Sage grouse, lagomorph, and pronghorn use of a sagebrush grassland burn site on the Idaho National Engineering Laboratory
by Robert John Gates

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Fish and Wildlife Management
Montana State University
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Abstract:
From May 1980 through July 1983, a study was conducted on the Idaho National Engineering Laboratory (INEL) in southeast Idaho to collect data on sage grouse (Centrocercus urophasianus), pygmy rabbit (Brachylagus idahoensis), black-tailed jack rabbit (Lepus californicus), and pronghorn (Antilocapra americana) use of a 405 ha sagebrush (Artemisia tridentata) grassland prescribed burn site.

Relative use of the burn site and an adjacent control area by the 4 species was determined for 2 years before and I year after treatment, in August 1981. Seasonal food habits of the 4 species in unburned habitat were determined. Radiotelemetry was used to determine the-seasonal distribution of grouse in relation to the burn site and post-fire mortality and dispersal of pygmy rabbits.

Pellet-counts indicated no difference in use of the burn and control sites ($P > 0.05$) by the 4 species prior to treatment. One year after the initial burn, relative use of the burn site by sage grouse and jack rabbits was greater ($P < 0.05$) than use of the control site while pronghorn use was lower ($P = 0.04$). Pygmy rabbit use did not differ ($P = 0.59$) between the burn and control sites I year after treatment; however, there was a decreased use of burned plots.

Fecal analyses showed that sagebrush comprised > 70% of grouse, pygmy rabbit, and pronghorn diets over the seasonal periods sampled. Grouse and pronghorn consumed increasing proportions of forbs through spring and summer, Pygmy rabbits consumed larger proportions of grasses and rabbitbrush (Chrysothamnus spp.) in the summer. Winterfat (Ceratoides lanata) was the predominant forage in the jack rabbit diet.

Grouse and pronghorn used the burn area during the fall, winter, and spring. The burn site was not critical grouse winter habitat. Desiccation of forbs in sagebrush habitats concentrated both species near irrigated cropland and lawns of INEL facilities during the summer.

The post-burn weekly mortality rate of radio-collared rabbits increased 66% after burning. Predation on dispersing and non-dispersing rabbits was the major cause of death. Sixteen unmarked rabbits were found which died during the fire. Pygmy rabbits were eliminated from a partially burned area 20 months after burning.

SAGE GROUSE, LAGOMORPH, AND PRONGHORN USE OF A SAGEBRUSH GRASSLAND BURN SITE ON THE IDAHO NATIONAL ENGINEERING LABORATORY

by

Robert John Gates

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

of

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in

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ABSTRACT

From May 1980 through July 1983, a study was conducted on the Idaho National Engineering Laboratory (INEL) in southeast Idaho to collect data on sage grouse (Centrocercus urophasianus), pygmy rabbit (Brachylagus idahoensis), black-tailed jack rabbit (Lepus californicus), and pronghorn (Antilocapra americana) use of a 405 ha sagebrush (Artemisia tridentata) grassland prescribed burn site.

Relative use of the burn site and an adjacent control area by the 4 species was determined for 2 years before and 1 year after treatment in August 1981. Seasonal food habits of the 4 species in unburned habitat were determined. Radiotelemetry was used to determine the seasonal distribution of grouse in relation to the burn site and post-fire mortality and dispersal of pygmy rabbits.

Pellet-counts indicated no difference in use of the burn and control sites ($P > 0.05$) by the 4 species prior to treatment. One year after the initial burn, relative use of the burn site by sage grouse and jack rabbits was greater ($P < 0.05$) than use of the control site while pronghorn use was lower ($P = 0.04$). Pygmy rabbit use did not differ ($P = 0.59$) between the burn and control sites 1 year after treatment; however, there was a decreased use of burned plots.

Fecal analyses showed that sagebrush comprised > 70% of grouse, pygmy rabbit, and pronghorn diets over the seasonal periods sampled. Grouse and pronghorn consumed increasing proportions of forbs through spring and summer. Pygmy rabbits consumed larger proportions of grasses and rabbitbrush (Chrysothamnus spp.) in the summer. Winterfat (Ceratoides lanata) was the predominant forage in the jack rabbit diet.

Grouse and pronghorn used the burn area during the fall, winter, and spring. The burn site was not critical grouse winter habitat. Desiccation of forbs in sagebrush habitats concentrated both species near irrigated cropland and lawns of INEL facilities during the summer.

The post-burn weekly mortality rate of radio-collared rabbits increased 66% after burning. Predation on dispersing and non-dispersing rabbits was the major cause of death. Sixteen unmarked rabbits were found which died during the fire. Pygmy rabbits were eliminated from a partially burned area 20 months after burning.

INTRODUCTION

Fire has historically been an important source of disturbance in sagebrush-grass communities (Wright et al. 1979, Shinn 1980), and prescribed burning is a commonly used technique for altering rangeland vegetation (Vale 1974). In spite of the importance of fire, burning is often conducted without proper evaluation of the effects of fire on animal populations. Many post-fire studies of vertebrate populations have been conducted without prior knowledge of the abundance, distribution, and ecology of the species present on areas impacted by unplanned fires (Renwald 1977, Riggs and Peek 1980, Bock and Bock 1981, Halford 1981). Such studies necessarily rely on comparisons of burned and unburned areas. A prescribed burn provides an opportunity to make comparisons before and after fire as well as of burned and unburned areas.

The effects of fire on birds and mammals vary with the intensity, size, shape, season of the burn, and on the type of habitat burned (Bendell 1974). Late summer or fall, fires in sagebrush grasslands usually do not severely damage perennial grasses and forbs; however, sagebrush is easily killed by fire. The initial release of nutrients after fire and the elimination of sagebrush competition for moisture and nutrients enhance the growth of perennial grasses, forbs, and shrubs which are able to resprout after burning (Blaisdell 1953). Sagebrush must reinvade burned areas entirely by seed; consequently,

30 years may be required for sagebrush cover to regain pre-burn levels (Harniss and Murray 1973).

Changes in the vegetal community after fire should have a long-term effect on the quality and quantity of forage and cover available to sage grouse (Centrocercus urophasianus), pronghorn (Antilocapra americana), pygmy rabbits (Brachylagus idahoensis), and black-tailed jack rabbits (Lepus californicus) which use the burn site. Quantity and quality of food are important factors which affect the population dynamics and distribution of birds and mammals (Watson and Moss 1970, Wolff 1980, Klein 1970, Keith 1974). This study addressed primarily the distribution aspect of these species' response to fire based upon the relative use of a portion of the burn site and an adjacent control area.

In May 1980, the Bureau of Land Management (BLM) and the Department of Energy (DOE) designated an area of sagebrush (Artemisia tridentata) grassland in southeast Idaho for a prescribed burn. The burn site included land withdrawn by DOE for nuclear energy research and was managed for livestock grazing by the BLM. Objectives of the burn were to increase the density of herbaceous vegetation on the burn site and to allow research to be conducted on the effects of fire on the flora and fauna of a sagebrush grassland type. This study was part of an overall research program funded by the DOE to determine the response of vegetation, insects, birds, and mammals to a prescribed burn.

Field work for the study was begun in May 1980 and was concluded in July 1983. Data were collected to provide information on seasonal use of the burn site prior to treatment and to document initial

responses of sage grouse and pygmy rabbits to burning. The specific objectives of this study were: 1) to determine relative use of the burn site and a control area by sage grouse, pygmy rabbits, black-tailed jack rabbits, and pronghorn prior to and 1 year after treatment; 2) to determine the seasonal food habits of the above species in unburned habitat; 3) to document seasonal distribution and movements of sage grouse in relation to the burn site; 4) to investigate post-fire mortality and dispersal of pygmy rabbits on the burn site.

STUDY AREA

This study was conducted on the DOE administered 2315 square kilometer (km^2) Idaho National Engineering Laboratory (INEL). The INEL, designated a National Environmental Research Park in 1975, is located along the western edge of the upper Snake River Plain at the foothills of the Lost River, Lemhi, and Bitterroot mountain ranges (Fig. 1). Climate and vegetation are characteristic of the northern cold desert shrub biome. Winters are cold, summers are hot, and precipitation is low. Temperatures at the Central Facilities Area (CFA) range from -41 Celsius (C) to 38C with a mean annual temperature of 6C. January is the coldest month and July is the hottest. The frost-free period averages 91 days. Annual precipitation at CFA averages 21 centimeters (cm) with 40% of the precipitation falling in April, May, and June (Fig. 2; Yanskey et al. 1966). Snowcover is variable but may persist from December through February (Fig. 3).

The burn site was a 405 hectare (ha) area located on the west-central boundary of the INEL, 10 km south of Howe, Butte County, Idaho. Most of the burn site occurred on an alluvial fan that extended east from the foothills of the Lost River Range (Fig. 4). Elevation of the burn site ranged from 1543 meters (m) at the top of the fan to 1487 m at the bottom. Floyd (1982) described the vegetal characteristics of the burn area prior to treatment. The dominant shrubs on the burn site were Wyoming big sagebrush (Artemisia tridentata

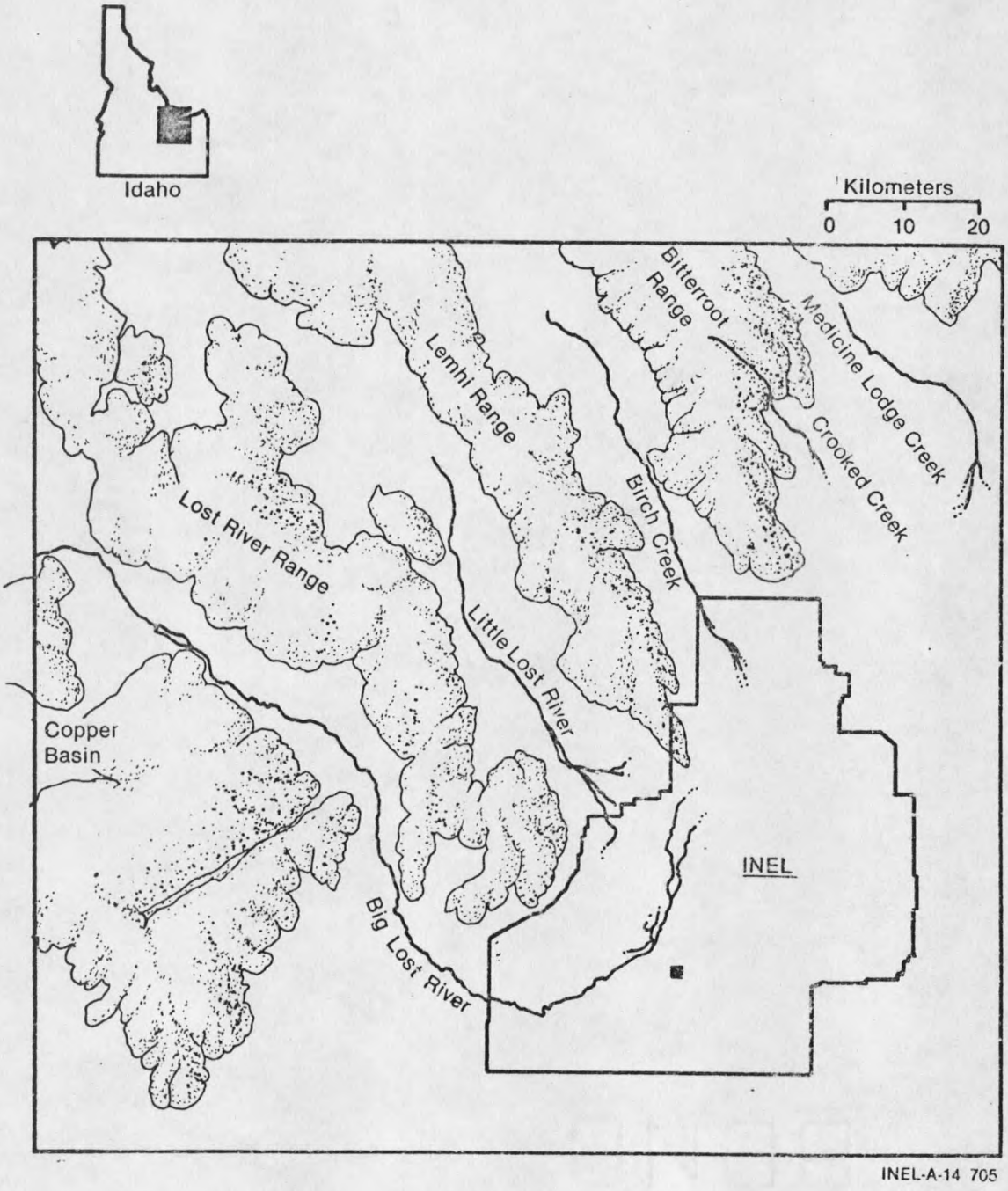


Fig. 1. Location of the INEL in relation to major mountain ranges and drainages in southeast Idaho.

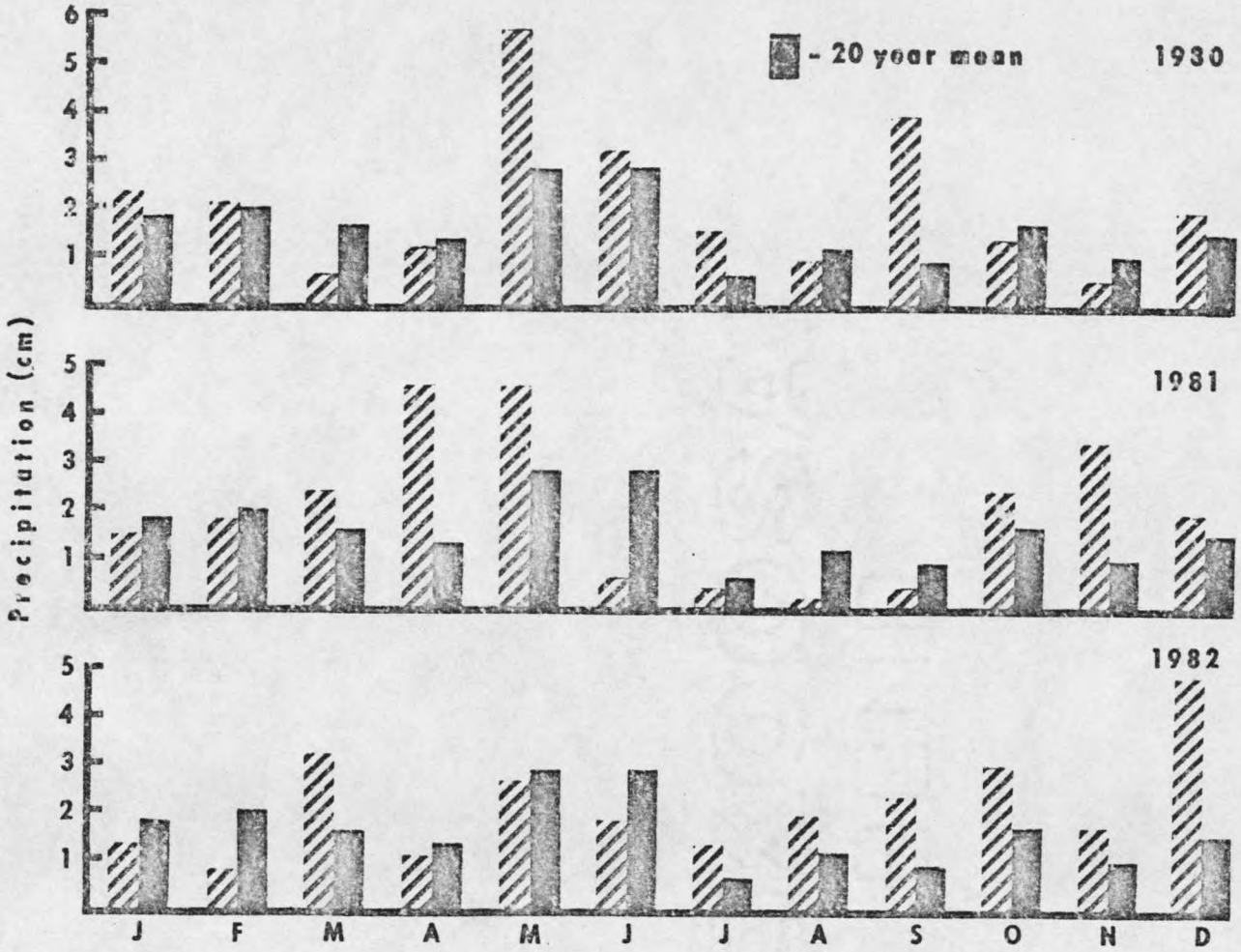


Fig. 2. Monthly precipitation at the Central Facilities Area (CFA) during 1980-82.

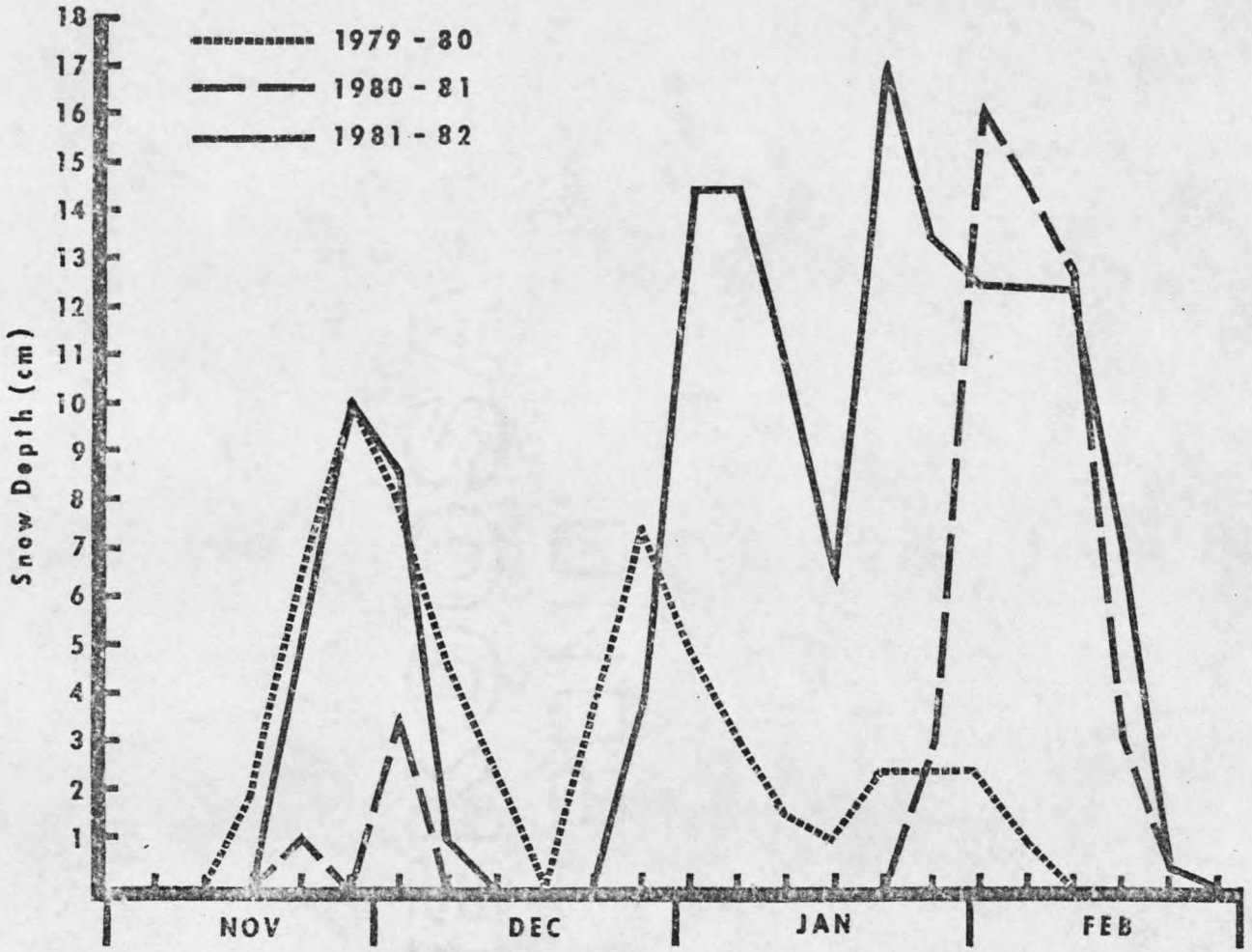


Fig. 3. Mean snowcover at CFA for 5 day intervals during November-February 1979-80, 1980-81, and 1981-82.

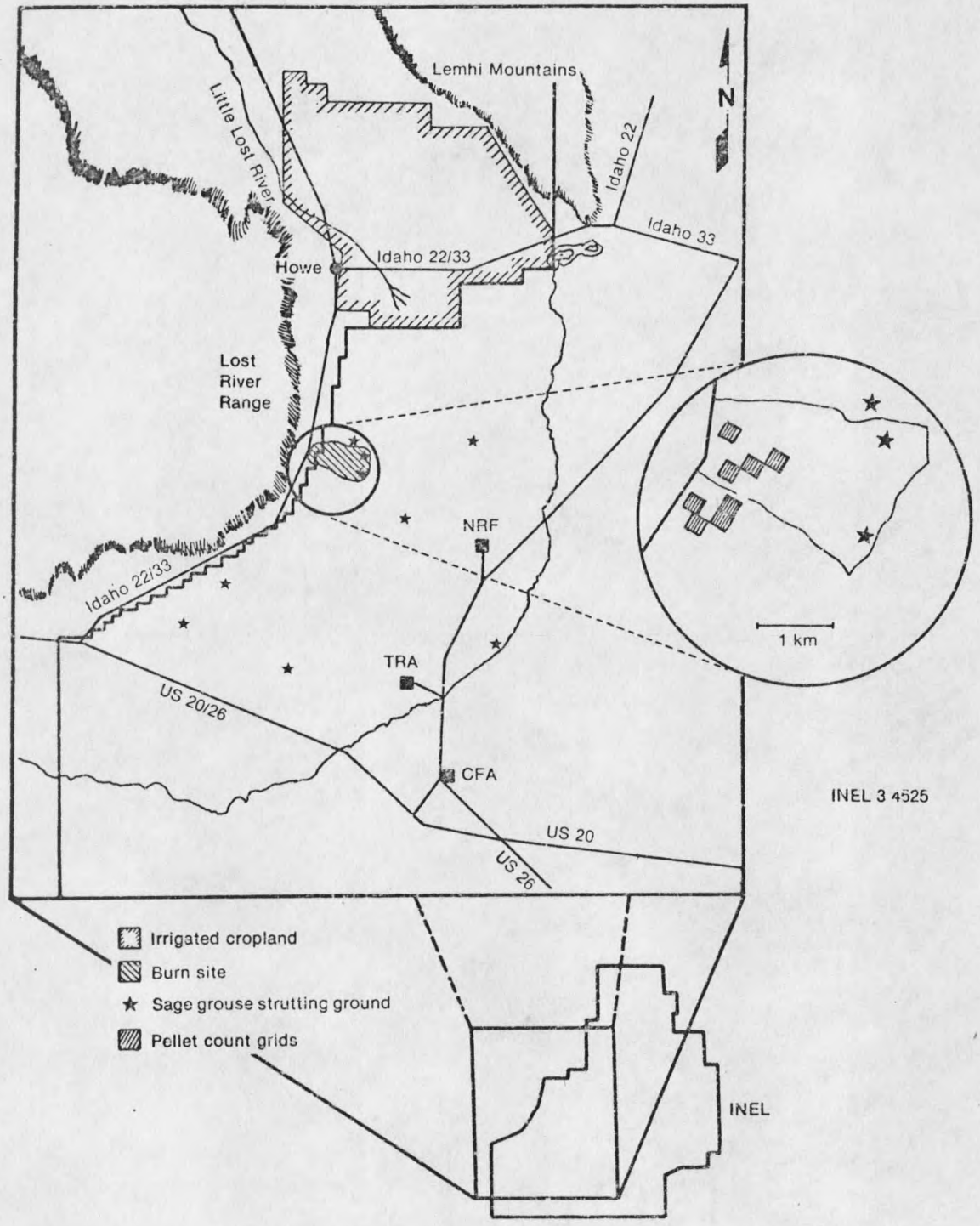


Fig. 4. Location of the study area, burn site, and sage grouse strutting grounds within the INEL.

subspecies wyomingensis) and green rabbitbrush (Chrysothamnus viscidiflorus). Big sagebrush cover in the burn area ranged from 12% to 33% and generally increased from the top to the bottom of the fan. Shrubby phlox (Leptodactylon pungens), black sagebrush (Artemisia nova), and winterfat (Ceratoides lanata) also contributed to the shrub cover of the burn area. Dominant grasses were bluebunch wheatgrass (Agropyron spicatum), Indian ricegrass (Oryzopsis hymenoides), and bottlebrush squirreltail (Sitanion hystrix). Grass cover ranged from 1% to 9% in the burn area and generally decreased from the top to the bottom of the fan. Floyd (1982) identified 50 species of annual and perennial forbs in the burn area. The most abundant of these were Phlox species (spp.), Arenaria franklinii, Cryptantha spp., Lappula redowskii, Schoencrambe linifolia, Erigeron spp., Descurainia spp., Astragalus spp., and Eriogonum spp. Total bare area ranged from 31% at the bottom of the fan to 51% at the top. Soils in the burn area were mostly loamy sands and sandy loams derived from loess and limestone alluvium. Basalt outcrops and ridges occurred in the east half of the burn site near the bottom of the fan.

Approximately 40-50% of the burn site was burned during controlled fires in August and October 1981 and September 1982. Only scattered patches (0.5-4.4 ha in size) were burned on the west half of the burn site where shrub cover was relatively sparse and much of the ground was bare. On the east half where shrub cover was more extensive and fuel abundant between sagebrush plants, the fire eliminated vegetation from larger, more continuous areas (up to 17.5 ha).

The study area included 300 km^2 surrounding the burn site (Fig. 4). Like the burn site, this area was predominantly sagebrush grassland. Three vegetation types (McBride et al. 1978) occurred over most of the study area. A big sagebrush-winterfat-green rabbitbrush type was associated with alluvial soils on the west edge of the study area. The north half of the area was a big sagebrush-green rabbitbrush-bottlebrush squirreltail type and the south half was a big sagebrush-bluebunch wheatgrass-green rabbitbrush type. Giant wildrye (Elymus cinereus) occurred in isolated depressions where soils were relatively deep and moist. There was an abrupt change to irrigated cropland along the INEL boundary 6.4 km north of the burn site. Alfalfa and barley were the principle crops.

Topography of the study area was flat to gently rolling with numerous lava outcrops and ridges. Elevation ranged from 1460-1650 m. Soils were silt loams and rocky silt loams overlying basalt and were derived from loess and alluvium.

Irrigated cropland, INEL facilities, and Big Lost River were the only sources of free water during the summer other than livestock tanks and ephemeral basins. During 1980 and 1981, the Big Lost River flowed continuously throughout the year in 1982.

That portion of the study area within the INEL boundary was closed to hunting and public access. Approximately 60% of the study area was grazed by livestock. Sheep were grazed on the north half of the study area during the spring, and cattle were grazed on the south half in late spring and summer. Livestock grazing was not permitted within 1 km of the burn site during the study.

METHODS

Pellet Counts

Fecal pellet counts (Neff 1968) were used to determine relative use of the burn site and a control area by sage grouse, pygmy rabbits, black-tailed jack rabbits, and pronghorn. Pellets were counted on the southwest quarter of the burn site and on an adjacent control area located immediately south of the burn site (Fig. 5). On both the burn and control sites, four 6.25 ha grids were selected randomly from a block of 12 potential locations. Within each grid, 25 plots were located at 50 m intervals in a 5 by 5 arrangement. Three concentric circular subplots were centered at each plot (Fig. 5). Single sage grouse fecal pellets and roost droppings (groups of 10 or more pellets) were counted on 40 m^2 plots. Pronghorn pellet groups (15 or more pellets) were counted on 10 m^2 plots. Pygmy rabbit and black-tailed jack rabbit pellets were counted on 1 m^2 plots. Pellets of these 2 species were distinguished by their size and morphology. Irregularly shaped, rough textured pellets less than 4 millimeters (mm) in diameter were considered to be from pygmy rabbits. Individual pygmy rabbit pellets were not counted due to the large numbers which were encountered. Pellet densities on each plot were assigned to 1 of 4 classes (0, 1-25, 26-50, > 50 pellets/m^2). All plots were examined twice during each count and cleared of pellets as they were counted.

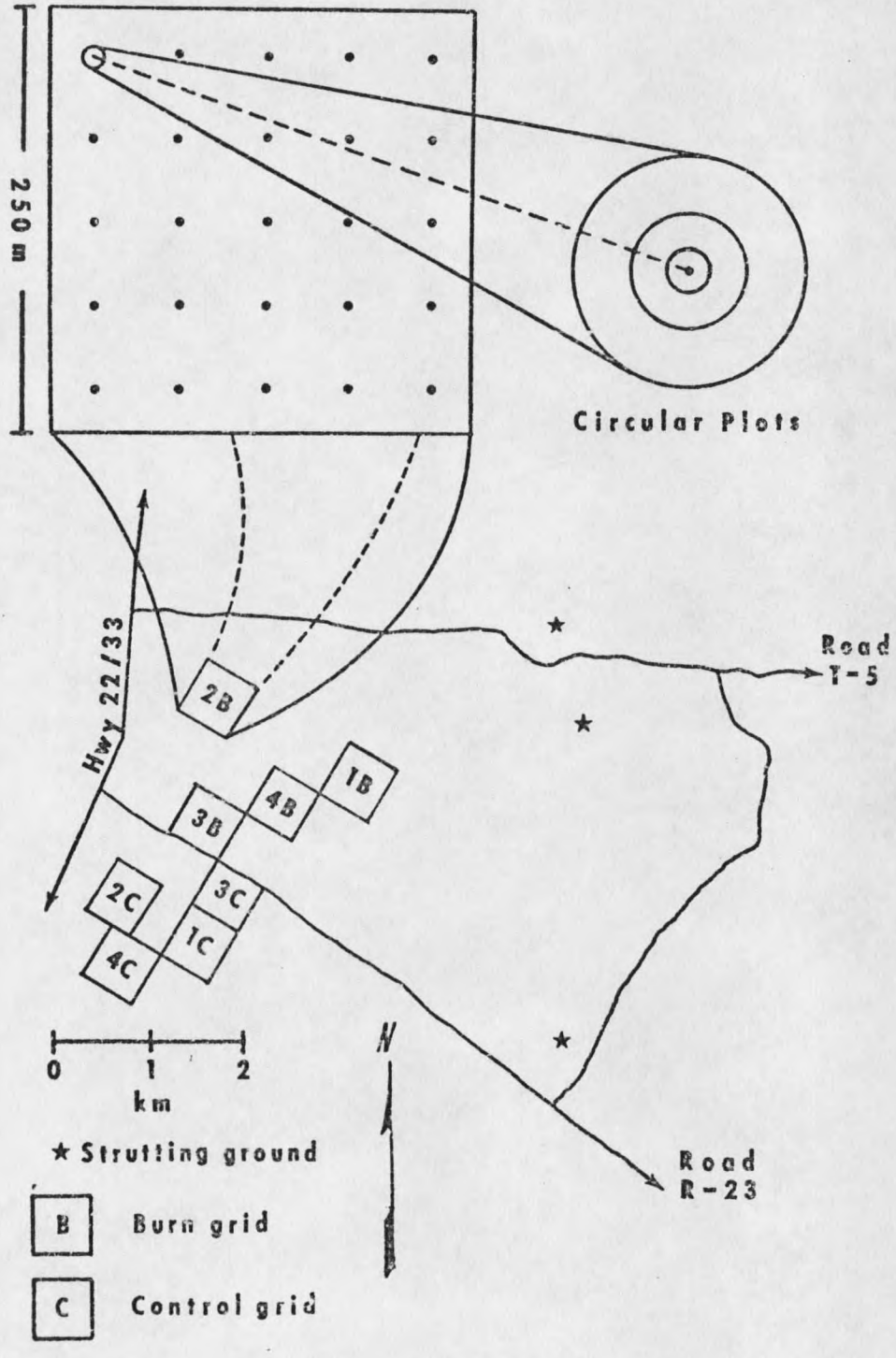


Fig. 5. Location of pellet grids on the burn site and configuration of pellet plots within grids.

Four pellet counts were conducted during the study. The first count was made as the plots were initially cleared in late September and early October 1980. The second count was completed in June 1981 and sampled approximately 8 months of fall, winter, and spring use of the burn and control sites. Burn plots were counted for the third time just prior to the initial burn in late August 1981; however, control plots were not counted until October 1981. Thus, the third count represented 2 months of summer use of the burn plots and 5 months of summer and early fall use of the control plots. The fourth count was completed in September 1982 and represented 1 year of use of the burn and control sites after the August and October 1981 burns.

Sage grouse and pronghorn pellet data were not adjusted for differences in time intervals between counts since they were conducted before and after seasonal periods of use of the burn area. The first count was assumed to represent 1 year of grouse and pronghorn use of the burn and control sites. Only those pellets which, by their appearance, were deposited during the previous year (Ferguson 1955, Pyrah et al. 1972) were counted in October 1980. Pyrah et al. (1972) reported a 70% deterioration rate of sage grouse pellets over 15 months. Since most grouse pellets found in the burn area are deposited during the fall, winter, and spring, few pellets older than 1 year should have been present during the first count. To compare 2 seasons of grouse and pronghorn use of the burn area in 1981, pellet densities observed in the second and third counts were divided by the time elapsed since the second count.

Jack rabbits were present in the burn area throughout the year, pellet densities were divided by the mean time interval between counts on the burn or control plots. Pellet densities in the first count were divided by 12 months; however, because of the persistence of jack rabbit pellets in arid environments (Flinders and Crawford 1977), this may have overestimated pellet deposition prior to October 1980. Jack rabbit densities were estimated by the following equation:

$$D = \frac{P}{M \times 16{,}350} \times 10{,}000$$

Where:

D = jack rabbits/ha

P = pellets/m^2 from pellet counts

M = number of months since pellet plots were cleared

16,350 = pellets defecated/month/jack rabbit (Arnold and Reynolds 1943)

10,000 = m^2/ha

Differences in grouse and pronghorn pellet densities on the burn and control sites were tested by Mann-Whitney tests (Snedecor and Cochran 1967) with $\underline{X}^2$ values corrected for ties. Mann-Whitney tests were also used to compare grouse and pronghorn pellet deposition rates for 2 seasonal periods (second and third counts) during 1981. Jack rabbit pellet deposition rates on the burn and control sites were compared by a one-way nested analysis of variance. Chi-square tests of homogeneity of the proportions of plots which were assigned to the

4 density classes were used to compare pygmy rabbit pellet densities. Differences in pellet densities or deposition rates were considered significant if $P \leq 0.05$.

Food Habits

Grouse, pygmy rabbit, jack rabbit, and pronghorn seasonal food habits were determined by microhistological analysis of fecal contents (Sparks and Malachek 1968). Sage grouse feces were collected during April-June 1981 and March-July 1982. Fecal samples were obtained from strutting grounds, flush sites of radio-collared and unmarked grouse, and near nest sites within the 300 km^2 study area surrounding the burn site. Except for feces collected on strutting grounds in 1981, each fecal sample represented a portion of the diet of 1 sage grouse. Covariance and correlation anlayses (Snedecor and Cochran 1967) using date of fecal deposition and the total relative density of summer food items as variables were used to compare the diets of grouse on the basis of sex and reproductive status. Summer food items included all animal and plant taxa except for Artemisia spp. and Atriplex spp. Feces collected on strutting grounds were obtained late in the breeding season when few or no hens were in attendance. Only fresh (1-2 days old) feces were collected from strutting grounds. Feces deposited near nests by incubating hens were easily identified by their size (2-4 cm in diameter; Patterson 1952) and were collected without regard for age. Unless defecation was observed, feces of incubating hens were considered to have been deposited during mid-incubation.

Pygmy rabbit fecal samples were collected from July through December 1981 and in March and July 1982. Feces were obtained from active burrows on and near the burn site and from beneath rabbits live-trapped on the burn site.

Jack rabbit feces were collected on or adjacent to the burn site from December 1980 through November 1981. Eight to 10 samples were composited monthly from the collections. When possible, pellets were collected from the top of fresh snow. The March 1981 samples were removed from the lower intestines of 8 jack rabbits collected near the burn site in early April. Most of the fecal samples obtained from April through November 1981 were collected from 5 permanent circular 50 m^2 plots located along the south boundary of the burn site. The remaining samples were collected on or near the pellet count plots and appeared at the time of collection to have been recently deposited.

Pronghorn pellet groups were collected from herd locations and along unimproved vehicle trails within a 300 km^2 area surrounding the burn site. Care was taken to collect only those pellet groups which were deposited during the month of collection. Ten pellet groups per month were collected from December 1980 through November 1981. Each fecal sample represented a portion of the diet of 1 pronghorn.

All fecal samples were analyzed by the Composition Analysis Laboratory at Colorado State University. The methodology of the fecal analysis has been described by Sparks and Malachek (1968) and Hansen et al. (1976). Botanical compositon of pronghorn and lagomorph samples was determined by viewing 20 microscope fields per sample at

100X magnification; 40 fields were viewed per sage grouse sample. Arthropod composition of grouse feces was determined before grinding by viewing 40 points per sample at 10X magnification. Plant fragments were identified by comparison of epidermal characteristics with reference specimens which were collected on the INEL. Unidentified species were grouped by genus or family. Fecal composition was reported as the relative density of plant or arthropod fragments identified in the samples. Since fecal samples were ground to particles of uniform size, relative density was a direct estimate of percent dry weight composition (Sparks and Malachek 1968).

Twenty-two grouse, 17 jack rabbit, and 17 pronghorn duplicate samples were analyzed to estimate the precision of the fecal analyses. Duplicate grouse samples were created by cutting individual pellets in half. Jack rabbit and pronghorn duplicate samples were ground and then shaken prior to separation to ensure that duplicate samples would be identical.

One-way analysis of variance was used to test for monthly differences in the relative density of shrub and forb taxa which comprised > 5% of all feces collected from pygmy rabbits, jack rabbits, and pronghorn. Other shrubs, other forbs, and grasses were analyzed as composite forage categories. Months in which the above forage categories did not occur were not included in the analyses. Duncan's new multiple range test was used to separate significant differences between monthly means. The significance level for all statistical tests of diet data was $P \leq 0.05$.

Sage Grouse Seasonal Distribution and Movements

Sage grouse strutting grounds within the 300 km^2 study area were located by ground surveys and from an airplane during the springs of 1981-82. Grouse were captured by nightlighting (Giesen et al. 1982) and mist-netting on 5 strutting grounds within 6.5 km of the burn site. Captured grouse were marked with numbered patagial tags (males), poncho tags (females; Pyrah 1970), or with poncho-mounted radio-collars (males and females; Amstrup 1980). Each captured bird was sexed, aged (Crunden 1963), and marked with a numbered leg-band.

Five strutting grounds were censused (Jenni and Hartzler 1978) during the springs of 1981-83. Three of the 5 grounds were censused from late March through mid-May in 1981. Two additional strutting grounds were discovered on the burn site and censused from late March through April in 1982. Four strutting grounds were censused 1 to 4 times in April 1983. Strutting ground attendance was reported as the maximum male count observed after peak female attendance. With 1 exception, strutting grounds were censused only on relatively calm, dry mornings.

During the summers of 1980-82, a 12 km sage grouse observation transect was driven along the sagebrush-cropland interface north of the burn site. The route was driven 1 to 2 times per week during mornings and evenings from June through September in 1980 and 1981. The route was driven once every 1 to 2 weeks from mid-June through August in 1982. Grouse were counted on the transect only during calm, warm, and dry weather. Males, broods, females without broods, mixed sex flocks, and flocks of unknown composition were recorded

separately. Grouse were captured in or near cropland along the transect with a net gun (Mechlin and Schaiffer 1980), mist nets, and by nightlighting. Captured grouse were leg-banded and tagged or radio-collared during the summers of 1980-82 as described for grouse captured on strutting grounds.

Observations of tagged grouse, band returns reported by hunters, and radiotelemetry data provided data on seasonal distribution and movements of sage grouse in relation to the burn site. Radio-collared grouse were located from the ground at least once per week during most of mid-spring through mid-fall. During June through September, individual grouse were located 2 to 6 times per week. From late fall through early spring, locations were obtained from 1 to 4 times every 2 months. Due to inaccessibility of areas used by radio-collared grouse during the winter, most locations were determined from an airplane. Airplane locations were considered to be accurate within 400 m (16 ha). Locations of radio-collared grouse were recorded on 1:24,000 scale topographic maps. A habitat description and the number and sex of other grouse observed were recorded at the site of all radio-locations determined from the ground. Seasonal ranges of radio-collared grouse were delimited by the minimum area method (Mohr 1947).

Pygmy Rabbit Post-burn Mortality and Dispersal

Radiotelemetry was used to investigate movements, mortality, and dispersal of pygmy rabbits on the burn site before and after treatment. Rabbits were captured with Tomahawk^{R} double-door live-traps set at

burrow entrances on the southwest corner of the burn site. Captured rabbits were marked with numbered ear tags and/or 9-11 gram.(g) radio-collars. Sex, weight, ear length, hind foot length, and trap location were recorded for each capture.

Pygmy rabbits were radio-collared prior to burning on 18 August 1981. Trapping was continued after the first burn in anticipation of a second burn which occurred in early October 1981. Rabbits were also trapped in December 1981 and in March, July, and August 1982. Radio-collared rabbits were located by triangulation with a vehicle-mounted null-peak antenna system. Additional locations were determined by flushing radio-collared rabbits and from trap recaptures. Individual rabbits were usually located 1 to 5 times per week from 13 July to 16 November, 1981. Dispersing rabbits were located from an airplane. Locations and the fate of dispersers were confirmed by ground observations.

Weighted mean weekly survival rates of radio-collared rabbits were calculated for the pre- and post-burn periods using the method of Trent and Rongstad (1974):

$$Sn = \sum_{i=1}^{n} (x_i - y_i) / \sum_{i=1}^{n} (x_i)^n$$

Where:

Sn = survival rate over a period of n weeks

n = number of weeks in the period

x_i = number of rabbits alive at the start of the ith week

y_i = number of rabbit mortalities observed in the ith week

Only those rabbits whose fates could be determined were used to calculate survival rates. Rabbits which were found dead after not being located for 1 or more weeks were assumed to have died during the week that they were discovered. Because of this assumption, a more conservative estimate of the post-burn mortality rate was obtained.

Burrow activity was determined in December 1981, March and July 1982, and May 1983 for those burrows at which pygmy rabbits were captured during the study. A rabbit captured or observed at a burrow or the presence of fresh tracks in snow or mud around an unoccluded burrow entrance were accepted as positive evidence of burrow use. Burrows which had all of their entrances completely closed by the accumulation of soil or plant litter were considered to be inactive regardless of the presence of other signs of acitvity.

SAGE GROUSE SEASONAL FOOD HABITS, DISTRIBUTION, AND MOVEMENTS IN RELATION TO THE BURN SITE

Results

Pellet Counts

Sage grouse pellet densities were not significantly different on the burn and control pellet plots in the 3 pre-burn pellet counts ($P > 0.350$). Pellet density was significantly higher ($P = 0.001$) on the burn site than on the control site in the post-burn count (Table 1). Twenty-five pellet plots were at least partially burned in 1981. Sage grouse pellet densities [mean ± standard error ($\bar{x} \pm SE$)] were higher on the 25 burned plots (400 ± 168 pellets/ha) than on the remaining 75 plots on the burn site (228 ± 88 pellets/ha); however, the difference was not significant (Mann-Whitney test, $P = 0.340$). Thus, the higher pellet densities observed on the burn site in the fourth count were characteristic of burned as well as unburned areas.

Estimated grouse pellet deposition rates on the control site were ($\bar{x} \pm SE$) 55 ± 14 pellets/ha/month from October 1980 through May 1981 (second count) and 28 ± 8 pellets/ha/month from June through August 1981 (third count). Deposition rates on the burn site were 48 ± 10 and 63 ± 19 pellets/ha/month for the same 2 periods, respectively. Pellet deposition rates on both the burn and control sites were significantly greater ($P < 0.05$) during mid-fall through late spring 1980-81 than during the summer of 1981. The discrepancy between the

Table 1. Sage grouse pellet densities (pellets/ha) and % occurrence on the burn and control pellet-count grids. The first 3 counts were pre-burn, the fourth count was 1 year post-burn.

Pellet grid		Count 1 October 1980	Count 2 June 1981	Count 3 August, October 1981	Count 4 August 1982
Burns grids[a] N = 25[b]	1	90 ± 48	210 ± 57	160 ± 78	270 ± 171
	2	20 ± 18	200 ± 61	20 ± 20	40 ± 19
	3	390 ± 139	320 ± 113	230 ± 128	310 ± 157
	4	615 ± 169	900 ± 307	160 ± 78	460 ± 208
All burn plots N = 100[b]		278 ± 60	408 ± 88	143 ± 43	270 ± 78
% occurrence		26%	49%	18%	27%
Control grids[a] N = 25[b]	1	73 ± 53	145 ± 58	63 ± 38	83 ± 54
	2	130 ± 75	450 ± 399	80 ± 54	60 ± 60
	3	310 ± 102	720 ± 140	70 ± 23	30 ± 17
	4	140 ± 53	410 ± 156	40 ± 19	20 ± 14
All control plots N = 100[b]		164 ± 37	434 ± 115	63 ± 18	48 ± 21
% occurrence		31%	44%	17%	10%
Burn vs control, Mann-Whitney test[c]	χ^2	0.86	0.40	0.20	10.08
	P	0.353	0.529	0.657	0.001

[a] $\bar{x}$ ± SE.
[b] Due to missing data some cells contain 1 or 2 fewer observations.
[c] Tests were conducted using the data collected on individual pellet plots.

means calculated for the burn site and the outcome of the statistical test arose from the relatively large (325-1300 pellets/ha/month) deposition rate estimates obtained on 8 pellet plots in the third count. There was no pellet deposition on 82 of the remaining 92 pellet plots in the third count. In the second count, however, pellet deposition was more evenly distributed with 49% of the plots containing feces and only 3 with deposition rates of 250-875 pellets/ha/month.

A comparison of sage grouse pellet densities between years was possible since the first, third, and fourth pellet-counts were conducted at approximately the same time of year. The second and third pellet-count results were combined to represent pellet densities from early fall 1980 through late summer 1981. The mean of the pellet densities obtained for each of the 8 pellet grids were ($\bar{x}$ ± SE) 220 ± 72, 523 ± 102, and 160 ± 58 pellets/ha in 1979-80, 1980-81, and 1981-82, respectively. These densities inversely followed yearly trends in mean snow depths recorded at CFA, 17 km south of the burn site. Mean daily snow depths at CFA during November through February were 2.6 and 2.3 cm in 1979-80 and 1980-81 when the 2 highest pellet densities were observed. The lowest pellet density was observed in 1981-82 when the mean daily snow depth was 6.4 cm. Although mean snow depths were similar in 1979-80 and 1980-81, snow cover at CFA was more persistent in 1979-80 (Fig. 3). Thus, the burn and control sites were probably snow-free or had minimal snow cover for a longer period in the winter 1980-81 than in the other 2 winters. This may at least partially explain the relatively high grouse pellet density which was observed in 1980-81.

Food Habits

One hundred thirty-nine fecal samples were collected from grouse of known sex and reproductive status during the springs and early summers of 1981 and 1982. Artemisia spp. comprised > 75% and other shrubs comprised < 1% of the fecal samples in both years (Tables 2 and 3). Forbs were the second most important forage, with arthropods (primarily insects) and grasses each accounting for < 1% of the identified fecal fragments. The composition of duplicate fecal samples were very highly correlated ($r \simeq 1.00$), indicating a high degree of precision in the fecal analyses.

Grouse of different sex and reproductive classes did not consume equal proportions of summer foods between April and July 1981 and 1982 ($P \leq 0.01$). In 1981, a single brood hen consumed the largest proportion of summer foods followed by broodless hens, incubating hens, and finally males. Broodless hens consumed the largest proportion of summer foods in 1982 with brood hens, pre-incubating hens, males, and incubating hens consuming successively smaller proportions (Table 4). Feces collected from brood hens in both years contained the highest relative densities of arthropods, > 50% of which were identified as Formicidae.

There were significant ($P < 0.01$) positive correlations between the relative density of summer food taxa occurring in fecal samples and dates of sample collection in 1981 and 1982 (Table 4). The rate of increase in summer food taxa was significantly higher during the 1981 sampling period than in 1982 (t-test, $P < 0.001$). The mean

Table 2. Relative densities of plant and arthropod taxa identified in sage grouse feces collected from 24 April through 23 June 1981.

Taxon	Males N = 17	Incubating hens N = 7	Brood hen N = 6	Broodless hens N = 9	All fecal samples N = 39
Artemisia spp.	90.7 ± 3.6	80.0 ± 7.2	54.7 ± 10.1	66.7 ± 10.3	77.7 ± 4.0
Chrysothamnus spp.	0.1 ± 0.1				Tr[a]
Total shrub	90.8 ± 3.6	80.0 ± 7.2	54.7 ± 10.1	66.7 ± 10.3	77.7 ± 4.0
Arabis spp.		0.1 ± 0.1		0.1 ± 0.1	Tr
Compositae		0.2 ± 0.1	0.4 ± 0.3	Tr	0.1 ± 0.1
Descurainia spp.	2.7 ± 2.4	0.3 ± 0.2	4.1 ± 2.3	29.0 ± 10.5	8.6 ± 3.1
Descurainia spp. seed				0.8 ± 0.8	0.2 ± 0.2
Erigeron spp.	0.1 ± 0.1	0.2 ± 0.2	1.6 ± 0.8	0.1 ± 0.1	0.4 ± 0.1
Eriogonum spp.		0.1 ± 0.1	0.8 ± 0.4	0.1 ± 0.1	0.2 ± 0.1
Medicago-Melilotus spp.	0.1 ± 0.1		0.3 ± 0.3		0.1 ± 0.1
Moss	Tr			0.4 ± 0.4	0.1 ± 0.1
Mycorrhiza spp.				0.1 ± 0.1	Tr
Nicotiana spp.			0.1 ± 0.1		Tr
Penstemon spp.	Tr	0.1 ± 0.1	0.7 ± 0.6		0.1 ± 0.1
Vicia spp.	6.0 ± 3.0	18.9 ± 7.4	36.3 ± 10.6	2.3 ± 1.4	12.1 ± 3.0
Total forb	8.9 ± 3.6	19.9 ± 7.2	44.3 ± 10.1	33.0 ± 10.3	21.9 ± 4.0
Coleoptera	0.1 ± 0.1	Tr	Tr	Tr	Tr
Diptera			0.1 ± 0.1		Tr
Formicidae	0.1 ± 0.1		0.8 ± 0.5	0.2 ± 0.1	0.2 ± 0.1
Other insect	Tr	0.2 ± 0.2	Tr	Tr	0.1 ± 0.1
Total insect	0.2 ± 0.2	0.2 ± 0.2	0.9 ± 0.5	0.2 ± 0.5	0.3 ± 0.1

[a]Trace, < 0.1.

Table 3. Relative densities of plant and arthropod taxa identified in sage grouse feces collected from 19 March through 19 July 1982.

Taxon	Males N = 37	Pre-incubation hens N = 25	Incubating hens N = 10	Brood hens N = 22	Broodless hens N = 6	All fecal samples N = 100
Artemisia spp.	98.0 ± 0.6	77.7 ± 5.4	98.7 ± 0.4	77.1 ± 5.2	34.4 ± 16.6	84.5 ± 2.6
Atriplex spp.		0.1 ± 0.1	0.1 ± 0.1	Tr[a]		
Chrysothamnus nauseosus		1.6 ± 0.9	0.1 ± 0.1	1.3 ± 0.7	0.1 ± 0.1	0.7 ± 0.3
Chrysothamnus viscidiflorus	Tr		0.2 ± 0.1	Tr		Tr
Opuntia spp. seed				0.1 ± 0.1		Tr
Total shrub	98.1 ± 0.6	79.1 ± 5.4	99.1 ± 0.4	78.5 ± 5.1	34.5 ± 5.1	85.3 ± 2.5
Agropyron spp.		Tr		0.1 ± 0.1		Tr
Poa spp.	Tr					Tr
Stipa spp.				0.1 ± 0.0	0.2 ± 0.2	Tr
Total grass	Tr	Tr	0.0 ± 0.0	0.2 ± 0.1	0.2 ± 0.2	0.1 ± 0.0
Araneida				Tr		Tr
Arthropod parts	Tr	0.2 ± 0.2				0.1 ± 0.1
Coleoptera	Tr	Tr	Tr	0.8 ± 0.5	Tr	0.2 ± 0.1
Coleoptera larvae	Tr					Tr
Curculioniday		Tr				Tr
Diptera	Tr	Tr				Tr
Formicidae	Tr	Tr	0.1 ± 0.1	2.0 ± 0.9	1.0 ± 0.6	0.5 ± 0.2
Lepidoptera	Tr	Tr	Tr	0.1 ± 0.1		Tr
Mallophaga	Tr					Tr
Orthoptera	Tr			0.6 ± 0.3	Tr	0.1 ± 0.1
Total arthropod	Tr	0.3 ± 0.2	0.1 ± 0.1	3.4 ± 1.1	1.0 ± 0.6	0.9 ± 0.3

Table 3. Continued.

Taxon	Males N = 37	Pre-incubating hens N = 25	Incubating hens N = 10	Brood hens N = 22	Broodless hens N = 6	All fecal samples N = 100
Astragalus spp.		0.1 ± 0.1			1.3 ± 0.8	0.1 ± 0.1
Compositae				0.2 ± 0.1		Tr
Compositae flower				1.0 ± 0.6	55.0 ± 16.8	3.5 ± 1.6
Conyza spp.				4.9 ± 4.0		1.1 ± 0.9
Cordylanthus spp.	Tr			0.1 ± 0.1		Tr
Crepis spp.	Tr	1.7 ± 0.8	0.6 ± 0.3	0.2 ± 0.1	0.6 ± 0.3	0.6 ± 0.2
Cymopterus spp.		Tr		0.1 ± 0.1		Tr
Descurainia spp.	0.2 ± 0.2	1.4 ± 0.5		5.4 ± 2.5	0.5 ± 0.3	1.6 ± 0.6
Erigeron spp.		0.2 ± 0.1		0.1 ± 0.1		0.1 ± 0.0
Eriogonum spp.	Tr	0.4 ± 0.4				0.1 ± 0.1
Kochia scoparia	Tr			0.1 ± 0.1		Tr
Lepidium spp.	Tr	0.5 ± 0.2			0.6 ± 0.6	0.2 ± 0.1
Lupinus spp.				0.1 ± 0.1		Tr
Medicago-Melilotus	0.4 ± 0.3	7.5 ± 2.1	0.1 ± 0.1	2.7 ± 2.0	2.7 ± 2.2	2.8 ± 0.7
Mentzelia spp.				1.4 ± 0.6		0.3 ± 0.1
Penstemon spp.	1.1 ± 0.5	7.5 ± 3.3	0.2 ± 0.1	0.4 ± 0.2	0.3 ± 0.2	2.4 ± 0.9
Phlox spp.		0.5 ± 0.3		0.3 ± 0.2		0.2 ± 0.1
Polemonium spp.					0.3 ± 0.3	Tr
Senecio spp.		0.6 ± 0.4		0.2 ± 0.1		0.2 ± 0.1
Sisymbrium spp.				0.4 ± 0.4		0.1 ± 0.1
Sphaeralcea spp.		Tr	0.1 ± 0.1			Tr
Vicia spp.		0.1 ± 0.1		Tr		Tr
Unknown forb				0.1 ± 0.0	0.5 ± 0.4	Tr
Unknown flower					2.2 ± 2.2	0.1 ± 0.1
Plantago spp. seed				Tr	0.3 ± 0.3	Tr
Total forb	1.9 ± 0.6	20.6 ± 5.3	0.9 ± 0.3	17.8 ± 4.8	64.3 ± 16.3	13.7 ± 2.5

[a]Trace, < 0.1

Table 4. Relationship of summer food proportions in sage grouse feces to date of sample collection and sample origin during March through July 1981-82. Summer foods included all food items except Artemisia spp. and Atriplex spp.

Year	Sex and reproductive class	N	% summer foods $\bar{x}$ ± SE	Adjusted mean[a] % summer foods	Daily change[b] in % summer foods	r
1981	Males	17	9.4 ± 3.6	15.8	0.6	0.39
	Incubating hens	7	20.0 ± 7.2	25.9	-0.4	-0.36
	Brood hen	6	45.3 ± 10.1	30.4	-0.5	-0.14
	Broodless hens	9	33.3 ± 10.3	26.9	1.4	0.87**
	All classes	39	22.4 ± 4.0		0.8	0.62**
1982	Males	37	2.0 ± 0.6	4.5 C[c]	0.0	0.10
	Pre-incubating hens	35	22.5 ± 4.6	28.0 AB	1.1	0.39**
	Incubating hens	10	1.2 ± 0.4	0.9 C	0.0	-0.35
	Brood hens	22	22.9 ± 5.2	15.1 BC	-0.8	-0.26
	Broodless hens	6	65.6 ± 16.6	55.9 A	1.8	0.60
	All classes	100	15.4 ± 2.6		0.3	0.33**

[a]Adjusted by covariance analysis with date of sample collection as the covariate.
[b]Estimated from slope of least squares line with date of sample collection as the independent variable.
[c]Adjusted means sharing common letters were not significantly different; t-test, $P \leq 0.05$.
*Significant at $P \leq 0.05$.
**Significant at $P \leq 0.01$.

relative density of Artemisia spp. was higher and that of forbs lower in the 1982 fecal samples, so pooling of the data from each year was not justifiable. Fewer shrub, forb, and arthropod taxa were identified in the 1981 samples. No grasses occurred in the 1981 samples, although 3 genera were detected in 1982.

Mean relative densities of summer foods determined for different sex and reproductive classes were adjusted by covariance analysis to remove the variation associated with date of sample collection (Table 4). Significant differences between adjusted means occurred only in the 1982 samples ($P < 0.001$). In 1981, dietary composition was related more to date of sample collection than to sex and reproductive status. In 1982, there was a stronger relationship of fecal composition with sex and reproductive status and a weaker relationship with date of collection. Within the 1982 samples, the adjusted means for broodless and pre-incubating hens were significantly higher (t-test, $P < 0.05$) than for males and incubating hens. The adjusted mean for brood hens was significantly different from only the adjusted mean for broodless hens.

Summer foods increased significantly ($P < 0.05$) with time only in the diets of broodless hens in 1981 and pre-incubating hens in 1982. A significant increase may have also been observed for broodless hens in 1982 if the sample size had been larger.

Individually, 5 of 7 hens from which successive fecal samples were obtained exhibited dietary changes associated with reproductive activity. These changes paralleled those observed in the sample of feces collected from all hens in 1982. There was an emphasis on

summer food consumption until incubation followed by increased use of sagebrush until after hatching. The dietary transition for 1 hen was very abrupt; her fecal content decreased from 97% the day of hatching to 49% 1 day later. The other 2 hens showed no definite relationship between diet and reproductive status other than the first appearance of arthropods after hatching.

Seasonal Distribution and Movements

Spring

Sage grouse used 9 strutting grounds within the 300 km^2 study area. Two grounds located on or adjacent to the burn site were used prior to the 1981 burns. One strutting ground was discovered in April 1982 on an area which was burned in August 1981. Three other strutting grounds were found within 6.5 km of the burn site.

Strutting ground counts indicated a substantial decline in the breeding population of male sage grouse between 1981 and 1983 (Table 5). Population trends on the 2 grounds located on and adjacent to the burn site prior to treatment (8-mile Canyon #1 and #2) were similar to the trends observed on 2 strutting grounds 3.5-6.5 km from the burn site (Sinks #1, Howe Peak). Although grouse were not observed on the Howe Peak strutting ground in 1982 and 1983, the presence of a few fresh feces indicated that a few grouse attended in those years.

One of 4 males observed displaying in April 1982 on an area which was burned in August 1981 was tagged as a juvenile near cropland north of the burn site in July 1980. This male (M510) was recaptured on the 8-mile Canyon #1 ground on 28 March 1981 and observed on 27 March 1982

Table 5. Sage grouse strutting ground count summary, 1981-1983.

Strutting ground (location)	1981 Date	1981 M-F	1982 Date	1982 M-F	1983 Date	1983 M-F
8-mile Canyon #1 (0.1 km north of burn site)	3/23	37-20	3/22	16-0	3/22	16-15
	4/3	41-8	3/26	18-0	4/1	18-7
	4/10	45-4	3/27	20-4	4/6	15-2
	4/11	33-2	4/12	12-11	4/9	17-0
	5/2	40-0	4/24	20-2		
	5/14	0-0	4/25	25-3		
			4/29	23-2		
Maximum count (males)		45		25		18
% change		—		-44%		-28%
8-mile Canyon #2 (0.5 km south of 8-mile Canyon #1)	No counts		4/13	12-5	3/22	3-0
			4/16	10-4	4/1	1-0
			4/24	6-0	4/6	0-0
			4/29	7-0	4/9	0-0
Maximum count (males)		—		12		3
% change		—		—		-75%
Sinks #1 (6.5 km east of burn site)	3/25	37-11	4/23	11-3	4/2	16-2
	4/3	35-4	4/26	20-2	4/9	16-2
	4/10	38-4				
	4/18	39-0				
	5/2	26-1				
Maximum count (males)		39		20		16
% change		—		-49%		-20%
Howe Peak (3.5 km southeast of burn site)	4/13	18-0	4/10	0-0	4/1	0-0
	4/18	13-0	4/23	0-0		
	4/22	17-0	4/23	0-0		
Maximum count (males)		18		0		0
% change		—		-100%		0%
Knob Butte (2.0 km south of 8-mile Canyon #1)	No counts		4/10	3-7	3/22	5-0
			4/12	3-11	4/1	4-3
			4/16	3-8	4/6	4-2
			4/23	4-0		
			4/24	0-0		
			4/29	0-0		
Maximum count (males)		—		4		5
% change		—		—		+25%

on this same ground. He appeared unable to defend a breeding territory and was continually displaced by other males. On 10 April 1982, he was observed displaying on a burned area 2 km to the south (Knob Butte strutting ground). He maintained what appeared to be a central position in a lek that consisted of 2 other males and 7 females. The 7 females remained mostly within an area which M510 successfully defended from intrusion by the other 2 males. Six days later M510 was observed copulating with 1 of 8 females attending the lek. No copulations involving 3 other males were observed. Two males and 3 females were captured and tagged while roosting on the new strutting ground in April 1982. Both males were adults (> 2 years) and were reobserved displaying with M510 on 16 and 23 April 1982. The 3 females were yearlings (< 2 years) which were radio-collared and followed to nest sites. Only 1 of the hens were relocated the following spring; however, the strutting ground which she attended in 1983 was unknown.

In April 1983, the Knob Butte strutting ground could be counted only by flushing the birds. No grouse were observed displaying in the exact area on which they were observed in April 1982. Instead they were heard displaying and subsequently flushed from small burned openings in the sagebrush within 30-75 m of the area used in 1982. One to 2 tagged males were observed each morning that this ground was visited; however, their identities were not determined.

Ninety-five grouse were marked on 5 strutting grounds closest to the burn site in the springs 1981-82. Six of 78 males and 15 of 17 females were radio-collared (Table 6). Excluding locations during

Table 6. Summary of sage grouse captures on and near strutting grounds during the springs of 1981-82.

Strutting ground	1981			1982			Total captures
	Males	Females	Mortalities	Males	Females	Mortalities	
8-mile Canyon #1	10(2)[a]	1(1)[b]	1	10(0)	5(5)	1	28
8-mile Canyon #2		No captures		5(0)	1(1)	0	6
Sinks #1	27(2)	3(3)	1[c]	20(0)	4(2)	0	55
Howe Peak	4(2)	0(0)	0		No captures		4
Knob Butte		No captures		2(0)	3(3)	0	5
Total	41(6)	4(4)	2	37(0)	13(11)	1	98

[a]Number of radio-collared grouse in parentheses.
[b]Captured on nest located on the burn site.
[c]Injury sustained prior to capture.

lek attendance, male grouse were located 41 times during April, May, and the first week of June. Locations were recorded at 0-8.9 km ($\bar{x}$ = 1.5 km) from their respective strutting grounds. Thirty-five (85%) locations were within 1.5 km of strutting grounds (Fig. 6). One male grouse was located 3 times, 8-9 km north of his strutting ground during late May and early June.

Movements to nest sites by 9 radio-collared hens from 4 strutting grounds on which they were captured ranged from 1.0-10.5 km ($\bar{x}$ = 4.5 km). Five of these hens were located 21 times prior to incubation at distances of 0.0-3.1 km ($\bar{x}$ = 0.7 km) from their nest sites. Eleven nests were discovered on the burn and control sites at distances of 1.9-2.6 km from the nearest strutting ground. Two other nests off the burn and control sites were discovered 2.7-4.3 km from the nearest known strutting ground. All nests of radio-collared hens and 12 of 13 nests discovered incidental to other field work were located beneath sagebrush in habitat dominated by sagebrush and perennial grasses. One nest was discovered in a grass meadow dominated by giant wildrye.

To determine nesting chronology of 6 radio-collared hens whose dates of hatching were known, the following assumptions were made: 1) hens captured on strutting grounds bred on the following day; 2) eggs were laid at the rate of 2 every 3 days and that there was a 1 day delay between completion of the clutch and onset of incubation (Petersen 1980); 3) the incubation period lasted 27 days (Patterson 1952, Petersen 1980). The actual incubation periods of 4 hens were known to be at least 25-31 days. The elapsed time between estimated

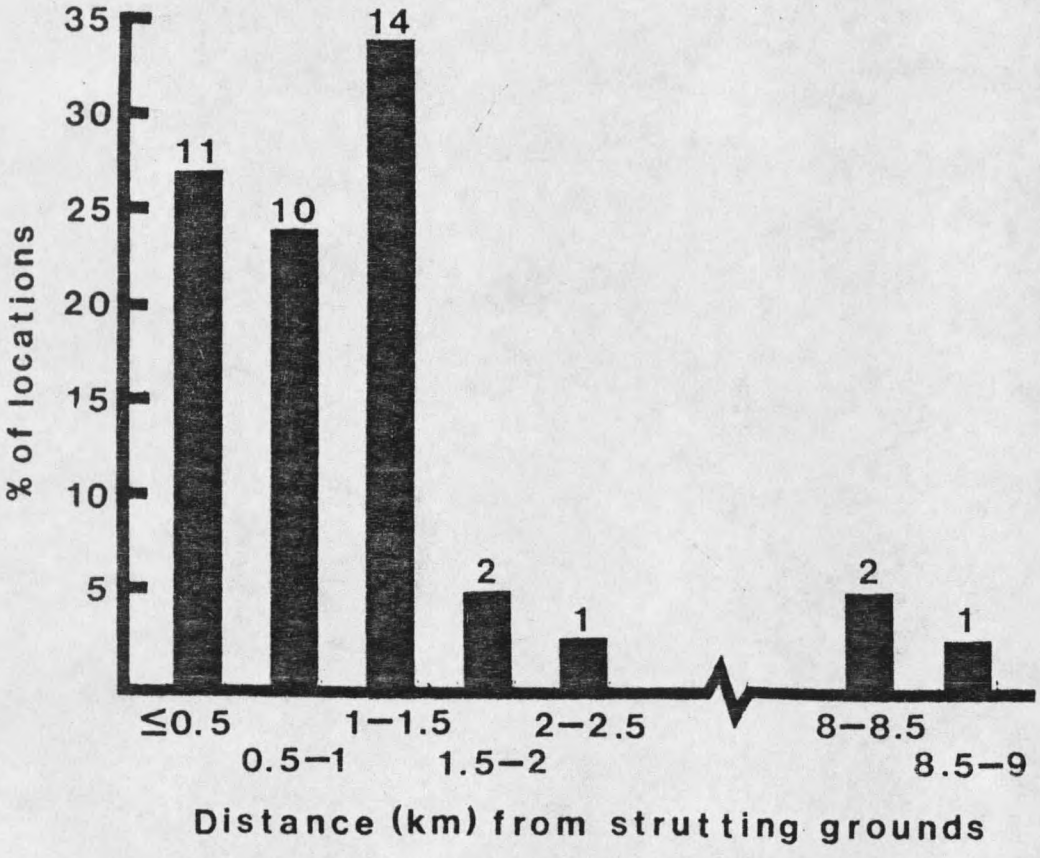


Fig. 6. Distances radio-collared male sage grouse were located from strutting grounds which they attended during 1 April-3 June 1981.

dates of breeding and onset of egg-laying was 7 to 14 days for 4 hens in 1982. These data are summarized in Appendix A, Table 27.

Twenty-two movements to summer habitat by marked grouse were observed; 18 were to irrigated cropland, 3 were toward INEL facilities, and 1 was to a natural spring. The movements of 10 males (8 wing-tagged, 2 radio-collared) were all to irrigated cropland north of the burn site (Fig. 7). Five of 6 radio-marked broods also moved to cropland north of the burn site during the summer (Fig. 8). In contrast to males and broods, broodless hens dispersed from breeding areas in more random directions (Fig. 9).

The minimum mean distance (12.5 km, range 3.7-22 km) that 14 radio-collared hens moved to summer ranges from strutting grounds on which they were captured was similar to the mean distance moved by males (14.2 km, range 8.9-22.5 km). Six broodless hens tended to move farther from strutting grounds to summer ranges ($\bar{x}$ = 13.8 km, range 3.7-22.2 km) than did 6 brood hens ($\bar{x}$ = 10.7 km, range 7.5-18.6 km); however, the difference was not significant (t-test, $P > 0.10$).

Due to transmitter failures, data on the timing of arrival of individual grouse on summer ranges were obtained for only 1 radio-collared brood hen and 1 male in 1981. These grouse completed movements to summer range by 16 June; however, the male was first located in cropland on 29 May 1981. Four broods were first located within 1 km of cropland between 3 June and 9 July ($\bar{x}$ = 22 June) in 1982, and a fifth did not arrive within 1 km of her summer range near NRF until the last week of July 1982. Three broodless hens did

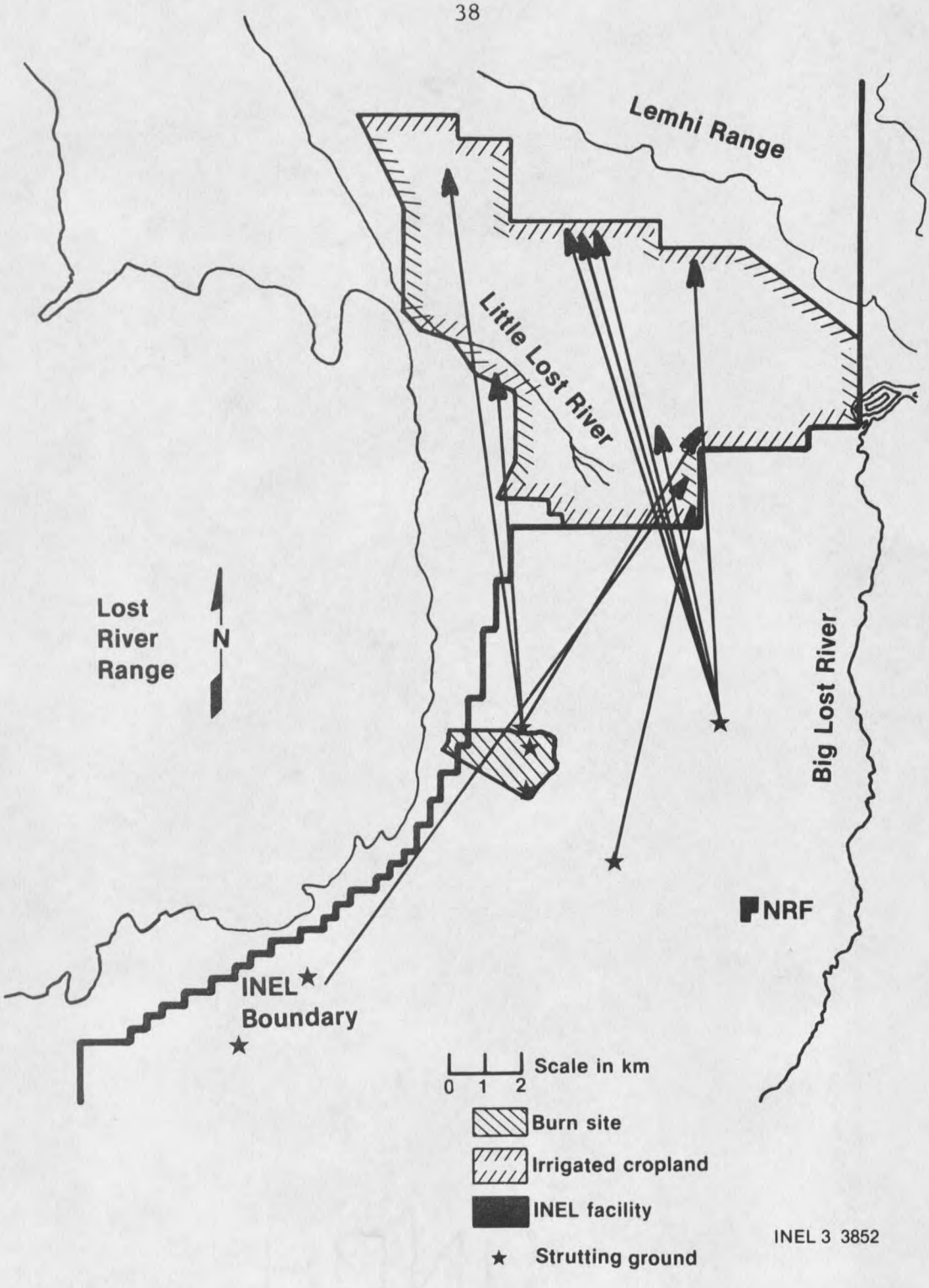


Fig. 7. Spring movements by male sage grouse from strutting grounds to summer ranges in 1981-83.

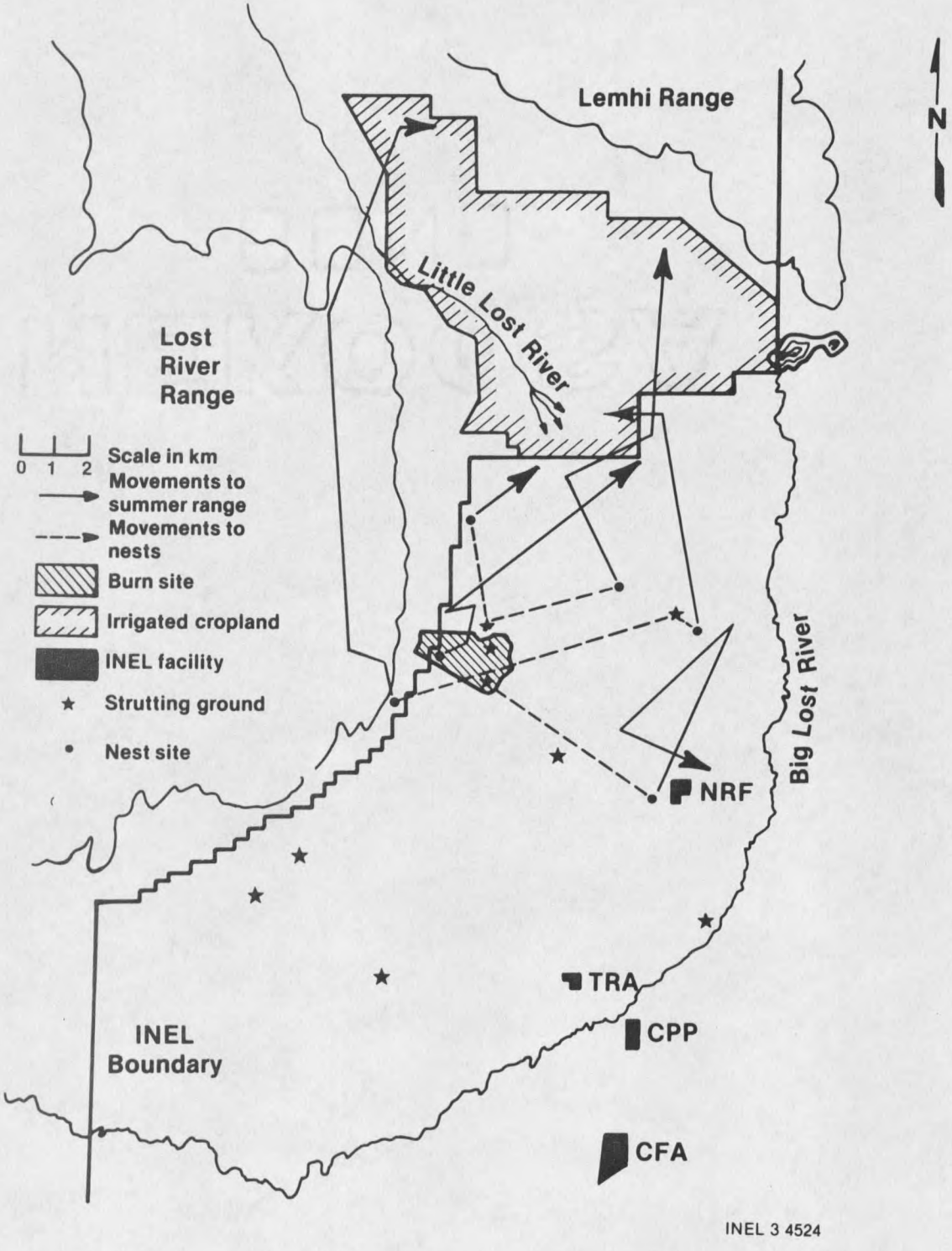


Fig. 8. Sage grouse brood hen movements to known nest sites and summer ranges during the springs of 1981-82.

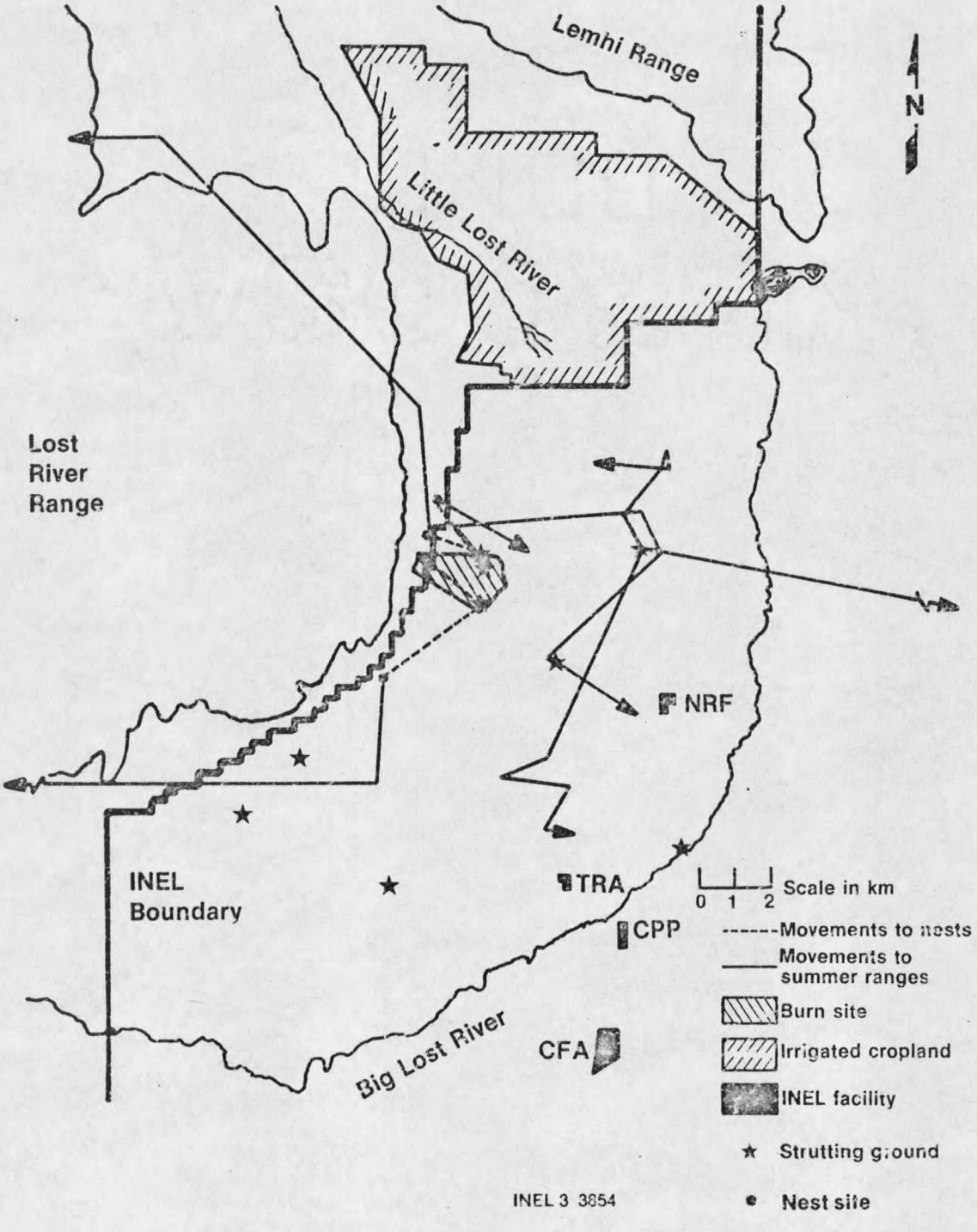


Fig. 9. Sage grouse broodless hen movements to known nest sites and summer ranges during the springs of 1981-82.

not arrive on summer ranges until early to mid-July (2 hens) or sometime during August 1982 (1 hen).

Five broods of known ages were located 105 times from the date of hatching through 64 days of age. During this period 2 types of brood movements to summer ranges were observed (Table 7). The 2 broods which hatched closest to their eventual summer ranges remained within 1 km of their nest sites for no longer than 4 days after hatching. These broods completed most of their movements to summer range prior to 13 days of age. The most rapid movement observed was made by a brood which moved 3.1 km from the nest within 2 days after hatching. Three broods which summered 2.3-17.2 km further from their nests than the above broods delayed their movements to summer range until 2 to 4 weeks after hatching. Although the distances these broods were located from the nest during the first 2 to 4 weeks varied considerably, movements were centered around or adjacent to the nest site.

Although the timing of brood movements varied with distances moved to summer ranges, the movements of 5 of 6 broods occurred in 2 stages. The first was an initial movement between early brood habitat near nest sites and a sagebrush-cropland ecotone. The second stage was movement into cropland followed by continued movements within cropland which tended to disperse the birds throughout the agricultural area. Two radio-collared males also exhibited this type of movement. Hunter returns and reobservations of male grouse indicated that other grouse which bred near the burn site also distributed themselves throughout the entire agricultural area.

Table 7. Movements and habitats used by 6 sage grouse broods.

Brood	No. locs.	Period	No. days after hatching	Brood range size (ha)	Max. dist. (km) and direction from nest	Habitat type[a]
514	7	27 May to 10 Jun 1981	1-15	208	2.9 NNE	Artemisia tridentata-Chrysothamnus viscidiflorus-Sitanion hystrix
	17	16 Jun to 23 Jul 1981	21-58	123	10.7 NE	Edge of cropland-Elymus cinereus-Sitanion hystrix-Chrysothamnus spp. meadow
564	6	4 Jun to 18 Jun 1982	1-15	8	0.6 SE	Elymus cinereus-Sitanion hystrix-Chrysothamnus spp. meadow
	6	22 Jun to 2 Jul 1982	19-29	443	6.0 N	Artemisia-tridentata-Chrysothamnus viscidiflorus-Sitanion hystrix adjacent to irrigated cropland
	5	9 Jul to 3 Sep 1982	36-93	ND[b]	13.4 N	Irrigated cropland
568	2	4 Jun to 7 Jun 1982	1-4	ND	0.8 S	Artemisia tridentata-Chrysothamnus viscidiflorus-Sitanion hystrix
	8	16 Jun to 2 Jul 1982	13-29	31	6.8 N	Artemisia tridentata-Chrysothamnus spp.-Sitanion hystrix adjacent to irrigated cropland

Table 7. Continued.

Brood	No. locs.	Period	No. days after hatching	Brood range size (ha)	Max. dist. (km) and direction from nest	Habitat type[a]
568	27	7 Jul to 22 Aug 1982	34-81	86	8.7 N	Irrigated cropland
569	16	3 Jun to 9 Jul 1982	2-38	46	3.1 NE	Agropyron cristatum seeding adjacent to irrigated cropland
573	10	21 Jun to 23 Jul 1982	ND	757	7.2 N	Artemisia tridentata-Chrysothamnus viscidiflorus-Sitanion hystrix
	2	3 Aug to 3 Sep 1982	ND	ND	3.6 NE	Naval Reactors Facility Area
699	15	3 Jun to 2 Jul 1982	2-31	207	2.4 N	Juniperus osteosperma-Artemisia spp.-Agropyron spicatum
	5	9 Jul to 3 Sep 1982	38-94	ND	21.1 N	Irrigated cropland

[a]Predominant vegetation observed at flush sites.
[b]Not determined.

A crested wheatgrass (Agropyron cristatum) seeding and grass-shrub meadow types adjacent to cropland received subterranean and surface runoff from irrigated fields which sustained forb growth after desiccation of forbs in sagebrush grassland. These meadow types provided transitional habitats which were used by broods after leaving the vicinity of their nests (Table 7).

Summer

Grouse were first observed on the cropland vehicle transect during the first, second, and fourth weeks of June in 1980, 1981, and 1982, respectively. Only males and broodless hens were observed during the first 2 weeks of June in 1980 and 1981. Broods were not observed in 1982 until mid-July. During 1980 and 1981, grouse observations on the transect tended to increase through June, peaked in early to mid-July, and declined thereafter (Fig. 10). Since there was no movement by radio-collared grouse away from cropland prior to late August, the tendency for grouse observations to decline after mid-July may have been due to grouse distributing themselves more evenly over the agricultural area. The large number of grouse observed in the third week of August 1981 resulted from enhanced visibility of birds using recently mowed alfalfa fields. No grouse were observed on the transect after the first week of October 1980 and after the last week of September after which the transect was discontinued.

Grouse observations per km of transect declined 72% between the summers of 1980 and 1982 (Table 8). The ratio of juveniles to adult hens observed on the transect indicated low production of young during the springs of 1980-82. Precipitation during May, the normal

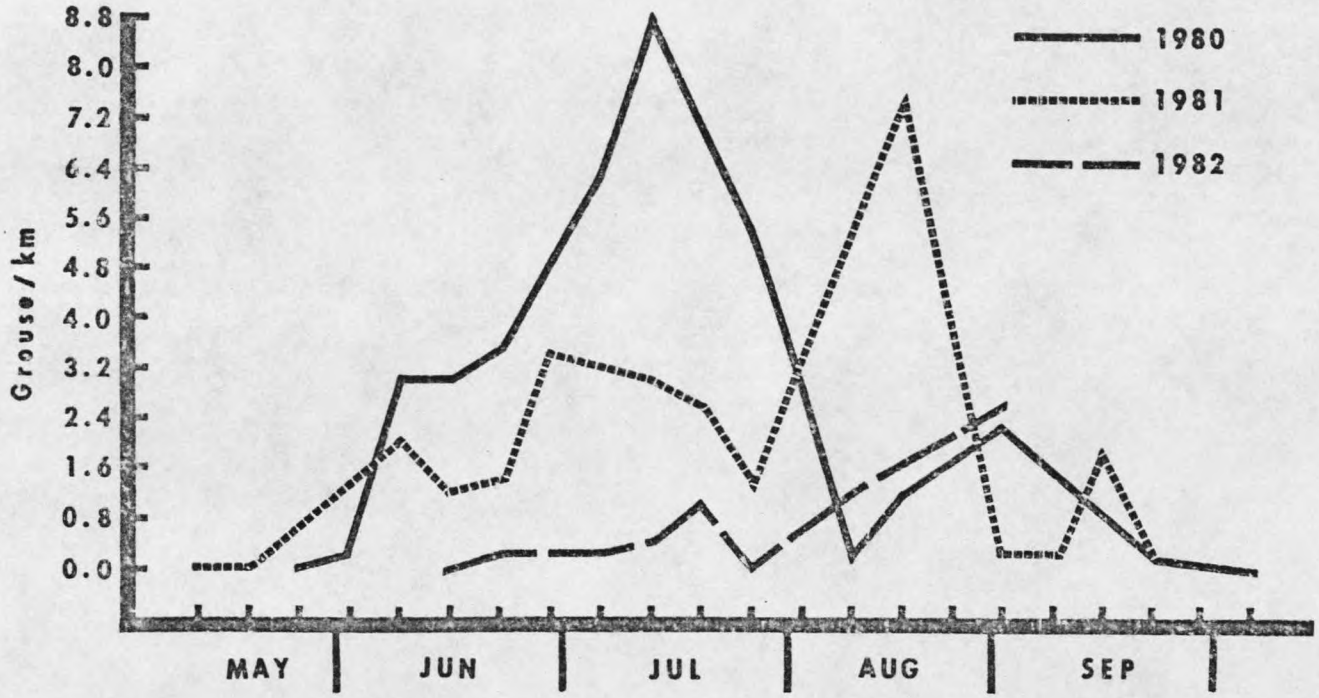


Fig. 10. Weekly sage grouse observations/km of transect adjacent to cropland from May through September 1980-82.

Table 8. Sex composition of sage grouse observations and production estimates obtained along a 12 km transect adjacent to cropland during the summers of 1980-82.

Year	Observations/km[a]					Mean[a] brood size $\bar{x}$(N) (range)	Juveniles[b] per 100 adult hens	Adult[b] males per 100 adult hens
	Males	Broodless hens	Broods	Other[c] grouse	Total grouse			
1980	1.04	1.13	0.15	0.83	3.16	3.00(27) (1-6)	34	72
1981	0.38	0.29	0.09	1.58	2.34	4.05(19) (2-7)	96	90
1982	0.12	0.15	0.04	0.56	0.88	3.17(6) (2-4)	68	54

[a]Based on observations made during June through September.
[b]Based on observations made during June and July in 1980 and 1981, and mid-June through mid-August in 1982.
[c]Includes unclassified birds, juveniles observed with brood hens, and mixed sex flocks.

month of peak hatching on the INEL (J. W. Connelly, pers. comm.), was 2.9 and 1.8 cm above the 20 year average in 1980 and 1981 (Fig. 3). Also, daily temperatures averaged 0.7C and 1.7C below normal in May of 1980 and 1981. Abnormally wet and cold weather during hatching adversely affects chick survival (Dalke et al. 1960). Despite below average precipitation during the spring of 1982, production was still estimated to be low; however, the small number of hens and broods observed in 1982 may not have accurately reflected reproductive success.

Telemetry data and grouse observations on the vehicle transect indicated that grouse began using cropland 3-4 weeks later in 1982 than in the 2 previous years. Klebenow (1969) and Oakleaf (1971) found that sage grouse moved to summer ranges later in wet years than in dry years because of delayed forb desiccation in sagebrush habitats. January through June precipitation totals recorded 17 km southeast of the burn site were 2.9 and 3.3 cm above average (12.2 cm) in 1980 and 1981 (Fig. 3). Precipitation during the same period in 1982 was 1.5 cm below average. Thus, during the years of this study in which precipitation during the first 6 months was above average, grouse moved to summer ranges earlier than in a year when precipitation was below average. In spite of lower precipitation, succulent forbs were observed in sagebrush grassland through most of the summer in 1982; whereas, during 1980 and 1981 most forbs became desiccated by the end of June. Abnormally high precipitation (1.3 cm above average) during July and August 1982 may have prolonged the season of forb growth into July and August 1982.

During the summers of 1980-82, 118 individual grouse were captured and marked in or near irrigated cropland north of the burn site (Table 9). Nightlighting accounted for nearly 90% of all captures. Only adult females and juveniles were captured with mist nets and the net gun. Since mortality was much higher for these 2 techniques, nightlighting was the only capture method used in 1981 and 1982.

The summer ranges of 11 radio-collared grouse using irrigated cropland averaged 297 ha (range 179-821 ha) based on 9-41 locations per grouse obtained during June-September 1981 and 1982 (Table 10). In addition, 80 relocations of tagged and radio-collared grouse with fewer than 10 locations were obtained in or near cropland during July-September 1980-82. Seventy-four (92.5%) of these relocations were within 2.0 km of capture sites in or near cropland (Table 11).

Two hundred sixty-two locations of 27 radio-collared grouse obtained during the summers of 1980-82 were assigned to 7 major habitat types in the agricultural area. Alfalfa fields were the habitat type most used by radio-collared grouse followed by sagebrush grassland and grass-shrub meadows which received irrigation runoff (Table 12). Smooth brome (Bromus inermis) dominated fencelines adjacent to alfalfa fields were used only during afternoons. Grouse were located in the other 6 habitat types at all times of day and while roosting.

Of 86 grouse marked on strutting grounds during the springs of 1981-82, 9 (10.5%) were harvested in irrigated cropland north of the burn site. Harvest mortality accounted for 27 of 109 (24.8%) grouse marked or known to be summering in cropland prior to opening day. The 1981 cohort of marked grouse summering in cropland was the most heavily

Table 9. Summary of sage grouse captures in and near cropland during the summers of 1980-82.

Year	Trap method	Adult[a] males	Adult[a] hens	Juveniles	Recaptures	Total captures	Trap deaths	% trap mortality
1980	Nightlight	2	3(2)[b]	4(1)		9	1	11%
	Mist net		5(3)	5	1	11	2	18%
	Net gun			5(2)		5	1	20%
1981	Nightlight	9(2)	21(7)	39(1)	2	71	1	1%
1982	Nightlight	4(3)	10(2)	11(4)		25	0	0%
All years	Nightlight	15	34	54	2	105	2	2%
All years	All methods	15(5)	44(17)	59(9)	3	121(31)	5	1%

[a]Includes yearling grouse.
[b]Number of radio-collared grouse in parentheses.

Table 10. Summer range sizes of 11 sage grouse using irrigated cropland.

Band number	Sex and age	Time period	Number locations	Range size (ha)
M640	JM	18 Aug-18 Sep 1982	13	286
M650	JM	2 Sep-18 Sep 1982	10	300
F096	JF	3 Aug-25 Sep 1982	19	229
M562	YM	24 Jun-19 Sep 1981	11	193
M565	AM	14 Jul-20 Sep 1981	14	200
M634	AM	14 Jul-29 Sep 1982	22	821
F518	YF	14 Jul-30 Sep 1981	21	314
F514	AF	16 Jun-9 Sep 1981	25	207
F517	AF	30 Jun-30 Sep 1981	9	179
F568	AF	16 Jun-29 Sep 1982	41	278
F569	AF	19 Jul-19 Sep 1982	15	264
mean			18	297

Table 11. Distances tagged and radio-collared sage grouse (birds with < 10 locations) were relocated from capture sites in and near cropland.

No. weeks after capture	Relocation distance from capture site (km)							Total number of relocations
	0-0.5	0.5-1.0	1.0-1.5	1.5-2.0	2.0-2.5	2.5-3.0	3.0-3.5	
1	16	11		1				28
2	9	9	1	2		1	1	23
3	2	3		4	1		1	11
4	1	4	3		2			10
5	1		2					3
6		1						1
7	1	2						3
8	1							1
Total relocations	31	30	6	7	3	1	2	80
%	38.8	37.5	7.5	8.8	3.8	1.2	2.5	100.1

Table 12. Locations of radio-collared sage grouse in and near cropland by habitat type during the summers of 1980-82.

Year	Sagebrush-grassland	Crested wheatgrass	Grass-shrub meadow	Alfalfa	Small grain	Pasture	Fenceline	Number of locations
1980	13 (31.0%)	5 (11.9%)	0 (0%)	20 (47.6%)	1 (2.4%)	3 (7.1%)	0 (0%)	42
1981	25 (25.0%)	0 (0%)	21 (21.0%)	40 (40.0%)	5 (5.0%)	7 (7.0%)	2 (2.0%)	100
1982	35 (29.2%)	3 (2.5%)	3 (2.5%)	64 (53.3%)	2 (1.7%)	1 (0.8%)	12 (10.0%)	120
All years	73 (27.8%)	8 (3.1%)	24 (9.2%)	124 (47.3%)	8 (3.1%)	11 (4.2%)	14 (5.3%)	262

harvested with 23 of 67 (34.3%) harvested. The combined hunting mortality rate was 34 of 195 (17.4%) grouse marked during the springs of 1981-82 and summers of 1980-83. Harvested grouse which were known to be present in cropland prior to the hunting season were all killed within 4.8 km of their summer ranges or capture sites. All but 2 were harvested during the first hunting season after their capture. Grouse seasons were opened on the third weekend of September in 1980-82 and lasted 14 days along the south edge of the agricultural area and 21 days over the rest of the area. Twenty-one of the 34 grouse harvested (61.8%) were killed during the first 2 days of the hunting season. No estimate of crippling loss was obtained; however, 2 grouse which were apparently crippled were included in the harvest totals reported above.

Fall and Winter

Fall movement away from irrigated cropland was documented for 13 female and 2 male radio-collared grouse. Most of these birds remained in cropland through the end of September; however, departures also occurred in late August and early November (Table 13). The minimum number of days spent in cropland by 10 radio-collared grouse averaged 83 days (range 65-110 days). These birds likely spent more time in and near cropland than the data indicated since precise date of arrival and departure were not determined.

Fall movement and dispersal away from cropland was primarily in the direction of sagebrush grassland habitat south of the agricultural area (Figs. 11 and 12). Maximum known movement between summer and winter ranges observed for 15 radio-collared grouse based on locations

Table 13. Fall movement away from cropland or summer range by 15 radio-collared sage grouse in 1980-82.

Year	Sex and age	Date of last[a] location near cropland	Date of first location > 1.6 km from cropland	Maximum movement away[b] from summer range: Distance (km) and direction	Maximum movement away[b] from summer range: Date observed
1980	AF	26 Aug	23 Sep	6.3 S	23 Sep
	YF	27 Sep	5 Nov	14.1 SSW	6 Nov
	JF	27 Sep	5 Nov	16.6 SW	6 Nov
1981	AF	5 Oct	21 Oct	3.1 SSW	21 Oct
	YF	5 Oct	21 Oct	3.8 ESE	21 Oct
	YF	30 Sep	21 Oct	4.5 SE	21 Oct
1982	AF	12 Oct	27 Oct	9.0 S	9 Dec
	AF	25 Sep	6 Oct	13.2 S	6 Oct
	AF	29 Sep	12 Oct	13.8 S	9 Dec
	AF	5 Nov	15 Nov	6.3 W	22 Nov
	AF	25 Sep	6 Oct	14.4 S	4 Nov
	JF	25 Sep	29 Sep	13.0 SSW	9 Dec
	AM	29 Sep	12 Oct	20.3 SW	9 Dec
	JM	25 Sep	6 Oct	16.1 SW	2 Nov
	AF	12 Oct[c]	27 Oct[c]	4.2 E	27 Oct
mean		30 Sep	17 Oct	10.6	10 Nov
SD		15	15	5.5	22

[a]Includes all locations within 1.6 km of cropland.
[b]Includes all locations obtained prior to 15 December.
[c]Bird did not summer in cropland, fall movements are reported in relation to the location of summer range.

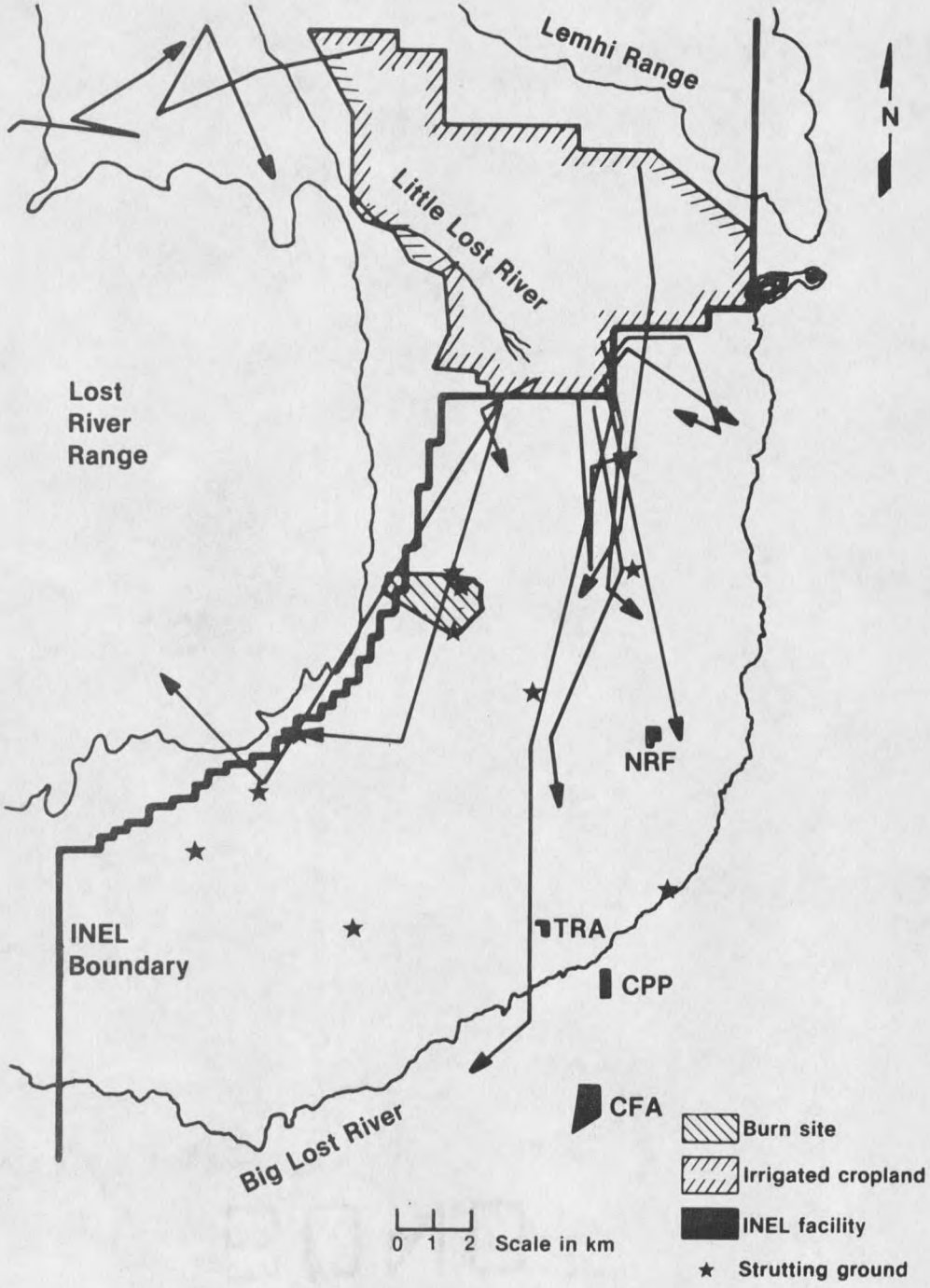


Fig. 11. Fall movements by female sage grouse from summer to winter ranges through 15 December 1981-82.

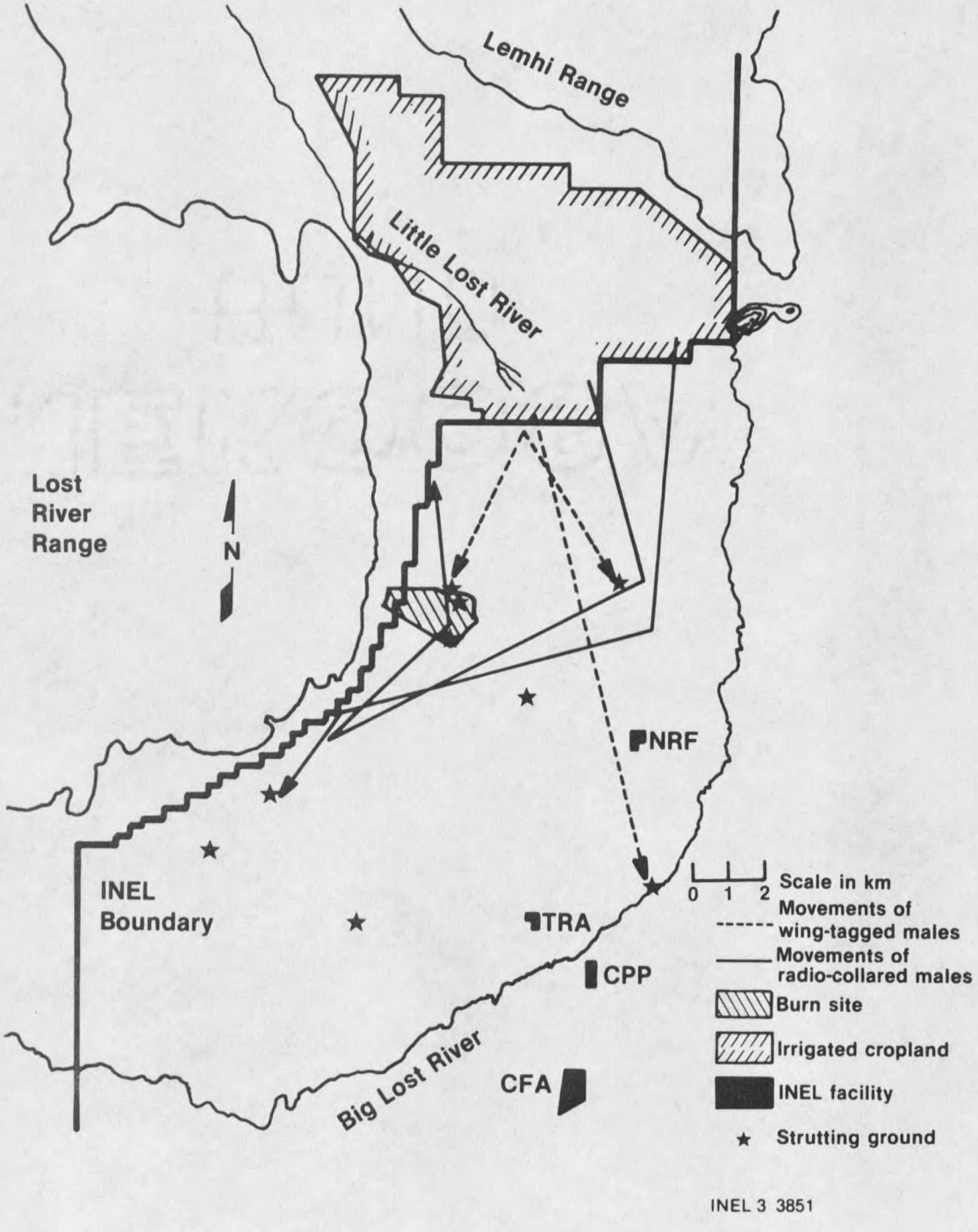


Fig. 12. Fall movements by male sage grouse from summer to winter ranges through 15 December 1981-82.

obtained no later than 15 December ranged from 3.1-20.3 km (Table 13). Three male grouse wing-tagged near cropland during the summer of 1980 were reobserved the following spring on strutting grounds 6.5-17.8 km from their capture sites (Fig. 12).

The winter range size of 1 adult male was 1190 ha based on 9 locations obtained from mid-November 1982 through March 1983. Exluding temporary excursions made back to summer ranges by 2 hens, the winter range sizes of 4 hens based on 7-12 locations/bird ranged from 176-1070 ha.

Individual Year-round Movements

Movement data spanning 1 year or more were obtained for 8 radio-collared grouse (1 adult male, 2 yearling hens, and 5 adult hens). Movements of these grouse are illustrated in Appendix B, Figs. 20-25. The male was radio-collared in cropland north of the burn site in July 1982; the females were radio-collared on strutting grounds on and near the burn site in April 1982. The nests of all 5 hens were located in 1982 and 3 of the hens hatched broods in that year.

Two patterns of year-round movement were clearly exhibited by the 5 hens. The 1982-83 winter ranges of 2 hens included their 1982 and 1983 nest sites (Figs. 20 and 21). In contrast, 2 other hens wintered 18-20 km north of their 1982 and 1983 nest sites during the winter of 1982-83 (Figs. 22 and 23). Between 3 and 31 March 1983, they returned to the vicinity of their 1982 and 1983 nest sites. The fifth hen, a yearling when captured, was not located during the winter of 1982-83 despite attempts to locate the bird by airplane

within and beyond the 300 km^2 study area. She was finally located on 17 May 1983, 1 km southwest of her previous year's nest site (Fig. 24). Apparently, this bird did not winter in the vicinity of her 1982 nest site but did return in the spring of 1983 to breed and nest in the same area that she did in 1982.

The nests of 3 of 5 hens were located in April 1983. Two nests were found within 20 m and 1 within 200 m of the previous year's nest site. Nests of the other 2 hens were not discovered; however, the movements of these birds during the spring of 1983 indicated that they attempted to nest within 500 m of their previous year's nest (Figs. 23 and 24).

The 2 hens which wintered north of their nests in 1982-83 could have attended a strutting ground adjacent to their winter ranges. The timing of their spring movements in 1983 indicated that they bred on a strutting ground located on or adjacent to the burn site. During the first 4 days of April, 1 of the hens was flushed with other males and females, an indication that she had not yet bred. Although this hen was captured on a strutting ground 6.5 km east of the burn site in 1982, she apparently bred on 1 of the strutting grounds on or adjacent to the burn site in 1983.

The male (Fig. 25) and 4 of the hens were followed back to summer ranges in 1983. Only 1 of 4 hens was known to have nested successfully in 1983. Although movements to summer ranges by 3 of the 4 hens occurred earlier in 1983 than in 1982, the pattern of movement was nearly identical in the 2 years. All 5 grouse returned in 1983 to portions of the summer ranges they used in 1982.

Two hens radio-collared in cropland during the summer of 1980 were harvested in the falls of 1981 and 1982 within 3.5 km of their capture sites. The hen which was shot during the fall of 1981 was an adult with a brood when she was captured. She wintered 2-6 km south of her summer range during the winter of 1981-82. The other hen was a broodless yearling (1.5 years) in the summer of 1980 and was never located on winter range.

Discussion

Fecal pellet counts in the burn area, movements of radio-collared grouse, and observations of unmarked grouse demonstrated that grouse used the 300 km^2 study area including the burn site as winter, breeding, nesting, and early brood-rearing habitat. Sage grouse used 2 strutting grounds on and adjacent to the burn site prior to burning. This and other studies (Wallestad and Schladweiler 1974, Emmons 1980) have found that male sage grouse utilize sagebrush habitat within 1-1.5 km of strutting grounds during the breeding season. Movements by hens from strutting grounds to nests after breeding range from 2.5-4.5 km (Wallestad and Pyrah 1974, Petersen 1980, this study).

Sagebrush eradication is detrimental to nesting habitat (Klebenow 1970) and has caused reduced numbers of males on strutting grounds where sagebrush was eradicated nearby (Wallestad 1975). Consequently, Braun et al. (1980) recommended that sagebrush not be eradicated within 3 km of strutting grounds to protect breeding and nesting habitat. The 405 ha burn site encompassed only 14% of the area within a 3 km radius of 2 strutting grounds. Sagebrush was

removed from < 50% of the burn site, so the actual loss of cover was < 7%. Considering the distances which radio-collared hens nested from strutting grounds, the loss of potential nesting habitat was no greater than 3%.

The male grouse breeding population on and near the burn site declined between 1981 and 1983. Beck and Braun (1980) criticized the use of strutting ground counts as spring population indices because daily fluctuations in male attendance may obscure actual differences in yearly attendance. Variation between the 3 highest counts obtained on individual strutting grounds in this study ranged from 0-42% ($\bar{x}$ = 19%). Thus, the observed 67% decline in the male breeding population between 1981 and 1983 could not be completely explained by random variation in daily attendance. The 72% decline in grouse observations near cropland between the summers of 1980 and 1982, and low juvenile/female ratios during those summers, provided additional evidence supporting the observed decline in breeding males. The decline occurred on all strutting grounds used prior to the burn and apparently resulted from the effects of adverse weather on reproductive success.

Despite a declining breeding population, sage grouse used a portion of the burn site as a strutting ground during the first and second springs after sagebrush was removed from the area by fire. Connelly et al. (1981) also reported that sage grouse used recently disturbed sites on the INEL as strutting grounds. These observations indicate that suitable openings for strutting grounds may be limited in many areas of the INEL.

Observations of marked males on the new ground suggested that the first males to appear on new strutting grounds may be adults which are not firmly established as members of other breeding populations. Although the creation of suitable sites for courtship and mating may allow males to breed which normally would not, additional strutting grounds do not necessarily mean increased numbers of sage grouse in following years. Because only a small proportion of males but nearly all females participate in breeding (Wiley 1973, Petersen 1980), reproductive output is determined by the female segment of sage grouse populations.

Recent research has implicated aggressive behavior to adult blue grouse (Dendragapus obscurus) hens as the cause of delayed breeding and greater distances traveled to nest sites by yearlings (Hannon 1982). Sage grouse yearling hens breed later, are less successful, and nest at greater distances from strutting grounds than older hens (Dalke et al. 1963, Wallestad and Pyrah 1974, Petersen 1980). Initially, without competition from adults for access to breeding males and nesting space, yearling hens could more easily establish a tradition of breeding in new areas. On the western portion of the INEL where sagebrush cover is extensive and openings widely spaced, suitable nesting habitat may be underutilized due to isolation from breeding areas; however, this is yet to be proven.

Seasonal changes in the distribution of sage grouse on the study area occurred between winter-breeding ranges and summer ranges. Less than 15% of the total annual precipitation on the INEL normally occurs during July through September. Low precipitation and high

temperatures during these months preclude any substantial forb growth in sagebrush grassland in most years. Movements to summer ranges in irrigated cropland and near INEL facilities apparently occurred as a result of forb desiccation on winter and spring ranges (Klebenow 1969, Oakleaf 1971). These areas provided a consistently abundant source of free water and forbs throughout the summer.

During 1980 and 1981, grouse used irrigated cropland from late May through early October; however, they began using cropland 3 to 4 weeks later in 1982. The late arrival apparently resulted from delayed forb desiccation due to above average precipitation during July and August 1982. The late arrival of broods in cropland may have been related to a delay in the 1982 breeding season. Males and hens which lost their nests early in the nesting period should not have been as restricted to breeding areas during the spring; their delayed movements to cropland may have been more related to forb phenology.

Although grouse used the burn site during the fall and winter prior to burning, it did not appear to have been critical winter habitat. Sage grouse distribution on winter range varies with snow depth (Beck 1977). During the winter, grouse seek an optimum height and at least 20% sagebrush cover as snow depth increases (Eng and Schladweiler 1972, Connelly 1982). Consequently, sage grouse concentrate on critical portions of winter range with increasing snow depth (Beck 1977). Since fecal pellet densities on the burn area varied inversely with the depth and persistence of snowcover over 3 years, grouse may have concentrated on portions of the study area other than the burn site as snow depth increased. The low pellet

density observed in 1982, after the winter of greatest snowcover, may also have in part reflected the declining population trend. Movements by radio-collared grouse in this and other studies (Connelly et al., unpubl. data) indicated that winter ranges occurred 3.2 km east and 4.8 km southwest of the burn site (Fig. 13).

Mid-spring though early summer is a transitional period between a winter diet of almost entirely sagebrush to a summer diet dominated by forbs and insects (Patterson 1952, Peterson 1970, Wallestad et al. 1975). Reflecting this dietary shift, the proportion of summer foods (mostly forbs, insects, and grasses) in grouse feces collected on and near the burn site increased between late March and early July in 1981 and 1982.

Fecal analyses showed that forbs were most important to hens before and after incubation. Males and incubating hens consumed the smallest proportions of forbs during the springs of 1981-82. Incubating hens consumed > 80% sagebrush during the springs of 1981-82. Selective feeding on a single forage item by incubating hens has been reported for ruffed grouse (Schladweiler 1968), blue grouse (Zwickel and Bendell 1972), and spruce grouse (Herzog 1978).

The predominance of sagebrush and low proportion of forbs in the diet of incubating hens may have resulted from restricted movements and shortened feeding periods. Petersen (1980) found that yearling and adult hens moved mean distances of 0.7 and 1.5 km from nests to feeding and loafing sites during egg-laying. During incubation, these movements decreased to 0.1 km.

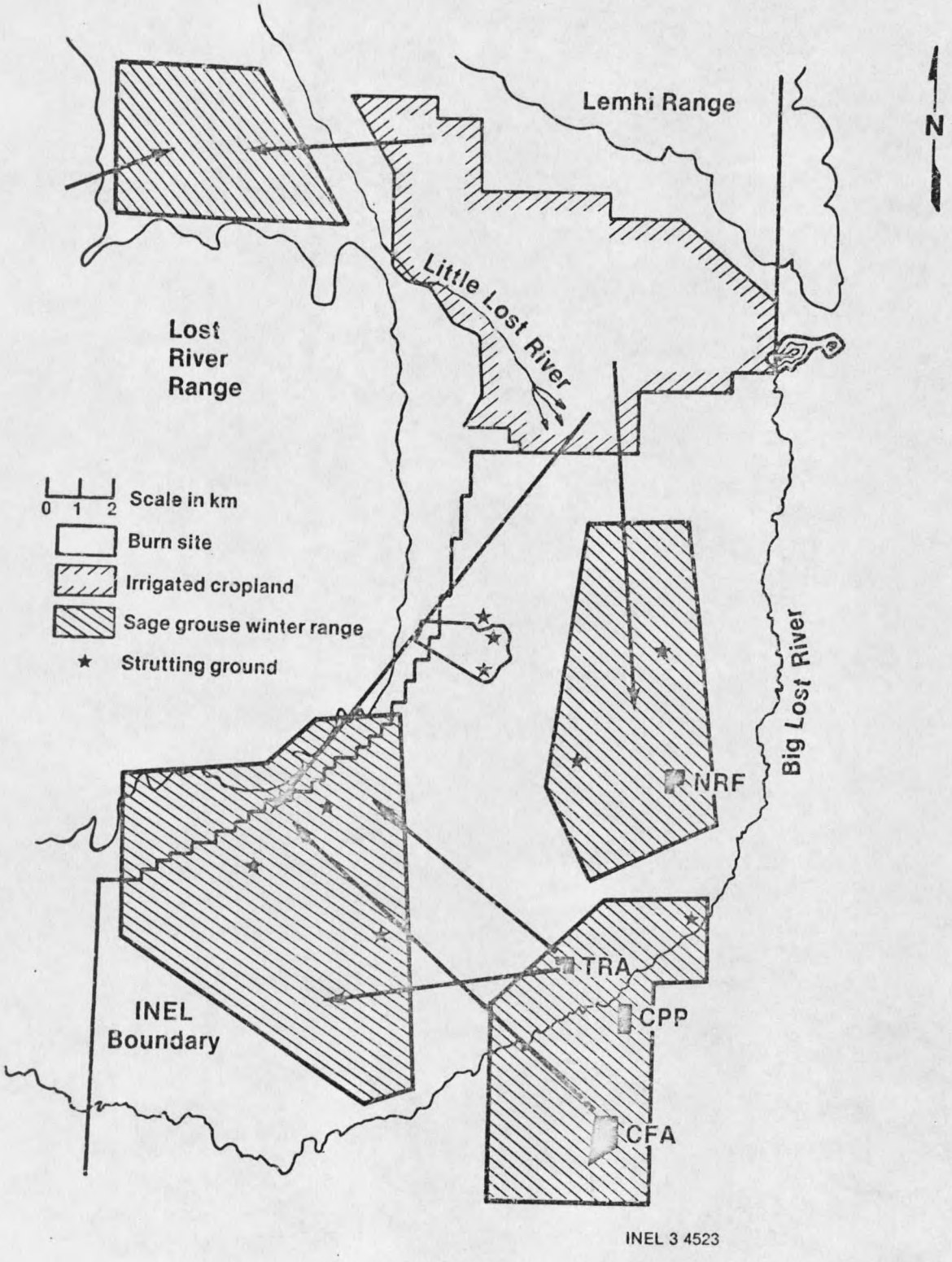


Fig. 13. Sage grouse winter ranges in relation to the burn site and summer habitats on the western INEL.

Dietary differences could also be related to metabolic requirements during the breeding season. Daily movements of males between strutting grounds and feeding sites were similar in distance to those of hens between nests and feeding sites during egg-laying. In spite of this, males in 1982 consumed smaller proportions of summer foods than did hens. The relatively large proportion of summer foods in the diet of hens before incubation may be the result of increased energy, protein, and mineral requirements of egg formation (West 1968, Robbins 1981). Consumption of summer foods could also be an attempt to enhance body reserved for incubation. Invertebrate consumption was highest for brood hens but was not important to pre-incubating hens as for waterfowl (Krapu 1974, Swanson et al. 1974, Drobney and Fredrickson 1979).

Klebenow (1970), Martin (1970), and Wallestad (1975) found sagebrush eradication to be detrimental to sage grouse. These studies were conducted on areas which were sprayed with herbicides rather than burned. Herbicidal eradication of sagebrush can be detrimental to the forb component of sagebrush grassland vegetation (Mueggler and Blaisdell 1958); whereas, late summer or fall burns can increase the production of perennial forbs. Since forbs become increasingly important to sage grouse during the transition between winter and spring diets, the burn could enhance forage availability.

On the basis of dietary composition, increased forb production on burned areas would be most important to laying hens and broods. If males and incubating hens consumed smaller proportions of forbs because their small seasonal ranges required them to forage near

strutting grounds and nest sites, then the forb component of their diets should increase with enhanced forb production on burned areas.

Due to its proximity to winter and breeding areas which normally become desiccated by early summer, the burn site could be used by sage grouse after burning as transitional habitat between winter and summer ranges but would probably be least important to males and broodless hens. These grouse are more mobile than young broods and are free to move directly to more permanent summer habitat after the breeding season.

Young broods must locate suitable feeding sites within the distance they are capable of traveling at 1-2 days of age. Daily brood movements occur between roosting sites in dense sagebrush and feeding sites in more open areas with abundant forbs (Wallestad 1971). The mosaic pattern of the burn resulted in a high degree of interspersion of sagebrush cover with small (< 20 ha) burned areas which could provide an abundant source of forbs. Since the burn site is within nesting habitat, young broods could easily reach feeding sites in burned areas.

Other studies have shown that broods follow continous microhabitats such as riparian areas and elevational gradients to summer range (Gill and Glover 1965, Klebenow 1969, Wallestad 1971), and are thereby assured of an adequate food supply on their way to more permanent summer habitat. On the western INEL, there are no elevational gradients or riparian areas between nesting habitat and

irrigated cropland. Enhanced forb production on the burn site could be important to broods which move long distances from nesting to summer habitat.

PYGMY RABBITS

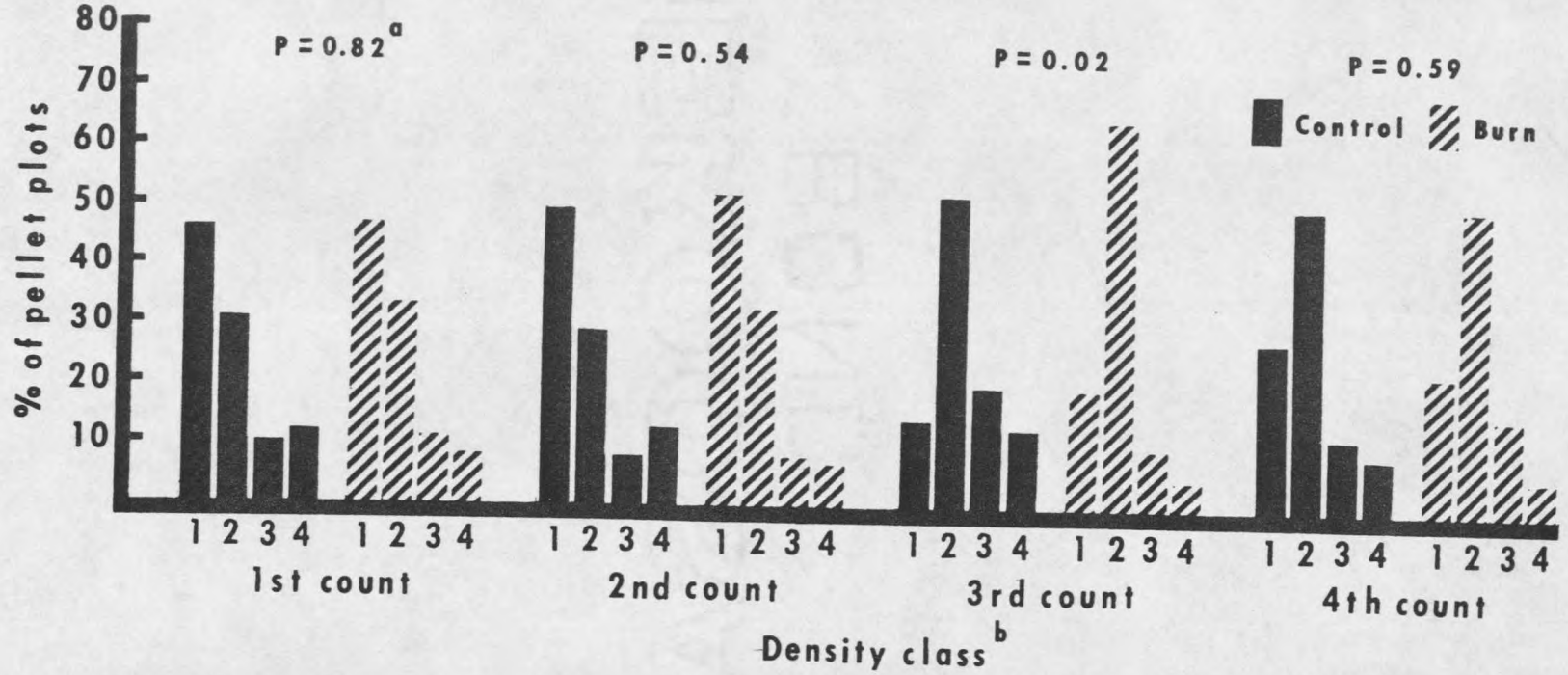
Results

Pellet Counts

Pygmy rabbit pellet densities did not differ between the burn and control sites in all but the last pre-burn (third) pellet count ($P < 0.05$, Fig. 14). In the third count, the control site had higher proportions of pellet plots assigned to the 2 highest density classes ($P < 0.005$) than the burn site. This probably occurred as a result of the longer period of time between the second and third counts on the control site (4.9 months) than on the burn site (2.3 months).

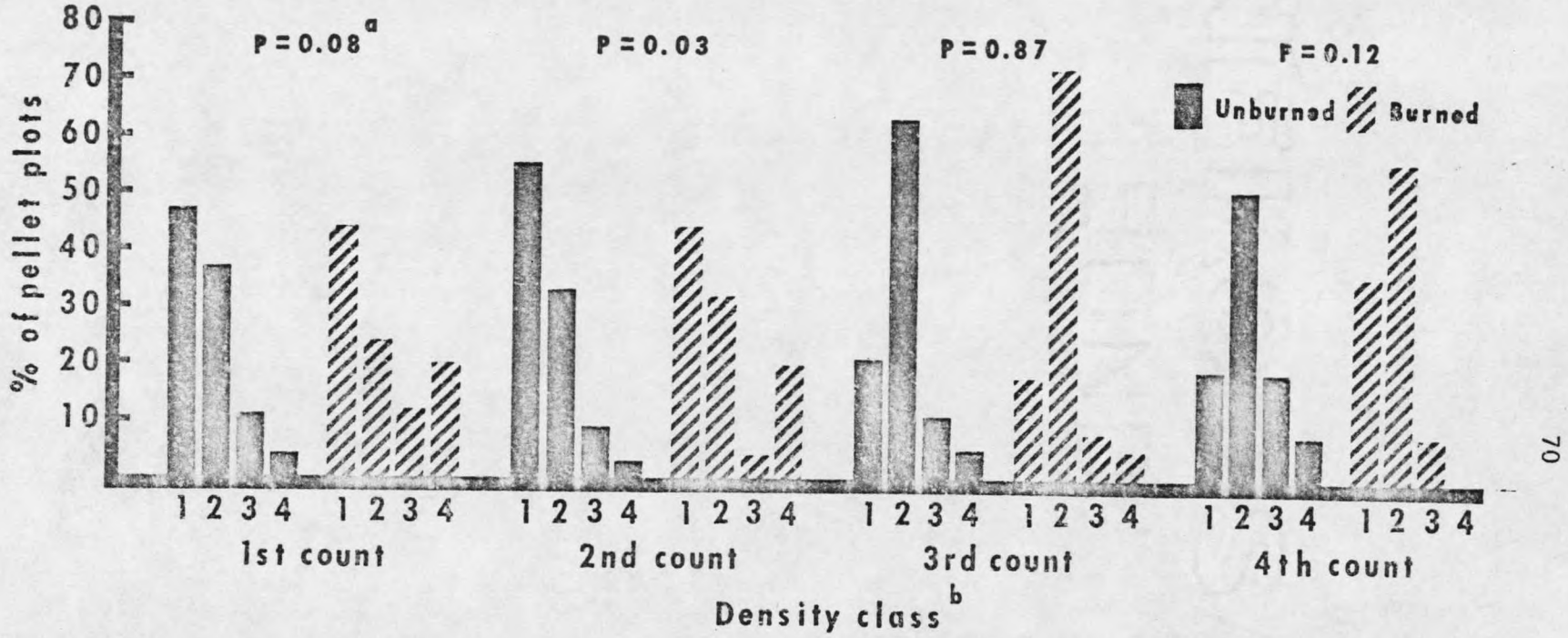
Since vegetation was burned on only 25 plots in 1981, comparisons were made between those plots and the remaining 75 unburned plots on the burn site (Fig. 15). One year after burning, no significant differences were detected between the burned and unburned plots when all 4 density classes were considered ($P = 0.12$). A significantly greater ($P = 0.05$) proportion of the unburned plots had densities > 25 pellets/m^2 when compared to the burned plots.

In the first 2 pre-burn counts, 24-32% of the burned plots had densities > 25 pellets/m^2 compared to 12-15% for the unburned plots; however, the difference was not significant ($P \geq 0.06$). There were significantly greater ($P \leq 0.01$) proportions of plots with > 50 pellets/m^2 among the burned plots (20%) than among the unburned plots (3-4% in the first 2 counts. No differences were detected in the third



[a] Chi-square test, burn vs control.
[b] 1 = 0, 2 = 1-25, 3 = 26-50, 4 = > 50 pellets/m^2.

Fig. 14. Percent of pygmy rabbit pellet plots assigned to 4 pellet density classes in 4 pellet-counts on the burn and control sites. The first 3 counts were conducted prior to burning.



[a]Chi-square test, burned vs unburned plots.
[b]1 = 0, 2 = 1-25, 3 = 26-50, 4 = > 50 pellets/m^2.

Fig. 15. Percent of 25 burned and 75 unburned pygmy rabbit pellet plots on the burn site assigned to 4 pellet density classes in 4 pellet counts. The first 3 counts were conducted prior to burning.

count ($P \geq 0.63$). The tendency for the burned plots to have higher pellet densities than the unburned plots prior to burning probably obscured the magnitude of change in pellet density 1 year after burning.

Food Habits

Four shrub, 6 grass, and 8 forb taxa were identified in 33 pygmy rabbit fecal samples (Table 14). Plant fragments identified in the samples consisted of 80.7% shrubs, 13.8% grasses, and 5.5% forbs. Sagebrush and rubber rabbitbrush (Chrysothamnus nauseosus) were the most important shrubs; needlegrass and Indian ricegrass were the most important grasses. Phlox and an unknown species comprised most of the forb fragments.

Shrub relative densities ranged from 67.2% in July to 99.6% in March. Sagebrush use was greater ($P < 0.05$) during November, December, and March than in the remaining 3 months. During August, sagebrush was replaced by rabbitbrush as the most important forage of pygmy rabbits on the burn site. Relative densities of other shrubs did not differ significantly between months ($P = 0.53$).

Grass use differed significantly ($P = 0.01$) between months and was highest in July and August ($P < 0.05$). During the remaining 3 months, grasses comprised > 10% of the diet. Forbs appeared in all monthly samples except for March. The highest proportion ($P < 0.05$) of forbs occurred in September.

Post-burn Mortality and Dispersal

Thirty pygmy rabbits were captured during the study; 18 were radio-collared, 6 were ear-tagged, and 6 died in traps. At least 4 of

Table 14. Relative densities of plant fragments ($\bar{x}$ ± SE) identified in pygmy rabbit feces collected on the burn site during March through December 1981-82.

Plant Taxon	March N = 4	July N = 7	August N = 8	September N = 8	November N = 3	December N = 3	All fecal samples N = 33
Agropyron spp.		0.8 ± 0.5	0.4 ± 0.4				0.2 ± 0.1
Oryzopsis hymenoides		6.9 ± 1.7	4.8 ± 1.0	1.7 ± 0.9			3.0 ± 0.7
Poa spp.			1.8 ± 1.0	0.6 ± 0.4	1.0 ± 1.0		0.7 ± 0.3
Sitanion hystrix		4.6 ± 2.2	0.8 ± 0.8				1.2 ± 0.6
Stipa spp.	0.4 ± 0.4	17.8 ± 8.1	14.1 ± 5.6	6.6 ± 2.7		0.5 ± 0.5	8.7 ± 2.5
Sporobulus spp.		0.2 ± 0.2					Tr[b]
Total grass	0.4 ± 0.4 B	30.2 ± 9.7 A	21.9 ± 5.6 AB	8.0 ± 3.6 B	1.0 ± 1.0 B	0.5 ± 0.5 B	13.8 ± 3.2
Artemisia spp.	99.6 ± 0.4 A	37.7 ± 12.4 C	8.7 ± 1.2 D	51.7 ± 10.3 B	89.4 ± 4.1 A	91.3 ± 0.6 A	51.1 ± 6.7
Chrysothamnus nauseosus		21.3 ± 9.2 B	60.0 ± 6.6 A	24.7 ± 8.5 B	4.9 ± 2.5 B	3.9 ± 2.0 B	25.9 ± 4.9
Ceratoides lanata		7.9 ± 4.5	4.1 ± 1.4	3.2 ± 0.9	1.1 ± 1.1	1.6 ± 0.9	3.5 ± 1.1
Tetradymia spp.		0.4 ± 0.4	0.8 ± 0.5			1.1 ± 1.1	0.3 ± 0.1
Total shrub	99.6 ± 0.4	67.2 ± 10.5	72.3 ± 6.1	79.6 ± 5.7	95.4 ± 3.0	97.9 ± 0.6	80.7 ± 3.6
Astragalus-Oxytropis		0.3 ± 0.3	2.3 ± 1.5				0.6 ± 0.4
Allium spp.			0.6 ± 0.4				0.2 ± 0.1
Misc. Compositae		1.1 ± 0.7		0.3 ± 0.3			0.3 ± 0.2
Cryptantha spp.		0.2 ± 0.2	0.4 ± 0.4				0.1 ± 0.1
Eriogonum spp.		0.3 ± 0.3					0.1 ± 0.1
Phlox spp.		0.3 ± 0.3		10.9 ± 3.2	3.7 ± 2.1	1.6 ± 0.9	3.2 ± 1.1
Sphaeralcea spp.		0.4 ± 0.4					0.1 ± 0.1
Unknown forb			2.5 ± 0.9	1.3 ± 0.4			0.9 ± 0.3
Total forb	0.0 ± 0.0	2.5 ± 0.8 B	5.8 ± 2.5 B	12.5 ± 2.8 A	3.9 ± 2.1 B	1.6 ± 0.9 B	5.4 ± 1.2

[a] Means sharing the same letter were not significantly different (Duncan's new multiple range test, $P > 0.05$.
[b] Trace, < 0.1.

the trap mortalites were caused by weasels (Mustela frenata) encountering captured rabbits before traps were checked.

Four cottontail rabbits (Sylvilagus nuttalli) were also captured at pygmy rabbit burrows before burning. Two were released untagged and 2 were radio-collared.

Twelve pygmy rabbits were radio-collared prior to the initial burn on 18 August 1981. Two rabbits were never relocated after they were radio-collared, and a third was relocated only twice. Thus, 9 pygmy and 2 cottontail rabbits were located 129 times prior to the first burn. Two more pygmy rabbits were radio-collared in mid-September and were assumed to have been present in the areas that they were captured before burning. After the initial burn, 13 rabbits, including both cottontails, were located 167 times.

Approximately 50% of the area used by radio-collared rabbits was burned. Nearly all of the burning in this area occurred on 18 August. Complete burns were obtained on areas no larger than 3 ha where there were dense stands of sagebrush and an adequate grass understory to carry the fire.

Based on a total of 34 rabbit-weeks, the weekly survival rate of 11 rabbits was 100% for 5 weeks prior to burning (Table 15). The first pygmy rabbit mortality occurred 4-7 days after burning. No further mortality occurred until 5 weeks after the first burn. During the first 13 weeks after burning, the weekly survival rate of 10 pygmy rabbits and 1 cottontail (100 rabbit-weeks) was 34%. Of 11 pygmy rabbits and 1 cottontail whose fates were known, only 3 pygmy rabbits and 1 cottontail survived beyond 8 weeks. The fate of the other

Table 15. Mortality and dispersal of radio-collared pygmy rabbits after burning on 18 August 1981.

Sex	Body measurements	Dispersal			Mortality		
		Date captured	Distance (km) and direction	Date	Cause of death	Date last known alive	Date discovered
F	51-72-595[a]	9 Jul	None		Unknown	21 Aug	27 Aug
M	48-68-430	9 Jul	0.6 E	27 Aug-[b]23 Sep[c]	Predator	27 Aug	29 Sep
F	48-63-500	14 Jul	0.7 NNE	21 Aug-29 Sep	Predator	21 Aug	29 Sep
F	52-71-465	22 Jul	1.8 SSE	17 Sep-23 Sep	Survived	16 Nov[d]	
M	51-65-395	30 Jul	None		Unknown	8 Oct	12 Oct
F	54-73-560	6 Aug	1.6 NW	17 Sep-23 Sep	Survived	10 Nov[d]	
F	53-70-550	6 Aug	None		Survived	7 Mar 1982[d]	
F	49-68-525	9 Aug	None		Predator	17 Sep	30 Sep
M	51-68-440	11 Aug	None		Predator	17 Sep	29 Sep
M	53-70-440	12 Sep	1.6 W	22 Sep-6 Oct	Predator	22 Sep	6 Oct
F	53-75-530	13 Sep	0.2 S	17 Sep-22 Sep	Predator	17 Sep	8 Oct

[a] Ear length (cm)-hind foot length (cm)-weight (g).
[b] Date last located within previously used home range.
[c] Date first located > 250 m from former home range or off of burn site.
[d] Last known location.

cottontail was not determined; however, it was still alive 5 weeks after burning.

Examination of the remains of rabbit carcasses indicated that predation was the probable cause of 6 of the 8 pygmy rabbit mortalities. Identities of the predators were not positively determined. A weasel and a raptor were the apparent causes of at least 2 mortalities, while coyotes were probably involved in 4 others. One rabbit was found dead in a burrow over which vegetation was completely burned within a 40 m^2 area. Another rabbit which was found dead at a burrow entrance had superficial injuries suggestive of biting wounds. The carcass was somewhat emaciated, indicating poor condition prior to death.

Although no radio-collared rabbits died as a direct result of the fire, 16 unmarked pygmy rabbits were observed which were burned or asphyxiated. Only 1 of these rabbits was found within the area used by radio-collared rabbits. The other 15 rabbits were discovered on 20 August 1981, on a 1.5 km transect located in the center of a 15.7 ha burned area, 0.6 km east of where rabbits were radio-collared. All but 1 of the 15 rabbits were severely burned; however, it was not known whether the initial causes of death were heat stress, asphyxiation, or physical burning. Recently used burrows were often observed in close proximity to burned rabbits. The vegetation in this area prior to the burn was a dense stand of tall sagebrush with an understory of dried forbs and wildrye. Consequently, when this area burned, the fire was very intense and advanced rapidly through the sagebrush.

Except for 1 pygmy rabbit whose home range occurred partially off of the burn site, no radio-collared rabbits were located off the burn

site prior to burning. Also, no rabbits were located > 250 m from burrows which they used prior to the burn. Dispersal by 8 of 13 radio-collared rabbits occurred within a 7 week period after the initial burn (Table 14). Both of the cottontails and 5 of 6 pygmy rabbits dispersed beyond the boundary of the burn site. One pygmy rabbit moved 0.7 km to an unburned portion of the burn site (Fig. 16). Distances from burrows at which 6 dispersing pygmy rabbits were captured prior to the burn to their last known locations ranged from 0.2-1.8 km ($\bar{x}$ = 1.1 km). The 2 cottontails dispersed to distances of 2.8 and 4.6 km. Dispersing rabbits were first located 5-39 days after they were last observed within their pre-burn home ranges. Efforts were made to locate the rabbits during each of 7 weeks after burning; however, locations were not usually obtained until it was possible to radio-track rabbits from the air. Considering the dates that these rabbits were last observed on their pre-burn home ranges, dispersal appears to have occurred from late August (1 to 2 weeks post-burn) to late September (5 weeks post-burn).

Four of 6 dispersing pygmy rabbits were preyed upon. Two pygmy rabbits established new home ranges around previously existing burrows at which other unmarked rabbits were observed. One of the cottontials established a new home range in the foothills of the Lost River range northwest of the burn site. All 3 of these rabbits were still alive when their transmitters ceased functioning in mid-November. Only 1 of 5 pygmy rabbits which did not disperse survived past mid-November 1981. This rabbit was recaptured on 7 March 1982 < 40 m from where it was originally captured.

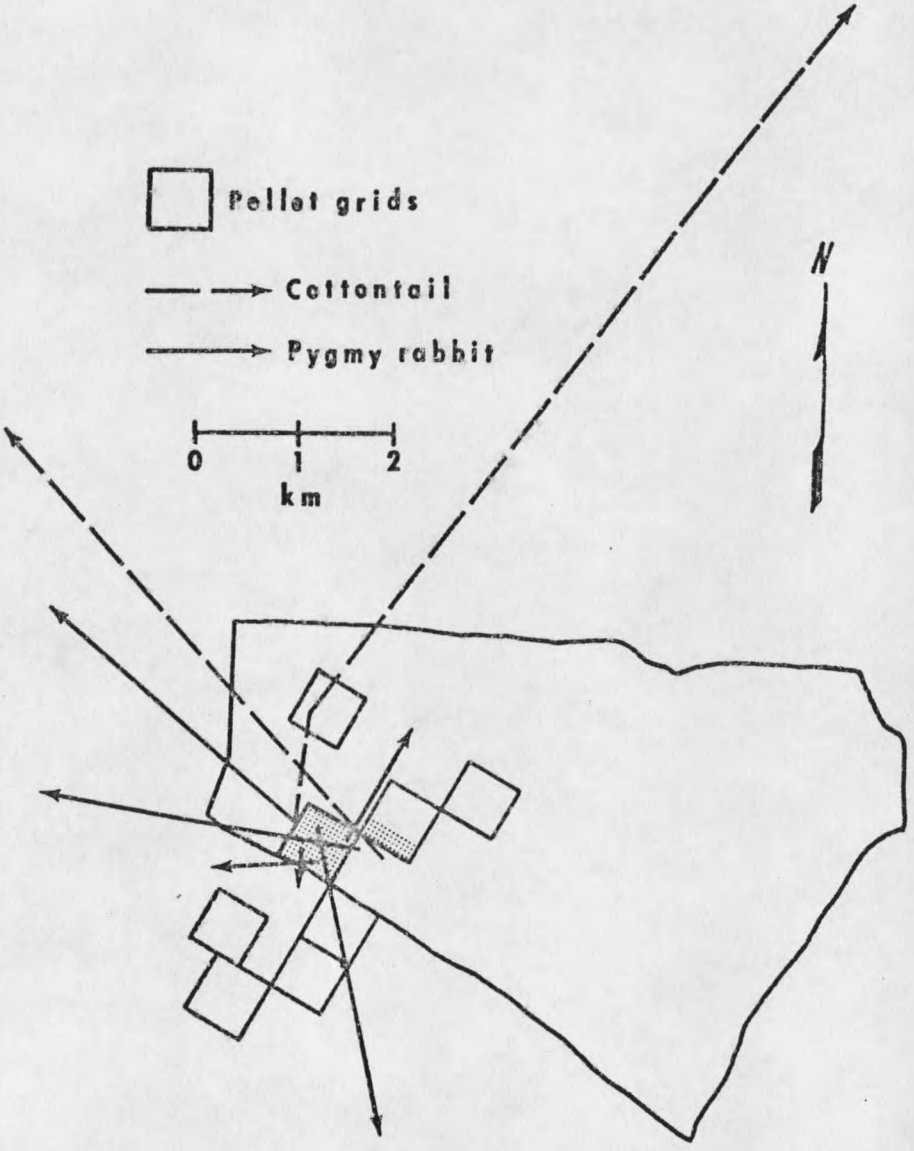


Fig. 16. Dispersal by 6 radio-collared pygmy and 2 radio-collared cottontail rabbits after burning on 18 August 1981. Shaded areas were portions of pellet grids burned in 1981.

The variability of pygmy rabbit body measurements and the lack of consistency between different measurements among individual rabbits prevented the separation of radio-collared rabbits by immature (< 1 year) or adult (> 1 year). Although the sample of radio-collared rabbits may have included 1 or 2 immatures, the body measurements of most of the rabbits indicated that they were adults (Wilde 1978).

Trapping success during July-September 1981 was significantly higher than during July and August 1982 ($\underline{X}^2 = 3.95$, $P = 0.05$). Only 7 different burrows were trapped in the summer of 1982 since 9 of the 15 burrows trapped in the summer of 1981 were inactive (Table 16).

All 16 burrows at which pygmy rabbits were captured during the study were inactive 20 months after the initial burn. Burrows over which vegetaion was burned within a 40 m^2 area tended to by used by pygmy rabbits for a longer time after burning. Some rabbits were captured in December 1981 and March 1982 at burrows over which vegetation was completely removed by fire. The only surviving radio-collared rabbit which remained on the burn site was captured at a burrow which was not burned over within a 40 m^2 area. All 8 rabbit captures during the summer of 1982 were also at burrows which were not burned over. By May 1983, 20 months after burning, none of the burrows at which rabbits were captured were active (Table 16).

Discussion

Although pellet densities were not significantly ($P > 0.05$) different between the burn and control sites 1 year after burning, a decrease in pellet density on 25 burned plots was indicated. The 25

Table 16. Trapping success and burrow activity at 16 pygmy rabbit burrows on the burn site, July 1981-May 1983.

Burrow	Number of[a] individual rabbits captured	% burn within 40 m^2	Trapping success[b]		Burrow activity[c]			
			Jul-Sep 1981	Jul-Aug 1982	Dec 1981	Mar 1982	Jul 1982	May 1983
3B-1	2	100	2/2	Not trapped	I	I	I	I
3B-4	4	0	2/4	2/10	A	A	A	I
3B-5	1	100	1/5	Not trapped	I	I	I	I
3B-7	4	60	2/5	Not trapped	A	A	I	I
3B-9	4	0	0/4	6/11	A	A	A	I
3B-11	2	100	1/2	Not trapped	A	ND	I	I
3B-12	2	80	2/5	Not trapped	I	I	I	I
3B-15	4	100	3/8	Not trapped	A	A	I	I
3B-18	1	100	Not trapped	0/6	A	A	I	I
3B-19	1	100	1/3	Not trapped	ND	ND	ND	I
4B-1	3	80	3/8	0/5	A	ND	ND	I
4B-2	2	0	1/3	0/9	A	A	A	I
4B-3	2	100	2/9	Not trapped	I	I	I	I
4B-9	4	70	3/9	Not trapped	A	ND	I	I
4B-13	2	100	2/5	0/3	ND	ND	ND	I
4B-17	1	100	1/3	0/1	ND	ND	ND	I
Total	39		26/75	8/45	9/13[d]	6/10	3/12	0/16
%			39%	18%	69%	60%	25%	0%

[a]Includes cottontail rabbits and recaptures of individuals at different burrows.
[b]Captures/burrow-night, includes all recaptures.
[c]A = active, I = inactive, ND = not determined.
[d]Proportion of burrows known to be active.

burned plots occurred in areas known to be used by radio-collared rabbits prior to burning. Abandonment of burrows used by radio-collared rabbits and the lower trapping success in the vicinity of the burned plots 1 year after burning appear to have resulted from the burn.

Radiotelemetry data indicated that an initial decline in rabbit density occurred after burning due to increased mortality and dispersal from burned areas. There was no fire-induced mortality of radio-collared rabbits in this area which was not completely burned. In contrast, where the burn was more extensive and flames advanced rapidly, fire-induced mortaltiy of unmarked rabbits was substantial.

The observations of burned rabbits are in contrast to the results of other studies in which little or no mortality of wildlife occurred after fire (Bendell 1974). Keith and Surrendi (1971) searched a 259 ha burn in Alberta for burned snowshoe hare (Lepus americanus) carcasses but found none. Likewise, Howard et al. (1959) and Lawrence (1966) observed little or no fire induced vertebrate mortality after brush burns. Chew et al. (1958) reported what they considered a nearly complete kill of woodrats (Neotoma fuscipes) and cottontail rabbits (Sylvilagus audoboni) on a 0.7 ha portion of a burned chaparral in southern California. The mobility, site attachment, and ability to seek refugia with suitable microclimates probably determine a species' vulnerability to fire. The nature and extent of different fires is also important. The relatively extensive, rapidly moving, and intense burn in the area where rabbits were killed by fire may have prevented some of them from taking refuge in burrows or elsewhere.

Since pygmy rabbits burrow to depths of up to 1 m (Wilde 1978), burrows should have protected the rabbits from heat prostration (Howard et al. 1959, Lawrence 1966). Burned rabbits may have avoided or been forced out of burrows because of inadequate ventilation or the accumulation of noxious gases. Lawrence (1966) suggested that mammals trapped in inadequately ventilated burrows during fires may suffocate; however, suffocation was more likely in burrows with 1 entrance rather than the multiple entrance burrows of pygmy rabbits.

On the southwest corner of the burn site, where a very uneven burn was obtained, radio-collared rabbits were able to escape the immediate effects of the fire. Nevertheless, these rabbits were also adversely affected by burning. Survival of 12 radio-collared rabbits decreased from 100% to 34% per week during a 13 week period after burning. The lowest bi-weekly survival rate observed in a tagged population of pygmy rabbits on the INEL by Wilde (1978) was 69% and occurred in late winter and early spring. Survival was highest in summer and early fall when the mortality observed in this study occurred.

Predators often concentrate near recently burned areas to take advantage of a prey population which has become more vulnerable due to loss of cover (Lawrence 1966, Komarek 1969). Pygmy rabbits prefer tall, dense, woody vegetation for cover (Green and Flinders 1980). Wilde (1978) suggested that, except when snowcover restricts movements, pygmy rabbits rely on sagebrush more than burrows for escape from predators. Removal of vegetation probably increased the vulnerability of radio-collared rabbits to predation.

Dispersal of radio-collared pygmy rabbits was not observed in a study conducted by Wilde (1978) in undisturbed habitat on the INEL. The pre-burn results of this study and those of Wilde (1978) indicated a high degree of fidelity of pygmy rabbits to 1 or more burrows which they use. Although emigration undoubtedly occurs in pygmy rabbit populations, it would normally be expected to occur largely among young individuals, especially young males (Dalke and Sime 1938, Shields 1960, Myers and Poole 1963, Lidicker 1975). Based on body measurements, all but 1 of the dispersing rabbits in this study were adults.

Dispersal is an important process by which small mammal populations adjust their densities to food and cover availability (Krebs et al. 1969, Tamarin 1977, Abramsky and Tracy 1979). Dispersing animals are usually individuals which cannot be supported by local food and cover resources (Wynne-Edwards 1962, Watson and Moss 1970, Lidicker 1975). Apparently, there was sufficient residual food and cover for radio-collared rabbits to remain on their home ranges for 31-49 days after burning. Dispersal and increased predation on emigrant and resident rabbits appears to have been the proximate cause of decreased use of burned pellet plots on the burn site 1 year after burning. Predation on dispersing rabbits suggested the importance of association with a burrow and/or acquisition of a familiar home range (Metzgar 1967).

The importance of sagebrush as food for pygmy rabbits was stressed by Wilde (1978) and Green and Flinders (1980). Sagebrush comprised 51% of the diet from March through December in this study

compared to the annual means of 86% and 65% reported by Wilde (1978) and Green and Flinders (1980), respectively. The lower proportion of sagebrush in the pygmy rabbit diet in this study was due, in part, to less intensive sampling during the winter and spring when sagebrush was eaten almost to the exclusion of other foods. Sagebrush comprised only 7% of the August diet in this study; whereas, Wilde (1978) and Green and Flinders (1980) found sagebrush to comprise no less than 36% and 43% of the diet in August. Rabbitbrush was the second most important food in this study (26%); however, it comprised < 2% of the diet in the above studies. All 3 studies showed similar increases in use of grasses and forbs during the summer and early fall.

During September, the proportion of sagebrush in the pygmy rabbit diet increased from 7% to 52% and by November to 89%. Thus, sagebrush was removed from portions of the study area during a time of year when it became increasingly important as a dietary item. This could have been an important factor in the timing of post-burn dispersal of radio-collared rabbits.

Apparently suitable areas for pygmy rabbits were left by the burn, including patches of sagebrush used by rabbits prior to burning. Nevertheless, pygmy rabbits were eliminated from this study site 20 months after burning. Although 4 additional rabbits were radio-collared on the burn site in July 1982, they provided no information on the final causes of pygmy rabbit disappearance on the southwest corner of the burn site.

Substantial erosion of surface soil occurred on some portions of the burn site. Windblown soil has accumulated in sagebrush stands on

the lee sides of burned areas. Once this soil has stabilized, suitable burrow sites may become available where sagebrush cover was adequate for pygmy rabbit, but soils were previously too shallow for burrowing. This could potentially mitigate the negative effects of burning on pygmy rabbits.

BLACK-TAILED JACK RABBITS

Results

Pellet Counts

No significant differences in pellet deposition rates on the burn and control sites occurred in the first 2 pre-burn pellet-counts. Differences were indicated in the third (pre-burn) and fourth (1 year post-burn) counts (Table 17). Jack rabbit pellet densities were not uniformly distributed between the 8 pellet grids. The higher pellet deposition rate observed on the burn site after burning may have been due to a prior tendency toward higher jack rabbit densities on the burn site and not the concentration of jack rabbits on burned areas. Vegetation on 25 of 100 pellet plots on the burn site was at least partially burned within a 40 m^2 area surrounding the center of the plots. Pellet densities ($\bar{x} \pm SE$) did not differ between the 25 burned plots (34.2 ± 2.8 pellets/m^2) and the remaining 75 unburned plots (38.2 ± 0.7 pellets/m^2) on the burn site (t-test, $P > 0.20$).

Jack rabbit densities on the burn and control sites increased from 0.3 hares/ha in the first count to 6.2 and 4.9 hares/ha in the third count. The second and third pellet-count results were combined to give an estimated density of 3.0 and 2.7 hares/ha from early fall 1980 to late summer 1981. Jack rabbit density declined to 1.9 and 1.2 hares/ha on the burn and control sites, respectively, from early fall 1981 to late summer 1982.

Table 17. Black-tailed jack rabbit pellet deposition rates (pellets/m^2/month) and % occurrence of pellets on pellet plots on the burn and control pellet-count grids. The first 3 counts were pre-burn, the fourth count was 1 year post-burn.

Pellet grid		Count 1 October 1980	Count 2 June 1981	Count 3 August, October 1981	Count 4 August 1982
Burn grids[a] N = 25[b]	1	0.92 ± 0.12	4.45 ± 0.65	8.38 ± 1.27	2.18 ± 0.26
	2	0.10 ± 0.02	1.85 ± 0.30	12.52 ± 1.15	4.34 ± 0.51
	3	0.58 ± 0.16	3.58 ± 0.50	9.84 ± 1.94	2.79 ± 0.26
	4	0.84 ± 0.14	4.67 ± 0.48	9.69 ± 1.25	2.99 ± 0.26
All burn plots N = 25[b]		0.61 ± 0.01	3.64 ± 0.27	10.11 ± 0.72	3.08 ± 0.19
% occurrence		82%	99%	100%	100%
Control grids[a] N = 25[b]	1	0.85 ± 0.14	3.59 ± 0.29	8.53 ± 1.13	2.00 ± 0.30
	2	0.24 ± 0.05	0.90 ± 0.14	7.90 ± 1.03	1.90 ± 0.25
	3	0.60 ± 0.11	2.59 ± 0.40	7.74 ± 1.12	1.82 ± 0.34
	4	0.35 ± 0.11	1.96 ± 0.33	7.89 ± 0.91	1.99 ± 0.36
All control plots N = 100[b]		0.51 ± 0.01	2.25 ± 0.18	8.02 ± 0.52	1.93 ± 0.16
% occurrence		83%	97%	97%	99%
Burn vs control,	F_6^1	0.19	2.66	5.60	6.27
ANOV	P	0.672	0.154	0.056	0.046

[a] $\bar{x}$ ± SE.
[b] Due to missing data, some cells may contain 1 or 2 fewer observations.

Food Habits

The relative densities of plant taxa were highly correlated between duplicate samples ($r = 0.87$, $P < 0.01$, $N = 95$). Thus, 24% of the variation in fecal composition could be attributed to imprecision of the analysis. Estimates of the relative densities of plant taxa occurring in amounts of < 5% were the most imprecise. The best estimates were obtained for plant taxa comprising > 30% of a duplicate sample (Table 18).

Table 18. Percent difference between relative density estimates of plant taxa occurring in various proportions in duplicate jack rabbit fecal samples.

% difference	Relative density of plant taxa				
	> 30%	21-30%	11-20%	5-10%	< 5%
mean	31	41	43	43	91
SE	9	3	10	6	4
N[a]	12	5	11	14	53

[a]N = number of individual comparisons between taxa.

Seven shrub, 10 grass, and 14 forb taxa were identified in 118 jack rabbit fecal samples collected in unburned habitat on and near the burn site from December 1980 through November 1981. Unidentified seed, presumed to be from forbs since they occurred only in feces collected in June through August, could have included grass seeds as well. Plant fragments identified in the 118 fecal samples consisted of 67.3% shrubs, 19.1% forbs, and 13.7% grasses. A large amount of variation was observed in the monthly proportions of shrubs, grasses, and forbs (Fig. 17).

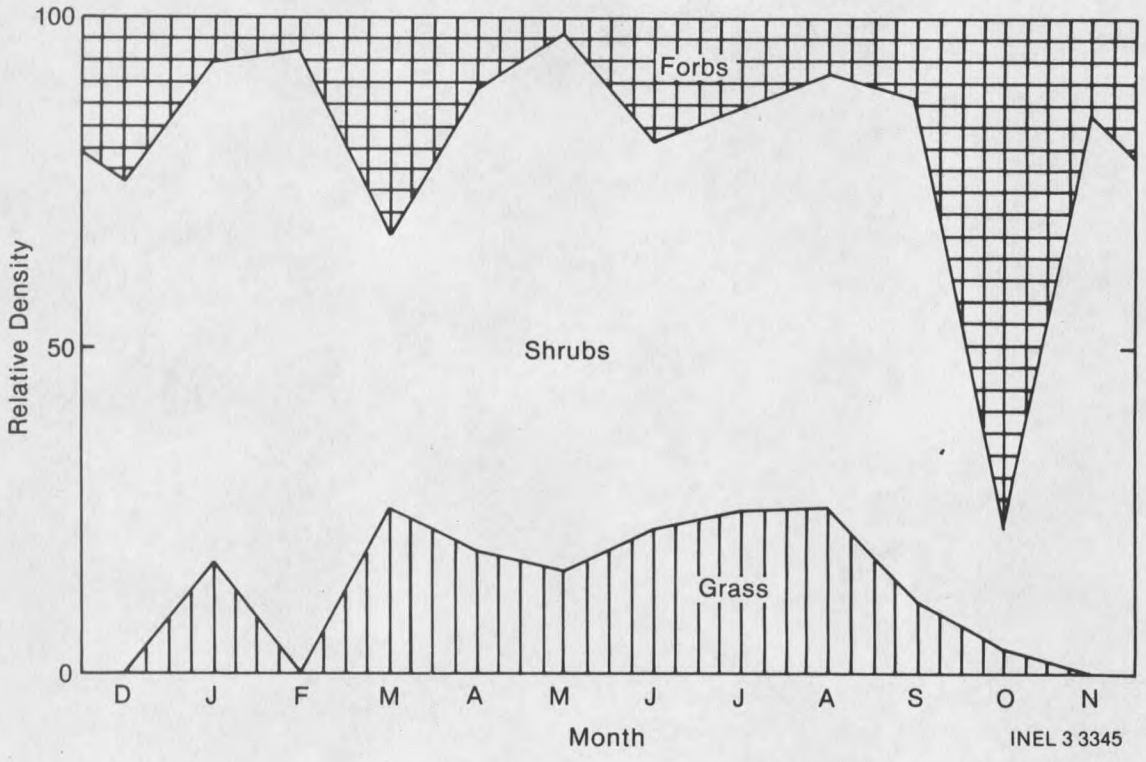


Fig. 17. Monthly relative densities of shrubs, grasses, and forbs in black-tailed jack rabbit feces collected in unburned habitat on and near the burn site, December 1980-November 1981.

Shrub relative densities ranged from 15.4% in October to 94.4% in February (Table 19). Winterfat was the most important shrub in the jack rabbit diet, occurring in fecal samples from all 12 months. Feces collected in April, May, September, and December contained the highest ($P < 0.05$) proportions of winterfat. Rabbitbrush (primarily Chrysothamnus nauseosus) was the second most important forage in the yearly jack rabbit diet. The highest ($P < 0.05$) relative density of rabbitbrush occurred in November. Sagebrush was consumed primarily during the winter months and was most important ($P < 0.05$) in February.

Forb relative densities ranged from 2.6% in May to 80.9% in October (Table 20). Phlox was the dominant forb consumed by jack rabbits and was most important in October. Forbs other than phlox occurred in all 12 monthly samples with June and March having the highest ($P < 0.05$) relative densities. Mustards (Descurainia spp.) and legumes (Astragalus, Oxytropis, and Vicia spp.) comprised most of the forbs other than phlox.

Grasses occurred in fecal samples from all months except November and December (Table 21). The most important grasses were Indian ricegrass, needlegrass (Stipa spp.), bluegrass (Poa spp.), wheatgrass (Agropyron spp.), and bottlebrush squirreltail. An unknown perennial grass seedling which was too young to have distinct microscopic characteristics comprised 14.7% of the plant fragments in January sample. The seedling may have been either an Elymus spp. or Agropyron spp. (Foppe, T., pers. comm.).

Table 19. Monthly relative densities of shrubs ($\bar{x}$ ± SE) in black-tailed jack rabbit feces collected in unburned habitat on and near the burn site, December 1980-November 1981.

Shrub taxon	Dec N = 8	Jan N = 10	Feb N = 10	Mar N = 8	Apr N = 10	May N = 10
Artemisia spp.		10.4±4.6 BC	58.0±9.2 A	21.8±5.8 B	1.8±0.6 C	
Ceratoides lanata	71.7±10.6 AB	37.2±12.4 CD	23.5±9.8 DE	12.1±11.5 E	62.6±6.9 AB	78.1±3.5 A
Chrysothamnus spp.	1.8±0.7 C	28.5±8.8 B	7.4±2.7 C	7.1±5.4 C	5.2±2.6 C	3.3±1.1 C
Other shrub	1.8±1.0 BC	0.2±0.2 C	5.5±3.0 B		0.3±0.3 C	
Atriplex spp.						
Tetradymia canescens	0.2±0.8	0.2±0.2				
Opuntia spp.	1.6±1.0		5.5±3.0		0.3±0.3	
Total shrub	75.3±9.3	76.3±8.5	94.4±2.2	41.0±10.1	69.9±7.0	81.5±4.0

Table 19. Continued.

Shrub taxon	June N = 10	Jul N = 10	Aug N = 10	Sep N = 10	Oct N = 10	Nov N = 10	12 month mean±SE
Artemisia spp.					0.6±0.6	7.0±2.8	8.2±1.8
Ceratoides lanata	48.6±15.4 BC	51.2±9.3 BC	39.1±9.3 CD	63.6±4.6 AB	5.1±1.5 E	4.1±2.5 E	41.4±3.1
Chrysothamnus spp.	11.1±3.5 C	10.4±2.7 C	26.6±5.8 B	11.7±3.3 C	8.7±3.5 C	62.5±6.3 A	15.5±2.0
Other shrub			0.8±0.5 C	1.7±1.3 BC	1.0±0.5 C	11.6±1.4 A	2.0±0.4
Atriplex spp.						0.4±1.1	Tr[b]
Tetradymia canescens						6.7±1.7	0.6±0.2
Opuntia spp.			0.8±0.5	1.7±1.3	1.0±0.5	4.5±1.4	1.3±0.4
Total shrub	59.7±3.8	61.6±7.3	66.5±4.8	76.9±3.7	15.4±3.4	85.2±3.6	67.3±2.5

[a]Means sharing the same letter were not significantly different (Duncan's new multiple range test, $P > 0.05$).
[b]Trace, < 0.1.

Table 20. Monthly relative densities of forbs ($\bar{x}$ ± SE) in black-tailed jack rabbit feces collected in unburned habitat on and near the burn site, December 1980-November 1981.

Forb taxon	Dec N = 8	Jan N = 10	Feb N = 10	Mar N = 8	Apr N = 10	May N = 10
Phlox spp.	23.4±27.4 B	3.2±1.6 D	4.6±2.2 D	22.8±7.7 BC	9.1±3.3 D	0.9±0.4 D
Other forb	1.3±0.7 C	3.8±1.1 C	0.6±0.6 C	10.7±6.9 AB	2.3±0.8 C	1.8±0.6 C
Allium spp.	0.8±0.6	0.3±0.3	0.6±0.6			0.2±0.2
Astragalus spp.-Oxytropis spp.	0.3±1.0				0.4±0.4	0.4±0.2
Vicia spp.						0.4±0.3
Unknown Compositae				0.5±0.5	1.0±0.6	0.7±0.3
Descurainia spp.		1.6±0.7		9.3±6.4	0.5±0.4	
Eriogonum spp.				0.9±0.9	0.3±0.3	
Unknown Hydorphyllaceae						
Mentzelia spp.						
Misc. see Unknown forb	0.2±0.8	1.3±0.6				
Total forb	24.7±9.3	7.0±2.3	5.3±2.2	33.5±8.7	11.4±3.5	2.6±0.7

Table 20. Continued.

Forb taxon	Jun N = 10	Jul N = 10	Aug N = 10	Sep N = 10	Oct N = 10	Nov N = 10	12 month mean±SE
Phlox spp.	7.0±2.8 D	8.4±2.5 D	6.5±1.7 D	10.5±2.3 CD	79.5±3.7 A	12.2±4.0 BCD	15.4±2.5
Other forb	11.6±3.2 A	5.5±1.4 BC	2.0±0.9 C	1.4±0.7 C	1.4±0.8 C	2.6±0.8 C	3.6±0.6
Allium spp.	1.6±1.1	0.4±0.4					0.3±0.1
Astragalus spp.-Oxytropis spp.	6.0±1.9	0.9±0.5	1.2±0.8	1.1±0.6	0.2±0.3		0.9±0.2
Vicia spp.							Tr[b]
Unknown Compositae	2.3±0.7	0.8±0.8					0.5±0.1
Descurainia spp.					0.3±0.3		0.9±0.5
Eriogonum spp.					0.8±0.8		0.2±0.1
Unknown Hydrophyllaceae	0.3±0.3						Tr
Mentzelia spp.	0.3±0.3						Tr
Misc. seed	0.5±0.5	0.4±0.4	0.4±0.4				0.1±0.1
Unknown forb	0.6±0.4	3.1±1.0	0.3±0.3	0.3±0.3		2.6±0.8	0.7±0.2
Total forb	18.6±4.1	13.9±3.3	8.4±2.2	11.9±2.3	80.9±3.5	14.8±3.7	19.1±2.2

[a]Means sharing the same letter were not significantly different (Duncan's new multiple range test, P > 0.05)
[b]Trace, < 0.1.

Table 21. Monthly relative densities of grasses ($\bar{x}$ ± SE) in black-tailed jack rabbit feces collected in unburned habitat on and near the burn site, December 1980-November 1981.

Grass taxon	Dec N = 8	Jan N = 10	Feb N = 10	Mar N = 8	Apr N = 10	May N = 10
Agropyron spp.		0.2±0.2		1.5±0.6	1.0±0.6	1.4±0.7
Bromus spp.						0.4±0.5
Elymus spp.		0.9±0.5				
Festuca spp.					1.0±0.7	0.3±0.3
Koeleria cristata				0.4±0.4		
Oryzopsis hymenoides				5.5±2.7	9.3±2.4	6.4±2.4
Poa spp.		0.4±0.4		10.8±5.1	3.2±1.3	2.3±0.9
Sitanion hystrix		0.3±0.3		3.5±1.2	2.3±1.1	3.2±1.5
Stipa spp.		0.2±0.2	0.3±0.3	3.5±1.3	1.9±1.1	1.9±0.7
Unknown grass		14.7±8.1		0.3±0.2		
Total grass	0.0±0.0	16.8±8.5 AB	0.3±0.3 C	25.5±5.4 A	18.7±5.0 A	15.9±3.9 AB

Table 21. Continued.

Grass taxon	Jun N = 10	Jul N = 10	Aug N = 10	Sep N = 10	Oct N = 10	Nov N = 10	12 month mean±SE
Agropyron spp.	4.2±1.0	1.6±1.0	2.0±0.7		0.3±0.3		1.0±0.2
Bromus spp.	6.0±2.3	1.4±0.7	0.4±0.4				0.7±0.2
Elymus spp.	0.9±0.6	0.6±0.4			0.2±0.2		0.2±0.1
Festuca spp.					0.7±0.7		0.2±0.1
Koeleria cristata				0.4±0.4	0.4±0.4		0.1±0.1
Oryzopsis hymenoides	4.5±1.2	13.2±3.1	14.4±2.4	6.2±1.9	0.7±0.4		5.1±0.7
Poa spp.	1.6±0.7				1.3±0.6		1.5±0.4
Sitanion hystrix	0.5±0.5	0.5±0.5	1.7±0.9	0.3±0.3			1.0±0.2
Stipa spp.	4.1±0.8	7.3±2.5	6.6±1.8	4.4±1.9			2.5±0.4
Unknown grass							1.3±0.8
Total grass	21.7±2.2 A	24.6±5.6 A	25.1±3.3 A	11.2±2.9 ABC	3.7±1.4 BC	0.0±0.0	13.7±1.4

[a]Means sharing the same letter were not significantly different (Duncan's new multiple range test, $P > 0.05$).

Discussion

Throughout the study period, pellet plots located on the burn site had higher pellet deposition rates than the control plots. The magnitude of the difference increased in successive pellet-counts until it became statistically significant 1 year after burning. Since jack rabbit pellet densities were not uniformly distributed on the burn and control sites, the higher pellet deposition rates which were observed on the burn site may have been due, in part, to experimental error. Additional pellet plots distributed over other areas of the burn and control sites might be helpful in future post-burn studies.

Seasonal shifts in jack rabbit distribution are known to occur presumably as a result of changes in food and cover requirements and availability (French et al. 1965, Currie and Goodwin 1966, Gross et al. 1974). Thus, relative use of burned and unburned areas by jack rabbits may also vary seasonally. The relatively high jack rabbit density observed in the third pellet count (5.5 hares/ha) may have indicated a summer concentration of jack rabbits on the burn and control sites in 1981. An alternate explanation might be the addition of young jack rabbits to the population.

Jack rabbit diets on and near the burn site differed from diets on other western rangelands and other areas of the INEL. Sparks (1968) and Fagerstone et al. (1980) reported smaller proportions of shrubs and larger proportions of grasses. Johnson (1979) reported a mean of 70% grasses in yearly composite samples of jack rabbit feces collected on the western INEL. Grass relative densities ranging from

65-95% were found by Johnson (1982) in feces collected in June and July from 9 study sites located in central and eastern portions of the INEL. Both of these studies found that wheatgrasses were the most important grass in the diets which they sampled. In contrast, the jack rabbit diet sampled in this study contained a yearly mean of 14% grasses. The most important grasses were Indian ricegrass and needlegrass. The results of this study were similar to the results which Johnson (1982) obtained on 2 of his study sites where winterfat was an important component of the vegetation. On these 2 sites, jack rabbits consumed 42-67% winterfat but only 24-38% grasses. During June and July 1981, jack rabbits on and near the burn site consumed 50% winterfat and 23% grasses. Thus, it appears that where jack rabbits consume a large proportion of winterfat, the importance of grasses in the diet may be diminished.

Rabbitbrush was an important shrub in the yearly diet of jack rabbits in the burn area; however, Johnson (1979) and Johnson (1982) reported little or no use of rabbitbrush by jack rabbits on the INEL. The results of this study are in aggreement with Johnson (1982) in that sagebrush contributes little or nothing to the summer diets of jack rabbits on the INEL. Currie and Goodwin (1966) reported that jack rabbits in Utah consumed 80% rubber rabbitbrush (Chrysothamnus nauseosus) and that sagebrush was not eaten until it became dormant in November. In contrast, Fagerstone et al. (1980) found that jack rabbits in southwest Idaho consumed 16-21% sagebrush during the summer.

The proportion of forbs in the jack rabbit diet in this study (19.4%) was similar to those reported by Johnson (1979) and Johnson

(1982). Studies conducted in other portions of the black-tailed jack rabbits' range have found higher proportions of forbs in the diet, ranging from 39-75% (Hayden 1966, Sparks 1968, Uresk 1978, Westoby 1980). The jack rabbit diet reported in this study was unique in its high proportion of phlox.

Black-tailed jack rabbit diets are influenced by forage availability and phenology. Succulent plants in pre-reproductive or early-reproductive stages are preferred (Sparks 1968, Fagerstone et al. 1980). Jack rabbit diets on the burn site should change as a result of post-burn vegetation changes. Perennial grasses and forbs usually increase after fall burns of sagebrush grassland (Blaisdell 1953). Johnson (1982) found that as the relative cover of grasses increases in jack rabbit habitats, so does the dietary importance of grasses. Although green rabbitbrush is a vigorous sprouter after burning, rubber rabbitbrush is more sensitive to the intensity of fire. Winterfat, the most important forage item found in this study, is also a vigorous sprouter after burning (Wright et al. 1979).

Johnson (1982) and MacCracken and Hansen (1982) found jack rabbit densities on the INEL to be positively correlated with grass cover. Jack rabbits select open grassy-areas for feeding during evening and night and move to shrub-dominated habitats for protection from weather and predators during the day (Fautin 1946, Lechleitner 1959). The interspersion of sagebrush cover with burned areas on which grasses should increase along with rabbitbrush and winterfat could improve jack rabbit habitat on the burn site.

PRONGHORN

Results

Pellet Counts

Pronghorn pellet-group densities were higher on the control site than on the burn site in all but the third pre-burn count. The differences were statistically significant only in the fourth count which was conducted 1 year after burning ($P = 0.04$; Table 22).

During the period from October 1980 through May 1981, mean pellet-group deposition rates on the burn and control sites were ($\bar{x} \pm SE$) 52 ± 7 and 85 ± 12 groups/ha/month, respectively. During June through August 1981, mean pellet-group deposition rates on the burn and control sites were 13 ± 10 and 4 ± 4 groups/ha/month, respectively. Pellet-group deposition rates calculated from the second count were significantly higher than those calculated from the third count on both the burn and control sites ($P < 0.001$). Thus, pronghorn used the burn and control sites primarily during the winter and spring in 1981 and very little during the summer.

Since the first, third, and fourth pellet-counts were conducted at approximately the same time of year, it was possible to compare pellet-group densities during the years 1979-80, 1980-81, and 1981-82. The second and third pellet-count results were combined to represent pellet-group densities for the period from early fall 1980 through late summer 1981. The mean of the pellet-group densities

Table 22. Pronghorn pellet-groups/ha and % occurrence on the burn and control pellet-count grids. The first 3 counts were pre-burn, the fourth count was 1 year post-burn.

Pellet grid		Count 1 October 1980	Count 2 June 1981	Count 3 August, October 1981	Count 4 August 1982
Burn grids[a] N = 25[b]	1	321 ± 170	200 ± 82	80 ± 80	40 ± 40
	2	375 ± 118	560 ± 142	0 ± 0	80 ± 80
	3	440 ± 142	480 ± 118	40 ± 40	0 ± 0
	4	458 ± 135	520 ± 118	0 ± 0	80 ± 80
All burn plots N = 100[b]		398 ± 71	440 ± 59	30 ± 22	50 ± 26
% occurrence		31%	43%	2%	4%
Control grids[a] N = 25[b]	1	375 ± 133	708 ± 186	0 ± 0	42 ± 41
	2	800 ± 208	800 ± 200	0 ± 0	360 ± 114
	3	360 ± 112	440 ± 130	0 ± 0	40 ± 40
	4	520 ± 154	720 ± 220	40 ± 40	80 ± 56
All control plots N = 100[b]		515 ± 79	667 ± 93	10 ± 10	131 ± 37
% occurrence		38%	39%	1%	12%
Burn vs control, Mann-Whitney test[c]	χ^2	1.13	1.62	0.33	4.32
	P	0.287	0.203	0.564	0.038

[a] $\bar{x}$ ± SE.
[b] Due to missing data, some cells may contain 1 or 2 fewer observations.
[c] Tests were conducted using the data collected on individual pellet plots.

observed on each of the 8 grids were ($\bar{x}$ ± SE) 458 ± 152, 574 ± 199, and 90 ± 113 groups/ha in 1979-80, 1980-81, and 1981-82, respectively. Since the burn and control sites received little use by pronghorn during the summer, the low pellet-group density observed between early fall 1981 and late summer 1982 may have been due, in part, to snow conditions during the winter of 1981-82. Mean daily snow depths ($\bar{x}$ ± SD) recorded at CFA were 2.6 and 2.3 cm during November through February in 1979-80 and 1980-81, respectively. During 1981-82 when the lowest pellet-group density was observed, mean daily snow depth was 6.4 cm.

Food Habits

The relative densities of plant taxa were highly correlated between duplicate samples ($r = 0.91$, $P < 0.01$, $N = 112$). Thus, 18% of the variation in fecal composition could be attributable to imprecision in the analysis. The most imprecise estimates were obtained for plant taxa occurring in amounts of < 5%. The best estimates were obtained for plant taxa comprising > 30% of a paired sample (Table 23).

Table 23. Percent difference between relative density estimates of plant taxa occurring in various proportions in duplicate pronghorn fecal samples.

% difference	Relative density of plant taxa				
	> 30%	21-30%	11-20%	5-10%	< 5%
mean	9	38	29	35	78
SE	4	6	5	7	5
N[a]	14	10	13	24	51

[a]N = number of individual comparisons between taxa.

Ten shrub, 8 grass, and 15 forb taxa were identified in 120 pronghorn fecal samples collected in unburned habitat surrounding and including the burn site from December 1980 through November 1981. Unidentified seeds were presumed to be from forbs since they occurred only in feces collected from July through September, although they could have included grass seeds as well. Plant fragments identified in the 120 fecal samples consisted of 76.2% shrubs, 22.9% forbs, and 0.9% grasses. The proportions of shrubs and forbs varied through the sample period with forbs dominating during June, July, and August and shrubs predominant in the remaining 9 months (Fig. 18).

Shrub relative densities ranged from 33.7% in August to 99.2% in February (Table 24). Sagebrush was the shrub in all monthly fecal samples. Relative densities were similar ($P > 0.05$) in the October through April samples when they averaged > 90%. The lowest ($P < 0.05$) proportions of sagebrush occurred in the June through August samples. Other shrubs were most important in July and August and comprised > 5% of the plant fragments in the February, June, and September samples. Bitterbrush (Purshia tridentata) was the most important shrub other than sagebrush.

Forb relative densities ranged from 1% in February to 62% in August (Table 25). Tansymustard (Descurainia spp.) and globemallow (Sphaeralcea spp.) were the most important forb taxa. The highest ($P < 0.05$) relative density of tansymustard occurred in the August samples and, globemallow was most important ($P < 0.05$) in the June samples. Legumes, primarily Astragalus spp.-Oxytropis spp. and lupine (Lupinus spp.) comprised the third most important taxa.

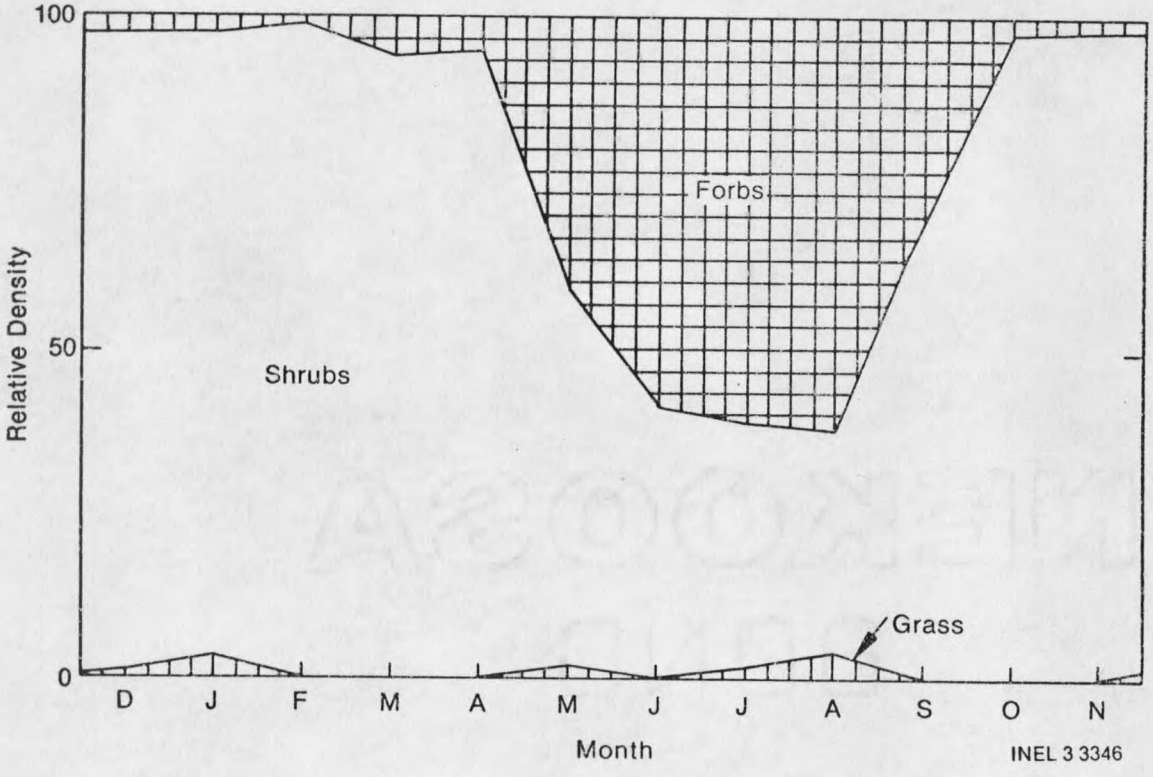


Fig. 18. Monthly relative densities of shrubs, grasses, and forbs in pronghorn feces collected in unburned habitat surrounding the burn site, December 1980-November 1981.

Table 24. Monthly relative densities of shrubs ($\bar{x}$ ± SE) in pronghorn feces collected in unburned habitat surrounding the burn site, December 1980–November 1981.

Shrub taxon	Dec	Jan	Feb	Mar	Apr	May
Artemisia spp.	95.2±1.1[a] A	93.5±3.4 A	93.0±1.5 A	93.5±0.7 A	95.4±1.5 A	57.0±10.1 B
Other shrub	2.5±0.8 C	1.1±0.6 C	6.2±1.7 BC	0.5±0.2 C	0.2±0.2 C	0.6±0.4 C
Ceratoides lanata	0.7±0.4		5.8±1.8	0.2±0.2		
Chrysothamnus nauseosus	0.3±0.3	0.2±0.2		0.2±0.2		
Chrysothamnus viscidiflorus						
Atriplex spp.	1.1±0.7	0.9±0.6	0.2±0.2			
Opuntia spp.			0.2±0.2		0.2±0.2	
Tetradymia canescens	0.2±0.2			0.2±0.2		
Purshia tridentata	0.2±0.2					0.6±0.4
Elaeagnus spp.-*Sheperdia* spp.						
Juniperus spp.						
Total shrub	97.7±0.7	94.6±3.5	99.2±0.4	94.0±0.9	95.6±1.4	57.7±10.2

[b]

Table 24. Continued.

Shrub taxon	Jun	Jul	Aug	Sep	Oct	Nov	12 month mean±SE
Artemisia spp.	32.4±8.9 C	22.4±9.8 CD	11.9±2.8 D	63.9±8.8 B	96.4±1.0 A	94.2±1.5 A	70.8±11.2
Other shrub	8.3±3.9 BC	15.4±9.3 AB	21.8±8.9 A	5.2±1.8 BC	0.5±0.4 C	3.3±0.9 BC	5.5±4.3
Ceratoides lanata						1.5±1.0	0.7±0.8
Chrysothamnus nauseosus			1.3±0.9	1.2±0.8			0.3±0.4
Chrysothamnus viscidiflorus		0.4±0.4					0.3±0.1
Atriplex spp.			0.7±0.6			0.5±0.4	0.3±0.4
Opuntia spp.	2.9±1.1	2.9±2.0	9.7±3.5	4.0±1.8	0.2±0.2	1.0±0.5	1.8±1.6
Tetradymia canescens						0.2±0.2	Tr[c]
Purshia tridentata	5.0±4.2	12.1±9.5	9.2±9.2		0.3±0.3		2.3±4.0
Elaeagnus spp.–Sheperdia spp.	0.4±0.4						Tr
Juniperus spp.			0.8±0.8			0.2±0.2	0.8±0.2
Total shrub	40.8±8.6	37.7±11.5	33.7±7.8	69.1±7.4	96.9±1.0	97.5±0.8	76.2±10.0

[a]N = 10 for all cells.
[b]Means sharing the same letter were not significantly different (Duncan's new multiple range test, $P > 0.05$).
[c]Trace, < 0.1.

Table 25. Monthly relative densities of forbs ($\bar{x}$ ± SE) in pronghorn feces collected in unburned habitat surrounding the burn site, December 1980-November 1981.

Forb taxon	Dec	Jan	Feb	Mar	Apr	May
Descurainia spp.	0.4±0.2[a] [b] C			1.5±0.7 BC	2.6±1.4 BC	16.2±8.6 ABC
Sphaeralcea spp.					0.2±0.2 C	8.3±3.6 BC
Other forb	1.8±0.6 C	2.2±0.8 C	0.8±0.4 C	4.2±0.6 C	1.5±0.7 C	16.9±4.6 AB
Arceuthobium spp.						
Mentzelia spp.						
Kochia spp.		0.3±0.3				
Balsamorhiza spp.						
Unknown Compositae	0.2±0.2	0.2±0.2		0.5±0.5	0.2±0.2	1.3±0.7
Cryptantha spp.				0.2±0.2	0.2±0.2	1.9±0.9
Draba spp.				0.3±0.3		
Phlox spp.	1.1±0.5	1.8±0.8	0.8±0.2	1.0±0.4	0.3±0.2	
Lupinus spp.	0.2±0.2					
Vicia spp.					0.2±0.2	
Melilotus-Medicago						
Astragalus-Oxytropis	0.3±0.3			1.3±0.5	0.3±0.3	10.4±3.0
Leguminosae seed						
Eriogonum spp.				1.0±0.4	0.3±0.2	3.3±1.2
Unidentified seed						
Total forb	2.1±0.7	2.2±0.8	0.8±0.2	5.7±0.7	4.3±1.4	41.4±9.9

Table 25. Continued.

Forb taxon	Jun	Jul	Aug	Sep	Oct	Nov	12 month mean±SE
Descurainia spp.	4.0±1.0 BC	16.5±9.6 ABC	30.8±7.9 A	19.1±6.0 AB			7.6±1.6
Sphaeralcea spp.	36.4±9.0 A	18.6±7.2 B	9.8±4.1 BC	0.8±0.8 C			6.2±1.4
Other forb	18.6±5.6 AB	25.9±9.1 A	21.8±6.0 AB	10.6±3.3 BC	2.9±0.9 C	2.2±0.6 C	9.1±1.4
Arceuthobium spp.						0.2±0.2	Tr[c]
Mentzelia spp.	5.3±3.8						0.4±0.3
Kochia spp.		1.3±1.3	0.4±0.4		0.2±0.2	0.3±0.3	0.2±0.1
Balsamorhiza spp.		12.4±9.3	3.4±2.0	2.0±0.9			1.5±0.8
Unknown Compositae	3.2±1.7	1.2±0.6		0.7±0.4			0.6±0.2
Cryptantha spp.	5.1±1.8	0.7±0.5	0.8±0.5				0.7±0.2
Draba spp.							Tr
Phlox spp.			5.0±3.4	7.2±3.4	0.5±0.4	1.1±0.4	1.6±0.4
Lupinus spp.		5.5±1.8	1.6±1.4		2.2±1.0	0.3±0.2	0.8±0.2
Vicia spp.							Tr
Melilotus-Medicago		1.4±1.0					0.1±0.1
Astragalus-Oxytropis	0.4±0.4	1.2±0.8	3.2±1.8	0.4±0.4			1.5±0.4
Leguminosae seed	2.7±2.4	0.6±0.4	1.3±1.0			0.2±0.2	0.4±0.2
Eriogonum spp.	1.9±1.9					0.2±0.2	0.6±0.2
Unidentified seed		1.6±0.9	6.0±5.6	0.4±0.4			0.7±0.5
Total forb	58.9±8.4	61.0±11.4	62.4±7.9	30.6±7.2	2.9±0.9	2.2±0.7	22.9±2.8

[a] N = 10 for all cells.
[b] Means sharing the same letter were not significantly different (Duncan's new multiple range test, P > 0.05).
[c] Trace, < 0.1.

Although the monthly mean relative densities of grasses did not differ significantly (P = 0.15) over the sample period, 3 small peaks occurred in January, May, and August. The January peak was due mostly to 1 fecal sample which contained 29% grasses. The dominant grasses occurring in the yearly pronghorn diet were brome (Bromus spp.), wildrye (Elymus spp.), and needlegrass (Table 26).

Discussion

A significant difference in pronghorn use of the burn and control sites was observed only in the fourth pellet-count which was conducted 1 year after burning. The higher pellet-group density on the control site in the fourth count was due to the influence of 1 grid which had a density of 360 pellet-groups/ha compared with densities ranging from 0-80 pellet-groups/ha on the remaining 7 grids. Thus, the greater use of the control site after burning may have been due to chance.

Although pronghorn were observed on or near the burn site throughout the year, the pellet-group counts conducted in 1981 showed that pronghorn used the burn and control sites primarily during the winter and spring. Field observations indicated that pronghorn concentrated near INEL facilities south and west of the burn site and near cropland north of the burn site from late spring through mid-fall. These areas provided an abundant source of free water and succulent forbs which are important to pronghorn populations in arid regions (Sundstrom 1968, Beale and Smith 1970).

Table 26. Monthly relative densities of grasses ($\bar{x}$ ± SE) in pronghorn feces collected in unburned habitat surrounding the burn site, December 1980-November 1981.

Grass taxon	Dec	Jan	Feb	Mar	Apr	May
Bromus spp.		0.7±0.7[a]				
Echinochloa spp.		0.2±0.2				
Elymus spp.		0.9±0.7			0.2±0.2	0.6±0.4
Poa spp.		0.4±0.4				
Sitanion hystrix		0.4±0.4				
Stipa spp.		0.7±0.7		0.3±0.2		0.4±0.4
Oryzopsis hymenoides						
Agropyron spp.	0.2±0.2					
Total grass	0.2±0.2[b]	3.2±2.9	0.0±0.0	0.3±0.2	0.2±0.2	0.9±0.5

Table 26. Continued.

Grass taxon	Jun	Jul	Aug	Sep	Oct	Nov	12 month mean±SE
Bromus spp.	0.3±0.3	0.9±0.6	0.5±0.5			0.2±0.2	0.2±0.1
Echinochloa spp.							Tr[c]
Elymus spp.			0.4±0.4	0.3±0.3	0.2±0.2		0.2±0.1
Poa spp.			0.4±0.4			0.1±0.1	Tr
Sitanion hystrix			0.4±0.4				Tr
Stipa spp.			0.9±0.6				0.2±0.1
Oryzopsis hymenoides		0.4±0.4					Tr
Agropyron spp.			1.3±0.9				0.1±0.1
Total grass	0.3±0.3	1.3±0.6	3.8±1.8	0.3±0.3	0.2±0.2	0.3±0.2	0.9±0.3

[a]N = 10 for all cells.
[b]Monthly means for relative densities of total grass were not significantly different (ANOV, $P > 0.05$).
[c]Trace, < 0.1.

The burn site is small (405 ha) in relation to the size of the winter range on which it occurs (Fig. 19) and the winter home range sizes of pronghorn in the Little Lost River valley (1000-4900 ha) reported by Hoskinson and Tester (1980). Consequently, small changes in the winter distribution of pronghorn on the study area may have a profound effect on pronghorn use of the burn site. This may have occurred in the deep snow winter of 1981-82 when pronghorn use of the burn area was much lower than in the previous 2 winters which had less persistent snowcover.

The diets of pronghorn on the western portion of the INEL from December 1980 through November 1981 were similar to pronghorn diets on other native shrub rangelands. Several studies have demonstrated the importance of sagebrush in the late fall, winter, and early spring diets of pronghorn (Mason 1952, Cole 1956, Beale and Smith 1970, Taylor 1972). These studies have also shown that forbs are an important part of the summer diet, while grasses are usually important only for brief periods in early spring or fall.

Sagebrush was the most important pronghorn forage in this study and comprised greater than 90% of the diet from mid-fall through mid-spring. Shrubs other than sagebrush were eaten mostly during the summer. Forbs comprised most of the summer diet and also comprised a large share of the late spring and early fall diets. The contribution of grasses to the diets of pronghorn in this study was much lower than previously reported (Cole 1956, Severson et al. 1968, Taylor 1972). Grasses were consumed primarily from May through August. The occurrence of a peak in grass use in January may have been due to an early growth

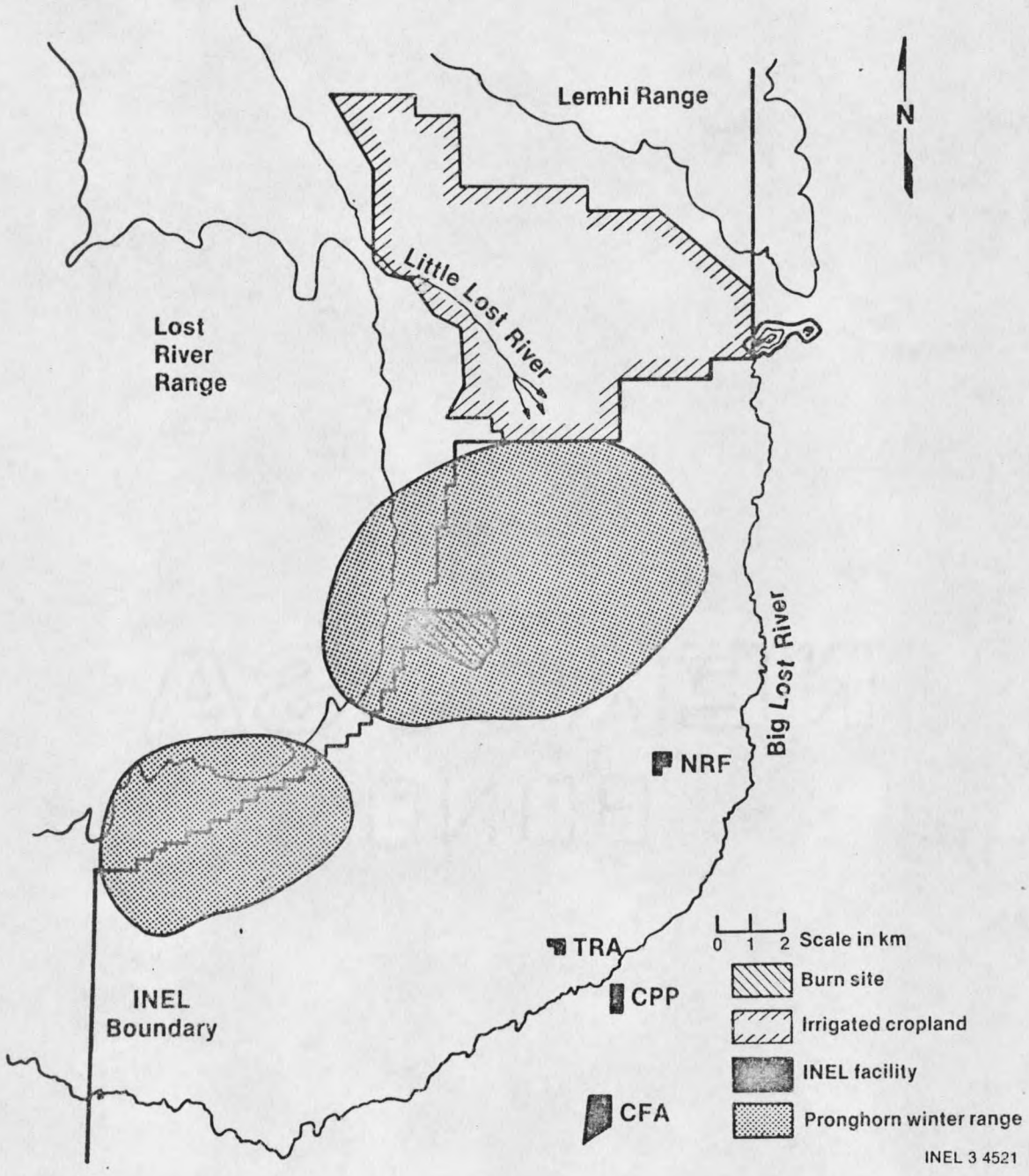


Fig. 19. Winter distribution of pronghorn (this study and after Reynolds, unpubl. data) on the western portion of the INEL.

of new grasses. A similar peak in grass use was observed in January for jack rabbits which were apparently consuming an immature grass.

The pronghorn diet in this study was similar to that reported by Johnson (1979) on the INEL. Winterfat was important in both winter and summer in Johnson's (1979) study; whereas, in this study, winterfat comprised only < 1% of the yearly diet. Similar to the results of this study, grass comprised < 2% of the winter and spring diets reported by Johnson (1979). This and Johnson's study found that legumes, mustards, and globemallow were the most important forbs in the summer diets of INEL pronghorn.

Since pronghorn rely on sagebrush for food and cover during the winter, burning could adversely affect the value of the burn site as winter habitat. Due to the small size of the burn site and the abundance of sagebrush cover in the surrounding area, the prescribed burn should not have a serious negative impact on pronghorn.

Enhanced growth of forbs and perennial grasses on burned areas could potentially benefit pronghorn during spring and early summer. Pronghorn select their foods on the basis of nutritional quality and succulence (Dirschl 1963, Beale and Smith 1970). Delayed maturation and desiccation of herbaceous vegetation on burned areas (Blaisdell 1953) could increase the diversity of palatable forage plants available to pronghorn through at least early summer. Low precipitation precludes any significant use of the burn site after mid-summer except in unusually wet years.

SUMMARY

The ecologies of sage grouse and pronghorn in the area surrounding the burn were similar in that these species relied on sagebrush for food during late fall through early spring. During the summer, grouse and pronghorn switched to a forb-dominated diet and moved to irrigated cropland and INEL facilities. Normally low precipitation on the burn site during July through September makes it unteneble as summer habitat for these species.

Removal of sagebrush from the burn site will almost certainly have a negative impact on the value of the burn site as winter habitat for grouse and pronghorn. The burn site, however, is smaller than the winter range sizes of these species and sagebrush was not eliminated from the entire burn site. The availability of sagebrush habitat near the burn site is probably not a limiting factor; however, openings in the sagebrush cover are small and widely scattered on the western INEL.

Any potential benefit of the burn to grouse and pronghorn would have to occur as a result of increased forb production and/or a lengthened season of forb growth in the spring. Blaisdell (1953) found that forb production on the upper Snake River Plain was enhanced for up to 12 years after burning and that forb phenology was delayed as long as 2 weeks on burned areas. Blaisdell's (1953) study areas

were 300 m higher in elevation and received 7-20 cm more precipitation than the burn site. Consequently, his results may not by entirely applicable to the burn site.

Final interpretation of the effects of the burn must await the results of post-burn studies of vegetation, grouse, and pronghorn response to burning. Results of this and future studies on the burn site would be most applicable to areas of low precipitation where sagebrush cover is extensive and not in short supply. Where sagebrush cover is limited, fire should have a serious negative impact on grouse and pronghorn. Considering the extent of sagebrush eradication which has occurred in the last 30 years, the latter may be the most common situation on many grouse and pronghorn ranges.

Pygmy rabbits depend on sagebrush for food and cover throughout the year. Sagebrush eradication can only have a negative impact on this species. Pygmy rabbits in this study were adversely affected by fire during and after burning. Although some radio-collared pygmy rabbits dispersed from the burn site after burning, most were killed by predators.

Black-tailed jack rabbits could increase on the burn site with increased production of grasses and shrubs such as winterfat and rabbitbrush. Sufficient sagebrush cover was left by the burn to provide food and cover through the winter. An increase in jack rabbit density on the burn site could be an economically negative impact of the burn since jack rabbits have caused serious depredation problems in cropland adjacent to the INEL.

Sufficient dietary data were collected in unburned habitat to compare pre- and post-burn trophic relationships of grouse, pronghorn, and lagomorphs. Post-burn changes in vegetation composition could alter the competitive relationships of wild and domestic herbivores on the burn site. This is an often overlooked aspect of vegetation manipulation with the dual purpose of range improvement for both livestock and wildlife.

LITERATURE CITED

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Abramsky, Z., and C. R. Tracy. 1979. Population biology of a "noncycling" population of prairie voles and the role of migration in regulating microtine cycles. Ecology. 60:349-361.

Amstrup, S. C. 1980. A radio-collar for game birds. J. Wildl. Manage. 44:214-217.

Arnold, J. F., and H. G. Reynolds. 1943. Droppings of Arizona and antelope jack rabbits and the "pellet census." J. Wildl. Manage. 7:322-327.

Beale, D. M., and A. D. Smith. 1970. Forage use, water consumption, and productivity of pronghorn antelope in western Utah. J. Wildl. Manage. 34:570-585.

Beck, T. D. 1977. Sage grouse flock characteristics and habitat selection in winter. J. Wildl. Manage. 41:18-26.

Beck, T. D., and C. E. Braun. 1980. The strutting ground count: variation, traditionalism, management needs. Proc. West. Ass'n. State Game and Fish Comms. 60:558-566.

Bendell, J. F. 1974. Effects of fire on birds and mammals. p.73-138 In: Kozlowski, T. T., and C. E. Ahlgren (eds.) Fire and Ecosystems. Academic Press, New York. 542p.

Blaisdell, J. P. 1953. Ecological effects of planned burning of sagebrush-grass range on the upper Snake River Plains. USDA Tech. Bull. 1075. 39p.

Bock, C. E., and J. H. Bock. 1978. Response of birds, small mammals, and vegetation to burning sacaton grasslands in southeastern Arizona. J. Range Manage. 31:296-300.

Braun, C. E., M. F. Baker, R. L. Eng, J. S. Gashwiler, and M. H. Schroeder. 1976. Conservation committee report on effects of alteration of sagebrush communities on the associated avifauna. Wilson Bull. 88:165-171.

Chew, R. M., B. B. Butterworth, and R. Grechman. 1958. The effects of fire on the small mammal populations of chaparral. J. Mammal. 40:253.

Cole, G. F. 1956. The pronghorn antelope, its range use and food habits in central Montana with special reference to alfalfa. Mont. Agric. Exp. Sta. Tech. Bull. 516. 63p.

Connelly, J. W. 1982. An ecological study of sage grouse in southeastern Idaho. Unpubl. Ph.D. Diss., Washington State Univ., Pullman. 84p.

Connelly, J. W., W. J. Arthur, and O. D. Markham. 1981. Sage grouse leks on recently disturbed sites. J. Range Manage. 34:153-154.

Crunden, C. W. 1963. Age and sex of sage grouse from wings. J. Wildl. Manage. 27:846-849.

Currie, P. O., and D. L. Goodwin. 1966. Consumption of forage by black-tailed jackrabbits on salt-desert ranges of Utah. J. Wildl. Manage. 30:304-311.

Dalke, P. D., and P. R. Sime. 1938. Home and seasonal ranges of the eastern cottontail in Connecticut. Trans. Third North Am. Wildl. Conf. 3:659-669.

Dalke, P. D., D. B. Pyrah, D. C. Stanton, J. E. Crawford, and E. Schlatterer. 1960. Seasonal movements and breeding behavior of sage grouse in Idaho. Trans. N. Am. Wildl. Conf. 25:396-407.

Dalke, P. D., D. B. Pyrah, D. C. Stanton, J. E. Crawford, And E. F. Schlatterer. 1963. Ecology, productivity and management of sage grouse in Idaho. J. Wildl. Manage. 27:811-841.

Dirschl, H. J. 1963. Food habits of the pronghorn in Saskatchewan. J. Wildl. Manage. 27:81-93.

Drobney, R. D., and L. H. Fredrickson. 1979. Food selection by wood ducks in relation to breeding status. J. Wildl. Manage. 43:109-120.

Emmons, S. R. 1980. Lek attendance of male sage grouse in North Park, Colorado. Unpubl. M.S. Thesis. Colorado State Univ., Fort Collins. 69p.

Eng, R. L., and P. Schladweiler. 1972. Sage grouse winter movements and habitat use in central Montana. J. Wildl. Manage. 36:141-146.

Fagerstone, K. A., G. K. LaVoie, and R. E. Griffith, Jr. 1980. Black-tailed jackrabbit diet and density on rangeland and near agricultural crops. J. Range Manage. 33:229-233.

Fautin, R. W. 1946. Biotic communities of the northern desert shrub biome in western Utah. Ecol. Monogr. 16:251-310.

Ferguson, R. B. 1955. The weathering and persistency of pellet groups as it affects the pellet group count method of censusing mule deer. Utah Acad. Sci., Arts, and Letters. 32:59-64.

Flinders, J. T., and J. A. Crawford. 1977. Composition and degradation of jackrabbit and cottontail fecal pellets, Texas high plains. J. Range Manage. 33:217-220.

Floyd, D. A. 1982. A comparison of three methods for estimating vegetal cover in sagebrush steppe communities. Unpubl. M.S. Thesis. Idaho State Univ., Pocatello. 178p.

French, N. R., R. McBride, and J. E. Detmer. 1965. Fertility and population density of the black-tailed jackrabbit. J. Wildl. Manage. 29:14-26.

Giesen, K. M., T. J. Schoenberg, and C. E. Braun. 1982. Methods for trapping sage grouse in Colorado. Wildl. Soc. Bull. 10:224-231.

Gill, R. B., and F. A. Glover. 1965. Daily and seasonal movements of sage grouse. Colo. Coop. Wildl. Res. Unit. Tech. Paper No. 3. 6p.

Green, J. S., and J. T. Flinders. 1980. Habitat and dietary relationships of the pygmy rabbit. J. Range Manage. 33:136-142.

Gross, J. E., L. C. Stoddart, and F. H. Wagner. 1974. Demographic analysis of a northern Utah jackrabbit population. Wildl. Monogr. 40:1-68.

Halford, D. K. 1981. Repopulation and food habits of Peromyscus maniculatus on a burned sagebrush desert in southeastern Idaho. Northwest Sci. 55:44-49.

Hannon, S. J. 1982. Spring movements of female blue grouse: evidence for socially induced dealyed breeding in yearlings. Auk 99:687-694.

Hansen, R. M., T. M. Foppe, M. B. Gilbert, R. C. Clark, and H. W. Reynolds. 1976. The microhistological analysis of feces as an indicator of herbivore dietary. Composition Analysis Lab., Range Sci. Dept., Colorado State Univ., Fort Collins. 6p.

Harniss, R. O., and R. B. Murray. 1973. 30 years of vegetal change following burning of sagebrush-grass range. J. Range Manage. 26:322-325.

Hayden, P. 1966. Food habits of black-tailed jack rabbits in southern Nevada. J. Mammal. 47:42-46.

Herzog, P. W. 1978. Food selection by female spruce grouse during incubation. J. Wildl. Manage. 42:632-636.

Hoskinson, R. L., and J. R. Tester. 1980. Migration behavior of pronghorn in southeastern Idaho. J. Wildl. Manage. 44:132-144.

Howard, W. E., R. L. Fenner, and H. E. Childs, Jr. 1959. Wildlife survival in brush burns. J. Range Manage. 12:230-234.

Jenni, D. A., and J. E. Hartzler. 1978. Attendance at a sage grouse lek: implications for spring censuses. J. Wildl. Manage. 42:46-52.

Johnson, M. K. 1979. Foods of primary consumers on cold desert shrub-steppe of southcentral Idaho. J. Range Manage. 32:365-368.

Johnson, R. D. 1982. Relationships of black-tailed jack rabbit diets to population density and vegetal components of habitat. Unpubl. M.S. Thesis. Idaho State Univ., Pocatello. 86p.

Keith, L. B. 1974. Some features of population dynamics in mammals. Proc. Int. Congr. Game Biol. 11:17-58.

Keith, L. B., and D. C. Surrendi. 1971. Effects of fire on a snowshoe hare population. J. Wildl. Manage. 35:16-26.

Klebenow, D. A. 1969. Sage grouse nesting and brood habitat in Idaho. J. Wildl. Manage. 33:649-661.

Klebenow, D. A. 1970. Sage grouse versus sagebrush control in Idaho. J. Range Manage. 23:396-400.

Klein, D. R. 1970. Food selection by North American deer and their response to over-utilization of preferred plant species. p.25-46 In: Watson, A. (ed.) Animal populations in relation to their food resources. Blackwell Scientific Publications, Oxford. 477p.

Komarek, E. V., Sr. 1969. Fire and animal behavior. Tall Timbers Fire Ecol. Conf. 9:161-207.

Krapu, G. L. 1974. Foods of breeding pintails in North Dakota. J. Wildl. Manage. 38:408-417.

Krebs, C. J., B. L. Keller, and R. H. Tamarin. 1969. Microtus population biology: demographic changes in fluctuating populations of M. ochrogaster and M. pennsylvanicus in southern Indiana. Ecology. 50:587-607.

Lawrence, G. E. 1966. Ecology of vertebrate animals in relation to chaparral fire in the Sierra Nevada foothills. Ecology. 47:278-291.

Lechleitner, R. R. 1959. Movements, density, and mortality in a black-tailed jack rabbit population. J. Wildl. Manage. 22:371-384.

Lidicker, W. Z., Jr. 1975. The role of dispersal in the demography of small mammals. p.103-128 In: Golley, F. B., K. Petrusewicz, and L. Ryszkowski (eds.) Small mammals: their productivity and population dynamics. Int. Biol. Progr. Vol. 5 Cambridge Univ. Press, Great Britain.

MacCracken, J. G., and R. M. Hansen. 1982. Herbaceous vegetation of habitat used by blacktail jackrabbits and Nuttall cottontails in southeastern Idaho. Am. Midl. Nat. 107:180-184.

Martin, N. S. 1970. Sagebrush control related to habitat and sage grouse occurrence. J. Wildl. Manage. 34:313-330.

Mason, E. 1952. Food habits and measurements of Hart Mountain antelope. J. Wildl. Manage. 16:387-389.

McBride, R., N. R. French, A. H. Dahl, and J. E. Detmer. 1978. Vegetation types and surface soils of the Idaho National Engineering Laboratory Site. IDO-12084. National Technical Information Service, Springfield, VA. 29p.

Mechlin, L. M., and C. W. Shaiffer. 1980. Net-firing gun for capturing breeding waterfowl. J. Wildl. Manage. 44:895-898.

Metzgar, L. H. 1967. An experimental comparison of screech owl predation on resident and transient white-footed mice (Peromyscus leucopus). J. Mammal. 48:387-391.

Mohr, C. O. 1947. Table of equivalent populations of North American small mammals. Am. Midl. Nat. 37:223-249.

Mueggler, W. F., and J. P. Blaisdell. 1958. Effects on associated species of burning, rotobeating, spraying, and railing sagebrush. J. Range Manage. 11:61-66.

Myers, K., and W. E. Poole. 1963. A study of the biology of the wild rabbit, Orytolagus cuniculus (L.), in confined populations. V Population dynamics. C.S.I.R.O. Wildl. Res. 8:166-203.

Neff, N. J. 1968. The pellet-group count technique for big game trend, census, and distribution: a review. J. Wildl. Manage. 32:597-614.

Oakleaf, R. J. 1971. The relationship of sage grouse to upland meadows in Nevada. Job Final Rept., Nevada Dept. of Fish and Game. Proj. W-48-2. 63p.

Patterson, R. L. 1952. The sage grouse in Wyoming. Sage Books Inc., Denver. 341p.

Petersen, B. E. 1980. Breeding and nesting ecology of female sage grouse in North Park, Colorado. Unpubl. M.S. Thesis. Colorado State Univ., Fort Collins. 86p.

Peterson, J. G. 1970. The food habits and summer distribution of juvenile sage grouse in central Montana. J. Wildl. Manage. 34:147-155.

Pyrah, D. B. 1970. Poncho markers for game birds. J. Wildl. Manage. 34:466-467.

Pyrah, D. B., H. E. Jorgensen, and R. O. Wallestad. 1972. Ecology of sagebrush control. Job Progr. Rept., Montana Fish and Game Dept. Proj. W-105-R-6. 79p.

Renwald, D. J. 1977. Effect of fire on lark sparrow nesting densities. J. Range Manage. 30:283-285.

Riggs, R. A., and J. M. Peek. 1980. Mountain sheep habitat-use patterns related to post-fire succession. J. Wildl. Manage. 44:933-938.

Robbins, C. T. 1981. Estimation of the relative protein cost of reproduction in birds. Condor 83:177-179.

Schladweiler, P. 1968. Feeding behavior of incubating ruffed grouse females. J. Wildl. Manage. 32:426-428.

Severson, K., M. May, and W. Hepworth. 1968. Food preferences, carrying capacities and forage competition between antelope and domestic sheep in Wyoming's Red Desert. Agr. Exp. Sta., Univ. Wyo., Laramie Sci. Monogr. 10. 51p.

Shields, P. W. 1960. Movement patterns of brush rabbits in northwestern California. J. Wildl. Manage. 24:381-386.

Shinn, D. A. 1980. Historical perspectives on range burning in the inland Pacific northwest. J. Range Manage. 33:415-423.

Snedecor, G. W., and W. G. Cochran. 1967. Statistical methods (6th ed.). Iowa State Univ. Press, Ames. 593p.

Sparks, D. R. 1968. Diet of black-tailed jackrabbits on sandhill rangeland in Colorado. J. Range Manage. 21:203-208.

Sparks, D. R., and J. C. Malechek. 1968. Extimating percentage dry weights in diets using a microscopic technique. J. Range Manage. 21:264-265.

Sundstrom, C. 1968. Water consumption by pronghorn antelope and distribution related to water in Wyoming's Red Desert. Proc. Biennial Antelope States Workshop. 3:39-46.

Swanson, G. A., M. I. Meyer, and J. R. Serie. 1974. Feeding ecology of breeding blue-winged teals. J. Wildl. Manage. 38:396-407.

Tamarin, R. H. 1977. Dispersal in island and mainland voles. Ecology. 58:1044-1054.

Taylor, E. 1972. Plant availability versus utilization by pronghorn antelope on the Red Desert of Wyoming. Proc. Bienn. Western Antelope States Workship. 6:95-103.

Trent, T. T., and O. J. Rongstad. 1974. Home range and survival of cottontail rabbits in southwestern Wisconsin. J. Wildl. Manage. 38:459-472.

Uresk, D. W. 1978. Diets of the black-tailed hare in steppe vegetation. J. Range Manage. 31:439-442.

Vale, T. R. 1974. Sagebrush conversion projects: an element of contemporary environmental change in the western United States. Biol. Cons. 6:274-284.

Wallestad, R. O. 1971. Summer movements and habitat use by sage grouse broods in central Montana. J. Wildl. Manage. 35:129-136.

Wallestad, R. O. 1975. Male responses to sagebrush treatment. J. Wildl. Manage. 39:482-484.

Wallestad, R. O., J. G. Peterson, and R. L. Eng. 1975. Food habits of adult sage grouse in central Montana. J. Wildl. Manage. 39:628-630.

Wallestad, R. O., and D. B. Pyrah. 1974. Movement and nesting of sage grouse hens in central Montana. J. Wildl. Manage. 38:630-633.

Wallestad, R. O., and P. Schladweiler. 1974. Breeding season movements and habitat selection of male sage grouse. J. Wildl. Manage. 38:634-637.

Watson, A., and R. Moss. 1970. Dominance, spacing behavior and aggression in relation to population limitation in vertebrates. p.167-220 In: Watson, A. (ed.) Animal populations in relation to their food resources. Blackwell Scientific Publications, Oxford. 477p.

West, G. C. 1968. Bioenergetics of captive willow ptarmigan under natural conditions. Ecology. 49:1035-1045.

Westoby, M. 1980. Black-tailed jack rabbit diets in Curlew Valley, northern Utah. J. Wildl. Manage. 44:942-948.

Wilde, D. B. 1978. A population analysis of the pygmy rabbit (Sylvilagus idahoensis) on the INEL Site. Unpubl. Ph.D. Diss., Idaho State Univ., Pocatello. 172p.

Wiley, R. H. 1973. Territoriality and nonrandom mating in sage grouse. Anim. Behav. Monogr. 6:85-169.

Wolff, J. O. 1980. The role of habitat patchiness in the population dynamics of snowshoe hares. Ecol. Monogr. 50:111-130.

Wright, H. A., L. F. Neuenschwander, and C. M. Britton. 1979. The role and use of fire in sagebrush-grass and pinyon-juniper plant communities, a state-of-the-art review. USDA Forest Service, General Technical Report INT-58. 48p.

Wynne-Edwards, V. C. 1962. Animal dispersion in relation to social behavior. Hafner Pub. Co., New York. 653p.

Yanskey, G. R., E. H. Markee, Jr., and A. P. Richter. 1966. Climatography of the National Reactor Testing Station. IDO-12048. U.S. Atomic Energy Commision.

Zwickel, F. C., and J. F. Bendell. 1972. Observations on food habits of incubating female blue grouse. Condor 74:493-494.

APPENDICES

APPENDIX A

FEMALE SAGE GROUSE BREEDING CHRONOLOGY

Table 27. Breeding chronology and nesting success of 10 radio-collared sage grouse hens.

Age	Capture location	Capture date	Date nest located	Nest distance from lek	Probable date of breeding	Estimated first day of Laying	Estimated first day of Incubation	Fate of nest	Hatching success
Adult	Nest on burn site	22 May 1981	27 Apr 1981	2.5 km	ND[a]	21 Apr 1981	2 May 1981	Hatched 27 May 1981	5 of 7
Adult	Sinks #1	26 Mar 1982	21 May 1982	10.5 km	ND	16 Apr 1982	5 May 1982	Hatched 2 June 1982	4 of 5
Adult	8-mile Canyon #1	10 Apr 1982	8 May 1982	4.9 km	11 Apr 1982	25 Apr 1982	7 May 1982	Hatched 4 June 1982	7 of 7
Adult	Near Sinks #1	12 Apr 1982	8 May 1982	1.0 km	16 Apr 1982	27 Apr 1982	8 May 1982	Hatched 4 Jun 1982	7 of 7
Adult	8-mile Canyon #1	13 Apr 1982	26 Apr 1982	4.1 km	14 Apr 1982	23 Apr 1982	2 May 1982	Hatched 2 Jun 1982	5 of 6
Adult	8-mile Canyon #1	10 Apr 1982	7 May 1982	2.1 km	11 Apr 1982	ND	ND	Abandoned 9 May 1982	0 of 7
Yrlng	8-mile Canyon #1	16 Apr 1982	7 May 1982	3.0 km	17 Apr 1982	ND	ND	Destroyed mid-May 1982	0 of 6
Yrlng	Knob Butte	17 Apr 1982	7 May 1982	4.9 km	18 Apr 1982	25 Apr[b] 1982	7 May 1982	Destroyed 4 Jun 1982	0 of ?
Yrlng	Knob Butte	18 Apr 1982	26 May 1982	2.8 km	19 Apr 1982	ND	ND	Hen collided with powerline	0 of ?
Yrlng	Knob Butte	18 Apr 1982	23 May 1982	7.0 km	19 Apr 1982	ND	ND	Hatched, date unknown	3 of 5

[a]Not determined.
[b]Calculated with the assumption that 7 eggs were laid.

APPENDIX B

YEAR-LONG MOVEMENTS OF RADIO-COLLARED SAGE GROUSE

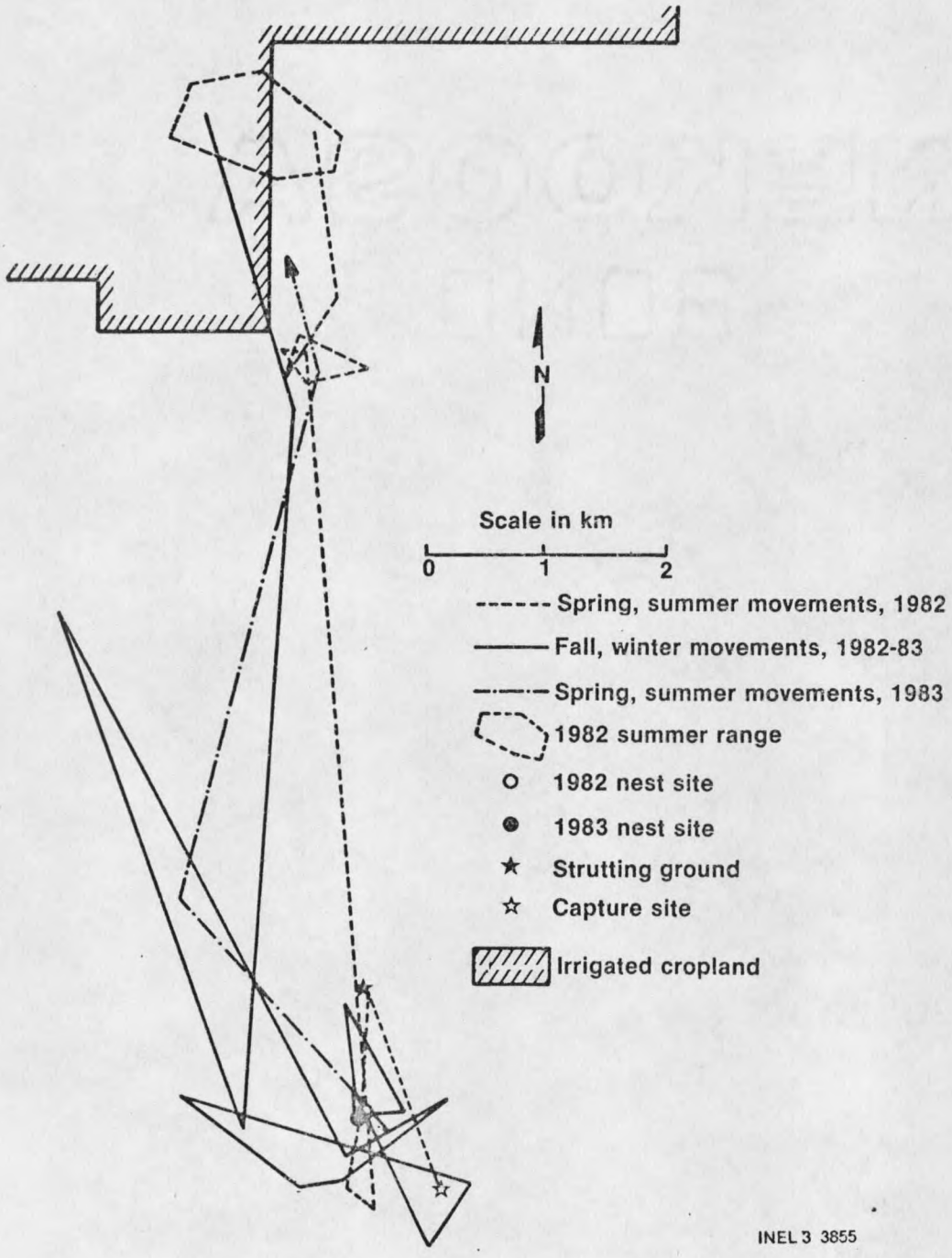


Fig. 20. Year-round movements of an adult female sage grouse from spring 1982-summer 1983.

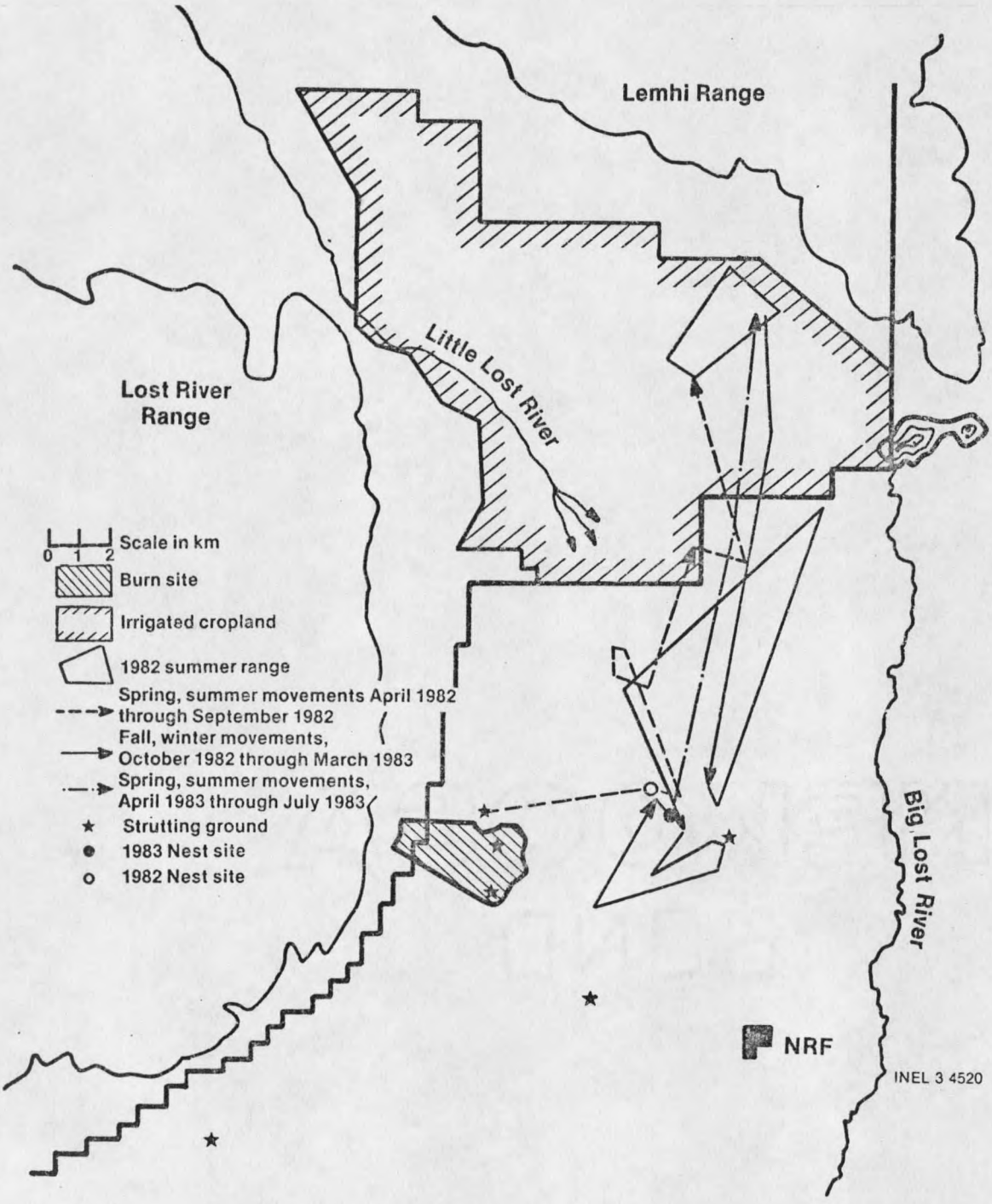


Fig. 21. Year-round movements of an adult female sage grouse from spring 1982-summer 1983.

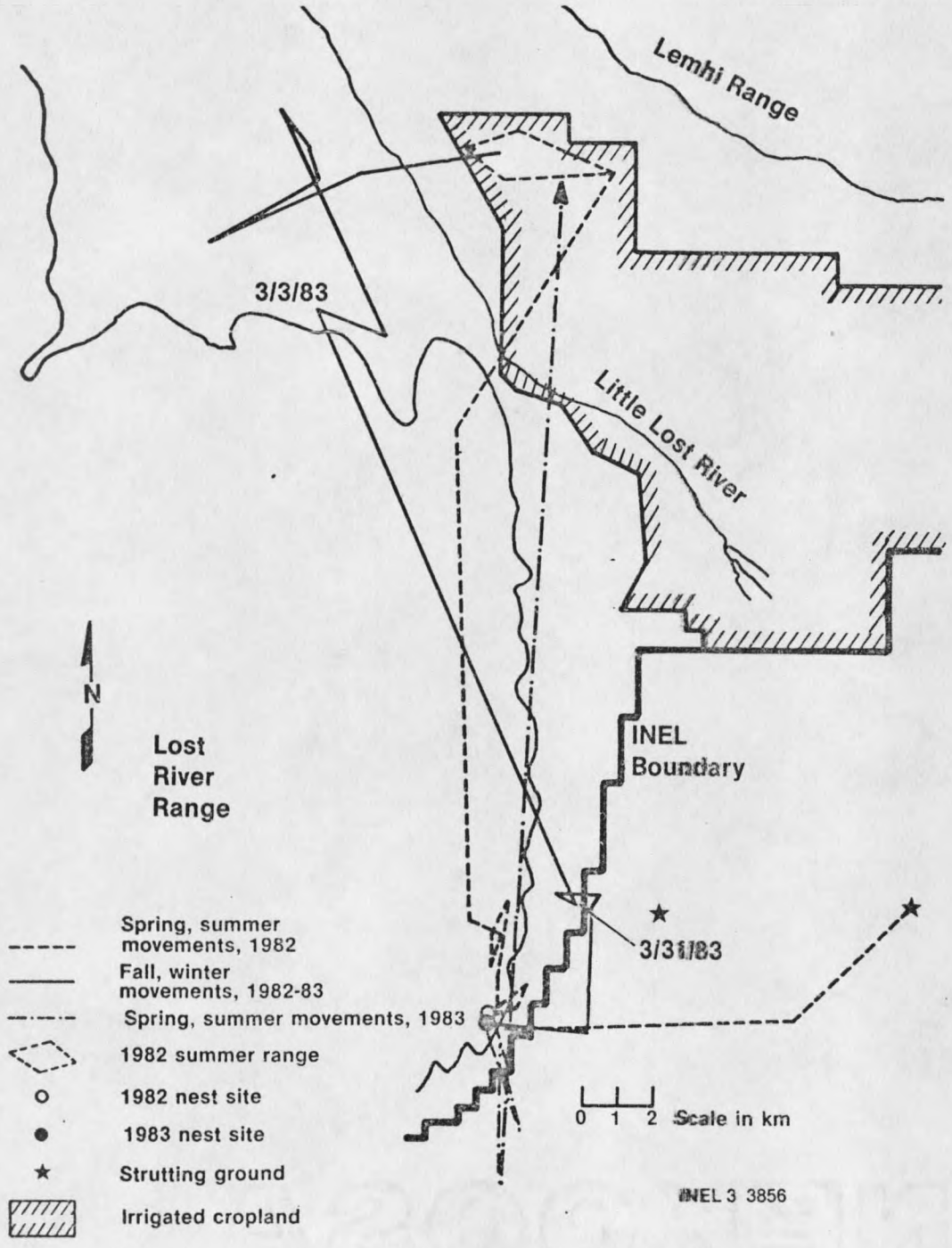


Fig. 22. Year-round movements of an adult female sage grouse from spring 1982-summer 1983.

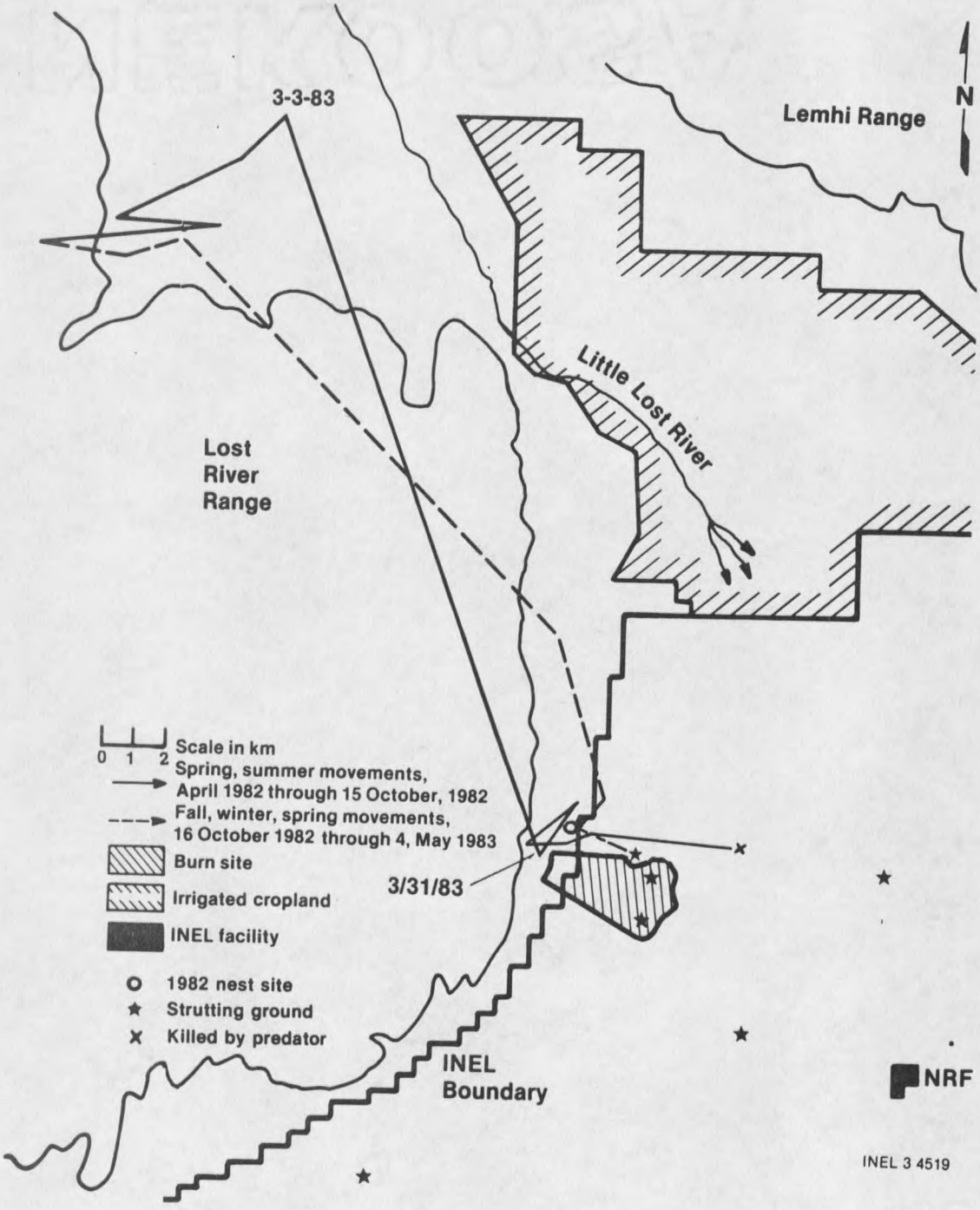


Fig. 23. Year-round movements of an adult female sage grouse from spring 1982-summer 1983.

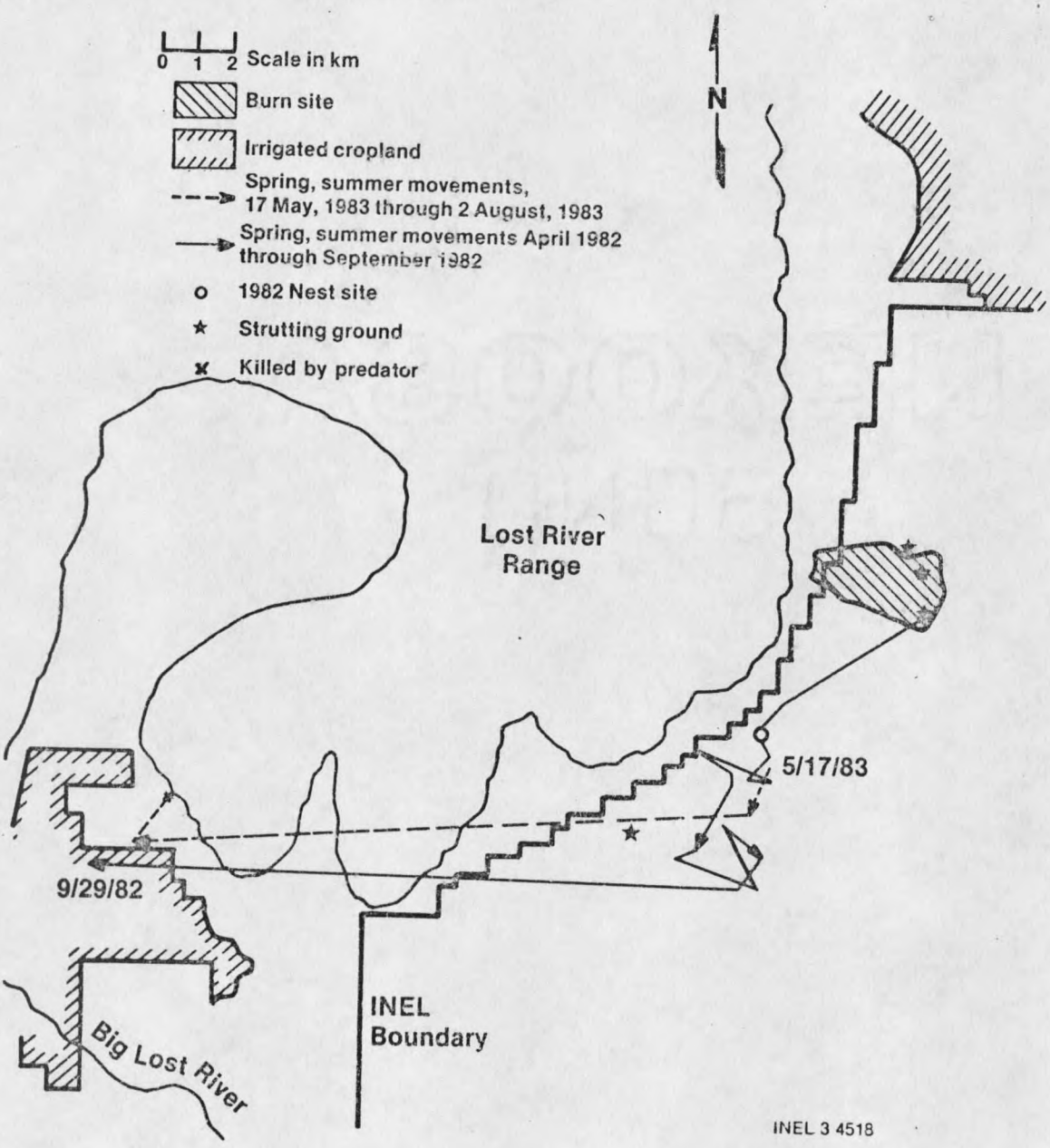


Fig. 24. Year-round movements of a yearling female sage grouse from spring 1982-summer 1983.

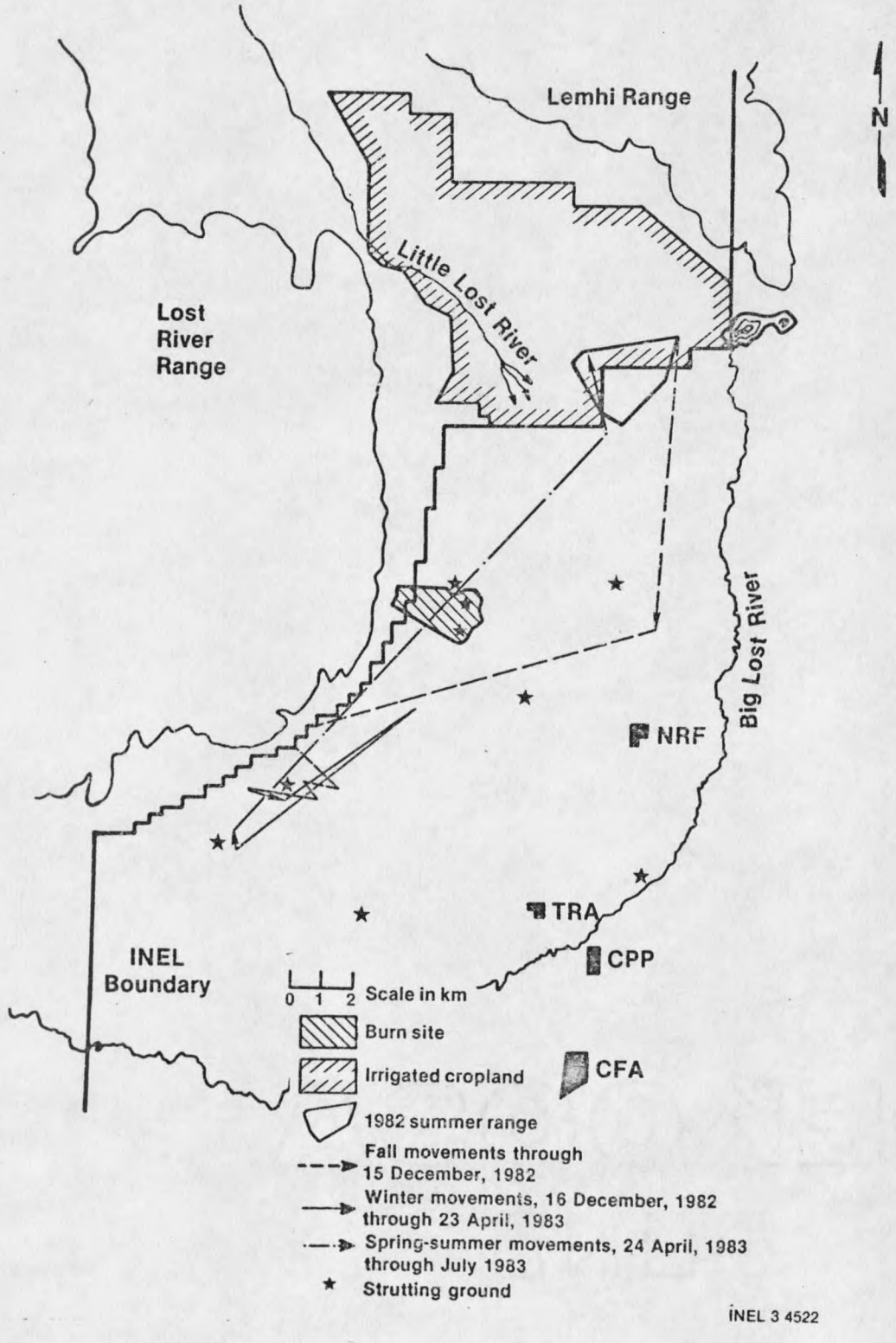


Fig. 25. Year-round movements of an adult male sage grouse from summer 1982-summer 1983.

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