AN ABSTRACT OF THE THESIS OF

Anita Kang DeLong for the degree of Master of Science in Wildlife Science presented on 19 July 1993.

Title: Relationships Between Vegetative Structure and Predation Rates of Artificial Sage Grouse Nests

Abstract approved: Redacted for Privacy

John A. Crawford, Ph.D.

Sage grouse (*Centrocercus urophasianus*) populations in Oregon have declined since the 1940s as a result of reduced productivity. Nesting success in southeastern Oregon was 15% from 1989 through 1992 and 96% of nest failures resulted from predation by avian and mammalian predators. Although predators may be the proximate cause of nest loss, vegetative cover available to nesting sage grouse may ultimately influence nesting success. I experimentally tested the hypothesis that tall ($\bar{x}$=25 cm), dense grass cover and medium height shrub cover reduced the likelihood of nest predation. I placed 330 artificial nests on Hart Mountain National Antelope Refuge, Oregon, during April-June of 1991 and 1992. Nests were divided into medium shrub cover (nest shrub 40-80 cm) and short shrub cover (nest shrub <40 cm) in areas used by sage grouse for nesting. Within each shrub height, nests were apportioned into sparse ($\bar{x}$=2-3%) and dense ($\bar{x}$=22-31%) tall grass cover. I identified nest predators at additional artificial nest sites equipped with a polaroid camera system or hair catchers and measured 2 indices to predator abundance. Coyotes (*Canis latrans*), common ravens (*Corvus corax*), badgers (*Taxidea taxus*), Belding's ground squirrels

(*Spermophilus beldingi*) and golden-mantled ground squirrels (*Spermophilus lateralis*) were identified as potential nest predators. Relative predator abundance did not differ by structural cover type or nest fate, which suggested that differences in predation rates was attributed to differences in vegetative cover. Results of this study indicated that nest fate was positively associated with tall, dense grass cover and medium height shrub cover collectively. In medium shrub cover, proportionally fewer nests with dense grass cover were depredated than nests with sparse grass cover, 56% and 74%, respectively. However, in short shrub cover, no difference in predation rates was detected between nests placed in dense and sparse grass cover, 80% and 71%, respectively. Based on the logistic regression model, the odds of predation for artificial nests characterized with 5% tall grass cover and 29% medium shrub cover (model for depredated sage grouse nests) was 1.34 times larger than the odds of predation for artificial nests with 18% tall grass cover and 41% medium shrub cover (model for nondepredated sage grouse nest). I concluded that the greater the amount of tall grass and medium shrub cover at nest sites, the lower the probability of nest predation. Land management practices that reduce tall grass cover (livestock grazing and fire suppression) and reduce shrub cover (eradication of sagebrush for agricultural production, mining activities, and urban development) may negatively impact sage grouse nesting habitat. However, temporary reduction of shrub cover may be necessary to increase herbaceous cover. Land managers should strive for a balance of shrubs, grasses, and forbs to improve sage grouse productivity.

Relationships Between Vegetative Structure and Predation Rates of Artificial Sage Grouse Nests

by

Anita Kang DeLong

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Master of Science

Completed July 19, 1993

Commencement June 1994

APPROVED:

Redacted for Privacy

Professor of Wildlife in charge of major

Redacted for Privacy

Head of Department of Fisheries and Wildlife

Redacted for Privacy

Dean of Graduate School

Date thesis is presented: July 19, 1993

Typed by Anita Kang DeLong for: Anita Kang DeLong

Dedicated with love to my parents,

Hugh and Ingrid

ACKNOWLEDGEMENTS

This research was accomplished with the help of many generous people. I am deeply grateful to Dr. John Crawford for his professional guidance, enthusiasm, and encouragement. I appreciate John's personal commitment to his graduate students and attribute much of my positive educational experience to him. I am grateful to Dr. William Krueger and Dr. Robert Anthony, committee members, for their valuable advice and critical review of this thesis. I thank Dr. Richard Tubb and Dr. James Nielsen for also serving on my graduate committee and Dr. Dan Schafer for his statistical assistance.

I am indebted to David Fischer, Andrea Erichsen, Marc Commandatore, and Mark Sturm for their excellent field assistance and to Wendy Boyd for her assistance with data entry. I thank Edward Shallenberger for his assistance with timer and camera design and for his enthusiastic support.

This research was funded by the Bureau of Land Management. Special recognition goes to Erick Campbell and Alan Sands for their support of this study. The U.S. Fish and Wildlife Service provided logistical assistance; I am grateful to Barry Reiswig, Mike Smith, Betsy Radtke, Doug Leehman, and Mike Webster. I appreciate the moral support offered by Alicia Cox, Gina Proctor, Vicki Rosette, and Ruth Anne Miller. I thank Jennifer and Joshua Smith for faithfully supplying chicken eggs and Barb Smith for storing 100 dozen in her refrigerator. I thank Bill Pyle and Blythe Brown for sharing with me their knowledge of Hart Mountain.

From the start of my research proposal to the final days of thesis preparation, I am grateful to many graduate students for their friendship. I am grateful to Jenny Barnett, Mike Gregg and Marty Drut for welcoming me into the sage grouse program and sharing their wisdom and experiences with me. I thank Steve DeStefano, Mike Gregg, Raymond Rainbolt and Edward Shallenberger for reviewing this thesis. LaVon Mauer assisted in many facets throughout this project; I am grateful for her support.

I thank my parents, Ingrid and Hugh, for instilling in me the desire to learn and for their love and support. Finally, a very special thanks to Don DeLong, my coworker and husband, for his invaluable assistance throughout this project and for his encouragement, confidence, patience, friendship and enduring love.

TABLE OF CONTENTS

LIST OF TABLES

Table

Relationships Between Vegetative Structure and Predation Rates of Artificial Sage Grouse Nests

INTRODUCTION

The western sage grouse (*Centrocercus urophasianus phaios*) was federally listed in 1985 as a category II candidate for threatened and endangered species status because of declines in Oregon, Washington and extirpation from British Columbia. Sage grouse populations in Oregon have declined since the 1940s and this decline has been attributed to reduced productivity (Crawford and Lutz 1985). Crawford et al. (1992) reported sage grouse nesting success at 2 study sites in southeastern Oregon was 15%, which was lower than reported previously by Nelson (1955) in Oregon, Wakkinen (1990) in Idaho, and Wallestad and Pyrah (1974) in Montana (39%, 61% and 64%, respectively).

Predators were suggested as the controlling factor of nest success in Oregon and Idaho (Batterson and Morse 1948, Autenrieth 1981). In southeastern Oregon, 96% of nest failures resulted from predation (Crawford et al. 1992). However, predators may only be the proximate cause of nest loss. The ultimate cause may be related to the amount and structure of vegetative cover available to nesting sage grouse (Gregg et al. 1994). Tall, dense vegetation may provide visual, scent, and physical barriers between predators and nests of ground-nesting birds (Bowman and Harris 1980, Redmond et al. 1982, Sugden and Beyersbergen 1986, 1987, Crabtree et al. 1989). Sage grouse nesting habitat is characterized by both shrub and herbaceous cover and each may contribute to nest concealment.

The relationship of sagebrush to sage grouse nesting success has been well documented. Connelly et al. (1991) reported greater nesting success for sage grouse hens that used sagebrush than for hens with non-sagebrush nest sites. Klebenow (1969) reported that sage grouse nests contained more shrub cover than non-nest sites. Wallestad and Pyrah (1974) and Gregg et al. (1994) reported that nondepredated nests had greater shrub cover than depredated nests. Specifically, Gregg et al. (1994) found that nondepredated nests had greater amounts of medium height shrub cover (40-80 cm in height) than depredated nests.

Few studies, however, evaluated the importance of herbaceous cover and height to sage grouse nest success. Wakkinen (1990) suggested that grass height may differentiate successful and depredated nests, although mean grass heights were not significantly different. Because of the trend in the data, Wakkinen (1990) recommended further investigation of the relationship between grass height and nest success. Gregg et al. (1994) reported that cover of tall grass (>18 cm) was greater at nondepredated nests than at depredated nests; however, the sample size of nondepredated nests was relatively small (18 of 124 nests). Conclusions drawn from this study were based on the assumption that 18 nests were representative of the larger population of nondepredated nests. Furthermore, this study was an associative study from which a causal relationship cannot be drawn. Tall grass cover was associated with nondepredated nests; however, this relationship may have been incidental and not a cause of enhanced nest success. Gregg et al. (1994) also recommended further investigation of the relationship between vegetative cover and nest predation in the form of controlled experimental tests.

Artificial nests have been commonly used to experimentally test the relationships between nest predation and potential influencing factors (Wilcove 1985, Yahner and Wright 1985, Angelstam 1986, Sugden and Beyersbergen 1986, Martin 1987, Yahner and Cypher 1987, Andren and Angelstam 1988, Yahner 1989, Reitsma et al. 1990, Esler and Grand 1993, Rudnicky and Hunter 1993). Artificial nests permit controlled experiments that allow for assessments of specific factors that may influence nest predation (Esler and Grand 1993) and allow for sample sizes often larger than is possible with real nests (Reitsma et al. 1990).

This study was conducted to experimentally test the hypothesis that increased amounts of tall, dense grass and medium height shrub cover reduced the likelihood of nest predation and to ascertain the relative contribution of each component. The goal of this study was to provide a better understanding of the relationship between vegetative structure and predation rates of sage grouse nests. My objectives were to 1) determine predation rates of artificial nests that differed in amounts of tall grass cover and medium shrub cover and 2) to describe predators of artificial sage grouse nests.

STUDY AREA

The study area was located at the Hart Mountain National Antelope Refuge (HMNAR), Lake County, Oregon. The refuge, administered by U.S. Fish and Wildlife Service, was established in 1936 and comprises approximately 102,000 ha. Topography of the area consisted of flat sagebrush plains interrupted by rolling hills, ridges, and draws. Elevation ranged from 1500 m in the eastern portion of the refuge to 2450 m at Warner Peak along the western portion of the refuge. Although temperatures and precipitation differed with elevation, annual temperatures ranged from -22 to 36 C and precipitation averaged 29 cm (40 year mean) at the refuge headquarters (1775 m). Precipitation from September through June (crop year) for 1989, 1990, 1991, and 1992 was 19.2, 19.8, 34.0, and 21.8 cm, respectively, compared with the 40 year mean of 28.4 cm.

HMNAR was characterized by low sagebrush (*Artemisia arbuscula*), big sagebrush (*A. tridentata vaseyana, A. t. wyomingensis, and A. t. tridentata*), bitterbrush (*Purshia tridentata*), green rabbitbrush (*Chrysothamnus viscidiflorus*), western juniper (*Juniperus occidentalis*), aspen (*Populus tremuloides*), and curl-leaf mountain-mahogany (*Cercocarpus ledifolius*) stands. Common forbs included mountain-dandelion (*Agoseris* spp.), hawksbeard (*Crepis* spp.), milk-vetch (*Astragalus* spp.), lupine (*Lupinus* spp.), and phlox (*Phlox* spp.). Grasses consist largely of bluegrass (*Poa* spp.), wheatgrass (*Agropyron* spp.), needlegrass (*Stipa* spp.), fescue (*Festuca* spp.), bottlebrush squirreltail (*Sitanion hystrix*), and giant wildrye (*Elymus cinereus*).

Historically, livestock grazing was allowed on the refuge from 15 April to 15 December and 2 livestock exclosures were maintained. From 1971 through 1990, domestic livestock grazing averaged 12,835 animal unit months. Livestock were not present on the refuge in 1991 and 1992.

METHODS

Distribution of Artificial Nests

Artificial nests were placed in mountain big sagebrush and low sagebrush stands within the area defined by sage grouse nest locations in 1989 and 1990 (Gregg 1992). I modelled nondepredated and depredated nests as described by Gregg et al. (1994) by placing artificial nests in medium (40-80 cm) shrub cover with dense and sparse, tall ($\geq$15 cm) grass cover. Sparse, tall grass cover was defined as <10% tall grass cover and dense, tall grass cover as $\geq$10% tall grass cover. Sage grouse also nest under sagebrush 23-40 cm in height (Klebenow 1969, Autenrieth 1981, Hulett et al. 1986). Therefore, additional nests were placed in short (<40 cm) shrub cover with dense and sparse, tall grass cover to determine if tall grass cover in short shrub cover influenced nest fate. Three-hundred-thirty nests were used for analysis. A range of 44 to 60 nests were set in each of April, May, and June of 1991 and 1992, which represented early, late, and renesting periods of sage grouse, respectively. Nests were placed 75 to 100 m perpendicular to roads with a minimum of 300 m between nests. Nest sites were selected during the day and marked with a reflective stake. I relocated each nest at night, placed 3 brown chicken eggs in a depression under a sagebrush, and removed the reflective stake. Eggs were placed at night to avoid avian predators associating eggs with human activity (W.L. Wakkinen, ID Fish and Game, pers. commun., Picozzi 1975). When handling eggs and preparing nest sites, I used rubber gloves and boots and a scent masking chemical. After 21 days each nest was relocated from a small wooden stake along the roadside with a compass bearing and distance to the nest. Status of each nest was recorded as depredated (a nest with $\geq$1 egg missing or destroyed) or nondepredated (a nest with 3 eggs remaining undisturbed).

To determine if the distributions of depredated and nondepredated nests were clumped or equitably apportioned regarding geographic location, I placed a 3 x 4 cell grid on a map of the study area. Cells were 6 x 6 km and 9 cells contained artificial nests. The number of depredated and nondepredated nests was determined for each cell and arranged in a 2 x 9 contingency table. I used Chi-square analysis (Snedecor and Cochran 1980) to determine if the probability of nest predation differed among locations. The density of artificial nests was determined for comparison with density estimates for sage grouse nests. Artificial nest area was calculated for a 400 m strip along roads that contained artificial nests.

Structural Cover Types

After the 21-day test, vegetation was measured in a 3 m^2 area (radius of 1 m) at the nest as described by Gregg et al. (1994). Percent canopy cover of shrubs was measured by line-intercept (Canfield 1941) along 2 2-m perpendicular transects intersecting at the nest center. The position of the first transect was determined randomly. Each shrub intercepted was placed into 1 of 3 height classes: short (<40 cm), medium (40-80 cm), and tall (>80 cm) as described in Gregg et al. (1994). Canopy cover of shrubs was recorded separately for each height class and was averaged over the total transect length, 4-m. Percent cover of forbs and grasses was estimated in 2 20-x 50-cm plots (Daubenmire 1959) placed at the midpoint of each transect. Cover of forbs and grasses was estimated in short (<15 cm) and tall ($\geq$15 cm) height classes based on results of previous studies (Wakkinen 1990, Gregg et al. 1994). The average of the 2 plots/nest was used to characterize herbaceous cover at the nest site. Each nest was assigned to a structural cover-type based on the height of the nest shrub and average amount of tall grass cover at the nest site.

Multivariate analysis of variance (MANOVA) was used to compare habitat components (short forb, tall forb, short grass, tall grass, short shrub, and medium shrub cover) by structural cover types (Zar 1984, Proc GLM, SAS Inst. Inc. 1989). If a significant MANOVA was found, an analysis of variance for each habitat component was performed and mean separation was ascertained with the Tukey test (Zar 1984). I tested all habitat components to determine the distribution of the data. For those variables that were not normally distributed, I used the $(x+1)^{1/2}$ transformation (Snedecor and Cochran 1980) to approximate normality.

Predator Identification and Relative Abundance

I used two methods to identify nest predators at artificial nest sites. Polaroid photographic systems with triggering devices (Goetz 1981) were placed at 17 additional nest sites for 21 days or until depredated in 1991 and 1992. In addition, hair-catchers (Baker 1980) were set at 23 nest sites to identify nest predators from hair samples.

Because differences in predator abundance may influence predation rates, I used 2 methods to determine relative predator abundance by structural cover type and nest fate. Weekly transects were conducted along roads that contained artificial nests. Each potential nest predator, including coyotes (*Canis latrans*), common ravens (*Corvus corax*), badgers (*Taxidea taxus*), and ground squirrels (*Spermophilus* spp.), seen was assigned to the nearest nest. In addition, I walked a 314-m circular transect (50 m radius) centered at each nest site to determine the presence of burrows as an indicator of potential nest predators (coyote, badger, and ground squirrel). Chi-square contingency tests (Proc Freq, SAS Inst. Inc. 1989) were used to determine if relative predator abundance was associated with structural cover types or nest fate.

Nest Predation

Artificial nests were combined by structural cover type over months and years. Nest fate (depredated or nondepredated) was compared for nests placed in sparse and dense, tall grass cover with Chi-square tests (2 x 2 contingency table) corrected for continuity. Nests in medium and short shrub cover were analyzed separately to isolate the influence of grass cover from the potentially confounding effects of shrub cover. An overall Chi-square analysis of nest fate by structural cover type (2 x 4 contingency table) also was conducted.

I used logistic regression (Proc Logistic, SAS Inst. Inc. 1989) to identify variables that predicted the probability of nest predation. Parameters considered for use in the model included 7 indicator variables (year, month, year-month interaction, and indices to predator abundance), 6 continuous vegetative variables (short shrub cover, medium shrub cover, short forb cover, tall forb cover, short grass cover, and tall grass cover), and 15 interaction terms of vegetative variables. I used a stepwise selection procedure with a 0.05 significance level for entry into the model (Neter et al. 1989). I calculated an odds ratio (Hosmer and Lemeshow 1989) to compare the odds of predation for artificial nests modelling nondepredated sage grouse nests with artificial nests modelling depredated sage grouse nests. All results were considered significant at the 95% level of confidence.

RESULTS

Distribution of Artificial Nests

Distribution of nondepredated and depredated nests was similar throughout the study area (Fig. 1). Nest predation in the 9 cells averaged 67% and ranged from 44% to 84% (Table 1). The probability of nest predation did not differ among cells, which suggested that frequencies of nondepredated and depredated nests were similar among geographic locations of the study area ($\chi^2 = 13.15$, 8df, $P=0.11$). Artificial nest density was 1 nest/87 ha.

Structural Cover Types

In medium shrub cover, artificial nests placed in sparse and dense grass cover were differentiated by the amount of tall grass (Table 2). Nests placed in dense grass cover averaged significantly more tall grass cover than nests placed in sparse grass cover, 31% and 3%, respectively ($P<0.05$). No difference was detected in mean shrub cover or forb cover between these two structural cover types ($P>0.05$).

In short shrub cover, artificial nests placed in sparse and dense grass cover were differentiated by the amount of tall grass, short grass, and tall forb (Table 2). Nests placed in dense grass cover averaged more tall grass (22%), short grass (16%), and tall forbs (2%) than nests placed in sparse grass cover, (2%, 7%, and 0%, respectively, $P<0.05$). Mean height for tall grass, short grass, tall forbs and

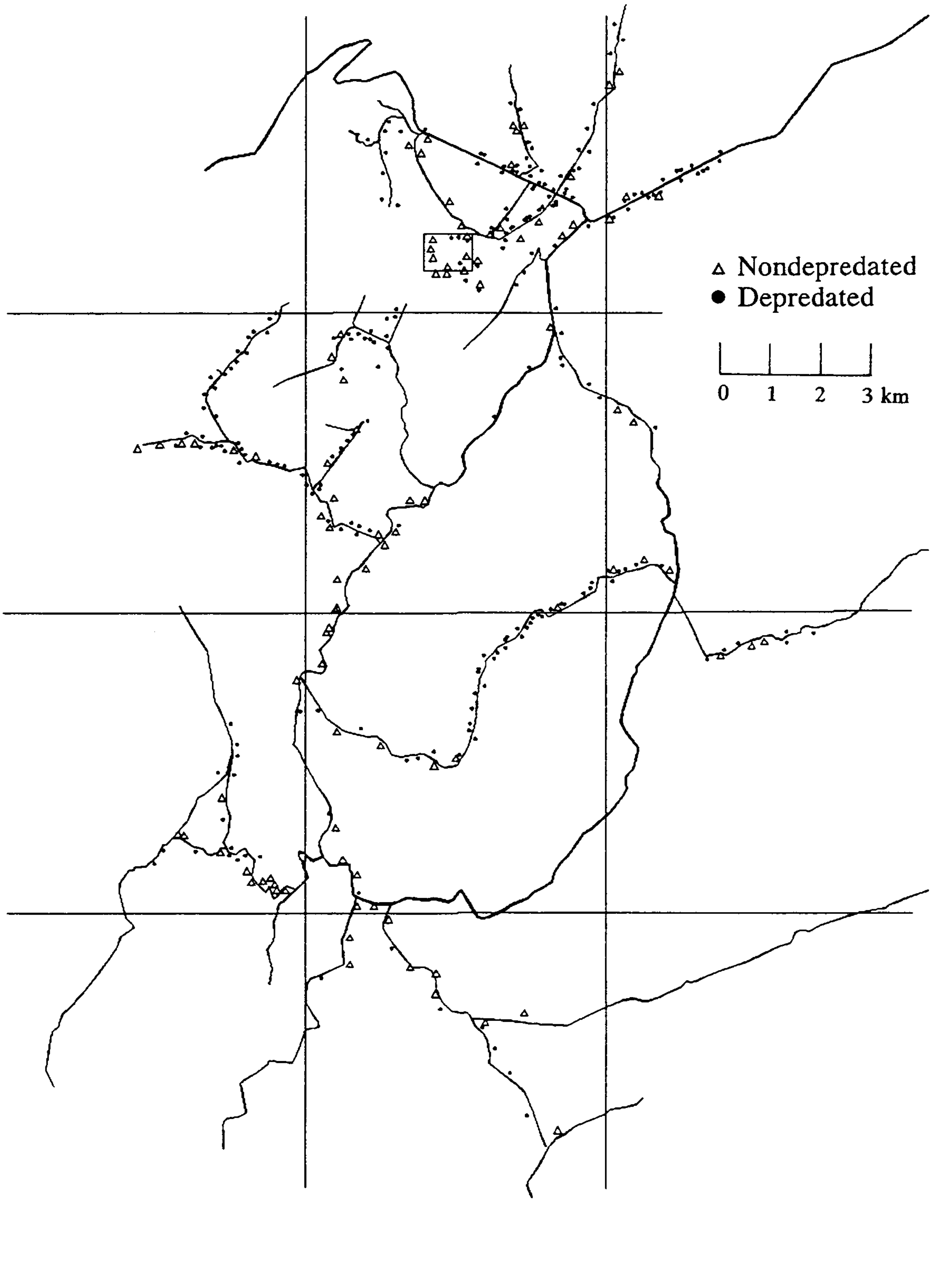

Fig. 1. Distribution of depredated and nondepredated artificial sage grouse nests, Hart Mountain National Antelope Refuge, Oregon, 1991-92.

Table 1. Frequencies of depredated and nondepredated artificial nests by geographical locations (36 km^2), Hart Mountain National Antelope Refuge, Oregon, 1991-92.[a]

Location	Depredated	Nondepredated
1	72 (73)	27 (27)
2	21 (81)	5 (19)
3	31 (84)	6 (16)
4	45 (70)	19 (30)
5	7 (58)	5 (42)
6	15 (58)	11 (42)
7	29 (71)	12 (29)
8	6 (67)	3 (33)
9	7 (44)	9 (56)

[a] Probability of nest predation did not differ among locations ($\chi^2 = 13.15$, 8df, $P = 0.11$).

Table 2. Vegetative characteristic (% cover) of artificial sage grouse nests (3 m^2 at nest), Hart Mountain National Antelope Refuge, Oregon, 1991-92.[a]

	Structural cover type							
	Short shrub				Medium shrub			
	Sparse grass		Dense grass		Sparse grass		Dense grass	
Vegetative characteristic	$\bar{x}$	(SD)	$\bar{x}$	(SD)	$\bar{x}$	(SD)	$\bar{x}$	(SD)
Short shrub (<40 cm)	42	(12)A	40	(18)A	23	(18)B	19	(18)B
Medium shrub (40-80 cm)	2	(8)A	1	(2)A	33	(22)B	33	(23)B
Short forb ($\bar{x}$=6 cm)	4	(4)A	3	(3)A	5	(4)A	5	(7)A
Tall forb ($\bar{x}$=22 cm)	0	(1)A	2	(5)B	2	(3)B	2	(3)B
Short grass ($\bar{x}$=8 cm)	7	(7)A	16	(10)B	10	(9)A	12	(9)AB
Tall grass ($\bar{x}$=25 cm)	2	(2)A	22	(10)B	3	(2)A	31	(21)C

[a] Means with the same letter within rows are not different ($P>0.05$).

short forbs was 25, 8, 22, and 6 cm, respectively (6, 2, 6, and 2 SD, respectively).

Predator Identification and Relative Abundance

Coyotes, common ravens, badgers, Belding's ground squirrels (*Spermophilus beldingi*) and golden-mantled ground squirrels (*Spermophilus lateralis*) were identified as potential nest predators. Photographs were taken of a common ravens (n=2), Belding's ground squirrels (n=2) and a golden-mantled ground squirrel (n=1). A badger was identified from a hair sample and a coyote identified from teeth marks on a timer and scat found at the nest site.

Relative predator abundance was independent of structural cover type. No difference was detected in the proportion of nests with predator sightings among structural cover types (χ^2=4.63, 3df, P=0.20). The percentage of nests with predator sightings ranged from 19% in short shrub-sparse grass cover to 33% in both short and medium shrub cover with dense grass cover (Table 3). Predators were associated with 95 nests (29%). Of the these nests, 79%, 23% and 5% were associated with ground squirrels, common ravens, and coyotes, respectively. Several nests were associated with >1 predator species. Likewise, no difference was detected in the proportion of nests with burrows among structural cover types (χ^2=1.29, 3df, P=0.73). The percentage of nests with burrows ranged from 59% in medium shrub-dense grass cover to 66% in medium shrub-sparse grass cover (Table 4).

Table 3. Frequency of artificial sage grouse nests with sightings of potential nest predators, indicator of relative predator abundance at Hart Mountain National Antelope Refuge, Oregon, 1991-92.[a]

	Structural cover type			
	Short shrub		Medium shrub	
Nests (n=330)	Sparse grass	Dense grass	Sparse grass	Dense grass
With predators	13 (19)[b]	5 (33)	56 (31)	21 (33)
Without predators	57 (81)	10 (67)	125 (69)	43 (67)

[a] Sightings of predators was independent of structural cover type (χ^2 = 4.63, 3 df, p=0.20).

[b] Number of nests (%)

Table 4. Frequency of artificial sage grouse nests with burrows as indicator of nest predator abundance, Hart Mountain National Antelope Refuge, Oregon, 1991-92.[a]

	Structural cover type			
	Short shrub		Medium shrub	
Nests (n=300)	Sparse grass	Dense grass	Sparse grass	Dense grass
With burrows	43 (61)[b]	9 (60)	120 (66)	38 (59)
Without burrows	27 (39)	6 (40)	61 (34)	26 (41)

[a] Burrow presence was independent of structural cover type (χ^2 = 1.29, 3 df, p=0.73).

[b] Number of nests (%)

Relative predator abundance was independent of nest fate. No difference was detected between nondepredated and depredated nests in the proportion of nests with predator sightings (χ^2=0.47, 1df, P=0.49). Predator sightings were associated with 32% of nondepredated nests and 27% of depredated nests. Likewise, no difference was detected between nondepredated and depredated nests in the proportion of nests with burrows (χ^2=0.04, 1df, P=0.85). Burrows were associated with 65% of nondepredated nests and 63% of depredated nests.

Nest Predation

An overall Chi-square test indicated a difference in the probability of nest predation among the structural cover types (χ^2=8.40, 3df, P=0.04). In medium shrub cover, proportionally fewer nests in dense grass cover were depredated than in sparse grass cover, 56% and 74%, respectively (χ^2=6.70, 1df, P=0.01, Table 5). In short shrub cover, no difference in nest predation was detected between nests placed in dense and sparse grass cover, 80% and 71%, respectively (χ^2=0.13, 1df, P=0.72). Among all cover types, 71% (233/330) of nests were depredated.

Results from logistic regression revealed similar results to the Chi-square analysis. The tall grass-medium shrub interaction term was the only variable that entered into the logistic regression model (P=0.01). The coefficient and standard error for this variable was -0.00049 and 0.00019, respectively. Effects of tall grass cover depended on medium shrub cover and likewise, the effects of medium shrub cover depended on tall grass cover. In general, however, the greater the

Table 5. Predation rates of artificial sage grouse nests at Hart Mountain National Antelope Refuge, Oregon, 1991-92.

	% Depredated							
	Short shrub				Medium shrub			
Year month	Sparse grass		Dense grass		Sparse grass		Dense grass	
1991								
April	85	(13)[a]	-		67	(30)	100	(1)
May	42	(7)	100	(2)	75	(32)	56	(18)
June	50	(12)	57	(7)	95	(22)	82	(11)
1992								
April	100	(8)	100	(2)	51	(39)	36	(11)
May	81	(16)	100	(1)	88	(32)	55	(11)
June	64	(14)	100	(3)	85	(26)	50	(12)
Total	71	(70)	80	(15)	74	(181)	56	(64)

[a] Number of artificial nests

amount of tall grass and medium shrub cover, the lower the probability of nest predation.

Based on the logistic regression model, the odds of predation for artificial nests characterized with 5% tall grass cover and 29% medium shrub cover (model for depredated sage grouse nests, Gregg et al. 1994) was 1.34 times larger than the odds of predation for artificial nests with 18% tall grass cover and 41% medium shrub cover (model for nondepredated sage grouse nest). A 95% confidence interval for the odds ratio was 1.07 and 1.67.

DISCUSSION

Results of this study indicate that the fate of artificial sage grouse nests was positively associated with tall grass cover and medium height shrub cover collectively (P=0.01). The greater the amount of tall grass and medium shrub cover at nest sites, the lower the probability of nest predation. These findings were concordant with the results of Gregg et al. (1994) in which nondepredated sage grouse nests contained more tall grass cover and medium shrub cover than depredated nests.

The value of sagebrush cover and height in reducing nest predation demonstrated in this study parallels results of other sage grouse studies. Braun et al. (1977), in a review of sage grouse literature, noted that nest shrubs ranged from 17 to 79 cm in height and typically were the tallest shrub available within the immediate area. Autenrieth (1981) found that nest shrubs were taller and had a greater average diameter than surrounding shrubs. In Montana, Wallestad and Pyrah (1974) reported that successful nests were located in sagebrush stands with greater shrub cover than stands of unsuccessful nests (27% and 20%, respectively, P=0.005) and had greater shrub cover within a 9-m^2 plot around the nest than unsuccessful nests, 33% and 21%, respectively. In Oregon, Gregg et al. (1994) found that nondepredated nests had more shrub cover of medium height than depredated nests, 41% and 29%, respectively. Although recommended guidelines for sage grouse nesting habitat addressed sagebrush issues extensively

(Braun et al. 1977), the importance of herbaceous cover to nesting success was only recently identified.

Autenrieth (1981) reported herbaceous cover and litter were associated with successful nests but did not present any statistical results. Wakkinen (1990) suggested grass was taller at successful nests than depredated nests, 19.0 and 16.5 cm, respectively, but means were not significantly different ($P=.09$). Gregg et al. (1994) found that the percent cover of tall grass (>18 cm) was significantly greater at nondepredated nests than depredated nests, 18% and 5%, respectively ($P<0.05$). However, the sample size of nondepredated nests was relatively small ($n=18$). Results of this study demonstrated that in medium shrub cover, nests with dense, tall grass cover had a significantly lower likelihood of predation than nest with sparse grass cover, 56% and 74%, respectively ($P=0.01$).

Studies of other upland gamebirds provided evidence that tall, dense herbaceous cover reduced nest predation. Riley et al. (1992) reported that abundance and height of sand bluestem (*Andropogon hallii*) was greater around successful lesser prairie chicken (*Tympanuchus pallidicinctus*) nests than unsuccessful nests. Likewise, tall, residual grass cover was associated with reduced nest predation rates of gray partridges (*Perdix perdix*) in Great Britain (Rands 1982).

Several artificial nest studies documented similar predation rates between artificial and real nests (Crabtree et al. 1989, Götmark et al 1990, Major 1990). At HMNAR, the predation rate of artificial nests was 71% compared with 80%

for sage grouse nests (Crawford et al. 1992). The density of artificial nests in this study, 1 nest/87 ha, fell within the range of density estimates for sage grouse nests of 1 nest/26 ha to 1 nest/128 ha (Klebenow 1969 and Gregg 1992, respectively). However, differences exist between artificial and real nests in appearance of nest, concealment of eggs by the hen, human compared with avian scent, disturbance at the nest, exposure time of the eggs, and possibly other factors (Reitsma et al. 1990). Despite differences between artificial nests and real nests, Yahner and Voytko (1989) concluded that artificial nest studies can be helpful in assessing depredation of avian nests in nature.

In this study, I compared predation rates among artificial nests that differed in amounts of vegetative cover and any biases of artificial nests were consistent for all nests. Therefore, differences in predation rates among artificial nests were primarily attributed to differences in vegetative structure. Influence of vegetative structure on predation rates of artificial nests serves as an indicator of the influence of vegetative structure on real sage grouse nests.

Tall, dense grass cover and dense, medium shrub cover provided the greatest amount of canopy cover and lateral cover available to nesting sage grouse. Increased amounts of canopy cover reduced overhead visibility of nests in this study and may have reduced avian nest predation. Previous studies (Dwernychuk and Boag 1972, Sugden and Beyersbergen 1987) demonstrated that predation of artificial nests was inversely correlated with the amount of overhead cover. Dwernychuk and Boag (1972) suggested that the visibility of eggs was a major factor in predation by avian predators. In addition, Sugden and Beyersbergen (1987) reported that tall, dense cover represented a behavioral deterrent as well as a physical barrier to American crows (*Corvus brachyrhynchos*) hunting on foot.

Increased lateral cover may have reduced mammalian predation of nests in this study. Lateral cover may provide scent, visual, and physical barriers to mammalian predators. Several studies demonstrated that nest predation by mammalian predators decreased with increasing lateral cover density, understory height, and vegetative impenetrability (Schranck 1972, Bowman and Harris 1980, Crabtree et al. 1989)

Common ravens, coyotes, badgers, and ground squirrels were identified as nests predators in this study, and although population estimates were unavailable, these species were all common on HMNAR. Predators identified during this study were similar to those identified in previous studies at HMNAR. Crawford et al. (1992) implicated coyotes, common ravens, badgers, and ground squirrels as nest predators. Nelson (1955) reported nest predators were primarily badgers, common ravens, and ground squirrels. In 1948, Batterson and Morse (1948) concluded that common ravens were the primary sage grouse nest predator in Oregon.

Previous studies reported that coyotes and common ravens were opportunistic and generalist feeders (Nelson 1934, Andelt and Knowlton 1987, Toweill and Anthony 1988, Stiehl and Trautwein 1991) and diets often reflected changing abundance of food items and vulnerability of prey. The diet of common ravens at Malheur National Wildlife Refuge in southeastern Oregon during spring and summer consisted of 17-24% eggs (Nelson 1934, Stiehl and Trautwein 1991), 39% mammalian prey, 14% avian prey (excluding eggs), and 21% combination of insects, vegetation and reptiles (Stiehl and Trautwein 1991).

Two philosophies to improve sage grouse nesting success are predator control and nesting habitat enhancement. Predator removal has resulted in increased nesting success of waterfowl (Schranck 1972, Duebbert and Lokemoen 1980), ring-necked pheasants (Chesness et al. 1968), and sandhill cranes (Littlefield 1976) and may increase sage grouse nesting success where implemented. Periodic predator control on HMNAR through 1967 may have influenced the greater sage grouse nesting success reported by Nelson (1955) versus Crawford et al. (1992). However, predator control raises ecological, sociological, and economical questions. Nest predation by non-targeted species may increase (Reitsma et al. 1990), and compensatory increases in targeted predator survival and immigration of predators may negate predator control (Robinson and Bolen 1989). Implementing predator control measures throughout eastern Oregon may be economically and logistically costly. Ethics of predator control is also questioned as non-targeted species may be affected and non-consumptive values of predators are prevalent (McCabe and Kozicky 1972, Kellert 1980).

Predator control may only address the proximate cause and not the ultimate cause of low nesting success. Excessive predation on sage grouse nests in Oregon implied that nests were readily available to predators. Results of this study suggested that tall, dense grass cover and medium height shrub cover reduced vulnerability of nests to predation. Increased amounts of vegetative cover and height may be sufficient to reduce sage grouse nest predation without implementing predator control. By increasing the herbaceous understory, the nutritional diet of sage grouse (Barnett and Crawford 1994, Drut et al. 1994) as well as nesting habitat could be enhanced. Habitat enhancement addresses cover and food requirements of sage grouse and, therefore, is a more holistic approach than predator control to improve sage grouse productivity in Oregon.

MANAGEMENT IMPLICATIONS

Results of this study indicate that cover and height of grasses and shrubs influenced nest fate. Increased availability of tall, dense grass cover and medium height shrub cover decreased the likelihood of nest predation. Results of this study and Gregg et al. (1994) suggested that sage grouse nesting habitat at HMNAR should contain 20-30% grass cover >18 cm in height and contain nest shrubs with a 30-40% shrub cover within a 3-m^2 area. Although suitable nest shrubs were abundant on HMNAR, tall grass cover was limited. Likewise, Winward (1991) concluded that throughout much of the Great Basin, the herbaceous understory is depleted.

Land management practices that reduce herbaceous cover may negatively impact sage grouse nesting habitat. Livestock grazing is a principal use of Oregon rangelands that affects herbaceous cover and height (Galbraith and Anderson 1971, Rickard et al. 1975). When sage grouse nesting habitat is an objective, land managers should actively monitor livestock distribution and utilization of grasses in order to remove livestock when the minimum herbaceous cover needed for nesting is reached. In certain cases, rangelands may need rest from grazing to increase herbaceous cover and height to desired levels. However, in many situations, resting rangeland from livestock grazing alone would not increase herbaceous cover because dense shrub cover effectively inhibits the herbaceous understory (Sneva et al. 1984, Laycock 1991, Winward 1991).

In Wyoming big sagebrush stands with shrub cover $\geq$20% and basin and mountain big sagebrush stands with shrub cover >30%, herbaceous understories are depleted and require thinning or sagebrush removal in order to reestablish a balanced herbaceous component (Winward 1991). Fires may effectively reduce shrub cover and allow for an increased herbaceous component (Pyle 1993). If prescribed fires are inappropriate, mechanical or herbicide treatments may be implemented to reduce shrub cover. In the short term, sagebrush reduction may negatively impact sage grouse nesting habitat, although increased forb availability may benefit pre-laying hens (Barnett and Crawford 1994) and chicks (Drut et al. 1994) as a high protein and phosphorous food source (Barnett and Crawford 1994). In the long term, once sagebrush has reestablished, sage grouse nesting habitat may be enhanced by an improved balance of shrubs, grasses, and forbs available to nesting sage grouse. Sagebrush stands permanently eradicated for agricultural production, urban development, and mining activities may negatively impact sage grouse populations by loss of nesting habitat and, in many cases, loss of winter and brooding habitat.

Public lands contain the majority of the sage grouse habitat in Oregon and, thus, land managers possess the capability to positively influence sage grouse populations and to promote recovery. Land management practices that enhance native grass and forb understories and that reduce high shrub densities should be implemented to achieve a balance of shrubs, grasses, and forbs.

LITERATURE CITED

Andelt, W. F., and F. F. Knowlton. 1987. Variation in coyote diets associated with season and successional changes in vegetation. J. Wildl. Manage. 51:273-277.

Andren, H., and P. Angelstam. 1988. Elevated predation rates as an edge effect in habitat islands: experimental evidence. Ecology 69:544-547.

Angelstam, P. 1986. Predation on ground-nesting birds' nests in relation to predator densities and habitat edge. Oikos 47:365-373.

Autenrieth, R. E. 1981. Sage grouse management in Idaho. Id. Dept. of Fish and Game. Wildl. Bull. 9. 238pp.

Baker, B. W. 1980. Hair-catchers aid in identifying mammalian predators of ground-nesting birds. Wildl. Soc. Bull. 8:257-259.

Barnett, J. K., and J. A. Crawford. 1994. Diet and Nutrition of sage grouse hens during the pre-laying period in Oregon. J. Range Manage. 47:(In Press.)

Batterson, W. M., and W. B. Morse. 1948. Oregon sage grouse. Oregon Fauna Ser. 1. Oregon Game Comm. 29pp.

Bowman, G. B., and L. D. Harris. 1980. Effect of spatial heterogeneity on ground-nest depredation. Ecol. Monogr. 38:269-308.

Braun, C. E., T. Britt, and R. O. Wallestad. 1977. Guidelines for maintenance of sage grouse habitats. Wildl. Soc. Bull. 7:99-106.

Canfield, R. 1941. Application of the line interception method in sampling of range vegetation. J. For. 39:388-394.

Chesness, R. A., M. M. Nelson, and W. H. Longley. 1968. The effect of predator removal on pheasant reproductive success. J. Wildl. Manage. 32:683-697.

Crabtree, R. L., L. S. Broome, and M. L. Wolfe. 1989. Effects of habitat characteristics on gadwall nest predation and nest-site selection. J. Wildl. Manage. 53:129-137.

Crawford, J. A., and R. S. Lutz. 1985. Sage grouse population trends in Oregon, 1941-1983. Murrelet 66:69-74.

-----, M. A. Gregg, M. S. Drut, and A. K. DeLong. 1992. Habitat use by female sage grouse during the breeding season in Oregon. Final Report submitted to Bureau of Land Management. Oregon State Univ., Corvallis. 83pp.

Connelly, J. W., W. L. Wakkinen, A. D. Apa, and K. P. Reese. 1991. Sage grouse use of nest sites in southeastern Idaho. J. Wildl. Manage. 55:521-524.

Daubenmire, R. F. 1959. A canopy-coverage method of vegetation analysis. Northwest Sci. 33:224-227.

Drut, M. S., W. H. Pyle, and J. A. Crawford. 1994. Technical note: Diets and food selection of sage grouse chicks in Oregon. J. Range Manage. 47:(In Press.)

Duebbert, H. F., and J. T. Lokemoen. 1980. High duck nesting success in a predator-reduced environment. J. Wildl. Manage. 44:428-437.

Dwernychuk, L. W., and D. A. Boag. 1972. How vegetative cover protects duck nests from egg-eating birds. J. Wildl. Manage. 36:955-958.

Esler, D., and J. B. Grand. 1993. Factors influencing depredation of artificial duck nests. J. Wildl. Manage. 57:244-248.

Galbraith, W. A., and E. W. Anderson. 1971. Grazing history of the Northwest. J. Range Manage. 24:6-12.

Goetz, R. C. 1981. A photographic system for multiple automatic exposures under field conditions. J. Wildl. Manage. 45:273-76.

Götmark, F., R. Neergaard, and M. Åhlund. 1990. Predation of artificial and real arctic loon nests in Sweden. J. Wildl. Manage. 54:429-432.

Gregg, M. A. 1992. Habitat use and selection of nesting habitat by sage grouse in Oregon. M.S. Thesis, Oregon State Univ., Corvallis. 35pp.

-----, J. A. Crawford, M. S. Drut, and A. K. DeLong. 1994. Vegetative cover and predation of sage grouse nests in Oregon. J. Wildl. Mange. 58:(In Press.)

Hosmer, D. W., and S. Lemeshow. 1989. Applied logistic regression. John Wiley and Sons, Inc., New York. 307pp.

Kellert, S. R. 1980. American's attitudes and knowledge of animals. Trans. North Am. Wildl. and Nat. Resour. Conf. 45:111-124.

Klebenow, D. A. 1969. Sage grouse nesting and brood habitat in Idaho. J. Wildl. Manage. 33:649-662.

Laycock, W. A. 1991. Stable states and thresholds of range condition on North American rangelands: A viewpoint. J. Range Manage. 44:427-433.

Littlefield, C. D. 1976. Productivity of greater sandhill cranes on Malheur National Wildlife Refuge, Oregon. Proc. Int. Crane Workshop. 1:86-92.

Major, R. E. 1990. The effect of human observers on the intensity of nest predation. Ibis 132:608-612.

Martin, T. E. 1987. Artificial nest experiments: effects of nest appearance and type of predator. Condor 89:925-928.

McCabe, R. A., and E. L. Kozicky. 1972. A position on predator management. J. Wildl. Manage. 36:382-394.

Nelson, A. L. 1934. Some early summer food preferences of the American raven in southeastern Oregon. Condor 36:10-15.

Nelson, O. C. 1955. A field study of the sage grouse in southeastern Oregon with special reference to reproduction and survival. M.S. Thesis. Oregon State Univ., Corvallis. 113pp.

Neter, J., W. Wasserman, and M. H. Kutner. 1989. Applied linear regression models. Second ed. Irwin, Homewood. 667pp.

Picozzi, N. 1975. Crow predation on marked nests. J. Wildl. Manage. 39:151-155.

Pyle, W. H. 1993. Response of brood-rearing habitat of sage grouse to prescribed burning in Oregon. M.S. Thesis, Oregon State Univ., Corvallis. 47pp.

Rands, M. R. 1982. The influence of habitat on the population ecology of partridge. Ph.D. Thesis, Univ. of Oxford, England. 350pp.

Redmond, G. W., D. M. Keppie, and P. W. Herzog. 1982. Vegetative structure, concealment, and success at nests of two races of spruce grouse. Can. J. Zool. 60:670-675.

Reitsma, L. R., R. T. Holmes, and T. W. Sherry. 1990. Effects of removal of red squirrels, *Tamiasciurus hudsonicus*, and eastern chipmunks, *Tamias striatus*, on nest predation in a northern hardwood forest: an artificial nest experiment. Oikos 57:375-380.

Rickard, W. H., D. W. Uresk, and J. F. Cline. 1975. Impact of cattle grazing on three perennial grasses in South-Central Washinton. J. Range Manage. 28:108-112.

Riley, T. Z., C. A. Davis, M. Ortiz, and M. J. Wisdom. 1992. Vegetative characteristics of successful and unsuccessful nests of lesser prairie chickens. J. Wildl. Manage. 56:383-387.

Robinson, W. L., and E. G. Bolen. 1989. Wildlife ecology and management. Second ed. Macmillan Publ. Co., New York. 574pp.

Rudnicky, T. C., and M. L. Hunter, Jr. 1993. Avian nest predation in clearcuts, forests, and edges in a forest-dominated landscape. J. Wildl. Manage. 57:358-364.

Schranck, B. W. 1972. Waterfowl nest cover and some predation relationships. J. Wildl. Manage. 36:182-186.

Snedecor, G. W., and R. G. Cochran. 1980. Statistical methods. Seventh ed. Iowa State Univ. Press, Ames. 507pp.

Sneva, F. A., L. R. Rittenhouse, P. T. Tueller, and P. Reece. 1984. Changes in protected and grazed sagebrush-grass in eastern Oregon, 1937-1974. Oregon St. Univ. Agric. Exp. Stn. Bull. 663, Corvallis. 11pp.

Stiehl, R. B., and S. N. Trautwein. 1991. Variations in diets of nesting common ravens. Wilson Bull. 103:83-92.

Sugden, L. G., and G. W. Beyersbergen. 1986. Effect of density and concealment on American crow predation of simulated duck nests. J. Wildl. Manage. 50:9-14.

-----, and -----. 1987. Effect on nesting cover density on American crow predation of simulated duck nests. J. Wildl. Manage. 51:481-485.

Toweill, D. E., and R. G. Anthony. 1988. Coyote foods in a coniferous forest in Oregon. J. Wildl. Manage. 52:507-512.

Wakkinen, W. L. 1990. Nest site characteristics and spring-summer movements of migratory sage grouse in Southeastern Idaho. M.S. Thesis, Univ. Idaho, Moscow. 57pp.

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

Wilcove, D. S. 1985. Nest predation in forest tracts and the decline of migratory songbirds. Ecology 66:1211-1214.

Winward, A. H. 1991. A renewed commitment to management of sagebrush grasslands. Pages 2-7 in Management in the sagebrush steppe. Agric. Exp. Stn. Spec. Rep. 880. Oregon State Univ., Corvallis. 48pp.

Yahner, R. H., and B. L. Cypher. 1987. Effects of nest location on depredation of artificial nests. J. Wildl. Manage. 51:178-181.

-----, and R. A. Voytko. 1989. Effects of nest-site selection on depredation of artificial nests. J. Wildl. Manage. 53:21-25.

-----, and A. L. Wright. 1985. Depredation on artificial ground nests: effects of edge and plot age. J. Wildl. Manage. 49:508-513.

Zar, J. H. 1984. Biostatistical analysis. Second ed. Prentice-Hall, Inc., Englewood Cliffs. 718pp.

APPENDICES

Appendix A. Characteristics of artificial nest sites at Hart Mountain National Antelope Refuge, Oregon, 1991-92.

OBS	YR	P	NE	SHL	SHM	SHT	GS	GT	FS	FT	PS	BU	CT	FATE[a]
1	1	1	1	41.50	0.00	0.00	2.0	0.0	12.0	0.0	0	0	SS	0
2	1	1	2	44.75	24.00	0.00	4.0	0.0	5.5	0.0	1	0	MS	0
3	1	1	3	52.75	0.00	0.00	0.0	0.0	6.0	0.0	0	0	SS	0
4	1	1	4	55.00	0.00	0.00	5.5	0.5	6.5	1.5	1	0	SS	0
5	1	1	5	68.75	0.00	0.00	2.5	0.0	5.0	0.0	0	1	MS	0
6	1	1	11	35.50	17.25	0.00	4.0	0.5	4.5	0.0	0	1	MS	0
7	1	1	12	8.25	51.25	0.00	21.5	1.5	1.5	0.0	0	0	MS	0
8	1	1	13	15.75	59.25	0.00	10.0	0.5	2.0	1.0	0	0	MS	0
9	1	1	14	0.00	50.25	5.50	5.0	1.0	3.0	0.5	0	1	MS	0
10	1	1	15	13.75	34.50	0.00	20.5	7.0	0.5	0.0	0	0	MS	0
11	1	1	16	6.25	59.50	7.50	8.5	1.0	13.0	1.0	0	0	MS	0
12	1	1	17	41.50	0.00	0.00	31.5	0.0	2.5	0.5	1	0	SS	0
13	1	1	18	9.75	62.25	0.00	15.0	7.5	2.5	0.0	0	1	MS	0
14	1	1	19	60.00	0.00	0.00	8.0	1.0	1.5	0.0	0	0	SS	0
15	1	1	20	24.50	19.50	0.00	35.5	7.5	2.0	0.0	1	1	MS	0
16	1	1	21	24.25	22.50	0.00	15.5	1.0	1.5	0.0	0	0	MS	0
17	1	1	22	41.00	30.25	0.00	6.0	2.5	1.0	0.5	0	1	MS	0
18	1	1	23	9.00	40.00	0.00	5.0	0.0	1.5	0.0	0	0	MS	0
19	1	1	24	33.50	0.00	0.00	0.0	0.0	4.5	0.0	0	1	SS	1
20	1	1	25	34.25	0.00	0.00	16.0	1.5	9.0	0.5	0	1	MS	1
21	1	1	26	34.75	0.00	0.00	5.0	0.5	3.0	0.0	0	1	SS	0
22	1	1	27	67.00	1.25	0.00	4.5	0.0	2.0	0.0	1	1	MS	0
23	1	1	28	49.00	0.00	0.00	1.0	0.0	7.5	0.5	1	1	SS	0
24	1	1	29	12.50	40.25	0.00	4.0	0.0	20.0	1.0	1	1	MS	0

Appendix A. (Continued)

OBS	YR	P	NE	SHL	SHM	SHT	GS	GT	FS	FT	PS	BU	CT	FATE[a]
25	1	1	30	32.25	0.00	0.00	2.5	0.0	6.5	0.0	0	1	SS	0
26	1	1	31	42.25	0.00	0.00	24.5	1.0	0.5	0.0	1	1	SS	0
27	1	1	32	0.00	60.75	0.00	31.0	1.5	5.5	0.0	0	1	MS	0
28	1	1	33	4.25	39.50	0.00	53.0	4.0	1.0	0.0	1	1	MS	1
29	1	1	34	9.50	28.75	5.50	6.0	1.0	2.5	0.0	0	1	MS	1
30	1	1	35	65.25	0.00	0.00	3.0	0.0	1.5	0.0	1	1	MS	0
31	1	1	36	25.75	28.75	5.00	31.5	18.5	2.5	0.5	0	1	MD	0
32	1	1	37	8.00	52.75	0.00	17.5	0.5	2.5	0.0	0	1	MS	0
33	1	1	38	20.75	23.50	0.00	3.5	1.0	2.0	0.0	0	1	MS	0
34	1	1	39	10.00	25.75	35.00	35.0	4.0	5.5	0.5	0	1	MS	1
35	1	1	40	47.75	0.00	0.00	25.0	3.0	2.5	0.0	1	0	MS	1
36	1	1	41	48.00	0.00	0.00	17.0	2.5	4.5	0.0	0	1	SS	1
37	1	1	42	7.00	56.00	0.00	11.5	0.0	2.0	0.0	0	0	MS	1
38	1	1	43	11.00	48.75	12.50	4.0	0.0	1.5	0.0	0	0	MS	1
39	1	1	44	37.50	21.75	0.00	15.0	1.5	0.0	0.0	0	1	MS	1
40	1	1	46	16.25	0.00	0.00	3.0	2.0	4.0	0.0	0	1	SS	0
41	1	1	47	17.00	29.75	0.00	1.0	2.5	0.0	0.0	0	0	MS	1
42	1	1	48	29.00	7.00	0.00	6.0	2.0	5.0	0.0	0	1	MS	1
43	1	1	54	40.00	20.00	0.00	1.0	0.0	3.5	0.0	1	0	MS	0
44	1	1	56	29.75	0.00	0.00	1.0	0.0	3.0	0.0	0	1	SS	0
45	1	2	1	37.50	1.25	0.00	20.5	0.5	3.0	0.0	0	0	MS	1
46	1	2	2	18.25	63.75	0.00	5.0	1.0	4.0	1.5	0	1	MS	0
47	1	2	3	20.75	58.75	0.00	7.0	12.5	3.5	1.5	0	1	MD	0
48	1	2	4	26.00	35.50	0.00	3.0	0.5	14.0	1.5	0	1	MS	0
49	1	2	5	24.00	56.00	0.00	8.5	8.0	5.0	3.5	0	1	MS	1

Appendix A. (Continued)

OBS	YR	P	NE	SHL	SHM	SHT	GS	GT	FS	FT	PS	BU	CT	FATE[a]
50	1	2	6	8.00	42.50	0.00	21.5	3.0	11.0	1.0	0	1	MS	0
51	1	2	7	54.50	9.25	0.00	25.5	2.5	12.5	3.0	0	0	MS	0
52	1	2	8	30.00	17.25	0.00	11.0	1.0	6.5	0.0	0	0	MS	0
53	1	2	9	28.00	40.50	0.00	4.5	1.0	28.0	0.0	0	0	MS	0
54	1	2	10	51.75	1.25	0.00	8.5	2.5	11.5	1.0	0	1	MS	0
55	1	2	11	48.50	0.00	0.00	18.0	2.5	7.0	0.0	0	0	SS	0
56	1	2	12	7.75	68.50	0.00	10.0	65.5	6.5	1.5	0	0	MD	0
57	1	2	13	78.00	6.25	0.00	16.5	5.5	3.5	0.0	0	0	MS	0
58	1	2	14	10.00	62.50	0.00	2.0	0.0	3.5	2.5	0	1	MS	1
59	1	2	15	8.75	65.75	0.00	0.5	21.5	42.0	1.0	0	1	MD	0
60	1	2	16	9.25	76.00	0.00	21.5	7.5	20.0	2.0	1	1	MS	1
61	1	2	17	24.25	50.25	0.00	7.0	1.0	6.5	1.0	0	1	MS	0
62	1	2	18	45.50	4.75	0.00	14.5	0.5	12.0	4.5	1	0	MS	1
63	1	2	19	87.00	0.75	0.00	14.5	2.5	5.5	0.5	0	1	MS	0
64	1	2	20	5.00	68.25	4.00	19.5	24.5	33.5	1.0	1	0	MD	1
65	1	2	21	11.25	60.00	1.25	11.0	10.5	1.0	3.0	0	0	MD	1
66	1	2	22	18.50	52.50	0.00	10.0	2.0	2.01	4.5	0	0	MS	0
67	1	2	23	11.25	38.50	0.00	8.5	8.0	1.02	0.0	0	0	MS	0
68	1	2	24	54.00	0.00	0.00	6.0	1.0	1.5	0.0	0	0	SS	1
69	1	2	25	40.50	0.00	0.00	15.5	8.0	0.0	0.5	0	0	SS	0
70	1	2	26	14.00	33.25	0.00	8.5	15.5	0.5	0.5	0	1	MD	0
71	1	2	27	1.50	34.50	13.75	10.0	7.5	8.0	2.0	0	0	MS	0
72	1	2	28	3.50	61.50	0.00	9.0	6.0	1.0	1.0	0	0	MS	0
73	1	2	29	23.50	18.00	0.00	25.0	67.5	4.5	1.0	0	0	MD	0
74	1	2	30	34.25	0.00	0.00	4.5	60.0	3.5	1.5	0	0	MD	0

Appendix A. (Continued)

OBS	YR	P	NE	SHL	SHM	SHT	GS	GT	FS	FT	PS	BU	CT	FATE[a]
75	1	2	31	13.00	28.50	0.00	11.5	60.0	1.0	0.0	0	0	MD	0
76	1	2	32	56.25	2.75	0.00	6.5	10.0	6.0	1.5	1	0	SD	0
77	1	2	33	11.25	46.25	0.00	1.5	51.0	4.0	1.5	0	0	MD	1
78	1	2	34	24.00	39.25	0.00	6.0	34.5	1.0	9.5	0	0	MD	1
79	1	2	35	52.75	1.75	0.00	12.5	33.5	1.0	1.5	1	0	MD	1
80	1	2	36	5.75	56.50	0.00	2.5	9.5	4.0	3.5	1	1	MS	1
81	1	2	37	30.00	0.00	0.00	20.0	1.5	3.5	0.0	1	1	SS	1
82	1	2	38	49.00	0.00	0.00	9.0	9.0	14.0	0.0	0	0	SS	1
83	1	2	39	15.25	54.25	0.00	0.0	47.0	2.0	1.0	0	1	MD	1
84	1	2	40	53.75	0.00	0.00	14.0	4.0	2.0	2.0	0	1	MS	0
85	1	2	41	19.25	13.50	0.00	10.0	3.5	1.5	0.0	0	1	MS	0
86	1	2	42	43.00	0.00	0.00	10.0	1.5	2.0	0.0	0	1	MS	0
87	1	2	43	13.75	32.00	0.00	4.0	1.5	0.0	0.0	1	1	MS	0
88	1	2	44	27.75	20.75	0.00	8.0	3.5	2.0	0.5	0	1	MS	0
89	1	2	45	7.50	41.25	0.00	2.5	31.0	0.0	8.0	0	1	MD	1
90	1	2	46	39.50	0.00	0.00	1.5	0.5	0.0	0.0	0	0	SS	1
91	1	2	47	28.50	31.25	0.00	14.0	3.0	2.0	1.0	0	1	MS	1
92	1	2	48	10.75	64.75	0.00	4.5	0.5	4.0	2.0	0	0	MS	0
93	1	2	49	32.25	40.75	0.00	15.5	3.0	0.0	3.5	0	0	MS	1
94	1	2	50	16.75	44.50	0.00	4.0	5.5	6.5	3.5	0	0	MS	0
95	1	2	51	59.25	0.00	0.00	0.0	1.0	2.0	1.0	0	0	MS	0
96	1	2	52	61.25	0.00	0.00	3.0	1.5	2.0	0.5	0	0	SS	0
97	1	2	53	56.00	0.00	0.00	2.0	4.0	5.5	0.5	0	1	MS	0
98	1	2	57	43.50	28.25	0.00	20.5	13.5	2.0	0.0	0	1	MD	0
99	1	2	58	21.00	36.25	0.00	7.0	53.5	5.0	0.0	0	1	MD	1

Appendix A. (Continued)

OBS	YR	P	NE	SHL	SHM	SHT	GS	GT	FS	FT	PS	BU	CT	FATE[a]
100	1	2	59	21.75	33.50	0.00	15.0	18.5	20.0	0.0	0	0	MD	0
101	1	2	60	44.75	8.25	0.00	13.5	38.0	3.5	0.0	0	1	MD	0
102	1	2	61	59.50	0.00	0.00	10.0	50.0	6.5	0.5	0	0	SD	0
103	1	2	62	8.75	45.75	0.00	15.0	6.0	9.5	7.0	0	1	MS	0
104	1	3	1	35.00	0.00	0.00	1.5	20.5	0.0	0.0	0	0	SD	1
105	1	3	2	7.50	45.25	0.00	4.0	8.5	6.0	6.0	0	1	MS	0
106	1	3	3	39.25	40.00	0.00	12.5	22.5	11.0	0.0	0	1	MD	0
107	1	3	4	60.00	0.00	0.00	24.0	4.0	9.5	0.0	1	1	MS	0
108	1	3	5	4.75	53.25	0.00	15.0	55.5	2.0	0.0	1	1	MD	0
109	1	3	6	37.25	0.00	0.00	41.5	19.0	1.0	0.0	0	1	SD	1
110	1	3	7	43.75	0.00	0.00	27.5	13.0	6.51	7.5	1	1	MD	1
111	1	3	8	48.25	0.00	0.00	5.5	4.0	19.5	3.5	0	1	SS	0
112	1	3	9	41.00	4.25	0.00	9.5	3.0	15.5	6.5	1	1	MS	0
113	1	3	10	57.00	0.00	0.00	5.5	1.5	6.5	2.0	0	1	MS	0
114	1	3	11	73.75	0.00	0.00	13.5	26.0	7.0	0.5	1	1	SD	0
115	1	3	12	44.75	0.00	0.00	2.0	18.5	4.0	3.0	0	1	MD	0
116	1	3	13	9.50	49.75	0.00	14.5	17.5	0.5	1.0	0	1	MD	0
117	1	3	14	16.25	0.00	0.00	28.5	11.0	4.0	1.0	0	0	SD	0
118	1	3	15	41.25	34.50	0.00	2.0	9.5	4.5	0.0	0	1	MS	0
119	1	3	16	52.50	0.00	0.00	10.0	2.5	1.5	3.0	0	1	MS	0
120	1	3	17	59.25	0.00	0.00	12.5	24.0	5.0	1.5	0	0	SD	0
121	1	3	18	54.00	0.00	0.00	11.5	4.5	5.5	0.0	0	1	SS	0
122	1	3	19	20.25	54.75	0.00	2.5	3.5	4.5	0.0	1	1	MS	0
123	1	3	20	9.00	62.25	0.00	8.5	23.0	4.0	1.0	0	1	MD	0
124	1	3	21	55.25	0.00	0.00	18.5	8.5	0.5	0.0	1	1	SS	0

Appendix A. (Continued)

OBS	YR	P	NE	SHL	SHM	SHT	GS	GT	FS	FT	PS	BU	CT	FATE[a]
125	1	3	22	66.25	0.00	0.00	1.0	1.5	2.0	0.0	0	1	SS	1
126	1	3	23	42.50	0.00	0.00	4.5	5.0	9.5	9.0	0	1	MS	0
127	1	3	24	38.75	16.75	0.00	34.5	3.0	5.5	8.5	0	1	MS	0
128	1	3	25	6.25	18.50	0.00	5.0	15.5	13.01	4.0	0	1	MD	0
129	1	3	26	23.50	43.00	0.00	5.5	1.5	15.0	8.5	0	1	MS	0
130	1	3	27	27.75	41.00	0.00	4.0	2.0	6.5	4.0	0	1	MS	0
131	1	3	28	45.00	16.75	0.00	1.0	0.5	4.5	4.5	0	1	SS	0
132	1	3	29	20.00	32.50	0.00	4.5	2.0	16.5	2.5	0	1	MS	0
133	1	3	30	17.00	67.75	0.00	8.0	3.5	7.0	0.5	0	0	MS	0
134	1	3	31	0.00	48.25	0.00	21.0	3.5	4.0	0.5	0	1	MS	0
135	1	3	32	23.00	56.00	0.00	2.0	3.5	5.5	0.5	0	0	MS	0
136	1	3	33	46.50	0.00	0.00	11.5	3.0	3.0	2.5	0	0	SS	1
137	1	3	34	30.50	28.25	0.00	7.0	31.5	3.0	1.5	0	0	MD	0
138	1	3	35	19.75	73.50	0.00	7.5	2.5	7.0	2.0	0	1	MS	0
139	1	3	36	48.00	0.00	0.00	8.5	1.5	3.5	0.5	0	1	SS	1
140	1	3	37	38.00	0.00	0.00	6.0	2.0	1.5	0.0	1	0	MS	0
141	1	3	38	53.25	0.00	0.00	5.5	1.5	3.5	0.0	1	0	MS	1
142	1	3	39	41.25	0.00	0.00	7.0	0.5	4.5	0.5	0	1	SS	0
143	1	3	40	46.50	0.00	0.00	2.0	1.0	2.0	0.0	0	1	MS	0
144	1	3	41	20.00	14.00	0.00	4.0	0.5	7.0	3.5	0	1	SS	1
145	1	3	42	46.50	11.50	0.00	1.0	1.5	8.5	0.0	0	1	SS	1
146	1	3	43	46.75	0.00	0.00	1.0	0.0	4.0	0.0	0	0	SS	1
147	1	3	44	20.50	15.25	0.00	6.5	0.5	2.5	0.5	0	0	SS	0
148	1	3	45	13.00	29.25	0.00	4.0	2.5	7.5	0.5	0	0	MS	0
149	1	3	54	7.50	15.50	0.00	3.0	35.5	2.0	3.5	1	0	MD	0

Appendix A. (Continued)

OBS	YR	P	NE	SHL	SHM	SHT	GS	GT	FS	FT	PS	BU	CT	FATE[a]
150	1	3	55	0.00	36.00	10.75	0.0	60.0	0.0	7.0	0	1	MD	1
151	1	3	56	15.25	0.00	0.00	15.5	15.0	1.5	3.5	0	1	SD	1
152	1	3	57	38.50	0.00	0.00	12.0	18.0	3.5	2.5	1	0	MD	0
153	1	3	58	13.25	50.00	0.00	4.5	1.0	0.0	0.0	1	0	MS	0
154	1	3	59	37.25	0.00	0.00	10.0	29.5	2.0	0.0	0	1	SD	0
155	1	3	60	16.00	33.50	0.00	9.5	2.5	2.0	4.0	0	1	MS	0
156	2	1	1	8.25	23.00	0.00	6.0	2.0	4.0	1.0	0	1	MS	1
157	2	1	2	0.00	58.00	0.00	12.0	3.5	4.01	0.5	0	1	MS	1
158	2	1	3	2.50	74.00	0.00	15.5	28.0	4.5	0.0	1	1	MD	1
159	2	1	4	3.00	34.25	0.00	3.5	1.0	6.0	0.0	0	1	MS	0
160	2	1	5	14.50	52.00	0.00	2.0	4.5	5.0	1.5	1	1	MS	0
161	2	1	6	8.75	48.25	0.00	1.0	5.5	4.5	0.0	0	1	MS	1
162	2	1	7	30.75	32.50	0.00	45.0	11.0	6.0	1.0	0	1	MD	0
163	2	1	8	55.50	0.00	0.00	1.5	0.5	5.0	0.0	1	1	MS	1
164	2	1	9	19.75	48.00	0.00	12.0	7.0	6.5	1.0	0	1	MS	0
165	2	1	10	1.25	42.25	0.00	20.0	8.0	9.0	0.5	0	0	MS	0
166	2	1	11	15.25	47.50	25.25	9.5	2.0	6.0	3.5	0	1	MS	1
167	2	1	12	3.50	74.75	0.00	11.0	2.0	2.5	0.0	0	1	MS	1
168	2	1	13	0.00	51.25	0.00	5.0	79.5	3.0	5.0	1	1	MD	0
169	2	1	14	11.50	35.25	0.00	4.5	2.5	16.0	2.0	1	1	MS	0
170	2	1	15	32.00	19.25	0.00	4.5	2.5	3.5	0.5	1	1	SS	0
171	2	1	16	52.75	0.00	0.00	14.5	6.0	3.0	0.0	0	1	SS	0
172	2	1	17	6.00	42.25	0.00	5.5	0.5	11.5	2.5	0	1	MS	0
173	2	1	18	40.00	2.75	0.00	16.5	11.0	3.0	0.0	1	1	MD	1
174	2	1	19	6.50	33.50	0.00	9.0	32.5	3.0	0.0	1	1	MD	1

Appendix A. (Continued)

OBS	YR	P	NE	SHL	SHM	SHT	GS	GT	FS	FT	PS	BU	CT	FATE[a]
175	2	1	20	0.00	76.25	0.00	1.0	0.0	6.0	0.0	0	1	MS	0
176	2	1	21	3.50	42.25	0.00	10.5	20.0	1.5	0.0	0	1	MD	0
177	2	1	22	25.25	48.25	0.00	5.5	9.0	0.5	0.0	0	1	MS	0
178	2	1	23	16.75	26.75	0.00	13.5	44.0	2.5	0.0	1	1	MD	1
179	2	1	24	17.25	69.00	0.00	2.5	3.0	3.5	0.0	0	1	MS	0
180	2	1	25	50.75	0.00	0.00	6.0	3.0	4.5	0.0	0	1	SS	0
181	2	1	26	31.00	33.50	0.00	1.5	0.5	0.5	0.0	0	1	MS	0
182	2	1	27	26.75	31.25	0.00	9.5	3.5	6.5	1.5	1	1	MS	1
183	2	1	28	24.25	25.25	0.00	14.0	1.5	3.5	0.5	1	1	MS	1
184	2	1	29	32.00	45.25	0.00	3.5	1.5	2.5	0.0	1	1	MS	1
185	2	1	30	31.25	51.25	0.00	15.0	0.5	6.5	2.0	1	1	MS	1
186	2	1	31	0.00	61.50	0.00	11.5	1.0	11.5	0.5	1	1	MS	0
187	2	1	32	8.75	45.25	0.00	0.0	19.5	10.5	1.5	0	1	MD	1
188	2	1	33	3.50	47.00	0.00	15.5	8.0	3.5	1.0	0	1	MS	0
189	2	1	34	12.25	50.00	0.00	2.5	1.0	2.0	2.0	0	1	MS	1
190	2	1	35	36.00	6.25	0.00	12.5	4.5	9.5	1.0	0	1	MS	1
191	2	1	36	2.50	40.00	0.00	3.0	22.0	3.0	0.0	0	1	MD	1
192	2	1	37	40.25	0.00	0.00	3.5	0.0	5.0	1.0	1	1	MS	0
193	2	1	38	35.25	3.75	0.00	21.0	16.5	2.0	2.0	1	1	SD	0
194	2	1	39	21.25	20.00	0.00	9.5	1.0	5.5	0.0	0	1	MS	0
195	2	1	40	23.25	0.00	0.00	15.0	1.0	4.5	0.0	0	1	SS	0
196	2	1	41	10.75	47.00	0.00	12.5	7.5	1.5	1.0	0	0	MS	1
197	2	1	42	16.50	0.00	0.00	7.0	11.5	1.0	2.5	1	1	SD	0
198	2	1	43	27.50	0.00	0.00	6.5	1.5	1.0	1.0	0	1	SS	0
199	2	1	44	23.50	0.00	0.00	6.5	1.5	1.5	0.5	1	0	MS	0

Appendix A. (Continued)

OBS	YR	P	NE	SHL	SHM	SHT	GS	GT	FS	FT	PS	BU	CT	FATE[a]
200	2	1	45	47.75	0.00	0.00	5.0	21.5	0.0	0.5	1	0	MD	0
201	2	1	46	7.75	63.50	0.00	14.5	9.5	1.0	0.0	0	1	MS	0
202	2	1	47	21.25	0.00	0.00	13.5	8.0	2.0	0.0	0	1	MS	0
203	2	1	48	30.00	0.00	0.00	17.5	11.0	2.5	0.0	1	0	MD	1
204	2	1	49	48.00	0.00	0.00	2.0	0.0	4.0	0.0	1	1	SS	0
205	2	1	50	26.25	15.00	0.00	8.0	1.5	6.0	0.0	1	1	MS	1
206	2	1	51	0.00	56.50	0.00	4.0	1.5	1.5	0.0	0	1	MS	0
207	2	1	52	37.25	0.00	0.00	11.0	2.0	4.5	0.0	0	1	SS	0
208	2	1	53	9.75	19.75	0.00	47.5	8.5	7.0	0.0	1	1	MS	1
209	2	1	54	39.75	14.25	0.00	18.0	1.5	2.5	0.5	1	1	MS	1
210	2	1	55	38.75	11.75	0.00	5.0	3.5	2.5	6.0	0	1	MS	1
211	2	1	56	28.50	16.50	0.00	20.0	2.5	1.0	0.0	0	1	MS	0
212	2	1	57	16.75	22.00	0.00	3.5	0.5	3.5	1.0	1	0	MS	0
213	2	1	58	25.50	0.00	0.00	2.5	0.5	9.0	0.0	1	1	SS	0
214	2	1	59	25.00	22.50	0.00	7.0	1.5	1.5	0.0	0	1	MS	1
215	2	1	60	0.00	36.25	0.00	1.5	7.0	2.5	3.5	0	1	MS	1
216	2	2	1	16.00	26.00	0.00	5.0	1.5	3.0	0.0	1	1	MS	0
217	2	2	2	21.75	16.50	0.00	2.0	1.0	3.0	0.0	0	0	MS	0
218	2	2	3	48.00	0.00	0.00	1.0	0.0	0.0	0.0	0	1	MS	0
219	2	2	4	29.00	0.00	0.00	2.5	3.5	0.0	0.0	0	1	MS	0
220	2	2	5	30.00	0.00	0.00	3.0	1.0	1.0	0.0	0	1	MS	0
221	2	2	6	39.50	0.00	0.00	1.5	1.5	0.5	0.0	0	1	SS	1
222	2	2	7	30.75	0.00	0.00	2.5	1.0	0.0	0.0	0	1	SS	0
223	2	2	8	23.25	0.00	0.00	4.5	2.5	1.5	0.0	0	1	SS	0
224	2	2	9	13.50	23.50	0.00	17.5	3.5	7.0	5.0	1	0	MS	0

Appendix A. (Continued)

OBS	YR	P	NE	SHL	SHM	SHT	GS	GT	FS	FT	PS	BU	CT	FATE[a]
225	2	2	10	17.25	0.00	0.00	23.5	34.0	0.5	0.0	0	1	MD	0
226	2	2	11	5.75	43.25	0.00	8.5	1.5	8.0	0.5	1	0	MS	0
227	2	2	12	27.50	11.75	0.00	17.0	11.5	17.5	5.0	1	1	MD	0
228	2	2	13	32.75	18.00	0.00	24.0	4.0	4.0	3.0	0	1	MS	0
229	2	2	14	46.00	8.25	0.00	7.5	1.5	13.0	1.0	0	1	MS	0
230	2	2	15	40.25	0.00	0.00	19.0	3.0	6.0	0.5	0	1	MS	0
231	2	2	16	35.25	30.25	0.00	9.5	7.0	7.5	9.0	0	1	MS	1
232	2	2	17	24.00	35.75	0.00	2.0	2.0	6.0	0.0	1	1	MS	0
233	2	2	18	4.50	50.50	0.00	10.5	6.5	0.5	0.0	1	1	MS	0
234	2	2	19	3.50	11.25	38.50	3.0	12.0	0.5	1.0	1	1	MD	1
235	2	2	20	7.25	50.50	0.00	0.5	13.5	1.0	0.0	0	0	MD	1
236	2	2	21	2.50	61.00	0.00	4.0	24.0	1.5	0.0	1	0	MD	0
237	2	2	22	22.25	43.25	0.00	6.5	1.0	8.0	1.5	0	0	MS	0
238	2	2	23	47.25	0.00	0.00	12.0	0.5	12.0	0.0	0	1	SS	1
239	2	2	24	42.25	0.00	0.00	17.5	2.5	9.5	3.0	1	1	MS	0
240	2	2	25	40.50	24.50	0.00	10.0	1.5	11.5	0.0	1	0	MS	0
241	2	2	26	7.25	44.75	0.00	9.0	2.5	2.0	4.5	1	1	MS	1
242	2	2	27	0.00	65.75	0.00	0.0	59.0	2.0	1.5	1	0	MD	1
243	2	2	28	57.50	0.00	0.00	3.0	1.5	3.0	0.5	0	0	SS	0
244	2	2	29	72.00	0.00	0.00	4.0	4.0	0.5	1.5	0	1	SS	1
245	2	2	30	4.25	53.75	0.00	12.0	19.0	2.5	1.5	1	0	MD	1
246	2	2	31	19.75	58.50	0.00	10.5	4.0	12.0	0.0	0	1	MS	0
247	2	2	32	78.75	0.00	0.00	7.0	2.5	12.0	0.5	0	1	SS	0
248	2	2	33	73.50	0.00	0.00	4.5	0.5	6.5	1.5	0	1	MS	0
249	2	2	34	26.25	0.00	0.00	1.0	3.0	9.5	0.5	0	0	SS	0

Appendix A. (Continued)

OBS	YR	P	NE	SHL	SHM	SHT	GS	GT	FS	FT	PS	BU	CT	FATE[a]
250	2	2	35	13.75	59.75	0.00	15.0	13.0	2.5	5.0	0	1	MD	0
251	2	2	36	28.00	0.00	0.00	18.0	14.5	11.0	0.0	0	1	MD	0
252	2	2	37	24.00	0.00	0.00	10.5	0.5	7.0	0.0	0	1	MS	0
253	2	2	38	49.00	0.00	0.00	4.0	7.0	4.5	5.0	0	1	SS	0
254	2	2	39	77.25	1.00	0.00	26.5	16.0	6.0	0.5	0	1	MD	0
255	2	2	40	20.50	53.75	0.00	6.5	0.5	6.5	0.0	0	0	MS	0
256	2	2	41	22.75	30.50	0.00	20.0	4.5	10.5	3.0	0	1	MS	0
257	2	2	42	10.75	33.25	0.00	18.0	5.0	3.0	0.0	0	1	MS	0
258	2	2	43	13.25	55.00	0.00	3.0	1.5	2.0	0.0	1	1	MS	1
259	2	2	44	0.00	43.00	0.00	15.5	10.0	5.5	0.0	0	0	MD	1
260	2	2	45	33.00	33.50	0.00	3.0	2.5	2.5	0.5	1	0	MS	1
261	2	2	46	24.25	21.50	0.00	10.0	2.5	0.0	0.0	1	1	MS	0
262	2	2	47	47.50	1.50	0.00	9.5	3.5	0.5	0.0	0	1	SS	0
263	2	2	48	41.00	0.00	0.00	2.5	3.5	2.0	0.0	0	0	SS	0
264	2	2	49	32.75	0.00	0.00	16.0	6.5	1.0	0.0	0	1	SS	0
265	2	2	50	41.25	0.00	0.00	5.0	1.5	1.5	0.0	1	1	SS	0
266	2	2	51	11.50	44.75	0.00	4.0	2.0	4.0	3.0	0	0	MS	0
267	2	2	52	5.00	47.50	20.00	5.5	3.5	1.0	0.0	1	1	MS	0
268	2	2	53	24.00	29.25	0.00	10.5	1.0	1.0	3.5	0	1	MS	0
269	2	2	54	52.25	0.00	0.00	2.0	0.5	1.0	0.0	1	1	SS	0
270	2	2	55	50.00	0.00	0.00	10.5	26.5	1.0	0.0	1	0	SD	0
271	2	2	56	42.00	0.00	0.00	2.5	1.5	0.5	0.0	0	1	SS	0
272	2	2	57	3.50	34.75	15.75	8.0	7.0	0.0	0.0	0	0	MS	0
273	2	2	58	44.00	0.00	0.00	2.0	1.0	1.0	1.0	0	0	SS	0
274	2	2	59	1.50	63.75	0.00	0.0	1.0	0.5	0.5	1	1	MS	0

Appendix A. (Continued)

OBS	YR	P	NE	SHL	SHM	SHT	GS	GT	FS	FT	PS	BU	CT	FATE[a]
275	2	2	60	16.75	34.50	0.00	3.0	0.5	0.0	0.0	1	1	MS	0
276	2	3	1	26.25	0.00	0.00	4.5	1.5	1.0	0.0	0	1	SS	1
277	2	3	2	2.75	57.75	0.00	1.0	7.5	4.0	2.5	1	1	MS	0
278	2	3	3	32.50	0.00	0.00	7.0	1.0	8.0	2.0	0	0	SS	0
279	2	3	4	0.00	32.50	0.00	37.0	4.5	5.0	0.0	0	0	MS	0
280	2	3	5	14.50	31.75	0.00	14.5	2.0	16.0	0.0	1	0	MS	0
281	2	3	7	3.50	62.50	0.00	6.0	1.0	4.5	0.0	0	0	MS	0
282	2	3	9	5.25	64.00	0.00	8.0	4.5	0.0	0.0	0	0	MS	1
283	2	3	10	38.50	43.75	0.00	23.5	1.5	0.0	0.0	0	0	SS	1
284	2	3	11	9.00	81.25	0.00	7.0	7.0	3.0	0.5	0	1	MS	1
285	2	3	12	20.25	43.00	0.00	6.5	1.5	1.5	0.0	1	1	MS	0
286	2	3	13	12.00	15.25	0.00	3.5	71.0	0.5	0.5	0	0	MD	1
287	2	3	14	4.00	29.25	0.00	2.5	92.5	0.0	3.5	1	0	MD	1
288	2	3	16	26.50	0.00	0.00	13.5	18.5	8.02	2.0	0	1	SD	0
289	2	3	17	63.75	0.00	0.00	9.0	1.5	3.5	0.0	0	0	SS	0
290	2	3	19	30.50	35.25	0.00	4.0	1.0	7.5	1.0	0	1	SS	0
291	2	3	20	0.00	78.00	0.00	17.5	3.0	2.5	6.0	0	0	MS	0
292	2	3	21	40.50	2.50	0.00	3.0	1.0	14.0	0.0	0	0	SS	0
293	2	3	23	0.00	55.50	0.00	2.0	5.0	6.0	0.0	1	1	MS	1
294	2	3	24	2.25	28.25	0.00	11.0	7.0	1.0	0.0	0	0	MS	1
295	2	3	25	35.25	0.00	0.00	6.5	1.0	10.5	0.0	0	0	SS	1
296	2	3	26	16.50	27.75	0.00	5.5	2.0	0.5	0.0	0	0	MS	0
297	2	3	27	33.50	0.00	0.00	9.0	0.5	0.0	0.5	0	1	SS	1
298	2	3	28	33.75	50.50	0.00	1.5	3.5	3.5	1.0	1	0	MS	0
299	2	3	29	22.25	0.00	0.00	14.5	34.5	1.5	0.0	0	1	SD	0

Appendix A. (Continued)

OBS	YR	P	NE	SHL	SHM	SHT	GS	GT	FS	FT	PS	BU	CT	FATE[a]
300	2	3	30	14.00	7.25	0.00	7.5	80.5	4.5	3.0	0	1	MD	1
301	2	3	31	43.75	0.00	0.00	22.5	11.0	2.0	0.0	0	1	MD	0
302	2	3	32	6.25	46.75	0.00	3.0	6.0	3.0	0.0	1	0	MS	0
303	2	3	33	0.00	83.25	0.00	7.0	9.0	9.5	0.0	0	1	MS	0
304	2	3	34	0.00	49.00	0.00	8.5	18.0	3.5	0.0	1	1	MD	0
305	2	3	35	10.75	27.00	0.00	21.5	1.5	8.0	0.0	0	0	MS	0
306	2	3	36	34.75	0.00	0.00	9.5	1.0	7.5	0.0	1	1	SS	0
307	2	3	37	29.00	26.25	0.00	14.5	5.5	9.0	0.0	0	0	MS	0
308	2	3	38	75.25	5.00	0.00	6.5	16.0	3.5	1.0	0	1	MD	1
309	2	3	39	17.25	62.75	0.00	22.5	20.5	6.0	0.5	0	0	MD	1
310	2	3	40	37.00	26.00	0.00	0.5	1.5	2.5	0.0	1	1	MS	0
311	2	3	41	27.75	11.50	0.00	14.0	4.0	4.0	0.0	1	1	MS	0
312	2	3	42	55.25	8.75	0.00	30.5	20.5	2.0	0.5	0	1	SD	0
313	2	3	43	12.50	50.00	0.00	4.5	0.5	6.5	0.0	1	1	MS	0
314	2	3	44	0.00	64.75	0.00	5.5	24.5	3.5	1.0	0	0	MD	0
315	2	3	45	25.75	8.50	0.00	6.0	1.0	4.5	0.0	1	1	SS	0
316	2	3	46	35.50	0.00	0.00	1.5	1.0	0.0	0.0	0	0	SS	0
317	2	3	47	1.25	42.50	0.00	7.5	9.0	2.5	2.0	0	0	MS	0
318	2	3	48	19.50	19.50	0.00	12.0	47.5	0.0	0.0	0	1	MD	1
319	2	3	49	36.25	0.00	0.00	3.5	2.5	5.5	0.0	0	0	SS	0
320	2	3	50	11.00	22.75	0.00	9.0	11.5	1.0	0.0	0	1	MD	0
321	2	3	51	42.75	0.00	0.00	7.5	1.0	13.5	0.0	0	0	SS	0
322	2	3	52	47.75	0.00	0.00	16.5	1.0	1.0	0.0	0	0	SS	1
323	2	3	53	31.00	14.00	0.00	4.5	1.0	0.5	0.0	0	1	MS	0
324	2	3	54	0.00	31.50	0.00	12.5	6.0	0.5	0.0	0	0	MS	0

Appendix A. (Continued)

OBS	YR	P	NE	SHL	SHM	SHT	GS	GT	FS	FT	PS	BU	CT	FATE[a]
325	2	3	55	4.00	45.25	0.00	9.5	3.0	3.0	0.0	0	0	MS	0
326	2	3	56	1.50	57.75	0.00	1.0	3.0	1.0	2.0	0	0	MS	0
327	2	3	57	0.00	58.50	0.00	36.0	48.5	0.0	0.0	1	0	MD	0
328	2	3	58	14.50	22.25	0.00	11.5	19.0	0.0	0.0	0	0	MD	0
329	2	3	59	48.50	0.00	0.00	5.0	0.5	0.0	0.0	0	0	MS	0
330	2	3	60	26.25	30.00	0.00	6.0	1.0	2.5	0.0	1	1	MS	0

[a] OBS: nest observation (1-330)
YR: year; 1=1991, 2=1992
P: period; 1=April, 2=May, 3=June
NE: nest number (1-62)
SHL: cover (%) of low shrub (<40 cm)
SHM: cover (%) of medium shrub (40-80 cm)
SHT: cover (%) of tall shrub ($\geq$80 cm)
GS: cover (%) of short grass ($\bar{x}$=8 cm)
GT: cover (%) of tall grass ($\bar{x}$=25 cm)
FS: cover (%) of short forb ($\bar{x}$=6 cm)
FT: cover (%) of tall forb ($\bar{x}$=22 cm)
PS: predator sighting associated with nest; 0=no, 1=yes
BU: burrow associated with nest; 0=no, 1=yes
CT: cover type;
- SS: short shrub and sparse, tall grass cover
- SD: short shrub and dense, tall grass cover
- MS: medium shrub and sparse, tall grass cover
- MD: medium shrub and dense, tall grass cover

Fate: 0=depredated, 1=nondepredated

Appendix B. Distribution of depredated and nondepredated artificial sage grouse nests by structural cover type, Hart Mountain National Antelope Refuge, Oregon, 1991-92.