AN ABSTRACT OF THE THESIS OF

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TITLE: Selection of Nesting and Brood-rearing Habitat by Female Ring-necked Pheasants in the Willamette Valley, Oregon

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During spring 1981, 112 radio-equipped female pheasants (Phasianus colchicus), were released in the Willamette Valley, Oregon. Hens were monitored to determine location of nest and brood-rearing sites. Vegetation around each nest and brood-rearing site was classified as one of 5 cover types available on the study areas. Further description of these sites was done by estimating percent of 9 structural characters of vegetation present around nests and brood locations. Selection indices (SI) were calculated for each cover type and structural character used for nesting and brood-rearing. Brood data were analyzed for 2 age classes, 1-4 weeks of age (young broods) and 5-8 weeks of age (older broods).

Though strip vegetation had the highest selection index (9.3) it also had one of the lowest nest success rates (33%). In contrast, grain and grass fields had the highest success rates (50%).

Selection indices for all nests indicated a trend for hens to select medium grass (SI = 1.5), tall grass (SI = 1.3) and forbs (SI = 1.5) in greater proportions than occurred in the habitat. Short grass

(SI = 0.6), shrubs (SI = 0.5) and trees (SI = 0.1) were selected less than their occurrence. Maximum vegetative height (MVH) was greater around nest sites than the general habitat (SI = 1.2). Percentage of tall grass and MVH estimated around successful nests were significantly greater ($\underline{P} < 0.05$) than around unsuccessful nests. Percent short grass was significantly greater ($\underline{P} < 0.05$) around unsuccessful nests. Taller vegetation and greater amounts of tall grass probably resulted in better concealment and security for successful hens and their nests.

Even though nesting hens and broods selected similar cover types, distinct differences existed in structural characters of nesting and brood-rearing vegetation. Selection indices for medium grass, tall grass, and MVH were all slightly less than 1.0 and short grass was selected proportional to it occurrence. Forbs (SI = 1.3) were selected similarily for both nesting and brood-rearing sites as were shrubs and trees (usually much less than 1.0). Foraging habits and need of areas less restrictive to brood movement probably determined brood-rearing sites more than need for concealment.

Broods did not select specific cover types or structural characters according to time of day (morning, midday, evening) with one exception. Older broods selected tree cover for shad on hot days in greater proportion than it occurred in the habitat during midday (SI = 1.3).

Grain fields probably provided the best habitat for successful nesting and brood-rearing. Security and concealment were factors in nest site selection and success. Broods apparently did not require the amount of concealment that hens did around nests.

SELECTION OF NESTING AND BROOD-REARING HABITAT BY FEMALE RING-NECKED PHEASANTS IN THE WILLAMETTE VALLEY, OREGON

by

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Finally, I wish to dedicate this thesis to my loving family, Barbara, Gavin, and Carynn, who have waited so patiently for daddy to come home.

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INTRODUCTION

In 1911, the State of Oregon opened its first game farm in the Willamette Valley for the production of ring-necked pheasants (*Phasianus colchicus*). The game-farm program reached a peak in 1950 when more than 70,000 birds were reared and released. Beginning in the early 1950's, however, the magnitude of the game-farm program was reduced because: 1) most of the productive pheasant habitat was already stocked with wild birds; 2) survival of released game-farm reared birds was low; and 3) the cost of producing birds was excessive. In 1965, the objective of the program was changed to that of supplying pheasants for hunters by releasing males before and during hunting seasons (Oregon Department of Fish and Wildlife, unpubl. report). Females and some males were released in the spring to facilitate game-farm operations (disposal of excess breeders) and to supplement wild populations with breeding-aged birds (Jarvis and Engbring 1976).

The demand for pheasants as a game bird has remained high in Oregon as evidenced by the 54,000-103,000 hunters that participated in pheasant hunting each year for the last 20 years (Oregon Department of Fish and Wildlife, 1978). Declining populations in the face of this demand resulted in the desire to increase pheasant populations in the Willamette Valley (Ralph Denney, pers. commun.).

The Wildlife Division staff and the Fish and Wildlife Commission in 1978 decided to once again change the objectives of the pheasant propagation program. The thrust of the new program was away from primarily releases of males and towards more equitable dispersal of both sexes. Part of the program emphasized release of breeding stock in habitats established through the Wildlife Division's habitat development and land-owner incentive programs in the Willamette Valley (Oregon Department of Fish and Wildlife, unpubl. report).

Pheasant densities are lowest in spring, thus, emerging vegetation creates new habitats that probably exceed the needs of spring population levels. Consequently, release of breeding-age pen-reared hens in spring might increase total pheasant production. This program would provide cock pheasants that were raised in the wild from hatching. Such a program, if successful, could reduce the need for fall "put-and-take" releases.

Information on habitat requirements and selection for nesting and brood-rearing sites of released pheasants is necessary to ensure proper habitat development and successful releases. Most previous studies were concerned only with general cover type discriptions (Eklund 1942, Baskett 1947, Linder et al. 1960, Trautman 1960, Hanson and Labisky 1964, Hanson and Progulske 1973, Dumke and Pils 1979). The project reported on herein was designed to determine cover type and structural components of nesting and brood-rearing sites of pen-reared and released female ring-necked pheasants in the Willamette Valley. The objectives of this study were: 1) to describe cover types and structural characters of vegetation selected for nesting and brood-rearing by ring-necked pheasants and 2) to determine frequency of occurrence in cover types and of structural characters of vegetation in relation to their availability for nesting and brood-rearing by ring-necked pheasants. I attempted to gain a better understanding of pheasant habitat selection that ultimately could be used to enhance pheasant populations in the Willamette Valley.

STUDY AREAS AND METHODS

Study Areas

Two study areas with typical land-use practices and crop types in the Willamette Valley, Oregon were selected. One area, Baskett Slough, included portions of the Baskett Slough National Wildlife Refuge and adjacent private land and was located 3.2 km north of Dallas, Polk County, Oregon (T7S, R5W parts or all of sections 11-15, 23-25). Major crops were annual and perennial ryegrasses, winter and spring grains, and fescue. Most of the grass crops were grown for seed production and, on the refuge, for goose forage. The second study site, Luckiamute, was located along the Luckiamute River 8.0 km south of Monmouth, Polk County, Oregon (T9S, R5W parts or all of sections 10-16, 21-24). Wheat, pasture, seed grass, and corn were among the major crops grown on this area.

Methods

Release Preparations

Pheasant hens were obtained from the E. E. Wilson Game Mangement Area/Game Farm. Staff at the game farm provided space and support for the care of the birds before release. All hens were first year breeders in 1981. One hundred twelve hens were selected for release.

Each hen was equipped with a RB-5 transmitting subsystem (Telonics Inc., 1300 W. University Dr., Mesa, Arizona). These units emitted a pulsed signal in the 150-151 MHz band that was discernible by hand-held receiving equipment at approximately 2.5 km under most field conditions. Transmitters were powered by a lithium cell with an operational life of 4 to 5 months. Weight of these hermetically sealed transmitters was approximately 27 g. Radios were attached to the hens (Brander 1968) with a teflon harness strap (Bally Ribbon Mills, 23 N. 7th Street, Bally, Pennsylvania). Hens were allowed a 2- to 4-day period before release to adjust to the radio transmitter and harness. This adjustment period was within the range of time suggested by Dumke and Pils (1979).

Pheasants were liberated in 3 releases during 15 days: 20 April (84 birds); 27 April (20 birds); and 4 May (8 birds). Equal numbers were dispersed on each study area throughout available habitat. Radios recovered from hens that died during the first few days of monitoring were reused on hens liberated in the second and third releases.

Monitoring

Each hen was located within 3 days after release and once weekly thereafter. It was not necessary to sight hens or to use multiple locations, as suggested by Mech (1967), to determine if hens were alive. The antenna capacitance changed as birds moved; a live hen was noted by fluctuations in signal intensity and quality (Hessler et al. 1970).

Nests, when located, were marked with flagging tape on a stake 5 to 10 m from the nest. The fate of each nest was recorded as successful (at least 1 egg hatched), abandoned, destroyed (by farm machinery or predators), or unsuccessful by death of hen.

The monitoring regimen for broods consisted of locating broods 3 times daily, twice each week. Daylight hours were divided to obtain 3 sampling periods as follows: morning, sunrise - 0900; midday, 1200-1500; and evening, 1800-sunset. Locations of broods also were marked with flagging tape and stake to establish a reference point at which vegetation samples were taken. Monitoring was terminated after all surviving hens were in the field for 120 days, at which time batteries of the transmitting units were expected to expire. Surviving hens were shot or captured by hand or net to recover radios.

Vegetation Analysis

Boundaries for the 2 study areas were defined by radio locations of hens throughout the study period. Peripheral locations were recorded on aerial photographs and connected to form the simplest convex polygon.

The area available for each brood at 4 and 8 weeks of age was determined by encircling brood observations located on aerial photographs with the nest locations as the focal point. Circles encompassed a minimum of 95% of the observations for each 4-week period. The remaining observations (5%) were excluded if the next location nearest the circle increased the brood-rearing area more than 25 percent.

Each crop or non-agricultural area was identified and classified in 1 of 5 cover types for nesting and brood-rearing periods: 1) strip vegetation: typically 3-6 m wide, consisted of fence rows, roadsides, and ditch banks; 2) grain fields: winter wheat and oats, spring wheat and oats, barley, corn, and sudan grass; 3) grass fields: ryegrass and fescue for seed production, pastures for grazing and hay; 4) miscellaneous agricultural areas: legumes, vegetables, and fallow fields; 5) wooded/grassland areas: oak woodlands, riparian woodlands, grassland and grassland/shrub areas. Aerial photographs were used to determine general habitat composition of each study area. Overlays were drawn outlining each cover type and were used to calculate total areas.

A modified life-form system was used to describe nesting and brood-rearing habitats (Crawford 1974). Percent cover of the structural characters of vegetation (life forms) were used: a) short grass (< 30 cm), b) medium grass (30-60 cm), c) tall grass (> 60 cm), d) forbs, e) litter, f) shrub cover, g) tree cover, h) maximum vegetative height (non-woody vegetation only). Percent bare ground also was recorded.

Randomly selected transects, 30 m long, were established in each cover type to characterize structural features of the habitat. The line-intercept method (Mueller-Dombois and Ellenberg 1974) was employed for trees and shrubs. A 0.1 m^2-circular-sampling frame, similar to the one described by Oates (1979), was placed at 10 m intervals along transects to estimate grass cover, herbaceous cover, litter, and percent bare ground (characters a-e and bare ground equalled 100%) within the frame.

After abandonment, hatching, or destruction of each nest, structural characteristics were measured from 4 10-m transects to estimate cover of shrubs and trees. The 0.1 m^2-circular-sampling frame was placed at 0, 1, 5, and 10 m from the nest along each transect to estimate structural characters present. The nest site was used as the focal point for transects. The 16 estimates from around the nest were combined to obtain mean structural characters for each nest site observed. The same vegetation estimating technique was used for brood-rearing sites with the initial radio location of the hen as the focus for transects and estimates were made at 1, 5, and 10 m.

Data from broods that were at least 8 weeks old at the end of the study (20 August) were used to determine if differences existed in selection of brood-rearing sites between 2 brood age classes. Radio location data for 6 broods were grouped into weeks 1-4 (younger broods) and weeks 5-8 (older broods).

Adequate sampling of both agricultural and non-agricultural areas was determined by calculating minimum number of transects needed for analysis from random samples. The following formula, modified from Snedecor and Cochran (1967), was used:

$$n = \frac{\underline{t}^2 s^2}{\pm 0.2 \, \overline{X}^2}$$

$\underline{t}$ = $\underline{t}$-statistic (≈ 2.0)

s^2 = variance

$\overline{X}$ = sample mean

Statistical Analysis

Selection indices were calculated for cover types and structural characteristics of vegetation selected for nest and brood-rearing sites. The following formula was used to calculate selection indices:

$$SI = \frac{\text{\% cover type (structural character) selected by hens or broods}}{\text{\% cover type (structural character) available to hens or broods}}$$

where SI < 1, selected less than occurrence on study area;

SI = 1, selected equal to occurrence on study area;

SI > 1, selected greater than occurrence on study area.

Selection indices were used as an index to preference for cover types and structural characters of vegetation available to pheasant hens within the defined study areas.

Distribution of nests among 5 habitats for the 2 study areas were compared by Chi-square analysis. Discriminant analysis and _t_-tests were used to compare structural characters between successful and unsuccessful nest sites (Nie et al. 1975, McClave and Dietrick 1979).

One-way ANOVA was used to determine if significant differences existed in structural characters between age groups and among the 3 times of day (Nie et al. 1975). Statistical significance was established at 95% unless otherwise indicated.

RESULTS AND DISCUSSION

Nesting Habitat

Cover Types

The proportions of each of the 5 cover types were approximately the same for both study areas, except for wooded/grassland areas (Table 1). On the Luckiamute area, there were large contiguous tracts of riparian habitat (224 ha) and oak-woodlands (192 ha) contributing to the large percentage of wooded/grassland cover type. Grassland (with scattered shrubs) was the predominant cover in the wooded/grassland category (87 ha) on Baskett Slough. Grain fields were the most numerous cover type on both areas and collectively accounted for 37% of the cover. The remaining habitat consisted of 20% grass fields, 22% miscellaneous agricultural areas, 19% wooded/grassland areas, and 3% strip vegetation. Approximately 2% of each study area (19 ha Baskett Slough, 27 ha Luckiamute) consisted of ponds, lakes, buildings, and parking lots.

Cover types in which nests were established were determined in 51 of 53 instances; 2 nests were not found, but these hens successfully produced broods. Of 51 nests located, 15 (28%) were in strip vegetation, 16 (31%) were in grain fields, 10 (20%) in grass fields, and 7 (14%) in miscellaneous agricultural areas.

The distribution of nesting attempts among the 5 cover types was significantly different between study areas (Table 2). The greatest difference existed between strip vegetation and grain fields.

Table 1. Area and percent of cover types available to pheasant hens for nesting, Baskett Slough and Luckiamute study areas, Polk County, Oregon, 1981.

	Study area					
	Baskett Slough		Luckiamute		Total	
Cover type	ha	%	ha	%	ha	%
Strip vegetation	41	3	41	2	82	3
Grain fields	493	39	703	36	1196	37
Winter	241	19	470	24	711	22
Spring	252	20	233	12	485	15
Grass fields	297	23	345	17	642	20
Pasture	34	3	173	9	207	6
Seed grass	263	20	172	9	435	13
Miscellaneous agricultural	298	23	416	21	714	22
Wooded/grassland	153	12	475	24	628	19
Total habitat[a]	1282		1980		3262	

[a] Adjusted to reflect entire nesting season and changes in cover types resulting from cultivation, does not include parking lots, buildings or ponds. Actual size of Baskett Slough study area was 1049 ha. Actual size of Luckiamute study area was 1774 ha.

Table 2. Number and percent of cover types used for nesting and selection indices (SI) for 5 cover types used by radio-equipped pheasant hens, Baskett Slough and Luckiamute study areas, Polk County, Oregon, 1981.

	Study area								
	Nests at Baskett Slough			Nests at Luckiamute			Total		
Cover type	N	%	SI	N	%	SI	N	%	SI
Strip vegetation	10	37	12.3	5	19	9.5	15	28	9.3
Grain fields	5	19	0.5	11	42	1.2	16	30	0.8
Winter	4	15	0.8	10	38	1.6	14	26	1.2
Spring	1	4	0.2	1	4	0.3	2	4	0.3
Grass fields	4	15	0.7	6	23	1.4	10	19	1.0
Pasture	0	0	0.0	5	19	2.1	5	9	1.5
Seed grass	4	15	0.8	1	4	0.4	5	9	0.7
Miscellaneous agricultural	5	19	0.8	2	8	0.4	7	13	0.6
Wooded/grassland	2	7	0.6	1	4	0.2	3	6	0.3
Unknown	1	4		1	4		2	4	
Total	27			26			53		

Fifteen nests were attempted in strips of which 10 were on Baskett Slough. In grain fields 16 attempts were made, 11 on Luckiamute. Each area had approximately the same proportion of strip vegetation and grain fields.

Selection indices (Table 2) indicated an extremely high preference for strip vegetation on both study areas (SI = 12.3 on Baskett Slough, SI = 9.5 on Luckiamute). Preference for strip vegetation was to some extent similar to results found by Gates (1966) and Dumke and Pils (1979) in Wisconsin. In the latter study, nests in strip cover accounted for 14% of nests located, whereas strip cover comprised only 1% of the home range of hens in April (SI = 14.0). In South Dakota, Trautman (1960) reported that nest densities were highest in fence rows and roadsides. In that study, 9% of the estimated acreage was strip vegetation, but approximately 29% of the nests were established therein (SI = 3.3). Similarily, in Nebraska, Linder et al. (1960) found that roadsides and fence rows to contain an average 26% of nests located; however, these areas occupied less than 2% the area (SI ≃ 13).

Winter grains were preferred (SI = 1.2) but spring grains were used much less frequently than their occurrence (SI = 0.3). Time of planting of spring grains and crop maturation did not coincide with the primary nesting period (1 May to 30 May) which resulted in low use. Contrastingly, winter grains planted during the previous fall were among the first crops available during the nesting season. Spring grain fields most likely did not provide cover until mid or late June and were used only by renesting hens (both nests found in spring grains were initiated after 20 June and were second and third attempts by these hens) to establish nests.

Baskett (1947) found high percentages of nests in oat fields (32% to 44% of all productive nests). He noted that oat fields did not become available for nesting until June and that many nests probably were from hens that had their nests destroyed earlier by mowing of hay fields.

Generally, the number of nests reported in the literature for grain fields was high but densities were low because of the abundance of this cover type (Linder et al. 1960, Trautman 1960). However, Bartmann (1969) found grain fields little used for nesting in Utah where less than 7% (36 ha) of the total area available in grains was searched. Perhaps low nest densities accounted for the lack of nests observed or other areas were not disturbed forcing hens to renest in grain fields.

Pastures had an overall selection index of 1.5. However, none of the nests discovered in pastures were on Baskett Slough. Pastures amounted to 3% of the Baskett Slough study area and generally were grazed heavily by sheep at the time of nesting. On Luckiamute pastures were mowed and lighly grazed by cattle. Nesting opportunities were afforded before mowing and grazing. Overall, 9% of the nests were in this cover type.

Seed grass fields, similar structurally to many pastures, also contained 9% of the nest sites. Selection indices for seed grass, though, were only 0.7 overall (SI = 0.8 Baskett Slough, SI = 0.4 Luckiamute).

An increase in the use of grain and grass fields was noticed for the latter portion of the nesting season. The percent of nests found in grain fields increased from 24% (8) for nesting before 1 June (early season) to 44% (8) for nesting after 1 June (late season). Similarily, use of grass fields increased from 15% (5) to 28% (5). A corresponding decrease from 32% during the early season to 22% (4) in the late season in the percent of nests located in strip vegetation occurred. Declines in the use of other agricultural (mostly fallow fields) and wooded/grassland cover types also were observed. The percent of nests in miscellaneous agricultural areas declined from 18% (6) to 6% (1) and wooded/grassland areas declined from 9% (3) to 0%. Other researchers reported similar changes or shifts in use of cover types as the nesting season progressed (Buss 1946, Linder et al. 1960, Gates 1966, Bartmann 1969, Dumke and Pils 1979). Many of these changes were a result of renesting hens establishing their nests in maturing crop cover after being unsuccessful in permanent cover (Gates 1966). Much of the permanent cover was in strip vegetation as well as woodlots and grasslands. Fields remaining fallow through winter and spring also provided nesting habitat.

Nest success (50%) was highest in grain and grass fields. Although strip vegetation had the highest selection index (9.3) for nesting, only 33% of the nests attempted in this cover type were successful. Nest success was lower (14%) only in miscellaneous agricultural areas. The use of strip vegetation for travel lanes by predators and the narrow nature of strips seemingly would provide insecure nest sites (Jarvis and Simpson 1978). In my study, 8 of 10 unsuccessful nests in strips failed because of predation (Table 3). A higher depredation rate was recorded in wooded/grassland areas, where both unsuccessful nests were destroyed by predators.

Baskett (1941) reported a nest success of 24% in fence rows and roadsides. In 1947, Baskett found nest success in strip vegetation was as low as 5% in fence rows and as high as 50% along sloughs. Although Linder et al. (1960) found a strong preference for roadsides (estimated SI = 15.7), nest success was only 19%; contrastingly, nest success in wheat fields was 29%. Eklund (1942) found nest success in strips in the Willamette Valley was 37% and 40% in grain fields. Nests in pastures and hay fields (unspecified plant species) were successful for 47% of the attempts. More recently Dumke and Pils (1979) found 31% nest success in strip vegetation. Ditch banks in their study contained 12 of 16 nests, but nest success was only 25%.

Predators destroyed 15 (28%) of 53 nests. The number of nests destroyed by predators was significantly different among cover types (Table 3). Predators were responsible for nest failues in 8 (53%) of the nests found in strip vegetation, 3 (19%) in grain fields, 2 (20%) in grass fields, and 2 (67%) wooded/grassland areas. There was no instance of nest depredation in miscellaneous agricultural areas recorded.

Overall, mammalian predators were the major cause of nest failure. Only 1 nest destroyed by predators was attributed to an avian species; it was located in strip vegetation. Baskett (1947) reported that approximately 38% of all nest losses were caused by predators, largely attributed to crows (Corvus brachyrhynchos). In contrast, Bartmann

Table 3. Cause of nest failure in 5 cover types for radio-equipped pheasant hens, Baskett Slough and Luckiamute study areas, Polk County, Oregon, 1981.

	Cause of nest failure														
	Predation			Abondonment			Farming operations			Hen killed			Total failures		
Cover type	BS[a]	LA[b]	Total[c]	BS	LA	Total	BS	LA	Total	BS	LA	Total	BS	LA	Total
Strip vegetation	5	3	8	1	1	2	0	0	0	0	0	0	6	4	10
Grain fields	2	1	3	0	3	3	0	1	1	0	1	1	2	6	8
Grass fields	0	2	2	0	1	1	0	1	1	1	0	1	1	4	5
Miscellaneous agricultural	0	0	0	1	1	2	2	1	3	1	0	1	4	2	6
Wooded/ grassland	2	0	2	0	0	0	0	0	0	0	0	0	2	0	2
TOTALS	9	6	15	2	6	8	2	3	5	2	1	3	15	16	31

[a] BS = Baskett Slough

[b] LA = Luckiamute

[c] Distribution of failures was significantly different ($\underline{P} < 0.05$) among cover types for predation.

(1969) found 75% of nests destroyed by predators, mostly mammals (badgers, Taxidea taxus). Without mentioning species involved, Dumke and Pils (1979) found that in Wisconsin depredation was the primary cause of nest disruption. Mammals were responsible for the destruction of approximately 23% of pheasant nests in Nebraska and avian species were responsible for less than 2% (Linder et al. 1960).

Abandonment was the second most-common cause of nest failure. Eight (15%) nests were abandoned. Numbers of abandoned nests were not significantly different among cover types. Other hens, predators, and human activities were among some of the causes of nest abandonment. In Iowa (Baskett 1947) found that desertion resulted in 51% of nest losses; human activities were cited as the cause of abandonment in most instances. Linder et al. (1960) reported 12% of nests were abandoned in their Nebraska study.

Farm equipment and farming operations were responsible for the loss of 5 (9%) nests. Three of 5 nests destroyed were in miscellaneous agricultural areas. The major component of the cover type was fallow fields (over winter) that were plowed, disked, and replanted in crops during spring 1981. Farming operations were a commonly recorded cause of nest loss in other pheasant studies particularily where mowing of hay or other grasses took place in late June-early July. Eklund (1942) indicated that mowing was the single most common cause of nest mortality in the Willamette Valley, but also indicated that other factors combined accounted for more total losses. Mowing also was the greatest single cause of nest destruction (37%) in Nebraska (Linder et al. 1960).

Structural Characteristics

The proportion of structural characters of vegetation on the two areas were similar with the exception of short grass and tree cover (Table 4). There was a significantly greater percentage of short grass available on Baskett Slough than on Luckiamute. A higher proportion of seed grass crops (ryegrass and fescue) were planted on Baskett Slough (263 ha, 20%) than on Luckiamute (173 ha, 9%). Seed grass was cut in late June-early July. This harvest, along with a greater percentage of grains planted in spring (252 ha, 20% Baskett Slough and 233 ha, 12% Luckiamute), lowered the overall vegetative height on Baskett and most directly affected the short grass character. Percent tree cover was significantly greater on Luckiamute because there was more than 6 times the wooded cover available on Luckiamute (416 ha, 21%) than on Baskett Slough (66 ha, 5%).

Selection indices for all nests (Table 5) indicated a trend for pheasant hens to select medium grass (SI = 1.5), tall grass (SI = 1.3), and forbs (SI = 1.5) in greater proportions than their occurrence in the habitat. Short grass (SI = 0.6), shrubs (SI = 0.5), and trees (SI = 0.1) clearly were not preferred. Maximum vegetative height (MVH) was greater around nest sites than in the general habitat (SI = 1.2). The preference for grasses and forbs agreed with the conclusions of other authors (Edminster 1954, Bartmann 1969, Hoffman 1973, Guthery et al. 1980) who reported that grass-forb mixtures were used frequently as pheasant nesting cover. The low selection index for shrub cover was contrary to findings of Bartmann (1969), who indicated that pheasant hens in Utah chose shrubby cover for nesting,

Table 4. Percent structural characters of vegetation available to pheasant hens for nesting, Baskett Slough and Luckiamute study areas, Polk County, Oregon, 1981.

Structural character	Percent on each study area		
	Baskett Slough	Luckiamute	Combined %[a]
Short grass[b]	18	9	13
Medium grass	6	7	6
Tall grass	20	22	21
Forbs	9	12	11
Litter	16	20	19
Bare ground	31	30	30
Shrub cover	4	8	6
Tree cover[b]	3	15	11
MVH (cm)	67	81	76

[a] Weighted by study area size.

[b] Structural character significantly different ($\underline{P} < 0.05$) between study areas.

Table 5. Mean percent of structural characters of vegetation used by radio-equipped pheasant hens and selection indices (SI) for successful and unsuccessful nest sites, Baskett Slough and Luckiamute study areas combined, Polk County, Oregon, 1981.

Structural character[a]	Nest fate: Successful		Nest fate: Unsuccssful		All nests combined	
	$\bar{x}$ ± SD	SI	$\bar{x}$ ± SD	SI	$\bar{x}$ ± SD	SI
Short grass[bc]	4 ± 6	0.3	11 ± 11	0.8	8 ± 10	0.6
Medium grass	7 ± 10	1.2	11 ± 12	1.8	9 ± 11	1.5
Tall grass[bc]	37 ± 20	1.8	21 ± 19	1.0	28 ± 20	1.3
Forbs	14 ± 17	1.3	17 ± 19	1.5	16 ± 18	1.5
Litter	14 ± 14	0.7	17 ± 13	0.9	16 ± 13	0.8
Bare ground	24 ± 20	0.8	23 ± 18	0.8	23 ± 18	0.8
Shrub cover	4 ± 11	0.7	2 ± 6	0.3	3 ± 9	0.5
Tree cover	3 ± 11	0.3	<1 ± 1	0	1 ± 7	0.1
MVH (cm)[b]	103 ± 20	1.4	78 ± 25	1.0	88 ± 26	1.2

[a] Shrub and tree cover were measured independently of one another and of other structural characters; therefore only the first 6 structural characters will total 100%.

[b] Means were significantly different ($\underline{P} < 0.05$) between successful and unsuccessful nests.

[c] Structural characters had the highest discriminating scores in discriminate analysis.

particularly early in the season. A review of pheasant habitat requirements by Olsen (1977) indicated that shrubby and wooded areas were of little value for nesting and received only minor use.

Nest success appeared dependent, at least in part, upon structural characters. Differences in the percentages of structural characters around nest sites (Table 5) existed between successful and unsuccessful nests. Unsuccessful nests were typified by greater percentages of short grass and medium grass, and lesser percentages of tall grass compared with those around successful nests. Of these differences, mean percent short grass was significantly greater in unsuccessful nests sites and mean percent tall grass was significantly greater in successful nest sites. Maximum vegetative height was significantly greater around successful nests than unsuccessful nests.

The proportion of structural characters around successful nest sites differed between study areas (Table 6). Percent tall grass was significantly greater for successful nests sites on Baskett Slough (45%) than on Luckiamute (25%). Maximum vegetative height was significantly greater for successful nest sites on Baskett (114 cm) than on Luckiamute (89 cm). This finding was in contrast with the similar percentages of tall grass available on both areas (22% Luckiamute, 20% Baskett). Maximum vegetative height available was greater on Luckiamute (81 cm) than on Baskett Slough (67 cm).

The proportion of structural characters around unsuccessful nests sites also differed between study areas. Unsuccessful hens nesting on Luckiamute chose a significantly greater amount of bare ground (32%) than unsuccessful hens on Baskett Slough (14%). Percent bare ground

Table 6. Mean percent structural characters of vegetation used by radio-equipped pheasant hens and selection indices (SI) for successful nests, Baskett Slough and Luckiamute study areas, Polk County, Oregon, 1981.

	Study area			
	Baskett Slough		Luckiamute	
Structural character[a]	x ± SD	SI	x ± SD	SI
Short grass	3 ± 3	0.2	5 ± 8	0.6
Medium grass	4 ± 3	0.7	12 ± 15	1.7
Tall grass[b]	45 ± 20	2.3	26 ± 12	1.1
Forbs	17 ± 21	1.9	8 ± 8	0.7
Litter	11 ± 7	0.7	19 ± 21	1.0
Bare ground	20 ± 18	0.6	30 ± 22	1.0
Shrub cover	<1 ± 1	0.1	8 ± 17	1.0
Tree cover	<1 ± 1	0.1	6 ± 18	0.4
MVH (cm)[b]	114 ± 17	1.7	89 ± 12	1.1

[a] Shrub and tree cover were measured independently of one another and of other structural characters; therefore only the first 6 structural characters will total 100%.

[b] Significantly different ($\underline{P}$ < 0.05) between study areas for these cover types.

available was similar on both areas (31% Baskett Slough, 30% Luckiamute). There was a trend for all nest sites to have more bare ground within them on Baskett Slough than on Luckiamute. This observation may be explained partly by the higher number of nests in strip vegetation on Baskett. Many nests in strip vegetation were located along unpaved roadsides or firebreaks that increased the bare ground component in the vicinty of a nest.

Little information was available in the literature relating structural characters and nest site selection in pheasants. There was some indication that vegetation height and density were influenced by hen nest site selection. For example, Hanson (1970) provided evidence of a direct relationship between the plant height and density and number of hens that nested in certain cover types. Gates and Hale (1974) found that peas were used mostly after obtaining a height of 23 cm, oats 75 cm, and hay fields 25 cm. Wood and Brotherson (1981) measured vegetation height above nests and found no significant differences between nest sites and adjacent sites (in same cover type), but they found a significantly greater percentage of vegetative cover at nest sites. My data indicated a similar trend. Bare ground and litter were selected slightly less than their occurrence (SI = 0.8) and 3 of the vegetative categories (medium grass, tall grass, forbs) were selected in greater proportion to their overall occurrence, indicating total vegetative cover at nest sites was greater than in the habitat in general.

Brood-rearing Habitat

Vegetation data from locations of 12 broods, 1-8 weeks of age, were used to describe cover type and selection of structural characters by hens for brood-rearing. Four of 12 broods were on Baskett Slough and 8 were on Luckiamute. The nest of one hen was not located; therefore mean area, percent of cover types, and structural characters available were calculated from 11 brood-rearing areas. Data were combined from the 2 study areas.

Only 6 of 11 broods were 8 weeks of age or older at the end of the study period (20 August). For the broods that reached their 8th week of age, there was a significant increase in the mean area available to them compared with the area available to them at 4 weeks of age (mean at 4 weeks = 50 ± 23 ha, mean at 8 weeks = 79 ± 23 ha). Proportions of each cover type remained nearly the same between age groups.

Cover Types

Among the brood-rearing areas, grain fields typically were the most abundant cover type available and the most frequently recorded type used by broods (Table 7). Percentage of sightings in grain fields for individual broods ranged from 33% to 100% of all sightings for younger broods and 54% to 96% of all sightings for older broods.

Wooded/grassland cover types and miscellaneous agricultural cover types were used little or not at all by broods. None of 12 broods I studied was sighted in wooded/grassland cover types during the first 4 weeks of age and only 2 broods in this age classes were sighted in

Table 7. Area and percent of 5 cover types available to pheasant hens for brood-rearing, Baskett Slough and Luckiamute study areas combined, Polk County, Oregon, 1981.

	Maximum areas available					
	All broods at 4 weeks of age (n=11)		Broods > 8 weeks of age at end of study (n = 6)			
			At 4 weeks		At 8 weeks	
Cover type	ha	%	ha	%	ha	%
Strip vegetation[a]	32	6	17	6	24	5
Grain fields[a]	313	61	183	64	279	61
Grass fields	83	16	52	18	104	23
Miscellaneous agricultural	38	8	16	6	25	5
Wooded/grassland	45	9	18	6	26	6
Total habitat available[a]	510	100	286	100	458	100
Non-vegetative cover[a]	18	3	12	4	17	4
Totals[1]	528		298		475	

[a] Mean area available significantly different ($P < 0.05$) between first 4 week period and second 4 week period.

miscellaneous agricultural cover. One of these 2 broods used a bean field extensively until the crop was harvested (brood age = 3 weeks) and the other brood used a small, newly planted ($\leq$ 1 year) Christmas tree plantation for the first 4 weeks. Only one brood sighting was recorded in wooded/grassland cover for the $\geq$ 5-week age group. Contrasting, other investigators (Bartmann 1969, Hanson and Progulske 1973, Dumke and Pils 1979) reported cover types similar to wooded/grassland and miscellaneous agricultural cover types were frequently used by pheasant hens and their broods.

Selection indices for cover types (Table 8) indicated a strong preference (SI = 2.3) for strip vegetation by all broods during their first 4 weeks of age. Grain fields and miscellaneous agricultural areas (SI = 1.2) were preferred but less than strip vegetation by young broods. Older broods selected grain fields in proportion to their overall occurrence. Grass fields were not preferred by all age groupings.

The selection indices for strip vegetation increased 2 fold from the first 4-week age period to the second. Even though grass fields were not preferred by either age group, use more than doubled (SI = 0.3 to 0.7). Older broods probably were more mobile than younger broods (Hanson and Progulske 1973). Increased movement of older broods probably accounted for some changes I observed in the use of strip vegetation and other cover types.

Table 8. Number and percent of locations of broods in 5 cover types and selection indices (SI) for radio-equipped pheasant hens and 2 age classes of their broods, Baskett Slough and Luckiamute study areas combined, Polk County, Oregon, 1981.

	All broods at 4 week of age (n = 12)			Broods > 8 weeks of age at end of study (n = 6)					
				At 4 weeks			At 8 weeks		
Cover type	No. of locations	%	SI	No. of locations	%	SI	No. of locations	%	SI
Strip vegetation	36	14	2.3	11	9	1.5	21	15	3.0
Grain fields	176	68	1.1	95	77	1.2	92	64	1.0
Grass fields	23	9	0.6	6	5	0.3	22	15	0.7
Miscellaneous agricultural	23	9	1.1	11	9	1.5	8	6	1.2
Wooded/grassland	0	0	0	0	0	0	0	0	0
Total no. of locations	258			123			144		

Structural Characteristics

Structural characters of vegetation available to broods (Table 9) changed with vegetation maturity and crop harvest occurring throughout the summer months. Those differences in availability that were statistically significant between age groups included percent medium grass and percent litter. There was a significant increase in medium grass and litter available to older broods, whereas percent tall grass, percent bare ground, and maximum vegetative height decreased. These changes were affected directly by harvest of grains in late summer. Typically, harvest of grains left stubble between 30 cm and 60 cm (medium grass) and considerable amounts of litter.

Selection indices for brood-rearing areas (Table 9) indicated a preference for forbs and bare ground by young broods. Older broods also selected forbs in greater proportion than their occurrence in the habitat, but selection index for bare ground decreased to < 1.0. The harvest of grains probably contributed to the decreased use of bare ground by providing attractive feeding areas (grain stubble) with abundant litter. Bare ground remained the second most abundant structural character ($> 25\%$) of brood-rearing habitat for both age classes. Areas with high percentages of bare ground probably were less restrictive to the movements of broods during foraging and escape behavior. In contrast, areas that were high in rank vegetation, such as grassland, possibly restricted movements, therefore were not used as frequently. Density of vegetation, as indicated by percent bare ground, was probably a critical factor in selection of brood-rearing

Table 9. Mean percent of structural characters of vegetation available to broods of radio-equipped hen pheasants and selection indices for 2 different brood age classes, Baskett Slough and Luckiamute study areas combined, Polk County, Oregon, 1981.

	All broods at 4 week of age (n = 11)[a]			Broods > 8 weeks of age at end of study (n = 6)[b]					
				At 4 weeks			At 8 weeks		
Structural character[c]	% Available	% Selected	SI	% Available	% Selected	SI	% Available	% Selected	SI
Short grass	6	6	1.0	6	2	0.3	8	8	1.0
Medium grass	8	7	0.9	6	4	0.7	10	6	0.6
Tall grass	28	21	0.8	32	26	0.8	26	27	1.0
Forbs	10	13	1.3	9	12	1.3	9	12	1.3
Litter	15	15	1.0	13	9	0.7	17	22	1.3
Bare ground	33	38	1.2	34	47	1.4	30	25	0.8
Shrub cover	5	1	0.2	4	1	0.3	4	1	0.3
Tree cover	6	2	0.4	4	1	0.3	4	3	0.8
MVH (cm)	92	79	0.9	93	88	0.9	88	84	1.0

[a] Data available on 12 broods for percent selected but only 11 brood-rearing areas were defined.

[b] The same 6 broods were observed for both age groups.

[c] Shrub and tree cover were measured independently of one another and of other structural characters; therefore only the first 6 structural characters will total 100%.

sites especially for young broods. Gates and Hale (1974) also found that areas of dense vegetation were not used by broods as much as areas with lower density.

As broods became older, the selection index for litter changed from 0.7 to 1.3. This change also likely was related to grain harvest and greater availability of food (scattered grains). Short grass also was used more as broods matured. Generally, for all age groups, shrub and tree cover were avoided, although there was some indication that older broods used tree cover more than younger broods.

Time of day played little role in the selection of either cover type or structural characters (Tables 10-13). The use of strips generally increased among broods during the midday period and use of the other 4 cover types declined slightly. Corresponding to the greater use of strip vegetation there was an overall increase in use of shrub and tree cover. Tree cover used by older broods not only increased at midday but the selection index was > 1.0. The increased use of strips, shrubs, and trees during the midday period was explained partly by observations of broods apparently seeking shade under trees in fence rows or in small orchards on hot days. Shrubby and wooded areas otherwise provided little in the way of desirable habitat for brood-rearing. In contrast to these results, Hanson and Progulske (1973) found that use of cover depended on time of day. They found that pheasants during summer and fall used strip vegetation less during midday. The use of strips by pheasants in South Dakota was particularly high in the afternoon and for night roosting. Broods on both Luckiamute and Baskett Slough roosted at night in the location

Table 10. Number and percent of locations in 5 cover types and selection indices (SI) by time of day for 6 radio-equipped pheasant hens and their broods (brood age 1 to 4 weeks combined), Baskett Slough and Luckiamute study areas combined, Polk County, Oregon, 1981.

	Time of day								
	Morning			Midday			Evening		
Cover type	No. of locations	%	SI	No. of locations	%	SI	No. of locations	%	SI
Strip vegetation	2	5	0.8	5	12	2.0	4	10	1.7
Grain fields	32	80	1.3	33	79	1.2	30	73	1.1
Grass fields	2	5	0.3	1	2	0.4	3	7	0.4
Miscellaneous agricultural	4	10	1.7	3	7	1.2	4	10	1.7
Wooded/grassland	0	0	0	0	0	0	0	0	0
Total no. of locations	40			42			41		

Table 11. Number and percent of locations in 5 cover types and selection indices (SI) by time of day for brood-rearing by 6 radio-equipped pheasant hens and their broods (brood age 5 to 8 weeks combined), Baskett Slough and Luckiamute study areas combined, Polk County, Oregon, 1981.

	Time of day								
	Morning			Midday			Evening		
Cover type	No. of locations	%	SI	No. of locations	%	SI	No. of locations	%	SI
Strip vegetation	8	17	3.4	10	21	4.0	3	6	1.2
Grain fields	31	65	1.1	28	58	1.0	33	69	1.1
Grass fields	7	15	0.6	6	13	0.6	9	19	0.8
Miscellaneous agricultural	1	2	0.4	4	8	1.6	3	6	1.2
Wooded/grassland	1	2	0.4	0	0	0	0	0	0
Total no. of locations	48			48			48		

Table 12. Mean percent and selection indices (SI) for structural characters of vegetation by time of day for 6 radio-equipped pheasant hens and their broods (brood age 1 to 4 weeks combined), Baskett Slough and Luckiamute study areas combined, Polk County, Oregon, 1981.

Structural character[a]	Morning		Midday		Evening	
	$\bar{x}$ ± SD	SI	$\bar{x}$ ± SD	SI	$\bar{x}$ ± SD	SI
Short grass	2 ± 4	0.3	2 ± 5	0.5	2 ± 5	0.3
Medium grass	4 ± 10	0.7	3 ± 4	0.5	5 ± 13	0.8
Tall grass	26 ± 12	0.8	26 ± 13	0.8	25 ± 12	0.8
Forbs	13 ± 15	1.4	11 ± 12	1.2	13 ± 15	1.4
Litter	9 ± 8	0.7	10 ± 9	0.8	10 ± 9	0.8
Bare ground	47 ± 14	1.4	49 ± 15	1.4	45 ± 16	1.3
Shrub cover	<1 ± 1	0.1	<1 ± 2	0.1	<1 ± 2	0.1
Tree cover	1 ± 3	0.3	1 ± 6	0.3	1 ± 3	0.3
MVH (cm)	88 ± 21	0.9	86 ± 24	0.9	87 ± 24	0.9

Time of day: Morning, Midday, Evening.

[a] Shrub and tree cover were measured independently of one another and of other structural characters; therefore only the first 6 structural characters will total 100%.

Table 13. Mean percent and selection indices (SI) for structural characters of vegetation by time of day for 6 radio-equipped pheasant hens and their broods (brood age 5 to 8 weeks combined), Baskett Slough and Luckiamute study areas combined, Polk County, Oregon, 1981.

	Time of day					
	Morning		Midday		Evening	
Structural character[a]	$\bar{x}$ ± SD	SI	$\bar{x}$ ± SD	SI	$\bar{x}$ ± SD	SI
Short grass	7 ± 12	0.9	7 ± 13	0.9	9 ± 16	1.1
Medium grass	7 ± 9	0.7	5 ± 7	0.5	7 ± 9	0.7
Tall grass	27 ± 19	1.0	29 ± 21	1.1	26 ± 19	1.0
Forbs	12 ± 12	1.3	12 ± 13	1.3	11 ± 16	1.3
Litter	24 ± 17	1.4	19 ± 16	1.1	22 ± 16	1.3
Bare ground	23 ± 15	0.8	28 ± 19	0.9	25 ± 6	0.8
Shrub cover	2 ± 9	0.5	1 ± 4	0.3	1 ± 3	0.3
Tree cover	3 ± 10	0.8	5 ± 13	1.3	2 ± 8	0.5
MVH (cm)	82 ± 37	0.9	90 ± 47	1.0	81 ± 30	0.9

[a] Shrub and tree cover were measured independently of one another and of other structural characters; therefore only the first 6 structural characters will total 100%.

of their last sighting of the day. Often broods were found in the same location the next morning, providing evidence that broods generally did not seek specific cover types for roosting but rather settled where their activities led them during the day-light hours.

Baxter and Wofle (1973) found preferences by broods for various cover types during certain periods of the day. For example broods preferred alfalfa during the evening sampling period, but grain sorghum was used mostly during morning and midday, and wheat stubble was used differentially during the evening and for roosting at night.

CONCLUSION

Selection of cover types by pen-reared pheasants in my study differed little from that reported for wild hens in other geographical regions (Hamerstrom 1936, Trautman 1960, Hanson and Labisky 1964, Hanson and Progulske 1973, Dumke and Pils 1979). Grain fields often contained a large proportion of nest sites and brood sightings throughout the pheasant's range (Olsen 1977). Because of large size, configuration, and late harvest, grain fields provide abundant, secure habitat not available in either strip vegetation or grass fields. Based on my research and that of others grain fields provide the best habitat for nesting and brood-rearing by both pen-reared and wild pheasants in the Willamette Valley.

Analysis of structural characteristics of vegetation indicated that hens did not select nest or brood-rearing sites merely by cover type. Rather, they selected for specific structural components within cover types. For example, my data suggested a relationship between vegetation height and abundance of tall grass and selection of a nest site. Furthermore, greater vegetative height and more tall grass were found around successful nests than around unsuccessful nests. Taller vegetation and greater amounts of tall grass probably resulted in better concealment and security for successful hens and their nests.

Further analysis provided evidence that even though hens may often nest and raise their broods in the same cover, as reported by Kuck et al. (1970) and Hanson and Progulske (1973), they do not select structural characters within those cover types in the same manner for both activities. It appeared that hens with broods did not require the concealment and security afforded by taller and more abundant vegetation as they did for their nests. I believe foraging habits and need of areas less restrictive to brood movement probably determined brood-rearing sites more than need for concealment.

In contrast with differences in vegetative height and tall grass found between nest and brood-rearing sites, percentages of forbs remained relatively constant. Forbs always were selected in greater proportions than they occurred on the study areas. Perhaps forbs were selected in this manner because pheasants consume considerable quantities of insects during nesting and brooding seasons (Olsen 1977) and insect are more abundant where greater amounts of forbs occur (Smith 1940, Nerney 1958, Jones 1963). In addition, pheasants consume leaf material and seeds of forbs (Olsen 1977). Selection of forbs therefore may benefit pheasants by attracting greater numbers of insects and by providing a source of vegetable matter.

Determination of structural characters selected by pheasants and how these characters are selected in relationship to their abundance in the habitat (selection indices) are crucial to understanding habitat requirements of these birds. Simple description of generalized cover type preferences only provides partial information on pheasant habitat needs. Grain fields, apparently of particular value for nesting, certainly are not all the same nor is any single field uniform in composition. How cover types are managed will determine how they are used by pheasants. In addition, my research has shown that hens and their broods tend to avoid shrub and tree cover, use of strips may be affected by advance of plant sucession from predominately herbaceous growth to woody growth.

This study reconfirmed the preferential use of certain general cover types of vegetation for nesting and brood-rearing by ring-necked pheasants. It also demonstrated that pheasants selected specific structural characteristics within these cover types. A management scheme designed to enhance pheasant habitat should entail development for structural characters as well as generalized cover types.

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