



Wildlife use of fire-disturbed areas in sagebrush steppe on the Idaho National Engineering Laboratory
by William Edward Moritz

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 June, 1984 through June, 1987, a study was conducted on the Idaho National Engineering Laboratory (INEL) in southeast Idaho to collect data on sage grouse (*Centrocercus urophasianus*), pronghorn (*Antilocapra americana*) and small mammal use of nine burned areas (fire scars) of various ages in sagebrush steppe. Information on plant community composition of burned areas and adjacent nonburned (control) areas was reported. Fire scars were characterized by an absence of sagebrush, although revegetation was not clearly directional or predictable. Two years of seasonal use by sage grouse and pronghorn of fire scars and control areas were determined. Sage grouse use of a newly burned area was significantly greater ($p < 0.05$) than controls. Fire scars dominated by cheatgrass (*Bromus tectorum*) were used by sage grouse significantly less than controls. Incomplete burns created a mosaic pattern of vegetation which sage grouse used significantly more than adjacent controls.

Significant trends in use by sage grouse of older burned areas, dominated by perennial grasses/rabbitbrush (*Chrysothamnus viscidiflorus*) were not detected. The lush growth of grasses and forbs following disturbance attracted pronghorn, as use of the fire scar was significantly higher than controls. Pronghorn use of cheatgrass-dominated fire scars was significantly greater than controls. Overall use of incompletely-burned areas was not significantly different than controls, although seasonal differences existed. Results of pronghorn use of perennial grass/rabbitbrush fire scars, indicated that fire did not reduce use of areas, although use of fire scars was not significantly greater in all areas. Mule deer (*Odocoileus hemionus*) and elk (*Cervus elaphus*) use of burned areas appeared greater than controls. Small mammal populations on fire scars were similar in composition but of lesser density than adjacent populations in sagebrush.

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STEPPE ON THE IDAHO NATIONAL
ENGINEERING LABORATORY

by

William Edward Moritz

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

of

Master of Science

in

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Bozeman, Montana

February 1988

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APPROVAL

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William Edward Moritz

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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ABSTRACT

From June, 1984 through June, 1987, a study was conducted on the Idaho National Engineering Laboratory (INEL) in southeast Idaho to collect data on sage grouse (Centrocercus urophasianus), pronghorn (Antilocapra americana) and small mammal use of nine burned areas (fire scars) of various ages in sagebrush steppe. Information on plant community composition of burned areas and adjacent nonburned (control) areas was reported. Fire scars were characterized by an absence of sagebrush, although revegetation was not clearly directional or predictable. Two years of seasonal use by sage grouse and pronghorn of fire scars and control areas were determined. Sage grouse use of a newly burned area was significantly greater ($p < 0.05$) than controls. Fire scars dominated by cheatgrass (Bromus tectorum) were used by sage grouse significantly less than controls. Incomplete burns created a mosaic pattern of vegetation which sage grouse used significantly more than adjacent controls. Significant trends in use by sage grouse of older burned areas, dominated by perennial grasses/rabbitbrush (Chrysothamnus viscidiflorus) were not detected. The lush growth of grasses and forbs following disturbance attracted pronghorn, as use of the fire scar was significantly higher than controls. Pronghorn use of cheatgrass-dominated fire scars was significantly greater than controls. Overall use of incompletely-burned areas was not significantly different than controls, although seasonal differences existed. Results of pronghorn use of perennial grass/rabbitbrush fire scars indicated that fire did not reduce use of areas, although use of fire scars was not significantly greater in all areas. Mule deer (Odocoileus hemionus) and elk (Cervus elaphus) use of burned areas appeared greater than controls. Small mammal populations on fire scars were similar in composition but of lesser density than adjacent populations in sagebrush.

INTRODUCTION

Fire has historically been a major source of disturbance in sagebrush-grass ecosystems (Mueggler 1976, Wright et al. 1979, Shinn 1980, Gruell 1985). Historically, lightning was the primary cause of fire, while man has become a significant source of ignitions in more recent times (Whitlock 1985). Indians used fire for hunting, food gathering, agriculture, and other purposes (Huston 1973). Since the appearance of white man in the Intermountain West during the last century, burning has been both suppressed and encouraged. Wildfire was feared because of its destructive potential and a lack of efficient control methods, while controlled fires were considered an effective means of improving sagebrush rangeland for livestock grazing. Today the role of fire is becoming better understood, and prescribed burning has become an important, if not fully accepted tool for improving livestock range (Britton and Ralphs 1978). However, management plans involving prescribed burning generally have given less consideration to the impact on wildlife species (Urness 1978).

Fire in sagebrush ecosystems has a highly variable impact on wildlife populations (Starkey 1985). Effects

are dependent on the size and season of burn, preburn plant composition and condition, fire intensity and many other factors (Urness 1978), causing variation in the conclusions of wildlife impact studies.

The most significant impact of fire is modification of the vegetation composition of the burned area (Wright 1974). Animal populations can be positively or negatively affected depending on their specific habitat requirements.

Numerous studies have recorded the immediate postburn effects of fire on wildlife use of an area (Chew et al. 1958, Best 1979, Peek et al. 1979, Keay and Peek 1980, Halford 1981, Hedlund and Rickard 1981, Castrale 1982, Gano and Rickard 1982, McGee 1982, Gates 1983, Winter 1984). Few studies have examined the extent and duration of habitat modification caused by sagebrush burning on wildlife species.

This paper investigates the long-term impacts of fire in a sagebrush steppe community by examining wildlife use of 9 fire-disturbed areas (fire scars), ranging from 0 to 75 years old, on the Idaho National Engineering Laboratory. Objectives were: 1) to describe the vegetation of fire scars and surrounding unburned areas; 2) to determine relative use of fire scars of various ages and adjacent control areas by sage grouse (Centrocercus urophasianus), pronghorn (Antilocapra americana) and various small mammals; 3) investigate the duration of

habitat modification by fire on these species. The study is part of an overall research program funded by the Department of Energy (DOE) to determine responses of vegetation, insects, birds and mammals to land treatments and perturbations.

STUDY AREA

The study areas were located on the Idaho National Engineering Laboratory (INEL) Site, a nuclear reactor testing facility under the jurisdiction of the United States Department of Energy (DOE). The Site is located on the upper Snake River Plain in southeastern Idaho. It occupies 23,315 km² at the foothills of the Lemhi and Lost River Mountain ranges. The topography is flat to rolling with frequent lava outcrops. Elevation ranges from 1,454 to 1,554 m ASL, the median being about 1,500 m (Reynolds 1978).

The climate is semi-arid, characterized by hot summers and cold winters. Annual precipitation averaged 21 centimeters (cm) during the 1950-1978 period (Anderson and Holte 1981). The months of May and June have maximum rainfall while July through September is generally a dry period (French and Mitchell 1983).

Big sagebrush (Artemisia tridentata) is the most common shrub on the INEL Site (McBride et al. 1978). Other prevalent shrubs include green rabbitbrush (Chrysothamnus viscidiflorus), saltbush (Atriplex nuttallii), winterfat (Ceratoides lanata) and horsebrush (Tetradymia canescens). Common grass species are

bottlebrush squirreltail (Sitanion hystrix), thickspike wheatgrass (Agropyron dasystachyum), Indian ricegrass (Oryzopsis hymenoides), needle and thread grass (Stipa comata), bluebunch wheatgrass (Agropyron spicatum) and Great Basin wildrye (Elymus cinereus).

Nine study areas, each consisting of a fire scar and an adjacent unburned sagebrush area, were included in this investigation (Table 1 and Figure 1), which was conducted from 1984 to 1987. Maps of each area are found in Appendix 1.

Table 1. Study area fire history.

AREA #	NAME	DATE OF FIRE	ORIGIN	SIZE ^b
1a	7MIRD	6/85	lightning	236ha
2	INEL	8/81	controlled burn	405
3	RABBIT EARS	8/81	lightning	67
4	UTAH P&L	7/80	lightning	207
5	FIRE STATION	9/74	controlled burn	113
6	ARCO HWY	7/74	unknown	73
7	N IDAHO 22	<1949	unknown	216
8	B&B CO.	<1949	unknown	1150
9	TRAC FLAT	1910	unknown	2728 ^c

- a) see Fig. 1 for relative location of study areas
 b) size measured from recent aerial photos
 c) McBride et al. (1978) report a 4050 ha fire occurred in this general area in 1910.

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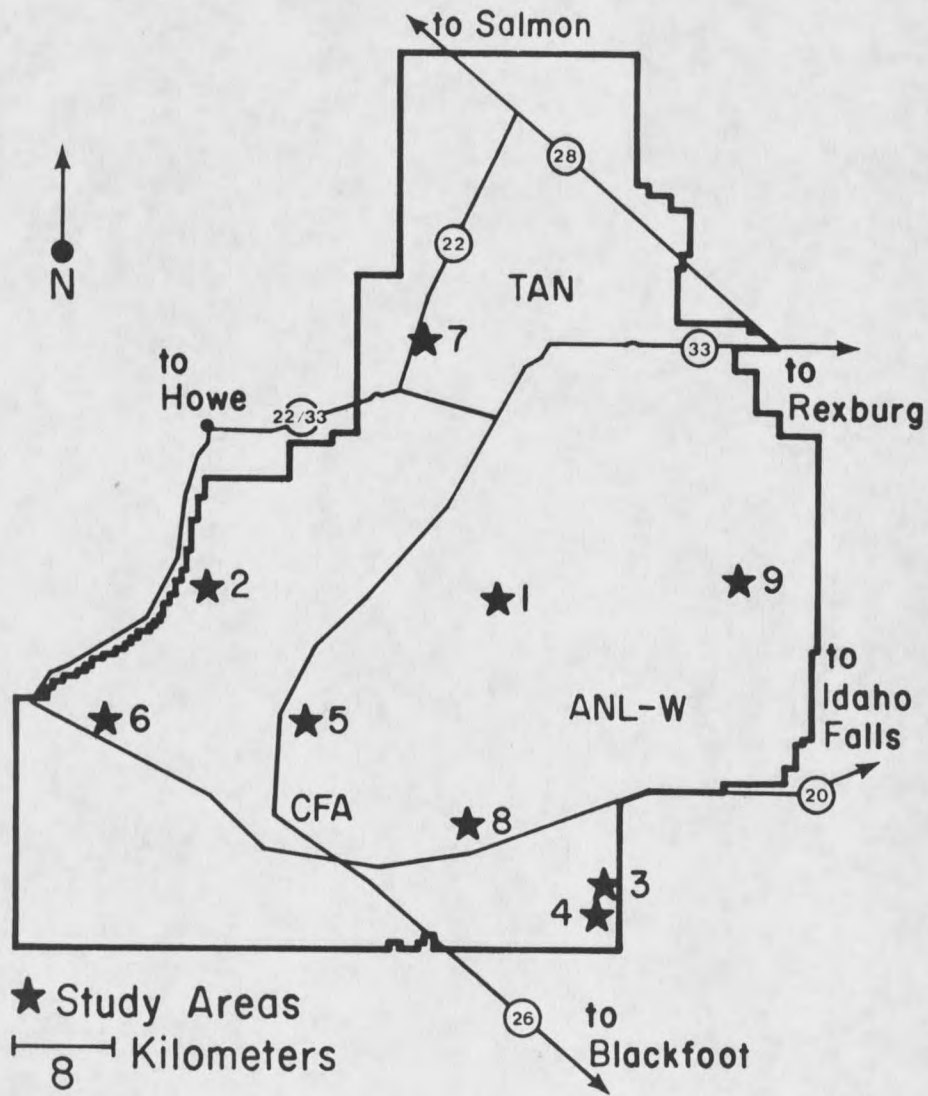


Figure 1. Location of study areas within the INEL.

METHODS

Introduction

A basic study design, modified from Gates (1983), was used on all study areas (Fig. 2). Each study area consisted of an area that had been burned (the burn site), and an adjacent unburned area (the control site). The mosaic of burned and non-burned area on the edge of the fire scar was designated as the interzone.

On both burn and control sites, three 6.25 ha grids were randomly selected from a block of potential locations (Neil Hamm, pers. commun.). Special consideration was made to ensure that grids were outside the interzone when possible. Within each grid, 25 points were located at 50 m intervals in a 5 x 5 arrangement. Twenty-four point grids, in a 3 x 8 arrangement, were used on burn sites that were too narrow to accommodate the square grid. One 3 x 8 grid was necessary on the Rabbit Ears, Fire Station and Arco Hwy burn sites.

Each point was marked with a wooden stake cut to a height that did not exceed the height of surrounding vegetation. Stakes were painted orange to aid in the location of the points. Data describing the vegetation

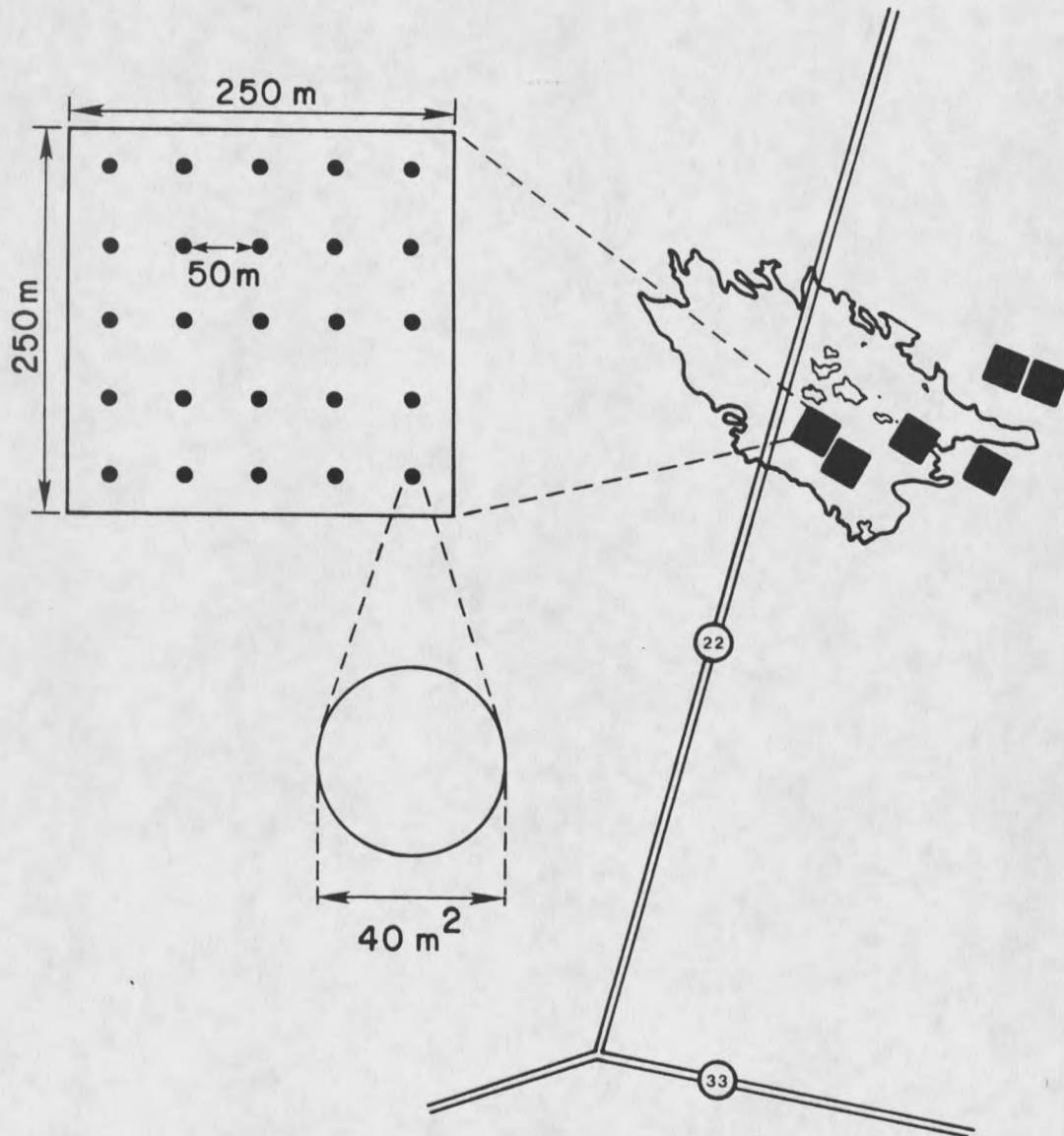


Figure 2. Study design (modified from Gates (1983)) with configuration of pellet plots and focal points within grids.

and use by sage grouse, pronghorn and small mammals were collected on these study grids, with each stake a focal point for intensive study.

Vegetation Measurements and Analysis

Data concerning flora of all study areas were not available at the time of this study. A brief survey was conducted to identify a general pattern of community composition in each study area.

Vegetation sampling was conducted on one burn grid and one control grid on each study area. Two of the 25 focal points on each grid were randomly selected as starting points for sampling. A 50 m tape was tightly stretched from the starting point to the next point to the east (or south if the starting point was in the easternmost column of points). Transects were discarded and new starting points selected if the sampling line was dominated by bare rock. These transects were used for all measurements describing the vegetation.

All shrubs intercepted by the line were counted and their maximum height measured to the nearest centimeter. Shrub canopy coverage (Canfield 1941) was measured as was the canopy coverage of each species of shrub. Total shrub canopy coverage was distinguished from the sum total of individual species canopy coverage because of interspecific plant overlap. The vigor of Artemisia

plants was determined by estimating the percentage of live plant crown by classes (dead, 0-5%, 6-25%, 26-50%, 51-75%, 76-100%). Dead plants were not included in canopy coverage measurements. Erect stems and branches were used to distinguish dead plants from litter.

Two by five decimeter (dm) canopy coverage quadrats (Daubenmire 1959) were used to determine abundance and frequency of grasses and forbs. Half-shrubs were measured as forbs and were not included in shrub measurements. Twenty-five canopy coverage quadrats were placed on odd-numbered meter marks along the sampling line. Total forb and grass canopy coverage were measured as well as individual species coverage.

Plant nomenclature follows Hitchcock and Cronquist (1974). Plants not immediately recognized in the field were identified by comparison with specimens in the INEL Site herbarium.

Analysis was limited to descriptive measures of site characteristics. The vegetation of the INEL is quite variable and its characteristics can change in short measures of distance or time. A considerably larger sample would have been necessary to obtain a statistically adequate representation of each area.

Trends in the vegetation recovery are presented for later analysis of the duration of the impacts of fire on wildlife. Fire scars are grouped by age (5 years old, 10-

15 years old, >35 years old) and vegetation characteristics are a composite representation of study areas. The INEL study burn is omitted in these calculations because the fire did not consume the entire shrub canopy as in the other study areas.

Measurement of Sage Grouse and Pronghorn Use

Fecal pellet counts (Neff 1968) were used to determine relative use on burn and control grids by sage grouse and big game animals. While pronghorn were the focus of the game animal segment, the presence of elk (Cervus elaphus) and mule deer (Odocoileus hemionus) on some study areas provided insight into relative use of burn areas by these species. Mule deer fecal pellets are not morphologically distinguishable from pronghorn pellets (Howard 1967), therefore pellet origins were identified by observation of the species present. On one study area where both species were infrequently observed, the few ungulate pellet groups found were recorded as of unknown ungulate origin.

Fecal pellets were counted in a 40 m² circular plot centered on each point (Fig. 2). Single pellets and roost droppings (groups of 10 or more pellets) were counted for sage grouse. Big game pellet groups were recorded if more than 50% of a pellet group (groups of >15 pellets) were

inside the sample area (Gates 1983). All plots were cleared of pellets as they were counted.

Two years of seasonal use are reported for 8 study areas, beginning with summer 1985 and concluding with spring 1987. These areas were originally cleared during June, 1985. The ninth study area, 7MIRD burned in late June, 1985. Pellets were first cleared in September, 1985 and counted for each seasonal period thereafter. The counts were temporally distributed to determine relative use as a function of seasons. Seasons of use, based on sage grouse movements recorded by Connelly (1982) and Gates (1983), were:

Spring	March 16 - June 15
Summer	June 16 - August 31
Winter	Sept. 1 - March 15

Spring included the interval when strutting and nesting activities occurred, summer the time spent on summer range, and winter included time spent moving from summer range to winter range, time on winter ranges, and time spent moving to strutting arenas.

Hoskinson and Tester (1980) studied pronghorn movements in this area. Spring movements were related to loss of snow cover and occurred during February and March in their study. Fall movements began after 1 October and appeared to be related to the moisture content of the vegetation. My sampling periods would best represent winter range use by pronghorn, early summer use (when new

grass and forb growth occurs) and late summer use (when grasses and forbs are cured).

Pellet count data were not adjusted for differences in time intervals between counts since they represented seasonal periods of use (Gates 1983). Counts for each species were converted to pellets (pellet groups) per hectare.

Paired t-tests were used to evaluate seasonal differences between burn and control habitats for all study areas as well as for overall trends of use on each study area. Chi-square tests were used to compare specific differences occurring in seasonal samples.

All statistical analyses were conducted using the MSUSTAT program (1986 microcomputer version 3.2--MSDOS) developed by Richard E. Lund, Montana State University, Bozeman, Mt. 59717. Values were considered significant if $p < 0.05$ for all tests.

Measurement of Small Mammal Use

Small mammal trapping was conducted on two burn grids and two control grids on each study area. Small mammals on one grid of each type were trapped during August-September, 1985 on each study area. Remaining grids were sampled during April-May, 1986.

Small mammal populations on study areas were sequentially sampled during each trapping period. The

sequence of study areas was not constant between fall and spring samples because of limited access to some areas during inclement weather.

Each grid was comprised of 12 systematically located traplines with 5 trap stations per trapline, providing a total of 60 trap stations per grid (Fig. 3). Each trap station consisted of four traps: one Sherman Live trap, one Victor M4 rat trap and two Museum Special snap traps. Traps were placed within 1 m of a centrally located surveyors flag, without directional orientation. The Sherman Live traps were baited with wheat kernals, the snap traps with peanut butter.

Trapping was conducted for three consecutive nights on each grid with no prebaiting. The traps were checked and baited each morning. Trap status was recorded as unsprung, sprung with no catch, or sprung with catch. Captured animals were identified and removed from the study area.

Configuration of small mammal trap grids.

Measurement of Population Indices

Species diversity (H') was calculated with a transformation of the Shannon-Weaver index (Zar 1984):

$$H' = (n \log n - \sum f_i \log f_i) / n$$

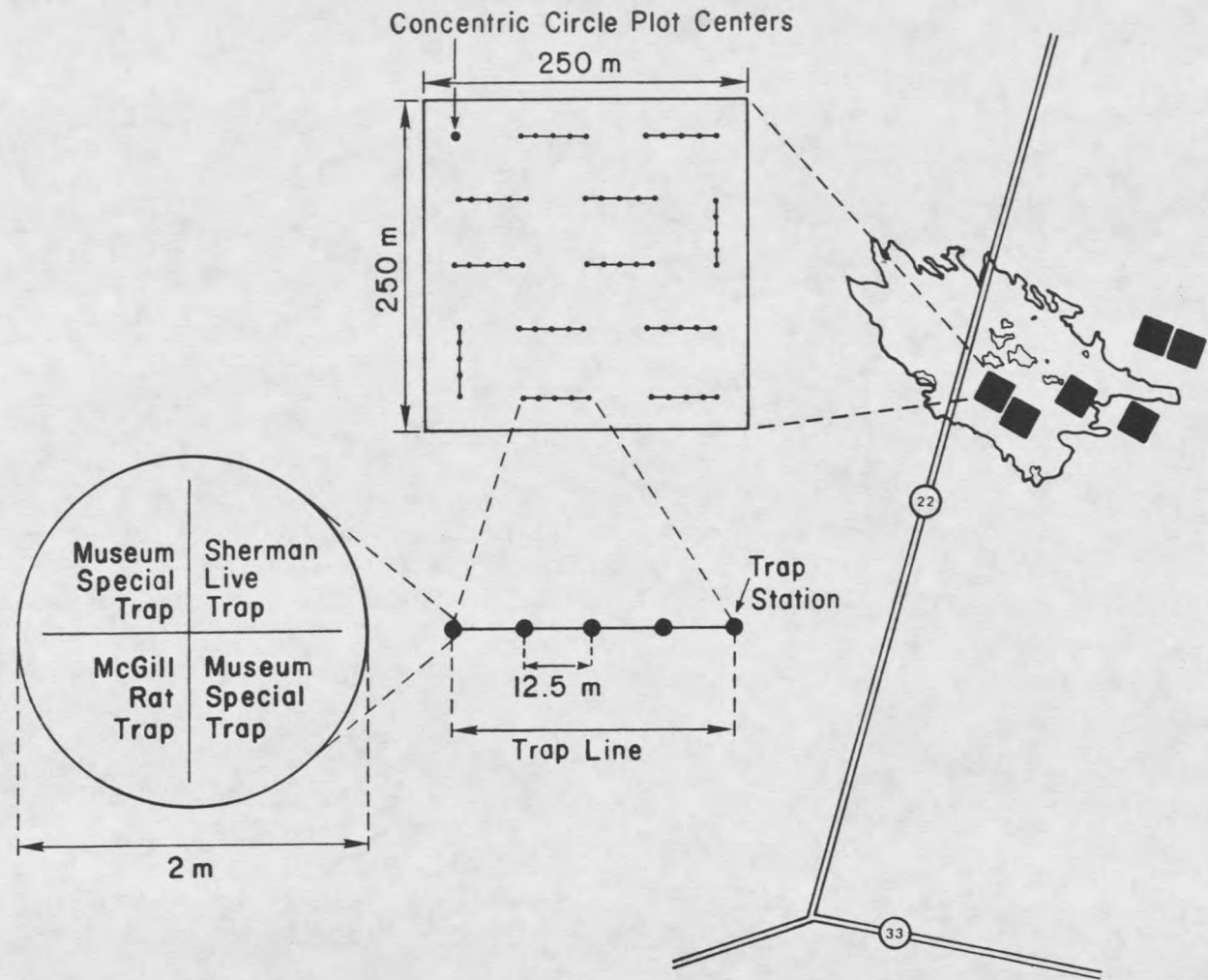


Figure 3. Configuration of small mammal trap grids.

where n is the sample size, f_i is the number of observations of animals of species i , and k is the number of species observed.

Species evenness (J') (Pielou 1966) was calculated with the formula (Zar 1984)

$$J' = \frac{H'}{H'_{\max}}$$

where H'_{\max} equals $\log k$.

Calculations of relative abundance were used to compare use of burn and control areas. Relative abundance was determined by the number of animals of each species caught per 100 trap nights.

Paired t -tests (Snedecor and Cochran 1980) were used to compare total captures of all animals and of individual species. Presentation and statistical analysis of data follow the form reported for the pellet count data.

RESULTS AND DISCUSSION

Vegetation7MIRD Study Area (Area 1 in Fig. 1)

The dominant shrub on the control grid was big sagebrush, which comprised 85% of living shrub canopy. Mean sagebrush height was greater than on any other study area except Utah P&L (Table 2). Green rabbitbrush was the only other shrub intercepted. Total shrub canopy coverage was 13.8%. Mean shrub height was 61.4 cm (Fig. 4).

Cheatgrass (Bromus tectorum) was the only grass encountered in sampling. It occurred in 94% of the quadrats and had a canopy coverage of 15.7%. Other grasses on the burn site included basin wildrye, bottlebrush squirreltail, bluegrass (Poa spp.) and wheatgrass (Agropyron spp.).

Total forb canopy coverage was 5.4%, and frequency was 84%. The forb component was dominated by the weedy annuals tansey mustard (Descurainia pinnata), tumble mustard (Sysmbrium altissimum) and stickseed (Lappula redowski).

Further evidence of a disturbed community was the presence prickly pear (Opuntia polycantha).

Table 2. Average canopy height (cm) of Artemisia tridentata on burn and control sample lines on all study areas, 1986 (number of plants measured in parenthesis).

STUDY AREA	CONTROL	BURN
7MIRD	67.8 (11)	0.0 (0)
INEL	46.7 (42)	40.6 (40)
RABBIT EARS	68.5 (17)	0.0 (0)
UTAH P&L	80.9 (50)	0.0 (0)
FIRE STATION	51.4 (57)	0.0 (0)
ARCO HWY	50.8 (49)	27.0 (1)
N IDAHO 22	47.8 (24)	0.0 (0)
B&B CO	63.5 (70)	40.0 (5)
TRAC FLAT	64.7 (39)	95.8 (4)
X	59.7 (359)	44.7 (50)

Litter was found in all of the quadrats and covered 82.8% of the ground surface. Bare ground occurred in 74% of the sampling frames and represented 16.4% of the area sampled.

The study area is located in an area of extensive sagebrush dieoff of unknown cause (Table 3). High densities and flammability of cheatgrass combined with dead sagebrush created a high fire potential. A lightning ground strike would readily have ignited this fire.

The fire, which occurred during the night of June 30, 1985 consumed all shrubs on the burn grid. Surviving shrubs were occasionally found in areas where rock outcrops or a lack of fuel were barriers to advancing flames. Resprouting rabbitbrush was noted in some areas on the burn site.

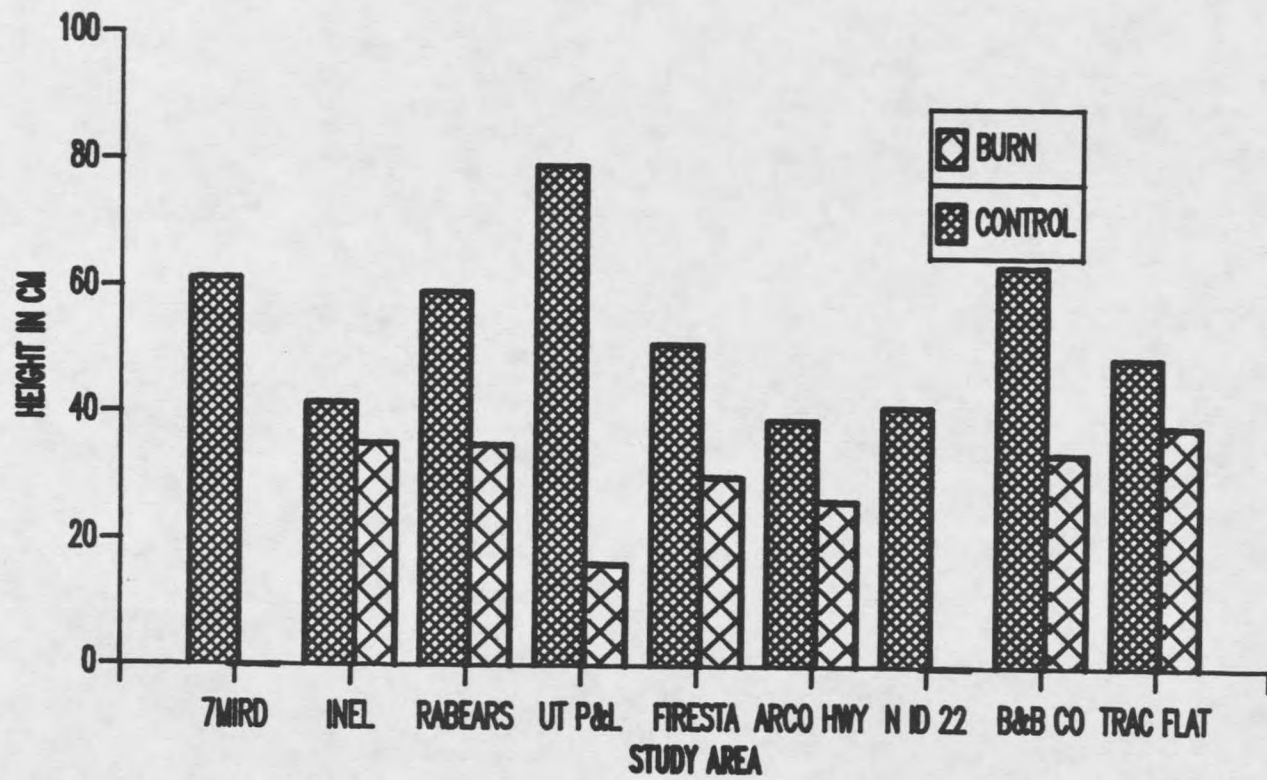


Figure 4. Mean height of shrubs occurring on study areas, 1986.

Prickly pear was the first plant to reappear on the burned area, in many instances growing rapidly to a size comparable to plants on the non-burned area. Until the needles hardened, pronghorn fed extensively on the young pads. This use appeared to stimulate growth as two or more new pads grew from the chewed portion of the plants.

The burned area was quickly overtaken by cheatgrass seedlings. Rhizomatous grasses and some bunchgrasses (particularly basin wildrye) re-established by winter.

Table 3. Relative amounts of dead and living Artemisia plants occurring in transects on control areas, 1986.

STUDY AREA	DEAD	LIVING	TOTAL	%DEAD
7MIRD	85	11	96	88.5
INEL	15	42	57	26.3
RABBIT EARS	8	17	25	32.0
UTAH P&L	0	48	48	0.0
FIRE STATION	53	57	110	48.2
ARCO HWY	12	46	58	20.7
N IDAHO 22	36	24	60	60.0
B&B CO	12	27	39	30.7
TRAC FLAT	12	40	52	23.0
\bar{X}	25.9	34.7	60.6	42.7

Cheatgrass seedlings grew very tall and rank in the first full year of growth, reaching 8 dm in some areas of the fire scar. Weedy annuals, including tansey mustard, were dominant in the forb component. The unknown forb category was comprised mainly of unidentifiable dead forbs.

Existing litter was completely consumed by the fire. Litter consisted of dead annual grasses and forbs remaining from fall and spring growth following the fire. Litter frequency was 96% and cover was 34%. Bare ground was recorded in 98% of the quadrats.

INEL Study Area (Area 2)

The dominant shrub on the control area was big sagebrush. Mean sagebrush height was 46.7 cm. Twenty-six percent of all big sagebrush plants encountered were dead. Green rabbitbrush was the next most common shrub, followed by rubber rabbitbrush (C. nauseosus), threetip sage (A. tripartita) and winterfat (Ceratoides lanata). Total shrub height was 41.6 cm.

A variety of grasses occurred in the transects with a total canopy coverage of 12.3% and a frequency of 88%. Dominant grasses were Indian ricegrass, bluebunch wheatgrass and needle-and-thread grass. Cheatgrass occurred in 22% of the sampling frames, and was less than 1% of canopy coverage.

Sixteen identified species of forbs were encountered during sampling. Total forb canopy coverage was 5%; forbs were found in 80% of quadrats. Most common were stoneseed (Cordylanthus ramosus), prickly phlox (Leptodactylon pungens), phlox, and littleflower collinsia (Collinsia parviflora).

Litter covered 32.4% of available ground surface, with a frequency of 88%. Bare ground was found in all sampling frames and was 63.3% of the ground sampled.

This fire scar resulted from a controlled burn conducted in 1981 and 1982 (Floyd 1982). The fire did not consume all vegetation on the burn site; instead, it created a "fine mosaic pattern with good interspersions of unburned, burned and edge habitats" (Winter 1984). Winter reported 36% of the area remained unburned. He also documented total shrub coverage decreased by 47%.

Canopy coverage of big sagebrush was approximately the same on the burn as on the control transects; that of green rabbitbrush was considerably higher. Other shrub species were not encountered in transects but were noted on the burn site.

Sagebrush is easily killed by fire (Blaisdell 1953), which may account for both the higher percentage of dead sagebrush (Table 3) and the slight decline in mean sagebrush canopy height (Table 2). Mean shrub canopy height decreased, probably as a result of this and increased abundance of the shorter rabbitbrush (Fig. 4).

Grass canopy coverage was lower on the burn than on the control grid. Indian ricegrass coverage was much lower, as was needle-and-thread. Rhizomatous grasses were slightly greater in abundance, perhaps indicating their ability to recover following disturbance.

Fall burning is one of the best methods for removing sagebrush and retaining forbs (Wright et al. 1979). Forb abundance was 40% higher on the fire scar than on the control grid. Most species of forbs measured were more abundant on the burn than on the control grid. Litter and bare ground coverages were approximately the same on the transects.

Rabbit Ears Study Area (Area 3)

This area is located on the toe slopes of East Twin Butte, a 300,000-year-old cinder cone in the SE corner of the INEL site. Changes in elevation and soils have resulted in a unique plant community characterized by juniper (Juniperus osteosperma). Snowberry (Symphoricarpos occidentalis) was also unique to this study area.

Seven shrub species were recorded on the control grid with a total canopy coverage of 39.1%. Threetip sage dominated the shrub component, followed by juniper and big sagebrush. Mean shrub canopy height was 59.2 cm; big sagebrush mean height was 68.5 cm. Thirty percent of big sagebrush plants counted were dead.

A variety of grasses occurred, with a total canopy coverage of 6.7%. Bluebunch wheatgrass dominated, followed by an unidentified grass species. Cheatgrass occurred in 10% of quadrats, with a canopy coverage of less than 1%.

Total forb canopy coverage was 8.1%, with a frequency of 90%. Stoneseed, phlox, hawksbeard and prickly phlox were the most common forbs on the control grid. Litter coverage was 30.9%, and was found in over 90% of the sampling frames.

The vegetation was well mixed, so pure stands or specific associations of species were not obvious. Large juniper trees tended to shade out other plants, so their understory consisted largely of bare ground, moss and a scattering of grasses and forbs.

The August, 1981 fire dramatically changed the appearance of the area. The entire shrub canopy was consumed, only skeletons of dead junipers remained. New growth of green rabbitbrush and snowberry were 99% of the existing shrub canopy, with an occasional threetip sage plant noted. Threetip sage does not recover readily after a fire but has been reported to resprout (Wright et al. 1979).

Grasses occurred in 98% of quadrats in the burn transects, with canopy coverage 33% higher than on the control. Cheatgrass was most common, with a canopy coverage of 3.1% and a frequency of 72%. Bluebunch wheatgrass coverage was 26% lower on the burn than on the control. The canopy coverage of most species of grass was lower on the burn, exceptions being cheatgrass and prairie junegrass (Koeleria cristata).

The number of forb species encountered was 77% higher on the burn grid and total canopy coverage was more than double that of the control. Much of this increase was attributed to an increased abundance of weedy annuals such as prickly lettuce (Lactuca serriola), tumble mustard and stickseed, although many native perennials were also more abundant.

Litter covered 26.3% of the burn surface, 15% less than on the control, while the amount of bare ground was only slightly higher than on the control grids.

Utah P&L Study Area (Area 4)

This study area is located about 1 km southwest of the Rabbit Ears study area, although the fire scar is located on the edge of the threetip sage-juniper association in that study area. Because most of the fire scar was located outside of the community type, vegetation transects were also located outside of this association.

The dominant shrub on the control grid was big sagebrush, with mean canopy coverage of 51.4% and a mean sagebrush height of 80.9 cm, the highest recorded for any control area. No dead sagebrush plants were recorded. Green rabbitbrush and low sagebrush (A. arbuscula) occurred in small amounts. Low sagebrush was restricted to the banks of gullies and washouts on the control site. Mean shrub canopy height was 79.2 cm.

Grasses were found in 94% of quadrats, with a total canopy coverage of 5.1%. Dominant grasses included bottlebrush squirreltail and basin wildrye. Cheatgrass canopy coverage was less than 1% and had a frequency of 12%.

Total forb canopy coverage was 2.8%. Common forbs were tansey mustard, tumble mustard and Nuttall's sandwort (Arenaria nuttallii). Ten known species of forbs were recorded.

Litter covered 37.8% of available ground surface and occurred in 94% of sampling frames. Bare ground was found in all sampling frames and 56.9% of the ground surveyed.

The fire, which occurred in 1980, consumed the entire shrub canopy. Green rabbitbrush was the only shrub noted on the fire scar.

Cheatgrass canopy coverage was 37.2%, 98% of the total grass canopy. Cheatgrass was 124 times more abundant on the burn than on the control grid. All other grass species were less abundant on the fire scar.

Exotic annuals dominated the forb component. Most common was prickly lettuce, with a canopy coverage of 5.6% (14 times greater than on the control). Tumble mustard, tansey mustard and musk thistle (Carduus nutans) were also abundant. Goatsbeard (Tragopogon dubius), a desirable forb, was found in 30% of sampling frames and had a canopy coverage of 1%.

Bare ground and litter coverage values were 28 and 47% lower (respectively) than control values. A possible cause for this dual decline was a difficulty in distinguishing between new growth cheatgrass (cured at the time of sampling) and old plants.

Fire Station Study Area (Area 5)

The dominant shrub on the control grids was big sagebrush, which made up over 98% of the living shrub canopy. Forty-eight percent of the sagebrush plants counted were dead (Table 3). Although winterfat was the only other shrub recorded on the sample line, green rabbitbrush was noted in the grid. Mean sagebrush height was 51.4 cm, mean shrub height was slightly less (Fig. 4).

Total grass coverage was 6.1%. Common species included bottlebrush squirreltail, thickspike wheatgrass and bluegrass. Cheatgrass was found in 20% of quadrats and had a canopy coverage of less than 1%.

Tansey mustard was the most abundant forb, followed by phlox and peppergrass (Lepidium perfoliatum). Total forb canopy coverage was 4.4%; forbs were found in 94% of quadrats.

Litter covered 40.4% of the available ground surface and was found in 96% of sampling frames. Bare ground coverage was 53.4%.

The fire, which occurred in 1974, consumed all above-ground vegetation (Halford 1981). Green rabbitbrush was

the dominant shrub at the time of sampling, with a canopy coverage of 27.1%. Mean shrub canopy height was 30.1 cm, 41% less than on the control grid (Fig. 4).

Grass canopy coverage on the burn grid was 33% lower than on the control. Bottlebrush squirreltail values were 84% lower on the burn. Cheatgrass occurred with the same frequency on both grids, but canopy coverage was slightly higher on the burn.

Western wheatgrass (A. smithii) was recorded on the burn, and probably also occurred on the control area but was missed in sampling. Removal of the shrub canopy allowed the uneven surface of the area (formed by meanders of the Big Lost River) to become noticeable. Low lying areas were occupied by the bluish western wheatgrass, distinguished from the greenish slender wheatgrass which grew on high areas. This phenomenon was easily noticed on the fire scar, where mostly pure stands of each grass occurred.

Forb canopy coverage was 18% lower on the burn than on the control grid. Peppergrass was the most common forb, with coverage levels nearly 3 times greater than control values. Seven of the 16 forb species found on the control grid were not recorded on the fire scar.

Bare ground coverage was 41% higher on the burn, and litter values declined correspondingly. The fire scar appeared sparsely covered by vegetation, bare ground and

rabbitbrush were the most obvious characteristics.

Arco Hwy Study Area (Area 6)

Big sagebrush was the dominant shrub on the control site. Mean sagebrush height was 50.8 cm. Forty-eight percent of sagebrush plants counted were dead (Table 3). Green rabbitbrush, horsebrush and threetip sage were also present. Total shrub canopy coverage was 29%, while total shrub canopy height averaged 39 cm.

Total grass canopy coverage was 5%. Grasses were found in 62% of the quadrats. Dominant grasses were bluebunch wheatgrass and Indian ricegrass. Cheatgrass was not found in the sampling frames, but was common on disturbed areas such as badger (Taxidea taxus) diggings and pocket gopher (Thomomys talpoides) mounds.

Phlox, stoneseed and hawksbeard (Crepis acuminata) were the most common forbs. Forbs were found in 94% of the sampling frames, with a canopy coverage of 20.2%, the highest coverage recorded for any of the study areas.

Litter covered 25% of the ground surface, occurring in 92% of sample frames. Bare ground was found in all sampling frames with a coverage of 71.4.

The fire, which occurred in July, 1974 appears to have been ignited by a motorist on U.S. Highway 20. The fire scar is horseshoe-shaped, with a large area of unburned vegetation in the center.

The fire consumed all shrubs. Green rabbitbrush was

3 times more abundant on the burn grid than on the control grid. Horsebrush also occurred, but was 44% less abundant than on the control.

Grasses were 52% more abundant on the burn than the control grid and were found in 90% of sampling frames. Indian ricegrass was 2.5 times more common on the burn; bluebunch wheatgrass was 50% more abundant. Cheatgrass plants were found in 18% of quadrats, canopy coverage was less than 1%.

Forbs were found in 82% of the quadrats, but were 76% less abundant than on the control grids. Of dominant forbs on the control, only phlox occurred as frequently on the burn grid.

Bare ground and litter values were approximately the same between burn and control grids. Litter on the burn grid was fine grass and leaf litter while that on the control grid also contained branches and limbs of dead shrubs.

N Idaho 22 Study Area (Area 7)

This area is located on the north end of the INEL site, in the Birch Creek drainage. Shrub canopy coverage on the control grid was a sparse 14.9%. Mean shrub height was 41.1 cm. Sagebrush canopy coverage was 10.9%, with a mean height of 47.8 cm. Sixty percent of sagebrush plants examined were dead.

Two grass species were recorded. Bottlebrush

squirreltail was dominant, with cheatgrass occurring in trace amounts. Total grass coverage was 3.4%, and were found in 74% of quadrats.

Forbs occurred in 86% of sampling frames while total forb coverage was 7.4%. Stickseed, halogeton (Halogeton glomeratus) and Russian thistle (Salsola kali) were the most abundant forbs. Litter covered 19.8% of the ground surface. Bare ground coverage was 71.6%.

The fire scar is apparent on aerial photographs from 1949, although little additional information was found. The longest axis of the fire scar is perpendicular to the predominant wind direction, the presence of charred sagebrush roots in the soil profile indicated the disturbance was caused by fire.

The fire consumed the entire shrub canopy on most of the burn site, though an island of partially burned or unburned vegetation remained in the center of the area. At the time of my study, winterfat plants were ubiquitous on the burn site, occurring in 96% of quadrats with a canopy coverage of 32.2%. No other shrubs were encountered on sample lines, although green rabbitbrush plants were common in the burn interzone on the north side.

Total grass coverage was 10.6%. The dominant grass species was bottlebrush squirreltail, while Indian ricegrass also occurred in smaller amounts. The

occurrence of these species in the same area is unusual, perhaps indicating a unique soil composition. Total grass canopy coverage was nearly 3 times greater on the burn grid than on the control. Four forb species were recorded during sampling on the burn grid, compared with 15 species on the control area. Forb canopy coverage of 0.6% on the burn was much less than on the control area.

Bare ground values on the burn grid were similar to control values. Litter values were 17% higher, likely due to the greater amount of grass occurring on the site.

The study area appeared to be heavily utilized by both livestock and wildlife. Cattle tracks and manure were found in most areas and pronghorn use appeared very heavy (See pronghorn data in results). The grazing may have altered the recovery of the burn site.

B&B CO Study Area (Area 8)

The dominant shrub on the control area was big sagebrush, with a canopy coverage of 34.1%. Mean sagebrush height was 63.5 cm. No dead sagebrush plants were encountered in sampling. Green rabbitbrush was the only other shrub encountered, although horsebrush and rubber rabbitbrush plants were noted. Total shrub canopy coverage was 40.9%. Mean shrub canopy height was 57 cm.

Four species of grass were recorded; dominants were thickspike wheatgrass, bottlebrush squirreltail and

bluegrass. Total grass canopy coverage was only 6.2%, though grasses were recorded in 82% of the quadrats.

Stoneseed and phlox were the most common forbs on the control grid. Forbs were found in 74% of the sampling frames; canopy coverage was 6.1%.

This fire scar is also readily apparent on the 1949 aerial photos of the INEL, although little other information was located. It is probable that the fire removed all shrubs in the burn grid. Areas of unburned vegetation exist around rock outcrops, especially along a large ridge of basalt which bisects the fire scar. The 5 Artemisia tridentata plants encountered were 36% shorter than those on the control grid. Green rabbitbrush canopy coverage was 61.7%, the highest recorded for any fire scar.

Grasses were 38% more abundant on the burn than control grid and were found in 92% of the quadrats. Bottlebrush squirreltail was 3 times more abundant while thickspike wheatgrass was not recorded. Total forb canopy coverage was 10.6%, 73% higher than on the control grid. The dominant forb was phlox, 2 times more abundant than in the control area. Most forbs, with the exception of stoneseed, were more abundant on the burn grid than on the control grid. Litter was 23% more abundant on the burn, though bare ground decreased only slightly from control values.

Trac Flat Study Area (Area 9)

The dominant shrubs on the control grid were green rabbitbrush and big sagebrush. Total shrub coverage was 40.9%, with a mean shrub canopy height of 49 cm. Big sagebrush canopy coverage was 20.6%, with a mean plant height of 64.7 cm. Twenty-three percent of all sagebrush plants examined were dead.

Total grass canopy coverage was 1.4% with grasses occurring in 46% of quadrats. The most common grass was bottlebrush squirreltail, with small amounts of cheatgrass and bluegrass recorded.

Eighteen species of forbs were encountered during sampling. Total forb canopy coverage was 10.9%; forbs were found in 96% of the quadrats. The most common forb species were prickly lettuce, stickseed and tansey mustard.

Litter covered 32.1% of available ground surface, occurring in 78% of the sampling frames. Bare ground was found in 96% of quadrats and was 66.5% of the ground sampled.

This was the largest and oldest of the fire scars studied. Although the exact size and completeness of the burn is unknown (McBride et al. (1978) reported a 4050 ha fire occurring in this area in 1910), it is assumed that, as a result of shrub encroachment on the edges, the actual size is larger than that measured from recent aerial

photos. It is difficult to believe that a burn of this magnitude would have been complete. Patches of unburned and incompletely burned vegetation must have remained. Burn grids were located in the core of the fire scar where the effects of the fire were obvious. Control grids were distant from the obviously burned areas to prevent measurement of the interzone area. This bias in grid placement allowed a more contrasting comparison of the firescar with adjacent areas, but does not consider that a gradation in sagebrush densities may occur.

Total shrub coverage on the fire scar was 10.9%. Mean shrub canopy height was 38.2 cm. The dominant shrub on the burn grid was green rabbitbrush, with a canopy coverage of 8.4%. Big sagebrush cover was 2.4%. The sagebrush plants tended to be clumped, with patches of large plants or a single large plant with smaller plants (roughly one-half the size of the large plant) occurring on the northeast side of the plant, downwind of the predominant wind direction. Mean sagebrush canopy height was 95.8 cm (n=4). Sagebrush is long-lived and it is possible that these plants survived the fire, utilizing the freed nutrients and reduced competition for their enhanced growth. Twenty-three percent of sagebrush plants encountered were dead.

Grass canopy coverage was 9.5%, 6.8 times more abundant than on the control grid. Dominant species were

needle-and-thread, indian ricegrass and thickspike wheatgrass. Bottlebrush squirreltail was encountered in 14% of sampling grids, one-third as frequently as in the control. Cheatgrass occurred in trace amounts in both burn and control areas.

Forbs were one-third as abundant on the burn as on the control grid. Six species were recorded, the most common being the exotic annuals tumble mustard and tansey mustard. Litter values were 17% higher on the burn than control grid, following the trend reported for most study areas. Bare ground values were slightly lower on the burn with a coverage of 60.9%.

Discussion of Post-burn Vegetation Trends

Results indicate that fires capable of burning all of the above-ground vegetation have had a dramatic and long-lasting effect on post-fire vegetation on the INEL Site. Most obvious is the apparent failure of sagebrush to successfully reinvade even the oldest fire scars (Fig. 5). This is contrary to published literature where authors generally found that sagebrush reinvaded and became dominant within 20-40 years (Blaisdell 1953, Pechanec et al. 1954, Harniss and Murray 1973).

Significant differences existed in shrub composition and structure between burn and control grids. Total shrub canopy coverage was lower on fire scars (Fig. 6).

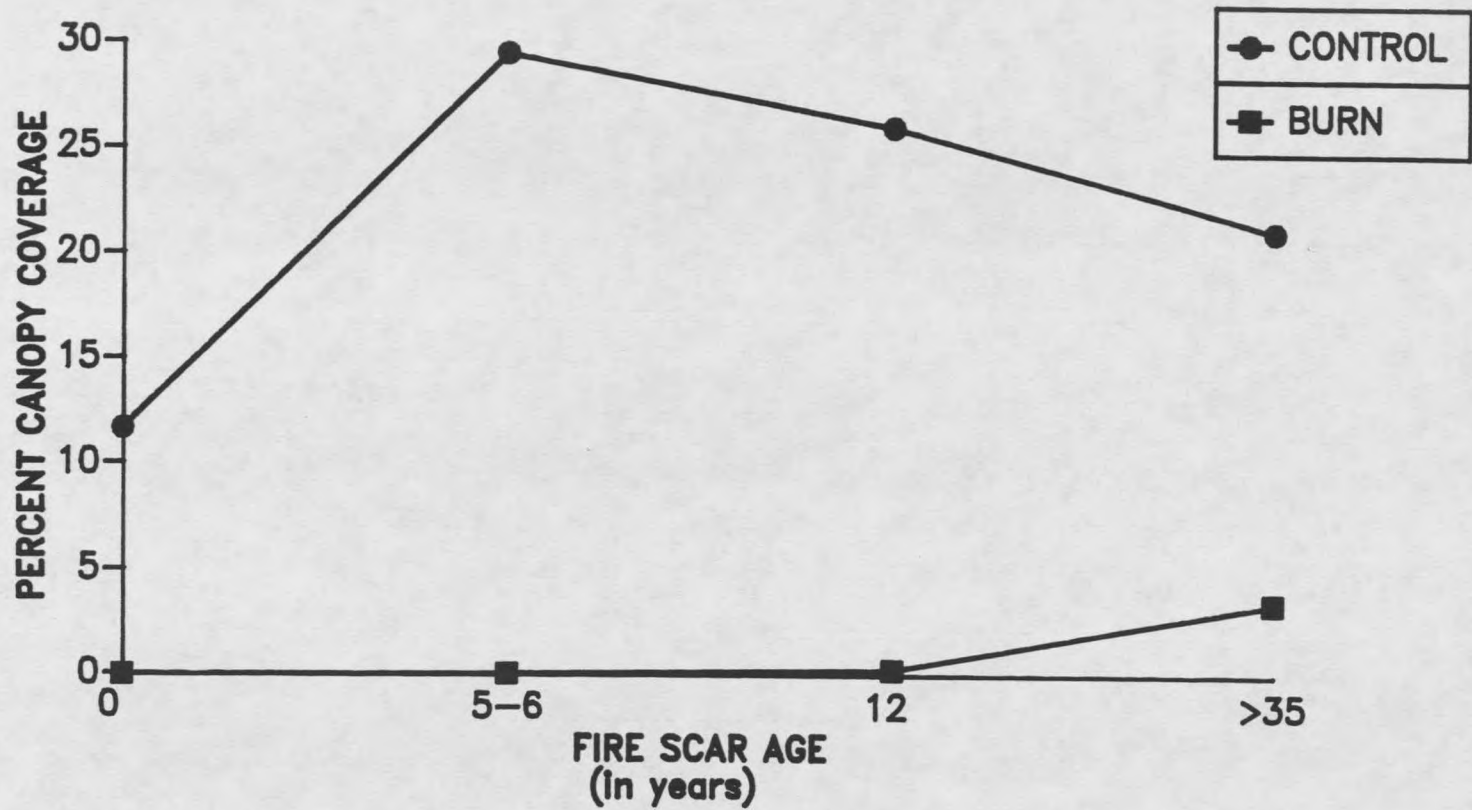


Figure 5. Trends in sagebrush revegetation on study areas.

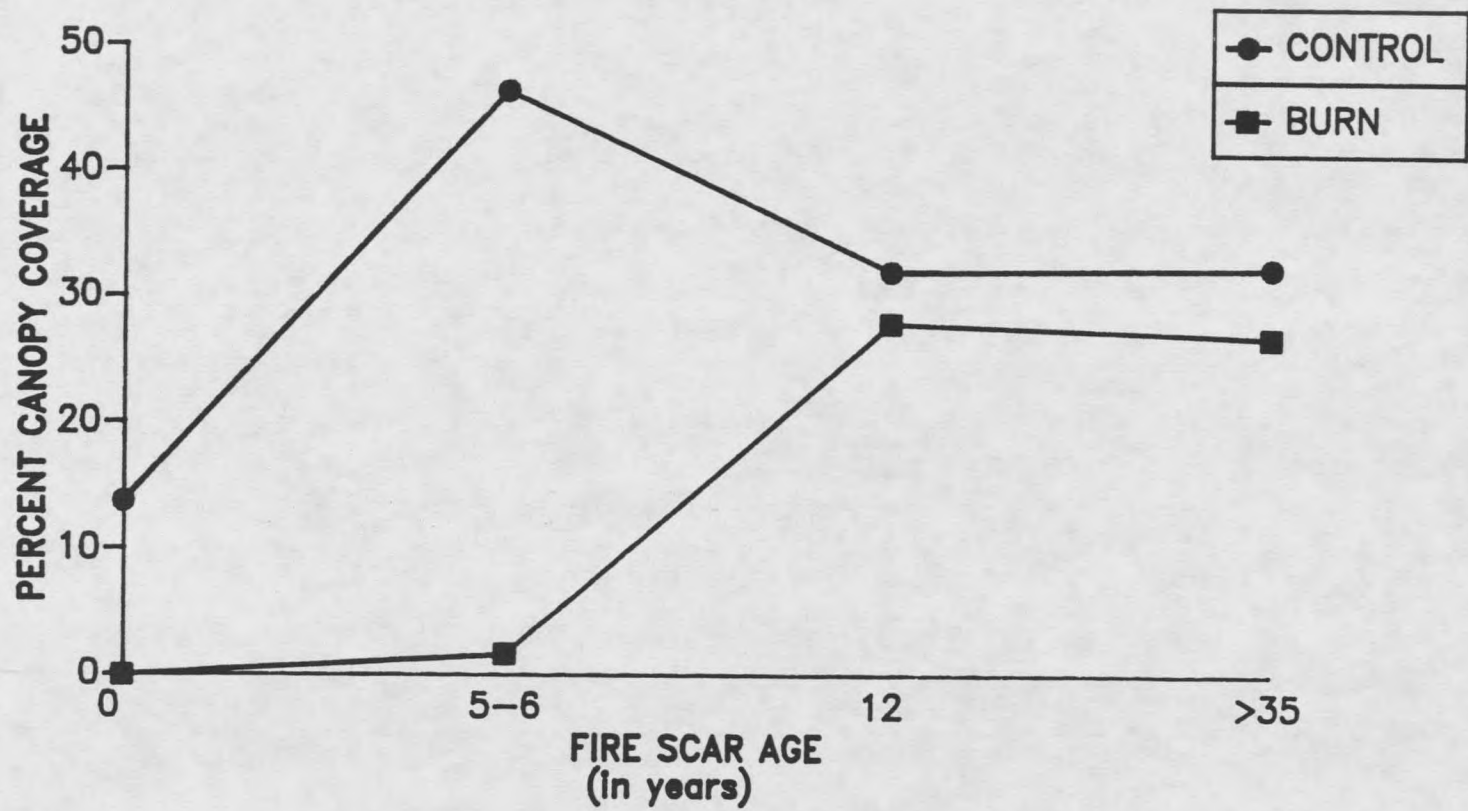


Figure 6. Trends in shrub revegetation on study areas.

Sagebrush canopy coverage comprised 68% of total shrub canopy coverage on control grids, but only 15% on burn grids. Rabbitbrush increased from 11% to over 80% of the total shrub coverage, and was generally higher on burned areas (Fig. 7). Mean shrub canopy height decreased from 54.0 cm (n=577) on control grids to 31.2 cm (n=352) on burn grids. The decline in shrub canopy coverage and height may be a key influence on animal use of these areas.

Forb levels were higher on more recent fire scars, but were lower on older scars as compared with controls (Fig. 8). Forbs generally respond favorably immediately after burning (Blaisdell 1953, Wright et al. 1979). Release of nutrients and removal of competition allow forbs, especially weedy annuals such as tansey mustard and tumble mustard, to become established. A decline in later stages of recovery would be expected as competition for moisture and light increases from grasses and shrubs.

The reported benefit to grasses from fire is a primary justification of prescribed burning. Grass values were higher in 7 of the 8 complete burns (Fig. 9). Many of the older fire scars represent the ideal response that range managers seek, a removal of sagebrush and an increase in grasses and forbs.

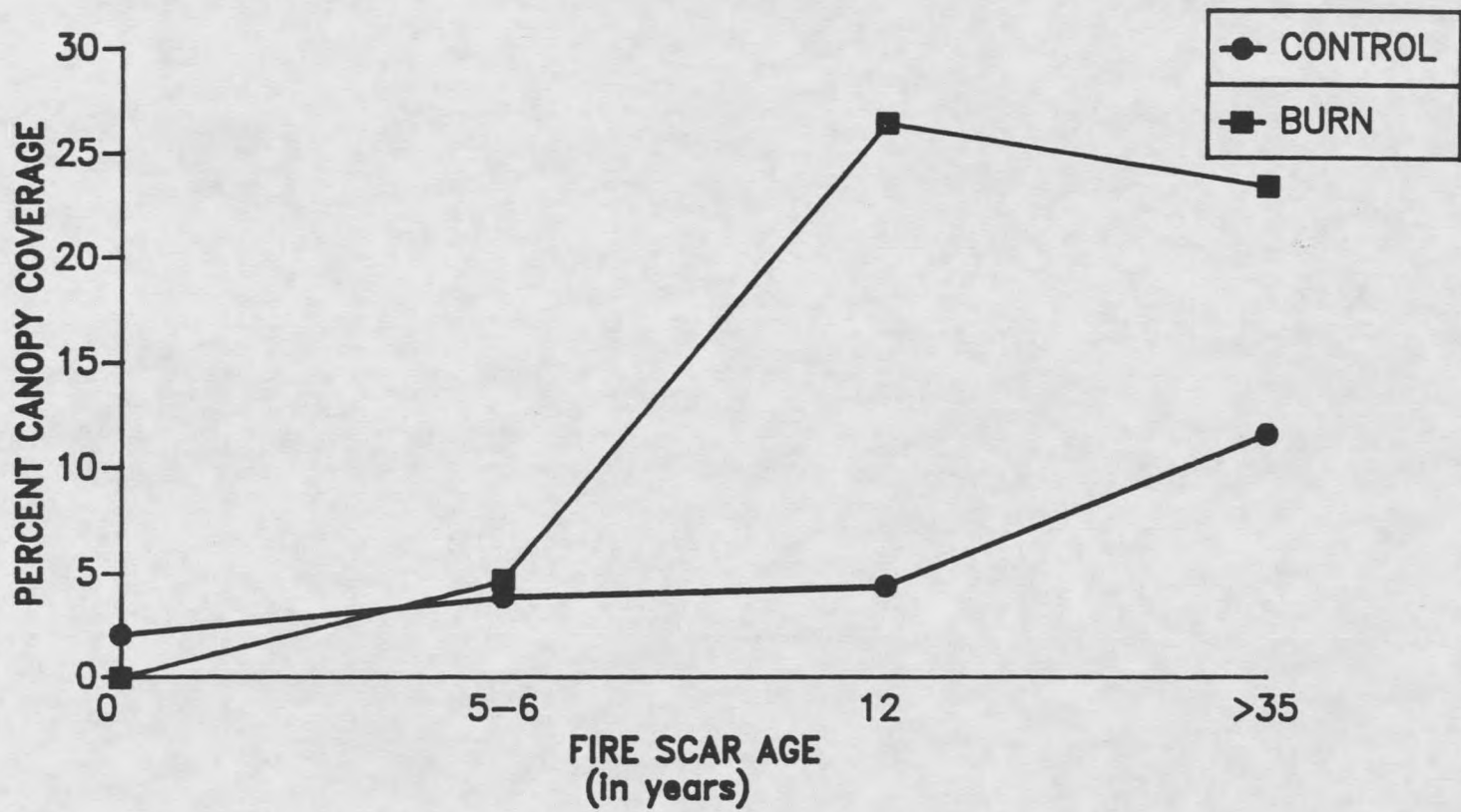


Figure 7. Trends in rabbitbrush revegetation on study areas.

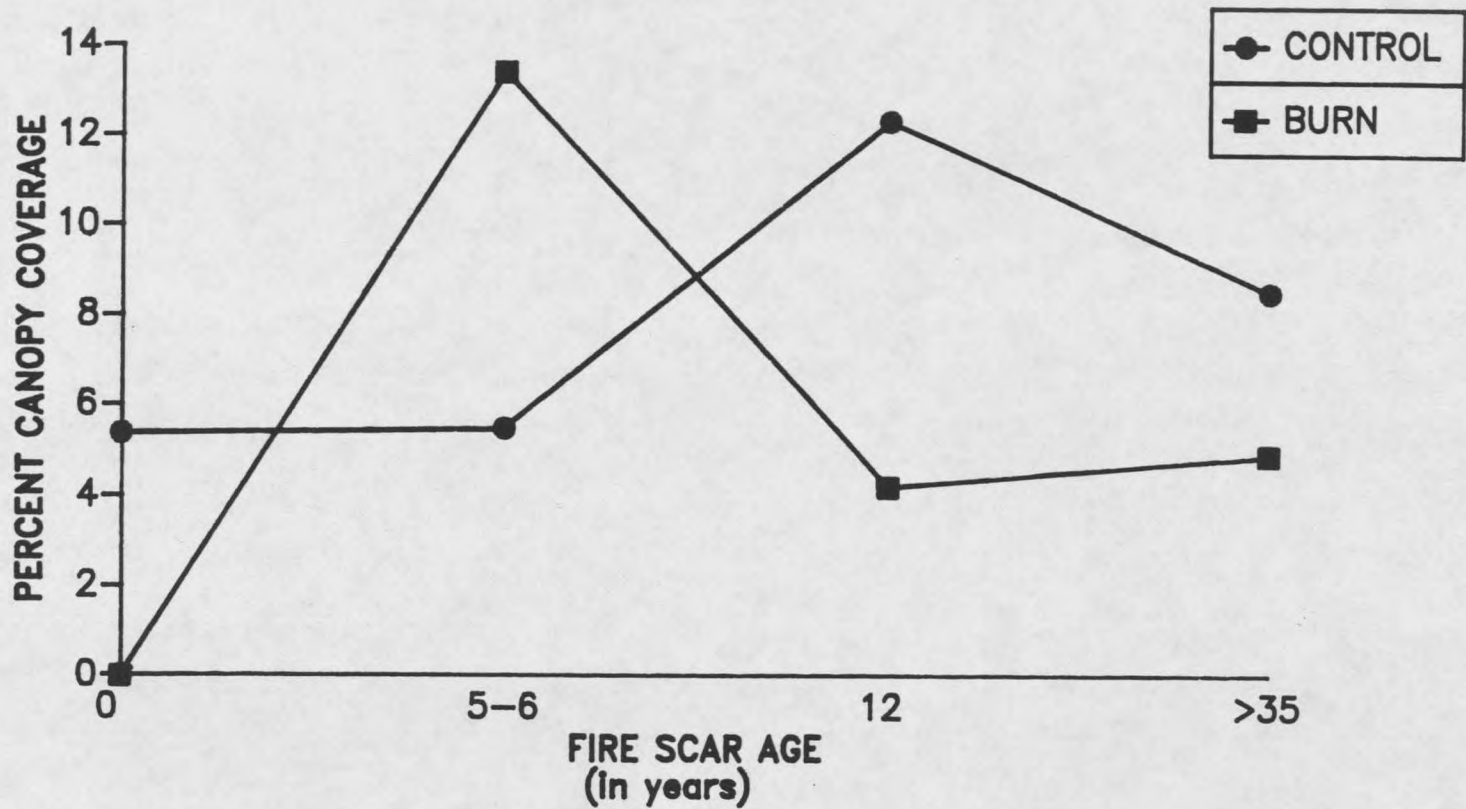


Figure 8. Trends in forb revegetation on study areas.

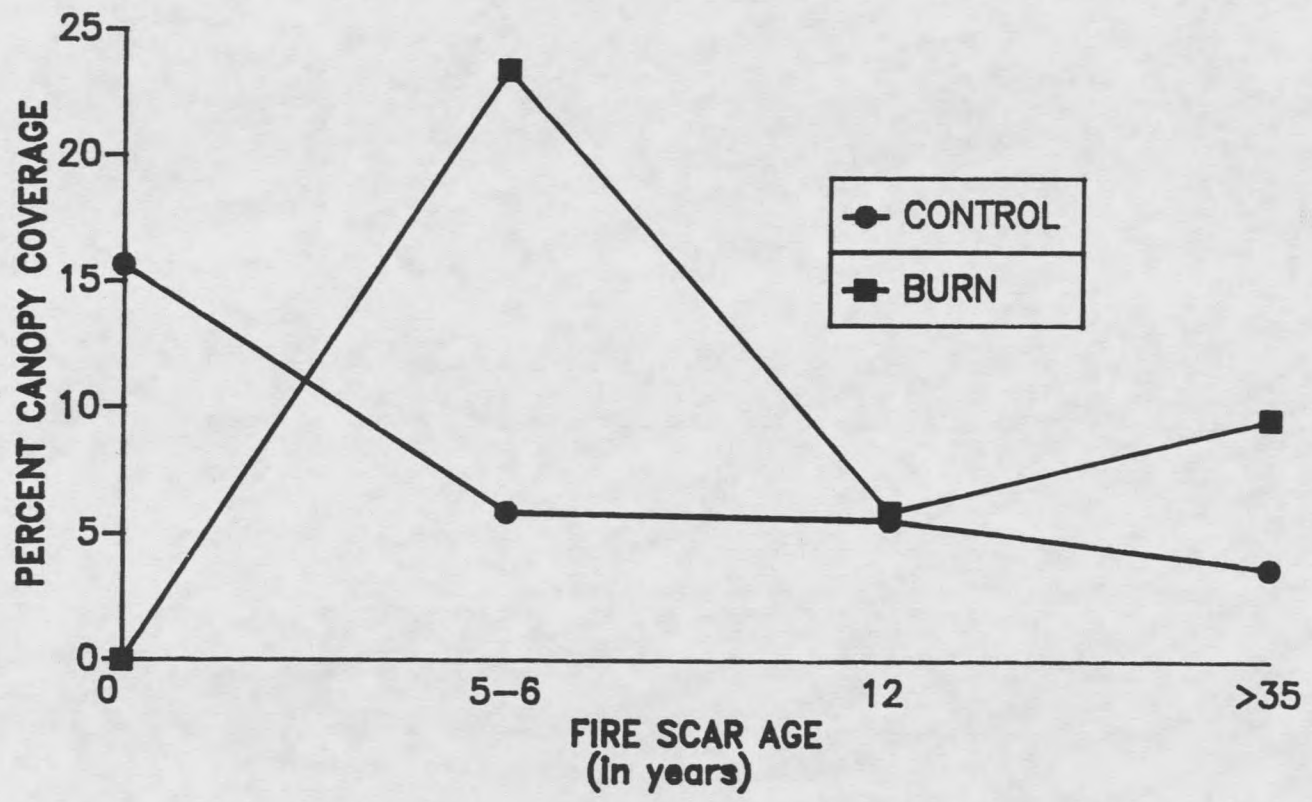


Figure 9. Trends in grass revegetation on study areas.

The appearance of cheatgrass (an undesirable exotic) on the more recent fire scars reduces the desirability of prescribed burning on the INEL. Alien annuals such as cheatgrass, tumble mustard and Russian thistle can have a dramatic influence on vegetation composition and recovery of a disturbed area (Daubenmire 1970, Yenson 1981, Branson 1985). Abundance of these species in an area should be considered when planning a sagebrush control program.

Many factors, including alien plants, influence the rate and direction of vegetation re-establishment. It can be argued whether a directional recovery to a sagebrush "climax" occurs (Anderson and Holte 1981), though paleontological evidence indicates that the vegetation of the INEL has been sagebrush steppe for at least 5000 years (Davis and Bright 1983).

The relative amounts and kinds of species on the upper Snake River plain have probably fluctuated, especially after the arrival of man. A major influence of man has been the manipulation of fire frequency. Indians may have increased fire frequency as part of their hunting and cropping activities (Gruell 1985), though this may have been of little significance in sagebrush steppe because of a lack of big game animals. Range burning was encouraged in the early part of this century as a means of improving livestock range.

More recently, wildfires have been restricted by

range managers, allowing for increases in shrubby and woody vegetation (Huston 1973). Huston estimated fire frequencies in northern Yellowstone National Park (containing areas of sagebrush steppe) at about 20-25 years. Other frequency estimates for sagebrush grasslands range from 13 to 40 years (Arno and Gruell 1983, Burkhardt and Tisdale 1976). Notably, all of these estimates are shorter than the age of the Trac Flat fire scar, which in no way resembles adjacent sagebrush areas.

Vegetation on the INEL has also been influenced by livestock grazing. Overgrazing by sheep and cattle in the late 1800's and early 1900's resulted in increased shrub canopy coverage (especially big sagebrush) and a deterioration of the grass and forb component in Idaho (Rhinehart 1932, Anderson and Holte 1981, Branson 1985). The INEL is assumed to have been in an overgrazed condition when first created in 1950 (Harniss and Murrary 1973), and probably has a greater sagebrush canopy as a result.

The size and intensity of a burn influences availability of seed sources. Freschknecht (1978) reported the maximum distance of sagebrush progeny spread averaged 12.6 m, but 90% of the total progeny were within 9 m of parent plants. Johnson and Payne (1968) and Marlette (1982) both indicated that sagebrush plants adjacent to large sagebrush-control areas were of no

practical importance as a seed source. Johnson and Payne (1968) concluded that surviving sagebrush on treatment areas provide the major seed source for reinvasion.

Romney et al. (1980) advocated the "pulse hypothesis" of sagebrush seedling establishment. They suggested that seedling establishment was related to soil moisture availability. More seedlings were established in wet years and in areas where competition for moisture was reduced. Competition from established grasses has also been shown to hinder sagebrush establishment (Freshknecht 1968). Grazing has been reported to increase the number of sagebrush seedlings on areas where sagebrush control practices were implemented (Johnson 1969), possibly by reducing grass and/or forb competition.

The literature suggests that sagebrush seedlings are weak competitors, requiring disturbance and adequate soil moisture for establishment. However, once established, plant communities dominated by big sagebrush are likely to persist for long periods of time (Anderson and Holte 1981). Results of this study support these conclusions and it can be predicted that sagebrush will not become re-established on these fire scars to any significant degree for many years. Impacts of a complete sagebrush burn on wildlife populations can be expected to persist for at

least 75 years and should be considered permanent for all practical purposes on the INEL site.

It appears that the revegetation of a fire scar may follow one of 4 pathways on the INEL (Fig. 10). The course followed is not predictable, as it is influenced by post-fire precipitation and availability of propagules. Incomplete burns, such as the INEL study area, can be expected to stabilize or return to a preburn condition.

Sage Grouse

Immediate Response Following a Complete Burn

Little use by sage grouse was noted during the first summer period following the fire on the 7MIRD study area. Few fresh fecal pellets were noted when study grids were established and cleared in early August, 1985.

Use of burn grids was significantly higher than on control grids during the winter period (chi-square $p < 0.001$). Fecal pellet densities in this area were among the highest found during the study (Table 4). The fire scar is located near a defined sage grouse wintering area (Connelly 1982). Grouse were attracted to the fire scar and utilized the bare area as a strutting arena in the early spring. Creation of strutting grounds on newly disturbed areas has been previously documented by Connelly et al. (1981) and Gates (1985). Dalke et al. (1963) reported several strutting arenas located on bare areas

Table 4. Sage grouse fecal pellet densities (single pellets/ha) found in all sample periods on all study areas, 1985-1987.

STUDY AREA	9/85		3/86		6/86		9/86		3/87		6/87	
	BURN	CONTROL	BURN	CONTROL	BURN	CONTROL	BURN	CONTROL	BURN	CONTROL	BURN	CONTROL
7MIRD	---	---	1017**	680	373**	263	190	330**	293	1363**	150	337**
INEL	20*a	6	60*	30	43**	10	130**	0	206**	10	80**	17
RABBIT EARS	3	7	3	3	6	7	10	20	0	10*	10	17
UTAH P&L	0	33**	70	94	37	67*	57	54	110	83	23	17
FIRE STATION	0	0	3	20**	7	13	13	10	80	257**	13	57**
ARCO HWY	180**b	6	73**	33	97**	20	157**	6	503**	40	37	37
N IDAHO 22	0	17**	0	60**	0	30**	0	6	0	13**	0	3
B&B CO	10	20	47	33	33*	13	63**	30	70**	23	77**	30
TRAC FLAT	160*	115	187	370**	337**	235	160	635**	833	1445**	240	305*
\bar{X}	46.6	25.5	162.2	147.0	103.7	73.1	86.7	120.6	232.8	360.4	70.0	91.1

a) Chi-square, significant at 0.05.

b) Chi-square, significant at 0.001.

c) Paired t-test, significant at 0.05.

created by mechanical means. Extensive use of this area during the late winter may have been related to the lush growth of cheatgrass. Because fire recycles nutrients into the soil that can be utilized by new growth, the new forage may have been higher in nutrient content (Blaisdell 1953).

The study area continued to be utilized by sage grouse during spring, with the burn area receiving significantly more use (chi-square, $p < 0.001$) than the control. Pellet densities declined dramatically (Table 4), probably due to the cessation of breeding activities and movement of male and non-productive females to summer range.

Cheatgrass reached full growth in May, in places reaching 8 dm in height. The high densities and the height of cheatgrass may have discouraged use of the fire scar by grouse. Cheatgrass was equally abundant on the control grid but was much shorter in height, suggesting visibility to be an important factor.

Use of the fire scar was significantly less than on control grids during summer (chi-square $p < 0.001$). Vegetation sampling in early July revealed a similar canopy coverage of forbs between grid types, although the frequency of occurrence was greater in the control area. Because forbs are the primary food source during summer (Braun et al. 1977), the local abundance of forbs may have

been an important influence on sage grouse use of the two areas.

Use of the fire scar was significantly lower in both winter and spring in the second year after the fire (chi-square $p < 0.001$). Future use of the fire scar can be expected to remain lower than or equal to adjacent control areas, as evidenced by data from the Utah P&L study area (Table 4), a 6-year-old scar dominated by cheatgrass.

Although no seasonal trends were established, the frequency of pellets on control grids from this site was significantly higher over all sample periods (paired t-test, 5 df, $p < 0.05$) (Table 5). The fire scar supported an abundance of prickly lettuce and common salsify, both of which are reported to be utilized by sage grouse (Peterson 1970, Wallestad et al. 1975). Although cheatgrass was much shorter on this area, the density of grass apparently has a negative effect on sage grouse use. Higher cheatgrass density has been suggested as a cause for lowered small mammal abundance (Gano and Rickard 1982), although small mammal populations were higher on the burn grids in this study area (Appendix 3, Table 30).

The 7MIRD area had some of the highest pellet counts recorded for any study area on the INEL, even though >90% of the sagebrush plants in the control area were dead. Although the length of time that the sagebrush had been dead is unknown, sage grouse are reported to show fidelity

Table 5. Frequency of single sage grouse pellets (plots/grid) occurring on pellet plots in all sample periods on all sample areas, 1985-1987 (all data arcsine transformed before analysis).

STUDY AREA	9/85		3/86		6/86		9/86		3/87		6/87	
	BURN	CONTROL	BURN	CONTROL	BURN	CONTROL	BURN	CONTROL	BURN	CONTROL	BURN	CONTROL
7MIRD	---	---	77	53	35	60	37	33	8	84**	21	37
INEL	4	3	12	8	11	4	17*	0	20*	4	15	5
RABBIT EARS	1	3	1	1	1	1	4	8	0	4*	3	7
UTAH P&L	0	5	9	12	7	19	9	13	23	31	8	7
FIRE-STATION	0	0	1	5	3	5	4	1	21	35	5	17
ARCO HWY	36*	3	18	11	27*	8	27*	3	59*	9	11	11
N IDAHO 22	0	7*	0	17**	0	3*	0	0	0	5*	0	1
B&B CO	4	7	11	11	7	4	12	8	13	7	17	7
TRAC FLAT	36	32	39	52	53	46	29	50	64	72	41	50

- a) All values arc-sin transformed before analysis.
 b) Paired t-test, significant at $p < 0.05$.
 c) Paired t-test, significant at $p < 0.05$.
 *) Chi square, significant at $p < 0.05$.
 **) Chi square, significant at $p < 0.001$.

to seasonal ranges. Use of strutting arenas is known to be traditional, with some areas thought to have been used for 80-90 years (Dalke et al. 1963). Use of winter ranges may be as traditional as strutting arena use (Eng and Schadweiler 1972, Berry and Eng 1985).

Because sagebrush control has been reported to cause a decline of sage grouse (Patterson 1952, Eng and Schladweiler 1972, Wallestad 1975, Braun et al. 1977), the continued use of this area during winter is unusual. Bendall and Elliott (1966) felt continued blue grouse (Dendrogapus obsurus) use of undesirable habitats as breeding sites was related to fidelity to breeding areas. Although mild winters of 1985-86 and 1986-87 may partially explain the use of this area, further investigation of sage grouse seasonal movements in this area may provide further insight on seasonal range fidelity.

Use of an Incompletely-burned Fire Scar

The INEL study area, representing an incomplete prescribed burn conducted in 1981-82, was also studied by Gates (1983), who found preburn use by sage grouse to be similar between proposed burn and control grids. The prescribed burn occurred in the fall, and levels of sage grouse use were significantly higher on the burned area in the following year (Gates 1983). Grouse utilized the study area as winter, breeding, nesting and brood-rearing habitat (Gates 1983). The formation of a strutting ground

on the newly disturbed area was also documented (Gates 1985).

Results of this study, conducted 4-5 years after the fire, indicate that use of the fire scar continues to be significantly higher than the control during all seasons (Table 4). The newly created strutting ground was present in 1986 and 1987. All sage grouse roost droppings were found on the area exposed to fire (Table 6). Night roosts are usually in open sites, indicating a preference for no overhead canopy (R. Eng, pers. commun.). Openings in the canopy created by fire may have been preferred roosting areas, though information on microhabitat use was not collected.

The mosaic pattern of vegetation created by the incomplete burn appears to have provided optimal habitat for sage grouse. Importance of habitat diversity for broods was documented by Wallestad (1971), who reported daily movements between roosting sites in dense sagebrush and feeding sites in more open areas. Klebenow (1969) found broods to occupy sites with fewer big sagebrush plants and more forbs than generally present on the study area. Dunn and Braun (1986) found horizontal cover and habitat interspersions to be 2 of the most important determinants of sage grouse habitat in the summer.

Table 6. Sage grouse roost pellet groups occurring on pellet plots in all sample periods on all study areas, 1985-1987.

STUDY AREA	9/85		3/86		6/86		9/86		3/87		6/87	
	BURN	CONTROL	BURN	CONTROL	BURN	CONTROL	BURN	CONTROL	BURN	CONTROL	BURN	CONTROL
7MIRD	-	-	3	13	0	0	0	0	5	23	1	.5
INEL	1	0	0	0	0	0	2	0	4	0	0	0
RABBIT EARS	0	0	0	0	0	0	3	0	0	0	0	3
UTAH P&L	0	1	0	1	0	0	0	2	0	0	0	0
FIRE STATION	0	0	1	0	0	0	0	0	2	4	3	1
ARCO HWY	0	0	8	0	0	0	12	0	3	0	1	0
N IDAHO 22	0	1	0	4	0	0	0	0	0	0	0	0
B&B CO	0	1	0	6	0	0	0	0	0	0	0	0
TRAC FLAT	2	0	10	1	0	0	1	5	14	8	5	0
\bar{X}	3	3	22	25	0	0	18	7	28	35	10	9

The fire left approximately 36% of the area unburned (Winter 1984). This area, plus adjacent control areas could provide adequate nesting habitat for sage grouse. Hens select stands of dense sagebrush in areas where sagebrush canopy coverage is low (Klebenow 1969), as well as taller plants within these areas. Klebenow found no nests in >25% canopy coverage suggesting that sagebrush densities can become too great for suitable nesting habitat, though Wallestad and Pyrah (1974) reported the average sagebrush coverage over successful nests was 27%.

Although this area does not appear to be critical winter range (Gates 1983), removal of any sagebrush probably reduced its suitability as winter habitat. Because sage grouse distribution on winter range has been reported to vary with snow depth (Beck 1977), high winter use of this fire scar may have been a result of mild winters occurring both years.

Data from this fire scar suggest that a properly implemented burning program can improve sage grouse habitat. Maintenance of sagebrush on winter range while improving conditions for nesting and brood rearing does provide a good distribution of seasonal habitat for these birds. However, continued spring grazing of this fire scar by sheep could cause a change in plant species composition, with reduced forb abundance and increased sagebrush densities a distinct possibility. Continued

monitoring of the plant community and sage grouse in this area may provide information on impacts of grazing on sage grouse habitat.

Use of Perennial Grass/Rabbitbrush Fire Scars

Significant trends in seasonal use were not detected in the 6 study areas representing this category (Rabbit Ears, Fire Station, Arco Hwy, N Idaho 22, B&B Co and Trac Flat) (paired t-test, 5 df, $p > 0.05$). All burns were older than 5 years, with only the Rabbit Ears area less than 14 years old (Table 1). The 6-year-old Rabbit Ears burn occurred in the juniper/threetip sage community.

Although relative sage grouse use of the fire scars varied considerably, overall use of fire scars was significantly different on several areas (Tables 4 and 5). Significantly lower use on the Rabbit Ears burn was probably related to the absence of an interspersed shrub cover, in that the areas had more grass and twice the canopy coverage of forbs as on control areas. The control area supported a vigorous shrub community as well as a diverse understory. Although a strutting arena was not located on this area, a sage grouse nest was found on a control grid in 1987, indicating the presence of a lek in the general area. Sage grouse use of the juniper/threetip zone appears to be limited although the small sample may have given misleading results.

No sage grouse use was detected on the N Idaho 22

fire scar, whereas limited numbers of fecal pellets were found on the control. Sparse vegetation of the entire area and especially the lack of any desirable plant species on the fire scar probably limited sage grouse use during all seasons.

The Arco Hwy study area is located in a known sage grouse wintering range (Connelly 1982, Gates 1983). Grouse are known to be dependant on sagebrush during the winter (Patterson 1952, Wallestad et al. 1975, Remington and Braun 1985), though greater use of the fire scar was highly significant in both winters of this study (chi-square, $p < 0.001$). Relatively high densities of fecal pellets through the year indicate that grouse utilize this portion of the INEL during all seasons, an aspect not mentioned by either Connelly (1982) or Gates (1983). Higher use of the fire scar during the non-winter seasons is unexplainable as forb canopy coverage was much higher in the control grid and shrub canopy coverage was within values considered adequate for grouse. However, a strutting ground does occur on the fire scar and another on the fire trail, at a point just west of where the trail leaves the fire scar.

Higher use of the B&B Co fire scar is more readily explained as shrub canopy coverage is extremely high in the control area. Grass and forb levels were higher on

the burn area and scattered sagebrush plants provided some cover.

The variability in these results indicates that a thorough knowledge of the use of an area by sage grouse is necessary before the impacts of a fire can be predicted. Winter range during severe winters requires sagebrush densities >20% (Eng and Schadweiler 1972, Connelly 1982), while open winters may not show such defined use (Gates 1983). The long period of time included in the Winter sample period also influenced results as no indication of intensity or evenness of use by grouse was obtained. Fecal pellet counts provide levels of sage grouse use during defined periods, thus providing a basis for more intensive research to determine how sage grouse utilize a grassland within their home range.

Removal of any sagebrush on critical winter range is detrimental to sage grouse (Patterson 1952, Eng and Schadweiler 1972, Braun et al. 1977, Beck 1977), whereas range that is utilized during multiple seasons may benefit. Winter range and breeding grounds are closely associated and in these areas of overlapping range, the creation of open areas may be of greatest benefit. Several authors, including Klebenow (1972), emphasized the interspersed habitat types necessary for optimal sage grouse habitat.

Connelly et al. (1981) and Gates (1985) reported use of newly disturbed areas as strutting grounds, indicating that such openings may be limited in portions of the INEL. If wintering areas are defined and open spaces suitable for strutting arenas are limited, spot burns could be used to create such areas. Strutting grounds are small, generally less than 4 ha (Dalke et al. 1963), and frequently in stands of sagebrush which are fairly open with canopy coverage from 13-20% (Klebenow 1972). Nests are associated with strutting grounds, but also must be near adequate brooding habitat for young birds to survive. Young grouse feed extensively on forbs and insects (Peterson 1970, Dunn and Braun 1986) so use of an area will depend on the availability of succulent forbs (Klebenow 1969, Wallestad 1971). Birds appear to prefer relatively open sagebrush stands where both cover and food are immediately available (Klebenow 1969, Wallestad 1971). Wallestad (1971) reported that large tracts of dense sagebrush appeared to be undesirable brood habitat. Fires that create a mosaic of habitat types (e.g. the INEL study site) or small fire scars in dense stands of sagebrush which increase forb and grass abundance would be beneficial to young grouse.

The precise use of prescribed burning to increase sage grouse populations requires detailed knowledge of sage grouse movements related to seasonal weather patterns

plus a detailed vegetation inventory of the entire area utilized. Such information gathering is generally not feasible in the public domain. Until such practices are feasible, the best management practice is a maintenance of sagebrush habitats known to be utilized by sage grouse (Baker et al. 1976, Braun et al. 1977).

Pronghorn

Immediate Response Following a Complete Burn

Pronghorn use of the 7MIRD area prior to the fire is unknown. Antelope were observed traveling between the fire scar and the Big Lost River floodplain approximately 3 km west. Bachelor herds and doe/fawn groups were seen on the burned area.

Three pronghorn were observed on the 7MIRD study area 2 weeks after the fire occurred in June, 1985. The number of animals increased during the following weeks, with a group of approximately 35 animals sighted in September and October.

Sample grids were established and cleared in late August, 1985. Pellet counts conducted in March, 1986 revealed winter use was significantly greater on the burned area than on the control grids (chi-square $p < 0.001$). Use of the burned area continued to be significantly greater during all sample periods (paired t-test, 4 df, $p < 0.05$), though use of the entire area

declined as seasons progressed (Table 7).

The antelope fed heavily on the new growth of prickly pear (whose needles had not yet hardened) on the fire scar. All plants examined were fed upon. Old pads, with needles burned off, did not appear to be utilized, in contrast to Stelfox and Vriend (1977). No cactus plants growing in control areas appeared to be utilized.

Growth of cheatgrass and rhizomatous grasses during late summer and early fall also provided succulent forage for pronghorn after the fire. Although use of grasses by pronghorn has been primarily in early spring (Dirshl 1963, Hanley and Hanley 1982), use of cheatgrass has been reported for other seasons. Schwartz and Nagy (1976) reported cheatgrass to be a preferred species during early stages of growth. Beale and Smith (1970) reported antelope use of fall growth cheatgrass.

Pronghorn use of the fire scar can be attributed to vegetational changes on the fire scar. Hobbs and Spowart (1984) reported burned range to improve the winter diets of mule deer and bighorn sheep, though the improvement was due to changes in diet selection rather than improvements in individual forages. In their study, green grass was available 1-2 weeks earlier on burned plots than on controls. In contrast, Blaisdell (1953) reported delayed maturation and desiccation of herbaceous vegetation in the first year after a fire. The 7MIRD fire scar appeared

Table 7. Pronghorn fecal pellet densities (groups/ha) occurring on pellet plots in all sample periods on all study areas, 1985-1987.

STUDY AREA	9/85		3/86		6/86		9/86		3/87		6/87	
	BURN	CONTROL	BURN	CONTROL	BURN	CONTROL	BURN	CONTROL	BURN	CONTROL	BURN	CONTROL
7MIRD	---	---	333*	67	153**	63	117**	63	127**	40	67**	10
INEL	60	93*	37	67*	40	60a	60	53	200**	57	67**	20
UTAH P&L	43*	6	80*	10	50**	3	43**	7	33**	3	3	0
FIRE STATION	0	7*	43*	20	30b	17	40**	10	173**	100	37*	13
ARCO HWY	133*	73	60	20	67**	13	80**	20	300**	157	77*	50
N IDAHO 22	303*	127	287*	90	110**	60	93	80	643**	127	70**	6
B&B CO	10*	0	3	0	0	0	0	0	0	20**	20**	3
TRAC FLAT	43*	25	20*	0	30	40	10	5	193**	15	10*	0
\bar{X}	84.6	47.3	107.9	34.3	60.0	32.0	55.4	29.8	208.6	64.9	43.9	12.8

- a) Chi-square, 1 df, p = 0.057.
b) Chi-square, 1 df, p = 0.080.
c) Paired t-test, 5 df, p = 0.061.
d) Paired t-test, 5 df, p = 0.074.

to green up earlier than surrounding areas in 1986, though the absence of overstory may have made new growth more visible.

Sagebrush has been reported as the most important forage in late fall, winter and early spring diets, whereas forbs are the most important summer forage (Mason 1952, Beale and Smith 1970, Gates 1982). The relative paucity of sagebrush in this area limits its value as winter range. Forb abundance on the fire scar was not greater than control values. Decline in use of the study area may have been related to increased litter and dead cheatgrass, which would reduce availability of green forage.

Ungulate use of the Utah P&L fire scar, a 6-year-old fire scar dominated by cheatgrass, was also significantly higher than control grids during all seasons (paired t-test, 5 df, $p < 0.05$). Although few pronghorn were seen on the fire scar, an adjacent stand of juniper increased the likelihood that at least some of the pellet groups may have been deposited by mule deer (based on observations of ungulates on the Rabbit Ears Study Area). All pronghorn, when disturbed on the fire scar, fled to other parts of the scar instead of entering the control area. Sagebrush canopy on the control was very dense (mean shrub height 79.2 cm) which may have discouraged pronghorn use (Yoakum 1980).

Use of an Incompletely-burned Fire Scar

The INEL study area, representing an incomplete prescribed burn conducted in 1981-82, was also studied by Gates (1983). He reported antelope used this area primarily during winter and spring. Post-burn results indicated that control grids were used significantly more than burn grids, though the conclusion was influenced by a very high density of pellets on 1 control grid.

Results of my study, conducted 4-5 years after the fire, revealed no significant trends of use over all seasons (paired t-test, 5 df, $p > 0.10$). Significant differences were noted between seasons (Table 7), although these differences were not consistent among years. Frequencies of occurrence of pellet groups on study grids showed no significant differences between grid types (Table 8), suggesting that differences among grids may have been due to the random movements of pronghorn throughout the area. Migrating pronghorn occurred in groups of 26-100 animals in February, 1986. Groups of this size could dramatically affect results if movements were unequally distributed over the area during spring and fall migration periods.

Pronghorn in this area forage primarily on sagebrush during the winter and spring (Gates 1983), so use of this area was likely related to sagebrush canopy and ease of movement (Yoakum 1980). Shrub canopy coverage was greater

Table 8. Pronghorn fecal pellet group frequency (plots/grid) found in all sample periods on all study areas, 1985-1987 (all data arcsine transformed before analysis).

STUDY AREA	9/85		3/86		6/86		9/86		3/87		6/87	
	BURN	CONTROL	BURN	CONTROL	BURN	CONTROL	BURN	CONTROL	BURN	CONTROL	BURN	CONTROL
7MIRD	---	---	63*	21	31	29	32	19	31a	12	21*	4
INEL	23	25	13	20	11	17	21	19	45b	20	21	8
UTAH P&L	13c	3	21*	4	15*	1	13d	3	8e	1	1	0
FIRE STATION	0	3*	12	7	9	7	15*	3	48	27	15	5
ARCO HWY	33	20	19	8	16	5	20	8	67	48	20	16
N IDAHO 22	71	40	53*	20	31	17	36	25	85*	32	24*	3
B&B CO	1	0	1	0	0	0	0	0	0	7**	8f	1
TRAC FLAT	13	10	8**	0	11	14	4	1	37**	3	4*	0

- a) Chi-square, 1 df, p = 0.076.
 b) Chi-square, 1 df, p = 0.09.
 c) Chi-square, 1 df, p = 0.072.
 d) Chi-square, 1 df, p = 0.070.
 e) Chi-square, 1 df, p = 0.055.
 f) Chi-square, 1 df, p = 0.055.
 g) Paired t-test, 5 df, p = 0.067.

in burn than control grids primarily due to an increase in rabbitbrush. Although Winter (1984) documented a 47% decrease in shrub coverage as a result of the fire, sagebrush was readily available as forage in both burn and control grids. Although animal mobility was difficult to assess, the reduction in tall sagebrush plants probably permitted greater mobility. Based on guidelines presented by Yoakum (1980), shrub coverage was above the optimal density in both burn and control grids. It appears that the incomplete burn did not remove enough sagebrush to attract significantly greater numbers of antelope.

Use of Perennial Grass/Rabbitbrush Fire Scars

The five oldest burns (Table 1), which occurred before 1975, were analyzed for antelope use. The sixth complete burn (1981 Rabbit Ears Study Area), was located in a juniper/threetip sage community in which antelope were never observed. Because mule deer were regularly observed in this area, pellet groups were assumed to have been deposited by that species.

Pronghorn use of the 5 study areas was variable (Table 7). Notably, control values were significantly greater than burn values in only 2 of 30 seasonal samples collected (chi-square $p < 0.05$).

Pellet group densities on burn areas were significantly greater than on controls in all seasons for the Arco Hwy study area (paired t-test, 5 df, $p < 0.05$).

Greater use was noted in the results of the Fire Station and N Idaho 22 study areas, where $p < 0.075$ in paired t-tests. Frequency of pellet group occurrence on burn areas was significantly greater in the N Idaho 22 overall values (paired t-test, 5 df, $p < 0.05$). No significant trends were detected in the Trac Flat or B&B Co study area, though winter use on the Trac Flat burn grids was significantly greater than controls in both years (chi-square, $p < 0.001$).

The Arco Hwy study area received high levels of use during spring pronghorn migration (Table 7). Herds of 30-50 animals were seen on the fire scar in spring, 1986, but were on the fire scar for only short periods. The high values for winter, 1987 may be the result of a slower daily migration rate during that year, as Hoskinson and Tester (1980) reported variation in the duration of spring migration relative to weather patterns.

Groups of 6-9 animals were regularly seen on the study area throughout spring and summer. Animals frequently bedded on the fire scar, and utilized sagebrush as escape cover.

The N Idaho 22 study area is located in the Birch Creek drainage. Hoskinson and Tester (1980) reported this area to be a major pronghorn wintering area. Use of the area was highest during winter in this study (Table 7). The dominance of winterfat and the relatively short height of vegetation on this fire scar probably attracted

pronghorn. Johnson (1979) reported antelope to utilize significant amounts of winterfat on the INEL. He also stated that some fecal pellets were found to contain only winterfat indicating that some animals may feed extensively in areas such as this fire scar.

The Fire Station study area received low but relatively constant use by groups of 1-9 antelope. A male was observed scent marking tall sagebrush plants on the edge of the fire scar. Pronghorn were frequently observed bedded in the middle of the fire scar, but animals were also observed bedded in adjacent sagebrush areas. Studies of pronghorn indicate that preferred habitat is a diverse plant community of grasses, forbs and shrubs. Plant height is also important, as areas with vegetation taller than 30 inches are infrequently used (Yoakum 1980).

It is apparent that the reduction in sagebrush was beneficial to antelope, even if the area was converted to a monotypic stand of cheatgrass. However, dense cheatgrass and a buildup of fine litter may reduce use of fire scars, as pronghorn use of the 7MIRD area was substantially lower in the second year of study and little use was recorded on the Utah P&L study area. Continued observation of the 7MIRD fire scar may provide further insight on pronghorn use of cheatgrass stands.

Conversely, burning of extensive areas of sagebrush can be detrimental to pronghorn, as browse is the primary

component of diets during all seasons, and is virtually the only food utilized in the fall and winter (Bayless 1969, Beale and Smith 1970, Yoakum 1980, Medcraft and Clark 1986). Thus, wildfires should not be allowed to burn uncontrolled. Management by prescribed burning should consider the size, intensity and season of burn to minimize deleterious impacts to the soil and flora of the area.

Mule deer use of the Rabbit Ears fire scar was significantly greater than on control grids during all seasons in both years (paired t-test, 5 df, $p < 0.05$). Also, deer were more frequently observed on the fire scar, as 25 of 28 observations were on the fire scar. Differences in animal observability restrict the validity of deer observations as an accurate measure of deer use. However, pellet group frequency of occurrence was significantly higher on the burn than control grid.

Elk

Elk fecal pellets were first noted on the 7MIRD fire scar in March, 1986 during the first spring following the fire. Although only 2 pellet groups were found in the established pellet plots, an expanded sampling scheme was utilized to obtain an actual count of 23 pellet groups/12,200 m². Elk tracks were abundant over much of the fire scar, whereas few tracks and no pellet groups were found in adjacent control plots. Elk pellets were

found on the 7MIRD and the Utah P&L fire scars in the June sampling period. Eight elk were observed on the Rabbit Ears study area during June, 1986.

The Utah P&L fire scar continued to be utilized by elk during the following year, as pellet groups were found in each sampling period. A dead juniper skeleton appeared to be utilized as a rub, as broken limbs and fresh scars on the trunk were observed as well as numerous elk tracks around the tree.

Arthur et al. (1984) lists elk as transient on the INEL, occurring for a relatively short time during seasonal migration or dispersal. While no evidence is available to validate year-round use of the Utah P&L study area by the same group of animals, it is probable that a small group of animals remained in the general area of the Twin Buttes during this period. A local conservation officer reported that local residents had observed a herd of approximately 20 elk near Atomic City, south of Twin Buttes throughout the summer of 1986 (Gary Hompland, pers. commun.). Continued observations of elk on the INEL may indicate the establishment of a local herd.

Small Mammals

A total of 25,781 trapnights produced 1,989 captures of 11 species of small mammals. The deer mouse (Peromyscus maniculatus) was the most common rodent,

accounting for 66% of the catch. Also abundant were the least chipmunk (Tamius minimus), the Great Basin pocket mouse (Perognathus parvus) and Ord's kangaroo rat (Dipodomys ordii). Eighty-five nontarget captures were recorded, including 1 mammal (Mustela frenata), 2 reptiles and 82 birds of 8 species.

Analysis of small mammal use of fire scars follows the hypothesized pathways of vegetation recovery (Fig. 10). Overall trends are based on the assumption that the vegetation on the fire scars will persist indefinitely.

Use of Cheatgrass-dominated Fire Scars

Vegetation recovery of this type is represented by the most recent fire scar (7MIRD Study Area) and by a 6-year-old fire scar (Utah P&L Study Area). Both are dominated by cheatgrass and annual forbs.

Small mammals were sampled on the 7MIRD area 2 months after the burn occurred. Total captures were significantly lower on the burn (chi-square, $p < 0.05$) than on the control, due primarily to a significant reduction in the number of deer mice occurring on the fire scar (Appendix 4, Table 27). Chipmunks were less abundant on the fire scar in fall, although the sample size was not large enough for statistical testing. Numbers of kangaroo rats and pocket mice were slightly higher on the burn grid.

Fall species diversity and evenness indices were

higher for the burn grid than the control (Table 9). The reduced number of deer mice on the fire scar appeared responsible for the increase.

Results of spring sampling (Table 10) were similar to fall, as little change in vegetation coverage had occurred. Later sampling (Fall 1986) showed an increased number of deer mice on both grids (Moritz, unpubl. data), with significantly more deer mice occurring in the control grid (chi-square $p < 0.05$). Chipmunks were of equal or greater abundance in control grids during all sampling periods. Data from the Utah P&L study area indicated the capability of deer mice to dominate in cheatgrass stands. Ninety-two percent of all captures on the fire scar were of this species. Diversity and evenness values were much higher on the control than the burn areas in both spring and fall samples (Table 9 & 10).

Five species were captured on the control grids, of which 2, T. minimus and Spermophilus townsendii, were not caught on the fire scar. A kangaroo rat was captured on the fire scar, while none was captured on the control grid. Total captures were significantly greater on the control grid in the fall sample (chi-square $p < 0.05$), while values were significantly higher on the burn grid in the spring (chi-square $p < 0.05$). The large number of immature deer mice captured on the burn grid (Moritz unpubl. data) suggested that a change in vegetation composition or

Table 9. Small mammal population indices, Fall, 1985.

STUDY AREA	DIVERSITY		EVENNESS		RELATIVE DENSITY		TOTAL CAPTURES		# SPECIES	
	BURN	CONTROL	BURN	CONTROL	BURN	CONTROL	BURN	CONTROL	BURN	CONTROL
7 MIRD	0.541	0.303	0.77	0.50	6.01	12.22	43	88*	5	4
INEL	0.552	0.364	0.79	0.52	9.76	15.00	70	107*	5	5
RABBIT EARS	0.055	0.302	0.18	0.50	5.31	7.22	36	52	2	4
UTAH P&L	0.110	0.264	0.23	0.55	7.38	12.50	53	90*	3	3
FIRE STATION	0.338	0.357	0.56	0.59	4.42	16.11	30	116**	4	4
ARCO HWY	0.498	0.343	0.64	0.49	6.68	7.22	48	52	6	5
N IDAHO 22	0.313	0.477	0.66	0.68	10.18	13.54	72	96	3	3
B&B Co	0.327	0.356	0.54	0.74	8.24	4.86	59*	35	4	3
TRAC FLAT	0.575	0.552	0.82	0.71	4.58	10.70	33	77**	5	6
\bar{X}	0.368	0.369	0.577	0.587	6.951	11.040	49.3	79.2	4.1	4.1

- a) * = $p < 0.05$
b) ** = $p < 0.001$

Table 10. Small mammal population indices, Spring, 1986.

STUDY AREA	DIVERSITY		EVENNESS		RELATIVE DENSITY		TOTAL CAPTURES		# SPECIES	
	BURN	CONTROL	BURN	CONTROL	BURN	CONTROL	BURN	CONTROL	BURN	CONTROL
7MIRD	0.447	0.332	0.57	0.47	6.81	10.97	49	79**	6	5
INEL	0.552	0.558	0.71	0.72	6.14	7.94	44	58	6	6
RABBIT EARS	0.374	0.610	0.54	0.87	5.56	4.86	40	35	5	5
UTAH P&L	0.154	0.338	0.32	0.48	17.69	5.75	127**	41	3	5
FIRE STATION	0.477	0.641	1.00	0.83	0.42	4.17	3	30**	3	6
ARCO HWY	0.568	0.542	0.81	0.78	4.17	5.28	30	38	5	5
N IDAHO 22	0.366	0.428	0.77	0.71	5.00	9.72	36	70*	3	4
B&B CO	0.489	0.502	0.81	0.83	1.67	4.63	12	33*	4	4
TRAC FLAT	0.693	0.722	0.82	0.85	5.83	9.17	42	66*	7	7
\bar{x}	0.458	0.519	0.706	0.727	5.92	6.94	42.6	50.0	4.7	5.2

a) * = $p < 0.05$
b) ** = $p < 0.001$

phenology may have influenced the timing of small mammal reproduction.

Use of an Incompletely-burned Fire Scar

The INEL study burn, conducted in 1981-1982, was the only study site to represent an incomplete burn. Permanent small mammal transects were established on the prescribed burn area and adjacent areas in 1982 to determine small mammal response to prescribed burning (Keller et al. 1983). The fire was not uniform, and vegetation in the area of small mammal transects received little or no exposure to fire (B. Keller pers. commun.). Thus, no data concerning the direct and indirect impacts of burning were obtained.

Both burn grids in the present study received greater exposure to fire, based on observations of relative rabbitbrush density and general observations of charred Artemisia stumps. The exact amount of burned and unburned vegetation on the sample grids is unknown.

Total small mammal captures were significantly higher on the control than the burn grid in the fall sample (chi-square $p < 0.05$) (Table 9), but were not significantly greater in the spring sample (Table 10). The number of species captured was the same in both samples, though slight differences in species composition occurred (Appendix 4, Table 28).

Total fall captures were higher on the control grid,

primarily because of significantly greater numbers of deer mice (chi-square, $p < 0.05$). Significantly more D. ordii were captured on the burn grid in the fall sample (chi-square $p < 0.05$). Three other species in the fall sample occurred in approximately equal numbers on burn and control grids, though sample sizes were small. Species diversity and evenness values were lower in the control grid in the fall, again due to dominance of deer mice.

Numbers of small mammals captured in spring were comparable to fall captures, except chipmunks were significantly more abundant on the control grid (chi-square $p < 0.05$). Discontinuity in chipmunk numbers between sample periods is not readily explained, but may be related to breeding movements, dispersal or seasonal differences in food availability.

Diversity and evenness values were similar between study grids in the spring sampling period and were comparable to those obtained in the fall (Tables 9 & 10).

Use of Perennial Grass/Rabbitbrush Fire Scars

Five of the 9 study areas (those older than 10 years) represent complete burns in sagebrush steppe. The Rabbit Ears Study Area, a complete burn that occurred in 1981 in a threetip sage/juniper community, is included in this category because the small mammal community composition appears similar to communities found in sagebrush areas.

Total captures were not significantly different

between burn and control grids in the fall sample (paired t-test, 5 df, $p=0.16$) (Table 9), although total captures were greater on the control grids in 5 of the 6 study areas. Significant differences occurred on some individual study areas, with greater burn values highly significant on the Fire Station study area and the Trac Flat study area (chi-square, $p<0.001$). Total captures on the B&B Co study area were significantly higher on the burn grid (chi-square, $p<0.05$) than on the control.

Significance of total capture values was dependant on the relative abundance of deer mice. Numbers of species captured on grids ranged from 2-6. Only one study area had a difference of 2 species between burn and control grids, whereas the mean number of species captured on each grid type was the same.

Spring total captures were significantly higher on control grids (paired t-test, 6 df, $p<0.05$) (Table 10). Captures were significantly higher in control grids in 3 study areas, and this difference was highly significant on the Fire Station study area.

Spring diversity values were higher on control than on burn grids on 5 of the 6 study areas (Table 10). Trends in evenness values were not apparent in the spring sample. Both diversity and evenness values were higher in the spring sample when compared to fall samples. The number of species captured in each grid during the spring

sampling period was generally equal to or higher than during the fall. Higher values for these indices may be the result of greater numbers of species active during the trapping period, decreased Peromyscus abundance, or a combination of factors.

Trends in Small Mammal Use

A shift from a shrub-dominated community to grassland can be expected to change the rodent community.

Feldhammer (1979) reported that areas with greater structural diversity had lower numbers of small mammals when compared to areas with uniform community structure. Habitat diversity reflects the variability and abundance of microhabitats available to animals with specialized habitat needs.

Rogers and Hedlund (1980) reported consistently greater small mammal biomass levels in grassland than in a sagebrush/juniper community. Grassland plots (located in stands of cheatgrass or needle-and-thread) were dominated by pocket mice (P. parvus) with few other animals captured, whereas sagebrush stands had a mixture of the four most common species in the area.

An incomplete burn (e.g. the INEL study area) may provide the greatest abundance of species and the highest small mammal biomass with the creation of new microhabitats and additional food supplies while maintaining sagebrush microhabitat. Although my data do

not support this hypothesis, Keller (1985) reported that permanent small mammal traplines in this area had the highest small mammal density of 6 study areas. He believed the data were influenced by emigration of deer mice from burned areas into unburned areas (B. Keller, pers. commun.).

Information on effects of incomplete burns is difficult to obtain because of variability in fire patterns in an area. Few data are available in the literature and research directed at such effects, especially the influence on microhabitat use, is needed.

Effects of complete burns on small mammals have been reported for a wide variety of habitats ranging from marshes to forests (Reams 1981). A complete burn can have both direct and indirect effects. Direct mortality from fire is usually limited (Howard et al. 1959), although Chew et al. (1958) and Cook (1959) reported substantial mortality of some species.

Changes in small mammal populations are directly related to habitat alteration (Howard et al. 1959, Reams 1981). Removal of standing cover and litter increase exposure to climate and predation (Meserve and Klatt 1985). Food availability may also be reduced immediately after fire (Reams 1981), although granivores generally benefit from the exposure of seeds. Loss of food resources to herbivores is frequently short-lived as new

growth of grasses and forbs often begins soon after fire.

Long-term impact on individual species is dependant upon specific habitat and food requirements of the species. Recolonization of fire scars by deer mice, a pioneer species occurs rapidly (Reams 1981). My study indicated that spring deer mice levels were comparable between fire scars and control areas, although fall population peaks were significantly lower on the fire scars (paired t-test, 7 df, $p < 0.001$)

Chipmunks are reported to be restricted to shrub dominated areas (e.g. Feldhammer 1979, Smith and Urness 1984). Preferred habitats are partially open areas with shelter provided by fallen trees, tree limbs or shrubs (Reams 1981). Removal of sagebrush canopy by fire appeared very detrimental as significantly fewer chipmunks occurred on the burn as compared with the control grids in both fall and spring (chi-square $p < 0.001$).

No conclusive trends were detected for other species when study area data sets were combined. Gano and Rickard (1982) and Feldhammer (1979) found P. parvus to be more abundant in grass stands than shrub stands. D. ordii are generally more abundant in grassland (Halford 1981, Groves and Keller 1983). Microtus have been reported to be more abundant in grassland (Feldhammer 1979), although I captured more animals in control than burn grids during both sampling periods. Microtus are cyclic, and numbers

in specific habitats may be dependant on the relationship between trapping period and population flucuations.

Overall, my data indicated that small mammal populations occurring on fire scars were similar in composition but had fewer animals than populations found in adjacent unburned habitats. The amount of movement between these areas is not known. Further study of small mammal populations related to fire ecology should include monitoring of movements between habitat types in relation to food resources and season.

SUMMARY

Results of this study indicate that wildfire has a long-term influence on the flora and fauna of the INEL. Impacts can be dramatic, although variations in plant community structure and animal density in a given area can influence relative use of a fire scar.

A catastrophic fire results in temporary elimination of all above-ground vegetation. Recovery is rapid as revegetation begins within 1 year of the fire, as also was noted by Halford (1981), but appears unpredictable (prior to burning) in direction or speed. In contrast to previously published literature, sagebrush did not readily reinvade fire scars, suggesting that current sagebrush distribution and density on the INEL may be an artifact of past zootic influences. Introduction of exotic annuals such as cheatgrass and tumble mustard has further disrupted the plant community.

Fire appears to improve spring and summer range for sage grouse, while it is detrimental to winter range. Results of sage grouse use were variable. It appeared that fire scars dominated by cheatgrass did not benefit grouse, whereas those covered with perennial grasses and rabbitbrush had less predictable influences. Openings

suitable for leks appear to be limited in many areas on the INEL, in which case burning may be a suitable means of creating openings.

Removal of sagebrush on the INEL generally appeared to benefit pronghorns. The creation of grassland provided increased levels of grasses and forbs in most areas, increasing spring and summer forage. However, because pronghorn feed extensively on shrubs during the winter, areas of sagebrush are necessary for winter survival.

Small mammal populations which occurred on fire scars were similar in composition but of lesser density than adjacent populations in sagebrush. Populations on these areas could not be distinguished from each other by species composition or diversity, although no evidence existed to indicate movement between burn and control areas. The fire scar may serve to increase density of small mammals in the general study area by providing additional food resources.

The INEL is best described as a sagebrush-dominated system, with limited areas which are grass-dominated. Fire is an inherent process in systems of this type, serving to create a mosaic of habitat types permitting a diversity of animal species to coexist. Overgrazing of the area in the past century, combined with fire suppression, has resulted in a mostly monotypic sagebrush stand.

Use of prescribed burning as a management tool requires that a manager have specific objectives and a thorough understanding of the interrelationships between flora and fauna. Habitat management for an individual species may result in the destruction of habitat for another.

Prescribed burning on the INEL could be used to generally improve habitat for most species of animals, though a more thorough understanding of seasonal animal distributions and habitat requirements is necessary. Critical to a management program involving prescribed burning is an ability to predict or manipulate post-fire recovery to minimize the occurrence of cheatgrass-dominated areas.

Future sage grouse research on the INEL should focus on this birds movements in and around fire scars to determine specific periods of use. Site-wide research should also identify critical winter ranges for sage grouse as well as intensively monitor strutting arenas for long-term population fluctuations.

Pronghorn use of the INEL does not appear to be uniform. Future research should be directed towards mapping seasonal distribution patterns and identifying limiting factors in areas of non-use.

Small mammal research on the INEL has been extensive and a tremendous data base for future research exists.

Continued research on the influence of habitat interspersion on animal home ranges and microhabitat use are necessary to more fully understand the use of fire scars by small mammals.

Distribution of elk and mule deer on the INEL is not well known. Data reported in this study consist of observations of animals which were incidental to other activities. Systematic monitoring in areas known to be inhabited by these species would provide more useful data on their distribution and abundance on the INEL.

Seasonal use and distribution of most mobile species on the INEL appears to be related to seasonal precipitation patterns. Snow depth and summer rains appear to follow storm tracks which may be related to the location of nearby mountain ranges. While weather monitoring stations currently exist on the area, a map of precipitation patterns and storm tracks would be of great benefit to investigations of animal movements, especially in situations where both migratory and non-migratory populations appear to co-exist.

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APPENDICES

APPENDIX 1
MAPS OF STUDY AREAS

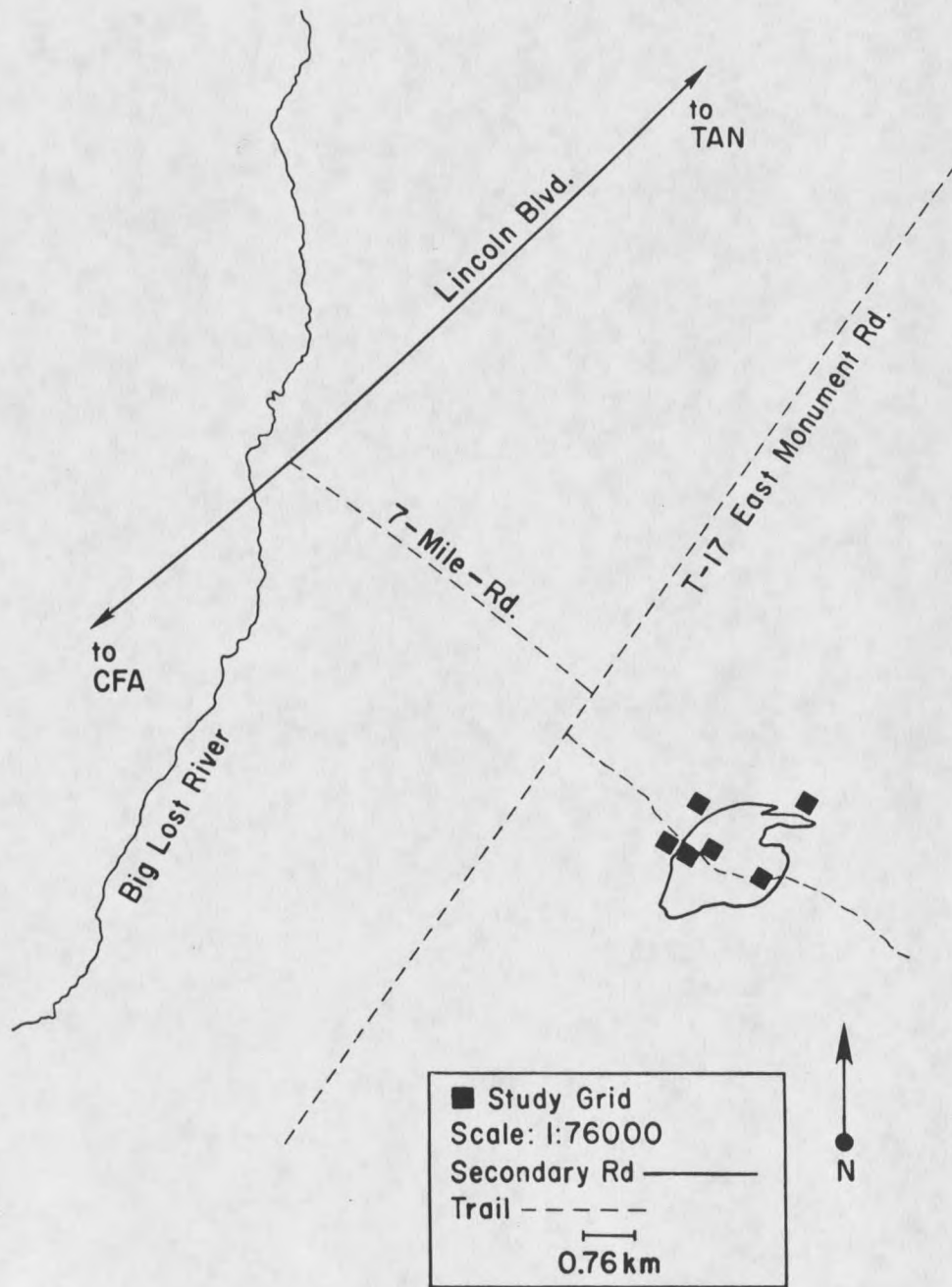


Figure 11. Map of Area #1, 7MIRD study area.

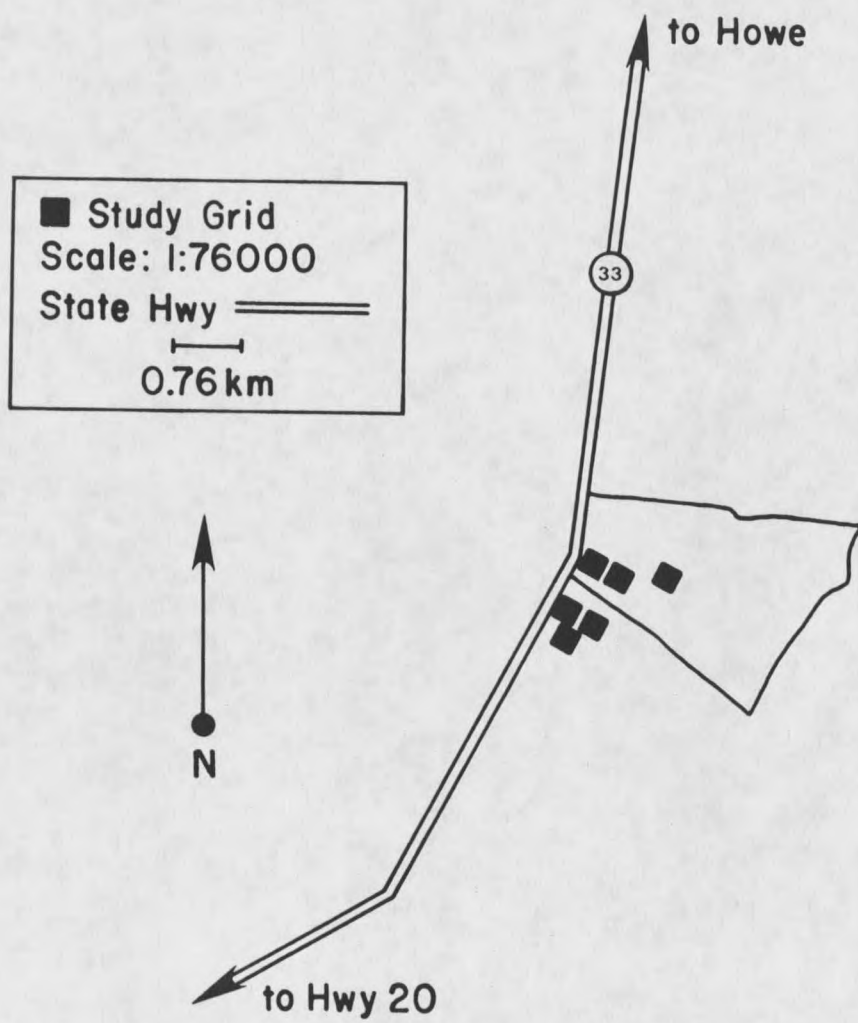


Figure 12. Map of Area #2, INEL study area.

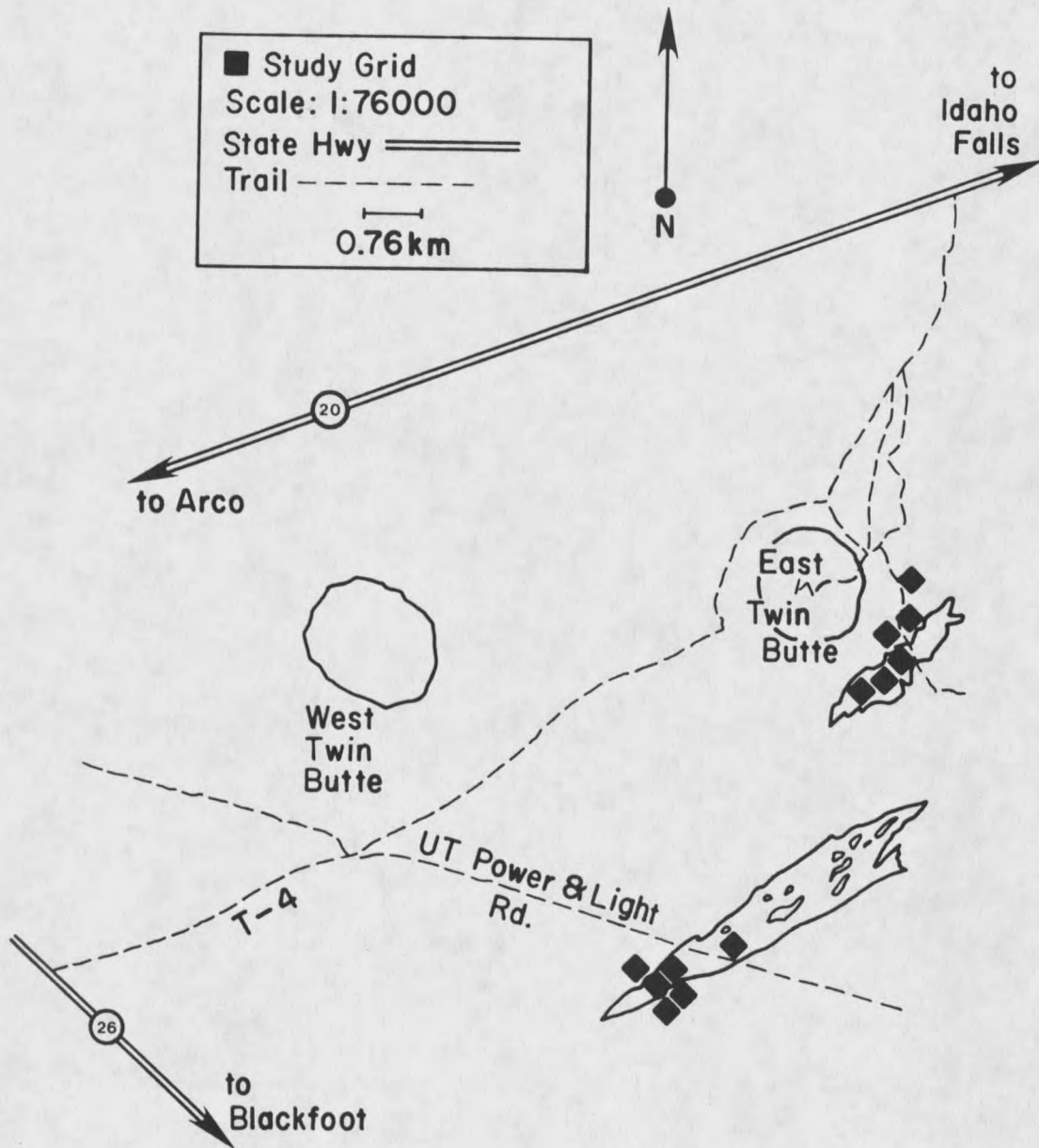


Figure 13. Map of Areas #3&4, Rabbit Ears and Ut P&L study areas.

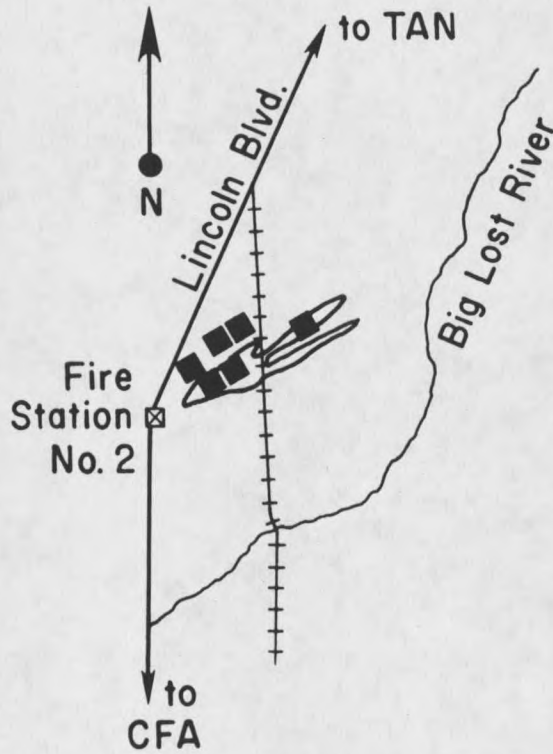
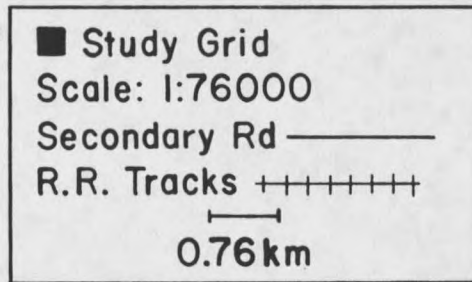


Figure 14. Map of Area #5, Fire Station study area.

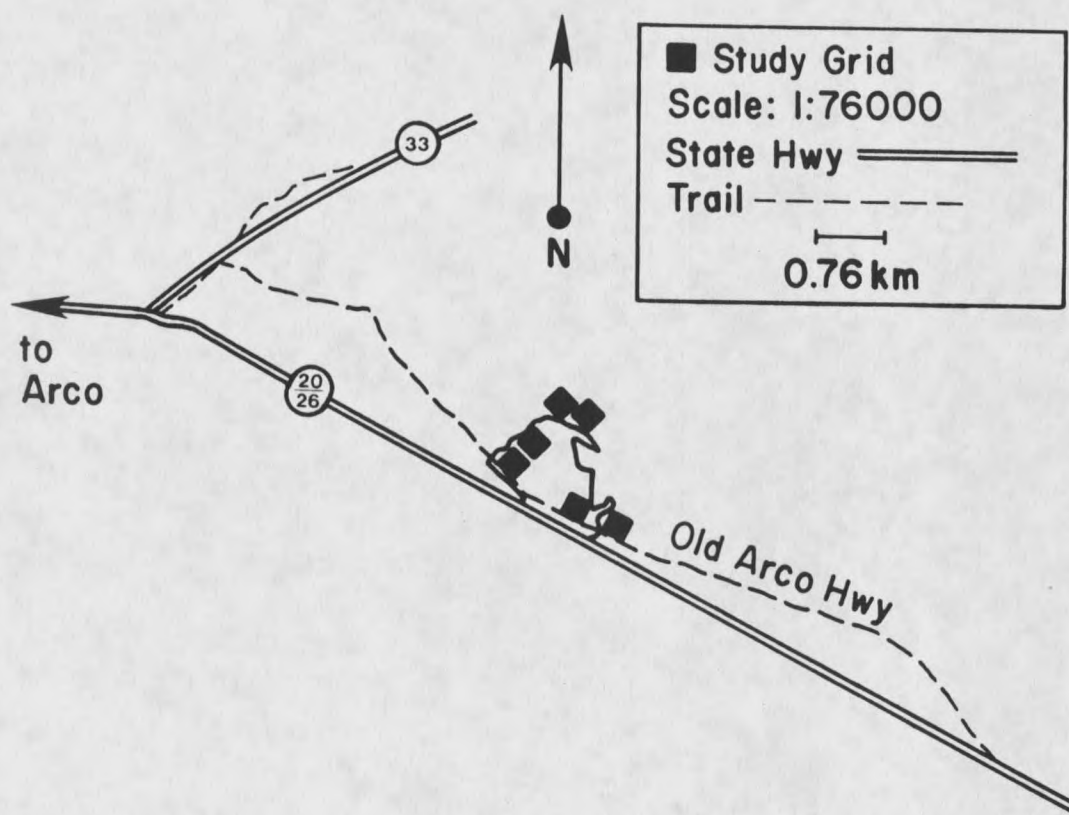


Figure 15. Map of Area #6, Arco Hwy study area.

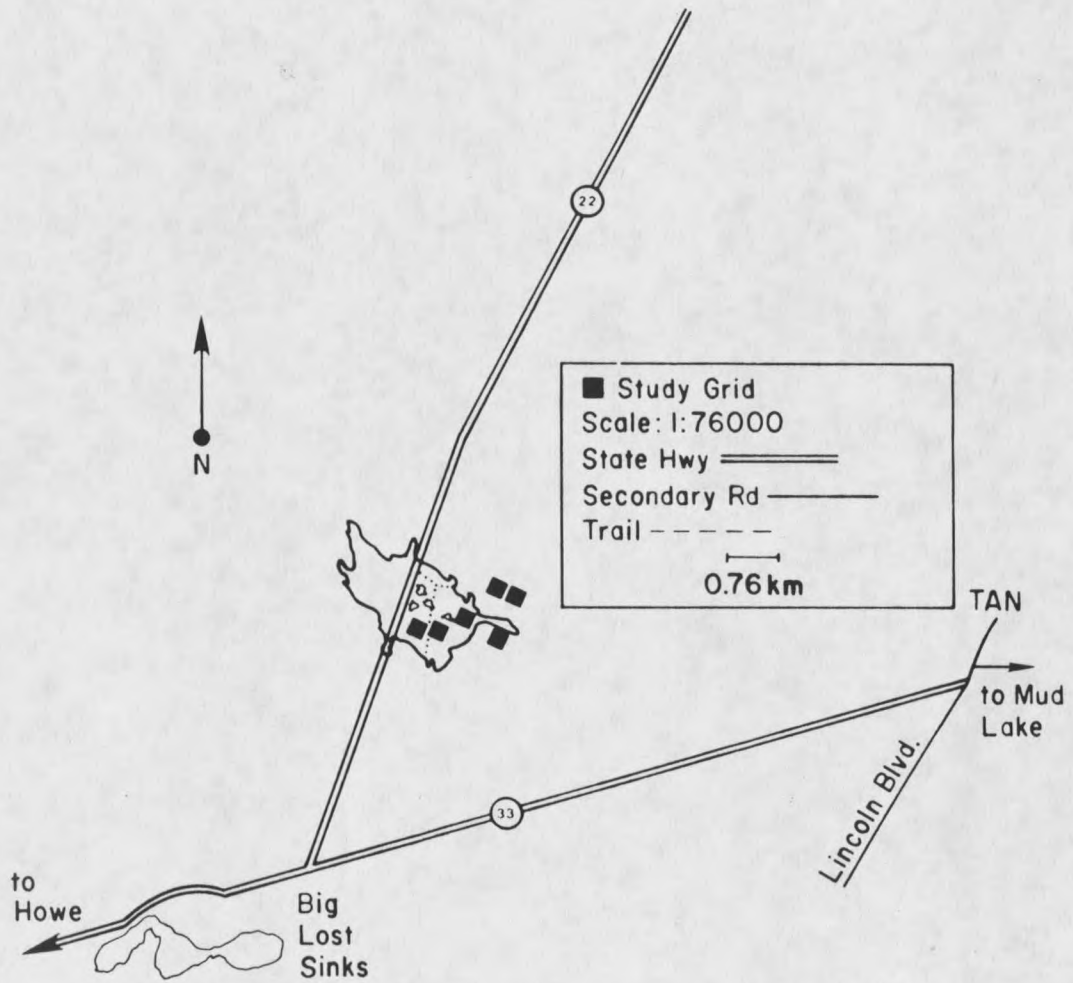


Figure 16. Map of Area #7, N Id 22 study area.

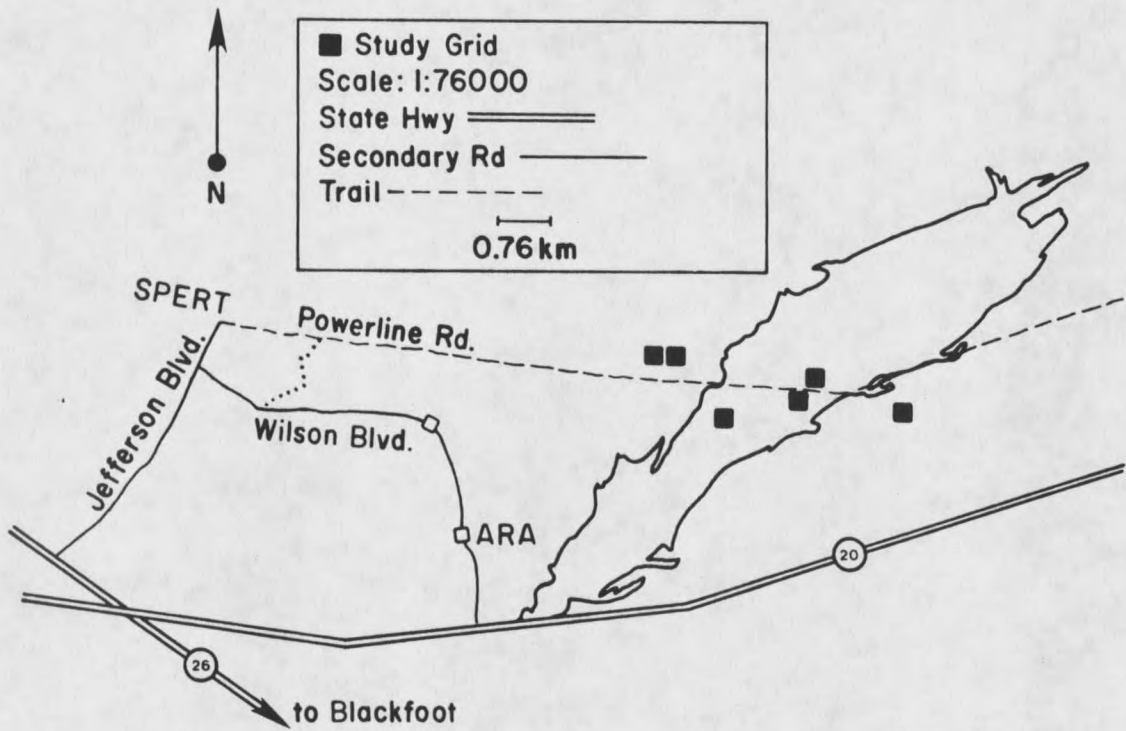


Figure 17. Map of Area #8, B&B Co study area.

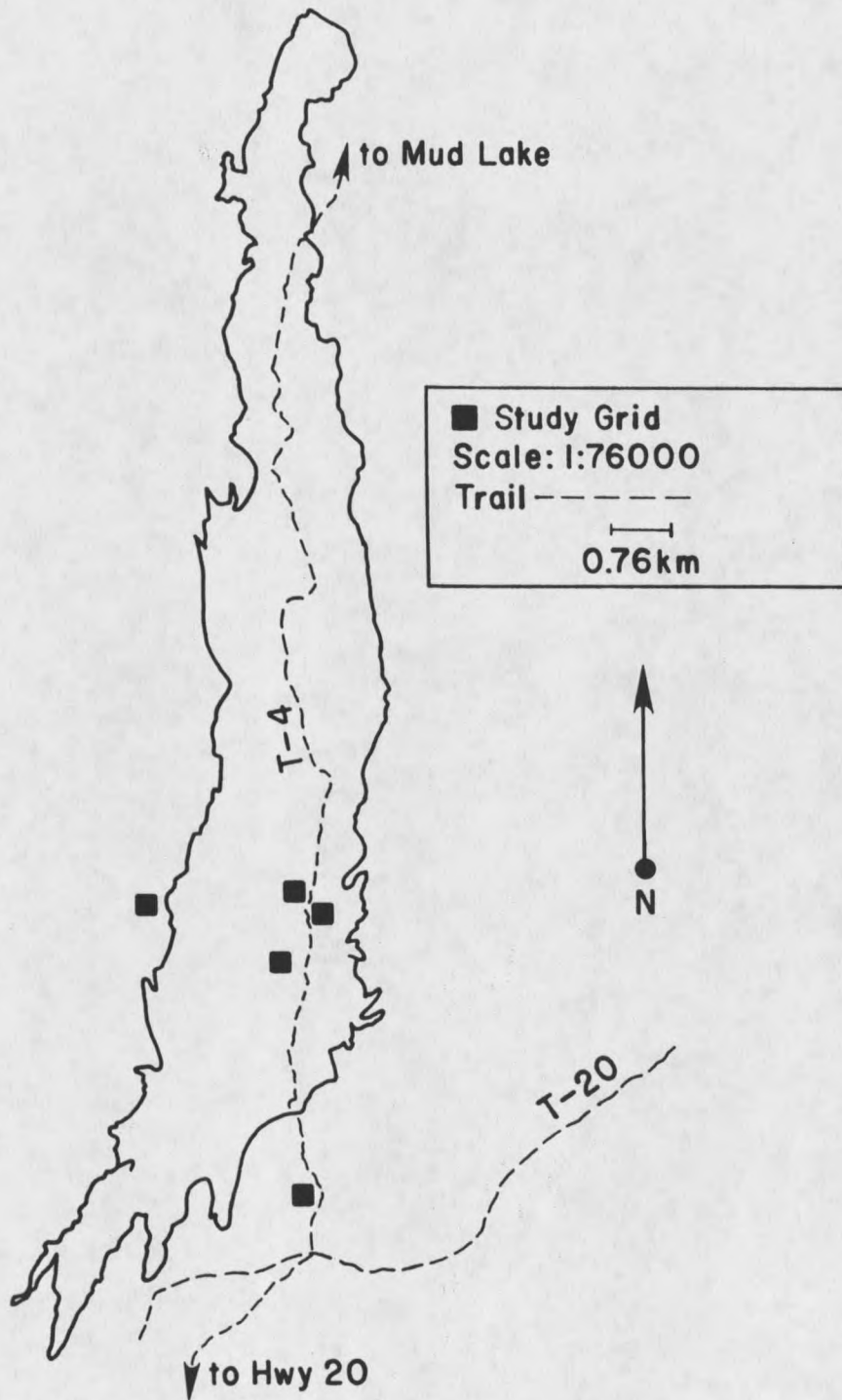


Figure 18. Map of Area #9, Trac Flat study area.

APPENDIX 2
SAGE GROUSE RAW DATA SETS

Table 11. Sage grouse pellet densities (pellets/ha) and % occurrence on the burn and control pellet grids, 7MIRD study area, 1985-1987.

Pellet Grid	Count 1 Sept. 1985	Count 2 Mar. 1986	Count 3 June 1986	Count 4 August 1986	Count 5 Mar. 1987	Count 6 June 1987
Burn Grids	1	**	2020	570	400	620
N=25	2	**	260	330	120	170
All Burn Plots	3	**	770	220	50	90
N=75		**	1017	373	190	293
% Occurrence		**	77%	35%	27%	39%
Control Grids	1	**	850	280	130	1070
N=25	2	**	300	100	80	990
All Control Plots	3	**	890	410	780	2030
N=75		**	680	263	330	1363
% Occurrence		**	53%	60%	33%	84%

Table 12. Sage grouse pellet densities (pellets/ha) and % occurrence on the burn and control grids, INEL study area, 1985-1987.

Pellet Grid	Count 1 Sept. 1985	Count 2 Mar. 1986	Count 3 June 1986	Count 4 August 1986	Count 5 Mar. 1987	Count 6 June 1987
Burn Grids	1	0	0	20	10	20
N=25	2	40	50	30	50	210
All Burn Plots	3	20	130	80	320	550
N=75		20	60	43	130	206
% Occurrence		4%	12%	11%	17%	20%
Control Grids	1	10	10	0	0	0
N=25	2	10	50	20	0	10
All Control Plots	3	0	30	10	0	20
N=75		6	30	10	0	10
% Occurrence		3%	8%	4%	0	4%

Table 13. Sage grouse pellet densities (pellets/ha) and % occurrence on the burn and control grids, Rabbit Ears study area, 1985-1987.

Pellet Grid	Count 1 Sept. 1985	Count 2 Mar. 1986	Count 3 June 1986	Count 4 August 1986	Count 5 Mar. 1987	Count 6 June 1987
Burn Grids	1	0	10	20	10	0
N=25	2	0	0	0	20	0
All Burn Plots	3	10	0	0	0	10
N=75		3	3	6	10	0
% Occurrence		1%	1%	1%	4%	0
Control Grids	1	0	10	20	10	20
N=25	2	0	0	0	10	0
All Control Plots	3	20	0	0	40	10
N=75		7	3	6	20	10
% Occurrence		3%	1%	1%	.8%	4%

Table 14. Sage grouse pellet densities (pellets/ha) and % occurrence on the burn and control grids, Utah P&L study area, 1985-1987.

Pellet Grid	Count 1 Sept. 1985	Count 2 Mar. 1986	Count 3 June 1986	Count 4 August 1986	Count 5 Mar. 1987	Count 6 June 1987
Burn Grids	1	0	0	20	10	60
N=25	2	0	10	0	10	100
All Burn Plots	3	0	200	90	150	170
N=75		0	70	37	57	110
% Occurrence		0	9%	7%	9%	23%
Control Grids	1	20	180	20	50	130
N=25	2	10	50	140	50	70
All Control Plots	3	70	50	40	60	50
N=75		33	94	67	54	83
% Occurrence		5%	12%	19%	13%	13%

Table 15. Sage grouse pellet densities (pellets/ha) and % occurrence on the burn and control grids, Fire Station study area, 1985-1987.

Pellet Grid		Count 1 Sept. 1985	Count 2 Mar. 1986	Count 3 June 1986	Count 4 August 1986	Count 5 Mar. 1987	Count 6 June 1987
Burn Grids N=25	1	0	0	10	30	70	0
	2	0	10	10	0	70	20
	3	0	0	0	10	100	20
All Burn Plots N=75		0	3	7	13	80	13
% Occurrence		0	1%	3%	4%	21%	5%
Control Grids N=25	1	0	40	20	0	160	70
	2	0	10	0	30	470	20
	3	0	10	20	0	140	80
All Control Plots N=75		0	20	13	10	257	57
% Occurrence		0	5%	5%	1%	35%	17%

Table 16. Sage grouse pellet densities (pellets/ha) and % occurrence on the burn and control grids, Arco Hwy study area, 1985-1987.

Pellet Grid		Count 1 Sept. 1985	Count 2 Mar. 1986	Count 3 June 1986	Count 4 August 1986	Count 5 Mar. 1987	Count 6 June 1987
Burn Grids N=25	1	230	150	80	70	180	20
	2	200	10	130	170	430	40
	3	120	60	80	230	900	50
All Burn Plots N=75		180	73	97	157	503	37
% Occurrence		36%	18%	27%	27%	59%	11%
Control Grids N=25	1	10	10	10	10	20	20
	2	0	10	10	10	30	80
	3	10	80	40	0	70	10
All Control Plots N=75		6	33	20	6	40	37
% Occurrence		3%	11%	8%	3%	9%	11%

Table 17. Sage grouse pellet densities (pellets/ha) and % occurrence on the burn and control grids, N. Idaho 22 study area, 1985-1987.

Pellet Grid		Count 1 Sept. 1985	Count 2 Mar. 1986	Count 3 June 1986	Count 4 August 1986	Count 5 Mar. 1987	Count 6 June 1987
Burn Grids	1	0	0	0	0	0	0
	2	0	0	0	0	0	0
N=25	3	0	0	0	0	0	0
All Burn Plots		0	0	0	0	0	0
N=75							
% Occurrence		0	0	0	0	0	0
Control Grids	1	20	30	10	0	10	0
	2	0	20	0	0	0	10
N=25	3	30	150	20	0	30	0
All Control Plots		17	60	10	0	13	3
N=75							
% Occurrence		7%	17%	3%	0	5%	1%

Table 18. Sage grouse pellet densities (pellets/ha) and % occurrence on the burn and control grids, Butte and Bingham Co. study area, 1985-1987.

Pellet Grid	Count 1 Sept. 1985	Count 2 Mar. 1986	Count 3 June 1986	Count 4 August 1986	Count 5 Mar. 1987	Count 6 June 1987
Burn Grids	1	0	10	10	0	10
N=25	2	0	0	0	10	10
All Burn Plots	3	20	140	90	180	210
N=75		10	47	33	63	77
% Occurrence		4%	11%	7%	12%	13%
Control Grids	1	0	40	10	0	30
N=25	2	50	20	0	20	40
All Control Plots	3	10	40	30	70	20
N=75		20	33	13	30	30
% Occurrence		7%	11%	4%	8%	7%

Table 19. Sage grouse pellet densities (pellets/ha) and % occurrence on burn and control grids, Tractor Flats study area, 1985-1987.

Pellet Grid		Count 1 Sept. 1985	Count 2 Mar. 1986	Count 3 June 1986	Count 4 August 1986	Count 5 Mar. 1987	Count 6 June 1987
Burn Grids	1	280	230	230	350	1260	130
	2	100	120	630	60	0	410
N=25	3	100	210	150	70	1240	180
All Burn Plots		160	187	337	160	833	240
N=75							
% Occurrence		36%	39%	53%	29%	64%	41%
Control Grids	1	130	250	300	260	2470	220
	2	100	490	170	1070	420	390
N=25	3	115	370	235	635	1445	305
All Control Plots							
N=75							
% Occurrence		32%	52%	46%	50%	72%	50%

APPENDIX 3
PRONGHORN RAW DATA SETS

Table 20. Pronghorn pellet densities (groups/ha) and % occurrence on burn and control grids, 7MIRD study area, 1985-1987.

Pellet Grid	Count 1 Sept. 1985	Count 2 Mar. 1986	Count 3 - June 1986	Count 4 August 1986	Count 5 Mar. 1987	Count 6 June 1987
Burn Grids	1	**	190	100	80	40
N=25	2	**	450	130	190	180
All Burn Plots	3	**	360	230	80	110
N=75		**	333	153	117	127
% Occurrence		**	63%	31%	32%	31%
Control Grids	1	**	70	40	60	40
N=25	2	**	80	90	60	30
All Control Plots	3	**	50	60	70	50
N=75		**	67	63	63	40
% Occurrence		**	21%	29%	19%	12%

Table 21. Pronghorn pellet densities (groups/ha) and % occurrence on burn and control grids, INEL study area, 1985-1987.

Pellet Grid		Count 1 Sept. 1985	Count 2 Mar. 1986	Count 3 June 1986	Count 4 August 1986	Count 5 Mar. 1987	Count 6 June 1987
Burn Grids N=25	1	90	40	60	50	360	50
	2	20	20	10	80	220	90
	3	70	50	50	50	20	60
All Burn Plots N=75		60	37	40	60	200	67
% Occurrence		23%	13%	11%	21%	45%	21%
Control Grids N=25	1	20	20	40	30	80	30
	2	70	40	50	80	60	20
	3	190	140	90	50	30	10
All Control Plots N=75		93	67	60	53	57	20
% Occurrence		25%	20%	17%	19%	20%	8%

Table 22. Pronghorn pellet group densities (groups/ha) and % occurrence on burn and control grids, Fire Station study area, 1985-1987.

Pellet Grid	Count 1 Sept. 1985	Count 2 Mar. 1986	Count 3 June 1986	Count 4 August 1986	Count 5 Mar. 1987	Count 6 June 1987
Burn Grids	1	0	0	30	50	130
N=25	2	0	50	10	10	220
All Burn Plots	3	0	80	50	60	170
N=75	-	0	43	30	40	173
% Occurrence		0	12%	9%	15%	48%
Control Grids	1	0	10	20	0	160
N=25	2	20	30	0	0	100
All Control Plots	3	0	20	30	30	40
N=75	-	7	20	17	10	100
% Occurrence		3%	7%	7%	3%	27%

Table 23. Pronghorn pellet group densities (groups/ha) and % occurrence on burn and control grids, Arco Hwy study area, 1985-1987.

Pellet Grid		Count 1 Sept. 1985	Count 2 Mar. 1986	Count 3 June 1986	Count 4 August 1986	Count 5 Mar. 1987	Count 6 June 1987
Burn Grids N=25	1	90	60	70	100	160	140
	2	120	40	90	0	290	20
	3	190	80	40	140	450	70
All Burn Plots N=75		133	60	67	80	300	77
% Occurrence		33%	19%	16%	20%	67%	20%
Control Grids N=25	1	20	30	0	50	200	80
	2	50	10	30	10	180	10
	3	150	20	10	0	90	60
All Control Plots N=75		73	20	13	20	157	50
% Occurrence		20%	8%	5%	8%	48%	16%

Table 24. Pronghorn pellet group densities (groups/ha) and % occurrence on burn and control grids, N. Idaho 22 study area, 1985-1987.

Pellet Grid		Count 1 Sept. 1985	Count 2 Mar. 1986	Count 3 June 1986	Count 4 August 1986	Count 5 Mar. 1987	Count 6 June 1987
Burn Grids N=25	1	210	470	180	100	940	80
	2	430	330	50	90	520	80
	3	270	60	100	90	470	50
All Burn Plots N=75		303	287	110	93	643	70
% Occurrence		71%	53%	31%	36%	85%	24%
Control Grids N=25	1	120	120	40	30	60	10
	2	120	70	20	70	80	0
	3	140	80	120	140	240	10
All Control Plots N=75		127	90	60	80	127	6
% Occurrence		40%	20%	17%	25%	32%	3%

Table 25. Pronghorn pellet group densities (groups/ha) and % occurrence on burn and control grids, Butte and Bingham Co. study area, 1985-1987.

Pellet Grid	Count 1 Sept. 1985	Count 2 -Mar. 1986	Count 3 June 1986	Count 4 August 1986	Count 5 Mar. 1987	Count 6 June 1987
Burn Grids	1	0	0	0	0	20
	2	0	0	0	0	30
N=25	3	30	10	0	0	10
All Burn Plots N=75		10	3	0	0	20
% Occurrence		1%	1%	0	0	8%
Control Grids	1	0	0	0	0	0
	2	0	0	0	20	10
N=25	3	0	0	0	40	0
All Control Plots N=75		0	0	0	20	3
% Occurrence		0	0	0	7%	1%

Table 26. Pronghorn pellet group densities (groups/ha) and % occurrence on burn and control grids, Trac Flat study area, 1985-1987.

Pellet Grid	Count 1 Sept. 1985	Count 2 Mar. 1986	Count 3 June 1986	Count 4 August 1986	Count 5 Mar. 1987	Count 6 June 1987
Burn Grids	1	30	20	10	10	100
N=25	2	80	30	70	10	470
All Burn Plots	3	20	10	10	10	10
N=75		43	20	30	10	193
% Occurrence		13%	8%	11%	4%	37%
						4%
Control Grids	1	30	0	10	0	0
N=25	2	20	0	70	10	30
All Control Plots	3	25	0	40	5	15
N=75						
% Occurrence		10%	0	14%	1%	3%
						0

Table 27. Pellet group densities (groups/ha) and % occurrence on burn and control grids, (unknown origin), Utah P&L study area, 1985-1987.

Pellet Grid		Count 1 Sept. 1985	Count 2 Mar. 1986	Count 3 June 1986	Count 4 August 1986	Count 5 Mar. 1987	Count 6 June 1987
Burn Grids	1	30	130	20	30	20	10
	2	60	50	80	70	80	0
N=25	3	40	60	50	30	0	0
All Burn Plots		43	80	50	43	33	3
N=75							
% Occurrence		13%	21%	15%	13%	8%	1%
Control Grids	1	0	0	0	0	10	0
	2	0	20	0	10	0	0
N=25	3	20	10	10	10	0	0
All Control Plots		6	10	3	7	3	0
N=75							
% Occurrence		3%	4%	1%	3%	1%	0

Table 28. Mule deer pellet densities (groups/ha) and % occurrence on burn and control grids, Rabbit Ears study area, 1985-1987.

Pellet Grid		Count 1 Sept. 1985	Count 2 Mar. 1986	Count 3 June 1986	Count 4 August 1986	Count 5 Mar. 1987	Count 6 June 1987
Burn Grids N=25	1	50	60	40	70	20	40
	2	110	40	100	60	40	40
	3	50	10	20	100	30	40
All Burn Plots N=75		70	37	53	77	30	40
% Occurrence		21%	12%	11%	21%	11%	13%
Control Grids N=25	1	60	0	10	0	0	40
	2	10	0	0	30	10	20
	3	20	0	20	20	10	0
All Control Plots N=75		30	0	10	17	7	20
% Occurrence		12%	0	4%	5%	3%	8%

APPENDIX 4
SMALL MAMMAL RAW DATA SETS

Table 29. Small mammal captures and community indices, 7MIRD study area, 1985-1986.

SPECIES	COMMON NAME	FALL, 1985		SPRING, 1986		TOTAL	
		BURN CONTROL		BURN CONTROL		BURN CONTROL	
<u>Peromyscus maniculatus</u>	Deer Mouse	20	70	35	63	55	133
<u>Tamias minimus</u>	Least Chipmunk	3	10	4	4	7	14
<u>Dipodomys ordi</u>	Ord's Kangaroo Rat	14	6	4	2	18	8
<u>Perognathus parvus</u>	Great Basin Pocket Mouse	5	2	3	3	8	5
<u>Spermophilus townsendii</u>	Townsend's Ground Squirrel	0	0	0	0	0	0
<u>Microtus montanus</u>	Montane Vole	1	0	1	7	2	7
<u>Thomomys talpoides</u>	Northern Pocket Gopher	0	0	0	0	0	0
<u>Onychomys leucogaster</u>	Northern Grasshopper Mouse	0	0	0	0	0	0
<u>Lemmyscus curtatus</u>	Sagebrush Vole	0	0	2	0	2	0
<u>Reithrodontomys megalotis</u>	Western Harvest Mouse	0	0	0	0	0	0
<u>Neotoma cinerea</u>	Bushy-tailed Woodrat	0	0	0	0	0	0
	Total Captures (N) ¹	43	88	49	79	92	167
	Number of Species (K)	5	4	6	5	6	5
	Trapnights (T)	716	720	720	720		
	Relative Density (D) ²	6.01	12.22	6.81	10.97		
	Diversity (H') ³	0.541	0.303	0.447	0.332	0.521	0.336
	Evenness (J') ⁴	0.77	0.50	0.57	0.47	0.67	0.48

1) Value does not include nontarget catches

2) $D_i = (N/T) * 100$

3) $H' = (N * \log N - \sum_{i=1}^k f_i \log f_i) / N$

4) $J' = H' / \log K$

Table 30. Small mammal captures and community indices, INEL study area, 1985-1986.

SPECIES	COMMON NAME	FALL, 1985		SPRING, 1986		TOTAL	
		BURN CONTROL	BURN CONTROL	BURN CONTROL	BURN CONTROL	BURN CONTROL	BURN CONTROL
<u>Peromyscus maniculatus</u>	Deer Mouse	36	78	21	29	57	107
<u>Tamias minimus</u>	Least Chipmunk	13	12	1	14	14	26
<u>Dipodomys ordi</u>	Ord's Kangaroo Rat	10	1	3	0	13	1
<u>Perognathus parvus</u>	Great Basin Pocket Mouse	10	15	15	10	25	25
<u>Spermophilus townsendii</u>	Townsend's Ground Squirrel	0	0	2	1	2	1
<u>Microtus montanus</u>	Montane Vole	0	0	0	1	0	1
<u>Thomomys talpoides</u>	Northern Pocket Gopher	0	0	0	0	0	0
<u>Onychomys leucogaster</u>	Northern Grasshopper Mouse	1	1	0	0	1	1
<u>Lemmys curtatus</u>	Sagebrush Vole	0	0	2	3	2	3
<u>Reithrodontomys megalotis</u>	Western Harvest Mouse	0	0	0	0	0	0
<u>Neotoma cinerea</u>	Bushy-tailed Woodrat	0	0	0	0	0	0
	Total Captures (N) ¹	70	107	44	58	114	165
	Number of Species (K)	5	5	6	6	7	8
	Trapnights (T)	717	713	717	730		
	Relative Density (D) ²	9.76	15.00	6.14	7.94		
	Diversity (H') ³	0.552	0.364	0.552	0.558	0.594	0.458
	Evenness (J') ⁴	0.79	0.52	0.71	0.72	0.70	0.51

1) Value does not include nontarget catches

2) $D_i = (N/T) * 100$

3) $H' = (N * \log N - (\sum_{i=1}^k f_i \log f_i)) / N$

4) $J' = H' / \log K$

Table 31. Small mammal captures and community indices, Rabbit Ears study area, 1985-1986.

SPECIES	COMMON NAME	FALL, 1985		SPRING, 1986		TOTAL	
		BURN CONTROL		BURN CONTROL		BURN CONTROL	
<u>Peromyscus maniculatus</u>	Deer Mouse	35	39	30	11	65	50
<u>Tamias minimus</u>	Least Chipmunk	0	11	0	11	0	22
<u>Dipodomys ordi</u>	Ord's Kangaroo Rat	0	0	0	0	0	0
<u>Perognathus parvus</u>	Great Basin Pocket Mouse	1	0	4	2	5	2
<u>Spermophilus townsendii</u>	Townsend's Ground Squirrel	0	0	4	2	4	2
<u>Microtus montanus</u>	Montane Vole	0	1	1	9	1	10
<u>Thomomys talpoides</u>	Northern Pocket Gopher	0	0	1	0	1	0
<u>Onychomys leucogaster</u>	Northern Grasshopper Mouse	0	0	0	0	0	0
<u>Lemmyscus curtatus</u>	Sagebrush Vole	0	0	0	0	0	0
<u>Reithrodontomys megalotis</u>	Western Harvest Mouse	0	0	0	0	0	0
<u>Neotoma cinerea</u>	Bushy-tailed Woodrat	0	1	0	0	0	1
	Total Captures (N) ¹	36	52	40	35	76	87
	Number of Species (K)	2	4	5	5	5	6
	Trapnights (T)	678	720	720	720		
	Relative Density (D) ²	5.31	7.22	5.56	4.86		
	Diversity (H') ³	0.055	0.302	0.374	0.610	0.253	0.495
	Evenness (J') ⁴	0.18	0.50	0.54	0.87	0.36	0.64

1) Value does not include nontarget catches

2) $D' = (N/T) * 100$

3) $H' = (N * \log N - \sum_{i=1}^k f_i \log f_i) / N$

4) $J' = H' / \log K$

Table 32. Small mammal captures and community indices, Utah P&L study area, 1985-1986.

SPECIES	COMMON NAME	FALL, 1985		SPRING, 1986		TOTAL	
		BURN CONTROL		BURN CONTROL		BURN CONTROL	
<u>Peromyscus maniculatus</u>	Deer Mouse	50	71	116	32	166	103
<u>Tamias minimus</u>	Least Chipmunk	0	16	0	5	0	21
<u>Dipodomys ordi</u>	Ord's Kangaroo Rat	1	0	0	0	1	0
<u>Perognathus parvus</u>	Great Basin Pocket Mouse	2	3	5	2	7	5
<u>Spermophilus townsendii</u>	Townsend's Ground Squirrel	0	0	0	1	0	1
<u>Microtus montanus</u>	Montane Vole	0	0	6	1	6	1
<u>Thomomys talpoides</u>	Northern Pocket Gopher	0	0	0	0	0	0
<u>Onychomys leucogaster</u>	Northern Grasshopper Mouse	0	0	0	0	0	0
<u>Lemmiscus curtatus</u>	Sagebrush Vole	0	0	0	0	0	0
<u>Reithrodontomys megalotis</u>	Western Harvest Mouse	0	0	0	0	0	0
<u>Neotoma cinerea</u>	Bushy-tailed Woodrat	0	0	0	0	0	0
	Total Captures (N) ¹	53	90	127	41	180	131
	Number of Species (K)	3	3	3	5	4	5
	Trapnights (T)	718	720	718	712		
	Relative Density (D) ²	7.38	12.50	17.69	5.75		
	Diversity (H') ³	0.110	0.264	0.154	0.338	0.149	0.296
	Evenness (J') ⁴	0.23	0.55	0.32	0.48	0.25	0.42

1) Value does not include nontarget catches

2) $D' = (N/T) * 100$

3) $H' = (N * \log N - \sum_{i=1}^k f_i \log f_i) / N$

4) $J' = H' / \log K$

Table 33. Small mammal captures and community indices, Fire Station study area, 1985-1986.

SPECIES	COMMON NAME	FALL, 1985		SPRING, 1986		TOTAL	
		BURN CONTROL		BURN CONTROL		BURN CONTROL	
<u>Peromyscus maniculatus</u>	Deer Mouse	23	81	1	11	24	92
<u>Tamias minimus</u>	Least Chipmunk	3	27	0	9	3	36
<u>Dipodomys ordi</u>	Ord's Kangaroo Rat	0	0	0	0	0	0
<u>Perognathus parvus</u>	Great Basin Pocket Mouse	3	4	1	2	4	6
<u>Spermophilus townsendii</u>	Townsend's Ground Squirrel	0	0	0	1	0	1
<u>Microtus montanus</u>	Montane Vole	1	4	1	3	2	7
<u>Thomomys talpoides</u>	Northern Pocket Gopher	0	0	0	0	0	0
<u>Onychomys leucogaster</u>	Northern Grasshopper Mouse	0	0	0	0	0	0
<u>Lemmyscus curtatus</u>	Sagebrush Vole	0	0	0	4	0	4
<u>Reithrodontomys megalotis</u>	Western Harvest Mouse	0	0	0	0	0	0
<u>Neotoma cinerea</u>	Bushy-tailed Woodrat	0	0	0	0	0	0
	Total Captures (N) ¹	30	116	3	30	33	146
	Number of Species (K)	4	4	3	6	4	6
	Trapnights (T)	679	720	720	720		
	Relative Density (D) ²	4.42	16.11	0.42	4.17		
	Diversity (H') ³	0.338	0.357	0.477	0.641	0.380	0.454
	Evenness (J') ⁴	0.56	0.59	1.00	0.83	0.63	0.58

1) Value does not include nontarget catches

2) $D_i = (N/T) * 100$

3) $H' = (N * \log N - \sum_{i=1}^k f_i \log f_i) / N$

4) $J' = H' / \log K$

Table 34. Small mammal captures and community indices, Arco Hwy study area, 1985-1986.

SPECIES	COMMON NAME	FALL, 1985		SPRING, 1986		TOTAL	
		BURN CONTROL	BURN CONTROL	BURN CONTROL	BURN CONTROL	BURN CONTROL	BURN CONTROL
<u>Peromyscus maniculatus</u>	Deer Mouse	30	41	8	16	38	57
<u>Tamias minimus</u>	Least Chipmunk	8	3	0	12	8	15
<u>Dipodomys ordi</u>	Ord's Kangaroo Rat	1	0	11	0	12	0
<u>Perognathus parvus</u>	Great Basin Pocket Mouse	6	3	9	8	15	11
<u>Spermophilus townsendii</u>	Townsend's Ground Squirrel	0	0	0	1	0	1
<u>Microtus montanus</u>	Montane Vole	0	0	1	0	1	0
<u>Thomomys talpoides</u>	Northern Pocket Gopher	0	0	0	0	0	0
<u>Onychomys leucogaster</u>	Northern Grasshopper Mouse	0	4	0	0	0	4
<u>Lemmys curtatus</u>	Sagebrush Vole	2	1	1	1	3	2
<u>Reithrodontomys megalotis</u>	Western Harvest Mouse	1	0	0	0	1	0
<u>Neotoma cinerea</u>	Bushy-tailed Woodrat	0	0	0	0	0	0
	Total Captures (N) ¹	48	52	30	38	78	90
	Number of Species (K)	6	5	5	5	7	6
	Trapnights (T)	719	720	720	720		
	Relative Density (D) ²	6.68	7.22	4.17	5.28		
	Diversity (H') ³	0.498	0.343	0.568	0.542	0.619	0.485
	Evenness (J') ⁴	0.64	0.49	0.81	0.78	0.73	0.62

1) Value does not include nontarget catches

2) $D_i = (N/T) * 100$

3) $H' = (N * \log N - \sum_{i=1}^k f_i \log f_i) / N$

4) $J' = H' / \log K$

Table 35. Small mammal captures and community indices, N. Idaho 22 study area, 1985-1986.

SPECIES	COMMON NAME	FALL, 1985		SPRING, 1986		TOTAL	
		BURN CONTROL		BURN CONTROL		BURN CONTROL	
<u>Peromyscus maniculatus</u>	Deer Mouse	54	61	21	47	75	108
<u>Tamias minimus</u>	Least Chipmunk	0	11	0	6	0	17
<u>Dipodomys ordi</u>	Ord's Kangaroo Rat	12	15	0	10	12	25
<u>Perognathus parvus</u>	Great Basin Pocket Mouse	6	7	13	7	19	14
<u>Spermophilus townsendii</u>	Townsend's Ground Squirrel	0	0	0	0	0	0
<u>Microtus montanus</u>	Montane Vole	0	0	2	0	2	0
<u>Thomomys talpoides</u>	Northern Pocket Gopher	0	0	0	0	0	0
<u>Onychomys leucogaster</u>	Northern Grasshopper Mouse	0	2	0	0	0	2
<u>Lemmyscus curtatus</u>	Sagebrush Vole	0	0	0	0	0	0
<u>Reithrodontomys megalotis</u>	Western Harvest Mouse	0	0	0	0	0	0
<u>Neotoma cinerea</u>	Bushy-tailed Woodrat	0	0	0	0	0	0
	Total Captures (N) ¹	72	96	36	70	108	166
	Number of Species (K)	3	3	3	4	4	5
	Trapnights (T)	707	709	720	720		
	Relative Density (D) ²	10.18	13.54	5.00	9.72		
	Diversity (H') ³	0.313	0.477	0.366	0.428	0.381	0.460
	Evenness (J') ⁴	0.66	0.68	0.77	0.71	0.63	0.66

1) Value does not include nontarget catches

2) $D_i = (N/T) * 100$

3) $H' = (N * \log N - \sum_{i=1}^k f_i \log f_i) / N$

4) $J' = H' / \log K$

Table 36. Small mammal captures and community indices, Butte and Bingham Co. study area, 1985-1986.

SPECIES	COMMON NAME	FALL, 1985		SPRING, 1986		TOTAL	
		BURN CONTROL		BURN CONTROL		BURN CONTROL	
<u>Peromyscus maniculatus</u>	Deer Mouse	44	22	4	15	48	37
<u>Tamias minimus</u>	Least Chipmunk	11	11	0	7	11	18
<u>Dipodomys ordi</u>	Ord's Kangaroo Rat	1	0	0	1	1	1
<u>Perognathus parvus</u>	Great Basin Pocket Mouse	3	2	6	10	9	12
<u>Spermophilus townsendii</u>	Townsend's Ground Squirrel	0	0	1	0	1	0
<u>Microtus montanus</u>	Montane Vole	0	0	1	0	1	0
<u>Thomomys talpoides</u>	Northern Pocket Gopher	0	0	0	0	0	0
<u>Onychomys leucogaster</u>	Northern Grasshopper Mouse	0	0	0	0	0	0
<u>Lemmyscus curtatus</u>	Sagebrush Vole	0	0	0	0	0	0
<u>Reithrodontomys megalotis</u>	Western Harvest Mouse	0	0	0	0	0	0
<u>Neotoma cinerea</u>	Bushy-tailed Woodrat	0	0	0	0	0	0
	Total Captures (N) ¹	59	35	12	33	71	68
	Number of Species (K)	4	3	4	4	6	4
	Trapnights (T)	716	720	720	712		
	Relative Density (D) ²	8.24	4.86	1.67	4.63		
	Diversity (H') ³	0.327	0.356	0.489	0.502	0.432	0.457
	Evenness (J') ⁴	0.54	0.74	0.81	0.83	0.56	0.76

1) Value does not include nontarget catches

2) $D_i = (N/T) * 100$

3) $H' = (N * \log N - \sum_{i=1}^k f_i \log f_i) / N$

4) $J' = H' / \log K$

Table 37. Small mammal captures and community indices, Tractor Flat study area, 1985-1986.

SPECIES	COMMON NAME	FALL, 1985		SPRING, 1986		TOTAL	
		BURN CONTROL	BURN CONTROL	BURN CONTROL	BURN CONTROL	BURN CONTROL	BURN CONTROL
<u>Peromyscus maniculatus</u>	Deer Mouse	14	43	18	24	32	67
<u>Tamias minimus</u>	Least Chipmunk	9	16	6	11	15	27
<u>Dipodomys ordi</u>	Ord's Kangaroo Rat	7	7	5	14	12	21
<u>Perognathus parvus</u>	Great Basin Pocket Mouse	2	7	7	7	9	14
<u>Spermophilus townsendii</u>	Townsend's Ground Squirrel	0	0	4	1	4	1
<u>Microtus montanus</u>	Montane Vole	0	3	1	4	1	7
<u>Thomomys talpoides</u>	Northern Pocket Gopher	0	0	0	0	0	0
<u>Onychomys leucogaster</u>	Northern Grasshopper Mouse	1	1	0	0	1	1
<u>Lemmyscus curtatus</u>	Sagebrush Vole	0	0	1	5	1	5
<u>Reithrodontomys megalotis</u>	Western Harvest Mouse	0	0	0	0	0	0
<u>Neotoma cinerea</u>	Bushy-tailed Woodrat	0	0	0	0	0	0
	Total Captures (N) ¹	33	77	42	66	75	143
	Number of Species (K)	5	6	7	7	8	8
	Trapnights (T)	720	719	720	720	8	8
	Relative Density (D) ²	4.58	10.70	5.83	9.17		
	Diversity (H') ³	0.575	0.552	0.693	0.722	0.678	0.657
	Evenness (J') ⁴	0.82	0.71	0.82	0.85	0.75	0.73

1) Value does not include nontarget catches

2) $D_i = (N/T) * 100$

3) $H' = (N * \log N - \sum_{i=1}^k f_i \log f_i) / N$

4) $J' = H' / \log K$

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