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HABITAT SUITABILITY INDEX MODELS: PLAINS SHARP-TAILED GROUSE

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HABITAT SUITABILITY INDEX MODELS: PLAINS SHARP-TAILED GROUSE

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PREFACE

This document is part of the Habitat Suitability Index (HSI) model series [Biological Report 82(10)], which provides habitat information useful for impact assessment and habitat management. Several types of habitat information are provided. The Habitat Use Information section is largely constrained to those data that can be used to derive quantitative relationships between key environmental variables and habitat suitability. This information provides the foundation for the HSI model and may be useful in the development of other models more appropriate to specific assessment or evaluation needs.

The HSI Model section documents the habitat model and includes information pertinent to its application. The model synthesizes the habitat use information into a framework appropriate for field application and is scaled to produce an index value between 0.0 (unsuitable habitat) and 1.0 (optimum habitat). The HSI Model section includes information about the geographic range and seasonal application of the model, its current verification status, and a list of the model variables with recommended measurement techniques for each variable.

The model is a formalized synthesis of biological and habitat information published in the scientific literature and may include unpublished information reflecting the opinions of identified experts. Habitat information about wildlife species frequently is represented by scattered data sets collected during different seasons and years and from different sites throughout the range of a species. The model presents this broad data base in a formal, logical, and simplified manner. The assumptions necessary for organizing and synthesizing the species-habitat information into the model are discussed. The model should be regarded as a hypothesis of species-habitat relationships and not as a statement of proven cause and effect relationships. The model may have merit in planning wildlife habitat research studies about a species, as well as in providing an estimate of the relative suitability of habitat for that species. User feedback concerning model improvements and other suggestions that may increase the utility and effectiveness of this habitat-based approach to fish and wildlife planning are encouraged. Please send suggestions to:

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PLAINS SHARP-TAILED GROUSE (Tympanuchus phasianellus jamesi)

HABITAT USE INFORMATION

General

Sharp-tailed grouse (Tympanuchus phasianellus) inhabit brushy grasslands of North America; however, the different subspecies occupy habitats with various amounts of woody vegetation (Aldrich 1963). Columbian sharp-tailed grouse (T. p. columbianus) are typically found in sagebrush (Artemisia spp.) semidesert; prairie sharp-tailed grouse (T. p. campestris) in oak (Quercus spp.) savannas and early successional stages of eastern mixed deciduous-coniferous forests; and northern, northwestern, and Alaskan sharp-tailed grouse (T. p. phasianellus, kennicotti, and caurus) in brushy stages of northern boreal forests. This model characterizes the subclimax brushy grassland habitat of the plains sharp-tailed grouse (T. p. jamesi); all further mention of sharp-tailed grouse or sharptails refers to this subspecies unless otherwise noted. This subspecies is found in suitable environments from east-central British Columbia to southwestern Manitoba, south through the Great Plains to eastern Colorado (Miller and Graul 1980). Plains sharp-tailed grouse have been extirpated from Kansas, Oklahoma, and New Mexico and are endangered in Colorado (Miller and Graul 1980). In the remaining States and Provinces where they occur (Montana, Nebraska, North Dakota, South Dakota, Wyoming, Alberta, British Columbia, Manitoba, and Saskatchewan), the plains sharptail is a game bird.

Food

Sharp-tailed grouse are primarily herbivorous and utilize a variety of leafy material and the buds and fruits of woody species (Johnsgard 1973). Sharptails less than 10 weeks of age primarily feed on insects such as short-horned (Locustidae) and long-horned (Tettigoniidae) grasshoppers, beetles (Coleoptera), and ants (Formicidae) (Kobriger 1965). At 12 weeks of age, young sharptails consume about 90% plant material, which closely resembles the adult diet in composition.

The summer diet of 44 adult sharptails without broods in the Nebraska sandhills was 91% plant material and 5% insects (Kobriger 1965). Important food items by volume included 54% clover (Trifolium spp.), 9% rose (Rosa spp.), 6% Bessey cherry (Prunus besseyi), 4% common dandelion (Taraxacum officinale), and 3% poison ivy (Rhus radicans = Toxicodendron radicans). October foods of 53 plains sharp-tailed grouse and five greater prairie-chickens (Tympanuchus cupido), showed a similar emphasis on plant items (89%), but indicated a shift towards fruits. Important plant foods during this period were rose (46%), clovers (16%), American nightshade (Solanum americanum)

(11%), clammy groundcherry (Physalis heterophylla) (7%), common dandelion (3%), and western snowberry (Symphoricarpos occidentalis) (2%). Insects were 8% of the October diet. The importance of clovers in this study may have reflected the abundance of large subirrigated meadows in this area.

Sisson (1976) analyzed sharp-tailed grouse crop contents from the Nebraska Sandhills where wet meadows were uncommon. Plant material was the primary food of adult sharptails during all seasons: 99.5%, 56.9%, 83.1%, and 99.7% of all crop contents by weight for spring, summer, fall, and winter; animal material made up 41.8% of the summer diet. Short-horned grasshoppers were the most important animal food during all seasons. Rose hips were the most important plant food during all seasons except summer and accounted for 31.5% of all winter food. Sunflower (Helianthus spp.), American plum (Prunus americana), and sumac (Rhus spp.) were common fall and winter foods. The crops of three sharptails collected during midwinter contained only fruit of eastern juniper (Juniperus virginiana).

Cultivated crops [corn (Zea mays), oats (Avena sativa), wheat (Triticum aestivum), barley (Hordeum spp.), and sorghum (Sorghum vulgare)] were the most common sharptail food items during the summer, fall, and winter in South Dakota, composing 23.1%, 54.8%, and 63.9% of the total food volume (Hillman and Jackson 1973). Common dandelion constituted 72.2% of the spring diet. Woody plants [hawthorn (Crataegus spp.), rose, western snowberry, and Russian-olive (Elaeagnus angustifolia)] provided 33.7% and 28.9% of the fall and winter diets. Short-horned grasshoppers were the primary animal food during summer, fall, and winter; crickets (Gryllidae) were the primary animal food during spring.

Aldous (1943) believed that winter food was limiting for sharptail populations in north-central North Dakota. Rose hips were the most important food during both fall and winter and, along with buds from willow (Salix spp.), common chokecherry (Prunus virginiana), serviceberry (Amelanchier spp.), cottonwood (Populus spp.), and aspen (Populus spp.), formed most of the winter diet. Other winter foods were seeds and leaves of sagebrush, leaves of rose, willow, currant (Ribes spp.), goldenrod (Solidago spp.), dandelion, and snowberry fruit. Cultivated grains were scarce in this area and, therefore, unimportant.

Sharp-tailed grouse in southeastern Montana made considerable use of harvested grain fields and succulent vegetation from roadsides, sheltered drainage sites, and winter wheat fields during fall (Brown 1961). Fruits and berries were predominant in the fall diet of sharptails in eastern Montana, followed by domestic grains (Swenson 1985). Russian-olive was heavily used even though it was relatively scarce on the study area. Grains were apparently preferred during winter, although fruits and buds were critical when snow became deep (>14 cm). Silver buffaloberry (Shepherdia argentea), fragrant sumac (Rhus trilobata = Rhus aromatica), Russian-olive, and creeping juniper (J. horizontalis) composed two-thirds of observed use during winter. Fruits were available only on rose, Russian-olive, and junipers, but buds were available from other trees and shrubs.

Although sharp-tailed grouse eat grain if available, it is not necessary for survival (Hamerstrom and Hamerstrom 1951). Sharptails often add grain to their winter diet without significantly changing their normal eating habits. Robel et al. (1972:91) reported good trapping success using corn and common sorghum as bait when "... lack of winter food provided suitable trapping conditions ..." in South Dakota; thus, grain may be an important component of the diet when natural winter foods are scarce.

Evans and Dietz (1974) investigated metabolizable energy values for corn and six common grouse foods from woody plants in South Dakota. Dry matter intake (an indication of palatability), nitrogen-corrected metabolizable energy (a measure of useable energy), and nitrogen (a positive balance indicates protein storage in the body; a negative balance indicates protein loss) were of primary interest (Table 1). Fruit of silver buffaloberry was identified as the best native winter food analyzed because it was high in metabolizable energy, palatable, and persisted on the plants throughout winter. In feeding trials using two-component diets, corn was preferred (>99% consumption) over western snowberry, Woods rose (*R. woodsii*), and fleshy hawthorn (*C. succulenta*). Russian-olive was selected over fleshy hawthorn. Grouse on single-item diets of plains cottonwood buds (*P. sargentii*), Woods rose hips, dried fruit of western snowberry, or corn could not maintain a positive nitrogen balance. In contrast, grouse fed the fruit of fleshy hawthorn, Russian-olive, silver buffaloberry, or frozen western snowberry maintained a positive nitrogen balance.

Water

No direct reference was found to sharp-tailed grouse using open water. There is an indication, however, that they spend more time in mesic situations, such as wet meadows, in summer (Kobriger 1965). Succulent winter wheat may be used extensively during drought periods (Brown 1961) and snow may be eaten in winter (Aldous 1943).

Cover

Good quality grassland and brushy cover are essential for sharp-tailed grouse (Hillman and Jackson 1973). Native grassland, in combination with cropland areas, provided the minimum cover requirements for nesting, brood rearing, loafing, roosting, and escape for sharptails in Montana (Brown 1961). Swenson (1985) suggested that optimum habitat in the mixed-grass prairie of Montana is a mosaic of upland grassland with fragrant sumac and riparian hardwood draws. An interspersion of plant communities, particularly grassland and grassland-shrub mixtures with extensive ecotone, apparently provided optimum habitat in the central Alberta parklands (Moyles 1981). Good sharp-tailed grouse habitat in South Dakota consisted of lightly grazed mixed-grass prairie occasionally broken by brushy draws (Hillman and Jackson 1973).

Table 1. Nutritional analysis of some air-dried winter foods of plains sharp-tailed grouse (adapted from Evans and Dietz 1974).

Diet	Males		Females		
	DM[a]	ME[b]	DM	ME	Nitrogen balance[c]
Silver buffaloberry fruit	48.9	3.16	38.5	2.81	0.115±0.026
Plains cottonwood buds	21.5	2.69			-0.611±0.203
Russian-olive fruit	59.6	2.42	47.5	2.60	0.094±0.043
Western snowberry fruit	39.9	2.31			-0.135±0.064[d]
Fleshy hawthorn fruit	92.3	1.86	55.7	1.74	0.057±0.020
Woods rose hips	63.3	1.42			-0.406±0.132

[a]Oven-dry matter intake in grams/grouse-day.

[b]Nitrogen-corrected metabolizable energy in kcal/gram.

[c]Grams N/day (mean±SE).

[d]Frozen western snowberry had a positive nitrogen balance (0.416±0.098).

Plains sharp-tailed grouse use grassland, woody cover, and grain fields year-round, but certain vegetation types become increasingly important during different seasons (Swenson 1985). Sharptails are closely associated with grassland during the spring and summer, although scattered shrubs and adjacent areas of woody cover also are used (Sisson 1976; Moyles 1981; Nielsen and Yde 1982; Swenson 1985). Scattered shrubs in the uplands and shrubby breaks are more important during summer and fall when grass height is insufficient (6.8 to 11.5 cm) (Nielsen and Yde 1982). Woody vegetation becomes increasingly important during fall and winter, especially when snow covers the ground (Swenson 1981). Sharp-tailed grouse often burrow into snow for winter roosting (Trippensee 1948).

Wintering sharptails in Alberta parklands roosted in the lee of quaking aspen (P. tremuloides) trees and fed on their buds (Moyles 1981). Bur oak (Q. macrocarpa), common chokecherry, aspen, cottonwood, and green ash (Fraxinus pennsylvanica) provided good winter cover in North Dakota (Aldous 1943). Willows in frozen marshes provided food and cover during midday. The distribution of sharptails in northern Montana during a harsh winter was associated with breaks containing high densities (10% to 15% canopy cover) of silver buffaloberry (Nielsen and Yde 1982; L.S. Nielsen, Wildlife Biologist, Montana Department of Fish, Wildlife and Parks, Deer Lodge; pers. comm.). G.A. Sipe (Refuge Manager, Bowdoin National Wildlife Refuge, Malta, MT; pers. comm.), over a period of several years in northern Montana, commonly found sharptails in coulees bordering live streams with 10% to 15% shrub canopy cover, primarily buffaloberry, antelope bitterbrush (Purshia tridentata), and common chokecherry; a few sharptails observed in Woods rose, willows, and a feedlot were exceptions.

Habitat use in eastern Montana was most diverse during winter and varied with snow depth (Swenson 1985). Croplands and hardwood draws received greatest use and grassy uplands the least use during this season. Upland use was greatest when snow depths were lowest. Fragrant sumac was the primary food source on uplands when snow depths exceeded 14.0 cm; however, the use of hardwood draws and riparian forest increased significantly and rapidly as snow exceeded this depth. These habitats were critical for food during deep snow conditions (Swenson 1981, 1985). Snow depths of 6.6 to 14.0 cm also resulted in increased feeding in cropland, although a berry failure during this study also could have been a factor. Columbian sharptails in California and Washington and sharptails of unspecified subspecies in Manitoba seemed less dependent on woody cover during winter and remained in the open where grain foods were available (Dawson and Bowles 1909; Dawson 1923; Hamerstrom and Hamerstrom 1951).

Information regarding amounts of woody cover and habitat quality for plains sharptails is minimal. Area of hardwood draws and density of male sharp-tailed grouse on leks in eastern Montana (Table 2) were correlated ($0.05<P<0.10$) (Swenson 1981). Variation in area of hardwood draws explained 69% of the variation in male grouse densities. Brown (1968) indicated that 1% to 4% area in shrubby cover types would be moderately valuable for sharptails in Montana, while ≥5% would be the most valuable. About 5% shrub canopy cover was suggested as the minimum tolerance for sharptail range in North Dakota (Edminster 1954); 1.5% area in woody cover types was typical of sharp-tailed grouse habitat in South Dakota (Janson 1953). Plains sharptail habitats in Saskatchewan that were shrubby to the exclusion of herbaceous vegetation were used only for escape (Pepper 1972). Prairie sharp-tailed grouse in Wisconsin probably do not tolerate >50% woody canopy cover (Grange 1948).

Although sharptails in Montana used croplands more than hardwood draws for winter foraging during mild weather, they used croplands only when near hardwood draws or riparian forest (Swenson 1985). About 90% of cropland use by sharptails occurred within 500 m of woody cover and 100% use occurred within 750 m (Table 3). Birds observed in grainfields were rarely >50 m from field edges (boundary of grainfield and any noncropland cover) and, therefore, only a small portion of a field was used by foraging sharp-tailed grouse.

Table 2. The relationship between percent area in hardwood draws and sharp-tailed grouse density in eastern Montana (adapted from Swenson 1981).

Percent area in hardwood draws	Number of lekking males/km²
5.5	1.01
2.0	0.57
0.04	0.36
2.5	0.28
0	0

Table 3. Relationship between the percent cropland occurring within certain distances of woody cover and the percent sharp-tailed grouse use within those distances (Swenson 1985).

	Cropland ≤500 m from woody cover		Cropland ≤750 m from woody cover	
Cropland location	Percent of total cropland area	Percent sharp-tailed grouse use	Percent of total cropland area	Percent sharp-tailed grouse use
Upland	23	90	36	100
Bottomland	27	91	41	100

The height and density of vegetation is generally more important than species composition in determining sharp-tailed grouse habitat quality (West 1961, cited by Hillman and Jackson 1973). Sharp-tailed grouse in the Nebraska Sandhills preferred a relatively dense canopy of woody vegetation with a relatively open understory for resting during the summer (Sisson 1976). The average height of all vegetation was 21.2 cm. Feeding sites had more forbs, less grass, lower vegetation heights, and a lower range condition than control sites. Roosting sites were typically dominated by grasses and often interspersed with woody vegetation.

The growth form of dominant grasses is important for roosting and escape cover during late winter and early spring when shrub canopies are open and dry snow is unavailable for burrowing (Brown 1967b). Sod-forming grasses are usually unavailable when snow is >10.2 cm deep, whereas bunch grasses are more resistant to collapsing under heavy snow and can provide cover when snow is up to 30.5 cm deep.

Reproduction

Reproductive requirements of sharp-tailed grouse can be separated into lek (display ground or arena) and nesting/brood-rearing components. Sharptail leks have been reported on mowed wet meadows (Kobriger 1965), cattle-trampled areas around windmills (Sisson 1970), low ridges and knolls (Rippin and Boag 1974; Sisson 1976), and recent burns (Sexton and Gillespie 1979). The common characteristic of leks appears to be low, sparse vegetation allowing good visibility and unrestricted movements (Johnsgard 1973).

Sharptail leks were uniformly distributed in Alberta where grouse were numerous and potential lek sites were plentiful (Rippin and Boag 1974). This pattern may have resulted from social interactions such as the distance that the sounds of displaying males carried. In contrast, the distribution of leks used by low-density populations in east-central North Dakota apparently was influenced by the proximity of dense residual herbaceous vegetation (Kirsch et al. 1973). Some grassland and cropland had been set aside or retired under the Soil Bank Program of 1956 and the Cropland Adjustment Program of 1965. These areas were not mowed or grazed for several years and supported heavy stands of residual growth each spring. Eleven of 14 sharptail leks were within 180 m of a retired area. There was a lek on or near every retired tract ≥24 ha, but none on haylands or heavily grazed pasture without an adjacent retired tract.

The number of breeding male sharptails on leks over a 4-year period in Saskatchewan was proportional to the area of ungrazed or lightly grazed natural grass-shrubland and uncut hayland within a 1.6 km radius of the lek (Pepper 1972). New leks were established in Montana following substantial increases of residual cover, and the largest leks were located in areas surrounded by dense stands of residual vegetation (Brown 1966). Brown (1966) believed that females frequented heavier cover, and implied that heavy cover may be the proximate cue used by males to locate leks in heterogeneous habitats.

An excess of woody cover can adversely affect leks. Density of displaying male sharp-tailed grouse in Alberta was inversely related to total coverage of aspen within a 0.8 km radius of the leks (Moyles 1981) (Figure 1). Variation in the percent area in aspen stands explained 48% of the variation in the number of displaying males. Similarly, sharp-tailed grouse leks in aspen parkland of Manitoba were abandoned when the area predominated by grasses fell below 58% (Caldwell 1976).

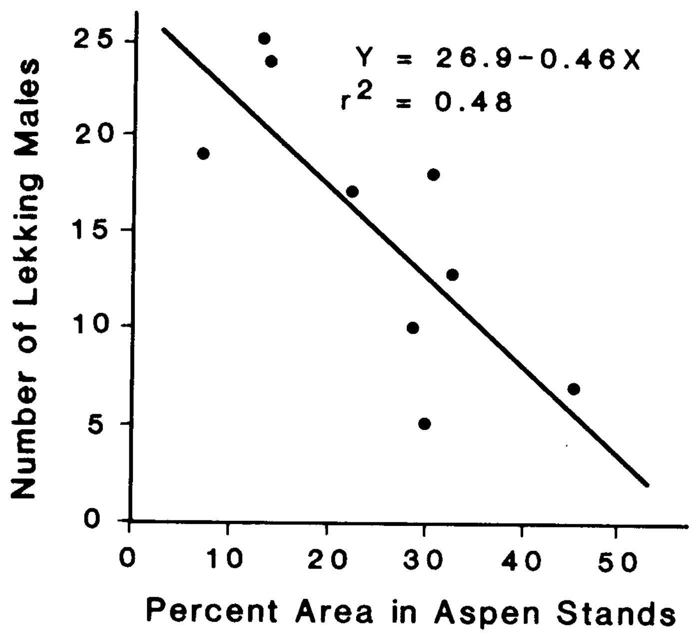

Figure 1. The relationship between percent area in aspen stands within a 0.8 km radius of sharp-tailed grouse leks and number of displaying males on leks (adapted from Moyles 1981).

Female sharp-tailed grouse usually do not travel far from a display ground to nest if suitable cover is available. The mean distance from known leks to 78 nests in western North Dakota was 1.3 km, with a maximum of 3.2 km (Kobriger 1980). The mean distance between nests and leks in Saskatchewan was about 0.9 km; all nests were within 1.6 km of leks (Pepper 1972).

Plains sharptail nesting cover tends to be more grassy and less shrubby than that of the prairie sharptail of the Great Lakes States (Pepper 1972). The lack of good quality nesting and brood-rearing cover generally is limiting for sharp-tailed grouse throughout their range (Hillman and Jackson 1973). Plains sharp-tailed grouse are generally limited by intensive grazing and conversion of rangeland to cropland (Miller and Graul 1980). Grazing reduces the quantity of residual vegetation (Kirsch et al. 1978). Residual herbaceous vegetation is important nesting cover (Brown 1967a; Christenson 1970) because little current growth is available in early spring when most nests are constructed (Blus and Walker 1966).

Cover height was the only consistent characteristic among all sharptail nest sites in North Dakota (Christenson 1970). Nesting hens apparently required uniform vegetation at least 30.5 cm tall or patchy vegetation at least 35.6 cm tall. Foliar density of nesting cover was apparently more important than height for plains sharptails in Saskatchewan (Pepper 1972). Many hens nested near edges between moderately heavy and lighter cover, with the heavier cover usually chosen for nest sites. Nest cover obscured an average of 64% of an incubating hen's body. Inadequate grassy cover forced some hens to nest in brushy draws that were definite predator lanes. Only 2 of 11 nests associated with woody draws were successful.

Kohn (1976) measured vegetation at sharp-tailed grouse nest and brood sites in North Dakota using Robel visual obstruction readings (VOR) (Robel et al. 1970). This method measures the height to which vegetation completely obstructs a pole from view when sighted from a distance of 4.0 m and a height of 1.0 m [The pole used by Kohn (1976) was a modification of the pole originally used by Robel et al. (1970)]. The VOR of vegetation at 40 of 43 nest sites averaged >1.5 dm. Hens nested in woody cover when grassy cover was of insufficient height; pastures containing sharptail nests in woody cover had low average VOR's (<0.82 dm). The lowest VOR recorded for a nest site early in the nesting season was 1.3 dm. The VOR at more than 75% of brood locations was ≥2.2 dm. Because the average height of visual obstruction at nest and brood locations was consistently higher than in the surrounding vegetation, Kohn (1976) concluded that complete visual obstruction to an average height of 1.1 dm within a pasture in the spring would provide sites of taller cover adequate for both nesting and brood rearing.

L. Rice (Big Game Biologist, South Dakota Department of Game, Fish and Parks, Rapid City; pers. comm.) compared nesting cover on rest-rotation and deferred-rotation pastures. Successful nesting required 2,242 kg/ha of residual vegetation (see Robel et al. 1970) at the nest site. Rest-rotation pastures provided this cover, but deferred rotation pastures were uniformly grazed and lacked sites meeting this cover requirement. Rice (pers. comm.) suggested that an average VOR <1.5 dm in the spring for an entire pasture would yield essentially no sharptail production if sites of taller and denser vegetation were unavailable (e.g., uniformly grazed pastures).

Woody cover was more important for broods than for nesting hens (Kohn 1976). Most hens nested >50 m from woody cover, but broods frequently used woody cover (usually buffaloberry) in draws or on uplands for shelter from rain and midday heat. Brushy draws were preferred shade cover for broods on hot days in South Dakota (Hillman and Jackson 1973), and broods in Nebraska used shrubby cover for escape and resting (Sisson 1975). Denser than usual woody cover was used by broods in Saskatchewan during very hot weather (Pepper 1972). Montana broods used woody vegetation more extensively during dry summers after herbaceous vegetation became desiccated (Brown 1966). Shrub canopy cover at 10 brood locations in Montana ranged from 6% to 67% and averaged 35.2% (Brown 1961).

Sharptail broods spend early morning and evening hours feeding in short vegetation (Christenson 1970). At other times, broods frequent tall vegetation, with midafternoon hours spent in woody cover. Similar diurnal activity patterns have been observed in Nebraska (Kobriger 1965; Sisson 1976) and Saskatchewan (Pepper 1972).

Composition and Movements

Janson (1953) and Podoll (1955) evaluated sharp-tailed grouse habitat over a 6-year period in South Dakota. Typical habitat consisted of 74% grassland, 21% cropland, 3.5% weedy cover, and 1.5% woody cover. Grouse densities were related ($P<0.001$) to the percent area of "good cover" (ungrazed to moderately grazed grassland, weedy cover, and trees and shrubs) on the study area (Figure 2). Variation in the percent area of good cover explained 30% of the variation in grouse densities. This relationship was strongest up to about 50% good cover. At >50% good cover, population densities were more variable and seemed less dependent on the percent good cover. However, Podoll (1955) indicated that some of this variation in population densities might have been due to human error in cover type evaluation, effects of hunting, predation, weather, and cyclic influences. Populations were highest with 50% to 80% good cover (Figure 2), and amounts <30% were capable of supporting only remnant populations. Populations were lowest with 5% to 15% good cover. J.E. Swenson (Wildlife Biologist, Montana Department of Fish, Wildlife, and Parks, Livingston; pers. comm.) believes that optimum proportions of cover types for plains sharptails would be about 10% shrubby and 90% grassy.

Cropland can be an important food source for sharp-tailed grouse (Swenson 1985), but excessive amounts have been a factor in the decline and extinction of sharptails in many parts of their range (Miller and Graul 1980). Areas with >60% cropland might be used during the winter by sharp-tailed grouse from adjacent grasslands, but reproduction would be severely impacted in such an area (Mitchell 1984).

Hamerstrom and Hamerstrom (1951) reviewed historic literature for both plains and prairie sharp-tailed grouse and found many references to extensive seasonal movements between grassland breeding grounds and woody winter cover. References to these extensive movements, or migrations, disappeared as extensive agriculture eliminated sharptails from most of their prairie breeding grounds (Johnsgard and Wood 1968). Seasonal movements still occur, but they usually are short, where grouse populations have been compressed into areas of marginal value by intensive agriculture. Examples of such areas include the

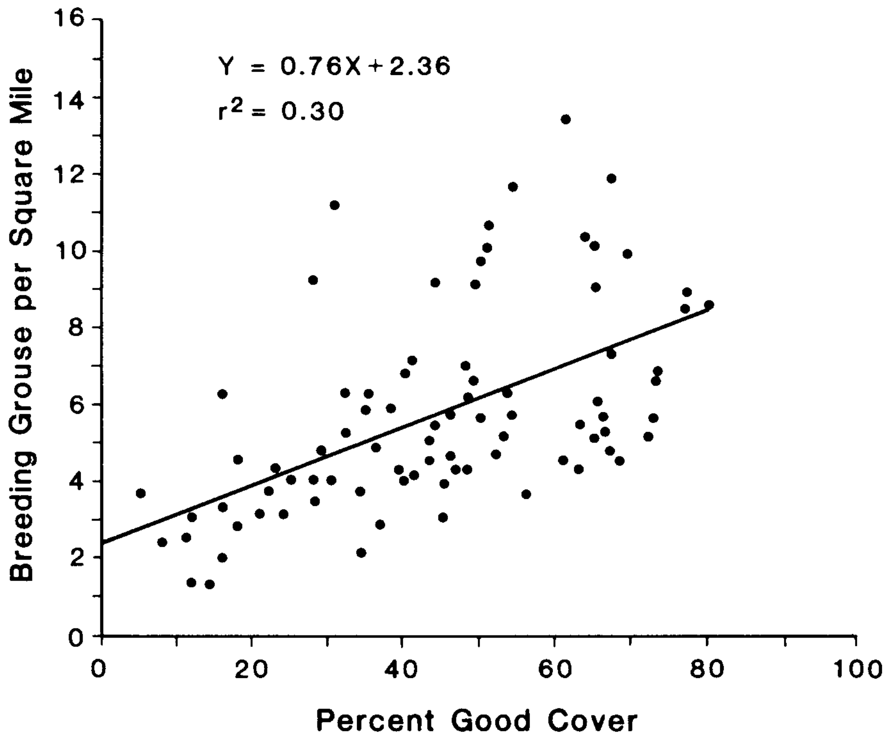

Figure 2. The relationship between the density of breeding sharp-tailed grouse and percent good cover (ungrazed to moderately grazed grassland, weedy cover, and trees and shrubs) in the habitat (adapted from Podoll 1955).

breaks and badlands of the Dakotas, the Nebraska Sandhills, and dry corners of Montana ranges too far from water for cattle to use (Hamerstrom and Hamerstrom 1951; Brown 1966). Such grasslands often are adjacent to or are interspersed with brushlands, and sharptails appear sedentary in their spatial utilization of cover types. Spring, summer, and fall distribution of male sharp-tailed grouse in Montana was generally within 1.6 km of their leks (Nielsen and Yde 1982).

The daily cruising radius of prairie sharp-tailed grouse in Wisconsin during fall and winter was about 1.6 km, and they were never more than a few hundred meters from heavy woody cover (Hamerstrom and Hamerstrom 1951). Plains sharp-tailed grouse in Nebraska were capable of long movements, but most ranged within an area of <4.8 km diameter during a year (Sisson 1976). Winter movements from one trap site to another averaged 3.4 km, ranging from 2.6 to 6.0 km. Movements from winter trap sites to leks averaged 2.2 km, ranging from 1.6 to 3.2 km. In South Dakota, Henderson and Jackson (1965) and Jackson (1967) observed movements of <1.6 km and <3.2 km from winter trap sites to leks. Movements of sharp-tailed grouse between preferred seasonal habitats in Montana could have exceeded 5 km (Swenson 1985).

HABITAT SUITABILITY INDEX (HSI) MODEL

Model Applicability

Geographic area. This model can be applied to the historic range of the plains sharp-tailed grouse (Figure 3).

Season. This HSI model was developed to evaluate the suitability of year-round habitat for plains sharp-tailed grouse.

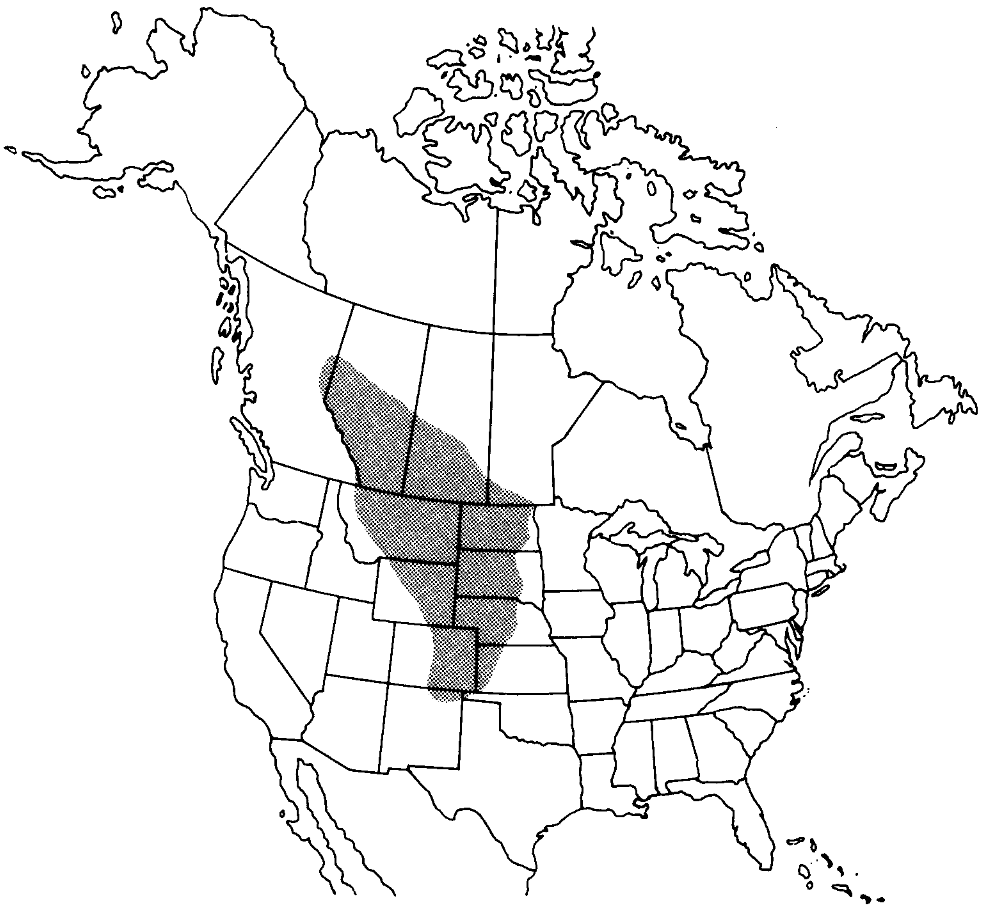

Figure 3. The historic range of plains sharp-tailed grouse (from Miller and Graul 1980).

Cover types. This model can be applied in cropland (AC), grassland (UG), pasture and hayland (AP), orchard and shelterbelt (AO), forbland (UF), deciduous forest (UFOD), evergreen forest (UFOE), deciduous shrubland (USHD), evergreen shrubland (USHE), deciduous shrub savanna (USSD), evergreen shrub savanna (USSE), deciduous tree savanna (UTSD), and evergreen tree savanna (UTSE) as defined by the U.S. Fish and Wildlife Service (1981). [Note: shelterbelts are not included with orchards in the U.S. Fish and Wildlife Service (1981) cover types, however, orchards and shelterbelts are combined in this model as the AO cover type to be compatible with version 2 of the Micro-HSI software (Hays 1987)].

Minimum habitat area. Minimum habitat area is defined as the minimum amount of contiguous suitable habitat that is required before an area will be occupied by a population of sharp-tailed grouse. The minimum area required to support a self-sustaining population of sharptails is unknown; however, Brown (1966) reported that breeding male populations were located on native rangelands that were in fair to good condition and at least 128 ha in size. Kirsch (1974) defined viable management units for prairie-chickens as dispersed blocks of high quality habitat at least 65 ha each and totaling at least 5.2 km^2 in an area not exceeding 21 km^2.

If it is assumed that the breeding ground or lek is the center of activity for a population or individual breeding unit, then the size of the dispersal area around such an activity center should represent a minimum habitat area for that local population. The mean distance from known leks to nest sites in western North Dakota was 1.3 km (Kobriger 1980). A circle with a radius of 1.3 km has an area of 5.3 km^2. Further insight pertaining to the minimum habitat area required by sharptails is provided by Rippin and Boag (1974), who estimated the average distance between 21 leks on an Alberta study area to be 2.6 km. This can be interpreted as a close approximation of a circle with an area of 5.3 km^2. For application of this model, the minimum area required for plains sharp-tailed grouse is assumed to be 5.3 km^2.

Verification level. This model is a hypothesis of species-habitat relationships and not a statement of proven cause and effect relationships. Preliminary drafts were reviewed by the persons listed below. Although their review comments and suggestions have been incorporated into the model, they do not necessarily concur with the final product.

L.L. McDaniel, Valentine National Wildlife Refuge, U.S. Fish and Wildlife Service, Valentine, NE

L.S. Nielsen, Montana Department of Fish, Wildlife, and Parks, Deer Lodge, MT

L. Rice, South Dakota Department of Game, Fish, and Parks, Rapid City, SD

G.A. Sipe, Bowdoin National Wildlife Refuge, U.S. Fish and Wildlife Service, Malta, MT

J.E. Swenson, Montana Department of Fish, Wildlife and Parks, Livingston, MT

Biologists of the Nebraska National Forest applied a draft of the model on the Fort Pierre National Grassland, South Dakota (G.L. Schenbeck, Wildlife Management Biologist, Nebraska National Forest, Chadron, NE; pers. comm.). Previous research in the area had shown that sharptail production and populations could be substantially increased by management of only nesting and brood-rearing cover. The objective of this model application was to determine which life requisite would be identified as limiting for sharp-tailed grouse. The model's output identified nest/brood cover as the limiting life requisite in this area, which agreed with the earlier research findings. Nebraska National Forest biologists are planning further testing and verification of the model over the next several years. Additional information on habitat variables and grouse populations will be collected for more-sensitive tests.

Model Description

Overview. This model is divided into two components, each representing a life requisite of the plains sharp-tailed grouse. A reliable source of food provided by shrubs and grain crops is critical during winter when herbaceous plants desiccate and snow accumulation precludes ground foraging. Shrubs also can provide important cover during severe winter weather. The lack of residual herbaceous vegetation used for nesting and brood rearing usually is the primary limiting factor for sharp-tailed grouse during the reproduction season. Therefore, winter food/cover and nest/brood cover are the two components in this model. Cover types providing winter food/cover and nest/brood cover must be properly interspersed to assure their availability to sharp-tailed grouse; thus, interspersion of winter food/cover and nest/brood cover types is considered.

Both life requisites are evaluated using the concept of percent equivalent optimum area. Percent equivalent optimum area expresses field conditions (i.e., percent area providing a life requisite, quality level of the life requisite, and distance between cover types providing different life requisites) in terms of percent area of available habitat providing the life requisite at maximum quality and interspersion levels. Available habitat is defined as the total land area having the potential to support sharp-tailed grouse. For example, 100% actual area providing a life requisite at a 0.5 quality level is equivalent to 50% of the area providing the life requisite at a 1.0 quality level, i.e., 50% equivalent optimum area. Therefore, the equivalent optimum area concept assumes that a large area of low quality can have a habitat value equivalent to a smaller area of higher quality.

Winter food/cover component. Sharp-tailed grouse rely primarily on fruits and buds of woody vegetation for food in late fall and winter, especially during periods of heavy snow accumulation. Woody vegetation also provides important cover during winter, although herbaceous vegetation and snow burrows sometimes are used. No information was found in the literature regarding the suitability of woody vegetation height or the maximum or minimum height that is useful for plains sharp-tailed grouse. However, sharp-tailed grouse are generally considered inhabitants of the ecotone between forest and prairie (Grange 1948). Although these grouse make limited use of plant successional stages preceding and following shrubland and may feed in tall trees (Edminster 1954), shrubland is the one indispensable cover type (Edminster 1954; Hillman and Jackson 1973). Since the shrub layer is acknowledged as the key component of woody cover used by sharp-tailed grouse, it is assumed in this model that characteristics of the shrub layer, as defined by the U.S. Fish and Wildlife Service (1981) (all forms of woody vegetation, including trees, that are ≤5 m tall), are most important for evaluating plains sharp-tailed grouse habitat. Taller woody cover is not considered because its life form is assumed to provide inferior winter cover relative to shrubs, because dense vegetation closer to the ground provides better protection from cold winds.

Habitats containing shrubs of high winter food/cover value (i.e., shrubs that provide superior protection from adverse weather or that yield highly nutritious and palatable foods) should support more wintering grouse than habitats lacking these shrubs. The potential significance of relative shrub value should be recognized by model users. Unfortunately, little information exists for quantifying the ability of different shrub species to support wintering sharp-tailed grouse. Table 4 rates the winter food/cover value of several shrub species (including trees <5 m tall) for supporting sharp-tailed grouse during winter. Species with a positive nitrogen balance and a high degree of observed use by sharp-tailed grouse were placed in the high value category. Shrub species with a negative nitrogen balance but a high degree of use by grouse received a medium value rating. A medium value was also assigned to species moderately used for food if they also provided good cover. Species of low food use or that primarily provided cover were assigned a low value rating.

Table 4. Examples of shrub species used by plains sharp-tailed grouse, classified by estimated winter food/cover value.

Winter food/cover value		
High	Medium	Low
Fleshy hawthorn	American plum	Green ash
Russian-olive	Aspen	Oak
Silver buffaloberry	Common chokecherry	Sagebrush
	Fragrant summac	
	Juniper	
	Plains cottonwood	
	Western snowberry	
	Willow	
	Woods rose	

Suitability of shrub cover in this model is a function of the amount of shrub cover present. This model considers only area of shrubby cover types for estimating habitat suitability; density of shrubs within shrub stands is not addressed because information equating density of shrub cover with habitat suitability is minimal. Shrubby cover types in this model are defined as areas of shrub cover (e.g., draws, breaks, and riparian areas) that are dense enough to form distinct shrub stands (10% canopy cover is a suggested minimum). These can be shrubland, shrub savanna, and forest cover types that have a shrub layer. Forest cover types or portions of forest cover types without a shrub layer do not qualify as shrubby cover types.

Situations may exist where shrubs are too scattered to form distinct shrub stands but are numerous enough to provide a significant source of winter food for sharp-tailed grouse, e.g., Woods rose in grasslands of the Nebraska Sandhills (G.L. Schenbeck; pers. comm.). However, this model does not consider this condition in habitat analysis because insufficient data preclude quantifying their influence on wintering sharptails.

As little as 1% area in shrubby cover types may be adequate for plains sharp-tailed grouse habitat, but ≥5% apparently is more suitable (Brown 1968). Density of displaying males on five areas in Montana was correlated ($r=0.83$, $0.05<P<0.10$) with percent area of hardwood draws (Swenson 1981). The highest density of males occurred with 5.5% hardwood draws, and males were absent where hardwood draws were absent (Table 2). However, sharp-tailed grouse populations decline when woody cover becomes excessive (Caldwell 1976; Moyles 1981). Numbers of displaying males in Alberta were inversely correlated ($r=-0.69$) with the percent area of aspen stands within 0.8 km of leks (Moyles 1981) (Figure 1). Sharptail numbers declined when aspen stands exceeded 10% to 15% area and were relatively low at 30% to 45%. Sharp-tailed grouse in aspen parklands of central Alberta abandoned leks when the area dominated by grasses within 0.8 km decreased to <58% (Caldwell 1976). Swenson (pers. comm.) does not believe, however, that shrub cover associated with the highest densities of sharptails in his study (Swenson 1981) was optimum. He suggests that maximum suitability would be reached at about 10% shrubby cover and then would decrease as indicated by Moyles' (1981) and Caldwell's (1976) data.

Proper interspersion of cover types providing winter food/cover and nest/brood cover ensures that winter habitat will be available for sharptails following the reproduction season. The distance between these cover types should be within limits of the bird's mobility. Wintering plains sharp-tailed grouse generally range within an area of 1.6 to 6.0 km diameter. Therefore, the optimum distance between cover types providing the different life requisites (winter food/cover and nest/brood cover) for this model is ≤1.6 km (Figure 4) because the resources associated with the different life requisites would be available within the normal movement range of sharp-tailed grouse. Suitability decreases with increasing distance until zero suitability is reached at 6.0 km where the different resources would be too far apart for use by sharp-tailed grouse. Equation 1 is used to calculate the contribution of shrubby cover to the percent equivalent optimum area of winter food/cover.

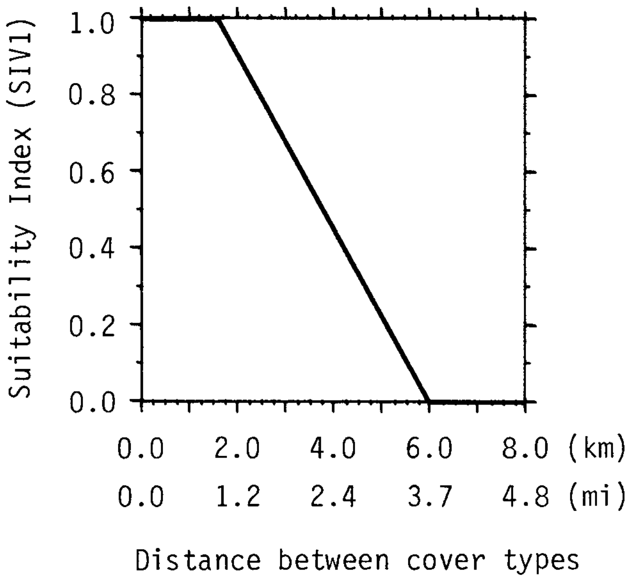

Figure 4. The relationship between distance separating cover types providing different life requisites and interspersion suitability for plains sharp-tailed grouse.

$$PAWS = \sum_{i=1}^{m} (S_i)(SIV1_i) \qquad (1)$$

where PAWS = percent equivalent optimum area providing winter food/cover contributed by shrubby cover types

m = total number of shrubby cover types present

S_i = percent of available habitat in shrubby cover type i

$SIV1_i$ = mean suitability index for distance between shrubby cover type i and the nearest cover type providing nest/brood cover

Sharp-tailed grouse do not require cultivated grain foods, but grain can be a preferred winter food when available. Availability of grain foods during winter may reduce the bird's dependence on shrubs. Therefore, grain crops are assumed to supplement shrubs in providing winter food for plains sharp-tailed grouse. No information was found in the literature relating amounts of grain crops and winter food suitability, but cropland ranging from <1.0% to 21% of the total area has been reported on plains sharp-tailed grouse range (Janson 1953; Sisson 1976; Swenson 1985). Excessive cropland is detrimental to sharp-tailed grouse; reproduction is severely impacted when cropland area exceeds 60% (Mitchell 1984). Not all grain crops may be available for sharptail use. Sharp-tailed grouse in Montana used cropland only within 750 m of woody cover (Table 3) and rarely foraged in cropland farther than 50 m from the cropland's edge (Swenson 1985). Available grain crops in this model are those within 750 m of woody cover and no more than 50 m inside the cropland's edge. The distance relationship illustrated in Figure 4 is used to evaluate the interspersion of available grain crops with cover types providing nest/brood cover. The percent equivalent optimum area of winter food/cover provided by grain crops is derived with equation 2.

Since grain crops may be unavailable to sharptails during periods of heavy snow cover, it is assumed that habitats with cropland but no shrubby cover types cannot have a winter food/cover suitability index >0.5. Therefore, percent equivalent optimum area of winter food/cover provided by grain crops cannot exceed 5% (the percent corresponding to a suitability index of 0.5) for its contribution to the total percent equivalent optimum area for the study area.

$$PAWC = \sum_{j=1}^{n} (C_j)(SIV1_j) \qquad (2)$$

where PAWC = percent equivalent optimum area providing winter food/cover contributed by grain crop cover types

n = total number of available grain crop cover types

C_j = percent of available habitat in available grain crop cover type j

$SIV1_j$ = average suitability index for distance between available grain crop cover type j and the nearest cover type providing nest/brood cover

Note: If PAWC exceeds 5%, it should be set to 5% for further calculations.

The overall percent equivalent optimum area providing winter food/cover is equal to the sum of that provided by both shrubby cover and grain crops (equation 3). Maximum winter food/cover suitability in this model is reached at 10% equivalent optimum area (Figure 5). Shrubs are the primary source of native winter foods and are a critical food source during periods of heavy snow cover. It is assumed, therefore, that shrubs are of primary importance for winter food/cover and that shrubs alone can provide optimum winter food/cover. The presence of grain crops need not be considered on study areas having ≥10% equivalent optimum area in winter food/cover that is provided by shrubby cover. Although habitat data (Caldwell 1976; Moyles 1981) suggest that suitability may decrease after about 10% shrubby cover and become zero at about 60%, the relationship in Figure 5 maintains a 1.0 index up to 100% because the effect of excessive shrubby cover on wintering sharptails is uncertain. This model assumes that excessive shrubby cover in sharptail habitat primarily affects nesting and brood-rearing, and that the effect of

$$\text{Percent Equivalent Optimum Area Providing Winter Food/Cover} = PAWS + PAWC \qquad (3)$$

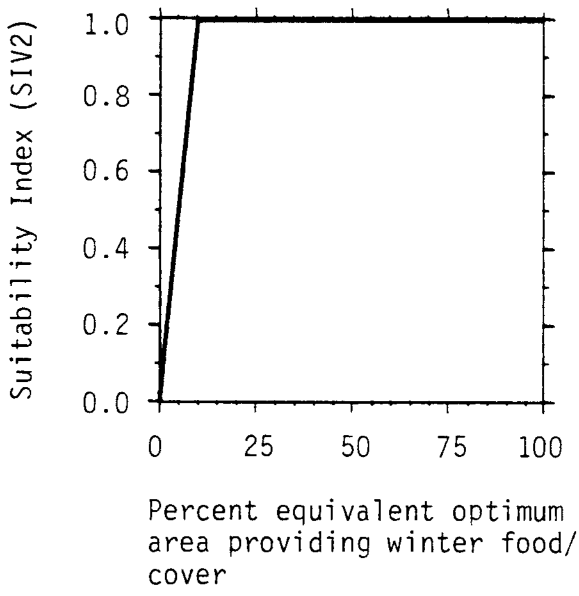

Figure 5. The relationship between percent equivalent optimum area providing winter food/cover and suitability of winter food/cover for plains sharp-tailed grouse.

this condition on habitat suitability will be reflected in the nest/brood cover component by an inadequate proportion of grass-dominated nest/brood cover. The suitability index for the winter food/cover life requisite (SIWFC) is equal to the suitability index for equivalent optimum area providing winter food/cover (equation 4).

$$SIWFC = SIV2 \tag{4}$$

Nest/brood cover component. Nesting and brood-rearing cover for plains sharp-tailed grouse can be characterized by the quality (height and density) of residual vegetation measured in spring before greenup and relative area providing such cover. A relatively high proportion of area in nesting and brood-rearing cover types is assumed to result in higher reproductive potential for sharp-tailed grouse. Cover types providing nest/brood cover in this model are grassland, pasture and hayland, and forbland; nesting and brood-rearing potential in cropland is considered insignificant.

Visual obstruction readings (VOR) taken in spring before greenup are assumed to reflect the factors affecting availability of nest/brood cover. Some of these factors are soil fertility, precipitation, harvesting, grazing, and amount and duration of snow and ice pack (Higgins and Barker 1982). In general, as height and density of vegetation increase, numbers of pairs and nest success of upland nesting ducks, upland game birds, and nongame birds also increase (Kirsch et al. 1978).

Duebbert et al. (1981) recommended that residual cover for upland nesting ducks should be tall and dense enough in mid-April to provide 100% effective screening to a height of 20 cm (i.e., VOR=2.0 dm). A similar relationship between height and density of residual vegetation and use by nesting sharptails appears to exist. The average VOR of vegetation at 40 of 43 nest sites in North Dakota was >1.5 dm (Kohn 1976). The VOR at nest sites was greater than that of surrounding vegetation. This indicates that a range of vegetation heights and densities existed, and that hens selected higher and denser than average vegetation for nesting. Consequently, cover types with relatively low average VOR's have potential to provide nesting cover if sites with a greater than average VOR exist. Over 75% of brood observations were in vegetation (growing and residual) with a VOR ≥2.2 dm. Hens kept their broods in the tallest available cover during feeding and resting. In this model, residual vegetation with a mean VOR ≥2.0 dm over the entire area represents optimal nesting and brood-rearing conditions (Figure 6).

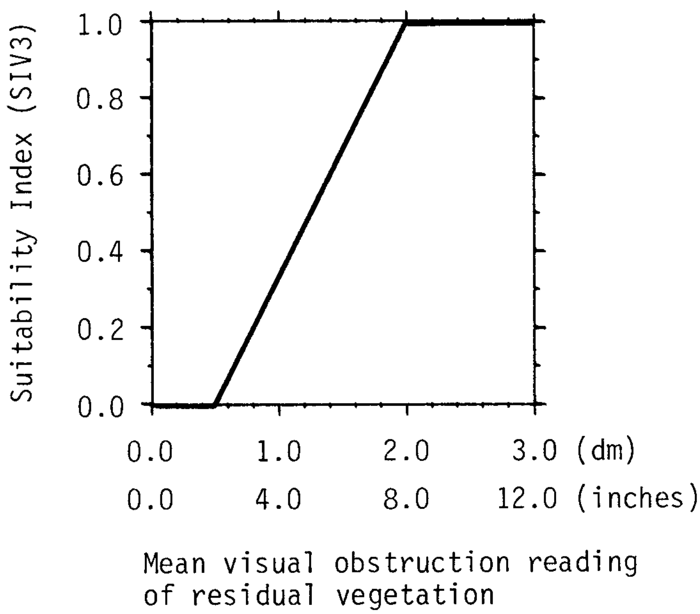

Figure 6. The relationship between mean visual obstruction of residual vegetation and nest/brood cover suitability for plains sharp-tailed grouse.

The lowest mean VOR obtained in May from a pasture used by nesting sharptails in North Dakota was 0.5 dm (Kohn 1976). It is assumed that nesting success would be very low in pastures with such a low VOR. In this model, suitability of residual vegetation becomes 0.0 when the average VOR decreases to 0.5 dm (Figure 6). VOR's from different studies cited in this model may not be exactly comparable because poles used for measurements were not exactly alike. The suitability relationship for VOR in this model is based primarily on measurements taken by Kohn (1976), who used a round pole 4 x 183 cm, painted in alternating sections of light gray and white.

The suitability levels shown in Figure 6 depend on the assumption that residual vegetation on the study area exists in a range of heights and densities. This assumption, however, may not always be valid. Rice (pers. comm.) observed that uniformly grazed deferred-rotation pastures in South Dakota yielded essentially no sharptail production because sites of relatively tall and dense residual vegetation were nonexistent. He suggested that an average VOR of 1.5 dm was the minimum necessary for nesting in such pastures.

Proper interspersion of cover types providing nest/brood cover and winter food/cover ensures that reproduction habitat will be available for sharptails following winter. As discussed earlier in the winter food/cover component, the optimal distance between cover types providing different life requisites (nest/brood cover and winter food/cover) for this model is ≤1.6 km (Figure 4). Suitability decreases with increasing distance until zero suitability is reached at 6.0 km.

Nest/brood cover suitability in this model is, therefore, a function of height and density of residual vegetation in spring, relative area of nest/brood cover types, and interspersion of cover types providing nest/brood cover and winter food/cover. This relationship is expressed as percent equivalent optimum area providing nest/brood cover and is derived with equation 5.

$$\begin{array}{c}\text{Percent Equivalent Optimum Area} \\ \text{Providing Nest/Brood Cover}\end{array} = \sum_{i=1}^{n} (SIV3_i)(N_i)(SIV1_i) \qquad (5)$$

where n = total number of nest/brood cover types

$SIV3_i$ = the suitability index for residual cover in cover type i

N_i = percent of study area in cover type i

$SIV1_i$ = mean suitability index for distance between nest/brood cover type i and the nearest cover type providing winter food/cover (including available cropland)

South Dakota data correlating percent good cover (ungrazed to moderately grazed grassland, weedy cover, and trees and shrubs) and grouse density (Figure 2) show a trend of increasing sharptail densities with increasing proportions of good cover up to about 80%, the maximum proportion found on the study area (Podoll 1955). Although no sharptail density data existed for areas >80% good cover, it can be inferred that higher sharptail densities might be associated with >80% good cover. Swenson (pers. comm.) believes that about 90% dense grass cover would be the optimal condition. Minimal population levels in South Dakota were associated with 5% to 20% good cover (Figure 2). Although grouse occupied habitats with only 5% good cover, it is assumed in this model that such a low proportion of good cover could not support sharptails over a long period of time. Therefore, maximum nest/brood cover suitability in this model exists when the equivalent optimum area providing nest/brood cover is ≥90% (Figure 7) and decreases as the percent equivalent optimum area decreases until zero suitability is reached at 5.0%. Although 100% equivalent optimum area providing nest/brood cover could exclude winter food and cover, it is still considered optimum nest/brood cover. The deficiency in winter food/cover will be reflected by the suitability index for the winter food/cover component. The suitability index for nest/brood cover (SINB) is equal to the suitability index for percent equivalent optimum area providing nest/brood cover (equation 6).

$$SINB = SIV4 \qquad (6)$$

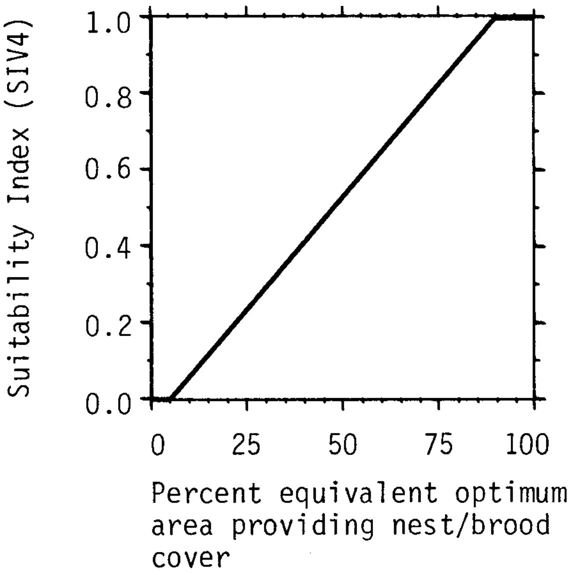

Figure 7. The relationship between percent equivalent optimum area providing nest/brood cover and suitability of nest/brood cover for plains sharp-tailed grouse.

HSI determination. The HSI is equal to the lower of the life requisite values for winter food/cover (SIWFC) or nest/brood cover (SINB). The following procedures can be used to calculate suitability indices for respective life requisites.

1. Winter Food/cover

   (a) Identify shrubby cover types and grain crops within 750 m of shrubby cover types and 50 m of field edges. Calculate the percent area of each relative to the total area of available habitat. Only cropland providing grain crops and within 750 m of shrubby cover types and 50 m of field edges should be used in determining the cropland portion of available habitat.

   (b) Select random points (on a map) in each shrubby cover type and measure the distance to the edge of the nearest cover type providing nest/brood cover. Enter each distance measurement into the suitability index graph (Figure 4), and calculate a mean index (SIV1) for each shrubby cover type.

(c) Enter the values calculated in the above steps into equation 1, and determine the resulting percent equivalent optimum area of winter food/cover contributed by shrubby cover types.

(d) If the equivalent optimum area calculated above from shrubby cover types is ≥10%, the suitability index for winter food/cover is 1.0, and no further calculations are necessary for the winter food/cover component. If the equivalent optimum area is <10%, select random points (on a map) in available grain crop cover types and measure the distance to the edge of the nearest cover type providing nest/brood cover. Enter each distance measurement into the suitability index graph (Figure 4), and calculate a mean index (SIV1) for each available grain crop cover type.

(e) Enter the pertinent values into equation 2 and determine the resulting percent equivalent optimum area for cropland. Sum this percent with the percent calculated for shrubby cover types (equation 3) and determine the resulting SIV2 from Figure 5.

(f) As shown in equation 4, the suitability index for winter food/cover (SIWFC) equals SIV2.

2. Nest/brood Cover

(a) Identify grassland, pasture and hayland, and forbland, and calculate the percent area of each relative to the area of all cover types used by plains sharptails.

(b) Within each of the above cover types, measure the mean VOR of residual vegetation using a Robel pole, and determine SIV3 from Figure 6 for each.

(c) Select random points (on a map) in each cover type providing nest/brood cover and measure the distance to the edge of the nearest shrubby or grain crop cover type. Enter each distance measurement into the suitability index graph (Figure 4), and calculate a mean index (SIV1) for each nest/brood cover type.

(d) Enter the values calculated in the above steps into equation 5, and determine the resulting SIV4 from Figure 7.

(e) As shown in equation 6, the suitability index for nest/brood cover (SINB) equals SIV4.

Application of the Model

Summary of model variables. Winter food/cover and nest/brood cover are the life requisites in this model for plains sharp-tailed grouse. Definitions of variables and suggested field measurement techniques (Hays et al. 1981, unless otherwise noted) are provided in Figure 8. The relationship between habitat variables, derived variables, life requisites, cover types, and the HSI is illustrated in Figure 9.

Variable (definition)	Cover types	Suggested techniques
Percent area of shrubby cover types (the percent area of cover types, relative to the total area of available habitat, that have shrub cover dense enough to form distinct shrub stands).	AO,UFOD,UFOE, USHD,USHE,USSD, USSE,UTSD,UTSE	Remote sensing, cover type map
Distance between cover types (the distance between cover types that are missing life requisites and the nearest cover type providing the life requisites).	All	Remote sensing, cover type map
Percent area of available grain crops (the percent area of cropland cover types, relative to the total area of available habitat, containing grain crops that are within 50 m of field edges and 750 m of shrubby cover types).	AC	Remote sensing, cover type map
Mean visual obstruction reading of residual vegetation (an estimate of the quantity of residual vegetation, expressed as the height of dried herbaceous vegetation providing 100% visual obstruction when a Robel pole is viewed from a height of 1.0 m (3.3 ft) and a distance of 4 m (13 ft); usually measured in decimeters, estimated to the nearest 0.5 dm, and measured in early spring before growth of new vegetation).	UG,AP,UF	Robel density pole (Robel et al. 1970)
Percent area of cover types providing potential nest/brood cover (percent area of cover types, relative to the entire area of available habitat, that may be used for nesting and brood-rearing).	UG,AP,UF	Remote sensing, cover type map

Figure 8. Definitions of variables and suggested measurement techniques.

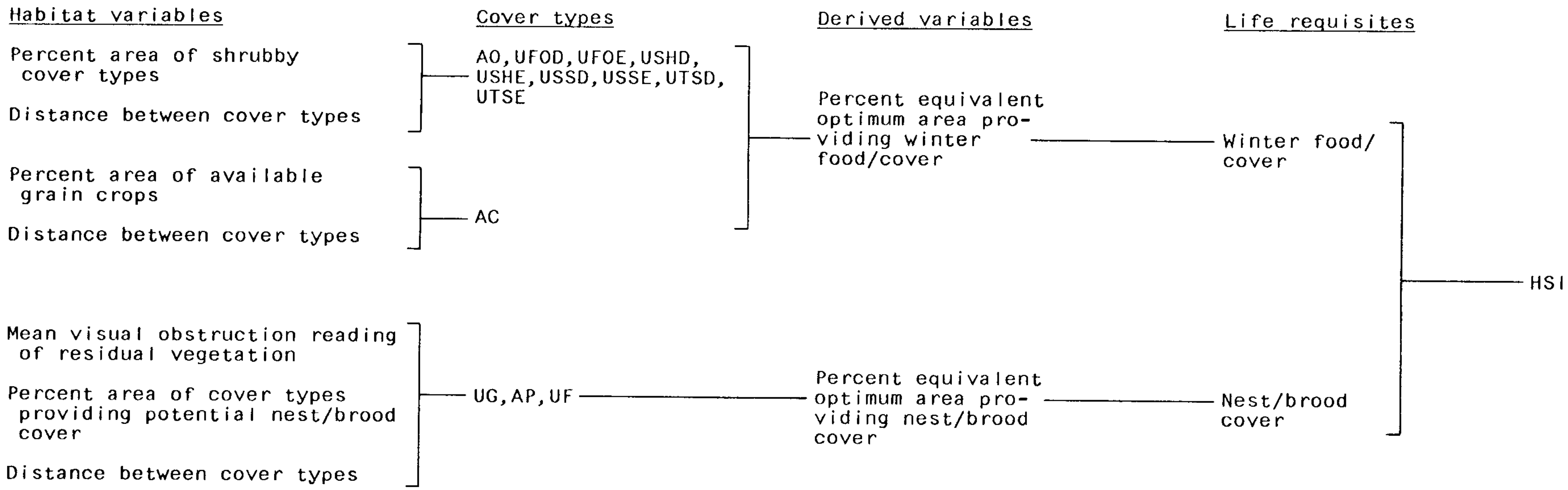

Figure 9. The relationship between habitat variables, derived variables, life requisites, cover types, and HSI for plains sharp-tailed grouse.

Model assumptions.

1. Winter food/cover and nest/brood cover are the most limiting habitat characteristics for long-term abundance of plains sharp-tailed grouse.

2. Winter food/cover suitability is a function of relative area of shrubby cover and availability of supplementary grain foods.

3. Nest/brood cover suitability is a function of the relative area of cover types used for nesting and brood rearing and the height and density of residual herbaceous vegetation.

4. Interspersion of cover types providing different life requisites can be characterized by the distance between them.

5. A large area of low quality can have an overall habitat value equivalent to a small area of high quality (i.e., area can compensate for quality and quality can compensate for area).

6. Woody cover >5 m tall is insignificant in estimating winter food/cover suitability compared to woody cover ≤5 m tall.

7. The presence of available cultivated grains increases the winter food/cover value of an area by providing a supplemental food source and reducing the dependency of sharp-tailed grouse on woody cover.

8. Habitat areas lacking shrubs cannot have a suitability index for winter/food cover >0.5.

9. Residual vegetation within cover types providing potential nesting and brood-rearing cover exists in a variety of heights and densities.

SOURCES OF OTHER MODELS

Brown (1968) presented a "Breeding Unit Habitat Index (HI)" with habitat components, index values, and component descriptors for evaluating areas surrounding leks. Habitat indices are not scaled between 0.0 and 1.0 but can be converted. Winter habitat is not considered.

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16. Abstract (Limit: 200 words)

A review and synthesis of existing information were used to develop a Habitat Suitability Index (HSI) model for the plains sharp-tailed grouse (Tympanuchus phasianellus jamesi). The model consolidates habitat use information into a framework appropriate for field application, and is scaled to produce an index between 0.0 (unsuitable habitat) and 1.0 (optimum habitat). HSI models are designed to be used with Habitat Evaluation Procedures previously developed by U.S. Fish and Wildlife Service.

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