



Characteristics of pocket gopher populations in relation to selected environmental factors in Pelican Valley, Yellowstone National Park
by Clifton Conrad Youmans

A thesis submitted in partial fulfillment of the requirements for the degree, of MASTER OF SCIENCE
in Zoology
Montana State University
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Abstract:

In 1977 and 1978 I examined characteristics of pocket gopher populations in relation to vegetation, soil texture, soil moisture, and snow melt phenology on nine belt transects (100 m by 10 m) established in Pelican Valley, Yellowstone National Park. Pocket gopher numbers on belt transects were indexed from 48-hour mound counts and trapping. Three hundred-one pocket gophers were dead-trapped during the study. Mound-building activity was lowest after snow melt in June and generally highest in August. Mound counts were not a reliable index of gopher numbers when taken prior to late July. Abundance of winter soil casts in June 1978 was correlated significantly ($P < .05$) with mound counts from the previous late summer and fall of 1977. The period of peak parturition was determined to be from mid-April to mid-May. Placental scars were persistent and quantifiable and enabled computation of a mean litter size of 4.9 ($n=67$). Maximum litter size recorded was seven. Females had significantly ($P < .025$) larger litters ($x=5.1$) their second (1978) reproductive effort than their first (1977, $x=4.4$). Significant ($P < .025$) differences in fertility occurred between 50 females collected from *Festuca idahoensis*/*Deschampsia aespitosa* habitat types ($x=4.7$) and 42 females collected from *Artemisia tridentata*/*Festuca idahoensis* community types ($x=5.2$). Population turnover averaged 76.5 percent on two belt transects which were live-trapped. Production of young exceeded replacement requirements. Juveniles composed 80 percent of 64 pocket gophers dead-trapped in September, 1978. Combined line intercepts of *Melilotus alba* and *Perideridia gairdneri* correlated significantly ($P < .01$) with 48-hour mound counts. Abundance of *Collomia linearis* also correlated significantly ($P < .01$) with 48-hour mound counts. Soil textures on belt transects did not appear to influence pocket gopher numbers, however soil depths and soil temperatures may have done so. Soil moisture limited distribution of pocket gophers. Swales were typically too wet for pocket gopher use until late summer. Dispersing juveniles established territories on the edge of swales in August, when soil moisture was lowest. Marked differences in the depth of snow on 1 May between 1977 and 1978 did not appear to influence juvenile survival and hence fall population levels.

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SELECTED ENVIRONMENTAL FACTORS IN PELICAN VALLEY,
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CLIFTON CONRAD YOUMANS

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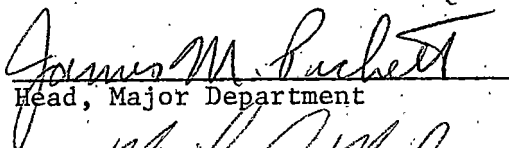
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October, 1979

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ABSTRACT

In 1977 and 1978 I examined characteristics of pocket gopher populations in relation to vegetation, soil texture, soil moisture, and snow melt phenology on nine belt transects (100 m by 10 m) established in Pelican Valley, Yellowstone National Park. Pocket gopher numbers on belt transects were indexed from 48-hour mound counts and trapping. Three hundred-one pocket gophers were dead-trapped during the study. Mound-building activity was lowest after snow melt in June and generally highest in August. Mound counts were not a reliable index of gopher numbers when taken prior to late July. Abundance of winter soil casts in June 1978 was correlated significantly ($P < .05$) with mound counts from the previous late summer and fall of 1977. The period of peak parturition was determined to be from mid-April to mid-May. Placental scars were persistent and quantifiable and enabled computation of a mean litter size of 4.9 ($n=67$). Maximum litter size recorded was seven. Females had significantly ($P < .025$) larger litters ($\bar{x}=5.1$) their second (1978) reproductive effort than their first (1977, $\bar{x}=4.4$). Significant ($P < .025$) differences in fertility occurred between 50 females collected from *Festuca idahoensis*/*Deschampsia caespitosa* habitat types ($\bar{x}=4.7$) and 42 females collected from *Artemisia cana*/*Festuca idahoensis* community types ($\bar{x}=5.2$). Population turnover averaged 76.5 percent on two belt transects which were live-trapped. Production of young exceeded replacement requirements. Juveniles composed 80 percent of 64 pocket gophers dead-trapped in September, 1978. Combined line intercepts of *Melica spectabilis* and *Perideridia gairdneri* correlated significantly ($P < .01$) with 48-hour mound counts. Abundance of *Collomia linearis* also correlated significantly ($P < .01$) with 48-hour mound counts. Soil textures on belt transects did not appear to influence pocket gopher numbers, however soil depths and soil temperatures may have done so. Soil moisture limited distribution of pocket gophers. Swales were typically too wet for pocket gopher use until late summer. Dispersing juveniles established territories on the edge of swales in August, when soil moisture was lowest. Marked differences in the depth of snow on 1 May between 1977 and 1978 did not appear to influence juvenile survival and hence fall population levels.

INTRODUCTION

The dynamics of pocket gopher populations in relation to ecosystem characteristics have been examined by numerous researchers. Attempts to isolate specific extrinsic ecosystem components and describe their influence on pocket gopher numbers and distribution have resulted in the identification of several important factors: water content at peak snowpack and depth of snow in spring (Hansen and Ward, 1966; Reid, 1973); weather and its influence on annual food supplies and cover (Howard and Childs, 1959); production of annual and perennial forbs (Keith et al., 1959; Tietjen et al., 1967); and ground water levels and snow depths (Ingles, 1949; Hansen, 1962).

The inherent complexity of pocket gopher-ecosystem interactions generally limits the degree to which site-specific data may be extrapolated to other locales. A need for specific information on pocket gophers in Pelican Valley, Yellowstone National Park arose from interest in interactions between grizzly bears (*Ursus arctos horribilis*) and northern pocket gophers (*Thomomys talpoides*). Mealey (1975) and Graham (1978) suggested that pocket gophers and their caches may serve as seasonally important food items for grizzlies in Yellowstone National Park.

Pelican Valley was selected as the study location due to its relative accessibility, vegetation in the valley being representative of large grass/shrub complexes found within the Yellowstone ecosystem (Mealey, 1975), and the high frequency of grizzly use along the southern edge of the valley, coinciding with generally high indices of pocket gopher numbers (Graham, 1978).

Objectives of this study were to select specific representative sites in Pelican Valley on which pocket gopher numbers could be quantified, monitored, and compared with data gathered concurrently on vegetative composition, standing crop, soil moisture, soil texture, and snow melt phenology. Changes in pocket gopher numbers were analyzed by gathering data on pocket gopher natality, sex ratios, age structure, annual population turnover, recruitment, period of peak parturition, and home range size. Frequency of infection with the parasitic nematode *Capillaria hepatica*, average weights, and composition of a pocket gopher cache were also determined. Field work was conducted from June to September in 1977 and from June to October in 1978.

STUDY AREA

Pelican Valley lies east of the geographic center of Yellowstone National Park and immediately to the northeast of Yellowstone Lake (Figure 1). Elevations vary from approximately 2362 m to 2437 m. The valley is approximately 2500 hectares in area. The mean annual temperature recorded at Lake Yellowstone weather station from 1948 to 1974 is 0.2° C (Dirks, 1974). July is the warmest month with a mean daily maximum of 22° C while the coldest month, January, has a mean daily minimum of -18° C (U.S. Weather Bureau, Climatological Data for Wyoming). Lake Camp snow course, approximately eight kilometers west of the valley at an elevation of 2392 m, had a mean snow depth of zero cm on 2 May, 1977 and 55.8 cm on 30 April, 1978 (Table 1, USDA Soil Conservation Service and Federal-State-Private Cooperative Snow Surveys 1977 and 1978).

Table 1. Snow depth and water content of snow on approximately 1 May for Lake Camp Snow Course, 1977 and 1978.

Date	Depth of Snow (cm)	Water Content (cm)
2 May 1977	0	0
30 April 1978	55.8	25.4

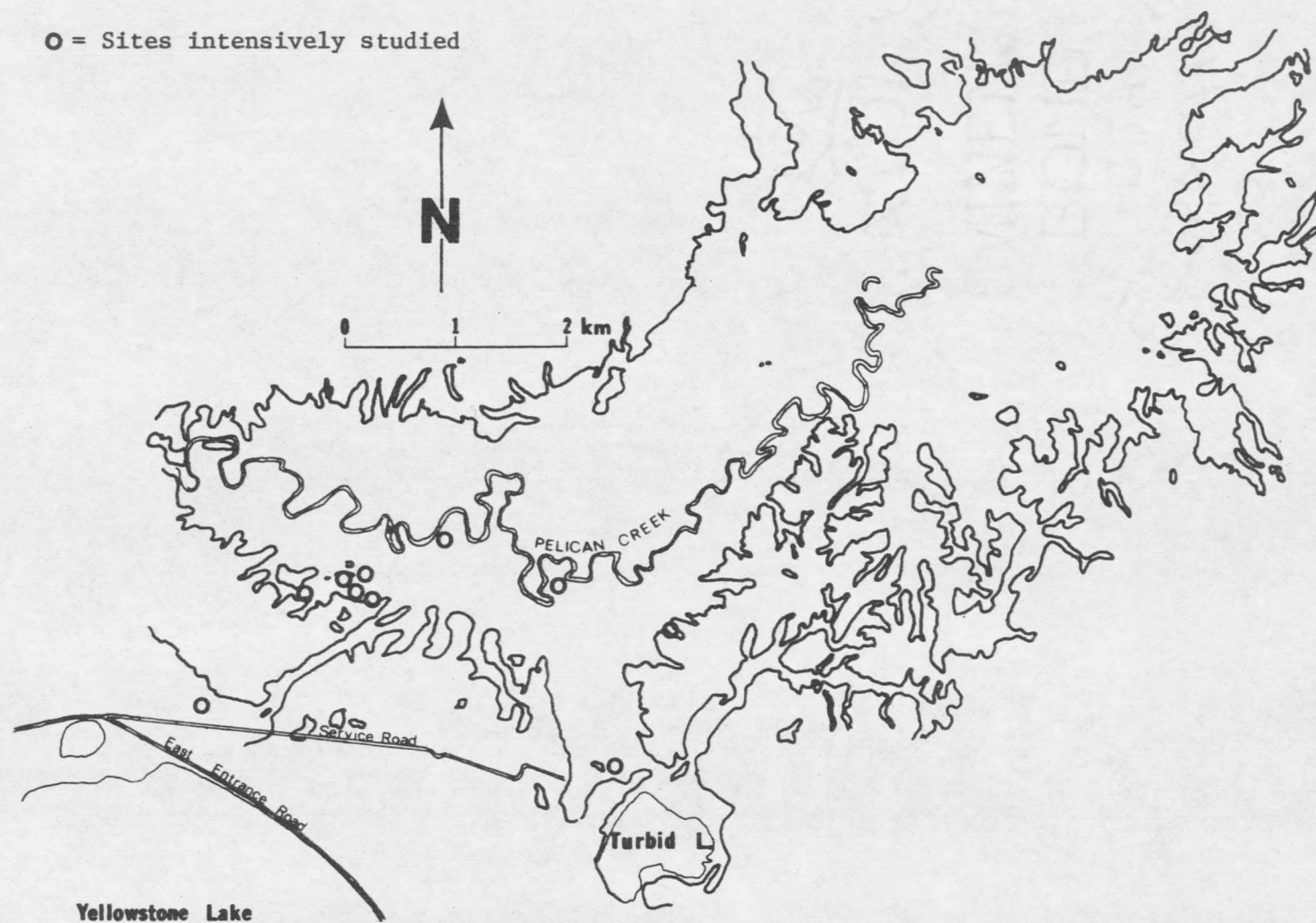


Figure 1. Pelican Valley, Yellowstone National Park

Graham (1978) observed that timber/grassland edge effectively divides Pelican Valley into separate ecological units. In particular, the southern edge of the valley exhibits a mosaic of small, discrete ecological units or 'patches'. Graham (1978) suggested that grizzlies exhibit a foraging strategy characterized by movement between small patches of seasonally high food abundance. Such foraging strategy may represent a long-term adaptation to fluctuations in spatial-temporal distributions of food (Royama, 1970; Smith and Sweatman, 1974; Pyke et al., 1977). In light of these observations, characteristics of pocket gopher populations on small, representative, and generally homogeneous ecological units were of particular interest.

METHODS

Belt transects were established along the southern edge of Pelican Valley on sites considered to be representative of existing plant communities and soil types. Eight belt transects 100 m long and 10 m wide were established during the summer of 1977. One additional belt transect of the same dimensions was established in June of 1978. These belt transects served as the primary sites of data collection during both field seasons.

Vegetation

The vegetation on all belt transects was classified as to habitat type (h.t.) (Mueggler and Handl, 1974) or community type (c.t.) (Graham, 1978) and quantitatively measured.

Vegetative composition on five of the nine belt transects was representative of a *Festuca idahoensis*/*Deschampsia caespitosa* (FEID/DECA) h.t. (FEID/DECA belt transect Nos. 1 through 5). Three belt transects were representative of an *Artemisia cana*/*Festuca idahoensis* (ARCA/FEID) c.t. (ARCA/FEID belt transect Nos. 1 through 3). One belt transect was representative of *Deschampsia caespitosa*/*Carex* spp. (DECA/*Carex*) h.t. (DECA/*Carex* spp. belt transect No. 1). Graham (1978) found that the FEID/DECA h.t. and the ARCA/FEID c.t. composed 51 percent and 31 percent respectively of all grizzly observation sites for both Pelican and Hayden Valleys.

Composition and canopy coverage of low growing vegetation were determined in August on each of the eight belt transects in 1977 and on each of the nine belt transects in 1978. A modification of the method described by Daubenmire (1959) was used. Twenty 2x5 decimeter plots were placed at five meter intervals along the centerline of each belt transect in 1977. Intensity of sampling was increased in 1978 to 25 plots placed at four meter intervals. Scientific and common names of plant species follow Hitchcock et al. (1969), Booth and Wright (1959), and Booth (1972).

Line intercepts coinciding with the centerline of each belt transect were used to index the relative abundance of yampa (*Perideridia gairdneri*) and purple oniongrass (*Melica spectabilis*) for the month of August in both 1977 and 1978. These two species are of possible importance to grizzly bears (Graham, 1978).

Data on standing crop for the month of August in 1978 were obtained on the nine belt transects by utilizing clip plots (USDA Forest Service, 1963).

Two of the nine belt transects were intensively sampled using 10 circular clip plots, each equal to 9.6 ft^2 . The remaining seven belt transects were sampled using 10 circular clip plots each equal to 0.96 ft^2 . On all nine belt transects a stratified random sampling scheme determined the location of clip plots. Belt transects were partitioned into 10 m^2 sections along their lengths. One clip

plot was randomly selected within each 10 m² section of the belt transects. Plant species clipped from each plot were bagged separately. Some species occurring only infrequently were lumped together. Clipped vegetation was oven dried at 50° C to a constant weight, then removed from bags and weighed to the nearest 0.01 gram.

Ordination and cluster analysis of canopy coverage data from belt transects for 1977 and 1978 followed Goldstein and Grigal (1972).

Indices of Pocket Gopher Numbers

Indices of pocket gopher numbers during snow-free months were accomplished through the use of mound counts (Reid et al., 1966) within each belt transect. Mound counts were made at arbitrary intervals during the 1977 field season and monthly intervals during the 1978 field season.

A relative index of prior gopher activity during winter snow cover was obtained in June of 1978 by quantifying abundance of winter soil casts. On each of eight belt transects, total centimeters of intercepted soil casts along each of three parallel lines were recorded. Placement of lines coincided with each side and the centerline of belt transects. The total number of centimeters intercepted per belt transect was compared with previous mound counts taken in late summer of 1977 and mound counts taken in June, 1978.

Dead-trapping and Necropsy

Macabee traps were used to collect pocket gophers from belt transects and other sites with similar vegetation and soils in Pelican Valley. Three hundred-one pocket gophers were collected during the 1977 and 1978 field seasons. Information on rates of mound building, natality, sex ratios, age classes, body weights, and the presence of parasites was obtained.

All pocket gophers within two belt transects (FEID/DECA 1 and ARCA/FEID 1) were trapped out during September, 1978 to obtain individuals live-trapped, marked, and released during the previous year's field season. Numbers of individuals collected on these two belt transects, along with mound counts taken immediately prior to trapping allowed for computation of the mean number of mounds built per pocket gopher per 48 hour time interval.

Pocket gophers on a semi-isolated north facing hillside (FEID/DECA h.t.) comprising an area of approximately 0.5 ha were trapped during the 1978 field season. Approximately 90 percent of all individuals on this site were collected to obtain information on the population characteristics of a discrete pocket gopher population.

Field weights were obtained for 231 pocket gophers collected during the 1978 field season through the use of a dial spring scale accurate to $\pm$ two grams. Specimens were placed in Whirl Pak plastic

bags upon collection in the field and frozen the same day. No specimens remained in traps longer than 24 hours.

In the laboratory, specimens were subsequently thawed and weighed to the nearest 0.1 gram. Comparison of laboratory weights with field weights revealed an average weight loss of approximately five grams due to desiccation. Compensation for weight loss due to desiccation was made in order to obtain approximate field weights of pocket gophers collected during the 1977 field season.

Pocket gopher natality was measured by counting placental scars and embryos of uteri excised from adult females. Rolan and Gier (1967) determined that placental scar counts, if interpreted judiciously, correlated well with embryo counts in *Peromyscus maniculatus* and *Microtus ochrogaster*. Preparation of excised uteri followed Orsini (1962).

Adult pocket gophers were discriminated from young in the field during the months of June and July on the basis of size and pelage. Accurate separation of adult males from young in the fall was not possible. However, the presence of a pubic gap and the size of the uterus in females allowed for accurate separation of adults from young in the fall (Hisaw, 1924; Hansen, 1960). Adult females were separated into year classes on the basis of numbers of placental scars after a mean litter size for the population was determined.

During necropsy, pocket gopher liver tissue was excised,

pressed between two glass microscope slides, and examined under magnification for determination of presence or absence of *Capillaria hepatica*, a parasitic nematode. Cunningham (1966) suggested that heavy liver infection from this parasite may affect the fat-storing ability of pocket gophers.

Live-trapping

Pocket gophers were live-trapped, marked, and released on FEID/DECA Belt Transect No. 1 and ARCA/FEID Belt Transect No. 1 during August of 1977. A modification of the pocket gopher live-trap described by Baker and Williams (1972) was used. Live-trapping enabled specific data to be gathered on population turnover and the computation of a ratio of mounds built per gopher per 48 hours for 1977 on both belt transects. Additionally, live-trapping provided known age individuals as standards for age determination and average litter size in females.

Burrow systems were located by probing the soil with an Oakfield Apparatus near fresh pocket gopher mounds. Live-traps were set around the periphery of burrow systems in order to obtain home range size. Capture sites were marked and subsequently mapped to accurately measure home range size. Individual pocket gophers were generally captured more than once; the maximum number of recaptures was that of an adult female captured 10 times. Home range sizes were

determined for individuals captured three or more times.

To minimize possible trap-related mortality, traps were checked on an hourly basis and live-trapping was conducted only during daylight hours. Despite such efforts, a few individuals showed obvious signs of physiological stress upon release. These individuals were considered trap-related mortalities if no subsequent recaptures were accomplished.

Soils

During the 1977 field season, collection of soil samples was restricted to the month of July. Soil samples were used to determine the soil texture on belt transects. Soil samples were taken at two depths at 20 m intervals along belt transects. Samples from zero to 10 cm, and 10 to 30 cm in depth were collected using an Oakfield Apparatus. Soil texture was determined through a modification of a method described by Bouyoucos (1928).

During the 1978 field season, soil samples were obtained at monthly intervals on nine belt transects at the 25 m and 75 m transect marks. Collection methods followed those of 1977 except that field and oven dry weights were obtained on all samples, and a relative index of water saturation was obtained.

Pocket gopher tolerance to percent water saturation of soil was estimated during the 1978 field season. Three line transects were

established between FEID/DECA Belt Transect No. 1 and ARCA/FEID Belt Transect No. 1 which are separated by a low DECA/*Carex* spp. h.t. swale. Monthly soil samples were taken at five meter intervals along these three line transects at depths of zero to 10 cm; and 10 to 30 cm. Comparison of oven dried soil weights and field weights allowed for computation of approximate percent saturation of water for each sampling period. Presence or absence of pocket gopher mounds within five meters of either side of each line transect was recorded simultaneously with collection of monthly soil samples.

Snow Melt Phenology

Aerial photography missions were flown in a Piper Super Cub aircraft on 28 April, 1977 and 1 June, 1978. On both dates, late melt snow patterns were photographed by using a 35 mm camera.

RESULTS

Indices of Pocket Gopher Numbers

Relative numbers of pocket gophers as indexed through mound counts (Reid et al., 1966) on belt transects during 1977 and 1978 are shown in Figures 2 through 7. On all belt transects, mound-building activity was lowest in the spring and increased throughout the summer months. Highest mound counts were generally obtained during August. A decline in mound-building activity, following a peak in late July occurred on FEID/DECA 1 (Figure 2), FEID/DECA 3 (Figure 4), ARCA/FEID 1 (Figure 6), and ARCA/FEID 3 (Figure 7).

Final mound counts on each belt transect in 1977 were compared with mound counts obtained at approximately the same time in 1978 (Table 2). Differences between final mound counts in 1977 and closest-date mound counts in 1978 are not significant ($P > .05$, paired t-test). Mound-building activity appeared to be greater in 1978 than in 1977 on belt transects FEID/DECA 1, FEID/DECA 3, and ARCA/FEID 3. Limited mound counts during the 1977 field season on ARCA/FEID 2 restricts strict comparison between the two years, however casual observations during August of 1977 indicated that mound-building activity was well below 1978 levels.

The ratios of mounds built per pocket gopher per 48 hours on

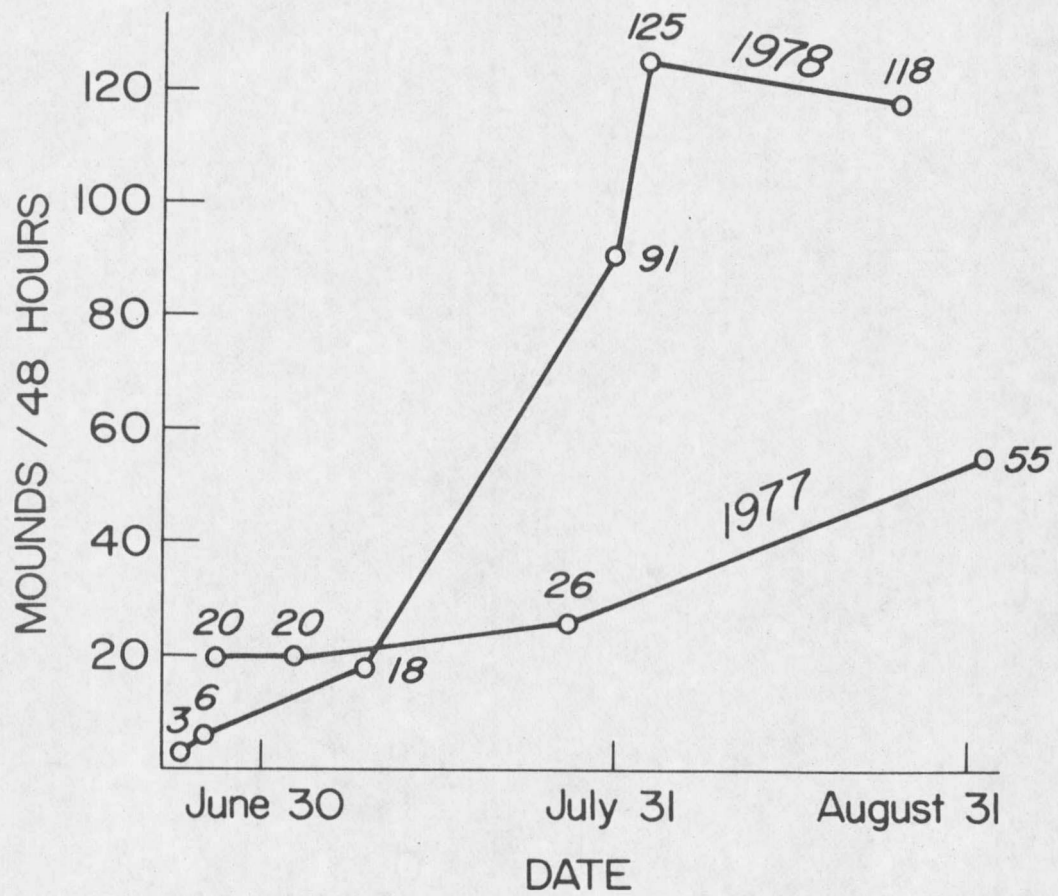


Figure 2. Mounds built per 48 hours versus date for 1977 and 1978 on belt transect FEID/DECA 1.

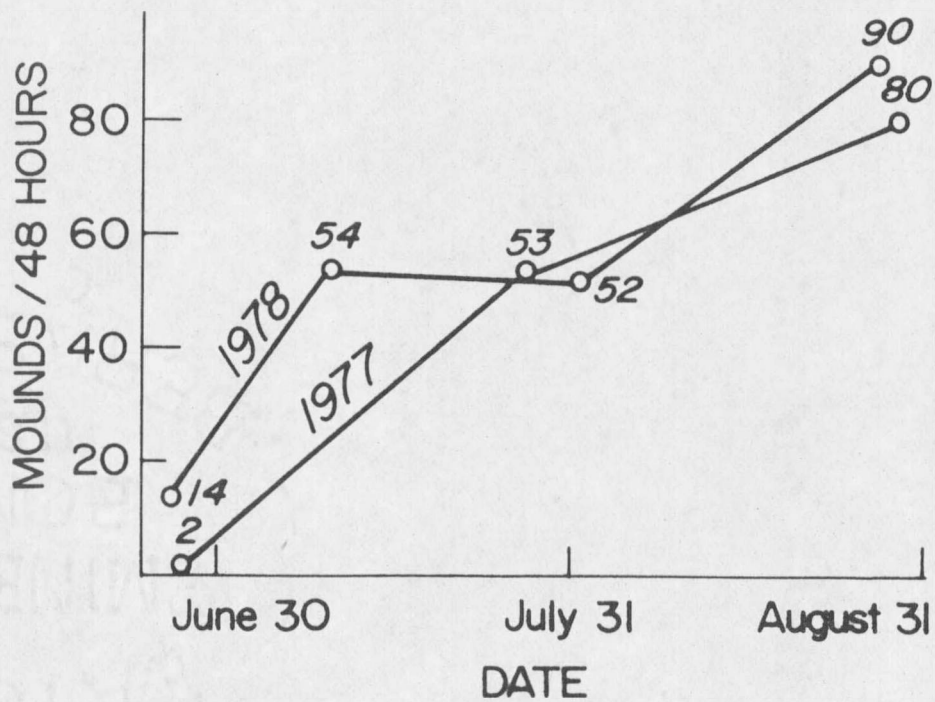


Figure 3. Mounds built per 48 hours versus date for 1977 and 1978 on belt transect FEID/DECA 2.

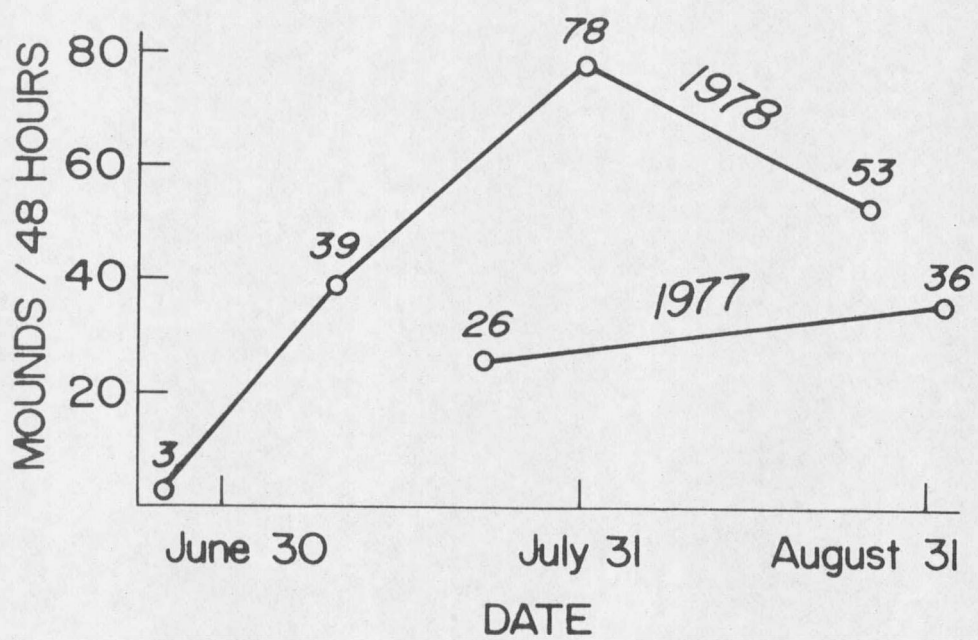


Figure 4. Mounds built per 48 hours versus date for 1977 and 1978 on belt transect FEID/DECA 3.

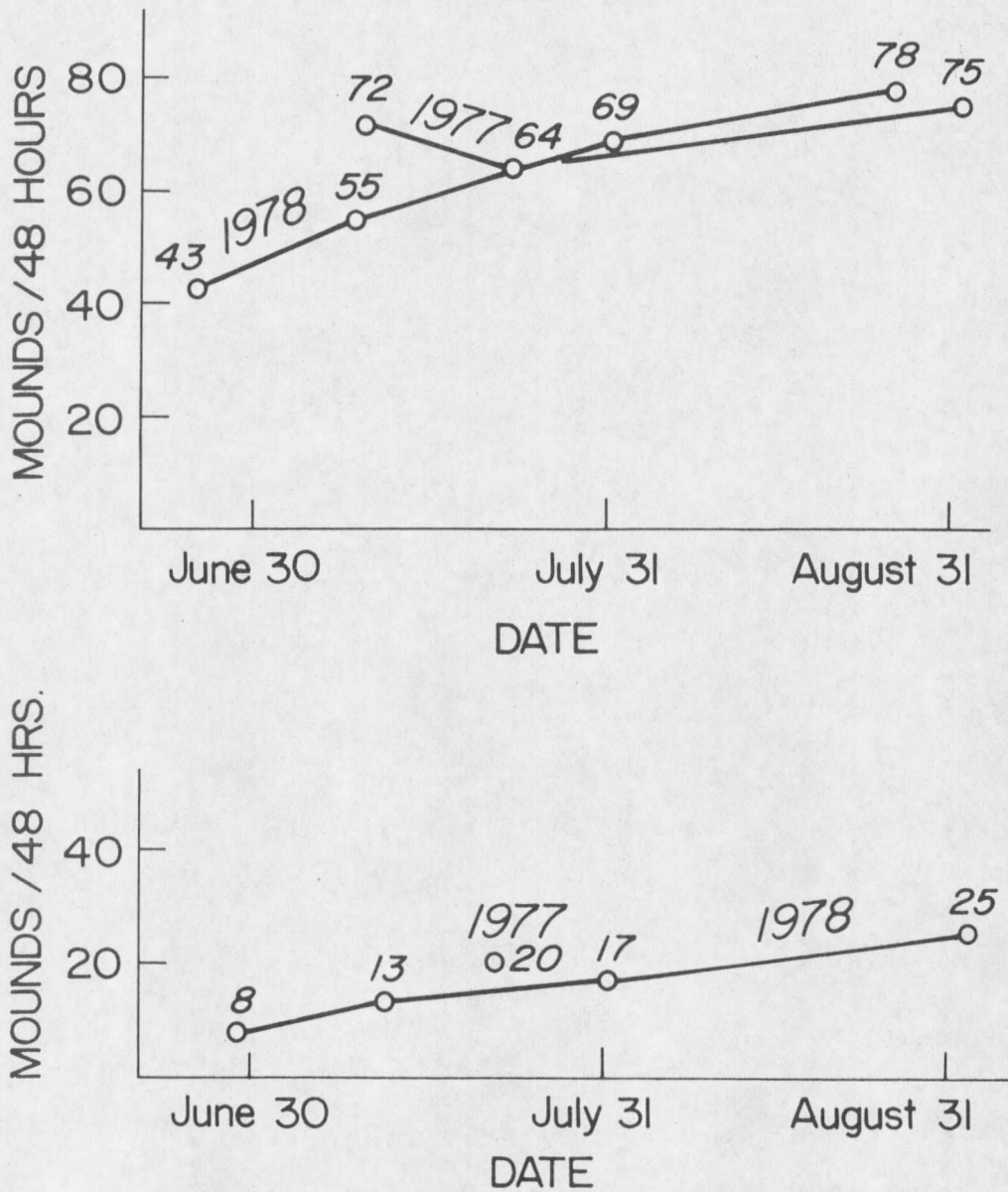


Figure 5. Mounds built per 48 hours versus date for 1977 and 1978 on belt transect FEID/DECA 4 (upper figure) and FEID/DECA 5 (lower figure).

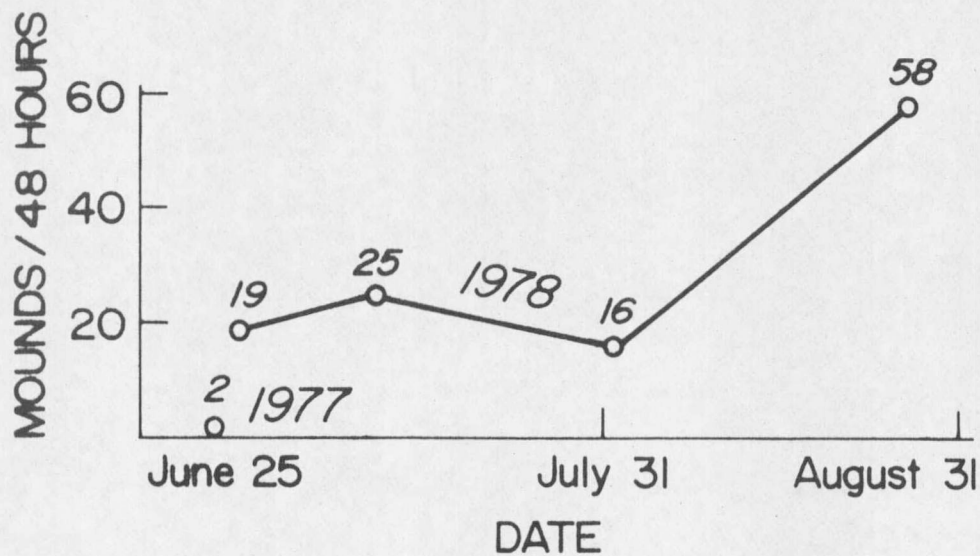
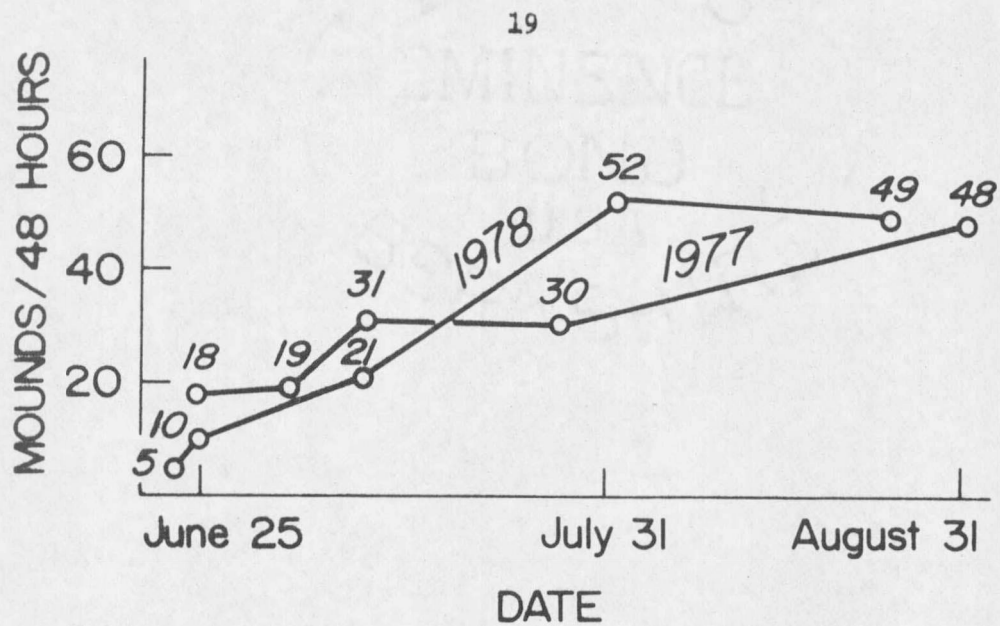


Figure 6. Mounds built per 48 hours versus date for 1977 and 1978 on belt transect ARCA/FEID 1 (upper figure) and ARCA/FEID 2 (lower figure).

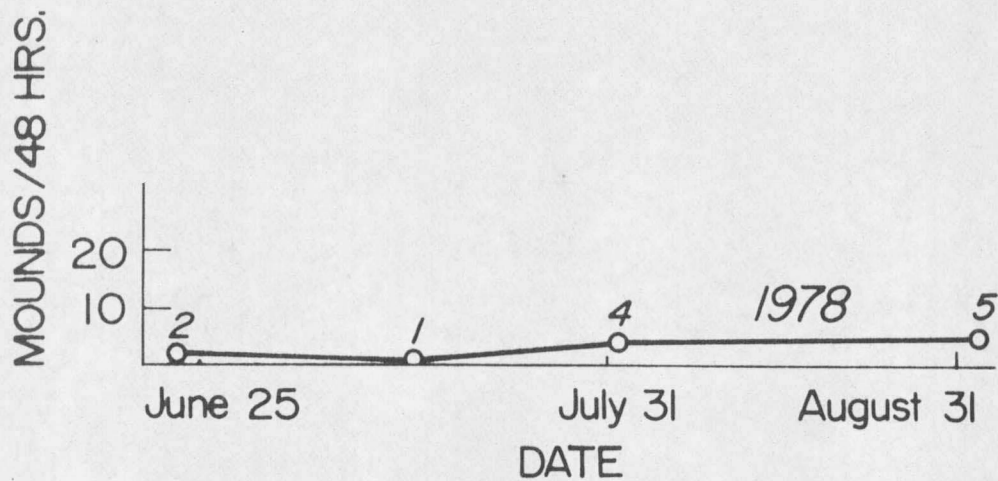
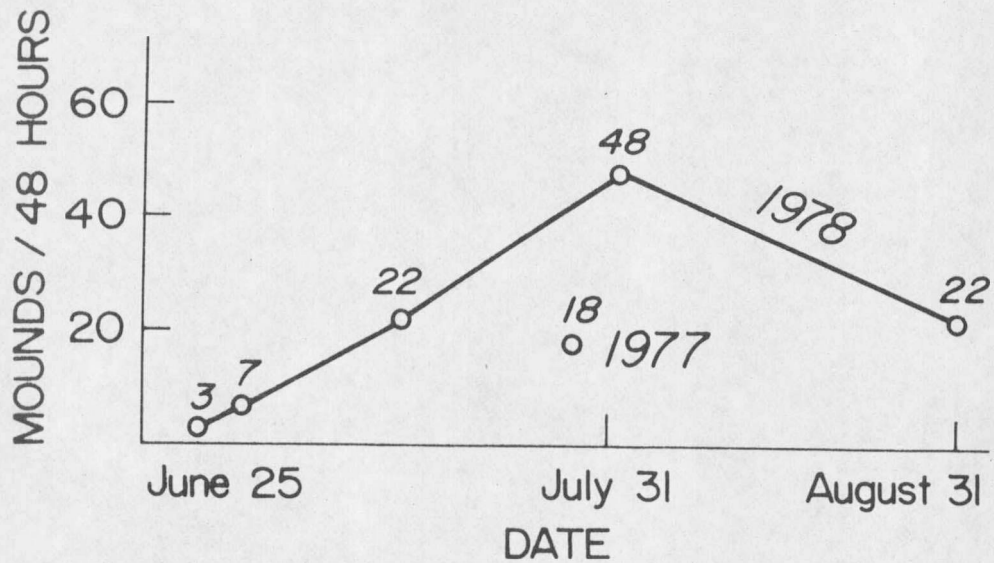


Figure 7. Mounds built per 48 hours versus date for 1977 and 1978 on belt transects ARCA/FEID 3 (upper figure) and DECA/*Carex* spp. 1 (lower figure).

Table 2. Comparison of final mound counts on belt transects in 1977 with closest-date mound counts in 1978.

Belt Transect	1977		1978	
	Mounds/48 hrs	Date	Mounds/48 hrs	Date
FEID/DECA 1	55	1 Sept	118	25 Aug
FEID/DECA 2	53	27 July	52	1 Aug
FEID/DECA 3	36	1 Sept	53	26 Aug
FEID/DECA 4	75	1 Sept	78	26 Aug
FEID/DECA 5	20	22 July	17	1 Aug
ARCA/FEID 1	48	1 Sept	49	25 Aug
ARCA/FEID 2	2	27 June	19	25 June
ARCA/FEID 3	18	28 July	48	1 Aug

FEID/DECA 1 and ARCA/FEID 1 during 1977 and 1978 are given in Table 3.

Differences between the four ratios are not significant ($.1 < P < .25$, X^2 test of independent sample proportions, Tate and Clelland, 1957).

Table 3. Comparison of mounds built/gopher/48 hours on FEID/DECA 1 and ARCA/FEID 1, 1977 and 1978.

Belt Transect	Year	Mounds/48 hrs	Gophers Trapped*	Mounds/ 48 hrs/ Gopher
FEID/DECA 1	1977	55	16	3.44
FEID/DECA 1	1978	118	25	4.72
ARCA/FEID 1	1977	48	11	4.36
ARCA/FEID 1	1978	49	15	3.26

*Pocket gophers on both belt transects were live-trapped in 1977, while in 1978 dead-traps were used.

Total centimeters of winter soil casts intercepted along line transects on each belt transect in June, 1978 correlate significantly ($r = 0.77$, $P < .05$ $n = 8$) with mound counts obtained during summer and fall of 1977 (Figure 8). No significant correlation exists ($r = 0.25$, $P > .05$) between centimeters of winter soil casts intercepted and mound counts taken in June of 1978.

Sex Ratios

Numbers and sex of adult and juvenile pocket gophers collected during both field seasons, along with resultant sex ratios, are presented in Table 4. Sex ratios do not depart significantly from 50 : 50 ($P > .05$, χ^2 test) within either the juvenile or adult reproductive age classes, although ratios appear to favor females within the juvenile age class.

Placental Scars

Placental scars were found to be persistent and quantifiable in all females examined. A total of 19 new and old placental scars were counted within the uterus of one adult female. Of all uteri cleared and examined ($n = 90$), none possessed more than seven placental scars attributable to a single parturition. Nine pregnant females were collected on the study area and none had more than six embryos developing in the uterus. Together, placental scar and embryo counts suggest that the litter size of pocket gophers in

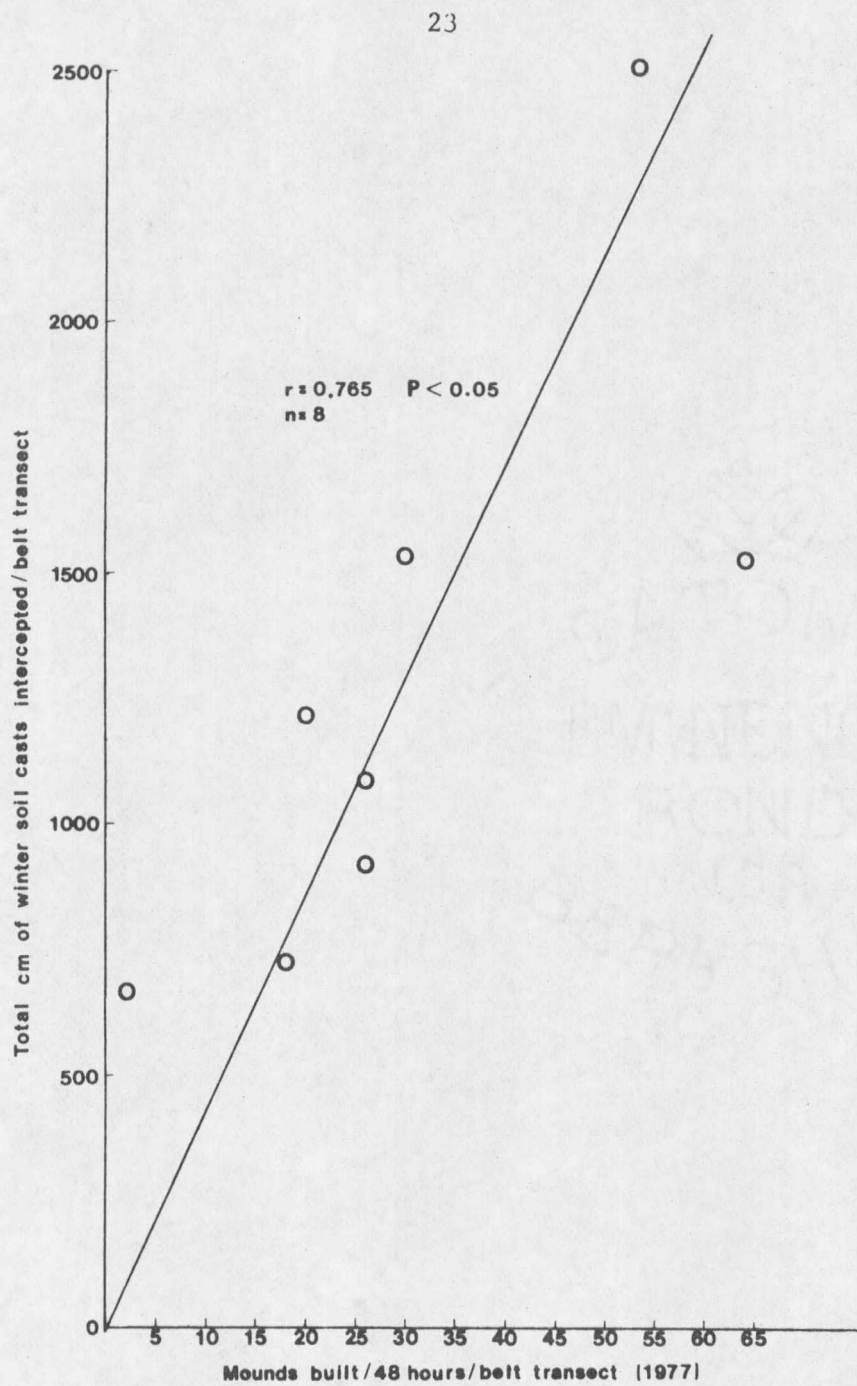


Figure 8. Total centimeters of soil casts intercepted in June, 1978 along line transects on each belt transect versus 1977 late-summer mound counts.

Table 4. Numbers and sex of adult and juvenile pocket gophers collected during 1977 and 1978.

Reproductive Class	Sex	Number Collected	Sex Ratios		
			Adults	Juveniles	Overall
Adult	F	95	52 : 48		
Adult	M	88			
					54 : 46
Juvenile	F	65		57 : 43	
Juvenile	M	50			
No data*	?	<u>3</u>			
		301			

*A weasel (*Mustela frenata*) consumed all but entrails of these kill-trapped individuals.

Pelican Valley does not exceed seven.

A mean litter size computed from females with seven or fewer placental scars was 4.88 ($n = 67$, $SD = 1.12$), while the mean number of embryos per pregnant female was 4.55 ($n = 9$, $SD = 1.23$).

Year classes of female pocket gophers as determined through placental scar and embryo counts are presented in Table 5. Females assigned to year class 2 ($n = 23$) had significantly larger ($P < .005$, paired t-test) litter sizes ($\bar{x} = 5.13$, $SD = .69$) their second (1978) reproductive effort than their first (1977, $\bar{x} = 4.43$, $SD = .87$).

Differences between the number of recent placental scars in 50 females from FEID/DECA h.t. areas ($\bar{x} = 4.72$, $SD = 1.11$) and the

Table 5. Year class of female pocket gophers as determined from placental scar and embryo counts

Year Class*	Number Collected	Percent Total
J#	65	41
1	67	42
2	23	14
3	5	3
	<u>160</u>	

*Females with ≤ 7 recent placental scars = year class 1; females with > 7 total placental scars but ≤ 14 total placental scars = year class 2; females with > 14 placental scars but ≤ 21 placental scars = year class 3.

#Juveniles.

number of recent scars in 42 females from ARCA/FEID c.t. areas

($\bar{x} = 5.21$, $SD = .87$) are significant ($P < .025$, $n = 92$, t-test).

Age Structure and Population Turnover

A total of 46 pocket gophers were collected from a north-facing FEID/DECA h.t. hillside of approximately .5 hectare. Placental scar counts of 17 adult females allowed for construction of a life table to estimate survivorship and mortality rates (Table 6). Life table information suggests that the population is stable ($R_0 = 1.01$), that the mortality rate (q_x) remains fairly constant to $x = 3$, and that there is a rapid turnover of adult pocket gophers. Additionally, the high mortality of juveniles ($q_x = .75$) suggests that production of young exceeds replacement requirements

Table 6. Life table for pocket gopher population collected on a north facing FEID/DECA h.t.

x	dx	lx	(lx)	Lx	(qx)	Ex	mx	l _x m _x	x _l xm _x	V _x
0	59	79	1.000	49.5	0.75	0.867	0.000	0.0000	0.000	1.000
1	13	20	0.253	13.5	0.65	0.950	2.706	0.6846	0.684	3.999
2	5	7	0.088	4.5	0.71	0.786	2.800	0.2480	0.496	3.737
3	2	2	0.025	1.0	1.00	0.500	<u>3.360</u>	<u>0.0840</u>	<u>0.252</u>	3.359
							8.866 (GRR)	1.0166 (Ro)	1.432 (T)	

x=Age group (initial age at start of age interval).
 dx=No. of individuals dying in age group x.
 lx=No. of individuals surviving at the beginning of each age interval.
 (lx)=Proportion of individuals surviving at the beginning of each age interval.
 Lx=Mean No. of individuals alive at each age interval.
 (qx)=Mortality rate.
 Ex=Mean average life expectancy of gophers attaining each age interval.
 mx=No. of female offspring per individual female in an age group at age x.
 GRR=Gross reproductive rate.
 Ro=Net reproductive rate.
 T=Mean generation length.
 Vx=Reproductive value.

and young are dispersing to other sites.

Age class composition of pocket gophers dead-trapped during 1978 (Table 7) indicates that juveniles predominated in late summer and fall populations.

Table 7. Percent composition by age class of pocket gophers dead-trapped in Pelican Valley during 1978:

Month	Total Trapped	% Juveniles	% Adults
June	69	7	93
July	89	39	61
August	9	78	22
September	64	80	20
October	13	69	31

Thirty-eight pocket gophers were captured, marked, and released on FEID/DECA 1 and ARCA/FEID 1 during 1977. Four of these individuals were considered trap-related mortalities (two from each belt transect) and thus were not included in determining percent turnover. On FEID/DECA 1, four of 19 pocket gophers marked and released during 1977 were recaptured in 1978 (79 percent turnover). All four of these individuals were juveniles in 1977. On ARCA/FEID 1, four of 15 pocket gophers marked and released in 1977 were captured in 1978 (73 percent turnover). Three of these individuals were

marked as juveniles in 1977 and one was identified as an adult male. The overall turnover for pocket gophers collected on both belt transects was 76.5 percent.

Estimate of Home Range Size

The greatest distance between capture points is given in Table 8 for pocket gophers trapped twice or more. Maximum capture distances of pocket gophers trapped on ARCA/FEID 1 ($\bar{x} = 7.3$ m, $n = 9$) do not differ significantly ($.05 < P < 0.1$, t-test) from those obtained from pocket gophers trapped on FEID/DECA 1 ($\bar{x} = 8.8$, $n = 13$).

Pocket gophers captured three or more times enabled the computation of a minimum home range area (Mohr, 1947). One adult male had a home range size of 51 m² which was the largest area found occupied by an individual pocket gopher. One female captured 10 times had a home range size of 37 m².

Weights

Adult male pocket gophers collected during 1978 ($n = 66$) had a mean field weight of 105.1 g (SD = 9.9) while females ($n = 70$) had a mean weight of 92.7 g (SD = 11.7). Differences between mean weights of males and females are significant ($P < .001$, t-test). Comparison of adult pocket gopher weights from FEID/DECA h.t. areas and ARCA/FEID c.t. areas show no significant differences ($P > .05$, t-test). Mean weights of juvenile pocket gophers collected during

Table 8. Index of home range size using linear distance between two most distant capture points.

Reproductive Class	Sex	Vegetation Type	Distance (m)
A	F	ARCA/FEID	9.6
A	F	"	5.6
A	F	"	8.0
A	F	"	5.7
A	M	"	5.5
A	M	"	13.2
A	M	"	6.4
J	?	"	10.3
J	?	"	5.3
			$\bar{x}=7.3$ SD=2.77
A	F	FEID/DECA	11.5
A	F	"	8.8
A	F	"	15.0
A	F	"	8.1
A	F	"	5.5
A	M	"	13.0
A	M	"	11.9
A	M	"	12.5
A	M	"	9.0
A	M	"	3.3
J	F	"	4.4
J	?	"	7.1
J	?	"	4.3
			$\bar{x}=8.8$ SD=3.77

1978 versus time are given in Figure 9. Mean weights of juveniles appeared to increase most rapidly during late August and early September.

Parasites

Capillaria hepatica was present in 96 percent of all adults examined (n = 172) and 28 percent of all juveniles (n = 113). Individuals infected with *C. hepatica* occurred with equal frequency on FEID/DECA h.t. areas and ARCA/FEID c.t. areas. Additional parasites recovered incidentally during necropsy of specimens included a tapeworm of the genus *Paranoplocephala* recovered from one individual and heavy infections of a stomach nematode of the genus *Physoloptera* from three individuals.

Pocket Gopher Cache

Composition of a pocket gopher cache found in June, 1978 on the surface of the ground near ARCA/FEID 1 indicates that corms, tubers, and roots of several plant species may be of importance to pocket gophers as winter food items (Table 9). Corms of *Claytonia lanceolata* and roots of *Polygonum bistortoides* composed greater than 50 percent of the cache by weight. The relative abundance and possible correlations of these two species with gopher numbers on belt transects were not obtained because both species were ephemeral and thus were unrecognizable in August when vegetation was analyzed.

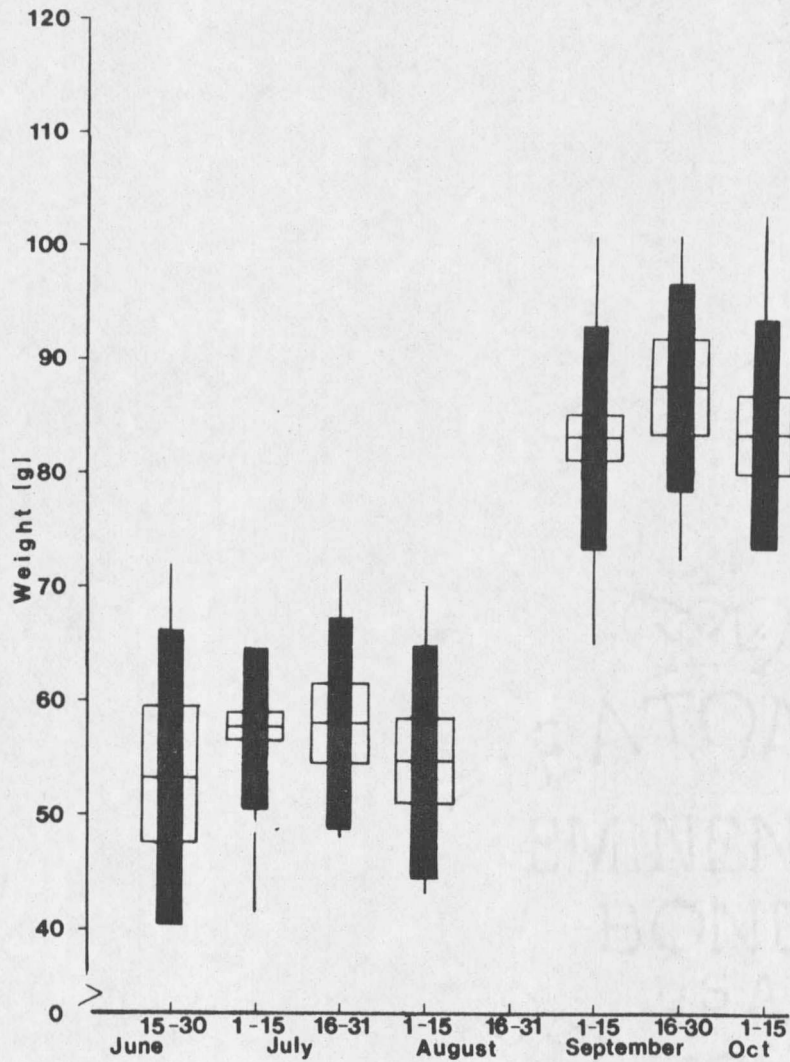


Figure 9. Mean weights of juvenile pocket gophers collected during 1978 versus month. Range (thin black line), standard deviation (black bar) and ± 1 standard error (open box) are also presented.

Table 9. Composition of a pocket gopher cache collected in Pelican Valley on the surface of the ground in June, 1978, following snow melt.

Taxa	Weight (g)	Percent Total Weight
<i>Claytonia lanceolata</i>	4.8	35.0
<i>Perideridia gairdneri</i>	1.3	9.6
<i>Melica spectabilis</i>	4.5	32.8
<i>Polygonum bistortoides</i>	2.4	17.6
<i>Artemisia cana</i>	0.7	5.0

Vegetation

Data on canopy coverage and frequency of occurrence of plant species on belt transects during August, 1978 are presented in Appendix Table 10. Comparison of 1977 canopy coverage data with 1978 canopy coverage data indicate significant differences ($P < .05$, t-test) between years among the mean canopy coverages of some plant species (Table 11). Changes in mean canopy coverage of any one particular plant species did not appear to influence pocket gopher numbers in a consistent manner. However, on those belt transects where mound-building activity increased in 1978 over 1977 (FEID/DECA 1, FEID/DECA 3, ARCA/FEID 2, and ARCA/FEID 3), overall increases in mean canopy coverage were recorded. On belt transect FEID/DECA 1,

Table 11. Plant species occurring on belt transects for which significant differences ($P < .05$, t-test) in mean canopy coverage were obtained between 1977 and 1978.

Belt Transect	Taxa	1977		1978	
		$\bar{x}$	SD	$\bar{x}$	SD
ARCA/FEID 1	<i>Agropyron caninum</i>	.6	1.2	1.4	3.1
	<i>Aster</i> spp.	2.9	5.3	9.3	12.4
	<i>Collomia linearis</i>	.6	1.1	3.6	4.4
	<i>Perideridia gairdneri</i>	1.1	1.3	3.8	19.6
ARCA/FEID 2*	<i>Agoseris glauca</i>	1.5	4.3	5.4	6.2
	<i>Deschampsia caespitosa</i>	9.0	9.8	21.0	23.9
	<i>Polygonum douglasii</i>	3.9	4.9	.7	1.1
ARCA/FEID 3*	<i>Danthonia intermedia</i>	.6	1.1	.0	.0
	<i>Galium boreale</i>	.6	1.6	5.8	7.1
	<i>Thalictrum occidentale</i>	1.8	3.4	6.5	7.1
	<i>Perideridia gairdneri</i>	.0	.0	.6	1.1
FEID/DECA 1*	<i>Collomia linearis</i>	1.9	1.1	5.8	8.1
	<i>Polygonum douglasii</i>	1.6	3.4	.0	.0
	<i>Stipa occidentalis</i>	.9	3.4	6.8	11.2
FEID/DECA 2	<i>Polygonum douglasii</i>	3.3	4.1	1.4	1.3
FEID/DECA 3*	<i>Agoseris glauca</i>	2.5	3.1	1.0	1.3
	<i>Perideridia gairdneri</i>	.4	.9	1.2	1.3
	<i>Ranunculus alismaefolius</i>	.0	.0	.5	1.0
FEID/DECA 4					
FEID/DECA 5	<i>Agoseris glauca</i>	1.6	1.2	.6	1.1
	<i>Potentilla gracilis</i>	2.5	2.9	6.0	6.4

*Belt transects where mounds built/48 hours increased in 1978 over 1977.

where mounds built/48 hours increased markedly in 1978 over 1977, a corresponding significant increase ($P < .05$, t-test) in the mean canopy coverage of *Collomia linearis* occurred (1.9 to 5.8). In Colorado, Ward and Keith (1962) found that *C. linearis* composed as much as 15 percent by volume and 44 percent by occurrence of plant species in *T. talpoides* stomachs.

Ordination and cluster analysis of canopy coverage data from belt transects are presented in Figure 10 and Table 12, respectively. Belt transect ARCA/FEID 1 appears to be least similar of all belt transects, while belt transects FEID/DECA 1 through FEID/DECA 5 have a high (.92) level of similarity.

Table 12. Cluster analysis of 1978 canopy coverage vegetation data for all belt transects.

Level of Similarity	Stands Included*
.9571	F3,F4
.9423	F2,F3,F4
.9348	F1,F2,F3,F4
.9319	A3,D1
.9204	F1,F2,F3,F4,F5
.8683	A2,A3,D1
.8322	F1,F2,F3,F4,F5,A2,A3,D1
.7658	All one group

*F1 through F5 = FEID/DECA h.t. Belt Transects 1 to 5; A1 to A3 = ARCA/FEID h.t. Belt Transects 1 to 3; D1 = DECA/*Carex* spp. h.t. Belt Transect 1.

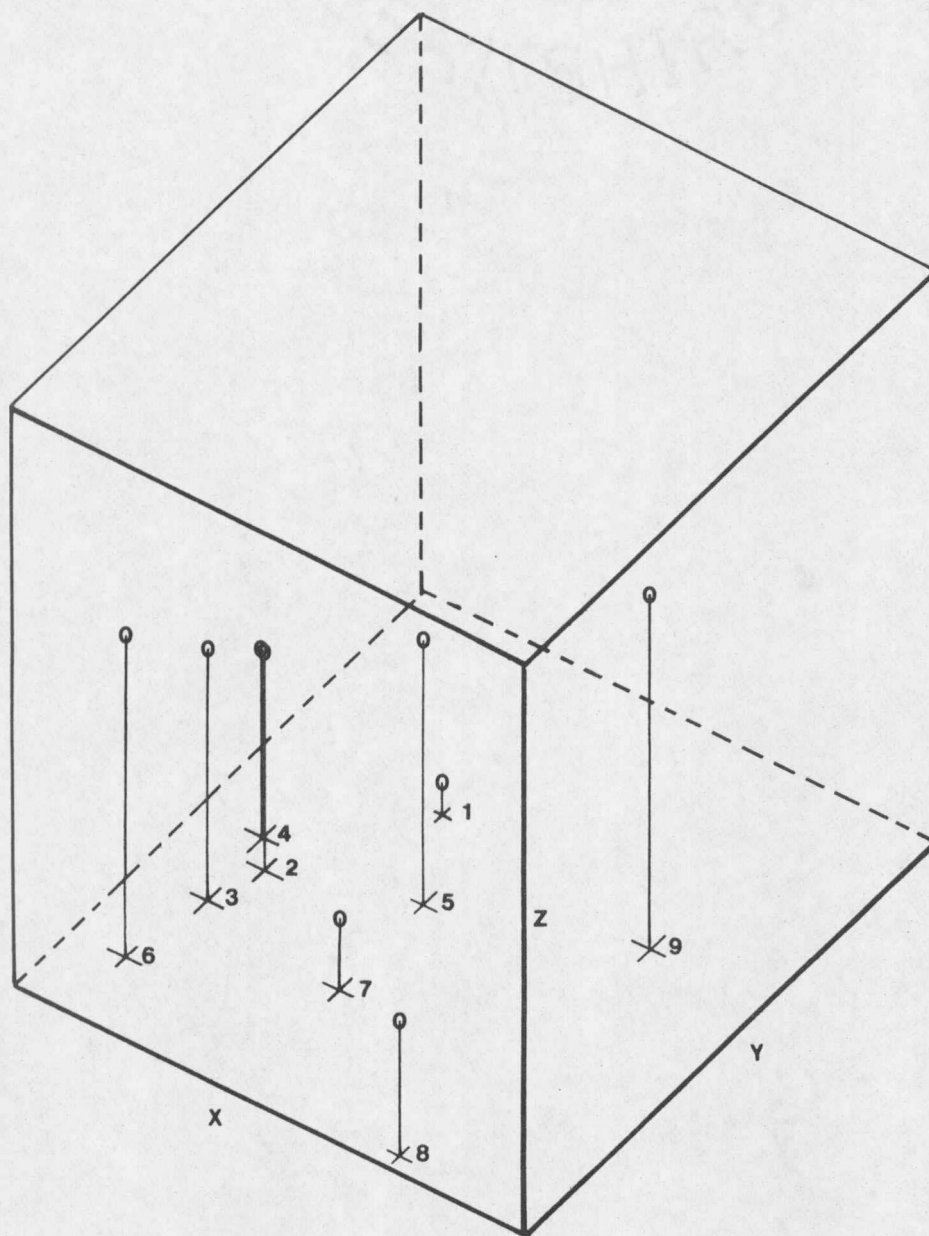


Figure 10. Three dimensional ordination of canopy coverage data from belt transects for August, 1978. Numbers 1 through 5 are FEID/DECA 1 through 5; numbers 6,7,8 are ARCA/FEID 1,2,3; number 9 is DECA/*Carex* spp. 1.

Combined line intercepts of yampa (*P. gairdneri*) and purple oniongrass (*M. spectabilis*) for both 1977 and 1978 correlate significantly ($r = .63$, $P < .01$) with mounds built/48 hours on belt transects (Figure 11).

Standing crop in kg/ha of individual plant species on belt transects in August, 1978 is presented in Appendix Table 13. A summary of total graminoid and forb standing crop is presented in Table 14. No significant correlation ($P > .05$) was obtained between either total graminoid standing crop or total forb standing crop, and fall mound counts.

Table 14. Standing crop (kg/ha) in August, 1978 of total graminoids and forbs on belt transects.

Belt Transect	Graminoids (kg/ha)	Forbs (kg/ha)
ARCA/FEID 1	209.7	581.7
ARCA/FEID 2	1183.9	466.1
ARCA/FEID 3	1017.8	728.4
		$\bar{x} = .592$
FEID/DECA 1	1248.2	394.6
FEID/DECA 2	1380.0	478.1
FEID/DECA 3	1692.2	408.2
FEID/DECA 4	1218.2	456.6
FEID/DECA 5	661.5	612.7
		$\bar{x} = 470$
DECA/ <i>Carex</i> spp.1	1263.6	702.1

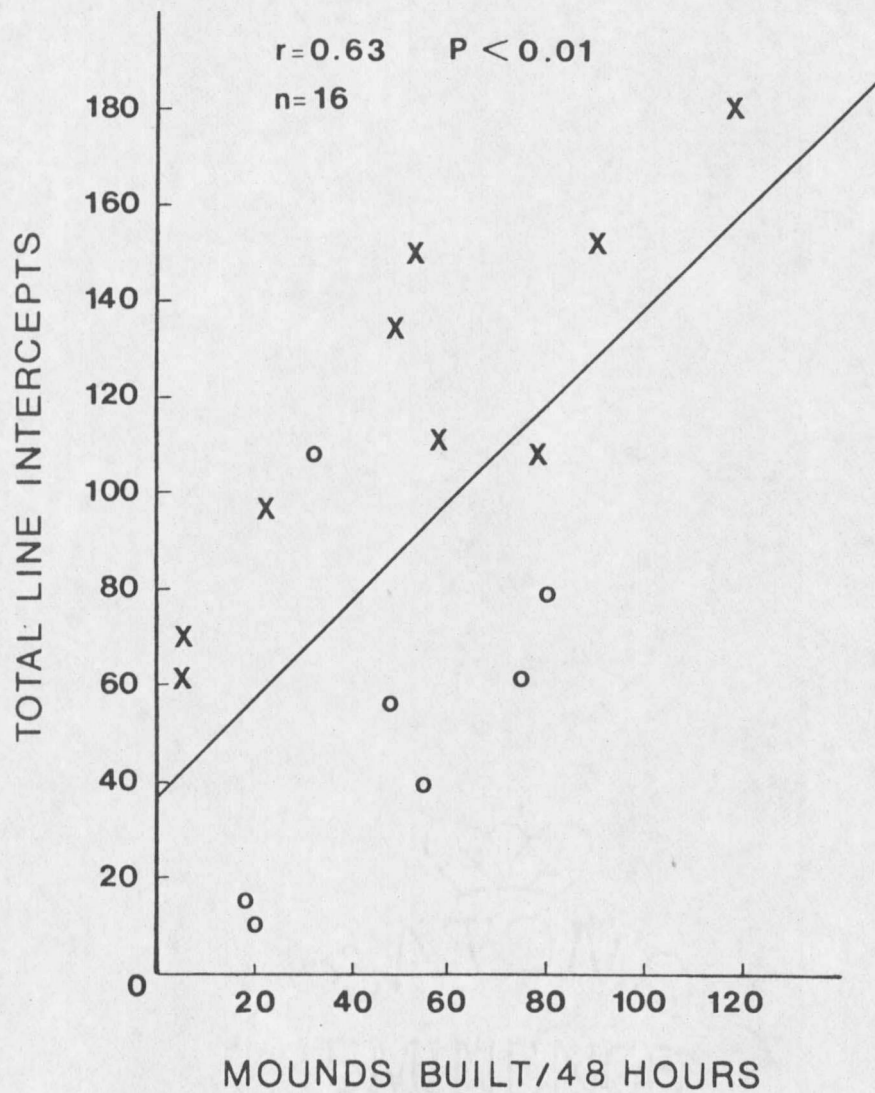


Figure 11. Correlation of combined line intercepts of *P. gairdneri* and *M. spectabilis* on each of 9 belt transects to late-summer mound counts on each belt transect for 1977 (o) and 1978 (X).

Correlation coefficients obtained between mean canopy coverage of individual plant species and fall mound counts are presented in Table 15 for 1977 and 1978. Correlation coefficients between standing crop in August, 1978 and fall mound counts are presented in Table 16. *Collomia linearis* abundance correlated significantly ($P < .01$) with fall mound counts for both years. Standing crop in kg/ha of *C. linearis* correlated very highly ($r = .94$) with mounds built/48 hours (Figure 12).

Soils

Soil textures on belt transects as determined through mechanical analysis are presented in Table 17. Belt transects ARCA/FEID 2 and ARCA/FEID 3 are 'sandy loams' while all other belt transects are 'loams' or 'silt loams'. Profile descriptions of soil horizons on FEID/DECA 1 and FEID/DECA 5 by Drs. Clifford Montagne and Lawrence Munn, Plant and Soil Science Department, Montana State University, suggest that the percent sand was overestimated in soils on FEID/DECA habitat types. Soil textures on belt transects appear well within the tolerance limits of pocket gophers as evidenced by mound-counts. In swales, where soil textures run heavily to clays, pocket gopher surface activity was typically absent.

Soil moisture on belt transects during July and September are expressed in percent dry weight (Table 18). Belt transect DECA/*Carex*

Table 15. Correlation coefficients obtained between mean canopy coverage of plant species and mounds built/48 hours on belt transects for 1977 (df = 5) and 1978 (df = 7).

Taxa	Correlation Coefficient	
	1977	1978
<u>Graminoid Species</u>		
<i>Agropyron caninum</i>	-.196	.572
<i>Bromus carinatus</i>	-.485	.271
<i>Calamagrostis montanensis</i>	---	-.641
<i>Carex</i> spp.	-.700	-.492
<i>Deschampsia caespitosa</i>	-.470	-.448
<i>Festuca idahoensis</i>	.020	.496
<i>Melica spectabilis</i>	.238	.837**
<i>Phleum alpinum</i>	---	.011
<i>Poa</i> spp.	.409	.205
<i>Stipa occidentalis</i>	.130	.797*
<u>Forb Species</u>		
<i>Achillea millefolium</i>	-.790*	-.188
<i>Agoseris glauca</i>	-.184	.044
<i>Androsace septentrionalis</i>	.576	.496
<i>Antennaria microphylla</i>	-.528	-.188
<i>Aster</i> spp.	-.600	-.577
<i>Cerastium arvense</i>	---	-.008
<i>Collomia linearis</i>	.900**	.836**

Table 15 (Continued)

Taxa	Correlation Coefficient	
	1977	1978
<i>Fragaria virginiana</i>	---	.142
<i>Gayophytum ramosissimum</i>	.500	.776*
<i>Perideridia gairdneri</i>	.465	-.061
<i>Polygonum douglasii</i>	.810*	.184
<i>Potentilla gracilis</i>	.530	-.794*
<i>Stellaria longipes</i>	---	.295
<i>Taraxacum</i> spp.	---	-.299
<i>Trifolium longipes</i>	-.763*	-.497
<i>Viola</i> spp.	.543	.488

*P < .05

**P < .01

Table 16. Correlation coefficients obtained between standing crop (kg/ha) on belt transects in August, 1978 and mounds built/48 hours in late summer, 1978 (df=7).

Taxa	Correlation Coefficient
<u>Graminoid species</u>	
<i>Agropyron caninum</i>	.187
<i>Agrostis scabra</i>	.293
<i>Bromus carinatus</i>	.221
<i>Calamagrostis montanensis</i>	-.624
<i>Carex</i> spp.	-.197
<i>Danthonia intermedia</i>	-.118
<i>Deschampsia caespitosa</i>	-.266
<i>Festuca idahoensis</i>	.734*
<i>Melica spectabilis</i>	.693*
<i>Phleum alpinum</i>	.406
<i>Poa</i> spp.	.451
<i>Stipa occidentalis</i>	.476
<u>Forb species</u>	
<i>Achillea millefolium</i>	-.223
<i>Agoseris glauca</i>	.266
<i>Antennaria microphylla</i>	-.323
<i>Aster</i> spp.	-.583
<i>Collomia linearis</i>	.939**

Table 16 (Continued)

Taxa	Correlation Coefficient
<i>Perideridia gairdneri</i>	-.160
other forb	-.664

*P < 0.05

**P < 0.01

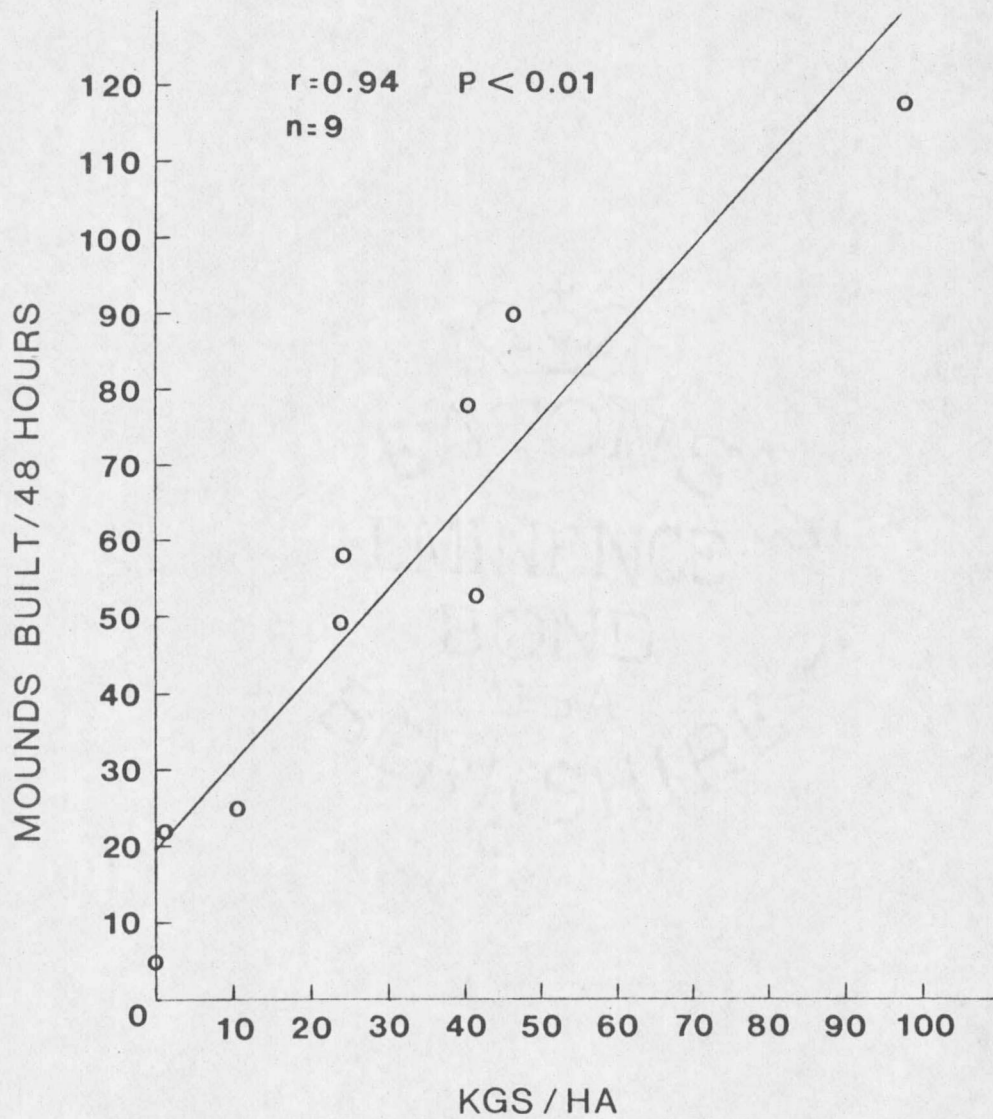


Figure 12. Correlation of *C. linearis* standing crop (kg/ha) and mounds built/48 hours on nine belt transects during August, 1978.

Table 17. Soil textures on belt transects as determined through mechanical analysis.

Belt Transect	Depth (cm)	Percent		
		Sand	Clay	Silt
ARCA/FEID 1	0-10	38	22	40
	10-30	50	18	32
ARCA/FEID 2	0-10	62	08	30
	10-30	56	12	32
ARCA/FEID 3	0-10	64	06	30
	10-30	62	08	30
FEID/DECA 1	0-10	52	16	32
	10-30	52	16	32
FEID/DECA 2	0-10	42	10	48
	10-30	28	20	52
FEID/DECA 3	0-10	32	18	50
	10-30	28	18	54
FEID/DECA 4	0-10	40	12	48
	10-30	34	20	46
FEID/DECA 5	0-10	44	20	36
	10-30	38	22	40
DECA/ <i>Carex</i> spp. 1	0-10	52	10	38
	10-30	42	18	40

Table 18. Mean soil moisture on belt transects during July and September of 1978, in percent dry weight.

Belt Transect	0-10 cm		10-30 cm	
	19 July	2 Sept	19 July	2 Sept
ARCA/FEID 1	8.6	14.6	12.4	17.0
ARCA/FEID 2	10.7	14.0	6.6	12.3
ARCA/FEID 3	19.3	18.7	23.4	17.5
FEID/DECA 1	15.2	19.0	22.0	24.5
FEID/DECA 2	11.7	23.9	17.3	20.3
FEID/DECA 3	13.3	21.9	17.5	23.0
FEID/DECA 4	11.4	18.6	16.3	17.0
FEID/DECA 5	15.5	19.2	8.6	20.0
DECA/ <i>Carex</i> spp.1	47.5	39.0	35.9	28.3

spp. 1 had the highest soil moisture values. Monthly soil moisture measurements taken along three line transects at depths of zero to 10 cm, and 10 to 30 cm are plotted in Figure 13 and Figure 14, respectively. Soil moisture was highest following snow melt in June and lowest in August prior to fall precipitation. July soil moisture levels in the swale separating belt transects ARCA/FEID 1 and FEID/DECA 1 were of higher values than those values obtained concurrently on belt transects where pocket gopher surface activity was present. Pocket gopher activity in swales appeared to be restricted to August and

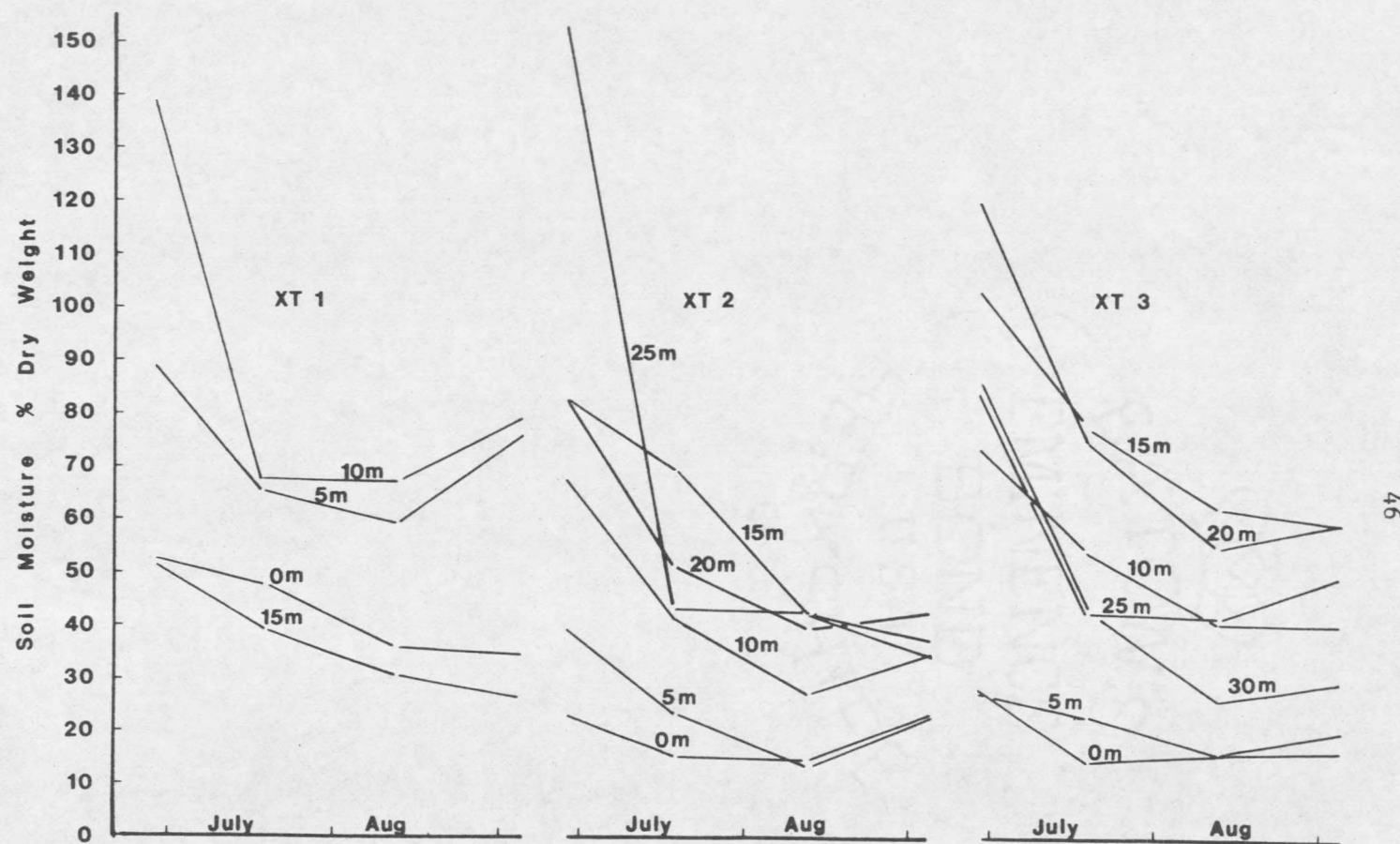


Figure 13. Monthly changes in soil moisture (% dry weight) at 0-10 cm depth versus time, of a swale area. Measurements made at each 5 m interval are given for each of 3 line transects (XT 1-3).

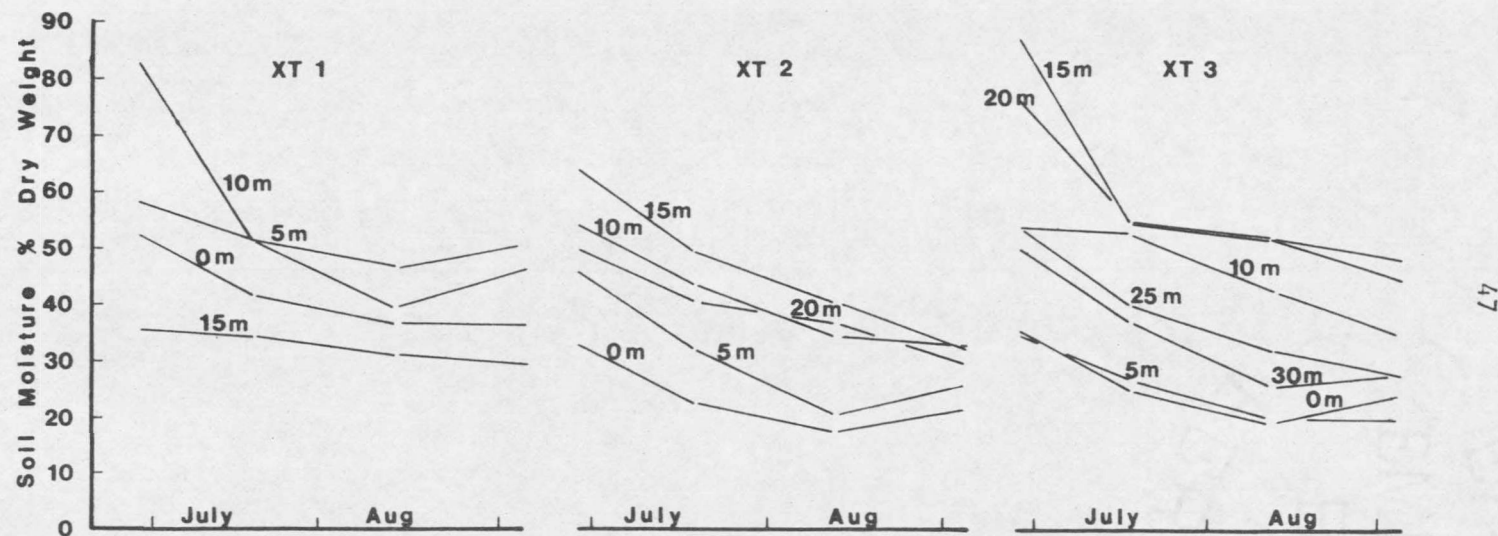


Figure 14. Monthly changes in soil moisture (% dry weight) at 10-30 cm depth versus time, of a swale area. Measurements made at each 5 m interval are given for each of 3 line transects (XT 1-3).

coincided with lowest soil moisture values. No adult pocket gophers were captured in swales. One juvenile pocket gopher was captured in the swale separating ARCA/FEID 1 and FEID/DECA 1 in August, 1977 at the 10 m point of line transect No. 2. Data on pocket gopher activity in the swale area between the two belt transects during 1978 indicate that surface activity of pocket gophers was restricted to the periphery of the swale. Soil textures that run heavily to clays in conjunction with high soil moisture levels likely prevent utilization of swales by pocket gophers. During August when dispersal of juveniles is at a peak, swales may serve as 'overflow' habitat.

DISCUSSION

Reliability of Counting Surface Sign to Index Pocket Gopher Numbers

Mounds and Plugs

Several authors have noted that surface activity of pocket gophers varies seasonally (Scheffer, 1931; Crouch, 1933; Miller, 1948; Laycock, 1957; Miller and Bond, 1960). Mound-building activity for *T. talpoides* is generally lowest during spring with increases in surface activity occurring progressively with time until a peak in late summer or early fall (Miller and Bond, 1960; Laycock, 1957). However, a period of surface inactivity occurring from mid-August until after the first week in September was observed by Laycock (1957) on the main floor of Jackson Hole, Wyoming (elevation 2057 m). Mound-building activity in Pelican Valley was lowest in spring with little surface activity occurring from snow melt in June until approximately the first week in July. Surface activity increased sharply after the first week in July and peaked in late summer. On some sites a decline in mound building followed a peak in late July/early August with overall surface activity decreasing and remaining intermediate until September, when mound counts were discontinued.

Richens (1965), in Utah, found a low correlation ($r = 0.14$) between 72-hour mound counts in early August and the gopher population

index (determined through dead-trapping) for his study area. Reid et al. (1966) pointed out that the sign-count inventory method gives the most accurate population estimate in the fall after young-of-the-year have dispersed, and in areas where the population density is high enough so that at least some animals must build new burrow systems upon dispersal. Results in Pelican Valley strongly suggest that mound counts taken prior to late July are of limited value as an index to numbers of pocket gophers.

Richens (1966) observed that the number of mounds built by an adult male pocket gopher (*T. talpoides*) during any one day varied from zero to 14 and that digging activity was characterized as periodic and irregular. Comparison of the mean number of mounds built per pocket gopher per 48 hour time interval for belt transects FEID/DECA 1 and ARCA/FEID 1 (Table 3) during 1977 and 1978 suggests that while there was doubtless a wide variation in individual rates of mound-building on any given day, the mean number of mounds built per pocket gopher per 48 hours did not differ significantly either between the two belt transects or between the two years.

Soil Casts

Richens (1965) obtained a positive correlation ($r = 0.80$) between the gophers dead-trapped on his study area and the number of casts per acre. Reid (1973) recommended that caution should be used in

interpreting abundance of soil casts as a direct measure of abundance of pocket gophers and cites several variables influencing construction of soil casts: the number of pocket gophers inhabiting the range at the beginning of winter; number of days of continuous snow cover, and depth and water content of the snow pack; and the condition of the surface soil (frozen or not frozen and for how long). Results from Pelican Valley suggest abundance of soil casts in June were not indicative of current spring population levels but could be used to estimate pocket gopher densities that occurred during the previous late summer/fall.

Population Characteristics

Sex Ratios and Period of Peak Parturition

Hansen (1960) suggested that the sex ratio of adult pocket gophers, as revealed by trapping, can be influenced by their seasonal activity cycle. Evidence of progressively decreasing susceptibility to trapping of females during pregnancy is presented by Miller (1946). He examined 145 pregnant females (*Thomomys bottae*) trapped near Davis, California. The numbers of females with small, medium, and large embryos found were 81, 43, and 21 respectively. Such an inequality in trap success for females in late pregnancy may be explainable if females become increasingly wary or secluded as pregnancy progresses toward term (Miller, 1946). Tryon (1947) in Montana and Hansen (1960) in

Colorado found that in *T. talpoides* the sex ratio did not differ significantly from 50 : 50 except during the breeding season in spring. Hansen (1960) obtained a sex ratio of 41 females to 59 males in April and May, coinciding with the period of pregnancy, parturition, and early postnatal care of young. In Pelican Valley, trapping was not initiated until 15 June, and sex ratios of adults collected at that time were not skewed toward males. This suggests that the peak of the breeding season was prior to 15 June. Pregnant females were trapped during June and early July; however these individuals were few in number (nine) and they likely represent only the last breeders.

Andersen (1978) estimated gestation in *T. talpoides* to be 18 days based on observed copulation and parturition in a single female. Growth rates of laboratory reared *T. talpoides* (Andersen, 1978) suggest weights of up to 50 grams may be attainable between 20 and 30 days post-partum. In Pelican Valley, juvenile pocket gophers were trapped with increasing frequency during the last week in June and the first week in July and weighed between 40 and 50 grams. Using information provided by Andersen (1978), the period of peak parturition in Pelican Valley is calculated to be from the middle of April to the middle of May.

Fertility

Litter size in *T. talpoides* varies with respect to locality and

perhaps, seasonally (Hansen, 1960). Tryon (1947) determined 4.4 to be the mean litter size in the Bridger Mountains, Montana based on embryo and placental scar counts. Wirtz (1954), found 4.8 to be the mean litter size in females from near Livermore, Colorado. Hansen and Ward (1966) gathered data on mean litter sizes from 1956 to 1962 from females collected from Grand Mesa, Colorado and found mean litter size to vary from a low of 3.7 in 1961 to a high of 4.6 in 1957 on their control area. Hansen (1960) found mean litter size to be 6.4 near Livermore, Colorado but only 4.4 near Grand Mesa, Colorado the same year. Miller (1946) found that mean litter size in *T. bottae* increased with weight (age) of females to an optimum after which a decline in fertility occurred. In Pelican Valley, mean litter size computed on the basis of placental scar and embryo counts was 4.9. Females were found to have significantly ($P < .005$) larger litters their second reproductive effort ($\bar{x} = 5.13$) than their first ($\bar{x} = 4.43$) based on placental scar counts. Additionally, females from ARCA/FEID c.t. areas were found to have significantly ($P < .025$) larger litters than females from FEID/DECA h.t. areas. This difference is not attributable to differences in age structures of females from the two vegetation types, as females from each year class are nearly equally represented from the two types.

Turnover

Hansen and Ward (1966) suggest that the measurable density of pocket gophers depends more upon the survival and growth of juveniles than on low mortality of adults. Evidence that maintenance or increases in gopher population levels are dependent upon recruitment and over-winter survival of young is presented by Tryon (1947), Hansen (1960, 1962), and Tietjen et al. (1967). Hansen (1960) in Colorado, determined that 75 percent of the population at Grand Mesa at the time of breeding consisted of individuals born the previous season. In Pelican Valley, an average turnover of 76.5 percent of all pocket gophers captured the previous year occurred. Mortality rates (q_x) for juvenile pocket gophers (Table 6) are the highest of any age class; however the mean number of individuals alive at each age interval (L_x) clearly indicates there is a rapid disappearance of adult pocket gophers from the population as time advances. In the absence of a high or moderate level of juvenile survival, population densities could be expected to rapidly decrease.

Influence of Forb Abundance

Miller (1946), in California, determined that significant differences in fertility of pocket gophers (*T. bottae*) could be attributed to nutritional factors. When green forage was available only in irrigated fields, the percentage of pregnant and recently-

pregnant females collected from irrigated fields was significantly greater than in non-irrigated fields. Hansen and Ward (1966) in Colorado, found the mean litter size of female pocket gophers (*T. talpoides*) inhabiting 2, 4-D treated rangeland to be slightly less than females from untreated range each year from 1957 to 1962. A decrease in forb production on the treated range may have influenced litter size of females. Evidence supporting the dependence of pocket gophers on annual and perennial forbs is presented by Keith et al. (1959), Tietjen et al. (1967), and Hansen and Ward (1966). In Pelican Valley, a significant difference obtained between mean litter sizes of females trapped from ARCA/FEID c.t. areas ($\bar{x} = 5.2$) and those trapped from FEID/DECA h.t. areas ($\bar{x} = 4.7$) may be related to the quality and quantity of annual and perennial forbs available to gophers. In August, 1978 a mean forb standing crop of 592 kg/ha (SD = 131.4) was obtained from the three ARCA/FEID c.t. belt transects while a mean forb standing crop of 470 kg/ha was obtained from the five FEID/DECA h.t. belt transects (Table 14). These differences lack statistical significance ($.10 < P < .20$, t-test), however they may in fact be representative of actual trends in forb production on the two vegetative types.

Estimates of total forb and graminoid standing crop on belt transects during August, 1978 are presented in Table 14. No apparent relationship exists between forb standing crop estimates and the number

of pocket gophers present within the belt transects as indexed through mound counts. Belt transect FEID/DECA 1 yielded the lowest forb standing crop estimate of any belt transect (394.6 kg/ha) yet mound count data indicated that it supported the highest pocket gopher density of any belt transect. Conversely, DECA/*Carex* spp. 1 yielded the second highest estimate of forb standing crop (702.1 kg/ha), yet mound count data indicated it had the lowest density of pocket gophers of any belt transect. A likely cause of the low pocket gopher numbers on DECA/*Carex* spp. 1 is high soil moisture content. Soil moisture data for 1978 (Table 18) suggest that soil water content on belt transect DECA/*Carex* spp. 1 exceeded pocket gopher tolerance limits. Mean soil moistures in percent dry weight were similar to soil moistures obtained in swale areas (Figures 13 and 14) where pocket gophers were typically absent.

Relationship Between Pocket Gopher Numbers and Plant Species

The preference *T. talpoides* exhibits towards annual and perennial forbs is well documented (Aldous, 1951; Keith et al., 1959; Ward, 1960; Ward and Keith, 1962; Hansen and Ward, 1966; Vaughan, 1967). Ward and Keith (1962) determined from the stomach contents of 397 pocket gophers collected near Black Mesa, Colorado that the summer diet consisted of 93 percent forbs, 6 percent grasses, and 1 percent shrubs. They further determined that *Collomia linearis* was the favored food

item during the summer period. Hansen and Ward (1966) found a general correlation between changes in abundance of gophers (especially the young) and herbage production of the most important foods of pocket gophers. However, they were unable to find any relationship between amounts of food relative to gophers and mean litter size, mean weights of adults or mean young/adult female indices. In Pelican Valley, *C. linearis* abundance correlated highly significantly ($P < .01$) with mound counts on belt transects (Tables 15 and 16). No other individual plant species consistently correlated as highly with mound counts; however both standing crop and canopy coverage of *Melica spectabilis* correlated significantly ($P < .01$) with mound counts in August, 1978.

Corms of *M. spectabilis* and tubers of *P. gairdneri* composed 32.8 and 9.6 percent respectively of the gopher cache found during the study (Table 9). Neither canopy coverage or standing crop data for *P. gairdneri* correlate significantly with pocket gopher abundance (indexed through mound counts), however combined intercepts of *M. spectabilis* and *P. gairdneri* (Figure 11) do correlate significantly ($r = .63$, $P < .01$) with mounds built/48 hours for 1977 and 1978. When only line intercepts of *M. spectabilis* are compared with mound counts, a highly significant correlation ($r = .84$, $P < .01$) is obtained. This suggests that *M. spectabilis* is largely responsible for the significant correlation coefficient obtained in Figure 11.

While significant correlation coefficients were obtained for plant species besides *C. linearis* and *M. spectabilis*, no consistent relationship for both years between pocket gopher numbers and coverage or standing crop of other plant species was demonstrated.

Standing crop data for all belt transects (Table 14) suggests that forb production was perhaps less limiting to gopher densities than other components of the environment. Soil depth and soil moisture may interact with forb production so as to mask any discernable relationship with abundance of pocket gophers. *Collomia linearis* abundance appears to be less likely a factor in determining gopher densities than it is to either share similar ecological requirements with gophers or to be provided favorable conditions by pocket gopher disturbance of soil. In the former case, deep, well-drained soils on north-facing slopes, where plant vigor and productivity appear highest, may provide both organisms ideal conditions for survival and reproduction. In the latter case, disturbed soil, such as high gopher densities produce, would provide sites for the germination and growth of this annual forb. A mutualistic relationship between *C. linearis* and pocket gophers could thus be hypothesized, whereby pocket gophers would actively forage for *C. linearis* while simultaneously creating new habitat for its perpetuation.

Influence of Soil

Miller (1964), in Colorado, found *T. talpoides* to have a wide tolerance of soil textures, including both compacted clay soils and shallow gravels with no visible A horizon. Howard and Childs (1959), in the San Joaquin Valley of California, found pocket gophers (*T. bottae*) to be absent from soils less than 30 cm in depth, while soils 60 cm or more in depth supported the greatest number of gophers. Hansen and Beck (1968), in the Cochetopa Creek drainage in Colorado, determined that soil depth had little effect on the occurrence of pocket gophers; however in alpine areas the deepest soils were also usually the wettest since both soil and water accumulate in depressions. In Pelican Valley, soil textures on belt transects (Table 17) appeared to be well within the tolerance limits of pocket gophers as evidenced by mound counts. Soil depths, however, may have influenced gopher numbers. On belt transect FEID/DECA 1, where 1978 population indices were highest (Figure 2), the A horizon extended to a depth of 52 cm. By comparison, on belt transect FEID/DECA 5, where population indices were among the lowest recorded (Figure 5), the A horizon extended to a depth of only 14 cm. Underlying soil on FEID/DECA 5 was an indurate, heavy clay of which penetration by an Oakfield soil sampling tube was nearly impossible. Kinnerly (1964) suggested that soil temperatures in excess of 40° C approach the thermoregulatory limits of the pocket gopher. Wilks (1963) exposed a pocket gopher

(*Geomys bursarius*) to the heat of the sun and recorded a rectal temperature of 44° C just prior to the animal's death. Burrow temperatures in Pelican Valley were not obtained and thus it is unknown if shallow burrows on FEID/DECA 5 approached gopher tolerance limits during summer. It seems logical to assume that the north facing exposure of FEID/DECA 1, coupled with its greater vegetative cover and deeper, more tractable soil provided a more favorable burrowing environment than that which existed on FEID/DECA 5.

In Pelican Valley, soil moisture was typically highest in swales, apparently exceeding the tolerance limits of pocket gophers during spring and early summer. Not until August, when soil moisture levels were lowest (Figures 13 and 14), did pocket gopher use occur; and then only by dispersing juveniles. Thus it appears likely that swales serve as marginal or 'over-flow' habitat during the peak of juvenile dispersal until fall rains render the soil in swales too moist for inhabitation by gophers.

Influence of Snow

Snow Melt

Hansen and Ward (1966) and Reid (1973) present evidence that the water content at peak snowpack and the depth of snow on May 1st influence the survival of young pocket gophers and may influence population density. On Grand Mesa, Colorado, Hansen and Ward (1966)

obtained an inverse correlation between the number of young pocket gophers per adult female and both the water content in snow at peak snowpack and the depth of snow on May 1st. Reid (1973) presented evidence that spring snow conditions, survival of young, and resulting changes in the age composition of the pocket gopher population were linked to population fluctuations on Black Mesa and Grand Mesa, Colorado. Hansen (1962) expressed belief that gopher populations suffer heavy mortality on flat, poorly-drained soils in the high mountains of Colorado at time of spring snow melt. Snow Survey data (USDA, 1977, 1978) from the Lake Camp Snow Course (eight km west of Pelican Valley) indicate the depth of snowpack on May 1st, 1978 was markedly greater than that in 1977 (Table 1). Population indices obtained from mound counts suggest that 1978 population levels were generally the same as those obtained in 1977 or higher. Data from dead-trapping indicate that over 75 percent of the fall population in 1978 consisted of juvenile pocket gophers (Table 7). Together, composition of the population by year class and mound count data suggest snow depths and snow melt conditions in Pelican Valley on May 1st had little influence on juvenile survival in spring of 1978.

Snow Cover

The importance of snow cover in Pelican Valley is difficult to assess as the study area was essentially inaccessible during winter. Aerial photography conducted in spring of both 1977 and 1978 indicated that while the phenology of snow melt differed markedly between years, snow melt patterns remained quite similar. Typically, north-facing slopes, swale areas, and timbered areas were the last to melt free of snow, while snow on slopes with south or southwest exposures melted first. Snow may serve an important role in pocket gopher survival, especially juvenile survival. Tryon (1947) observed that winter soil casts were most abundant in high mountain meadows where snow comes early, possibly insulating the ground from freezing. Additionally, snow provides a medium in which pocket gophers may forage over frozen ground without exposing themselves to predators. Hansen (1962) observed that snow cover permitted pocket gophers living on a mima-mound habitat on Black Mesa, Colorado to obtain an adequate supply of winter food from intermound areas which were of such shallow soil that they were inaccessible to burrowing gophers during snow-free months. Under such circumstances, snow cover may actually increase the amount of habitat available to pocket gophers for foraging.

Juvenile survival is likely dependent upon the availability of suitable areas to occupy upon dispersal from the maternal burrow

system. Many suitable areas are usually already occupied, and a vigorous defense of the best territories by adults may force many juveniles to inhabit marginal areas such as swales. Although high mortality may occur at time of spring snow melt (Hansen, 1962; Ingles, 1952), the presence of snow cover may afford juvenile pocket gophers increased opportunity to locate suitable territories as they become available through population turnover. Thus snow cover may 'carry over' a sizeable portion of the juvenile population which would otherwise be exposed to predators while in search for food and cover.

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APPENDIX

Table 10. Canopy coverage ($\bar{X}$ and SD) and frequency of plant species in 25 2x5 dm plots taken along the centerline of each belt transect during August, 1978. A1-A3=ARCA/FEID belt transects 1-3; F1-F5=FEID/DECA belt transects 1-5; D1=DECA/*Carex* spp. belt transect 1.

Taxa		A 1	A 2	A 3	F 1	F 2	F 3	F 4	F 5	D 1
<u>Graminoid species.</u>										
<i>Agropyron caninum</i>	$\bar{x}$	3.8	5.9	2.6	7.7	7.7	5.4	6.4	3.4	4.8
	SD	5.8	6.5	3.9	11.6	11.1	6.8	9.1	4.7	5.9
	freq	(48)	(76)	(60)	(52)	(56)	(56)	(60)	(52)	(72)
<i>Agrostis scabra</i>			0.1 0.5 (04)				0.2 0.7 (08)			
<i>Bromus carinatus</i>		7.3 13.2 (56)	0.6 3.0 (04)			13.6 6.5 (24)	6.1 10.9 (52)	2.0 4.9 (20)	3.3 6.0 (32)	
<i>Calamagrostis montanensis</i>			1.0 3.1 (20)	11.9 11.5 (84)	2.6 4.8 (44)	0.1 0.5 (04)			2.1 4.9 (24)	15.4 14.1 (80)
<i>Carex</i> spp.			2.2 4.9 (28)	4.9 5.9 (72)	2.9 5.5 (36)	4.5 9.2 (24)	1.0 3.1 (20)	1.6 4.1 (24)	4.3 5.6 (72)	9.8 9.9 (76)
<i>Danthonia intermedia</i>			0.1 0.5 (04)		0.1 0.5 (04)				2.7 4.8 (48)	
<i>Deschampsia caespitosa</i>		0.6 3.0 (04)	21.0 24.0 (04)	25.6 24.8 (72)	10.1 13.6 (60)	15.4 23.5 (60)	5.2 10.9 (36)	10.2 19.1 (44)	15.7 16.9 (72)	23.4 18.9 (80)
<i>Festuca idahoensis</i>		8.8 11.0 (60)	15.4 16.9 (80)	5.6 2.4 (36)	8.8 9.1 (76)	8.3 11.0 (60)	8.2 9.2 (72)	5.5 10.8 (48)	5.2 9.3 (32)	

Table 10 (Continued)

Taxa		A 1	A 2	A 3	F 1	F 2	F 3	F 4	F 5	D 1
<u>Graminoid species (cont.)</u>										
<i>Melica spectabilis</i>	$\bar{x}$	1.0	0.7	0.6	1.8	1.1	1.5	1.0	0.6	0.1
	SD	1.3	1.1	1.1	1.1	1.3	1.3	1.3	1.1	0.5
	freq	(40)	(28)	(24)	(72)	(44)	(60)	(40)	(24)	(04)
<i>Phleum alpinum</i>		0.1	0.2	0.1	0.7	0.8	1.7	0.2	1.7	0.3
		0.5	0.7	0.5	1.1	3.0	4.1	0.7	4.1	0.8
		(04)	(08)	(04)	(28)	(12)	(24)	(08)	(28)	(12)
<i>Poa spp.</i>		0.2	2.5	0.2	1.5	2.4	1.1	5.9	5.1	0.6
		0.7	4.9	0.7	4.1	5.6	3.1	10.9	7.0	3.0
		(08)	(40)	(08)	(20)	(16)	(24)	(44)	(44)	(04)
<i>Stipa occidentalis</i>		1.9	1.1		6.8	6.4	2.8	3.2	4.3	
		4.1	3.1		11.2	11.1	8.3	6.1	6.2	
		(36)	(24)		(40)	(44)	(16)	(28)	(52)	
<u>Forb species</u>										
<i>Achillea millefolium</i>		1.4	3.6	4.7	4.2	0.4	1.2	0.2	2.8	1.4
		3.1	4.4	5.3	5.6	0.9	1.3	0.7	3.8	3.1
		(36)	(84)	(84)	(68)	(16)	(48)	(08)	(72)	(36)
<i>Aconitum columbianum</i>								0.3		
								0.8		
								(12)		
<i>Agoseris glauca</i>		1.8	5.4	0.9	2.5	1.4	1.0	1.9	0.6	3.6
		3.0	6.2	1.2	2.8	3.1	1.3	4.1	1.1	8.6
		(52)	(76)	(36)	(80)	(36)	(40)	(36)	(24)	(28)

Table 10 (Continued)

Taxa		A 1	A 2	A 3	F 1	F 2	F 3	F 4	F 5	D 1
<u>Forb species (cont.)</u>										
<i>Androsace septentrionalis</i>	$\bar{x}$	0.1	0.1		0.4	2.0	1.5	1.2	0.4	
	SD	0.5	0.5		0.9	4.1	3.1	3.1	0.9	
	freq	(04)	(04)		(16)	(40)	(40)	(28)	(16)	
<i>Antennaria microphylla</i>		1.5	5.5	0.5	6.8	1.5	2.1	0.2	12.9	5.9
		7.5	11.1	1.0	14.6	4.1	4.9	0.7	12.8	14.6
		(04)	(28)	(20)	(40)	(20)	(24)	(08)	(72)	(24)
<i>Arabis spp.</i>		0.4	0.1			0.4	0.4			0.1
		0.9	0.5			0.9	0.9			0.5
		(16)	(04)			(16)	(16)			(04)
<i>Aster spp.</i>		9.3	2.0	6.5	1.7	2.7	4.0	3.6	8.9	4.0
		12.4	4.1	8.6	4.1	5.5	6.4	5.9	9.0	6.4
		(64)	(40)	(80)	(28)	(28)	(40)	(44)	(80)	(40)
<i>Cerastium arvense</i>		1.5	7.3	4.2	2.4	2.3	2.0	1.1	1.8	1.4
		4.1	9.0	6.3	4.0	4.9	4.1	3.1	4.1	4.2
		(20)	(76)	(48)	(56)	(32)	(40)	(24)	(32)	(16)
<i>Cirsium spp.</i>			0.7	8.0	0.2	0.2	3.4	0.3	0.8	0.8
			3.0	3.0	0.7	0.7	6.0	0.8	3.0	3.0
			(08)	(08)	(08)	(08)	(36)	(12)	(12)	(12)
<i>Collomia linearis</i>		3.6	2.0	0.3	5.8	6.5	6.1	6.1	0.5	0.4
		4.4	3.0	0.8	8.1	6.6	6.3	8.4	1.0	0.9
		(84)	(60)	(12)	(96)	(80)	(84)	(88)	(20)	(16)

Table 10 (Continued)

Taxa	A 1	A 2	A 3	F 1	F 2	F 3	F 4	F 5	D 1
<u>Forb species (cont.)</u>									
<i>Delphinium spp.</i>	$\bar{x}$ SD freq		0.3 0.8 (12)						
<i>Draba spp.</i>	0.6 3.0 (04)	0.1 0.5 (04)			0.3 0.8 (12)	0.4 0.9 (16)	0.1 0.5 (04)	0.1 0.5 (04)	
<i>Epilobium spp.</i>				0.2 0.7 (08)				0.1 0.5 (04)	0.2 0.7 (08)
<i>Erigeron spp.</i>		0.1 0.5 (04)							
<i>Eriogonum spp.</i>	0.1 0.5 (04)								
<i>Eriophyllum lanatum</i>	1.3 4.2 (12)								
<i>Fragaria virginiana</i>		0.1 0.5 (04)	1.3 4.2 (12)		0.3 0.8 (12)	2.8 8.3 (16)			
<i>Galium boreale</i>		0.6 3.0 (04)	5.8 7.1 (48)		2.0 4.9 (20)				

Table 10 (Continued)

Taxa	A 1	A 2	A 3	F 1	F 2	F 3	F 4	F 5	D 1
<u>Forb species (cont.)</u>									
<i>Gayophytum ramosissimum</i>	$\bar{x}$ 0.6 SD 3.0 freq (04)			0.9 3.1 (16)	0.6 3.0 (04)		0.2 0.7 (08)		
<i>Geum triflorum</i>			0.6 3.0 (04)						
<i>Linum perenne</i>							0.2 0.7 (08)		
<i>Lupinus spp.</i>				0.2 0.7 (08)					
<i>Perideridia gairdneri</i>	3.8 5.1 (68)	1.7 1.2 (68)	0.6 1.1 (20)	0.5 1.0 (20)	1.3 1.3 (52)	1.2 1.3 (48)	1.1 1.3 (44)	0.7 1.1 (28)	1.1 1.3 (40)
<i>Polygonum douglasii</i>	1.7 3.0 (48)	0.7 1.1 (24)	0.4 0.9 (16)		1.4 1.3 (56)	1.5 1.3 (60)	5.4 10.0 (84)	0.5 1.0 (20)	0.9 3.1 (16)
<i>Potentilla gracilis</i>	5.3 8.8 (56)	1.8 7.5 (16)	3.8 5.8 (48)		3.8 6.5 (52)	3.0 5.4 (40)	2.4 4.9 (36)	6.0 6.4 (80)	5.9 9.4 (40)

Table 10 (Continued)

Taxa	A 1	A 2	A 3	F 1	F 2	F 3	F 4	F 4	D 1
<u>Forb species (cont.)</u>									
<i>Ranunculus alismaefolius</i>	$\bar{x}$					0.5			1.4
	SD					1.0			1.3
	freq					(20)			(32)
<i>Senecio spp.</i>			0.2						3.6
			0.7						5.9
			(04)						(44)
<i>Stellaria longipes</i>	2.7	0.6	1.7	0.9	2.2	0.4	3.1	0.1	0.7
	4.8	1.1	1.2	1.2	4.0	0.9	4.6	0.5	1.1
	(48)	(24)	(64)	(36)	(48)	(16)	(64)	(04)	(28)
<i>Taraxacum spp.</i>		0.2	1.6			0.3	0.6		0.1
		0.7	4.1			0.8	3.0		0.5
		(08)	(24)			(12)	(04)		(04)
<i>Thalictrum occidentale</i>		0.7	6.5						
		3.0	7.1						
		(08)	(56)						
<i>Trifolium longipes</i>	0.1	0.6	1.2	0.3	0.1	0.3	0.5	2.4	0.5
	0.5	1.1	1.2	0.8	0.5	0.8	1.0	4.0	1.0
	(04)	(24)	(44)	(12)	(04)	(12)	(20)	(56)	(20)
<i>Viola spp.</i>	1.3	0.6	1.1	2.2	0.4	0.4	1.0		0.8
	3.1	1.1	3.1	4.0	0.9	0.9	1.3		3.0
	(32)	(24)	(24)	(48)	(16)	(16)	(40)		(12)

Table 10 (Continued)

Taxa	A 1	A 2	A 3	F 1	F 2	F 3	F 4	F 5	D 1
<u>Shrub species</u>									
<i>Artemisia cana</i>	$\bar{x}$ 15.0	15.9	14.8						
	SD 20.5	17.8	18.6						
	freq (48)	(64)	(68)						
<i>Bare ground</i>	30.5	16.9	7.8	26.2	28.2	35.3	38.2	26.5	7.0
	19.6	20.7	10.2	26.0	22.6	25.4	29.3	19.7	6.1
	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)
<i>Litter</i>	18.4	32.2	52.6	28.8	25.4	26.8	21.0	27.3	51.6
	11.9	17.9	14.2	21.1	19.3	20.9	19.6	15.7	14.3
	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)

Table 13. Standing crop ($\bar{X}$ and SD) in kg/ha of commonly occurring plant species on belt transects in August, 1978 as determined by clip plots. A1-A3=ARCA/FEID belt transects 1-3; F1-F5=FEID/DECA belt transects 1-5; D1=DECA/*Carex* spp. belt transect 1.

Taxa		A 1	A 2	A 3	F 1	F 2	F 3	F 4	F 5	D 1
<u>Graminoid species</u>										
<i>Agropyron caninum</i>	$\bar{X}$	47.1	385.6	133.4	144.6	246.6	541.4	181.2	61.9	122.7
	SD	91.9	761.0	132.3	184.0	321.7	578.3	288.0	55.0	181.6
<i>Agrostis scabra</i>		0	4.5	0	1.9	0	0	0	.05	0
		0	15.7	0	3.0	0	0	0	.10	0
<i>Bromus carinatus</i>		29.4	1.8	0	0	188.3	302.6	92.0	31.7	0
		419.2	5.6	0	0	450.6	661.3	211.8	64.3	0
<i>Calamagrostis montanensis</i>		0	13.0	172.6	26.2	0	16.8	0	3.9	433.8
		0	21.0	161.4	31.0	0	48.2	0	12.4	503.2
<i>Carex spp.</i>		0	3.0	70.6	102.3	69.5	69.5	51.1	116.8	128.9
		0	9.5	84.1	101.3	201.7	217.4	118.4	122.8	133.4
<i>Danthonia intermedia</i>		0	3.0	35.5	31.9	0.9	0	0	50.6	0
		0	9.5	94.9	36.9	3.4	0	0	66.4	0
<i>Deschampsia caespitosa</i>		33.6	350.8	456.2	336.2	309.3	406.9	68.0	143.0	534.6
		105.4	520.1	422.5	282.6	446.1	623.2	131.1	65.1	532.4
<i>Festuca idahoensis</i>		18.9	264.5	30.3	297.2	321.7	230.9	55.3	79.8	0
		227.5	264.5	63.3	156.6	346.3	220.8	174.8	78.3	0
<i>Melica spectabilis</i>		14.6	53.8	32.5	52.6	34.5	30.3	35.6	12.1	15.5
		25.8	56.0	69.5	39.0	52.7	25.8	37.2	14.7	40.6
<i>Phleum alpinum</i>		0	15.4	16.1	27.1	19.8	7.3	8.6	23.5	6.4
		0	48.5	51.0	45.6	42.8	15.7	27.2	57.5	20.2

Table 13 (Continued)

Taxa	A 1	A 2	A 3	F 1	F 2	F 3	F 4	F 5	D 1
<i>Poa</i> spp.	$\bar{x}$ 13.5 SD 103.3	65.0 124.4	70.6 124.4	91.1 103.3	86.6 154.6	25.0 47.1	237.6 460.7	65.5 74.3	21.7 42.0
<i>Stipa occidentalis</i>	52.7 88.5	23.5 56.0	0 0	137.0 108.7	102.8 258.9	61.6 179.3	488.7 702.7	72.7 62.1	0 0
<u>Forb species</u>									
<i>Achillea millefolium</i>	25.8 57.2	77.6 110.5	67.3 42.6	66.5 57.4	14.6 35.9	38.3 60.5	5.4 9.9	53.4 35.3	49.3 101.7
<i>Agoseris glauca</i>	49.3 71.7	15.0 18.4	14.9 31.4	35.1 13.6	38.6 54.3	22.4 30.3	5.4 6.5	47.0 38.6	1.08 16.8
<i>Antennaria microphylla</i>	3.4 10.1	132.3 419.2	0 0	83.4 75.3	46.0 139.0	0 0	0 0	139.2 162.6	195.0 313.8
<i>Aster</i> spp.	132.3 228.6	9.4 16.8	156.9 230.9	29.0 32.4	30.3 262.3	59.4 128.9	112.6 167.0	173.1 110.7	78.6 109.8
<i>Collomia linearis</i>	23.5 41.5	24.2 29.4	1.7 4.0	97.5 66.2	46.0 50.4	41.5 46.0	41.5 65.0	10.8 24.6	0 0
Other forb	224.2 281.3	189.4 126.7	479.7 272.4	108.3 66.7	230.9 262.3	193.9 134.5	272.4 261.1	154.7 145.6	492.0 443.8
<i>Perideridia gairdneri</i>	124.4 76.2	18.3 39.8	8.0 24.7	19.8 26.7	71.8 82.6	52.7 54.6	20.4 26.5	34.7 41.3	74.5 111.6

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