, forbs, and shrubs. In addition to prairie dogs, other kinds of rodents are linked to precipitation patterns: the red squirrel (Tamiasciurus hudsonicus) in Canada (Kemp and Keith, 1970); a tree squirrel (Sciurus vulgaris, Formosov, 1933); ground squirrels (Kalabukhov, cited by Dice, 1952); voles (Microtus californicus; Marsh, 1962); and heteromyid rodents (Beatly, 1969).

Predation

Of all types of predation, shooting and badgers probably exert the most pressure upon prairie dogs; neither of these types of predation is greatly hindered by the visual and auditory defenses of prairie dogs. Yet, neither were highly significant in relation to abundance ($p \leq .90$). The interaction of shooting intensity and badger excavation was significant ($p > .025$) in simple regression, but not in multiple regression ($p \leq .95$). Evidence on other species of prairie dogs corroborates the idea that predation does not exert a controlling influence on density (Tileston and Lechleitner, 1966; King, 1955; and T. W. Clark, unpublished data). Predation upon prairie dogs definitely is less important than Hairston et al. (1960) suggest for herbivores in general.

Synthesis of factors affecting abundance

The level of abundance of the Utah prairie dog appears to be determined mostly by the moisture and concomitant quality of the vegetation available to this animal. Two lines of evidence support this conclusion: (1) A positive relationship to vegetative moisture and quality was suggested by 6 parameters. These parameters were relatively consistent, either positively or negatively, to levels of this animal's abundance (see Table 16). Two of these parameters were vegetative components: heterogeneity among plant communities, and the mean number of grasses, forbs, and shrubs. Two parameters were indicative of moisture available to plants: water in addition to precipitation, and greeness of grass. A 5th parameter (past cultivation within the dog town) influenced the mean number of grasses, forbs, and shrubs, and was favorable to forbs. The remaining parameter (elevation) reflected the availability of water to plants; more water was available at lower elevations because of irrigation and wet meadows. (2) Most of the variability in this prairie dog's abundance (75%) was explained by 2 vegetative parameters: the mean number of grasses, forbs, and shrubs and heterogeneity among plant communities. Each of these parameters indicated relative moisture and quality of the available vegetation. Other parameters explained no unique variability of abundance in multiple regression ($p \leq .95$).

The levels of abundance in numerous herbivores appear closely related to the moisture and quality of vegetation. This is suggested by evidence on diverse species: voles (*Microtus* sp., Batzli and Pitekla, 1971); European rabbits (*Oryctolagus cuniculus*, Myers, 1970); grouse (*Lagopus lagopus*, Miller et al., 1966); and deer (*Odocoileus*, spp. Swan, 1956 and Taber, 1956). Perhaps the abundance levels of most herbivores, other than seed eaters, are determined by the moisture and quality of available vegetation (see Pitelka and Orians, 1960).

Factors Affecting Distribution of Dog Towns

This section of the discussion is presented in 5 parts: interspecific competition, soil, vegetation height, rodent control, and drought and aridity. The last 2 parts are of greatest concern; rodent control and moisture relations are critical to the survival of the Utah prairie dog. Interspecific competition is of historical interest and the remaining parts, soil and vegetation height, represent indirect influences on the distribution of dog towns.

Interspecific competition

The range of the Utah prairie dog does not contact the ranges of any other species of *Cynomys*. Outside the genus *Cynomys*, the most similar animals are the ground squirrels (*Spermophilus*). Only 2 ground squirrels are sympatric with the Utah prairie dog: the Townsend and Uinta (*S. armatus*). Presence of the Townsend ground squirrel was not significant relative to prairie dog abundance ($p \leq .90$). Casual observations indicated that this ground squirrel was not abundant near Utah prairie dog towns. Only 1 observation was made where the 2 species were in contact: 2 Townsend ground squirrels were observed at the periphery of dog town 6. Vegetation in the periphery of this dog town was drier than elsewhere.

In competition between ground squirrels, Hansen (1954) observed that species which are more tolerant of aridity are displaced by those with less tolerance. The Townsend ground squirrel is more tolerant to dry conditions than other ground squirrels in Utah. Where it occurs sympatric with the Belding (S. beldingi) and Uinta ground squirrels, it is displaced by them to drier habitats. The last 2 species require more moisture than the Townsend ground squirrel. In the past, when both the Townsend ground squirrel and the Utah prairie dog were abundant, Utah prairie dogs probably displaced Townsend ground squirrels in a similar manner.

Historically, the ranges of the Uinta ground squirrel and the Utah prairie dog overlapped in southern Sevier County (Durrant, 1952). At present, there is essentially no contact between the 2 species. However, their distributional patterns suggest past competitive interactions (see Nadler et al., 1971). General habitat features of these 2 species are similar, according to a description by Hansen (1954). Since the Uinta ground squirrel is a more northern species, it probably is less tolerant to dry conditions than the Utah prairie dog and, thus, may have been a strong competitor in the area of sympatry.

Soil

Soil structure supposedly affects the burrowing of prairie dogs. However, neither the abundance of stones nor extremes of soil texture were significant relative to the abundance of this prairie dog ($p \leq .95$). Overall texture of the soil, on the other hand, correlated highly with abundance (r^2 .53), but was only weakly significant ($p \leq .10$). In my opinion, this correlation reflected a relationship of the soil to plant composition. To illustrate, every dog town with high abundance had a history of disturbance by cultivation (see Table 16). Since disturbance is favorable to forbs (Box, 1961), prairie dogs in disturbed areas can capitalize on the increased forb cover. Reid (1954) made similar observations on the blacktail prairie dog in North Dakota.

Soil chemistry, in relation to prairie dog abundance, was an unfruitful route of research. Of 4 parameters on soil chemistry, only 1 (nitrogen) was associated significantly with prairie dog abundance. The negative correlation of nitrogen probably was incidental to irrigation, since nitrogen and irrigation were 98% overlapped.

Soil color is a selective factor important to numerous mammals of desert regions (Dice, 1937; Hardy, 1945). The blending of soil-prairie dog color, an indication of the value of cryptic coloration, was significantly correlated to Utah prairie dog abundance ($p \leq .05$). Perhaps camouflage and silence are critical to the survival of dispersing animals and establishment of new colonies. I observed that lone Utah prairie dogs or groups of 2 or 3 seldom barked. Lack of vocalization also was observed in arctic ground squirrels (S. undulatus) living away from the main colonies (Carl, 1971).

Vegetation height

Vegetation taller than 31 cm (12 in.), such as tall shrubs or ungrazed grasses and forbs, was correlated positively with the Utah prairie dog's abundance ($p \leq .025$). This correlation, however, was incidental to other factors. Taller vegetation was more than 90% overlapped with forbs and other important vegetative parameters (see Table 14). In addition, vegetation cover taller than 31 cm (12 in.) was rare in nearly all dog towns.

The rarity of taller vegetation in dog towns indicated that Utah prairie dogs avoided such vegetation. Rarity of taller vegetation did not result from clipping of vegetation by prairie dogs. Clipping of tall plants, which was commonly observed in the blacktailed prairie dog (King, 1955; Koford, 1958), was not observed in the Utah prairie dog. Another idea, susceptability to predation, is sometimes used to explain prairie dog's preference of low vegetation. But, if predation were the major factor, a few, low-abundance dog towns should occur in taller vegetation. Instead, the dog town with the highest percentage of tall vegetation (31) had 1 of the highest densities for the species. Recent cultivation in this dog town allowed plants to grow rapidly in the weeks before data were collected.

Grazing has considerable influence upon the height of grasses and forbs. Although none of the grazing parameters were significant, all but 2 dog towns (25 and 31) were grazed. One of these ungrazed dog towns (31) became extinct following data collection; and the other (25) exhibited a downward population trend. Ungrazed plots, adjacent to several dog towns, seldom were used by prairie dogs.

Although dog towns were found only in areas of naturally short vegetation or vegetation kept short by grazing, individual prairie dogs sometimes were seen in taller vegetation at the periphery of dog towns. Individuals at the periphery were in a position to replenish parent populations in the event of normal losses or catastrophe. Many species of small mammals quickly replace individuals that are snap-trapped (Stickle, 1946 and others). Exchange between animals in a parent population with the individuals at its periphery has several advantages (Healy, 1967). Since the Utah prairie dog has been controlled heavily throughout its range during this century, the species may owe its present survival to repopulation by individuals that were outside the main dog towns during these catastrophes.

Rodent control

Rodent control, with the use of treated grain, was a major influence on the distribution of Utah prairie dog populations. In 1970 alone, 9 populations became extinct (see Appendix Table 6). Six of these populations apparently were exterminated by rodent control. Rodent control affected not only local populations, but also entire regions (see Table 1). The species essentially disappeared from 6 of 10 regions in southern Utah. Control efforts were extensive in all 10 of these regions during this century. Information about control in specific areas was given by Collier and Spillett (1972a, 1972b, and 1973).

Although rodent control was a major influence on distribution of dog towns it was not sufficient to explain all of the species' decline. Such control did not account for the evident pattern of relict populations (see Fig. 2), but the critical nature of plant water did. This argument is discussed next, but it is pointed out here that plant water is indirectly related to rodent control: all recent control occurred on private lands where streams and irrigation provided adequate plant moisture. Thus, man has been eliminating the Utah prairie dog from its best habitat, while nature has been eliminating the species from its remaining habitat.

Drought and aridity

Droughts in southern Utah are frequent (Wernstedt, 1960), and their impact upon plant moisture, which is vital to prairie dogs, is obvious. A drought in the mid-1950's was apparently a key factor in eliminating the Utah prairie dog from an entire region, the Paria Valley (Collier and Spillett, 1972a). Another drought, which occurred during 1971 and 1972, had a marked affect upon prairie dog populations. Drought was severe on the Awapa Plateau, where Utah prairie dogs were widespread. In late July and early August of 1972, only 3 animals were observed on the plateau at elevations between 8,200 and 8,400 feet. Whereas, during the previous July and August, 297 animals were observed in the same area. By contrast, at elevations between 8,800 and 9,300 feet, prairie dogs were active in July and August of 1972 and their numbers had increased since 1971. Vegetation obviously was greener at the higher elevations as a result of greater precipitation. The drought also was severe in Grass Valley, immediately west of the Awapa Plateau. Of 6 dog towns in Grass Valley, only 1 did not exhibit a sharp decline between 1971 and 1972. This was the only dog town with adequate plant moisture; it was adjacent to an irrigated field. On the other hand, drought was less severe on the Paunsaugunt Plateau. Although drier than normal, vegetation was obviously greener than in Grass Valley or on the Awapa Plateau. No decline was apparent in the number of prairie dogs on the Paunsaugunt Plateau.

Although drought has had an obvious impact on Utah prairie dogs, changes in general aridity provide the best clue toward understanding the species' relict populations. Some 10,000 years ago, the Great Basin was cooler and less arid than at present (Antevs, 1925; Martin, 1963; Wells and Berger, 1967; and Brown, 1971). Since the habitat then was more favorable than at present, the Utah prairie dog probably occupied large segments of the Great Basin, in what is now western Utah and eastern Nevada. At the same time, the animal's present range was less favorable, because of the extension of forests and brush to lower altitudes. During the last 4,000 years, the Great Basin has grown progressively drier (Martin, 1963). As this happened, the western and major portion of the species' range became less favorable, concurrent with higher temperatures, less moisture, and the development of a salt-shrub vegetation type. By the time the white man came to Utah, the animal was reduced to relict populations in the southwestern portion of the Great Basin. While the western extreme of the species' range grew less favorable because of drying, the eastern extreme became more favorable as the forest and brush receded to higher elevations. Therefore, populations shifted toward the east, where they presently occur. Evidence supporting this idea was discussed in detail by Collier and Spillett (in press).

The basic problem of the Utah prairie dog appears to be drought and increased aridity. These factors make the animal more vulnerable to rodent control, a secondary factor. If the present climatic trends continue, the Utah prairie dog may become extinct. However, several steps can be taken to delay its possible extinction. These are specified under recommendations.

RECOMMENDATIONS

1. The Utah prairie dog should be kept on the endangered list until population trends stabilize. The endangered status is a prerequisite for action aimed at perpetuating the species.
2. One office should coordinate planning and management of the Utah prairie dog. Annual surveys on abundance are recommended. With information provided by such surveys, appropriate action, such as protecting and transplanting, can be taken.
3. Acquisition of land by purchase, lease, or exchange is needed if the species is to survive in its best habitat. The prairie dog reaches its greatest abundance on irrigated areas where high densities often irritate landowners. Yet, the presence of the Utah prairie dog in such areas is the only insurance against extinction during a major drought. Accordingly, purchase of the Enoch dog town would be a major accomplishment. Prairie dogs were largely eliminated from this dog town in 1972, but probably would recover rapidly with proper management.
4. Existence of the Utah prairie dog should be given high priority in land management of the Awapa Plateau (Bureau of Land Management, Richfield District) and the Paunsaugunt Plateau (Dixie National Forest, Powell Division). Specific portions or all of these lands should be designated as prairie dog areas for perpetuity. Potential population increases should be considered either as natural, expected phenomena or as phenomena to

be controlled by methods other than massive poisoning campaigns similar to those of the past 4 decades. Failure to provide such plans would endanger the species on public lands--the only lands presently affording means whereby the species may be perpetuated.

5. The natural history, ecology, and behavior of this unique species should be made known to the public. Specific recommendations include: interpretive car trails on the Awapa and Paunsaugunt Plateaus (Bryce Canyon area), and a visitor display at the Y dog town (15) near the Panguitch-Bryce Canyon highway junction.
6. The number of dog towns should be increased by transplanting animals to appropriate public and private lands. Buckskin Valley in Iron County could be developed and maintained as a major prairie dog area.
7. Transplanting of prairie dogs should be successful if critical conditions are met: (a) Water, in addition to precipitation, should be on or near the site. This condition is most important for sites of less than 2,196 m (7,200 ft.) elevation. (b) Transplanting to areas having any of the following conditions is likely to be unsuccessful: elevations higher than 2,745 m (9,000 ft.), tall vegetation (31 cm or 12 in.) comprising more than 10% of the vegetation cover, and saline soils. Narrow variability among these factors implies that prairie dogs cannot maintain themselves in such situations. (c) Areas high in forb cover are ideal transplant sites, if other conditions are suitable. Forb cover can be increased by disturbances such as grazing or plowing. In fact, disturbance is necessary to maintain the animals. (d) When

prairie dogs are released in a new area, they are not familiar with their surroundings and have not developed burrow systems. Badger control and protection from hunting, therefore, are important.

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APPENDIX

Appendix Table 1. Data code for a single quadrat used in sampling vegetation cover in Utah prairie dog towns

Column[a]	Item
1-2	Dog town number
3	Portion of dog town sampled
5	Number of the plant community (corresponds to number on sketches)
6-7	Percent to which this community occupies the dog town unit
11-13	Plant species number. Data in the next 7 columns are observations on this species.
14-15	Percent cover
16	Type cover 1. Grass 2. Grass-like 3. Horsetails 4. Forb 5. Suffrutescent 6. Shrub 7. Lichen 8. Cactus
17	Vegetation height 1. Less than .39 cm (1 in.) 2. .39-15.3 cm (1-6 in.) 3. 15.3-31 cm (6-12 in.) 4. 31-46.3 cm (12-18 in.) 5. 46.3-62 cm (18-24 in.) 6. 62 cm (24 in. or greater)
18	Greenness of grass 1. Green predominant 2. Intermediate 3. Brown predominant
19	Phenological stage 1. Vegetation stage 2. Culms and/or buds 3. Blossoming 4. Unripe seeds & fruits 5. Ripe seeds 6. Leaves yellowing 7. Plant dry 8. Stages 1 & 2 9. Stages 3 & 4
20	Percent not available (nearest 10%); shrubs above 46 cm (18 in.)

[a] Items in columns 11-20 are repeated in columns 21-30, 31-40 and so on through column 80. Data on up to 7 plant species were collected on one data sheet.

Appendix Table 2. List of specific areas in 9 counties from which the Utah prairie dog was exterminated between 1920 and 1970. Information is based on interviews conducted 1970-1972.

Sevier County: Gooseberry Flat; Bear Valley; Forsythe Reservoir; Three Creeks area (Hawley Ranch); Koosharem Reservoir.

Piute County: Angle; Circleville; Dog Lake on the Parker Mountain

Garfield County: Aquarius Plateau (widely scattered); Paria Valley (Tropic, Canonville, Henrieville); Rock Canyon (west of Hatch); and Dog Valley, northwestern corner of the county.

Kane County: Long Valley Junction; head east fork of the Sevier River; Sheep and Willis Creek area (just south of Garfield County line, near Bryce Canyon).

Wayne County: Vicinity of Torrey, Teasdale, Fremont, and Bicknell.

Washington County: Near New Harmony.

Iron County: Antelope Springs; Iron Springs; area 2 miles west of Cedar City; Cedar Bottoms, west of Parowan Gap; Lund area; Modena; Buckhorn Flat (near junction of highways U.S. 91 and Utah 20); and Buckskin Valley.

Beaver County: Near Minersville.

Millard County: Dog Valley, near Kanosh.

Note: Validity of the occurrences in Beaver, Millard and westernmost Iron County are difficult to confirm because of the length of time involved and the presence of Townsend ground squirrels.

Appendix Table 3. Location of areas with less than 25 Utah prairie dogs each

Number	Township, Range and Section	Prairie Dogs Observed or Reported	Estimated Number	County
1	T34S R5W S4	2	5	Garfield
2	T28S R3E S8,9,15,16,17, 20,22,23	2	15	Wayne
3	T27S R1W S2	2	10	Sevier
4	T27S R1W S22			Piute
5	T27S R1W S29			Piute
6	T28S R1W S3,4,5,8,9,16, 17,20			Piute
7	T36S R5W S21	2	5	Garfield
8	T36S R5W S27,28			Garfield
9	T36S, R5W S32	2	10	Garfield
10	T35S R4W S33			Garfield
11	T37S R3W S24			Garfield
12	T36S R3W S23			Garfield
13	T36S R3W S7	12	20	Garfield
14	T36S R4W S33	1	1	Garfield
15	T33S R5W S21			Garfield
16	T33S R5W S33	1	2	Garfield
17	T34S R5W S3			Garfield
18	T32S R41/2W S18			Garfield
19	T29S R4E S11			Wayne
20	T36S R3W S36	3	5	Garfield
21	T35S R5W S24,25; T35S R41/2W, S19,30; T35S R41/2W S27			Garfield
22	T33S R1W S19			Garfield
23	T36S R7W S6			Garfield
24	T30S R2W S29			Piute
25	T25S R5W S16,17			Sevier
26	T34S R10W S34	7	15	Iron
27	T34S R9W S16	1	2	Iron
28	T34S R9W S16	7	15	Iron
29	T36S R11W S3	2	5	Iron
30	T35S R11W S14,24	1	1	Iron
31	T34S R9W S30	2	5	Iron
32	T37S R12W S14	5	15	Iron
33	T37S R12W S34	3	10	Iron

Appendix Table 3. Continued

Number	Township, Range and Section	Prairie Dogs Observed or Reported	Estimated Number	County
34	T33S R8W S36	4	10	Iron
35	T34S R9W S14	4	10	Iron
36	T33S R9W S32			Iron
37	T34S R10W S34	14	20	Iron
38	T36S R11W S10			Iron
39	T22S R2E S17			Sevier
40	T29S R2E S16		20	Wayne
41	T28S R1E S22,23			Wayne
42	T28S R1E S30,31		15	Wayne
43	T30S R2E S31			Wayne
44	T30S R2E S34	2	15	Wayne
45	T28S R3E S4	4	15	Wayne
46	T37S R6W S23	2	10	Garfield
47	T30S R2E S7,8,16,17	4	20	Wayne
48	T28S R3E S17,20,21	6	15	Wayne
49	T32S R6W S7	1	4	Iron
50	T25S R6W S3			Millard
51	T36S R5W S35	3	6	Garfield
52	T32S R7W S7	2	5	Iron
53	T34S R5W S26	7	20	Garfield
54	T29S R2E S35; T30S R3E S2	2	4	Wayne
Total		106	330	

Appendix Table 4. Names, specific localities, and type of land control for all known dog towns of Cynomys parvidens in 1971. Habitat data were collected on dog towns 1-31 in 1972.

Dog Town Number	Name	Township, Range and Section (s)	Land Control
1	Horse Valley 1	T27S R3E S26,27	Private
2	Horse Valley 2	T27S R3E S26,27	Private
3	Lyman Cemetery	T28S R3E S8	Private
4	Hare Lake 1	T30S R1W S25	Public
5	Hare Lake 2	T30S R1W S25	Public
6	Delange 1	T26S R1W S26	Private
7	Delange 2	T26S R1W S26	Private
8	Ahlstrom Hollow	T36S R4W S9,16	Combined
9	Red Hills	T36S R3W S33	Public
10	Tom Best 1	T34S R3W S35,36	Combined
11	Tom Best 2	T34S R3W S27	Public
12	Ruby's Inn	T36S R3W S18	Private
13	Island	T34S R5W S34	Private
14	Berry Spring	T35S R4W S22	Public
15	Y	T35S R5W S24	Private
16	Whittaker Ranch	T35S R2W S6	Private
17	John's Valley	T33 R2W S27,28,33,34; T34S R2W S3,4	Private
18	Flake Road	T35S R3W S30,31	Mostly Public
19	Flake Bench	T35S R3W S19,20	Mostly Public
20	Texaco	T35S R11W S26	Private
21	Church Reservoir 1	T35S R11W S13	Private
22	Church Reservoir 2	T35S R11W S13	Private
23	Rush Lake	T34S R11W S12	Private
24	Quichapa	T37S R12W S11,14	Private
25	Parowan Airport	T34S R8W S6,7	Private
26	Weasel	T30S R1W S29	Public
27	Swale	T30S R1E S36	Public
28	Top	T31S R1E S20,29	Public
29	U.E. 1	T36S R5W S24	Private
30	U.E. 2	T36S R5W S24	Private
31	Olds	T35S R11W S22	Private
32	Middle	T28S R3E S8	Private
33	Dry Lake	T29S R2E S33; T30S R2E S3,4	Public

Appendix Table 4. Continued

Dog Town Number	Name	Township, Range and Section(s)	Land Control
34	Combined	T29S R2E S28,29,31,32,33	
		T30S R2E S5,6,7	
		T29S R1E S36;	
		T30S R1E S1,12	Public
35	Flossie Lake	T29S R1E S27,34;	
		T30S R1E S2,3,10	Public
36	Middle Balsam	T30S R2E S9	Public
37	Bobcat	T29S R1E S4,5,9	Public
38	Parker Road	T28S R1E S32	Public
39	Roadside	T30S R2E S20	Public
40	Greenwitch	T27S R1W S21	Private
41	Red Knoll	T27S R1W S16	Private
42	Crandel Ranch	T27S R1W S28	Private
43	Magleby Ranch	T28S R1W S4,5	Private
44	Bagley Ranch	T27S R1W S33;	
		T28S R1W S4	Private
45	Panguitch Lake	T35S R7W S34	Mostly Private
46	Bear Valley	T33S R7W S12,13,26;	
		T33S R6 1/2 W	Combined
47	Tropic	T36S R3W S35	Private
48	County Line	T37S R6W S33,34;	
		T38S R6W S3,4	Private
49	Enoch	T35S R10W S6,7	Private
50	Lowry	T35S R11W S13,14	Private
51	Mortensen	T34S R9W S20	Combined
52	Divide	T37S R12W S33,34	Private
53	Savannah	T38S R12W S17	Private
54	Racetrack	T34S R9W S13	Private
55	Paul Miller	T33S R9W S35	Private
56	Cedar Grove	T28S R1E S9	Public
57	Big Hollow	T29S R1E S24	Public

Appendix Table 5. Prairie dog numbers and areas inhabited for individual dog towns. Data on dog towns 1-31 were utilized in the study of habitat and abundance.

Dog Town Number	1971 Areas Hectares	1971 Areas Acres	1971 Estimated Numbers	1971-1972 Trend[a]
1	21.9	54	170	a
2	2.0	5	80	a
3	2.0	5	20	a
4	10.9	27	30	a
5	7.7	19	35	a
6	2.8	7	25	a
7	4.0	10	45	a
8	7.7	19	155	a
9	5.7	14	50	a
10	17.8	44	125	a
11	28.7	71	145	a
12	11.7	29	90	a
13	1.2	3	50	a
14	9.7	24	40	a
15	1.6	4	50	a
16	31.5	78	125	a
17	91.1	225	165	a
18	12.9	32	50	a
19	13.8	34	150	a
20	7.7	19	40	a
21	2.8	7	190	a
22	1.2	3	60	a
23	6.9	17	90	a
24	79.4	196	120	a
25	8.1	20	100	c
26	2.8	7	25	a
27	.8	2	25	a
28	2.0	5	25	a
29				b
30				b
31				b
32	3.6	9	75	d
33	93.1	230	150	d
34	186.2	460	435	d
35	41.3	102	103	d
36	8.1	20	70	d
37	27.5	68	45	d
38	3.2	8	45	d

Appendix Table 5. Continued

Dog Town Number	1971 Areas Hectares	1971 Areas Acres	1971 Estimated Numbers	1971-1972 Trend[a]
39	11.3	28	30	d
40	3.2	8	30	d
41	4.0	10	30	d
42	3.6	9	75	d
43	2.0	5	30	d
44	4.9	12	75	d
45	6.9	17	100	a
46	14.9	37	90	e
47	.4	1	30	d
48	4.9	12	170	d
49	79.4	196	1040	d
50	2.0	5	50	d
51	2.0	5	25	d
52	1.2	3	35	d
53	5.3	13	90	d
54	4.8	12	65	d
55	9.3	23	75	d
56	21.1	52	100	d
57[b]	16.2	40	50	d
Totals	197.4	489	2190	

[a] Code:

a = stable
b = not located until 1972
c = some decline
d = sharp decline
e = uncertain

[b] This number does not match the number (48) in tables on status because it includes 3 dog towns that were found in 1972 and 6 dog towns that were each treated as 2 dog towns in the 1972 study.

Appendix Table 6. Populations of the Utah prairie dog that became extinct between 1970 and 1971

Name	Locality	No. of Prairie Dogs
Loa Airport	T28S R3E S17,20,21	1,000
Lyman	T28S R3E S10	50
Wilson Peak	T34S R4W S32,33	100
Panguitch Hatchery	T36S R5W S32	200
Henrie	T33S R5W S16,17,21,22	200
Summit	T34S R10W S35,36; T35S R10W S1,2	400
Adams	T33S R8W S36	50
Berry	T37S R12W S34	50
Pavant	T25S R5W S10,11,15	100
Total		2,150

Appendix Table 7. A list of each taxon encountered in vegetative samples of dog towns. The number of each taxon corresponds to the numbers in Appendix Table 5. Nomenclature follows Holmgren and Reveal (1966).

1			Amaranthaceae
2			Asclepiadaceae
3			Cactaceae
4			Chenopodiaceae
	5		Atriplex
		6	A. canescens
		7	A. truncata
	8		Bassia hyssopifolia
	9		Chenopodium album
	10		Eurotia lanata
	11		Halogeton glomeratus
	12		Kochia scoparia
	13		Salsola kali
	14		Sarcobatus vermiculatus
	15		Suaeda occidentalis
16			Compositae
	17		Achillea
	18		Artemisia
		19	A. arbuscula nova
		20	A. cana
		21	A. dracunculus
		22	A. frigida
		23	A. pygmaea
		24	A. tridentata
	25		Aster frondosus
	26		Chaenactis douglasii
	27		Chrysothamnus
		28	C. spp.
		29	
		30	C. depressus
		31	C. nauseosus
		32	C. parryi
		33	C. viscidiflorus
	34		Cirsium
	35		Franseria acanthicarpa
	36		Grindelia squarrosa
	37		Gutierrezia sarothrae
	38		Haplopappus lanceolatus
	39		Helianthus annuus
	40		Hymenoxys richardsonii
	41		Iva

Appendix Table 7. Continued

		42	I. axillaris
		43	I. xanthifolia
	44		Machaeranthera grindelioides
	45		Petradoria pumila
	46		Senecio
		47	S. longilobus
		48	S. multilobatus
	49		Taraxacum
	50		Tetradymia canescens
	51		Tragopogon
	52		Xanthium
	53		Convolvulus arvensis
54			Cruciferae
	55		Camelina microcarpa
	56		Cardaria repens
	57		Descurainia richardsonii
	58		Draba arida
	59		Lepidium perfoliatum
	60		Sisymbrium altissimum
	61		
62			Cryptogamic Crust
63			Cyperaceae
	64		Carex spp.
	65		C. douglasii
	66		C. elynoides
	67		C. nebraskensis
68			Boraginaceae
69			Euphorbiaceae
	70		Euphorbia fendleri
	71		E. robusta
72			Equisetaceae
73			Geraniaceae
	74		Geranium caespitosum
	75		Erodium circutarium
76			Gramineae
	77		Agrostideae
	78		Agrostis exarata
	79		Aristida
		80	A. fendleriana
		81	A. purpurea
	82		Sporobolus
		83	S. airoides
		84	S. cryptandrus

Appendix Table 7. Continued

  - 85 . . . . Stipa comata
- 86 . . . . Aristideae
  - 87 . . . . Muhlenbergia
    - 88 . . . . M. arsenei
    - 89 . . . . M. asperifolia
    - 90 . . . . M. filiculmis
    - 91 . . . . M. richardsonis
  - 92 . . . . Aveneae
  - 93 . . . . Chlorideae
    - 94 . . . . Bouteloua gracilis
    - 95 . . . . Phalaris arundinaceae
  - 96 . . . . Festuceae
    - 97 . . . . Bromus
      - 98 . . . . B. anomalus
      - 99 . . . . B. commutatus
      - 100 . . . . B. inermis
      - 101 . . . . B. tectorum
    - 102 . . . . Distichlis
    - 103 . . . . Poa
      - 104 . . . . P. arida
      - 105 . . . . P. pratensis
      - 106 . . . . P. sandbergii
  - 107 . . . . Hordeae
    - 108 . . . . Agropyron
      - 109 . . . . A. cristatum
      - 110 . . . . A. smithii
      - 111 . . . . A. spicatum
      - 112 . . . . A. trachycaulum
    - 113 . . . . Hordeum
    - 114 . . . . Sitanion
  - 115 . . . . Zoysieae
- 116 . . . . Juncaceae
  - 117 . . . . Juncus spp.
  - 118 . . . . J. balticus
- 119 . . . . Labiatae
  - 120 . . . . Marrubium vulgare
  - 121 . . . . Monardella odoratissima
- 122 . . . . Leguminosae
  - 123 . . . . Astragalus
    - 124 . . . . Astragalus spp.
    - 125 . . . . A. agrestis
    - 126 . . . . A. diversifolius
    - 127 . . . . A. tegetarius
  - 128 . . . . Glycyrrhiza lepidota

Appendix Table 7. Continued

- 129 . . . . . Lotus wrightii
- 130 . . . . . Lupinus
  - 131 . . . . . L. spp.
  - 132 . . . . . L. pusillus
- 133 . . . . . Melilotus officinalis
- 134 . . . . . Lichens
  - 135 . . . . . Ground Lichens
  - 136 . . . . . Foliose Rock Lichens
- 137 . . . . . Linaceae
- 138 . . . . . Malva rotundifolia
  - 139 . . . . . Malva rotundifolia
  - 140 . . . . . Sphaeralcea coccinea
- 141 . . . . . Onagraceae
- 142 . . . . . Paeoniaceae
- 143 . . . . . Papaveraceae
- 144 . . . . . Polemoniaceae
- 145 . . . . . Polygonaceae
  - 146 . . . . . Eriogonum
    - 147 . . . . . E. spp.
    - 148 . . . . . E. alatum
    - 149 . . . . . E. microthecum
    - 150 . . . . . E. racemosum
    - 151 . . . . . E. umbellatum
  - 152 . . . . . Polygonum
  - 153 . . . . . Rumex crispus
- 154 . . . . . Scropulariaceae
  - 155 . . . . . Cordylanthus ramosus
  - 156 . . . . . Penstemon
    - 157 . . . . . P. spp.
    - 158 . . . . . P. spp.
    - 159 . . . . . P. linarioides
- 160 . . . . . Plantaginaceae
- 161 . . . . . Rosaceae
  - 162 . . . . . Potentilla
    - 163 . . . . . P. anserina
    - 164 . . . . . P. fruticosa
    - 165 . . . . . P. gracilis
  - 166 . . . . . Ivensia gordonii
  - 167 . . . . . Rosa woodsii
- 168 . . . . . Solanaceae
  - 169 . . . . . Physalis
    - 170 . . . . . P. longifolia
    - 171 . . . . . P. subglabrata

Appendix Table 7. Continued

	172	Solanum triflorum
173	Verbenaceae	
174	Anacardiaceae	
175	Total Unidentified	
	176	Unidentified Plant
	177	Unidentified Forb
	178	Unidentified Grass
	179	Unidentified Shrub
	180	Missing
181	Antennaria Compositae	
182	Alfalfa Medicago	

Appendix Table 8. Percent cover of plants sampled within each dog town. Dog town numbers appear at the top and bottom of each page and are arranged from highest to lowest abundance of prairie dogs (left to right). Numbers to the left of each page correspond to the numbers of plant taxa listed in Appendix Table 7.

	13	31	22	21	15	7	1	3	2	29	6	30	12	9	25	24	23	20	4	8	18	11	10	19	27	16	5	17	14	28	26
1																															
2																															
3									1																						
4		55	23	25	23	21		7	16	1	49				41	42	2	31					1		2	1		7			
5					1			3																	1	1		6			
6								3																	1	1		6			
7					1																										
8		31	20	24											4			11							1						
9																															
10								3		1													1			1					
11																															
12																															
13		24	3	1	22	21		2	16		49				37	42		20													
14																	2														
15																															
16	15	12	7	6	3	4	4	8	6	1	3	4	27	25	1	7	13	3	21	13	8	12	19	14	19	30	9	13	13	8	7
17	1																														
18						2		1				1	13	11					3	8	3	10	4	7	7	32	1	4	5	6	3
19														6					3	8	1	10		7		31	1		5	1	3
20																									3					5	
21								1																							
22													13										3			1		4			
23														5							2				1						
24						2																			3						
25	13	3	1	1	1													2													
26																															
27	1				2	2	4	6	6	1	1	3	4	6	1	3			17	5	3	2	15	7	7	2	4	7	8	2	4
28																															
29																															
30														1																	
31	1				2	2	4	1		1	3	2	2		1	3												2			
32													2	4																	
33								6	6			1		2					17	5	3	2	15	7	7	2	4	5	8	2	4
34																		1													
35																															
36																															
37													7	7		4									1			2			
38																					2										
39		3																													
40													1																		
41		6	4	5													13														
42		6	4	5													13														
43																															
44																															
45																															
46																															
47																															
48																															
49																															
50													1						1						3						
51																															
52			1																												
53																															
54	4					1					6					1															
55																															
	13	31	22	21	15	7	1	3	2	29	6	30	12	9	25	24	23	20	4	8	18	11	10	19	27	16	5	17	14	28	26

Appendix Table 8. Continued

	13	31	22	21	15	7	1	3	2	29	6	30	12	9	25	24	23	20	4	8	18	11	10	19	27	16	5	17	14	28	26
56																															
57	4										6																				
58																															
59																															
60																															
61																1															
62																															
63											1		7				21										12		3	6	
64																	21														
65																															
66											1		7														12		3	6	
67																															
68													2																		
69																															
70																															
71																															
72	10																					1									
73																															
74																															
75																															
76	37	13	14	6	9	2	7	4	16	20	4	13	3	2	4	39	32	13	7	24	11	18	11	15	26	13	24	2	19	21	14
77	7															37		9	7	11			1	1	16		11		5	2	2
78	7																	9													
79																8													1		
80																															
81																8													1		
82																29															
83																															
84																29															
85																			7	11			1	1	16		11		4	2	2
86	14																			6		1			9		4		1	12	9
87	14																			6		1			9		4		1	12	9
88																						1								5	
89	7																														
90	7																			2					9				1	6	9
91																				4							4			1	
92		10																													
93			5					2	16	3		1								6		11		2	2				2		2
94								2	16	3		1								6		11		2	2				2		2
95			6																												
96	9		3			2		1			4						32	4			6						6		1	2	1
97			3			2		1			4							4											1		
98																															
99			3																												
100						2		1																					1		
101											4							4													
102																	32													2	
103	9							1													6						8				1
104																															1
105								1																							
106	9																				6						8				
107	6	3	6	6	9	1	7			17		12	2	2	4	1				1	4	6	10	12		13	2	2	10	5	2
108	6	3	4	6	3	1	7			17		12		2	4	1					4	6	10	12		13		2	10	2	
109					3		7			17		12		1	4						4	6	9	12					10		
110	6	3	4	6	5	1										1										13		2		2	
	13	31	22	21	15	7	1	3	2	29	6	30	12	9	25	24	23	20	4	8	18	11	10	19	27	16	5	17	14	28	26

Appendix Table 8. Continued

	13	31	22	21	15	7	1	3	2	29	6	30	12	9	25	24	23	20	4	8	18	11	10	19	27	16	5	17	14	28	26
111																															
112																															
113			1		1																										
114													2							1							2	1	1	3	2
115																															
116																	1														
117																	1														
118																															
119																									1						
120																															
121																									1						
122		1							1				1				1		1						4		3		1		
123									1								1		1						2		1				
124									1								1														
125																											1				
126																															
127																			1						2						
128																															
129																													1		
130													1												2		2				
131													1												2		2				
132																															
133		1																													
134								5	1										1								1		1		
135								5											1								1		1		
136									1																						
137														1						1											
138		10	1		1	2																1	1					6			
139		10	1																												
140		1			1	2																1	1					6			
141													1																		
142																															
143																1															
144														1						2					1		4				5
145																				1	1			2					1		1
146																				1	1			2					1		1
147																															
148																															
149																				1				1							1
150																													1		
151																															
152																															
153																															
154													5						5								2				2
155																															
156													5						5								2				2
157																															
158																															
159													4						5								2				2
160	4																														
161																									1					1	
162																									1					1	
163																														1	
164																									1						
165																															
	13	31	22	21	15	7	1	3	2	29	6	30	12	9	25	24	23	20	4	8	18	11	10	19	27	16	5	17	14	28	26

Appendix Table 8. Continued

	13	31	22	21	15	7	1	3	2	29	6	30	12	9	25	24	23	20	4	8	18	11	10	19	27	16	5	17	14	28	26
166																															
167																															
168	1		6																												
169	1		6																												
170																															
171			6																												
172	1																														
173																															
174													1																		
175	9							3			1		1				8			1	10						2				4
176	9										1		1							1	10						1				2
177																	8										1				1
178								2																							1
179																															
180																															
181																														10	
182			9	15		1		5																							
	13	31	22	21	15	7	1	3	2	29	6	30	12	9	25	24	23	20	4	8	18	11	10	19	27	16	5	17	14	28	26

Appendix Table 9. Results of LSD test among mound distances. An "x" indicates that distances of two dog towns were not significantly different. Numbers at the left and top of each group of figures are dog town numbers.

	31	30	29	28	27
1	x	x	x		
2	x	x	x		
3		x	x		
4					
5					x
6		x	x		
7	x	x	x		
8					x
9		x	x		
10					x
11					x
12		x	x		
13	x				
14					
15	x	x	x		
16					x
17					
18					x
19					x
20					
21	x	x	x		
22	x				
23					
24					
25		x	x		
26					
27					
28					
29	x	x			
30					

	26	25	24	23	22
1					x
2		x			x
3		x			x
4		x	x	x	
5					
6		x			
7					x

Appendix Table 9. Continued

	26	25	24	23	22
8			x	x	
9		x	x	x	
10					
11					
12		x	x	x	
13					x
14					
15					x
16					
17					
18					
19					
20		x	x	x	
21					x
22					
23		x	x		
24		x			
25					
	21	20	19	18	17
1	x				
2	x				
3	x				
4		x	x	x	
5			x		x
6	x				
7	x				
8		x	x	x	
9		x			
10			x	x	
11			x	x	
12					
13	x				
14					x
15	x				
16			x		
17					
18		x	x		
19					
20					

Appendix Table 9. Continued

	16	15	14	13	12
1		x			x
2		x			x
3		x			x
4					
5	x		x		
6		x			x
7		x			x
8					
9		x			x
10					
11					
12		x			
13					
14					
15					

	11	10	9	8	7
1			x		x
2			x		x
3			x		x
4	x	x		x	
5					
6			x		x
7			x		
8	x	x			
9					
10	x				

	6	5	4	3	2
1	x			x	x
2	x			x	
3	x				
4					
5					

Appendix Table 10. Key to data collected in each of 31 Utah prairie dog towns. Column numbers correspond to columns of the data sheet in Appendix Table 11. Listing of parameters follows the order outlined in Table 10.

Item	Column	Explanation
Barriers		
Habitat	1	Percentage, rounded to nearest 10%
Topographic	2	Percentage, rounded to nearest 10%
Other Animals		
Badger Excavation	3-4	Percentage
Shooting Intensity	5	(1) Heavy (2) Intermediate (3) Light
Townsend Ground Squirrels	6	(1) Absent (2) Present
Grazed or Not Grazed	7	(1) Grazed (2) Not Grazed
Intensity of Grazing	8	(1) Substantial (2) Intermediate (3) None
Type of Grazing Animal	9	(0) None (1) Cattle (2) Sheep (3) Horses (4) Cattle and Sheep (5) Cattle and Horses (6) Sheep and Horses (7) Cattle, Sheep and Horses
Soil		
Nitrogen	10-11	Percentage
Soil and Prairie Dog Colors, Contrast	12	(1) Distinct (2) Intermediate (3) Little or None
Phosphorus	13-14	Parts per Million
pH	15-16	Decimal understood between numerals
Percent Coarse Matter	17-18	Percentage
Texture	19-20	(1) Clay (2) Silty Clay (3) Clay Loam (4) Gravelly-Clay Loam (5) Silty Clay Loam (6) Silt Loam (7) Gravelly Silt Loam (8) Loam (9) Gravelly Loam (10) Sandy Loam (11) Gravelly-Sandy Loam
Mound Stone Abundance	21	(1) Rare (2) Intermediate (3) Abundant

Appendix Table 10. Continued

Item	Column	Explanation
Water Table Depth	22	(1) Less than .9 m (3 ft.) (2) More than .9 m (3 ft.) (3) Varied
Total Soluble Salts	23-24	Percentage
Temperature-Precipitation		
Mean Max. Temp., Growing Season to August 15	25-26	Degrees Fahrenheit
Number of Days with Max. Temp. less than 10 C, 5-yr. Total	27-29	Actual Number
Elevation	30-31	Hundreds of Feet
Total Precipitation	32-33	Inches, Decimal understood between numerals
Accumulated Winter Precipitation	34-35	Inches, Decimal understood between numerals
Mean Minimum Temp., Growing Season to August 15	36-37	Degrees Fahrenheit
Total Amount of Water	38-39	Inches
Annual Growing Season, 5-yr. Mean	40-42	Days
Precipitation, Growing Season to August 15	43-44	Inches, Decimal understood between numerals
Topography		
Topographic Region	45	(1) Horse Valley (2) Fremont Valley (3) Awapa Plateau (4) Paunsaugunt Plateau (5) Grass Valley (6) Sevier Valley (7) Cedar Valley
Solar Radiation	46-47	Add 200 to each statistic to obtain the number of langleys
Ridges	48	(1) Substantial number of mounds on ridges (2) Some mounds on ridges (3) Few or no mounds on ridges
Drainage	49	(1) Good (2) Fair (3) Poor
Aspect	50	(1) North (2) North-East (3) East (4) South-East (5) South (6) South-west (7) West (8) North-West

Appendix Table 10. Continued

Item	Column	Explanation
Homogeneity of Terrain	51	(1) Homogeneous (2) Intermediate (3) Heterogeneous
Swales	52	(1) Substantial number of mounds (2) Some mounds in swales (3) Few or no mounds in swales
Slope	53-54	Degrees of Arc
<u>Vegetation</u>		
Heterogeneity Among Plant Communities	55	Percentage/10
Mean Number Grasses, Forbs, and Shrubs	56-57	Decimal understood between numerals
Percent of dog towns within 91.5 m (100 yds.) of Cultivation	58	Percentage/10
Percent Shrub Cover	59-60	Percentage
Standard Error of Shrub Cover	61-63	Decimal understood before all numerals
Percent Forb Cover	64-65	Percentage
Standard Error of Forb Cover	66-68	Decimal understood before all numerals
Number of Communities Greater than 10% of Total Dog Town Size	69	Actual Number
Percent Vegetative Cover 12 in. or Higher	70-71	Percentage
Percent of Dog Town Seeded in Wheat Grasses	72	Percentage/10
Percent Lichen Cover	73-74	Percentage
Percent Grass Cover	75-76	Percentage
Number Quadrats/Dog Town	77-79	Actual Number Sampled
<u>Water, Non-Precipitation</u>		
Irrigation, Percent of Dog Town within 91.5 m (300 ft.)	80	Percentage/10
Irrigation, Inches Applied	81-82	Inches
Greenness of Grass	83	(1) Green (2) Intermediate (3) Brown
Any Water, Percent of Dog Town within 91.5 m (300 ft.)	84	Percentage/10

Appendix Table 10. Continued

Item	Column	Explanation
Wet Weather, Percent of Dog Town within 91.5 m (300 ft.)	85	Percentage/10
Permanent, Percent of Dog Town within 91.5 m (300 ft.)	86	Percentage/10

Appendix Table 11. Data collected in each of 31 Utah prairie dog towns. Appendix Table 10 is a key to the column numbers in this table.

Column Numbers

Dog town Numbers	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
1	3	0	6	3	2	1	1	1	4	0	7	3	1	1	7	8	0	2	1	0	1	2	0	2	8	2	0	8	9
2	3	0	4	9	2	1	1	1	2	0	0	3	0	0	7	8	0	2	1	0	1	2	0	2	8	2	0	8	9
3	1	0	1	7	2	1	1	1	1	0	7	2	0	5	7	4	3	3	1	1	1	2	1	5	8	2	0	8	9
4	0	0	6	0	3	1	1	1	4	0	0	2	0	0	6	6	3	2	0	4	3	2	0	4	7	8	1	6	0
5	0	0	2	1	2	1	1	1	7	1	4	2	0	9	6	6	3	2	0	4	3	3	0	4	7	8	1	6	0
6	5	2	1	5	2	2	1	1	1	1	9	3	3	2	7	8	2	6	0	9	2	2	0	5	8	3	0	9	4
7	2	0	0	5	2	2	1	1	1	1	9	3	3	2	7	8	2	6	0	9	2	2	0	5	8	3	0	9	4
8	0	0	2	6	3	1	1	1	1	1	6	3	2	2	7	6	0	0	0	6	2	2	0	4	7	8	1	6	0
9	7	0	5	1	2	1	1	1	1	1	2	3	0	2	7	7	1	3	0	3	3	2	0	6	7	8	1	6	0
10	0	0	3	7	3	1	1	1	4	1	2	3	0	2	8	1	0	9	0	5	2	2	0	5	7	8	1	6	0
11	0	0	3	1	2	1	1	1	4	1	5	3	0	9	7	8	3	4	0	9	3	2	0	5	7	8	1	6	0
12	2	0	1	1	2	1	1	1	3	0	9	3	0	3	7	6	3	0	0	9	1	3	0	4	7	8	1	6	0
13	9	9	0	1	3	1	1	1	1	2	0	3	0	1	7	9	0	0	1	0	1	1	0	4	8	5	0	8	1
14	0	0	1	7	3	1	1	1	1	1	2	3	1	4	6	9	1	8	0	9	3	2	0	4	7	8	1	6	0
15	8	0	0	1	3	1	1	1	1	0	9	3	0	2	8	3	0	0	0	2	1	2	0	4	8	5	0	8	1
16	0	0	4	6	3	1	1	1	1	1	0	2	0	6	7	6	0	0	0	6	1	2	0	4	7	8	1	6	0
17	7	2	1	9	1	1	1	1	1	0	8	3	0	6	7	9	0	0	0	1	1	2	0	8	7	8	1	6	0
18	0	0	0	9	3	1	1	1	1	1	0	3	0	2	7	8	0	0	0	7	2	2	0	3	7	8	1	6	0
19	0	0	1	1	3	1	1	1	1	0	9	3	0	3	7	9	2	1	0	9	3	2	0	4	7	8	1	6	0
20	9	5	1	3	2	2	1	1	1	0	6	3	1	2	7	9	0	0	0	8	2	2	0	4	8	3	0	6	2
21	4	2	0	0	2	2	1	1	4	1	8	2	1	1	7	5	0	0	0	5	1	2	0	8	8	3	0	6	2
22	1	0	0	1	2	2	1	1	4	0	0	2	0	0	7	5	0	0	0	5	1	2	0	9	8	3	0	6	2
23	3	0	0	1	3	1	1	1	1	2	5	2	9	9	8	6	0	0	0	5	1	1	0	9	8	3	0	6	2
24	4	0	0	3	1	1	1	1	7	0	0	3	0	5	7	8	0	0	0	3	1	2	0	5	8	3	0	6	2
25	7	0	1	0	2	1	2	3	0	0	9	3	1	2	7	8	1	5	0	3	1	2	0	5	8	1	0	4	8
26	0	0	5	2	3	1	1	1	4	1	4	1	1	5	6	7	3	2	0	8	3	2	0	2	7	8	1	6	0
27	2	0	1	9	3	1	1	2	4	1	1	1	4	1	6	5	2	0	0	9	3	2	0	2	7	8	1	6	0
28	2	0	1	3	3	1	1	1	4	1	5	3	1	7	6	5	0	6	0	8	2	3	0	2	7	8	1	6	0
29	3	0	0	6	3	1	1	1	1	1	0	3	2	8	8	3	1	0	9	9	3	2	0	4	8	5	0	8	1
30	7	0	0	6	3	1	1	1	1	0	0	3	0	0	8	3	1	0	9	9	3	2	0	4	8	5	0	8	1
31	9	0	0	4	3	2	2	3	0	1	3	3	3	0	7	8	0	0	9	9	1	3	0	5	8	3	0	6	2

Appendix Table 11. Continued

	Column Numbers																													
Dog town Numbers	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
1	7	8	4	9	2	4	4	4	0	5	0	8	2	2	6	1	6	0	3	1	8	1	3	0	5	6	1	0	0	0	4
2	7	8	4	9	2	4	4	4	0	8	0	8	2	2	6	1	5	9	2	1	8	3	2	1	0	7	1	3	5	0	6
3	7	1	4	9	2	4	4	4	1	9	0	8	2	2	6	2	0	1	1	1	1	2	2	1	5	8	1	9	9	1	2
4	8	9	8	7	5	0	4	0	0	9	0	7	5	3	7	3	8	1	2	1	6	2	2	1	0	5	3	0	0	2	0
5	8	9	8	7	5	0	4	0	1	5	0	7	5	3	7	3	7	6	2	2	4	2	1	0	5	3	3	2	0	0	6
6	7	0	6	7	3	8	4	4	1	5	0	8	2	2	9	5	6	0	3	1	7	1	3	0	5	8	1	4	4	0	3
7	7	0	6	7	3	8	4	4	2	0	0	8	2	2	9	5	6	0	3	1	7	1	3	0	5	9	1	1	8	0	4
8	7	7	8	9	6	2	4	2	0	9	0	7	9	2	7	4	5	6	1	1	9	3	1	1	0	1	2	5	0	1	3
9	7	8	8	9	6	2	4	2	0	9	0	7	9	2	7	4	4	1	3	3	1	3	1	0	5	8	2	2	0	1	7
10	7	5	8	9	6	2	4	2	0	9	0	7	9	2	7	4	6	0	3	1	7	2	3	0	5	0	2	1	0	1	8
11	7	5	8	9	6	2	4	2	0	9	0	7	9	2	7	4	7	6	1	1	4	2	3	0	5	0	1	5	0	1	1
12	7	5	8	9	6	2	4	2	2	5	0	7	9	2	7	4	5	9	2	1	9	2	2	0	5	8	2	3	8	0	4
13	6	8	7	9	4	7	4	4	2	4	0	8	4	3	3	6	6	0	3	3	8	1	3	0	0	9	2	1	0	0	1
14	7	9	8	9	6	2	4	2	0	9	0	7	9	2	7	4	6	0	2	1	9	2	3	0	5	0	2	7	0	1	3
15	6	8	7	9	4	7	4	4	0	8	0	8	4	3	3	6	6	0	3	1	8	1	3	0	5	6	1	5	9	0	2
16	7	5	8	9	6	2	4	2	0	9	0	7	9	2	7	4	6	0	3	3	8	1	3	0	6	0	2	0	0	3	3
17	7	4	8	9	6	2	4	2	0	9	0	7	9	2	7	4	6	0	3	3	8	1	3	0	0	5	2	5	0	1	2
18	7	6	8	9	6	2	4	2	0	9	0	7	9	2	7	4	5	9	2	1	9	2	3	0	5	0	2	5	0	0	6
19	7	7	8	9	6	2	4	2	0	9	0	7	9	2	7	4	9	0	1	1	4	3	1	1	0	1	1	7	0	1	6
20	5	6	6	0	4	3	5	1	2	4	1	3	4	1	8	7	5	9	3	1	9	1	3	0	5	5	1	6	0	0	0
21	5	6	6	0	4	3	5	1	2	8	1	3	4	1	8	7	6	0	3	1	8	1	3	0	5	6	1	2	4	0	0
22	5	6	6	0	4	3	5	1	2	8	1	3	4	1	8	7	6	0	3	1	8	1	3	0	5	8	1	4	9	0	0
23	5	4	6	0	4	3	5	1	1	7	1	3	4	1	8	7	7	6	3	2	4	2	3	0	5	1	1	5	0	0	2
24	5	5	6	0	4	3	5	1	0	6	1	3	4	1	8	7	7	1	3	2	6	1	3	0	5	2	2	1	0	0	3
25	6	0	2	9	2	0	4	9	0	3	1	2	4	0	9	7	4	7	3	1	2	1	3	0	5	4	1	2	0	0	1
26	8	8	8	7	5	0	4	0	0	9	0	7	5	3	7	3	5	9	1	1	9	1	3	0	5	0	3	0	0	1	0
27	8	9	8	7	5	0	4	0	1	5	0	7	5	3	7	3	9	0	3	1	4	3	1	1	0	4	2	6	0	1	8
28	9	3	8	7	5	0	4	0	1	5	0	7	5	3	7	3	7	6	3	3	4	2	1	0	5	4	3	0	0	0	8
29	7	1	7	9	4	7	4	4	0	8	0	8	4	3	3	6	5	9	2	1	9	2	3	0	5	6	1	3	0	0	2
30	7	1	7	9	4	7	4	4	0	8	0	8	4	3	3	6	5	9	2	1	7	3	2	1	0	7	1	5	0	0	4
31	5	6	0	2	4	3	5	1	2	8	1	3	4	1	8	7	6	0	3	1	8	3	2	0	5	9	1	2	9	0	0

Column Numbers

Dog town Numbers	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
1				0	1				1	0	4	9	0	0	0	7	0	4	0	0	0	0	2	0	0	0
2	0	0	7	1	7	0	0	9	3	0	1	0	0	1	1	6	1	1	9	3	0	3	2	3	0	0
3	0	0	4	1	1	0	1	0	2	0	3	0	0	5	0	6	1	9	2	9	1	4	2	9	0	0
4	0	1	2	0	7	0	2	1	1	0	0	0	0	1	0	7	0	8	0	0	0	0	2	0	0	0
5	0	1	1	0	6	0	1	0	2	0	0	0	0	1	2	5	0	8	0	0	0	0	2	9	9	3
6	0	2	4	5	5	0	0	1	1	0	7	0	0	0	0	0	0	4	0	3	0	9	2	8	0	0
7	0	2	4	2	8				2	0	4	0	0	0	0	2	0	5	1	8	1	4	1	8	0	0
8	0	0	8	0	3	0	1	1	2	0	0	2	0	1	2	4	0	7	5	0	0	0	2	0	0	0
9	0	0	4	0	2	0	1	9	3	0	1	2	0	0	0	2	0	9	0	0	0	0	2	0	0	0
10	0	0	2	1	0	0	2	2	2	0	0	3	0	0	1	1	0	6	1	0	0	0	2	0	0	0
11	0	0	3	0	1	0	1	8	2	0	2	3	0	1	1	9	0	7	3	0	0	0	2	0	0	0
12	0	1	2	1	0	0	1	4	3	0	1	0	0	0	0	4	0	8	0	5	0	8	2	8	8	0
13	0	3	5	2	4	0	0	4	2	0	1	0	0	0	4	6	0	6	0	9	0	0	1	9	0	9
14	0	0	5	0	3	0	2	2	1	0	3	3	0	2	1	8	0	5	9	0	0	0	2	0	0	0
15	0	1	7	2	4	0	1	1	3	0	4	9	0	0	0	9	0	8	0	0	0	0	1	0	0	0
16				0	0	0	3	9	1	0	0	2	0	0	1	3	0	3	0	0	0	0	3	0	0	0
17	0	0	7	0	6	0	1	9	1	0	2	2	0	0	0	2	0	8	0	0	0	0	3	0	0	0
18	0	0	5	0	4	0	0	9	2	0	0	2	0	0	1	1	0	7	6	0	0	0	3	0	0	0
19	0	0	3	0	1	0	2	3	2	0	1	4	0	0	1	5	0	6	9	0	0	0	2	0	0	0
20	0	2	3	3	4				1	0	0	0	0	0	1	3	0	6	0	9	1	8	3	9	0	0
21	0	1	6	4	6				2	0	0	0	0	0	0	5	0	8	0	9	2	2	1	9	0	0
22	0	2	3	4	9				2	0	0	0	0	0	1	5	0	9	8	9	2	2	1	9	0	0
23	0	0	5	0	2	0	0	3	3	0	3	0	0	0	6	6	0	5	5	0	0	0	1	9	9	3
24	0	3	4	4	4	0	0	3	1	0	0	5	9	0	0	3	9	0	5	7	0	0	2	3	0	3
25	0	3	1	4	0	0	0	3	2	0	1	8	0	0	0	4	0	5	0	0	0	0	2	4	4	0
26	0	0	4	0	4	0	1	7	2	0	0	0	0	1	1	5	0	8	1	0	0	0	3	0	0	0
27	0	1	9	0	7	0	2	1	1	0	5	0	0	1	2	6	0	6	0	0	0	0	1	9	9	0
28	0	1	2	1	2	0	1	7	1	0	0	0	0	0	1	9	0	6	5	0	0	0	2	9	9	0
29	0	0	1	0	1	0	0	7	2	0	1	9	0	0	2	0	0	5	4	0	0	0	2	0	0	0
30	0	0	2	0	1	0	0	7	2	0	3	3	0	1	1	3	0	7	1	0	0	0	2	0	0	0
31	0	4	2	9	4				5	2	8	0	0	0	1	3	0	7	0	9	2	2	1	9	0	0

VITA

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Doctor of Philosophy

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Graduated from Decatur High School in 1961; received the Bachelor of Science degree from Athens College, Alabama; with a major in Biology; received the Master of Science degree from Tennessee Technological University in Biology (1967); completed requirements for the Doctor of Philosophy in Wildlife Science at Utah State University in 1975.

Professional Experience:

1970-1974, Research Assistant, Utah Cooperative Wildlife Research Unit; 1967-1970, Instructor of Biology and Coordinator of General Biology, Tennessee Technological University; 1969, Director of the Cumberland Regional Science Fair (Tennessee); summer 1969, Nature Instructor, YMCA Camp Widgiwagan; 1965-1967, Teaching Assistant, Tennessee Technological University; summer 1965, Sanitation Officer, Alabama Health Department and Wildlife Aide, Wheeler National Wildlife Refuge.

Publications:

Status of the Utah Prairie Dog, Cynomys parvidens. Utah Academy of Science, Arts and Letters 49:27-39 (1972). G. Donald Collier and J. Juan Spillett.

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Lectures, 1973:

"A Preliminary Report of Factors Influencing Density of the Utah Prairie Dog," Utah Wildlife Society, Salt Lake City, Utah.

"Factors Influencing Distribution of the Utah Prairie Dog," Utah Academy of Science; spring meeting, Logan, Utah.

"Prairie Dogs, a Legend in Danger," Natural Resources Week Program, Utah State University.

"Status of the Utah Prairie Dog," American Society of Mammalogists, Pacific Grove, California.

"Population Control in Prairie Dogs," Utah Academy of Science, fall meeting, Ogden, Utah.

"Prairie Dogs and People," Logan Audubon Society, Logan, Utah.

Professional Societies, 1965-1974:

American Institute of Biological Sciences
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