AN ECOLOGICAL STUDY OF SAGE GROUSE
IN SOUTHEASTERN IDAHO

By

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To the Faculty of Washington State University:

The members of the Committee appointed to examine the dissertation of JOHN WILLIAM CONNELLY, JR. find it satisfactory and recommend that it be accepted.

Chairman

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ABSTRACT

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This study was conducted between June 1977 and April 1981 on the United States Department of Energy's Idaho National Engineering Laboratory (INEL) site in southeastern Idaho. The INEL site is a 231,600 ha area dominated by sagebrush (Artemisia spp.) and various bunchgrasses.

The first section of this dissertation describes the movements and radionuclide concentrations of sage grouse (Centrocercus urophasianus) summering near 3 INEL facilities; the Test Reactor Area/Idaho Chemical Processing Plant (TRA/ICPP) complex, the Radioactive Waste Management Complex (RWMC), and the Central Facilities Area (CFA). The potential dose commitment to a person consuming a grouse that summered near these facilities is also discussed.

Sage grouse used lawns surrounding INEL facilities for feeding and loafing throughout the summer. These birds were captured and marked to provide information on home range and movements. From July through September, 95% of all radio-locations were within 2 km of INEL facilities. During October and November, 82% of all radio-locations were greater than 2 km from these areas. Mean summer home range was 406 ha for adult female sage grouse and 94 ha for juveniles.

Radionuclide concentrations in TRA/ICPP grouse were significantly higher than those of RWMC or control birds. Sage grouse acted as transport mechanisms and removed radionuclides from waste storage systems, but the quantities removed per individual were small and apparently constituted no hazard to the bird or to a person consuming the bird. The highest estimated potential dose commitment to a person consuming a grouse from TRA/ICPP, RWMC, or control areas was 2.37 mrem, and would have resulted from eating an adult male sage grouse that had summered near TRA/ICPP.

The second section describes sage grouse seasonal movements, flocking characteristics, and habitat use. Sage grouse moved from 2 to 83 km during seasonal migration. Fall movements from INEL facilities to winter range were slow and meandering. Adult grouse moved northwest to winter range and juveniles tended to move southwest. Mean fall home range for 5 radio-marked grouse was 2,246 ha. Spring movements of females from leks to summer range were also slow and meandering but male movements appeared rapid and direct. Mean spring home range for 7 radio-marked females was 882 ha.

Sage grouse remained in segregated flocks during early summer, but the number of mixed sex flocks increased in late summer. Mixed sex flocks were significantly larger than male, female, or female/juvenile flocks. Sage grouse occurred in segregated flocks throughout the winter. Mean flock size was significantly different among all flock types. Further, male and mixed sex flocks were significantly larger in low sagebrush (A. arbuscula) than in big sagebrush (A. tridentata) habitats. Sage grouse responded to increasing snow depths by moving into denser and taller sagebrush stands. Mean flock size remained relatively constant as winter weather became more severe.

Agricultural areas were an important component of sage grouse summer range on and near the INEL site. This habitat was preferred by all sage grouse sex and age classes. During winter, differences were detected in habitat use by males, females, and grouse occurring in mixed sex flocks. Sage grouse winter range was generally characterized by sagebrush stands with 11 to 30% canopy coverage and a mean height of less than 40 cm.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF TABLES

LIST OF ILLUSTRATIONS

PART I

MOVEMENTS AND RADIONUCLIDE CONCENTRATIONS OF SAGE GROUSE IN SOUTHEASTERN IDAHO

PART I

MOVEMENTS AND RADIONUCLIDE CONCENTRATIONS OF SAGE GROUSE IN SOUTHEASTERN IDAHO

Radionuclides are similar to other environmental pollutants because they can enter biological cycles and may pose a danger to various components of these cycles, including wildlife and man (Woodwell 1967). Therefore, the fate of radionuclides released to the environment and the effect of these nuclides on ecosystem components must be documented. The transport of radionuclides from various disposal sites by wildlife has been investigated (Brisbin et al. 1974, Straney et al. 1975, Cadwell et al. 1979, Springer 1979, Halford et al. 1981); however, most of this research has dealt with waterfowl or mammals. To our knowledge there have been no situations documented in which gallinaceous birds aggregate near nuclear facilities during the summer and then move to areas open to hunting.

Sage grouse (Centrocercus urophasianus) summer near nuclear facilities on the Idaho National Engineering Laboratory (INEL) site in southeastern Idaho (Connelly and Ball 1978). They are attracted to these areas by an abundance of forbs and free water during the summer. Some of these birds then move off-site just prior to or during the hunting season. The purposes of this paper are to: (1) document the number of sage grouse and their residence time at INEL facilities and define their movement patterns away from these facilities; (2) document the kinds and amounts of radionuclides accumulated by grouse summering near some of these facilities; and (3) calculate the potential dose commitment to a person consuming a sage grouse shortly after it left the vicinity of an INEL nuclear facility.

This study was supported by the Office of Health and Environmental Research, U. S. Department of Energy. Technical assistance was supplied by the Idaho Department of Fish and Game. I thank all of the individuals from the above agencies who contributed to this study. I am especially grateful to I. J. Ball and O. D. Markham for administrative guidance, advice, and field assistance. I. J. Ball, R. J. Jonas, O. D. Markham, J. M. Peek, and V. Schultz reviewed earlier drafts of this manuscript.

STUDY AREA

The INEL site is a 231,600 ha area administered by the U. S. Department of Energy. The site is located in a semi-arid, cold desert on the upper Snake River Plain. The area lies at the foothills of the Lost River, Lemhi, and Bitterroot mountain ranges. The climate is characterized by hot summers and cold winters with annual precipitation averaging 20.6 cm. Big sagebrush (Artemisia tridentata) and various bunchgrasses are common in most habitats (Harniss and West 1973). McBride et al. (1978) described 20 cover types occurring on the INEL site.

Sage grouse were studied near 3 INEL facilities and in 2 off-site areas (Fig. 1.1). The Central Facilities Area (CFA) and the Test Reactor Area/Idaho Chemical Processing Plant complex (TRA/ICPP) are located in the south central portion of the site along the Big Lost River. Both areas contain irrigated lawns, abundant forbs, and sources of free water. Additionally, the Test Reactor Area (TRA) contains a leaching pond complex that has been used for the disposal of low level liquid radioactive waste since 1952 (Halford and Markham 1978). Approximately 48,000 curies of beta-gamma activity were released from the TRA facility into the ponds from 1952 to 1977 (White 1978) and 1,290, 1,250 and 1,494 curies were

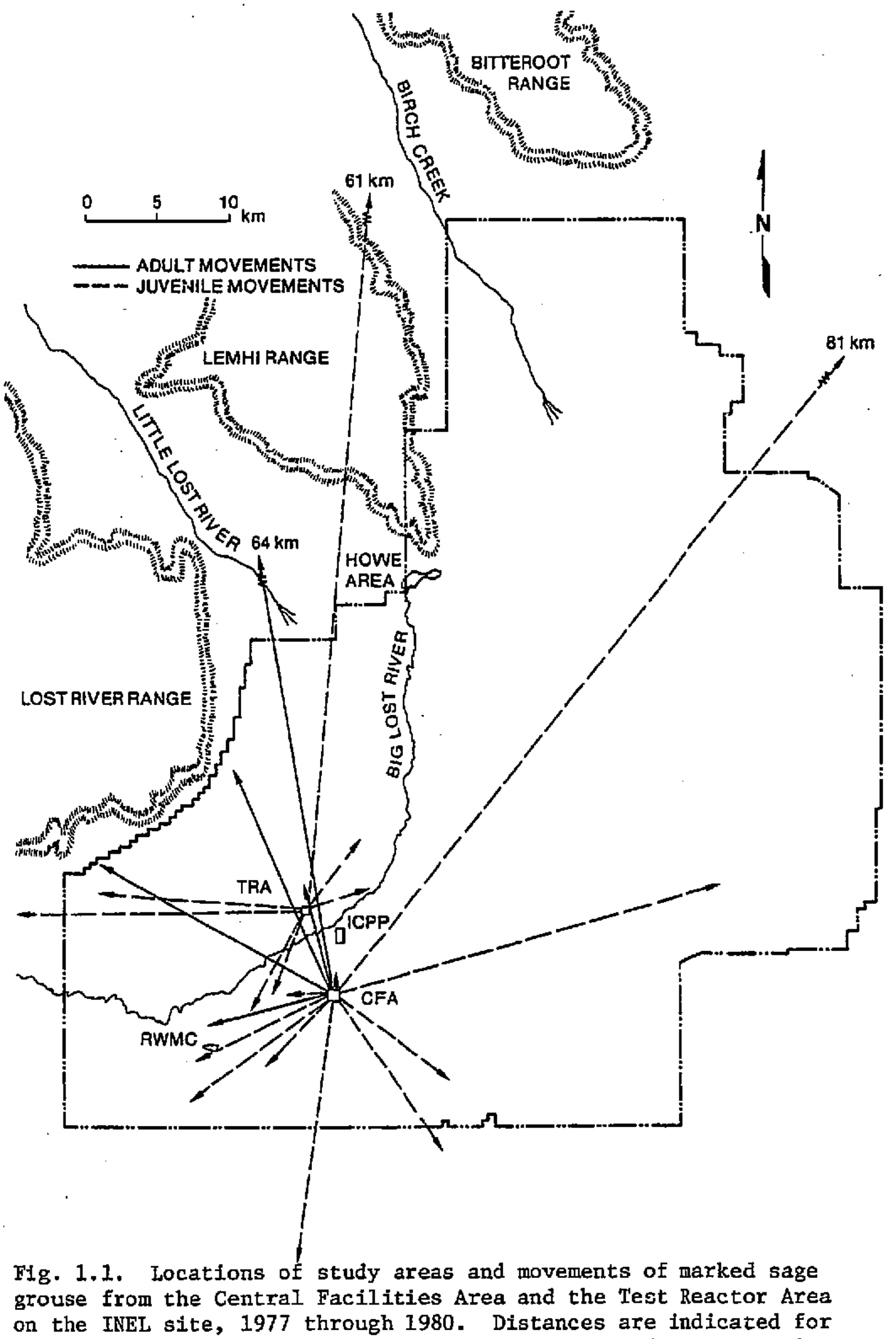

Fig. 1.1. Locations of study areas and movements of marked sage grouse from the Central Facilities Area and the Test Reactor Area on the INEL site, 1977 through 1980. Distances are indicated for movements greater than 30 km; other movements are drawn to scale.

released in 1977, 1978, and 1979, respectively (Batchelder 1980). The majority of the radionuclides released into the ponds had physical half-lives of less than 1 year (Halford and Markham 1978). The Idaho Chemical Processing Plant (ICPP) is located 4.7 km southeast of TRA. This facility released a total of 1.1 curies of particulate activity to the atmosphere from 1977 through 1979 (U. S. Department of Energy 1978, 1979, 1980). Previous releases have resulted in surface soil contamination in the ICPP vicinity (Bowman et al. 1976). TRA and ICPP were grouped because marked birds moved back and forth between these facilities. CFA contains various support services for the INEL and is not a nuclear facility. TRA is an advanced nuclear materials testing complex and the ICPP recovers uranium from spent nuclear fuels and processes radioactive liquid waste into noncorrosive solid form.

The Radioactive Waste Management Complex (RWMC) is located in the southern portion of the INEL site. The RWMC has been used since 1952 to store transuranic contaminated waste and to dispose of waste contaminated with activation and fission radionuclides. That portion of the RWMC utilized for the burial of radioactive waste occupies a 36 ha area within the complex. Between 1952 and 1979, 8.14×10^6 curies of radioactive waste were disposed of at the RWMC. This facility has many disturbed sites containing a variety of forbs, and free water is often available.

Two areas were used as control sites. The Howe area consists of big sagebrush habitat bordering alfalfa and wheat fields at the mouth of the Little Lost River (Fig. 1.1). The lower Birch Creek area lies approximately 26 km northeast of the Howe area and consists of an interspersion of big sagebrush and low sagebrush (*A. arbuscula*) habitats. Sage grouse used the Howe area throughout the summer and early fall;

however, they were only found in the lower Birch Creek area during early summer. Both areas provide sources of free water throughout the summer.

METHODS AND MATERIALS

The study was conducted from June through November from 1977 through 1980. Sage grouse were censused at CFA, TRA, and Howe 2 or 3 times per month from June through October. Because sage grouse were easily seen on the CFA and TRA lawns, we were able to obtain virtually a complete count during each census. A 14.5 km census route was established in the Howe area and all grouse observed along this route were recorded. The RWMC and lower Birch Creek were not censused because of access and time limitations. Sage grouse were captured with drive traps (Gill 1965) and mist nets at CFA and TRA. All captured birds were banded. Females were fitted with a poncho-mounted transmitter (Amstrup 1980) or a back-pack transmitter, or were color-marked with numbered ponchos (Pyrah 1970). Males were fitted with a back-pack transmitter or color-marked with numbered patagial tags. I attempted to obtain locations on radio-marked birds at least once a week during the summer and once a month during the fall. Summer home range was estimated by measuring the area within the polygon formed by connecting the outermost locations of each radio-marked grouse (Mohr 1947).

During the 4 years of the study, 43 sage grouse were collected near nuclear facilities and 21 birds were collected in the control areas. A 70 g muscle sample and the gastrointestinal (G.I.) tract from each grouse were analyzed for gamma emitting radionuclides using a 65 cm^3 germanium lithium crystal coupled to a computer controlled multi-channel analyzer. All tissues were gamma-scanned as fresh or frozen material with uniform dimensions and volumes. Results are reported in picocuries per gram (pCi/g). A picocurie is one trillionth of a curie, which is a unit quantity of any nuclide in which 3.7×10^{10} disintegrations occur per second. The minimum detection limit for all nuclides detected ranged from 0.14 to 2.20 pCi/g for muscle samples and from 0.04 to 1.78 pCi/g for G.I. tract samples. Some of the radioactivity decreased between the time of collection and analysis because of the short half-lives of some of the radionuclides; therefore, sample results were corrected for radioactive decay. All data were coded and log-transformed prior to statistical analysis (Steele and Torrie 1960). Analysis of variance and Student's t test were used to make statistical comparisons. The least significant difference (lsd) test for unequal sample sizes (Steele and Torrie 1960:114) was used to compare means when analysis of variance indicated a significant difference between groups.

The average and maximum potential whole-body dose commitments to a person consuming sage grouse muscle were calculated using a formula from Hoanes and Soldat (1977) where

$$DC = \sum_{i=1}^{n} [DCF_i \cdot M \cdot C_i]$$

and DC equals the whole-body dose commitment, DCF_i is a dose commitment factor for the i^{th} radionuclide, M is the muscle mass consumed, and C_i is the concentration of the i^{th} radionuclide. The average concentration of each radionuclide detected in at least 10% of the muscle samples was used in calculating the average dose commitment and the maximum concentration for each radionuclide detected was used in calculating the maximum dose commitment. The calculations were based on the consumption of the entire muscle mass of one sage grouse on the same day the bird left the nuclear facility. Radioactive decay, biological elimination, and volatilization of radionuclides during cooking were not considered in dose calculations. While this method was originally intended for chronic intake, it can be used for acute intake with an error of 5% or less (Hoanes and Soldat 1977).

RESULTS

Residence Time and Movements

Sage grouse arrived on the study areas between mid-June and mid-July and remained until early September to mid-November (Table 1.1). Grouse left CFA and TRA later in relatively dry summers; however, spring precipitation did not seem to affect arrival dates. Sage grouse using the Howe area arrived late in a dry spring and remained longer during wet summers. Grouse spent a minimum of 43 days at the INEL facilities, a maximum of 139 days, and an average of 95 days over the 4 years of the study. Sage grouse used the Howe area for an average of 102 days from 1978 through 1980. Census data from CFA, TRA, and Howe reflect a generally stable to increasing population from 1977 to 1979 with a slight decrease in 1980; however, this may be biased during drier years as more grouse concentrate near these relatively moist sites (Table 1.2). These data generally agree with lek census data for the same areas which also suggested a stable to increasing sage grouse population (Connelly, unpubl. data). The majority of sage grouse using the study areas were females and juveniles. Adult males accounted for 25% or less of the total number of birds utilizing CFA, TRA, and Howe during this study.

A total of 245 sage grouse were marked at CFA and TRA during the study. From this sample, data were obtained on the movements of 29 grouse, 14 of which were radio-marked. Of these 29 birds, I documented the movements of 22 grouse away from their summering areas. Radios ceased

Table 1.1. Total spring (May-June) and summer (July-September) precipitation at the Central Facilities Area (CFA), and residence time of sage grouse summering near CFA, the Test Reactor Area (TRA), and Howe from 1977 through 1980. Dates indicate the first and last times grouse were observed in these areas.

	Precipitation (cm)		CFA			TRA[a]			Howe[b]		
Year	Spring	Summer	Arrive	Depart	Days	Arrive	Depart	Days	Arrive	Depart	Days
1977	6.7	2.6	6/28	11/13	139	7/7	11/18	135			
1978	2.5	3.9	7/14	11/9	119	7/7	9/9	65	6/30	9/14	77
1979	4.6	5.8	7/2	10/26	117	7/6	9/13	70	6/19	9/28	102
1980	8.9	6.2	7/10	9/16	69	7/26	9/6	43	6/3	10/8	128

[a] 1980 TRA data provided by H. W. Browers, Jr., Wildlife Department, South Dakota State University.

[b] Howe was not censused in 1977.

Table 1.2. Maximum and mean number of sage grouse censused at the Central Facilities Area, Test Reactor Area, and Howe, 1977 through 1980. Counts were made at least twice per month. Howe was not censused in 1977 and the Test Reactor Area was not censused in 1980.

	July		August		September		October	
Year	Max.	$\bar{X}$	Max.	$\bar{X}$	Max.	$\bar{X}$	Max.	$\bar{X}$
Central Facilities Area								
1977	15	10	32	21	30	15	32	25
1978	37	25	34	20	20	10	3	2
1979	21	13	43	24	55	49	23	13
1980	35	16	48	25	19	12	0	
Test Reactor Area								
1977	11	8	20[a]		7[a]		10	7
1978	14	10	31	20	23[a]			0
1979	27	17	18	9	2[a]			0
Howe								
1978	42	25	36	22	26	24	0	
1979	44	33	206	49	104	62	0	
1980	114	79	21	12	27	15	1	1

[a]Only one count made during the month.

functioning on 5 grouse and 2 others died before leaving the study areas. I recorded 177 locations while monitoring these birds over a total of 550 grouse days.

During the summer (1 July to 7 September), 72% of all radio-locations were made within 1 km of the facilities and 95% were within 2 km (Fig. 1.2). Individuals did not always remain on their banding sites for the entire summer. Three of the 14 radio-marked sage grouse left their summer areas prior to 7 September; 2 of these birds moved to sagebrush habitat and 1 moved to another INEL facility. One of the grouse moving to sagebrush habitat returned to CFA after 14 days; however, the other sage grouse was killed approximately 2 weeks after leaving its summer range. At least 3 color-marked grouse also left their banding areas before 7 September. Two of these grouse moved from CFA to TRA while the third was killed on a highway but was moving toward the RWMC. The last 3 weeks of September appeared to be a transition period in which relatively few locations were made within 1 km of the summer feeding sites. By the first week of October, most birds had abandoned their summering areas and were depending solely on sagebrush habitat (Fig. 1.2). The majority of October radio-locations were made over 2 km from the facilities and ranged from 2 to 32 km at this time. Movements generally occurred in northerly or southerly directions from the INEL facilities (Fig. 1.1). The average one-way movements to winter range from CFA and TRA were 19.9 and 15.5 km, respectively, and ranged from 0.2 to 81.0 km.

I determined summer home ranges for 5 adult females, 2 juvenile males, and 1 juvenile female. All of the adults were marked at CFA and 4 of these 5 birds had broods when captured. Females with broods remained at CFA for an average of 47 days and had a mean summer range of 406 ha. The

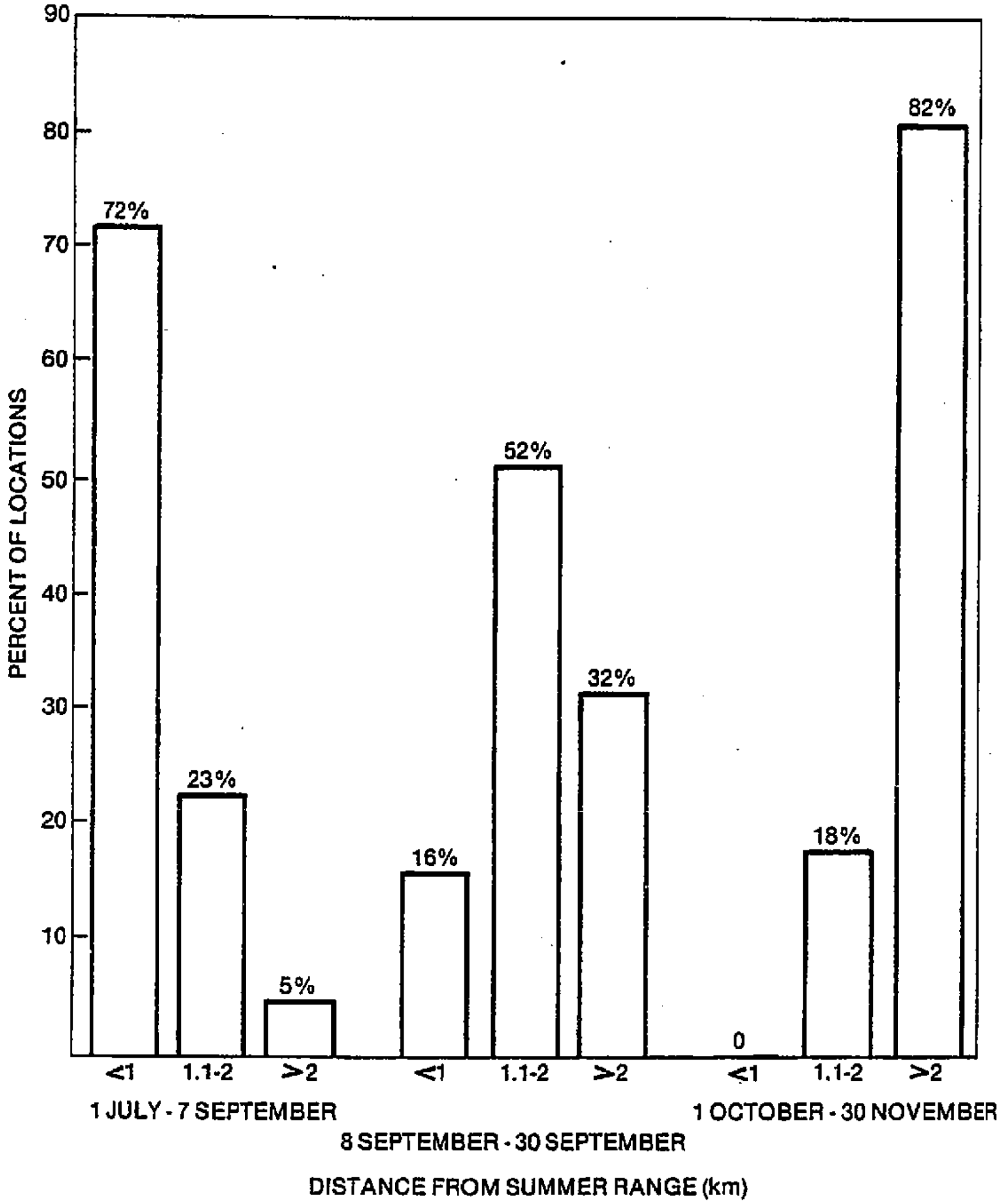

Fig. 1.2. Frequency of locations of radio-marked sage grouse with respect to their feeding areas at INEL facilities.

female without a brood remained at CFA for 25 days and occupied a summer range of 174 ha (Fig. 1.3). The 3 juveniles were marked at TRA and remained at this facility for an average of 35 days. These birds occupied a mean summer range of 94 ha (Fig. 1.4). The estimated residence times at these facilities are minimum figures because the exact arrival dates for these birds were not known, but most sage grouse were captured within approximately 1 week of arriving at a facility.

Six radio-marked grouse were monitored throughout the hunting season and none left the site during this period. Only 5 of the 245 sage grouse marked during this study were shot by hunters and 1 of these birds was shot on site.

Radionuclide Concentrations

Seventeen radionuclides were detected in sage grouse collected at TRA/ICPP and 2 radionuclides were detected in RWMC birds (Table 1.3). Seven radionuclides were detected in control grouse. ^{137}Cs was the most frequently occurring radionuclide and was detected in samples from all locations. Of the radionuclides detected, only ^{137}Cs, ^{134}Cs, ^{60}Co, and ^{106}Ru had half-lives exceeding 1 year. ^{51}Cr had the highest average concentration in the G.I. tract samples but was not detected in muscle samples. ^{137}Cs had the highest average concentration in muscle samples and was the only radionuclide detected in at least 25% of muscle samples from all areas. ^{24}Na had the highest maximum concentration of all radionuclides but was only detected in 1 sample. This radionuclide may have occurred in other samples but was not detected because of its short half-life (15 h) and the time lag between collection of a specimen and its analysis. The concentration of the ^{24}Na was less than 3 times the detection limits at the time of analysis, and this radionuclide was not

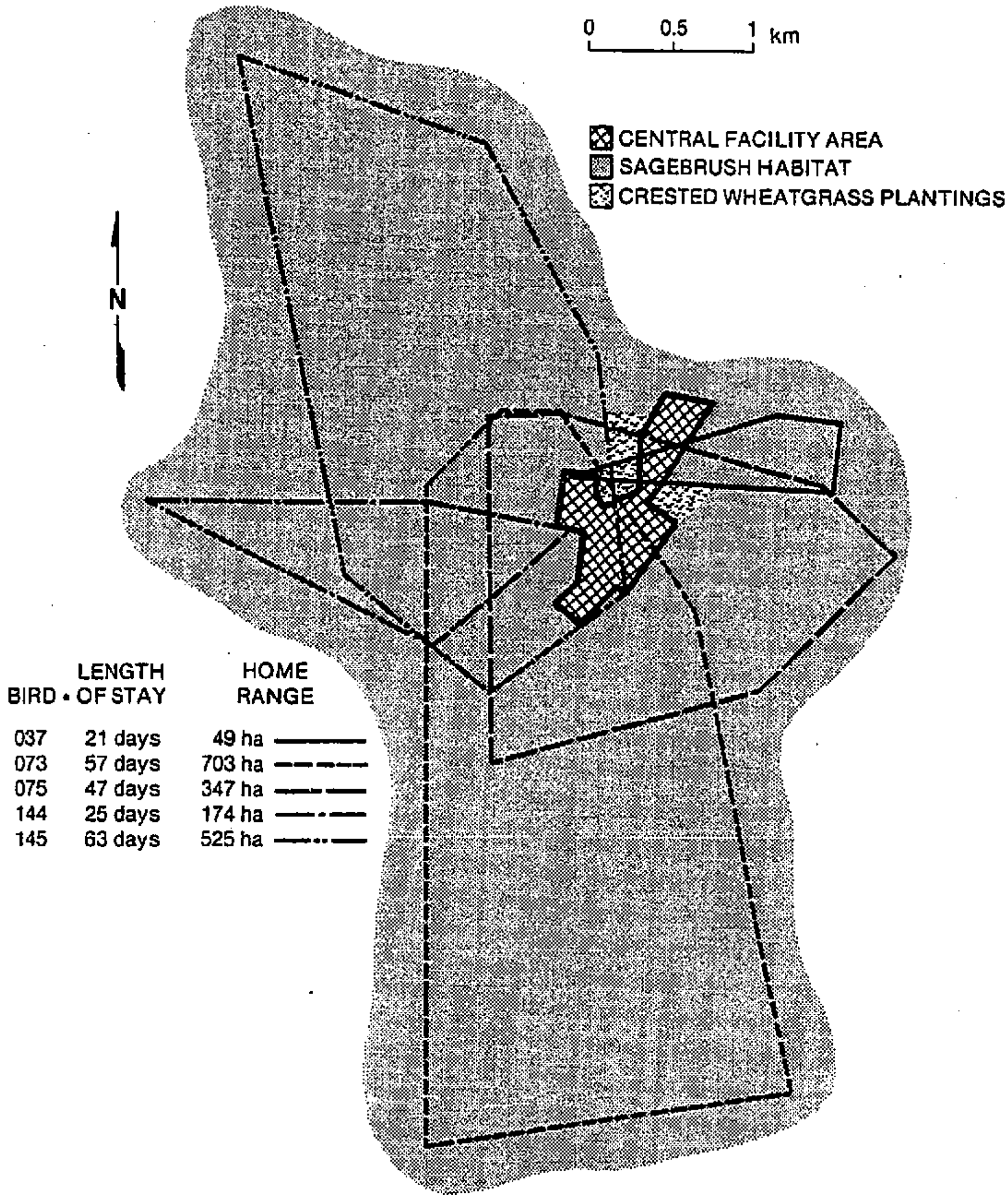

Fig. 1.3. Summer home ranges of 5 adult female sage grouse marked at the Central Facilities Area on the INEL site during 1979 and 1980. Length of stay and size of summer range are indicated for each bird. The transmitter on female 037 stopped functioning after 21 days.

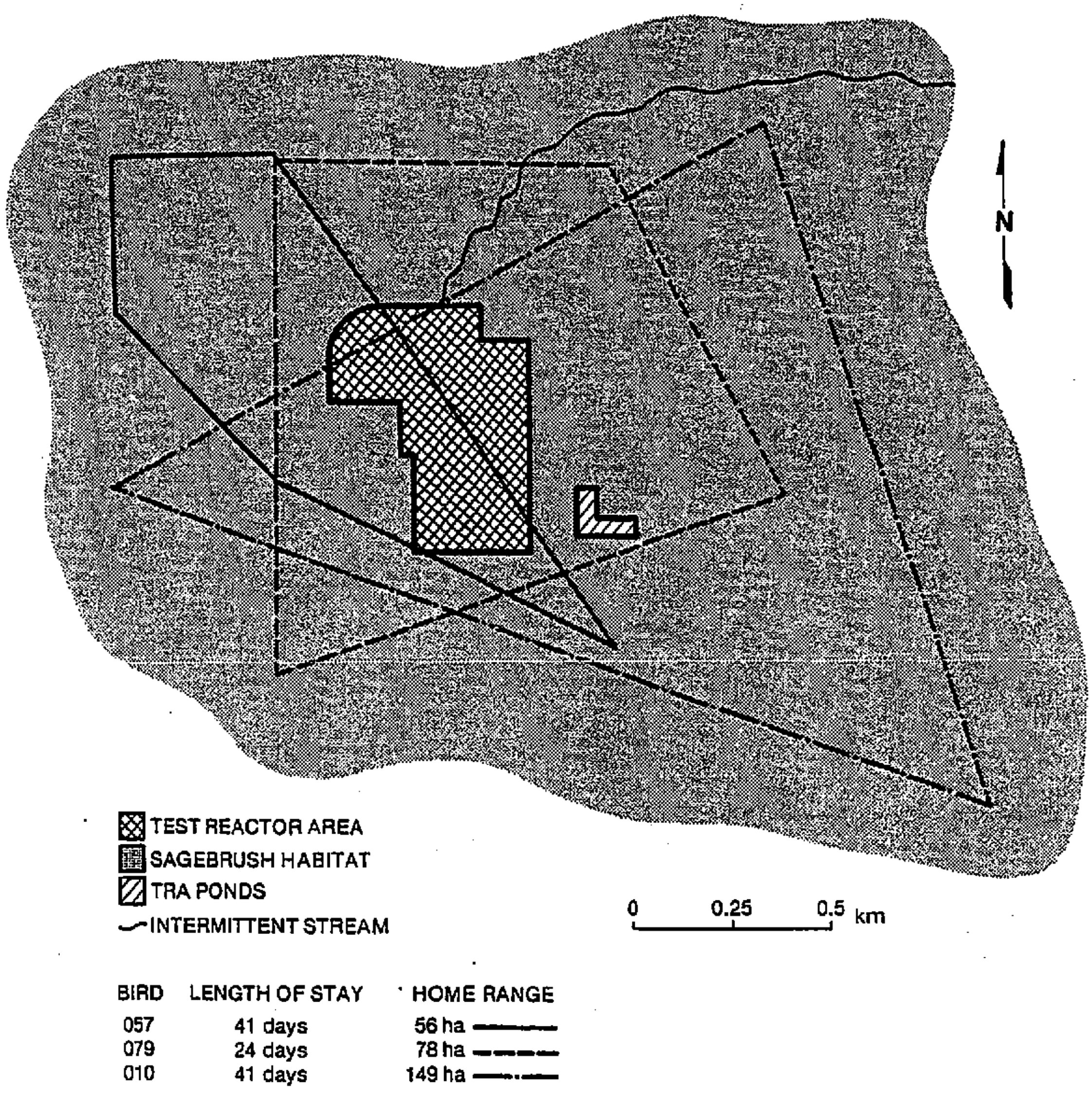

Fig. 1.4. Summer home ranges of 3 juvenile sage grouse marked at the Test Reactor Area on the INEL site during 1978 and 1979. Length of stay and size of summer range are indicated for each bird.

Table 1.3. Frequency of occurrence (%) and maximum and mean[a] radionuclide concentrations (pCi/g fresh weight) in tissue samples from sage grouse collected during summer and fall, 1977 through 1979, at the Test Reactor Area/Idaho Chemical Processing Plant (TRA/ICPP) complex, the Radioactive Waste Management Complex (RWMC), and in off-site control areas.

	TRA/ICPP						RWMC						Control Areas					
	G.I. Tract(N=29)			Muscle (N=29)			G.I. Tract(N=14)			Muscle (N=14)			G.I. Tract(N=19)			Muscle (N=20)		
Nuclide	Freq.	Max.	$\overline{X}$	Freq.	Max.	$\overline{X}$	Freq.	Max.	$\overline{X}$	Freq.	Max.	$\overline{X}$	Freq.	Max.	$\overline{X}$	Freq.	Max.	$\overline{X}$
Cr-51	38	539	60.3		ND[b]	1.8		ND			ND			ND			ND	
Cs-137	93	107	6.2	86	30.1		100	0.2	0.1	100	0.4	0.3	89	0.2	0.1	90	0.4	0.3
Co-60	31	25.2	2.0	24	1.9			ND			ND			ND			ND	
Ce-144	7	7.1			ND			ND			ND		5	1.5			ND	
Cs-134	28	26.8	1.3	14	5.8			ND			ND			ND			ND	
Nb-95	24	1.8		3	0.2			ND			ND		16	0.7			ND	
Zr-95	10	1.1			ND			ND			ND		11	0.7			ND	
Ce-141	3	2.2			ND			ND			ND		11	0.8			ND	
Ru-103	7	0.9		3	0.4			ND		7	0.6		11	0.6		5	0.3	
La-140	7	0.6			ND			ND			ND			ND			ND	
Se-75	17	4.5		3	1.4			ND			ND			ND			ND	
Na-24		ND		3	3.8[c]			ND			ND			ND			ND	
Ru-106		ND			ND			ND			ND			ND		11	1.5	
Co-58	3	0.1			ND			ND			ND			ND			ND	
Hg-203	7	0.6		7	0.5			ND			ND			ND			ND	
Ba-140		ND		3	2.7			ND			ND			ND			ND	
Mn-54	14	0.7		3	0.3			ND			ND			ND			ND	
Zn-65	34	12.7	0.9	7	1.5			ND			ND			ND			ND	

[a]Means only given for those radionuclides occurring in at least 25% of the samples.

[b]ND = Not detected.

[c]Ci/g, see text for explanation.

detected in the bird's G.I. tract.

Radionuclide concentrations in muscle samples of TRA/ICPP grouse ($\bar{X}$ = 0.29 pCi/g, N=29) were significantly higher than those of control birds ($\bar{X}$ = 0.13 pCi/g, N=20) (ANOVA, $P<0.05$). No difference could be demonstrated in muscle concentrations between TRA/ICPP and RWMC samples ($\bar{X}$ = 0.14 pCi/g, N=14) or between RWMC and control samples ($P>0.05$). G.I. tract radionuclide concentrations in TRA/ICPP grouse ($\bar{X}$ = 0.080 pCi/g, N=29) were significantly higher than those of RWMC ($\bar{X}$ = 0.05 pCi/g, N=14) or control birds ($\bar{X}$ = 0.11 pCi/g, N=19) ($P<0.01$). No significant difference existed between G.I. tract concentrations in RWMC and control grouse.

G. I. tract radionuclide concentrations in both RWMC and control samples were equal to or less than muscle concentrations; however, in TRA/ICPP grouse, G.I. tract concentrations were significantly higher than muscle concentrations (t test, $P<0.01$). Additionally, there were a greater number of radionuclides detected in G.I. tract samples, and they occurred with greater frequency (Table 1.3).

Dose Commitments

The average and maximum potential dose commitments to a person consuming the entire muscle mass of a sage grouse were greater for TRA/ICPP birds than for either RWMC or control grouse (Table 1.4). The highest estimated potential dose commitment was 2.37 mrem and would have resulted from consuming an adult male sage grouse that summered near TRA/ICPP. The average and maximum potential dose commitments from RWMC and control grouse ranged from 0.01 to 0.04 mrem. Little difference in either the average or maximum potential dose commitment was noted between the RWMC or control areas. Potential dose commitments varied because of

Table 1.4. Estimated dose commitments (mrem)[a] to a person consuming the entire muscle mass[b] of a sage grouse from the Test Reactor Area/Idaho Chemical Processing Plant (TRA/ICPP) complex, the Radioactive Waste Management Complex (RWMC), and from off-site control areas.

Sage Grouse	TRA/ICPP (N=29)		RWMC (N=14)		Control Areas (N=20)	
	Maximum	$\bar{X}$ [c]	Maximum	$\bar{X}$ [c]	Maximum	$\bar{X}$ [c]
Male						
Juvenile	1.66	0.10	0.02	0.01	0.03	0.01
Adult	2.37	0.14	0.02	0.02	0.04	0.02
Female						
Juvenile	1.25	0.07	0.01	0.01	0.02	0.01
Adult	1.45	0.08	0.01	0.01	0.03	0.01

[a] Doses were based on tissue weight before cooking.

[b] Muscle was about 42% of live sage grouse weight.

[c] Only radionuclides occurring in at least 10% of the muscle samples were used in calculating the mean dose commitment.

the difference in body size of the various sage grouse sex and age classes.

DISCUSSION

Oakleaf (1971) discussed the importance of natural upland meadows to sage grouse during the brood rearing season. The lawns surrounding the INEL facilities provide a unique substitute for natural meadows, as do the alfalfa fields near the Howe study area. Both provide a predictable source of forbs, insects, and free water during the summer and early fall. Also, because they are irrigated, neither type of summering area is as seriously affected by drought as are natural meadows. Sage grouse used lawns and other moist areas near facilities for feeding and loafing in the early morning and evening and spent most of the day in adjacent sagebrush areas, usually less than 1 km from those feeding sites. This pattern of use is similar to that described for sage grouse using alfalfa fields (Patterson 1952) and upland meadows (Oakleaf 1971). INEL sage grouse remained on their summering areas well into September and in several years some birds did not return to sagebrush habitat until October or November. In contrast, Wallestad (1971, 1975) reported that many sage grouse broods in Montana moved back to sagebrush habitat in late August and September.

Sage grouse summering near INEL facilities occupied larger summer ranges than grouse using upland meadows (Oakleaf 1971) or sagebrush and bottomland habitats (Wallestad 1971). However, these summer ranges were smaller than sage grouse winter ranges documented by Eng and Schladweiler (1972). The larger summer ranges of INEL sage grouse may be attributable to more human disturbance than occurs near grouse summering in more natural habitats. Also, 4 of the 8 sage grouse for which we have summer range data were monitored during the relatively wet summer of 1980. It is possible that sage grouse occupy larger summer ranges in wet years because of greater availability of succulent forbs and water in sagebrush habitats during these years.

The number and concentration of radionuclides in sage grouse muscle and G.I. tract samples were generally lower than those reported for waterfowl (Halford et al. 1981) and mourning doves (Zenaida macroura) (Markham unpubl. data) studied in the same areas. ^{137}Cs concentrations reported for dove muscle were approximately 3 times greater than ^{137}Cs concentrations in sage grouse muscle. ^{137}Cs concentrations reported for waterfowl muscle were over 400 times greater than those found in sage grouse. The higher concentrations in doves and waterfowl were probably due to their greater use of the TRA ponds. Further, the relatively large summer range of INEL sage grouse reduced their exposure to these contaminated areas. While some grouse were observed feeding and watering at these ponds, this use appeared irregular and the majority of the birds summering at the TRA facility used the facility lawns. The difference in radionuclide concentrations between TRA/ICPP and RWMC grouse suggests that the transfer of radioactivity from liquid waste systems is greater than the transfer from solid waste systems.

Although there were 15 radionuclides detected in sage grouse G.I. tract samples, many of these could be considered biologically inactive because they either did not occur in the muscle or occurred in much smaller concentrations than were found in the G.I. tract. Because ^{137}Cs and ^{134}Cs follow the same biological pathway as potassium when ingested, they are readily incorporated into soft tissue and were responsible for most of the radionuclide concentration in grouse muscle tissue. Other radionuclides occurred in muscle tissue but their frequency of occurrence was generally lower. ^{24}Na was only detected in 1 sage grouse and 3 of 28 ducks collected at TRA (Halford et al. 1981) and was not detected in a sample of 50 mourning doves collected at TRA (Markham unpubl. data). The fact that radionuclide concentrations in grouse G.I. tract samples were higher than muscle concentrations only at the TRA/ICPP area further reflects the greater number of radionuclides and the higher radionuclide concentrations associated with the immediate TRA/ICPP environment.

The biological half-life of radiocesium for an animal the size of a sage grouse (800 to 2,000 g) should be between 10 and 15 days (Reichle et al. 1970). This estimate is in general agreement with that given for wood ducks (Aix sponsa) of 5.6 days (Fendley et al. 1977). However, the mean biological half-life of radiocesium in blue jays (Cyanocitta cristata) was estimated at 6.7 days (Levy et al. 1976) indicating that weight is not the sole factor influencing biological half-life. If the biological half-life of radiocesium in sage grouse is 10-15 days, any contaminated grouse consumed 10 to 15 days after leaving the vicinity of a nuclear facility would have lost at least half of its cesium body burden, and, on average, would have less than 1 pCi/g of radiocesium.

The maximum potential whole-body dose commitment to a person eating a sage grouse shortly after it left the vicinity of an INEL facility was estimated at 2.37 mrem. The recommended maximum permissible whole-body dose commitment to an individual in the general public is 500 mrem/year (ICRP 1959) or 208 times the maximum dose commitment from a sage grouse summering near an INEL facility. The average radiation dose equivalent received by the general public in the INEL area from naturally occurring sources is 149 mrem (U. S. Department of Energy 1980). To exceed the 500 mrem/year maximum recommended dose commitment, a person would have to eat approximately 422 kg of sage grouse meat or about 211 sage grouse containing maximum concentrations in 1 year. Therefore, based on current guidelines, the potential dose commitment to a person consuming a sage grouse shortly after it left an INEL facility does not constitute a radiation health hazard.

This study indicated that sage grouse moved relatively long distances from their summering areas near INEL facilities and that some grouse did move off-site. Average movements from these facilities were longer than those reported by Wallestad (1971) for Montana sage grouse but appear similar to those described by Dalke et al. (1960, 1963) for a sage grouse population in southeastern Idaho. The sage grouse hunting season in Idaho begins the third weekend in September and lasts for 2 to 3 weeks. However, the number of grouse from INEL facilities available to hunters was relatively low because most birds did not begin leaving their summering areas until mid-September and had not moved far from these areas until early October. The tendency of these grouse to remain at the facilities throughout the hunting season in drier years further decreased their availability to hunters. The fact that the band recovery rate for grouse marked while summering at INEL facilities was only 2% while the recovery rate for sage grouse marked on leks located on and near the INEL was 6% (Connelly unpubl. data) also reinforces the notion that few grouse from INEL facilities have moved off-site prior to or during the hunting seasons.

While sage grouse did act as transport mechanisms and removed radionuclides from waste storage systems, the quantities removed per individual were small and apparently constituted no hazard to the bird or a person consuming the bird. Further, the relatively short biological half-life of radiocesium reduced any potential harm to the animal from the ingested radionuclides. This short biological half-life as well as the timing of the sage grouse movements from summering areas near nuclear facilities also reduced any potential health hazard to a person consuming one of these birds. Other research has also shown that various wildlife species can serve as a means of transport for radiocontamination but pose no radiological health hazard (Brisbin et al. 1974, Cadwell et al. 1979, Halford et al. 1981). In contrast, other environmental pollutants have been associated with declining animal populations (Mullins et al. 1977, Stromberg 1977, Zinkl et al. 1978). High levels of mercury in pheasants (Phasianus colchicus) and Hungarian partridge (Perdix perdix) forced the closing of the hunting season on these game birds in 1969 in Alberta (Wishart 1970). Furadan 3G was found to be toxic to birds, fish, and invertebrates in Texas (Flickinger et al. 1980). Further, low reproductive success in a population of Great Basin Canada geese (Branta canadensis moffitti) has been attributed to heptachlor-treated-wheat seed and it has been suggested that this pesticide may cause the extirpation of this small population (Blus et al. 1979). Therefore, when viewed in perspective, radionuclides in wildlife do not seem to pose any more of a problem than many other environmental pollutants.

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PART II

SEASONAL MOVEMENTS, FLOCKING CHARACTERISTICS, AND HABITAT USE BY SAGE GROUSE IN SOUTHEASTERN IDAHO

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Sage grouse (Centrocercus urophasianus) dependence on sagebrush (Artemisia spp.) habitat has been well documented (Patterson 1952, Klebenow 1969, Eng and Schladweiler 1972, Wallestad 1975, Beck 1977, and others). Over 2 million ha of western rangeland have experienced some form of sagebrush control during the past 40 years (Braun et al. 1977). To fully understand the impact of habitat loss on sage grouse, it is necessary to first understand sage grouse seasonal habitat use, and seasonal movements and flocking characteristics as they relate to habitat.

Sage grouse occupy seasonal habitats and may be migratory or nonmigratory (Patterson 1952, Dalke et al. 1963, Eng and Schladweiler 1972, Beck 1977). Unfortunately, information on the timing and distance of seasonal movements, and the spatial relationships of seasonal ranges to migration routes and breeding complexes, is often lacking. Only Dalke et al. (1963) attempted to demonstrate these relationships. Sage grouse flocking characteristics have been investigated (Dalke et al. 1963, Wallestad 1975, Beck 1977) but little information is available on the flocking behavior of each sex and age class or the effect of environmental variables on flock size. Much of the research on sage grouse habitat use has emphasized use of spring and summer ranges (Klebenow 1969, 1970, Wallestad and Pyrah 1974, Wallestad and Schladweiler 1974, and others). Less is known about sage grouse winter range (Wallestad 1972, Eng and Schladweiler 1972, Beck 1977).

The Idaho National Engineering Laboratory site in southeastern Idaho contains both mountain valley and plains populations of sage grouse (Pyrah and Mooney 1966) and thus affords an opportunity to compare the seasonal movements, flocking characteristics, and habitat use of these populations. The purposes of this paper are to: (1) describe sage grouse seasonal movements; (2) describe seasonal flocking characteristics of sage grouse and document the effects of weather conditions and habitat on flocking behavior; (3) describe seasonal habitat use by sage grouse; and (4) define sage grouse summer and winter range with respect to each other and to known breeding complexes and migration routes.

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STUDY AREA

The study was conducted on the Idaho National Engineering Laboratory (INEL) site in southeastern Idaho. The INEL site is a 231,600 ha area administered by the U. S. Department of Energy. The site is located in a semi-arid, cold desert on the upper Snake River Plain, approximately 35 km west of Idaho Falls, Idaho. The area lies at the foothills of the Lost River, Lemhi, and Bitterroot mountain ranges. The Big Lost River and Birch

Creek flow onto the INEL (Fig. 2.1) but both are intermittent and usually dry during summer. Topography is flat to rolling, and elevation ranges from 1,463 m to 1,829 m above sea level. Temperatures range from -42°C to 39°C with an annual average of 6°C, and annual precipitation averages 20.6 cm.

Vegetation is dominated by big sagebrush (*Artemisia tridentata*), rabbitbrush (*Chrysothamnus viscidiflorus*), and various bunchgrasses. Twenty distinct cover types have been described on the INEL, 12 of which are dominated by sagebrush (McBride et al. 1978). Big sagebrush occurs throughout the INEL site while low sagebrush (*A. arbuscula*) is generally confined to the foothills of the Lost River Range and the lower Birch Creek valley. Portions of the INEL site have been seeded to crested wheatgrass (*Agropyron cristatum*) (McBride et al. 1978) and most of these seedings contain small, scattered stands of big sagebrush. The site borders agricultural land for approximately 37 km of its boundary, and irrigated lawns at a number of INEL facilities provide a predictable source of free water and forbs that are used each summer by sage grouse. Four of these facilities have been described elsewhere (Connelly 1981).

Large areas in the southern portion of the INEL site are covered by basalt flows. Soils are gravelly to rocky and generally shallow. The northern portion of the INEL is covered by lake and eolian deposits, mostly composed of unconsolidated clay, silt, and sand (Atwood 1970).

Approximately 60% of the INEL is open to livestock grazing (Fig. 2.1). The intensity of grazing varies from year to year depending on range and weather conditions. Most of the areas closed to grazing are not fenced and livestock occasionally wander into these areas.

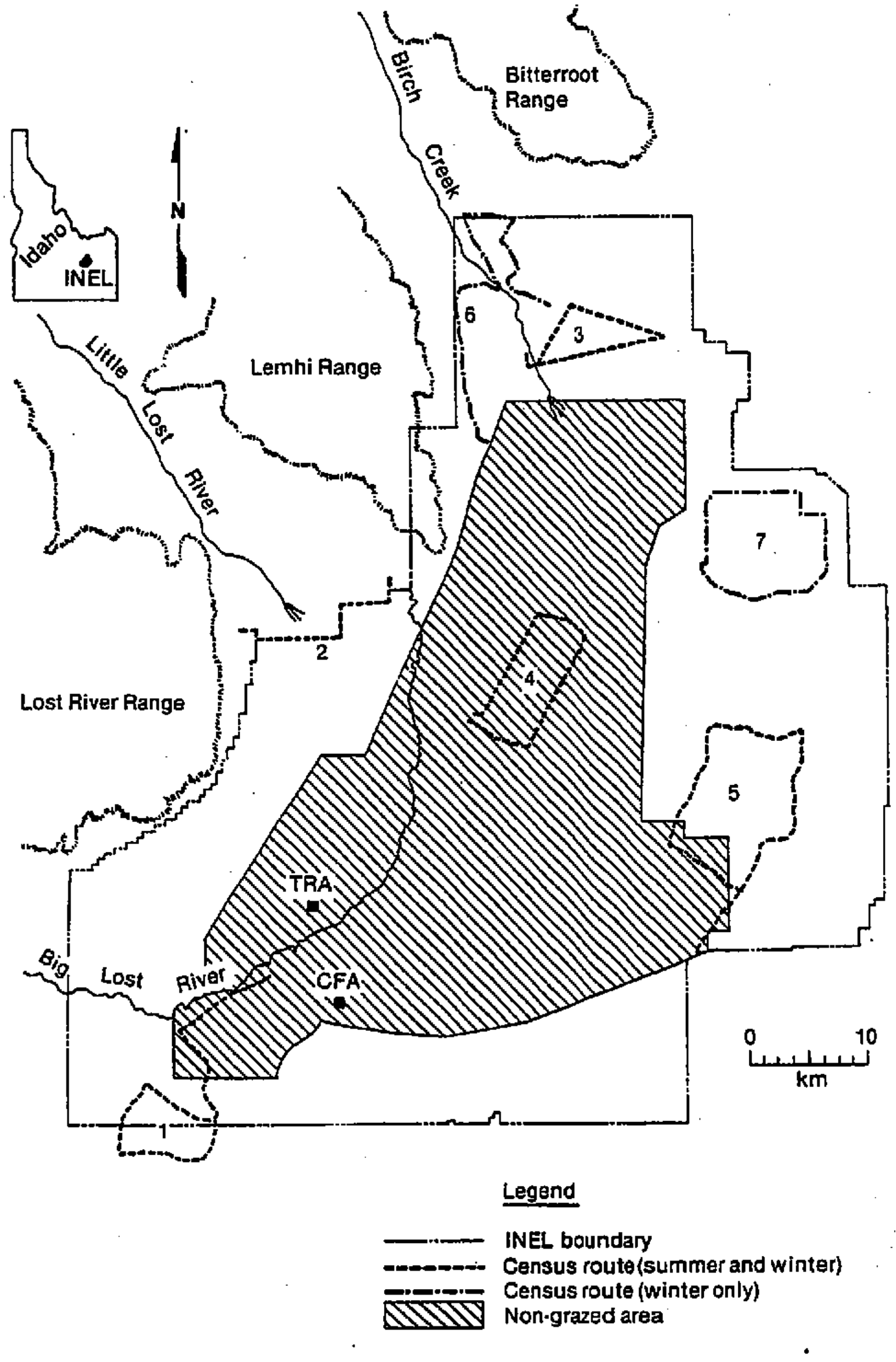

Fig. 2.1. The study area in southeastern Idaho. The Central Facilities Area (CFA), Test Reactor Area (TRA), census routes, and areas open to grazing on the INEL site are indicated.

METHODS AND MATERIALS

Movements

Sage grouse were captured and marked during the summer of 1977 and the spring and summer from 1978 through 1980. During the summer, sage grouse were captured on lawns at the Central Facilities Area (CFA) and Test Reactor Area (TRA) on the INEL site (Fig. 2.1) using drive traps (Gill 1965) and mist nets. Sage grouse were captured by night lighting (Labisky 1968) on and near leks during March and April.

All captured birds were marked with numbered, aluminum leg bands. Additionally, females were color-marked with numbered ponchos (Pyrah 1970) or were radio-marked with a poncho harness (Amstrup 1980) or back-pack harness. Males were color-marked with numbered patagial tags or were radio-marked with a back-pack harness. Ponchos and patagial tags were color-coded to allow immediate identification of the capture site. Both types of markers were made from brightly colored Herculite. Patagial tags were attached to "All-flex" livestock ear tags and fastened, using an "All-flex" applicator (All-flex Tag Company, Culver City, California), to each wing as suggested by E. J. Pitcher (pers. comm.). Both battery powered and solar transmitters were used but solar transmitters were preferred because of their lighter weight and longer life.

Sage grouse were radio-tracked to provide data on length and timing of spring (15 March through 30 June) and fall (1 September through 15 November) movements. These movements can be classed as local movements within the bird's seasonal range prior to migration or long distance migration. Radio-marked grouse were located at least once per week prior to migration. During spring and fall migration, radio-marked grouse were located at least once per month. It was difficult to locate these birds at regular intervals of less than 1 month during migration because of their long distance movements and the relatively inaccessible areas in which many of them summered and wintered. Sage grouse were located from the ground using a hand-held, 4-element yagi, until they began their seasonal movements. At this time, radio-tracking was accomplished from a light aircraft with 4-element yagi's attached to each wing strut. Additional movement data resulted from band returns and reobservations of marked sage grouse.

The habitat and topography of the Birch Creek valley (mountain valley) differed from that of the central and southern portions of the INEL site (plains area). Therefore, spring movements of sage grouse from the mountain valley and plains areas were analyzed separately and compared.

The distances of sage grouse seasonal movements were determined by calculating the straight-line distances from the capture sites to the points of recovery, reobservation, or final radio-location; thus all distances can be considered minimum. Estimates of daily movements were based on locations of radio-marked grouse. The minimum area method (Mohr 1947) was used to calculate home range. Spring home ranges were estimated based on movements made from the date of the birds' capture through 30 June. Fall home ranges were calculated based on movements made from 1 September until 15 November. Student's t test, analysis of variance, and chi square analysis (Steele and Torrie 1960) were used to make statistical comparisons. Duncan's new multiple range test for unequal sample sizes (Steele and Torrie 1960:114) was used to compare means whenever analysis of variance resulted in a significant F value.

Flocking Characteristics

Flock size, sex, and age composition were recorded throughout the year for all flocks observed while engaged in any aspect of this research. If a single sex appeared to comprise at least 3/4 of a flock, the flock was classified as that sex, otherwise it was recorded as a mixed sex flock. Female flocks were differentiated from female/juvenile flocks between 1 June and 31 July. Because these birds congregate in August and September (Wallestad 1975) and are difficult to distinguish at this time, all female flocks and female/juvenile flocks were recorded as female/juvenile flocks after 31 July. For the purpose of flock analyses, grouse observed on INEL lawns and in agricultural areas were grouped. All flocks were flushed to ensure an accurate count and classification. Analysis of variance, Student's t test (Steele and Torrie 1960), and Satterwaithe's t test (Ostle 1963:302) were used to make statistical comparisons. Duncan's new multiple range test for unequal sample sizes (Steele and Torrie 1960:114) was used to compare means whenever analysis of variance resulted in a significant F value.

Habitat Use

Seasonal habitat use was studied from summer (1 June through 30 September) 1977 through winter (1 November through 15 March) 1981. Analyses of seasonal habitat use were based on data collected while running monthly census routes. One census route was established along the border of a big sagebrush stand and an agricultural area consisting of an interspersion of alfalfa and wheat fields because sage grouse were known to use this area during summer. All other routes were established without prior knowledge of sage grouse concentrations or the habitats along these routes. In the summer, 5 routes were censused during early mornings or evenings from a vehicle traveling less than 25 kph, and flock locations, cover type and the flock's proximity to water were recorded. A total of 2,450 km of summer census routes were run during the study.

All summer routes plus 2 additional routes were censused during the winter. These routes were censused throughout the day using 4-wheel drive vehicles or snowmobiles traveling less than 32 kph, but were not censused on extremely windy days or during snow storms. A total of 3,245 km of winter routes were censused during the study. Flock locations, cover type, snow depth, and mean daily temperature were recorded during winter. A circular plot technique (Lyon 1968, Peek et al. 1978) was used to quantify the winter habitat at locations of flocks numbering 3 or more birds. At each site, sagebrush canopy coverage, height, and density were estimated. Prior to making vegetation measurements, the approximate center of the flock was located and from this point 15 m lines were run to the cardinal compass points. Three, 1 m radius sub-plots were randomly located along each line for a total of 12 sub-plots per site. Within each sub-plot, I measured the snow depth and counted the number of distinct sagebrush plants or clumps, where individual plants could not be distinguished. Two diagonal crown measurements (Peek et al. 1978) and the height were measured on 3 or 4 sagebrush plants located nearest the center of each sub-plot until a total of 40 plants had been measured on the site. Winter habitat analyses were made in both the mountain valley and plains areas. To characterize sites that were not used as winter range, 5 locations were randomly selected from each winter census route where neither grouse nor grouse sign had been observed during the winter; within these locations, sites were randomly selected and analyzed using the same procedures as at flock locations.

Chi square analysis was used to test the hypothesis that sage grouse use habitats in proportion to their availability. When chi square analysis indicated a significant difference in habitat use, Bonferoni Z statistics were used to indicate preference and avoidance of habitat types (Neu et al. 1974). Student's t test and analysis of variance were used to make statistical comparisons of sites used by different flock types and to compare vegetative characteristics of different areas. Duncan's new multiple range test for unequal sample sizes (Steele and Torrie 1960:114) was used to compare means when analysis of variance resulted in a significant F value.

RESULTS

Movements

<u>Fall-winter.</u> A total of 251 sage grouse were marked during summers and, disregarding grouse known to have died shortly after being marked, movement data was obtained on 11.7% of the birds in this sample. Movements by adult grouse from summer areas ranged from 1.6 to 63.6 km ($\overline{X}$ = 19.9 km, N=6) and were not significantly different from movements by juvenile sage grouse which ranged from 0.2 to 81.0 km ($\overline{X}$ = 17.8 km, N=17)(t test, P>0.05). Adult grouse moved northwest to winter range while juveniles tended to move southwest (Fig. 2.2). The difference in the direction moved by each age class was significant (chi-square test, P<0.01).

Fall movements to winter range were generally slow and meandering (Fig. 2.3) and began in late August and continued into December. The length and timing of these movements varied among individual birds. For example, an adult female moved 64 km to winter range over a period of 100 days while a juvenile female moved 61 km in 47 days. Five radio-marked sage grouse

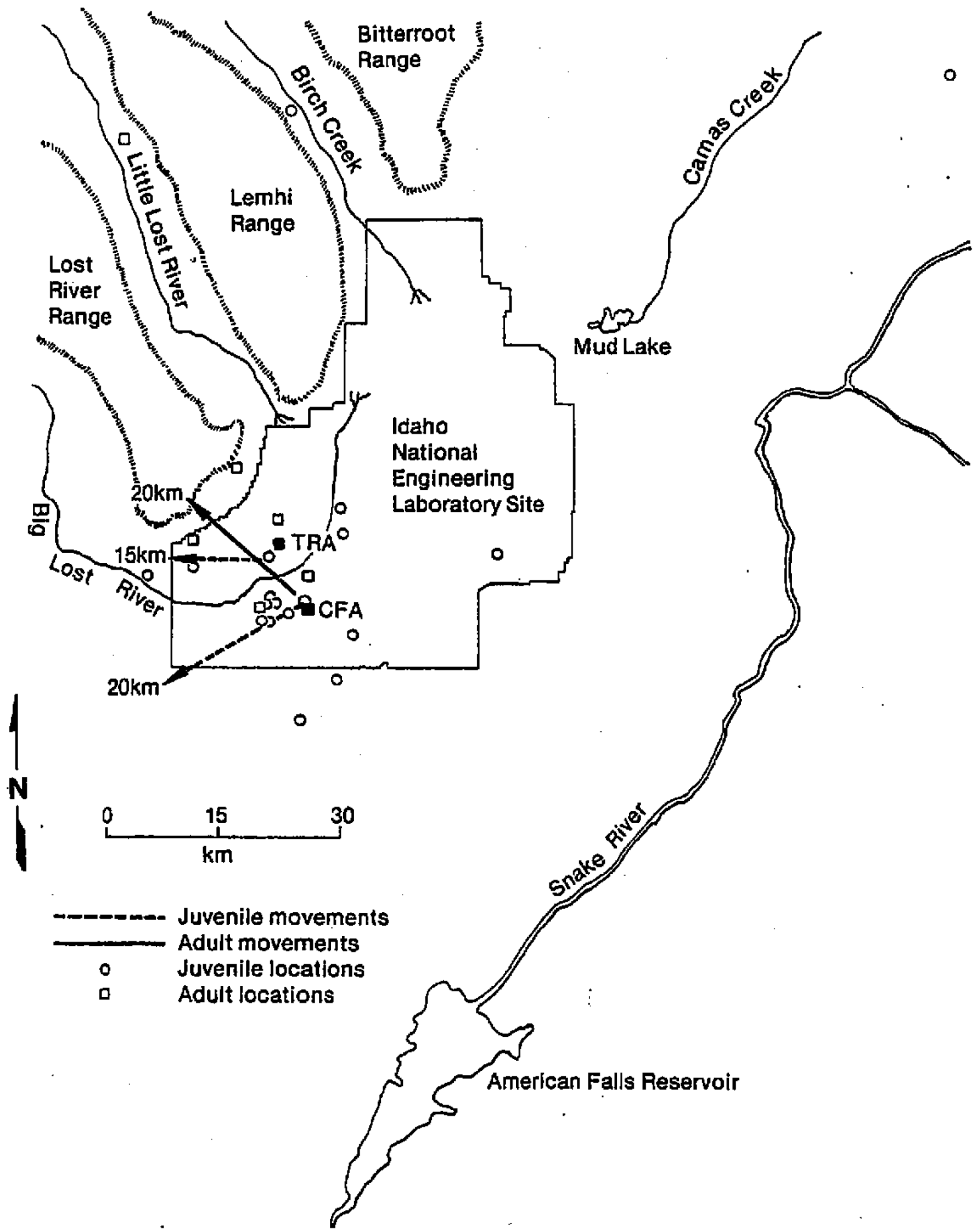

Fig. 2.2. Locations of sage grouse recoveries and mean vectors of fall movements by adult and juvenile sage grouse. All grouse were marked during summers, 1977 through 1980, at the Central Facilities Area (CFA) or the Test Reactor Area (TRA) on the INEL site.

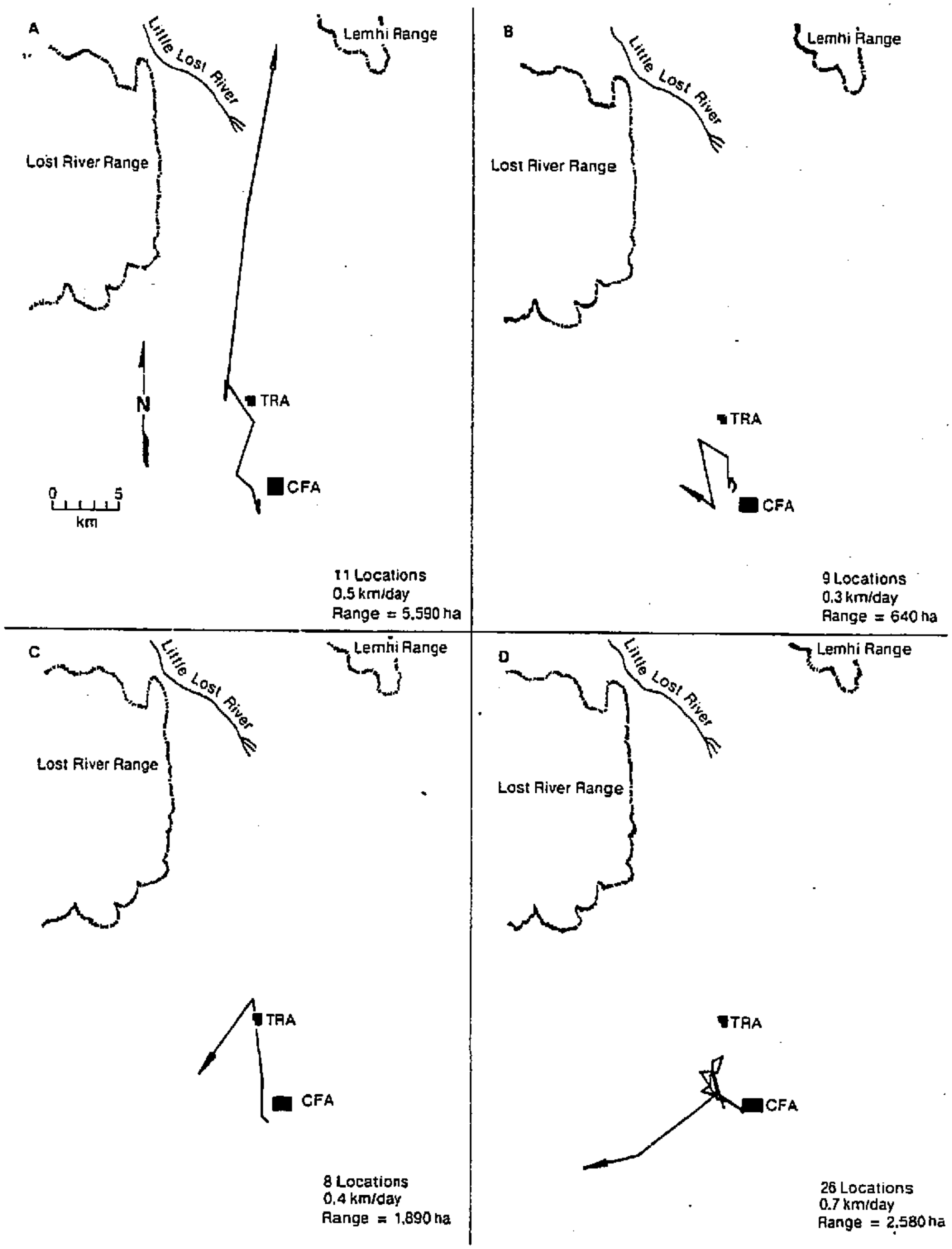

Fig. 2.3. Fall movements of 4 female sage grouse radio-marked at the Central Facilities Area (CFA) on the INEL site during summers, 1978 and 1980. Females A, B, and C were adults and D was a juvenile. The number of locations, mean daily movement, and fall home range are indicated for each bird.

moved an average of 0.4 km per day. Fall home ranges for these grouse averaged 2,246 ha and ranged from 530 to 5,590 ha. In addition to those grouse represented by Fig. 2.3, a yearling male sage grouse that summered in alfalfa fields north of the INEL site was also monitored. This bird occupied a fall home range of 530 ha and moved an average of 0.1 km per day during the fall.

Spring-summer. A total of 195 sage grouse were marked on 4 leks in the mountain valley area and 178 grouse were marked on 9 leks in the plains area of the INEL site. Movement data was obtained on 11.0% of the birds in this sample. Spring movements by grouse from both populations were analyzed by sex and movements by mountain valley males were also examined according to age classes. Of the 23 summer reobservations, locations, and band returns of mountain valley birds, 21 (91%) occurred in the Birch Creek valley (Fig. 2.4). Spring movements of adult males from the mountain valley population ranged from 12 to 83 km ($\overline{X}$ = 51 km, N=14), movements of immature males ranged from 13 to 58 km ($\overline{X}$ = 34 km, N=4), and female movements ranged from 5 to 72 km ($\overline{X}$ = 31 km, N=5). The differences in distances moved to summer range among the 3 groups were not significant (ANOVA, P>0.05), nor were the directions moved to summer range significantly different (chi square test, P>0.05).

Adult and immature male sage grouse from the mountain valley population left their leks in late April and May. Their movements to summer range were more direct and rapid than those of females and for this reason spring home ranges for males were not calculated. Three radio-marked males moved an average of 0.9 km per day (Fig. 2.5).

Daily movements for females were not calculated until they had ceased all nesting efforts. Females from the mountain valley population did not

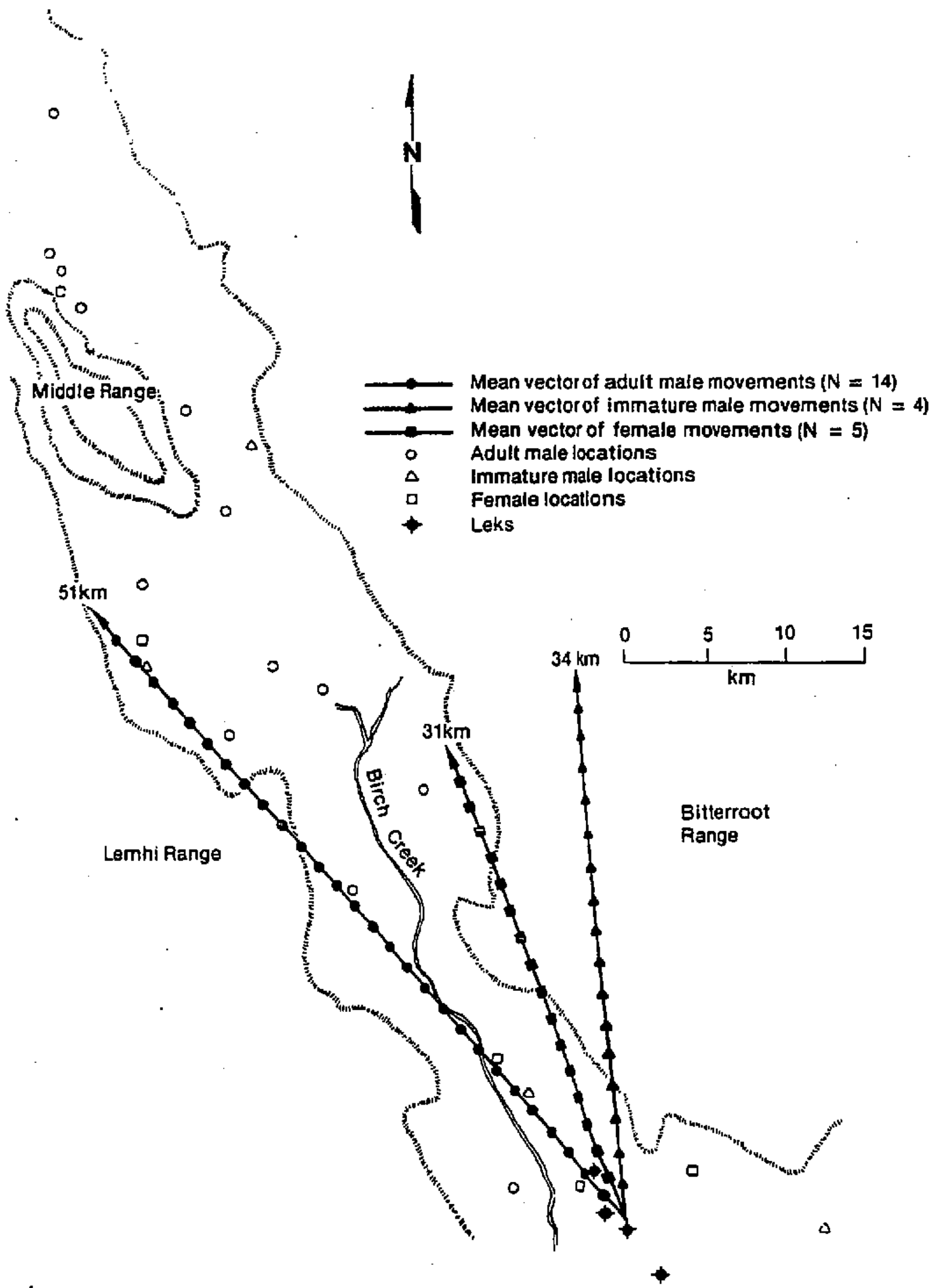

Fig. 2.4. Locations of sage grouse recoveries and mean vectors of spring movements by sage grouse marked on leks in the lower Birch Creek valley, 1978 through 1980. The location of an adult male grouse that moved south to the Central Facilities Area on the INEL site is not shown, but its movement was used in calculating the mean vector of movements by adult males.

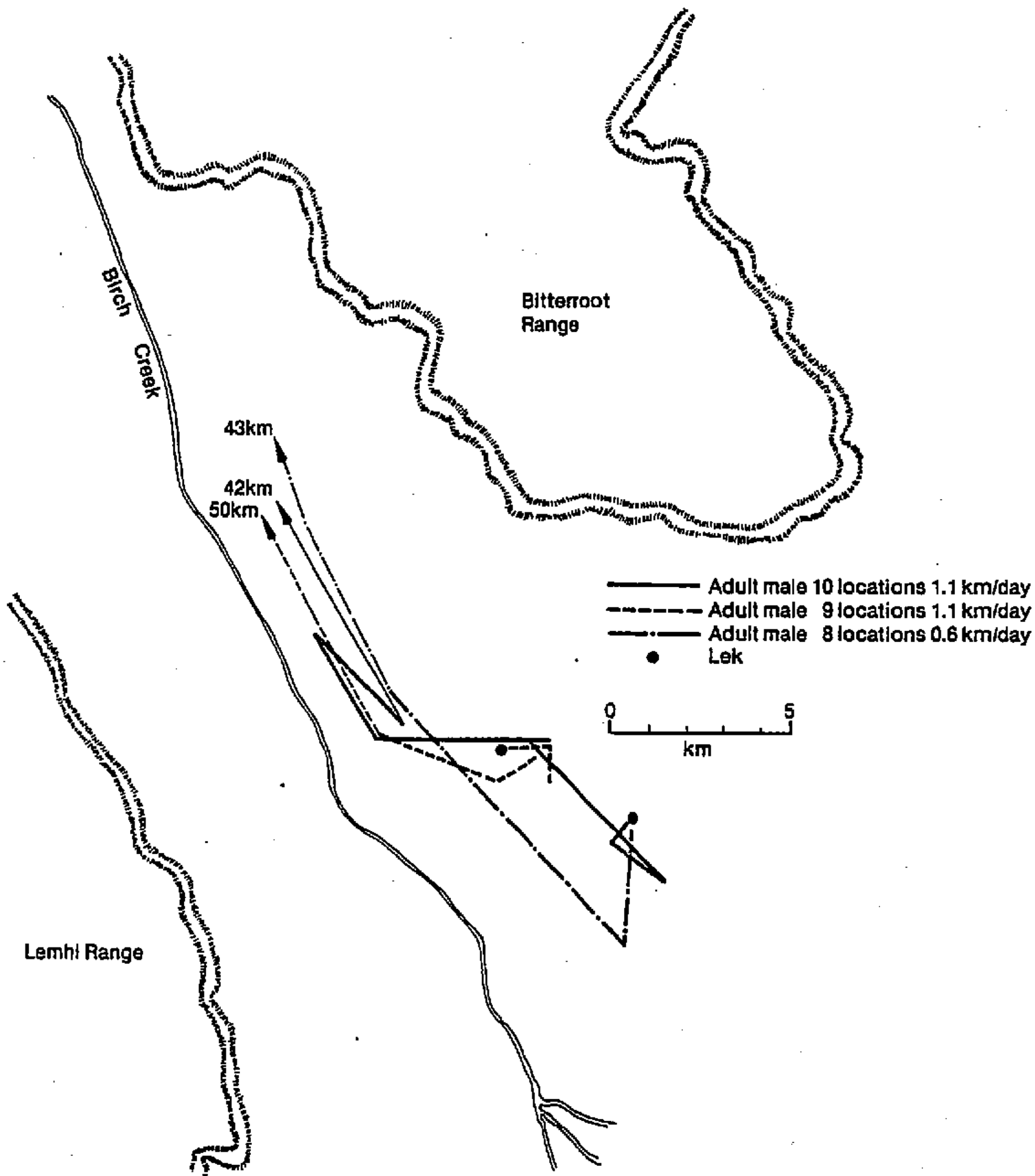

Fig. 2.5. Spring movements of 3 radio-marked male sage grouse in the lower Birch Creek valley during 1978 and 1980. Heavier lines indicate March-April movements and lighter lines indicate May-June movements. The distance moved to summer range, number of locations, and mean daily movement are indicated for each bird.

move directly to summer range after nesting (Fig. 2.6). Instead, these birds made relatively extensive movements in the general area of the lek on which they had been captured. Four radio-marked females occupied mean spring home ranges of 810 ha and moved an average of 0.3 km per day.

For purposes of analysis, data from 2 breeding complexes in the plains area were grouped, even though these complexes were separated by approximately 45 km (Fig. 2.7). Sage grouse males from the plains population moved in a southwesterly direction to summer range while females moved north. The difference between the directions moved to summer range by males and females was significant (chi square test, $P<0.05$). Males also moved farther to summer range ($\overline{X}$ = 30 km, range = 2-55 km, N=11) than did females ($\overline{X}$ = 10 km, range = 2-27 km, N=5), (t test, $P<0.05$).

Limited data on males from the plains population suggest that they also moved directly to summer ranges after leaving their leks in late April and May. Females made relatively extensive movements during the spring. Three radio-marked females occupied a mean home range of 978 ha (Fig. 2.8) and moved an average of 0.6 km per day during the spring.

Mountain valley male sage grouse moved significantly farther to summer range than did plains males or females (ANOVA, $P<0.05$). No differences were detected between spring movements of mountain males and mountain females, mountain females and plains females, or mountain females and plains males ($P>0.05$). However, sample sizes for the female groups from both populations were quite small.

Spring precipitation influenced the distances sage grouse moved to summer range. Grouse from both the mountain valley and plains populations moved farther to summer range in dry springs (Table 2.1), although only mountain valley grouse moved significantly farther (t test, $P<0.05$).

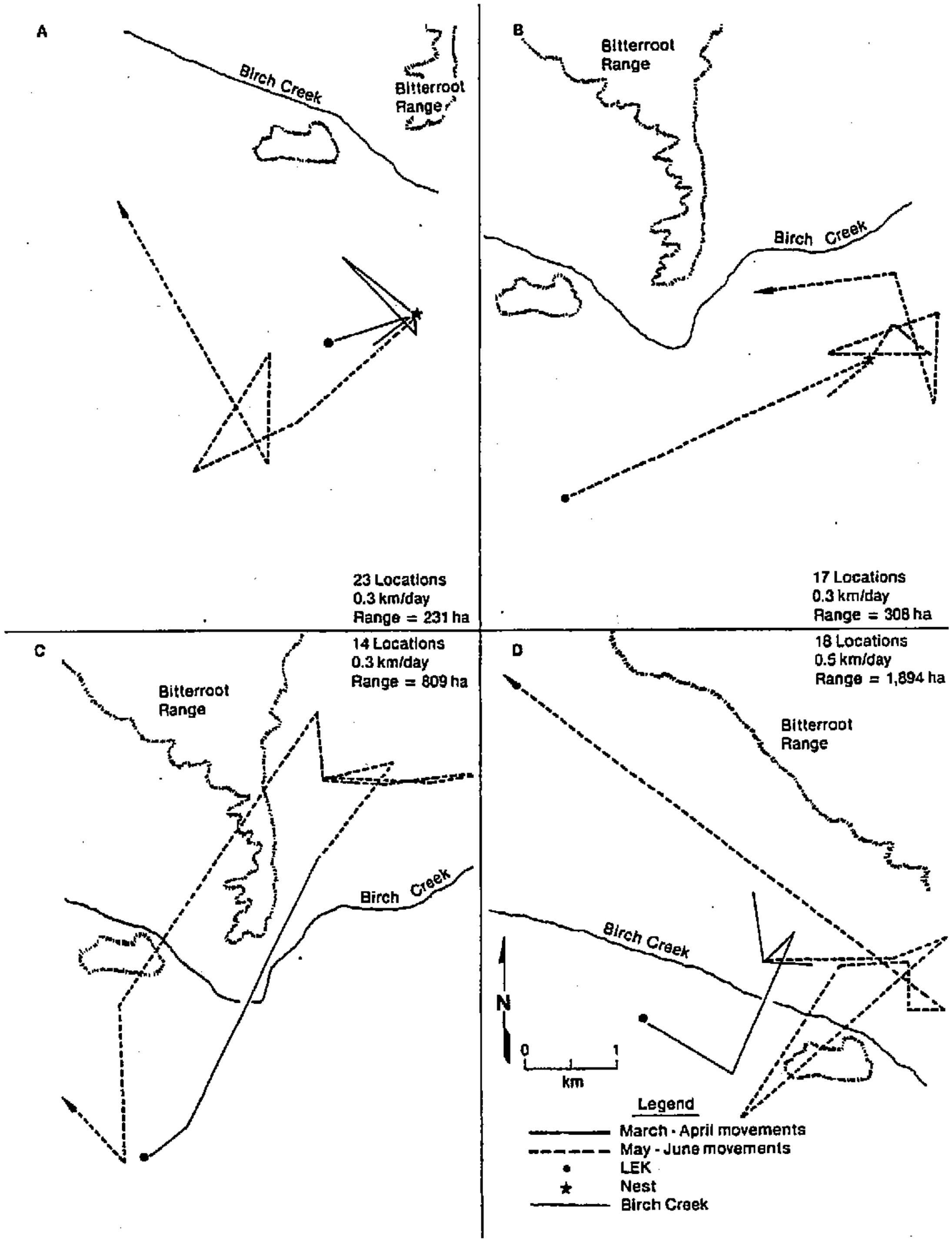

Fig. 2.6. Spring movements of 4 radio-marked female sage grouse in the lower Birch Creek valley during 1980. Females A and B successfully brought off broods; females C and D did not nest. The number of locations, mean daily movement, and spring home range are indicated for each bird.

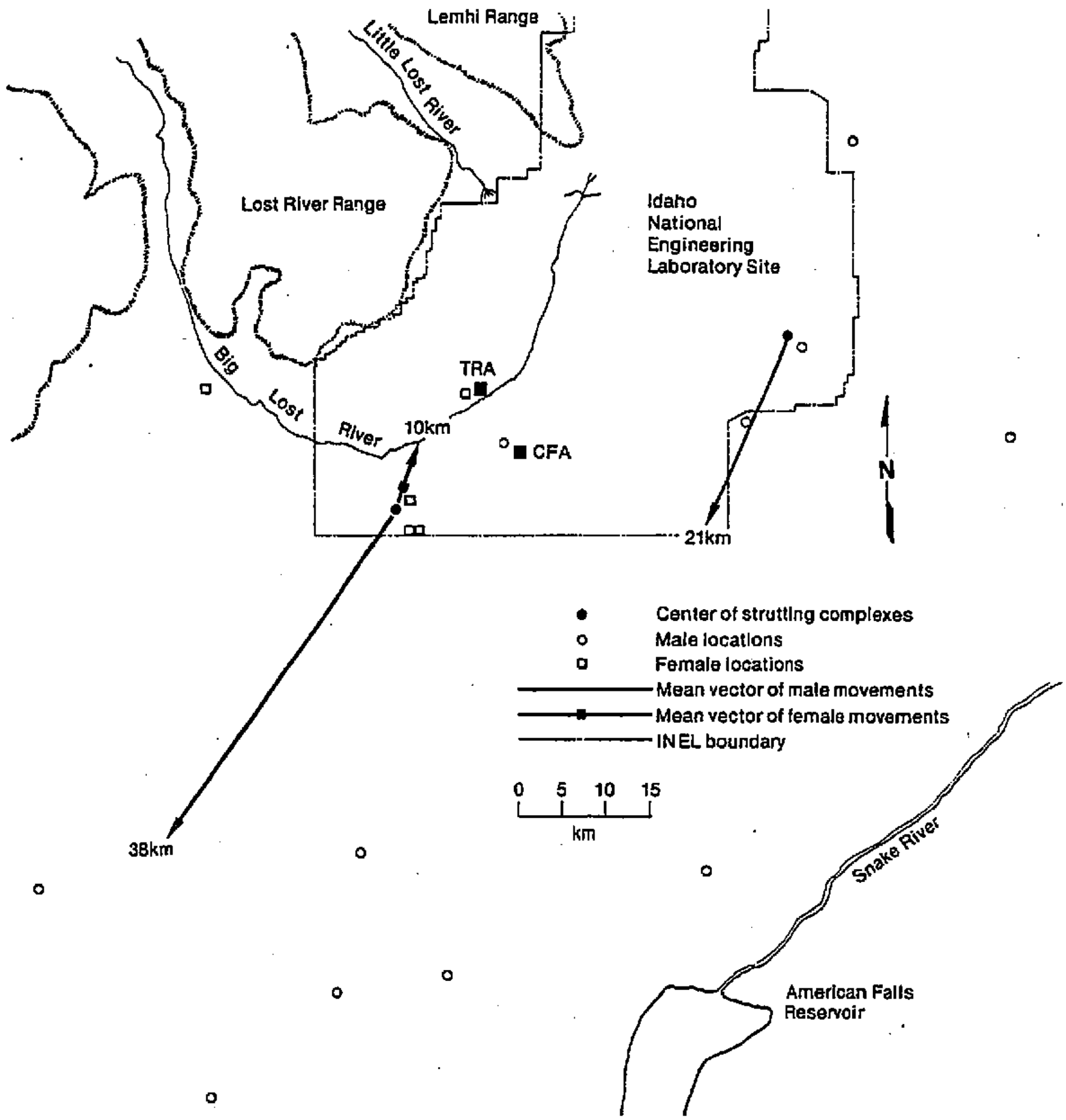

Fig. 2.7. Locations of sage grouse recoveries and mean vectors of spring movements by sage grouse marked on leks in the plains area of the INEL site, 1978 through 1980.

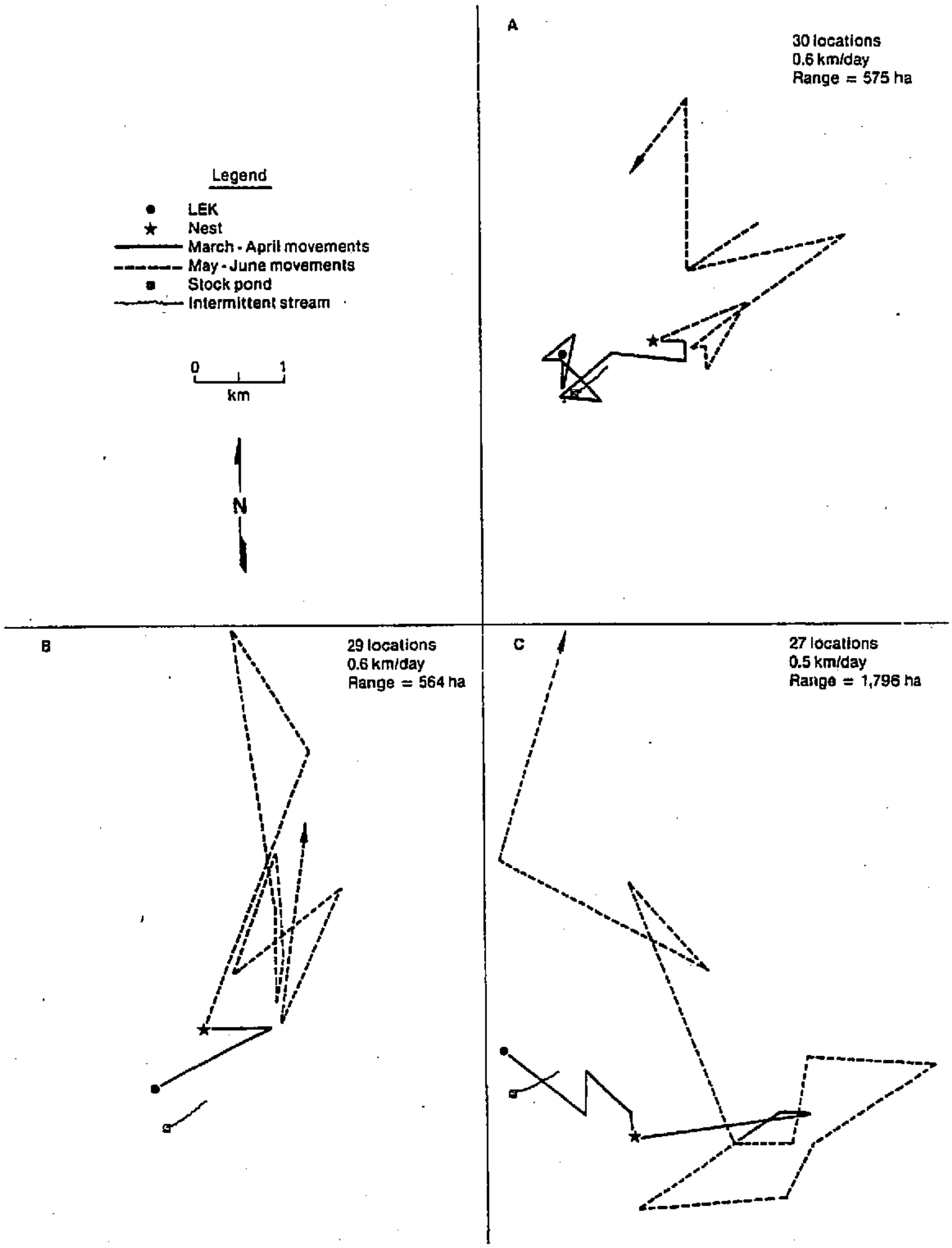

Fig. 2.8. Spring movements of 3 female sage grouse in the plains area of the INEL site during 1980. All 3 grouse nested but none were successful. The number of locations, mean daily movement, and spring home range are indicated for each bird.

Table 2.1. Movements of mountain valley and plains sage grouse from leks to summer range during dry (1978, 1979) and wet (1980) springs on the INEL site. Total April-June precipitation was 5.9 cm, 4.7 cm, and 10.1 cm in 1978, 1979, and 1980, respectively.

	Movements							
	Dry Springs (1978, 1979)				Wet Spring (1980)			
Population	N	$\bar{X}$	SD	Range	N	$\bar{X}$	SD	Range
Mountain Valley[a]	13	51.2	23.0	12-82	10	33.8	21.1	5-62
Plains	4	36.0	23.0	2-55	13	20.8	17.6	2-55

[a]Significant difference between years (t test, $P<0.05$).

Disregarding grouse known to have died the first year in which they were marked, 14% of all grouse marked at CFA and TRA from 1977 through 1979 (N=177) returned in subsequent years. Because these birds used the lawns surrounding CFA and TRA for feeding and loafing, it is likely that all marked grouse that returned to these areas were observed. All sage grouse sex and age classes showed some fidelity to the summer range on which they were marked (Table 2.2). Adult sage grouse returned at a higher rate than juveniles 1 year after marking. Two years after marking, adult males had the highest return rates followed by juvenile females. No second year returns were recorded for adult females or juvenile males. The estimates of these return rates should be considered minimal because they did not take into account undocumented mortality.

Flocking Characteristics

Summer. During this period, 635 sage grouse flocks were recorded. Sage grouse were usually found in segregated flocks during June and July (Fig. 2.9); mixed sex flocks accounted for less than 10% of the total flocks observed during this period. The frequency of mixed sex flocks increased in late summer and comprised 36% of the total number of flocks observed during September. Mean size of each flock type varied only slightly throughout the summer (Table 2.3), although mean flock size differed among flock types (ANOVA, $P<0.01$). Mixed sex flocks were significantly larger than other flock types ($P<0.01$) but differences among male, female, and female/juvenile flocks were not significant ($P>0.05$).

Both precipitation and habitat had some effect on flock sizes. Female flocks were significantly larger in the wet year of 1980 and female/juvenile and mixed sex flocks were significantly smaller than in the drier

Table 2.2. Percentage of marked sage grouse that returned to their summering areas 1 and 2 years after being marked. Sage grouse known to have died less than 1 year after being marked were not included in the calculations.

Age[a]/Sex	Year 1			Year 2		
	Max.[b] No. Available	Returns No.	Returns %	Max. No. Available	Returns No.	Returns %
Adult						
Male	8	2	25	7	2	29
Female	8	2	25	4	0	
Juvenile						
Male	93	6	6	36	0	
Female	68	11	16	31	7	23

[a]Age when marked.

[b]Includes undocumented mortality.

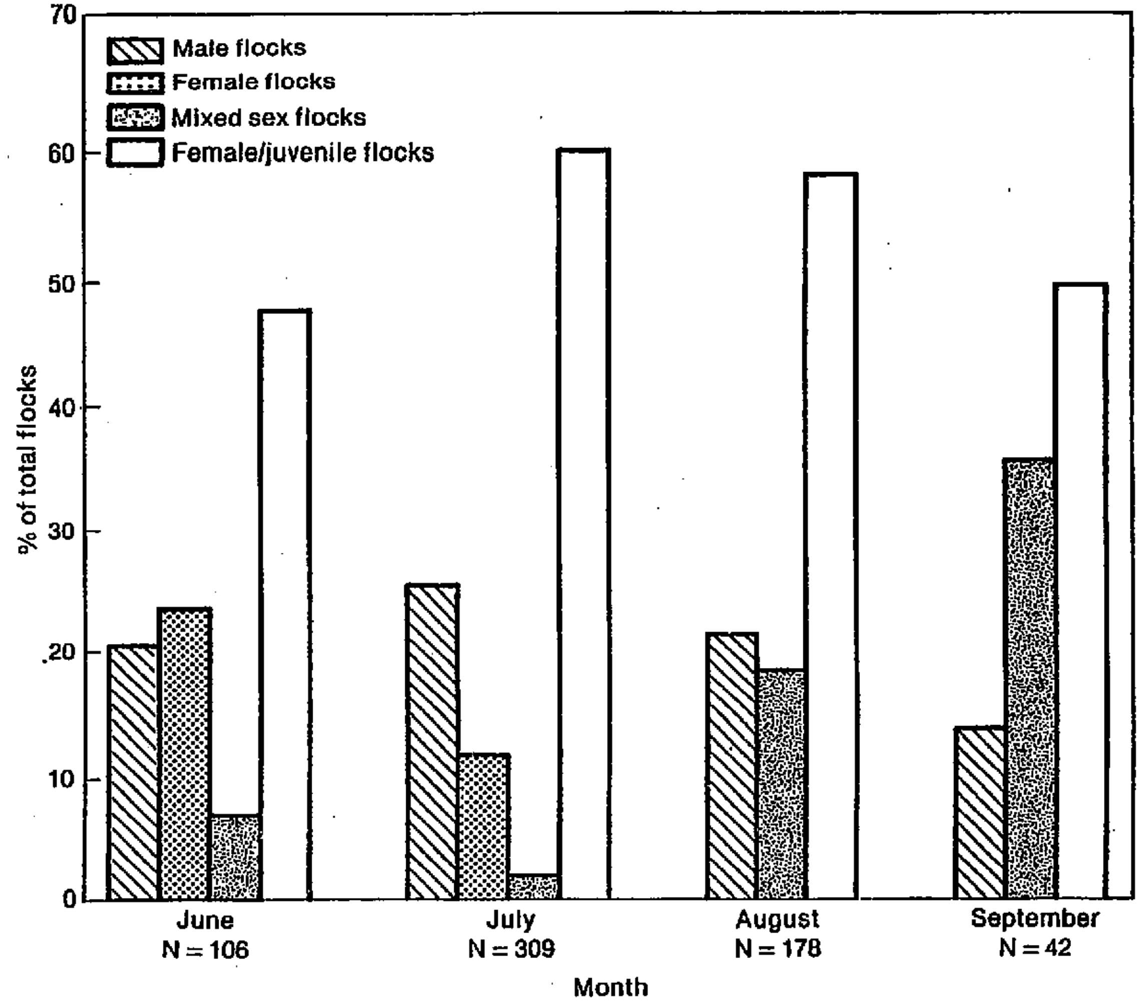

Fig. 2.9. Composition of sage grouse flocks observed during summers, 1977 through 1980, on the INEL site.

Table 2.3. Mean size of sage grouse flocks observed during summer (1 June-30 September) and winter (1 November-15 March), 1977 through 1981, on the INEL site.

	Flock Type															
	Male				Female[a]				Mixed Sex				Female/Juvenile			
Month	N	$\overline{X}$	SD	Range	N	$\overline{X}$	SD	Range	N	$\overline{X}$	SD	Range	N	$\overline{X}$	SD	Range
Summer																
June	22	5.8	8.5	1-39	25	4.8	5.2	1-25	7	9.9	9.4	2-28	52	5.3	2.3	1-13
July	80	3.5	4.2	1-30	36	3.2	4.3	1-18	6	17.8	8.6	9-31	187	5.7	3.7	1-25
August	39	2.4	1.8	1-8					34	14.7	14.5	3-62	108	6.0	4.3	1-24
September	6	3.8	6.0	1-16					15	14.7	15.9	3-59	18	6.1	6.4	1-23
Totals	147	3.6	4.8		61	3.8	4.7		62	14.5	13.8[b]		365	5.8	3.9	
Winter																
November	12	4.6	4.1	1-14	20	14.3	18.2	1-75	6	5.3	2.9	3-11				
December	41	5.5	5.2	1-23	50	11.6	16.4	1-90	5	14.2	12.3	3-35				
January	54	8.7	18.2	1-131	78	11.0	11.6	1-65	17	34.5	35.7	3-135				
February	43	4.4	5.0	1-30	47	14.0	20.8	1-125	11	51.3	68.7	8-200				
March	26	5.5	5.8	1-20	45	16.5	20.2	1-75	14	32.1	36.1	10-150				
Totals[c]	176	6.2	11.0		240	13.0	16.9		53	32.1	42.8					

Table 2.3. Continued.

[a]Female flocks were only identifiable through July, after which they were grouped into the female/juvenile class.

[b]During summer, mixed sex flocks were significantly larger than other summer flock types (ANOVA, $P<0.01$).

[c]Significant difference between means of all flock types during winter (ANOVA, $P<0.01$).

years of 1978 and 1979 (t test, $P<0.05$) (Table 2.4). Male flocks in sagebrush habitat ($\bar{X} = 6.2$, N=26) were significantly larger than those in agricultural areas ($\bar{X} = 2.3$, N=31) (t test, $P<0.05$), but differences among other sage grouse flock types in sagebrush and agricultural habitat were not significant ($P>0.05$).

Winter. Habitat was divided into low sagebrush (*A. arbuscula*) and big sagebrush (*A. tridentata*) cover types and the effects of cover and flock type on winter flock size were examined. A total of 469 sage grouse flocks were recorded during this period. Both cover and flock type had a significant effect on sage grouse flock size (ANOVA, $P<0.01$). Differences among mean sizes of male, female, and mixed sex flocks were significant in both low sagebrush and big sagebrush cover types (Table 2.5). Male and mixed sex sage grouse flocks in low sagebrush habitat were significantly larger than those in big sagebrush habitat ($P<0.05$). No difference was detected between female flocks in low sagebrush and big sagebrush habitat ($P>0.05$).

Most sage grouse remained in segregated flocks throughout the winter. Mixed sex flocks never comprised more than 16% of all flocks recorded in any month from November through March (Fig. 2.10). There was little change in the mean size of male and female flocks during the winter but mixed sex flocks increased in size from November through February, and decreased in March (Table 2.3).

During the winter of 1978-79, more snow fell and average daily temperatures were lower than in the following winters of 1979-80 and 1980-81 (Table 2.6). The mean size of sage grouse flocks during 1978-79 was larger in big sagebrush habitat and smaller in low sagebrush habitat than in the milder winters of 1979-80 and 1980-81 (Table 2.5). However, due to the

Table 2.4. Mean size of sage grouse flocks from 1 June through 30 September during dry and wet years. Total spring/summer (April-July) precipitation was 7.0 cm and 8.1 cm in 1978 and 1979, respectively. Precipitation totaled 11.6 cm in spring/summer 1980.

	Dry Years (1978-1979)			Wet Year (1980)		
Flock Type	No. Flocks	$\overline{X}$	SD	No. Flocks	$\overline{X}$	SD
Male	39	3.6	4.0	23	5.1	8.4
Female[a,b]	10	2.1	2.0	12	6.6	6.8
Female/Juvenile[b]	101	6.4	4.2	34	4.6	3.5
Mixed Sex[b]	24	18.2	16.6	9	8.1	7.8

[a]Female flocks were identifiable through July after which they were grouped into the female/juvenile flock class.

[b]Significant difference between years (t test, $P<0.05$).

Table 2.5. Mean size of sage grouse flocks in low sagebrush and big sagebrush habitats from 1 November through 15 March, 1977-78 through 1980-81, on the INEL site.

	Low Sagebrush				Big Sagebrush			
Flock Type[a]	N	$\bar{X}$	SD	Range	N	$\bar{X}$	SD	Range
Male	68	7.6[b]	16.3	1-131	108	5.0	5.0	1-30
Female	61	14.9	16.0	1-75	179	12.4	17.3	1-125
Mixed Sex	19	45.6[b]	58.0	3-200	34	24.6	29.8	3-150

[a]Significant difference between all flock types within both habitats ($P<0.05$).

[b]Significant difference within flock type between habitats ($P<0.05$).

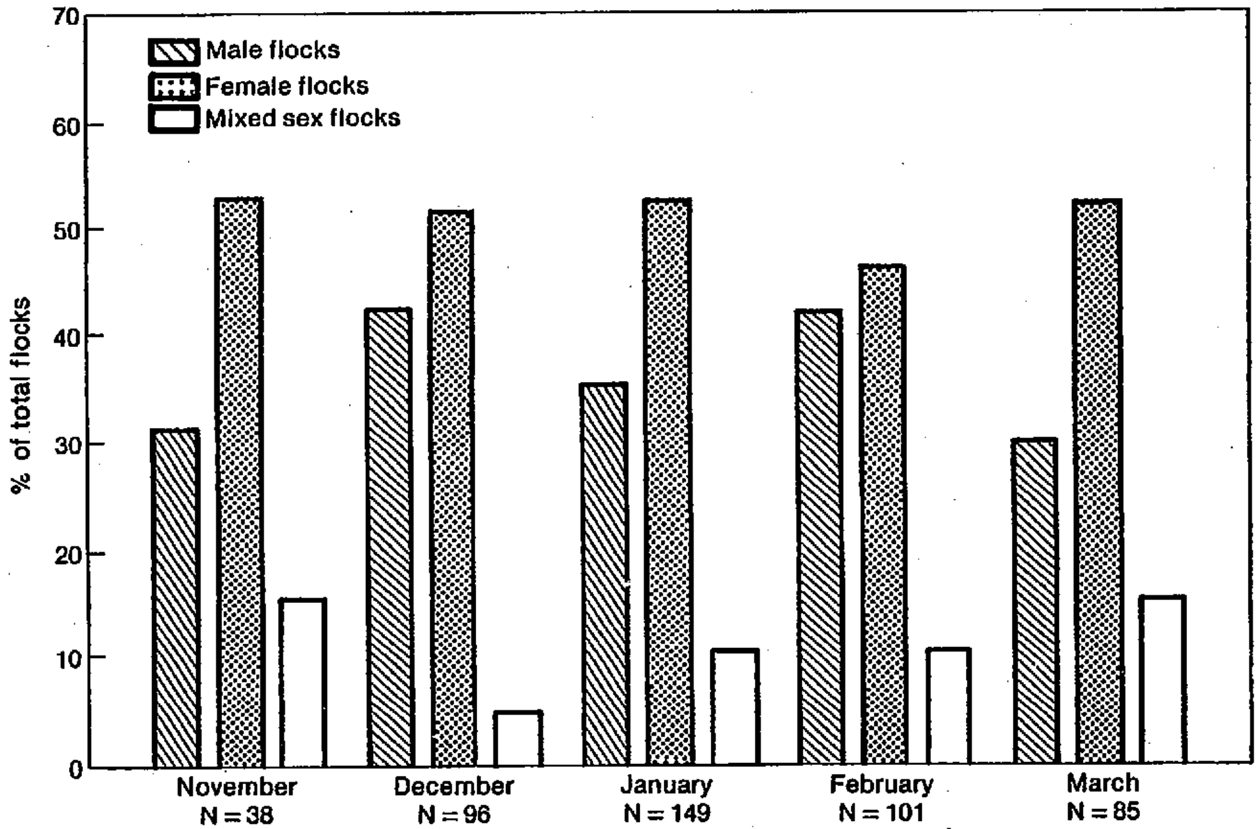

Fig. 2.10. Composition of sage grouse flocks observed during winters, 1978-79 through 1980-81 on the INEL site.

Table 2.6. Mean size of sage grouse flocks in big sagebrush and low sagebrush habitats on the INEL site during relatively harsh (1978-79) and mild winters (1979-80, 1980-81)[a].

	Big Sagebrush						Low Sagebrush					
	1978-79			1979-80/1980-81			1978-79			1979-80/1980-81		
Flock Type	N	$\overline{X}$	SD	N	$\overline{X}$	SD	N	$\overline{X}$	SD	N	$\overline{X}$	SD
Male	32	5	4	76	5	5	47	7	19	20	8	8
Female	87	15	22	92	10	10	25	13	17	36	16	15
Mixed Sex	10	32	43	22	19	16	4	13	14	15	54	62

[a]Total snowfall was 10.9 cm in 1978-79, 7.4 cm in 1979-80 and 9.3 cm in 1980-81. Temperature averaged -6.9°C, -3.5°C, -1.7°C in 1978-79, 1979-80, and 1980-81, respectively.

variation in flock size for all flock types, the differences between years were not significant ($P>0.05$). Regression analyses did not suggest that any single environmental variable (i.e., snow depth, temperature, sagebrush height, or sagebrush canopy coverage) had a strong influence on sage grouse flock size; R^2 values for these regressions ranged from 0.00 to 0.22. Further, multiple regressions indicated that snow depth and mean daily temperature had little effect on the size of male (R^2=0.10), female (R^2=0.10), or mixed sex (R^2=0.09) flocks.

Habitat Use

Summer. Habitat was classified into 4 cover types (Table 2.7). During summers, 289 sage grouse flocks totaling 1,930 birds were recorded along 5 census routes. Seventy-nine percent of all grouse observed along these routes were located in agricultural areas, 14.9% in sagebrush, and 6.1% in disturbed areas. Disturbed areas consisted of dikes and flood control basins near the Big Lost River and contained scattered rabbitbrush and big sagebrush plants as well as a variety of annual forbs. These disturbed areas comprised only 2% of the total habitats available along the census routes. Sage grouse were never observed in crested wheatgrass plantings during the summer. Differences in habitat use were significant for all flock types (chi-square test, $P<0.01$). Adult males and broods preferred agricultural and disturbed areas. Females and birds occurring in mixed sex flocks also preferred agricultural areas, but used disturbed areas in proportion to their occurrence (Table 2.7).

All sage grouse recorded in the agricultural area were within 500 m of free water, but grouse summering in sagebrush and disturbed areas were not closely associated with water; 89% of all grouse recorded in these areas

Table 2.7. Occurrence of sage grouse in 4 habitats along summer census routes on the INEL site, 1977 through 1980. Female flocks were only identified in June and July and thereafter were grouped with female/juvenile flocks.

Habitat	Proportion of Habitat Available (H)[a]	Number Observed	Number Expected[b]	Proportion Observed ($\bar{p}$)	Confidence Interval on Proportion Observed (P_i)[c]
Total Grouse					
Sagebrush	.758	288	1,463	.149	$.131 \le P_1 \le .167$
Agriculture/Sage	.145	1,524	280	.790	$.769 \le P_2 \le .811$
Disturbed Area	.021	118	40	.061	$.049 \le P_3 \le .073$
Grass[d]	.076	0	147	—	
Total (T)	1.000	1,930	1,930	1.000	
Males					
Sagebrush	.758	40	252	.120	$.080 \le P_1 \le .160$
Agriculture/Sage	.145	272	49	.817	$.770 \le P_2 \le .864$
Disturbed Area	.021	21	7	.063	$.033 \le P_3 \le .093$
Grass[d]	.076	0	25	—	
Total (T)	1.000	333	333	1.000	
Females					
Sagebrush	.758	33	147	.170	$.110 \le P_1 \le .230$
Agriculture/Sage	.145	155	28	.799	$.735 \le P_2 \le .863$
Disturbed Area	.021	6	4	.031	$.003 \le P_3 \le .059$
Grass[d]	.076	0	15	—	
Total (T)	1.000	194	194	1.000	
Mixed Sex					
Sagebrush	.758	20	390	.039	$.020 \le P_1 \le .058$
Agriculture/Sage	.145	485	75	.942	$.919 \le P_2 \le .965$
Disturbed Area	.021	10	11	.019	$.006 \le P_3 \le .032$
Grass[d]	.076	0	39	—	
Total (T)	1.000	515	515	1.000	

Table 2.7. Continued.

Habitat	Proportion of Habitat Available (H)[a]	Number Observed	Number Expected[b]	Proportion Observed $(\bar{p})$	Confidence Interval on Proportion Observed (P_i)[c]
Female/Juvenile					
Sagebrush	.758	194	653	.225	$.193 \le P_1 \le .257$
Agriculture/Sage	.145	587	125	.681	$.645 \le P_2 \le .717$
Disturbed Area	.021	81	18	.094	$.072 \le P_3 \le .116$
Grass[d]	.076	0	66	--	
Total (T)	1.000	862	862	1.000	

[a]Proportions of total habitat (H) represent expected grouse observation values if grouse occurred in each habitat type in exact proportion to availability.

[b]Calculated by multiplying H x T; i.e., .758 x 1,930 = 1,463.

[c]P_i represents the theoretical proportion of occurrence and is compared to H to determine if the hypothesis of proportional use is accepted or rejected (Neu et al. 1974). If H lies within the 90% confidence interval, the habitat is used in proportion to its occurrence; if $P_i > H$, the habitat is preferred and if $P_i < H$, the habitat is avoided.

[d]Crested wheatgrass planting.

were located more than 2 km from free water. Mean distance to water for all grouse observed in sagebrush and disturbed areas was 5.0 km and ranged from 0.1 to 12.9 km.

Winter. Habitats in both the mountain valley and plains areas were characterized according to the 3 most abundant plant species. These cover types were similar to those recognized by McBride et al. (1978) but all species of grass were grouped and winterfat (*Eurotia lanata*), saltbush (*Atriplex confertifolia*), and horsebrush (*Tetradymia canescens*) were classified together as low shrubs. Four cover types were recognized in the mountain valley area (Table 2.8) and 6 in the plains area (Table 2.9).

During winters, 103 flocks totaling 1,993 sage grouse were recorded in the mountain valley area, and habitat use by these birds varied significantly from the expected (chi-square test, $P<0.01$). Overall, the low sagebrush habitat was preferred and the others were used in proportion to their occurrence or avoided (Table 2.8). Habitat use differed among flock types. Males showed no preference for any single habitat but avoided big sagebrush/rabbitbrush/grass areas. Females also avoided this habitat and preferred areas characterized by big sagebrush and low shrubs. Sage grouse occurring in mixed sex flocks avoided all big sagebrush habitats and showed a rather strong preference for low sagebrush areas. The habitat that was avoided by all grouse had a lower density and canopy coverage of sagebrush than the other sagebrush habitats in the mountain valley area (Table 2.10).

In the plains area, 127 flocks totaling 1,229 sage grouse were recorded during winters. Differences in habitat use by sage grouse in this area were also significant (chi-square test, $P<0.01$). Overall, a preference

Table 2.8. Occurrence of sage grouse in 4 habitats along winter census routes in the lower Birch Creek valley on the INEL site, 1978-79 through 1980-81.

Habitat	Proportion of Habitat Available (H)[a]	Number Observed	Number Expected[b]	Proportion Observed ($\bar{p}$)	Confidence Interval on Proportion Observed (P_I)[c]
Total Grouse					
Sage/rabbitbrush/ grass	.154	42	307	.021	$.014 \leq P_1 \leq .028$
Sage/low shrub/ rabbitbrush	.528	1,062	1,052	.533	$.508 \leq P_2 \leq .558$
Sage/low shrub/ low shrub	.258	454	514	.228	$.207 \leq P_3 \leq .249$
Low sage	.060	435	120	.218	$.197 \leq P_4 \leq .239$
Total (T)	1.000	1,993	1,993	1.000	
Males					
Sage/rabbitbrush/ grass	.154	1	8	.019	$-.023 \leq P_1 \leq .061$
Sage/low shrub/ rabbitbrush	.528	30	29	.555	$.404 \leq P_2 \leq .706$
Sage/low shrub/ low shrub	.258	19	14	.352	$.206 \leq P_3 \leq .498$
Low sage	.060	4	3	.074	$-.006 \leq P_4 \leq .154$
Total (T)	1.000	54	54	1.000	
Females					
Sage/rabbitbrush grass	.154	0	98		
Sage/low shrub/ rabbitbrush	.528	392	336	.615	$.572 \leq P_1 \leq .658$
Sage/low shrub/ low shrub	.258	203	165	.319	$.278 \leq P_2 \leq .360$
Low sage	.060	42	38	.066	$.044 \leq P_3 \leq .088$
Total (T)	1.000	637	637	1.000	

Table 2.8. Continued.

Habitat	Proportion of Habitat Available (H)[a]	Number Observed	Number Expected[b]	Proportion Observed ($\bar{p}$)	Confidence Interval on Proportion Observed (P_i)[c]
Mixed Sex					
Sage/rabbitbrush/ grass	.154	41	111	.057	$.038 \leq P_1 \leq .076$
Sage/low shrub/ rabbitbrush	.528	281	379	.391	$.350 \leq P_2 \leq .432$
Sage/low shrub/ low shrub	.258	47	185	.066	$.045 \leq P_3 \leq .087$
Low sage	.060	349	43	.486	$.444 \leq P_4 \leq .528$
Total (T)	1.000	718	718		

[a]Proportions of total habitat (H) represent expected grouse observation values if grouse occurred in each habitat type in exact proportion to availability.

[b]Calculated by multiplying H x T; i.e., .154 x 1,993 = 307.

[c]P_i represents the theoretical proportion of occurrence and is compared to H to determine if the hypothesis of proportional use is accepted or rejected (Neu et al. 1974). If H lies within the 90% confidence interval, the habitat is used in proportion to its occurrence; if $P_i > H$, the habitat is preferred and if $P_i < H$, the habitat is avoided.

Table 2.9. Occurrence of sage grouse in 6 habitats along winter census routes in the plains area of the INEL site, 1978-79 through 1980-81.

Habitat	Proportion of Habitat Available (H)[a]	Number Observed	Number Expected[b]	Proportion Observed ($\bar{p}$)	Confidence Interval on Proportion Observed (P_i)[c]
Total Grouse					
Sage/rabbitbrush/ grass	.525	616	645	.501	$.467 \leq P_1 \leq .535$
Sage/grass/grass	.313	433	385	.352	$.319 \leq P_2 \leq .385$
Crested wheatgrass	.050	0	61		
Grass/rabbitbrush/ sage	.048	172	59	.140	$.116 \leq P_4 \leq .164$
Agriculture/sage	.047	0	58		
Sage/low shrub/ rabbitbrush	.017	8	21	.007	$.001 \leq P_6 \leq .013$
Total (T)	1.000	1,229	1,229	1.000	
Males					
Sage/rabbitbrush/ grass	.525	149	129	.608	$.533 \leq P_1 \leq .683$
Sage/grass/grass	.313	50	77	.204	$.142 \leq P_2 \leq .265$
Crested wheatgrass	.050	0	12	--	
Grass/rabbitbrush/ sage	.048	38	12	.155	$.100 \leq P_4 \leq .210$
Agriculture/sage	.047	0	11	--	
Sage/low shrub/ rabbitbrush	.017	8	4	.033	$.066 \leq P_6 \leq .060$
Total (T)	1.000	245	245	1.000	

Table 2.9. Continued.

Habitat	Proportion of Habitat Available (H)[a]	Number Observed	Number Expected[b]	Proportion Observed ($\bar{p}$)	Confidence Interval on Proportion Observed (P_i)[c]
Females					
Sage/rabbitbrush/grass	.525	302	370	.428	$.383 \leq P_1 \leq .473$
Sage/grass/grass	.313	269	221	.382	$.338 \leq P_2 \leq .426$
Crested wheatgrass	.050	0	35	--	
Grass/rabbitbrush/sage	.048	134	34	.190	$.155 \leq P_3 \leq .225$
Agriculture/sage	.047	0	33	--	
Sage/low shrub/rabbitbrush	.017	0	12	--	
Total (T)	1.000	705	705	1.000	
Mixed Sex					
Sage/rabbitbrush/grass	.525	153	134	.600	$.526 \leq P_1 \leq .674$
Sage/grass/grass	.313	102	80	.400	$.326 \leq P_2 \leq .474$
Crested wheatgrass	.050	0	13	--	
Grass/rabbitbrush/sage	.048	0	12	--	
Agriculture/sage	.047	0	12	--	
Sage/low shrub/rabbitbrush	.017	0	4	--	
Total (T)	1.000	255	255	1.000	

[a]Proportions of total habitat (H) represent expected grouse observation values if grouse occurred in each habitat type in exact proportion to availability.

[b]Calculated by multiplying H x T; i.e., .525 x 1,229 = 645.

[c]P_i represents the theoretical proportion of occurrence and is compared to H to determine if the hypothesis of proportional use is accepted or rejected (Neu et al. 1974). If H lies within the 90% confidence interval, the habitat is used in proportion to its occurrence; if $P_i > H$, the habitat is preferred and if $P_i < H$, the habitat is avoided.

Table 2.10. Sagebrush characteristics of 6 vegetative types in sage grouse winter range on the INEL site, 1978-79 through 1980-81.

Vegetation	Density (per m^2)			Canopy Coverage (%)			Height (cm)[d]		
	N[c]	$\bar{X}$	SD	N	$\bar{X}$	SD	N	$\bar{X}$	SD
Sage/rabbitbrush/[a,b] grass	11	1.6	1.0	11	18.3	5.3	11	25.3	6.7
Sage/grass/[b] grass	12	1.5	0.5	10	28.5	9.7	12	38.7	10.1
Grass/rabbitbrush/[b] sage	5	1.5	1.0	5	20.3	17.9	5	28.3	11.2
Sage/low shrub/[a,b] rabbitbrush	8	2.2	1.8	8	19.2	7.4	8	26.0	6.8
Sage/low shrub/[a] low shrub	12	2.6	1.0	12	27.9	14.5	12	21.6	6.2
Low Sage[a]	13	3.2	1.8	13	22.0	8.7	14	16.3	6.6

[a]Available in mountain valley area.

[b]Available in plains area.

[c]Number of plots.

[d]Height of exposed plant.

was shown only for the grass/rabbitbrush/big sagebrush area, and other habitats were used in proportion to their occurrence or avoided (Table 2.9). Sage grouse were never observed in crested wheatgrass plantings or the agricultural area during winter. Habitat use differed among flock types in the plains area as it did in the mountain valley area. Males preferred big sagebrush/rabbitbrush/grass and grass/rabbitbrush/big sagebrush habitats and avoided or used other habitats in proportion to their occurrence. Females preferred big sagebrush/grass/grass and grass/rabbitbrush/big sagebrush habitats and avoided all others. Generally, males preferred habitats with a lower sagebrush canopy coverage and height than did females in the plains area (Table 2.10).

Sagebrush density, height, and canopy coverage at sage grouse winter use sites with and without snow cover were compared to the same characteristics in control areas (Table 2.11). Control areas were locations along census routes not used by sage grouse, although crested wheatgrass plantings were not used as control sites because they were obviously different from sage grouse winter range. At different locations within each area, 62 flock site analyses were made in grouse winter range and 32 site analyses were made in control areas. Generally, areas used as winter range in big sagebrush habitats had a higher density of sagebrush and lower height of exposed sagebrush above the snow than control areas (Table 2.11). Canopy coverage between areas did not differ significantly (t test, $P>0.05$). All low sagebrush habitat appeared to be used as winter range. Low sagebrush habitat was characterized by denser and lower sagebrush than big sagebrush winter habitat (Table 2.10). Canopy coverage in big sagebrush and low sagebrush habitats was not significantly different ($P>0.05$).

Table 2.11. Sagebrush characteristics of sage grouse winter range compared to control areas when the ground was covered by snow and free from snow. Data was collected on the INEL site during winters, 1978-79 through 1980-81.

	Big Sagebrush									Low Sagebrush								
	Density[a]			Height (cm)			Canopy (%)			Density[a]			Height (cm)			Canopy (%)		
Type	$\bar{X}$	SD	N	$\bar{X}$	SD	N	$\bar{X}$	SD	N	$\bar{X}$	SD	N	$\bar{X}$	SD	N	$\bar{X}$	SD	N
No Snow																		
Winter Range	2.5[b]	1.6	15	25.6	9.2	15	24.2	14.0	15	4.2	2.7	4	14.1	6.2	5	20.3	8.0	4
Control	1.3	1.0	24	31.2	12.5	23	17.9	12.8	24									
Snow Cover																		
Winter Range	1.7	0.7	33	29.3[b]	10.4	33	24.2	12.3	32	2.8	1.2	9	16.9	6.6	9	22.2	9.6	9
Control	1.4	0.8	8	44.8	14.2	7	27.7	12.6	8									

[a] Plants/m^2.

[b] Significant difference between winter range and control areas ($P<0.01$).

Sagebrush characteristics of sites used by male, female, and mixed sex flocks in big sagebrush habitats were not significantly different (ANOVA, $P>0.05$) (Table 2.12). However, sites used by mixed sex flocks tended to have a lower sagebrush density and less canopy coverage.

Sagebrush density, height of exposed plant, and canopy coverage at sage grouse winter use sites did not differ under 3 levels of snow depth (ANOVA, $P>0.05$) (Table 2.13). If the total height of the sagebrush was considered, rather than just the exposed height, the differences were significant (ANOVA, $P<0.01$), suggesting that sage grouse moved to areas with higher sagebrush as snow depth increased (Table 2.13).

Sage grouse winter ranges were closely associated with breeding complexes on the INEL site. Summer ranges were often located more than 30 km from wintering/breeding areas, although a few summering areas were located within 10 km of winter ranges and breeding complexes (Fig. 2.11).

DISCUSSION

Some adult sage grouse summering on the INEL site moved more than 60 km to winter range and juveniles dispersed over 80 km, even though census route and radio-telemetry data indicated that suitable winter habitat occurred much closer to their summer range (Fig. 2.11). Since sage grouse winter range occurs in close proximity to leks on the INEL site, adult movements to winter range represent their return to traditional breeding areas. Fall movements of juvenile sage grouse (Connelly 1981) suggest that these birds are dispersing in random directions. These random movements may occur throughout the winter and spring as has been suggested for juvenile prairie chickens (*Tympanuchus cupido*) (Bowman and Robel 1977).

Spring movements by female grouse were slow and meandering when compared to the rapid and direct movements of males. Further, spring

Table 2.12. Sagebrush characteristics of winter range used by male and female sage grouse and by grouse occurring in mixed sex flocks on the INEL site, 1978-79 through 1980-81.

	Density[a]			Height (cm)			% Canopy Coverage		
Flock	$\overline{X}$	SD	N	$\overline{X}$	SD	N	$\overline{X}$	SD	N
Male	2.0	1.6	10	26.4	10.0	10	25.2	12.7	10
Female	2.1	1.1	30	28.6	10.8	30	25.5	13.7	30
Mixed	1.3	0.3	8	28.7	7.9	8	18.1	7.2	8

[a]Plants/m^2.

Table 2.13. Sagebrush characteristics of sage grouse winter use sites under 3 snow levels in big sagebrush habitats on the INEL site, 1978-79 through 1980-81.

	Snow Level								
	< 2 cm			2.1 - 6 cm			> 6 cm		
	$\bar{X}$	SD	N	$\bar{X}$	SD	N	$\bar{X}$	SD	N
Density[a]	2.5	1.6	15	1.8	0.9	13	1.6	0.6	20
Height[b] (cm)	25.6	9.2	15	31.6	14.0	13	27.7	7.2	20
Height[c] (cm)	25.6	9.2	15	35.1[d]	14.0	13	39.0[d]	6.8	20
Canopy(%)	24.2	14.0	15	24.2	14.2	12	24.2	11.3	20

[a]Plants/m^2.

[b]Total height of plant above snow.

[c]Total height of plant.

[d]Mean total height of sagebrush is significantly different from mean total height when snow is < 2 cm ($P<0.05$).

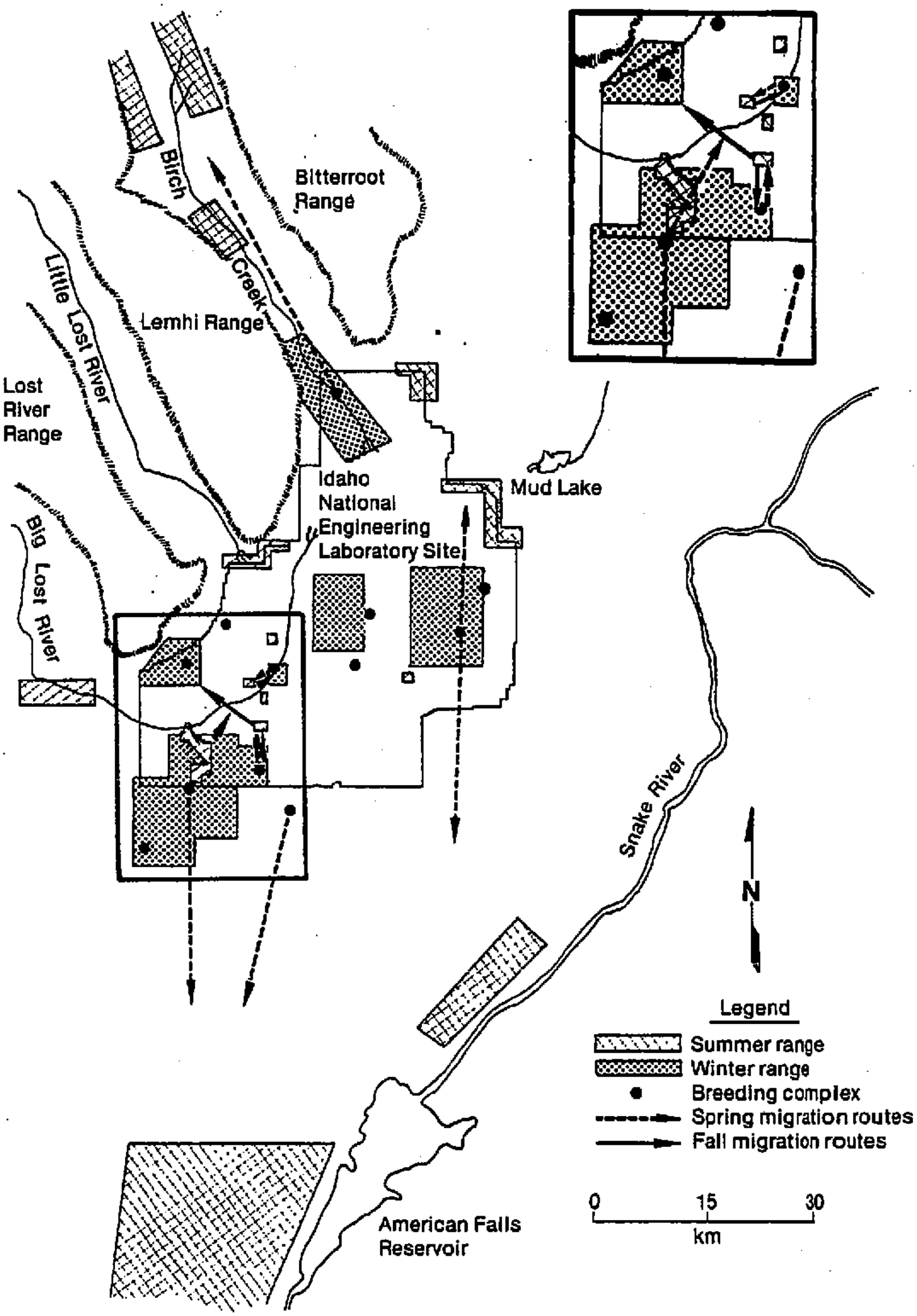

Fig. 2.11. Locations of major sage grouse seasonal ranges, breeding complexes, and migration routes on and near the INEL site.

movements by successful and unsuccessful females were similar. Many grouse from leks in the plains and mountain valley areas moved more than 30 km to summer range even though there was suitable summer habitat much closer (Fig. 2.11). In the plains areas, most males moved south to summer range up to 55 km from their leks instead of moving approximately 10 km north to INEL facilities or 25 km northwest to agricultural fields. Similarly, in the mountain valley area, many sage grouse moved more than 50 km to summer range even though agricultural fields occurred 15 km to the east. These movements are probably the result of traditional migratory patterns established before agricultural developments created suitable summer range closer to breeding areas. Random movements from leks by some yearlings probably accounts for the use of more recently developed summer range. The tendency of males to move longer distances, and in a different direction than females, may serve to reduce competition between the sexes.

Dalke et al. (1963) indicated that sage grouse from leks on the upper Snake River Plain made long distance seasonal migrations. Sage grouse breeding on the INEL site occurred at lower elevations than those studied by Dalke et al. (1960, 1963), yet they also underwent long distance seasonal migrations. Klebenow (1969) suggested that sage grouse broods moved to higher elevations as more food plants became available in these areas. This may also explain spring movements of sage grouse breeding in the mountain valley area of the INEL site. The plains population of sage grouse on the INEL site did not follow an elevational gradient to summer range, but they apparently moved to more moist areas as plants in the sagebrush habitat began to cure.

Weather influenced spring movements of sage grouse breeding on the INEL site. These birds did not move as far to summer range during the wet spring of 1980 as they did in the drier springs of 1978 and 1979. Apparently grouse summered in areas along their migration routes during the wet spring that were not usually suitable in dry years, although a more intensive radio-tracking effort would be needed to support this hypothesis.

Sage grouse returned to the same summer range on which they were marked for up to 3 years after their capture. Reobservations of these marked grouse on the same summer range year after year indicates that sage grouse use traditional summer ranges. Gill (1965) has also suggested that Colorado sage grouse use traditional summer ranges.

Braun (1977) reported that yearling male sage grouse had a higher survival rate than adult males. Female grouse generally have been found to have higher survival rates than males (June 1963, Braun 1977). However, no differences were detected among survival rates of any of the sex and age classes of prairie chickens in Wisconsin (Hammerstrom and Hammerstrom 1973). In this study, adults returned at a higher rate than juveniles the first year after marking, suggesting that either the juvenile age class is subject to a higher mortality rate during this first year or that they use other areas during their second summer. Further, no second year returns to summer range were recorded for sage grouse marked as adult females or juvenile males, suggesting that these groups may have lower survival rates than adult males or juvenile females. It is also possible that the lack of returns for adult females and juvenile males may be the result of a relatively small sample size.

Summer home ranges for sage grouse in the plains area on the INEL site averaged 260 ha (Connelly 1981) and were generally smaller than spring ($\overline{X}$ = 882 ha for both mountain valley and plains populations) and fall ($\overline{X}$ = 2,246 ha) ranges. Fall home ranges were similar to winter home ranges

($\overline{X}$ = 1,816 ha) reported by Eng and Schladweiler (1972). Estimates for spring and fall home ranges were somewhat inflated because they included long distance movements towards seasonal ranges for 1 grouse monitored during spring and 1 bird monitored during fall. Nevertheless, these seasonal ranges were still relatively large and support the contentions that sage grouse need vast expanses of suitable habitat (Eng and Schladweiler 1972, Wallestad 1975) and that the protection of sagebrush within a 3.2 km radius of leks is not sufficient (Beck 1977).

Patterson (1952) indicated that sage grouse remained in segregated flocks throughout the summer. During this study, sage grouse were found in segregated flocks during early summer but the number of mixed sex flocks increased in August and September. Past research has also suggested that flock size increases during late summer (Dalke et al. 1963). The size of male and female/juvenile flocks on the INEL site did not increase in late summer. Instead, the frequency of mixed sex flocks increased (Fig. 9) and these flocks were significantly larger than other flock types.

Although female flocks were significantly larger in the wet year (1980) and female/juvenile and mixed sex flocks were significantly smaller than in the drier years (1978, 1979), these differences were probably a reflection of the poor production that occurred during 1980 (R. E. Autenrieth, pers. comm.). Even though male flocks were larger in sagebrush than agricultural habitats, little difference was detected in the size of the other flock types in these 2 habitats. The difference in the size of male flocks in sagebrush and agricultural habitats is difficult to understand.

Wallestad (1972, 1975) indicated that Montana sage grouse group into larger flocks during severe weather (i.e., deep snow) while Beck (1977) suggested that sage grouse cope with severe winter weather by breaking up into smaller flocks. Weather and habitat variables, such as canopy coverage and density, seemed to have little influence on sage grouse flock size during the winter on the INEL site. However, flock size did differ somewhat between relatively severe and mild winters during this study. Sage grouse were found in smaller flocks in low sagebrush areas and in larger flocks in big sagebrush habitat during the severe winter, although these differences were not significant. This suggests that when snow is deep enough to decrease the food supply such as in the low sagebrush habitat, sage grouse may respond by forming smaller flocks. If winter conditions are severe but food is not limited, such as in the big sagebrush habitat, grouse may respond by grouping into larger flocks. Under severe winter conditions sage grouse are more visible and larger flocks may afford better protection from predators (Patterson 1952). It appears that winter conditions during this study were not severe enough to elicit much of a change in grouse flocking behavior. Instead, sage grouse responded to increasing snow depths by moving into areas of denser and taller sagebrush where existing vegetative characteristics were similar to those in the areas they used prior to snowfall.

Although weather did not seem to affect winter flock sizes, flock composition and habitat had a strong influence. The smaller size of male flocks was probably due to fewer males in the population, although males may also be less gregarious than females. Male and mixed sex flocks were larger in low sagebrush than big sagebrush habitat. Sage grouse were highly visible in low sagebrush habitat and larger flocks may serve as a predator avoidance system. Brown (1975) stated that larger groups of animals are characteristic of flat, open country with few hiding places. In such areas, the ability of the sage grouse to locate a potential predator before it approaches closely may be of utmost importance. Patterson (1952) discussed the importance of sage grouse flocking to avoid predation, and Hartzler (1974) suggested that predation has influenced the evolution of sage grouse social systems.

INEL sage grouse began arriving on summer range in early to mid-June and often remained through early fall, although the arrival, departure, and length of stay on summer range varied greatly among individual birds. The use of these areas by grouse did not appear to be greatly influenced by spring/summer precipitation as Oakleaf (1971) has suggested for Nevada sage grouse. Wallestad (1971) indicated that sage grouse spend a large portion of the summer in sagebrush habitat. However, in this study, less than 15% of all grouse observed during summers were found in sagebrush habitat. Sage grouse showed a strong preference for agricultural habitat and disturbed areas and both of these habitats were vital components of sage grouse summer range at low elevations. Summer habitat use data were not biased due to a greater visibility of sage grouse in agricultural areas because alfalfa and vegetation bordering agricultural fields provided as much or more cover than sagebrush.

Patterson (1952) reported that sage grouse do not need free water but will use it when available. Similarly, INEL sage grouse that summered in sagebrush habitats were not closely associated with water. Sage grouse did not congregate near water sources in late summer as reported by Dalke et al. (1963) and Klebenow (1969). The most important function of water on sage grouse summer range may be to provide succulent vegetation.

Both Ihli et al. (1973) and Beck (1977) reported little use of crested wheatgrass plantings by sage grouse. The crested wheatgrass areas used as leks on the INEL site contained small, scattered stands of sagebrush.

In spite of this, sage grouse were never observed in these areas at any other time of the year, suggesting that these plantings are totally unsuitable as winter or summer range.

Use of cover types by male and female sage grouse wintering on the INEL site differed, although sagebrush characteristics (density, canopy coverage, and height) of winter use sites by male and female grouse were similar. However, female sage grouse on winter range in Colorado used sagebrush stands that were denser and taller than those used by males (Beck 1977). Lance (1978) indicated that forage nutrient content influences use of areas by red grouse (Lagopus lagopus). This may also account for differences in habitat use between sexes among sage grouse and more fully explain why some areas of winter range received little use by sage grouse. Information on forage quality and nutrient content of sage grouse winter use sites is needed.

During this study, 53% of the sage grouse observed on winter range occurred in areas with a canopy coverage greater than 20%, and 89% of the observations occurred in areas with greater than 10% canopy coverage. Montana sage grouse preferred winter range with sagebrush canopy coverage greater than 20% (Eng and Schladweiler 1972). Perhaps grouse wintering in southeastern Idaho use less dense stands of sagebrush than do those on Montana winter range; however, there may also be a difference in the availability of sagebrush stands between the 2 areas. Sagebrush densities on INEL sage grouse winter range (Table 2.12) were slightly higher than those reported for grouse winter range in Colorado (Beck 1977). Mean sagebrush height at grouse winter use sites on the INEL (Table 2.12) was quite similar to sagebrush heights reported for grouse winter range in Montana (Eng and Schladweiler 1972) and Colorado (Beck 1977). Big sagebrush stands with 11 to 30% canopy coverage and a mean height of less than 40 cm constitute important sage grouse winter range in southeastern Idaho. Further, most low sagebrush stands meet these criteria and also form an important component of grouse winter range.

Many sagebrush habitats are becoming increasingly vulnerable to sagebrush control projects and agricultural development (Vale 1974, Braun et al. 1977). If sage grouse populations are to be maintained, both summer and winter ranges must be protected. Since these ranges are often widely separated, migration routes should be identified and corridors of sagebrush along these routes should also be preserved.

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