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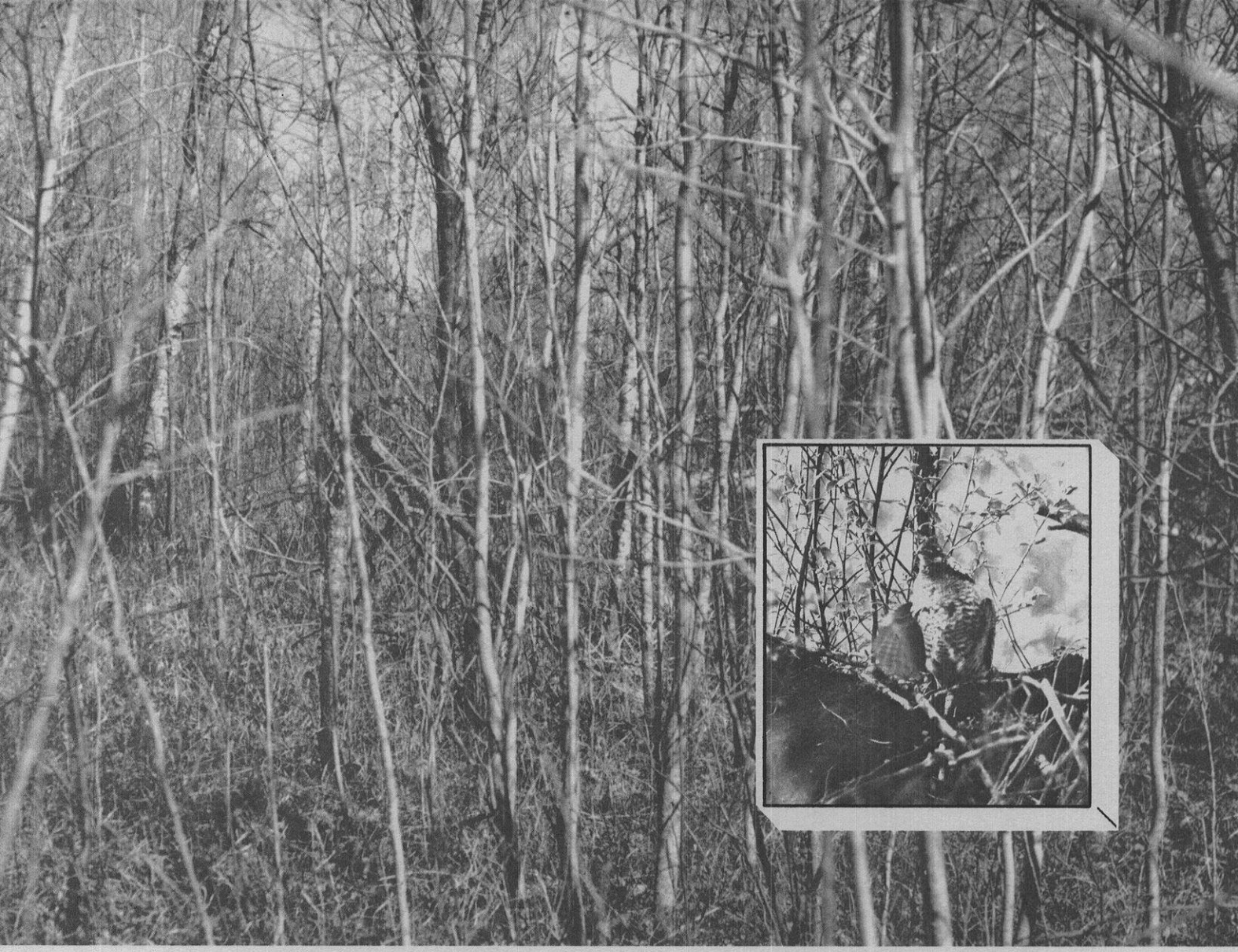

Ruffed Grouse Habitat Relationships in Aspen and Oak Forests of Central Wisconsin

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ABSTRACT

Ruffed grouse (*Bonasa umbellus*) populations were studied in central Wisconsin from 1968-82 to determine grouse response to habitat management, densities by forest types and age classes, and to refine guidelines for maintaining or improving habitat quality for grouse. The study area included the Sandhill Wildlife Area and a portion of the nearby Wood County Forest.

Ruffed grouse population changes on tracts managed for aspen regeneration demonstrated a positive response to habitat management from 1969-1982. Drummer densities were 1.6 times higher on the managed areas than on the unmanaged area after 10 years. Densities more than doubled and most grouse were redistributed into regenerating habitats under 26 years old on the managed area between 1969 and 1981. During this period, the proportion of upland forest in 0- to 25-year-old stands increased from 13% to 55% on the managed area.

Drumming grouse exhibited a strong preference for aspen compared to oak and were highly selective for aspen-alder. In aspen stands devoid of alder, drummer densities were considerably higher in regeneration under 26 years old. Drummer densities peaked at 7.2 grouse/100 acres in 6- to 10-year-old stands compared to the long-term mean of 4.1 in aspen of all ages. Higher grouse densities, particularly in 6- to 25-year-old aspen, appeared to be influenced by the density, structure, and species composition of the understory cover, and presence of older aspen trees.

Habitat management practices recommended include manipulating the size, shape, spacing, and timing of all clear cuts (5-20 acres) to maintain a continuous supply of stands under 26 years old interspersed with mature aspen wherever practical. Other management options discussed include regenerating aspen-alder, cutting aspen at shorter rotations, intermediate thinning of aspen, hybrid aspen reforestation, prescribed burning, and conifer planting. Habitat composition guidelines are prescribed for grouse incorporating the current statewide criteria for deer. Intolerant types should constitute at least 65% of the forest canopy, and 30-35% of the aspen type should occur in well-distributed stands under 26 years old.

RUFFED GROUSE HABITAT RELATIONSHIPS IN ASPEN AND OAK FORESTS OF CENTRAL WISCONSIN

by
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INTRODUCTION

Ruffed grouse habitat requirements and management opportunities have been defined by Bump et al. (1947), Grange (1948), Dorney (1959), Gullion et al. (1962), Moulton (1968), and Gullion (1972), among others. It is generally agreed that interspersion of cover types and age classes is one of the keys to better grouse populations. However, more information is needed to develop or refine management strategies to maintain or improve habitat quality for ruffed grouse and other forest wildlife, while producing wood fiber.

Aspen and forest types containing aspen provide the greatest potential for improving habitat quality for ruffed grouse (Gullion 1972, 1977; Perala 1977; Kubisiak et al. 1980). Aspen is also the most extensive forest type in Wisconsin, occupying 25% (3.6 million acres) of commercial forest land (Spencer and Thorne 1972). Oak-hickory, another important grouse habitat, occupies 2.7 million acres. Other types, including northern hardwoods and spruce-fir-pine, are important in Wisconsin because of their acreage, but management potential for grouse is considerably lower. Thus, the need to improve practical habitat management guidelines in aspen and oak remains a concern of wildlife managers.

An average of 80,600 acres of aspen were cut annually in Wisconsin from 1969-78. Of this, about 10,000 acres were treated annually since 1971 under the Forest Wildlife Habitat Management Program to improve growth in aspen sale areas (Lindberg and Hovind 1983). This harvest record not withstanding, most sales on public forests exceed 40 acres (Wis. Dep. Nat. Resour. 1983), suggesting that improved cutting practices for grouse are needed. In addition, stand deterioration in overmature aspen, natural succession to other hardwoods and balsam fir on loamy soils, and white pine succession on sandy soils have added to the loss of aspen as suitable grouse habitat. Projected surpluses of overmature stands in central and northwestern Wisconsin also emphasize the need to accelerate cutting in aspen. Statewide, 50% of the aspen type occurs on non-industrial private lands where under-utilization is a serious problem. The supply of ruffed grouse is related to the quantity and quality of important habitats, particularly aspen, oak, alder, and upland brush. As loss or deterioration of those habitats continues, the need for developing and implementing effective management programs increases.

Previous studies in the Great Lakes region (Dorney 1959, Gullion et al. 1962, Hale and Dorney 1963, Berner and Gysel 1969) suggested management options for improving grouse habitat, but their recommendations were either stated in general terms or were not based on a long-term documentation of grouse densities by forest type and age class. Gullion and Marshall (1968) analyzed ruffed grouse survival and densities relative to habitat quality in aspen, northern hardwood, and coniferous forests in northern Minnesota, providing a basis for setting priorities for grouse habitat management. Gullion (1972) expanded on this study and emphasized that aspen provides the greatest potential for improving grouse habitat. He recommended various methods of intensive habitat management while speculating on the expected grouse response. But many questions remained largely unanswered regarding the potential applicability and subsequent impact of various methods of habitat management on grouse densities and survival in similar habitats within the occupied grouse range.

To address this need for further information, the present study was undertaken in 1968 to evaluate grouse re-

sponse to habitat management in central Wisconsin where aspen and oak were dominant species in the forest canopy. It was designed as a follow-up to the work of Kubisiak et al. (1980) which focused on factors influencing grouse densities, population changes, and drumming site selection and distribution on the Sandhill Wildlife Area and the Stone Lake Experimental Area. The present study was directed at a more comprehensive treatment of grouse response to habitat management, factors influencing selection and distribution of drumming sites, and options for managing the aspen and oak forest types.

STUDY AREAS

The Sandhill Wildlife Area, a 9,150-acre state-owned tract, is located within former Glacial Lake Wisconsin (Fig. 1). Plainfield sand and sedge peat overlying very fine sands are the major soil types, with silt loam locally distributed on some uplands. Topography is generally flat, with sandy islands or ridges interspersed with extensive marshes. Uplands comprise 51% of the area and water and unforested wetlands, 49% (Table 1). The upland forest is dominated by aspen and oak. Scattered stands of pine occupy less than 1% of the uplands.

Comparative information on grouse habitat relationships was also obtained on a 1,110-acre portion of the Wood County Forest located 2 miles east of Sandhill. Uplands occupy 1,000 acres of the area, and small sedge-willow marshes the remainder. This tract is also dominated by aspen and oak forests, 85% of which were stocked with pole-sized stands more than 40 years old.

In addition, separate 1,000-acre managed and unmanaged tracts were designated. The managed tract included three distinct areas (Deer Shack, Deer and Shorey islands) which represented good grouse habitat on Sandhill (Fig. 2). Upland habitat types included aspen (700 acres), aspen-alder (190 acres), oak (100 acres), and brush-grass (10 acres). Habitat manipulations (cutting and shearing) averaged 14 acres/treatment and were implemented in blocks or strips. Habitat treatments in this study were principally confined to commercial cutting or shearing by dozers with cutter blades or chain saw crews. The unmanaged tract was the Wood County Forest area. No habitat treatments were made on this area during the study.

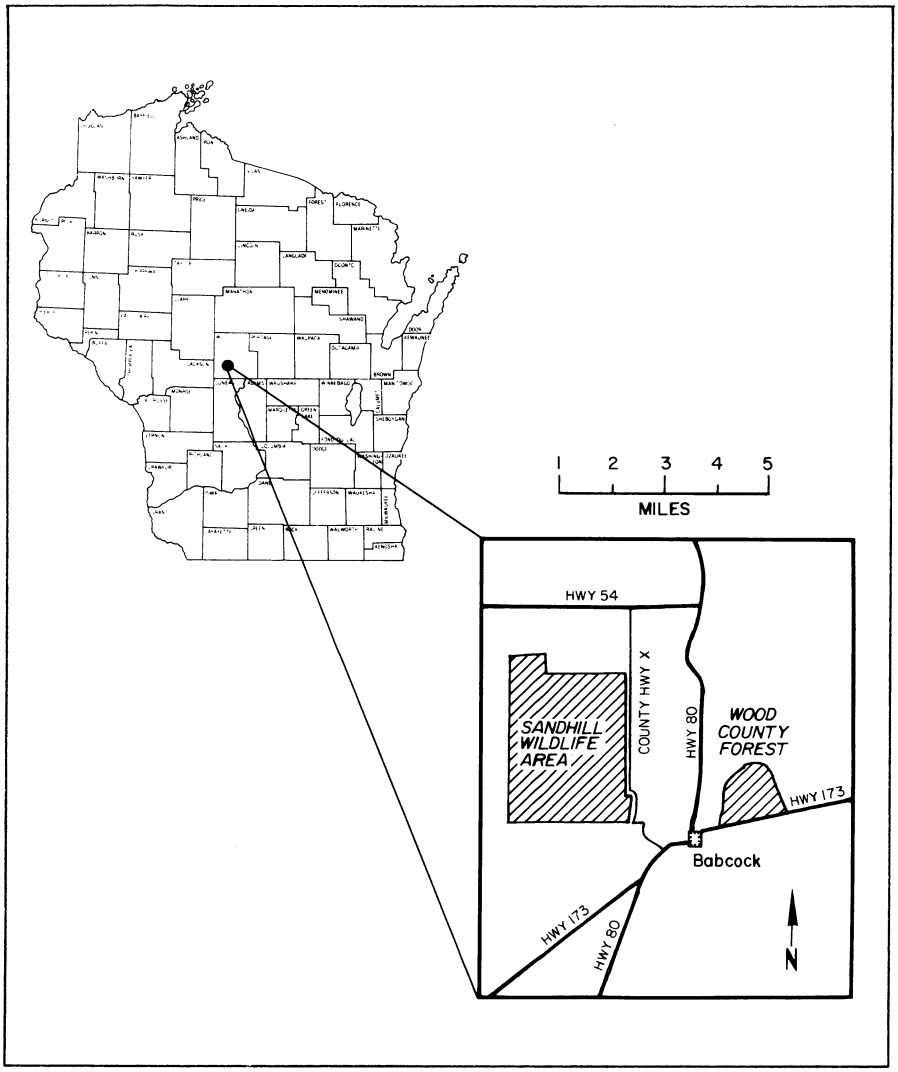

FIGURE 1. *Location of the Sandhill-Wood County ruffed grouse habitat study areas.*

TABLE 1. *Habitat composition of the Sandhill Wildlife Area and Wood County study areas, 1982.*

	Sandhill		Wood County	
Habitat Type	Acres	Percent	Acres	Percent
Aspen	2,576	28	395	36
Aspen-alder	470	5	170	15
Oak	1,360	15	427	38
Pine	30	<1	8	1
Upland brush and grass (old fields)	218	2		
Lowland brush (willow/bog birch)	1,087	12	49	4
Marsh (woolgrass/sedge/cat-tail)	2,344	26	61	6
Other (gravel pits, water, roads, parking lots, etc.)	1,065	12		
Total	9,150	100	1,110	100

*Upland types described in Appendix B.

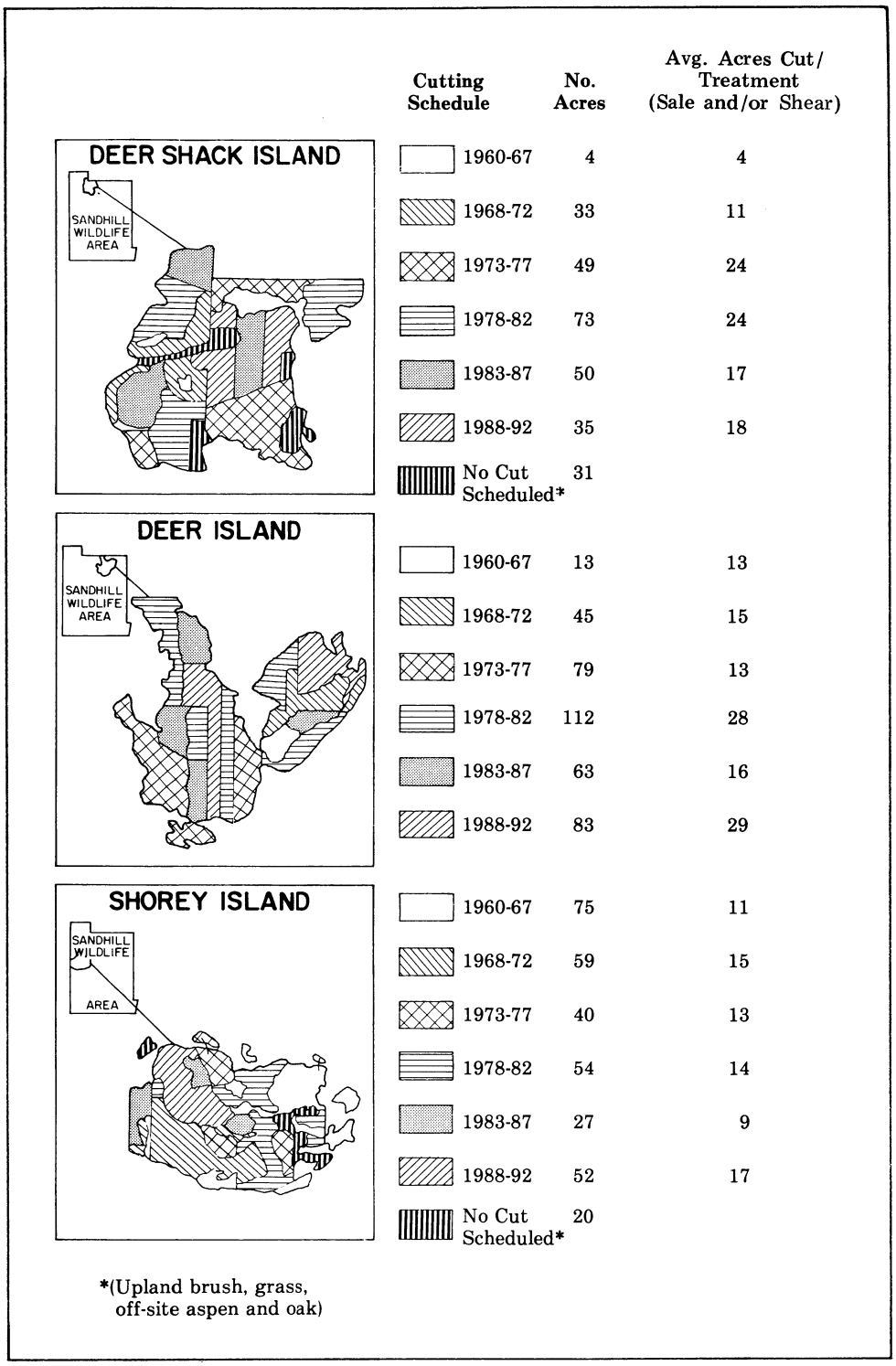

FIGURE 2. *Design of timber harvest to improve interspersion of aspen and oak age classes on three tracts on Sandhill Wildlife Area—Deer Shack Island (275 acres), Deer Island (395 acres), and Shorey Island (330 acres).*

METHODS

Grouse Census

Grouse populations were monitored from 1968-82 on Sandhill by censusing drumming grouse (Gullion 1966). The census was conducted on 2,400 acres of upland in 1968-78. Coverage was expanded to 3,720 acres in 1979. This included complete coverage of the 2,020 acres of upland on the southern part and about two-thirds of the 2,560 acres of grouse range on the northern part. The Wood County census area included 1,000 acres of upland surveyed from 1969-78. It provided an unmanaged control for comparing population responses to habitat manipulations on Sandhill. Data on drumming grouse habitat were gathered throughout the study and combined with those of Sandhill and reported as the Sandhill-Wood County study areas.

Some cutover aspen stands did not require post-sale clearing since the loggers removed most sub-merchantable trees. These areas produced adequate regeneration without further treatment.

Habitat Measurements

A forest cover type map was maintained to record the occurrence and distribution of habitats. Forest type, age class, and other habitat parameters within a 0.1-acre area around active primary logs (Gullion 1967) were used to characterize habitats chosen for drumming by grouse. Densities of grouse were compared between forest types and age classes to determine relative habitat use. Densities were expressed as numbers of drumming grouse/100 acres of habitat.

Habitat measurements were also made at the drumming stage to determine the relative importance of various factors affecting grouse use of the major forest types and aspen age classes. These included log species, height and diameter of the drumming stage, distance from the drumming stage to the nearest pole-sized aspen tree (greater than 5 inches dbh), number of mature aspen within 100 ft of the stage, and distance to the nearest different forest type or age class or upland-lowland edge.

Shearing was conducted using KG blades or chain saws to achieve a complete clear cut following timber sales in aspen stands.

In larger habitat treatments over 20 acres, scattered clones of mature aspen were left uncut to maintain an interspersion of young and old aspen.

In areas where oak was a dominant species in the forest canopy, either scattered trees or small groups of oak were left uncut. These trees provided a good mast source and served as nest or den trees for wildlife.

All woody vegetation less than 5 inches dbh and greater than 2 ft in height was counted on five milacre circular plots at 60 drumming logs and 60 random locations in sapling aspen (0- to 25-year-old) on Sandhill. Plots were centered at the drumming stage and at 10 ft from the stage at 0°, 90°, 180°, and 270° azimuths. Measurements of woody vegetation were made at another 130 drumming sites using 0.01-acre plots centered at the drumming stage. These included 50 sites in sapling aspen, 40 in pole-sized (26 years and older) aspen, and 40 in pole-sized oak.

Counts of woody stems (less than 5 inches dbh and greater than 2 ft in height) at 50 randomly located points using milacre circular plots were made in selected 0- to 25-year-old clear cut or sheared aspen stands on Sandhill. Counts were also made at 40 randomly located points in pole-sized (26 years and older) aspen and 40 in pole-sized oak stands using milacre plots. Most vegetative measurements were made between 1975 and 1981. Comparisons were made between woody stem densities and principal understory species providing cover for grouse at drumming sites and random locations using a t-test.

Habitat Management

During this study, Sandhill was intensively managed to maintain aspen and oak while improving interspersion of forest types and age classes. Most stands with volumes greater than 3 cords/acre were commercially logged. Habitat management was modified to benefit ruffed grouse as follows: (1) Good spatial and chronological distribution of young and old stands was maintained. (2) Most commercial sales were restricted to 20 acres or less and some stands were cut before rotation age; in larger sales, separate and distinct stands were cut to improve interspersion. (3) Trees remaining after completion of commercial sales were sheared (by dozers or chain saw crews). (4) Scattered standing (less than 20 ft^2 basal area) or blowdown trees or small groups or clones of aspen, oak, and pine were left uncut to maintain type diversity and residual cover while providing food trees for grouse and seed, mast or den trees for other wildlife. (5) Most shearing was conducted in recent cutover stands or in poorly stocked "offsite" or unsaleable timber to encourage aspen regeneration. (6) Sales and shearing were generally conducted during the winter months to maximize operability which is often restricted by high water levels during frost-free periods. This also insured better sprout growth while providing supplemental browse for white-tailed deer (*Odocoileus virginianus*). (7) Other habitat manipulations included conifer planting, prescribed burning, and disking, but their impact on habitat quality for grouse was negligible.

Comparisons were made between the managed and unmanaged tracts to assess the impact of habitat management on grouse populations. Comparisons were also made of pre- and post-treatment grouse population changes on selected areas with intensive strip or block cutting prescriptions.

HABITAT MANAGEMENT AT SANDHILL

Management of Sandhill as a state-owned wildlife area began in 1963, but habitat manipulations through timber sales or shearing were not begun in earnest until 1968 (Table 2). Habitat treatments averaged 138 acres/year from 1968-82, compared to 65 acres/year before 1968. Eighty-nine percent of these manipulations occurred in the aspen type where treatments have averaged 117 acres/year since 1968. Timber sales have accounted for 79% of the area treated, while shearing by dozers or chain saw crews constituted the remainder.

Generally, size of timber sales and shearing treatments have been kept small in Sandhill since 1963. Aspen timber sales averaged 23 acres (range 3-49 acres) and 48% were 20 acres or less. Sheared areas in aspen were somewhat smaller, averaging 14 acres. Oak timber sales averaged 21 acres (range 2-69 acres), and 74% were under 20 acres. As expected, size of stands within timber sales were considerably smaller, averaging 13 acres in aspen and 7 acres in oak. In comparison, timber sales were considerably larger on other public lands in Wisconsin in 1982-83, averaging 47 acres (range 13-149 acres) on county forests, and 63 acres (range 26-120 acres) on state forests of Wisconsin in 1982-83 (Wis. Dep. Nat. Resour. 1983).

Only 207 acres (5%) of 4,436 acres of upland forest lands were in 0- to 25-year-old aspen and oak stands in 1962. This increased to 676 acres (15%) in 1968 and 2,524 acres (57%) in 1982. During this period, most of the habitat manipulations were concentrated in the aspen forest type where 0-to 25 year-old stands constituted an increasing proportion of the upland forest lands (Fig. 3). During the 1963-67 period, only 7% of the upland forest lands occurred as 0- to 25 year-old aspen, but this age class averaged 29% in 1973-77 and increased to 41% during 1978-82. About 890 acres of pole-sized aspen are scheduled to be cut before 1992, but some may remain unsuitable for commercial sale. Included in this category are commercially inoperable "off-site" and inaccessible overmature stands which are vulnerable to deterioration by insects, disease, or windthrow.

The proportion of the upland forest stocked with "prime-age" (6- to 25-year-old) aspen provides additional evidence of the significance of habitat ma-

TABLE 2. *Habitat manipulation in aspen and oak habitats on the Sandhill Wildlife Area, 1963-82.*

	Acres/Habitat Type and Treatment					
	Aspen					
		Shear				
Year	Timber Sales	Post-Sale*	Uncut**	Total	Oak Timber Sales[a]	Total Area Treated
1963	46	0	0	46	45	91
1964	21	0	0	21	47	68
1965	0	0	5	5	43	48
1966	0	0	0	0	43	43
1967	71	14	5	76	0	76
1968	105	6	38	143	0	143
1969	75	0	9	84	36	120
1970	127	22	8	135	0	135
1971	123	0	45	168	0	168
1972	0	0	28	28	75	103
1973	101	0	0	101	0	101
1974	135	0	175	310	12	322
1975	49	57	0	49	69	118
1976	45	0	72	117	0	117
1977	113	29	0	113	0	113
1978	108	20	0	108	56	164
1979	80	0	0	80	5	85
1980	83	0	82	165	34	199
1981	30	6	6	36	0	36
1982	117	0	0	117	26	143
Avg. acres/year	71	8	24	95	25	120
Treatment size						
Avg.	23		14		21	
SE	1.4		1.7		3.8	
N	63		46		23	
Stand size[b]						
Avg.	13		-		7	
SE	1.2		-		1.2	
N	123		-		71	

*Acreage included in aspen timber sales total, but not in total by type.
**Includes standing timber not sold and treated by KG blade or chain saw crews.
[a]Includes 25 acres sheared in 1972.
[b]Average stand size calculated by averaging smaller distinct portions of a sale more than 300 ft apart (e.g., 40-acre sale with 20-, 10-, 5-, and 5-acre stands = avg. stand size of 10 acres).

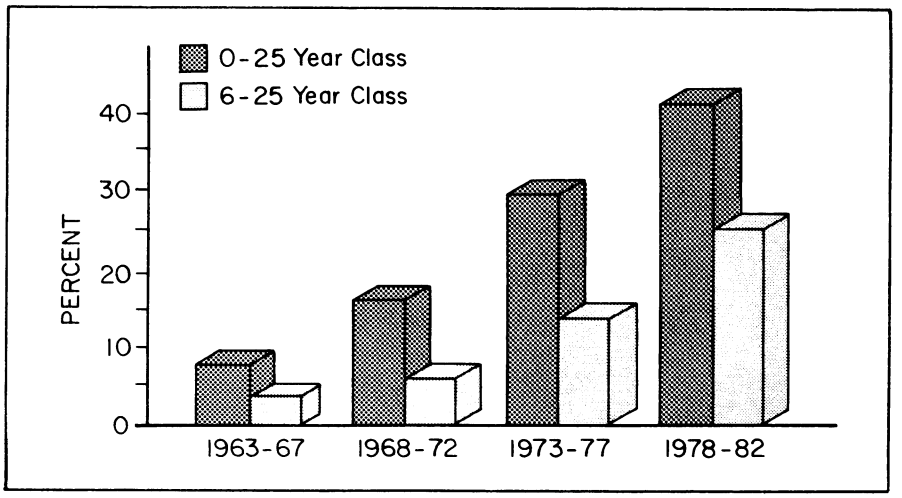

FIGURE 3. *Occurrence of aspen regeneration in upland forest lands on the Sandhill Wildlife Area, 1963-82.*

nipulations on Sandhill (Fig. 3). The importance of this age class to grouse will be discussed later, but it has constituted an increasing proportion of upland forest lands, particularly since 1977. During the 1963-67 period, only 3% of the upland forest lands occurred as 6- to 25-year-old aspen, but this component averaged 13% in 1973-77 and increased to 25% during 1978-82.

Habitat treatments within the oak type have been considerably less than in aspen (Fig. 4). Cutting in oak was not initiated until 1963 and 0- to 25-year-old stands constituted only 178 acres (4%) of the upland forest in 1968. This proportion increased to 491 acres (11%) in 1982, and will remain near 10% since cutting is scheduled to average about 20 acres/year in the remaining 877 acres of pole-sized stands.

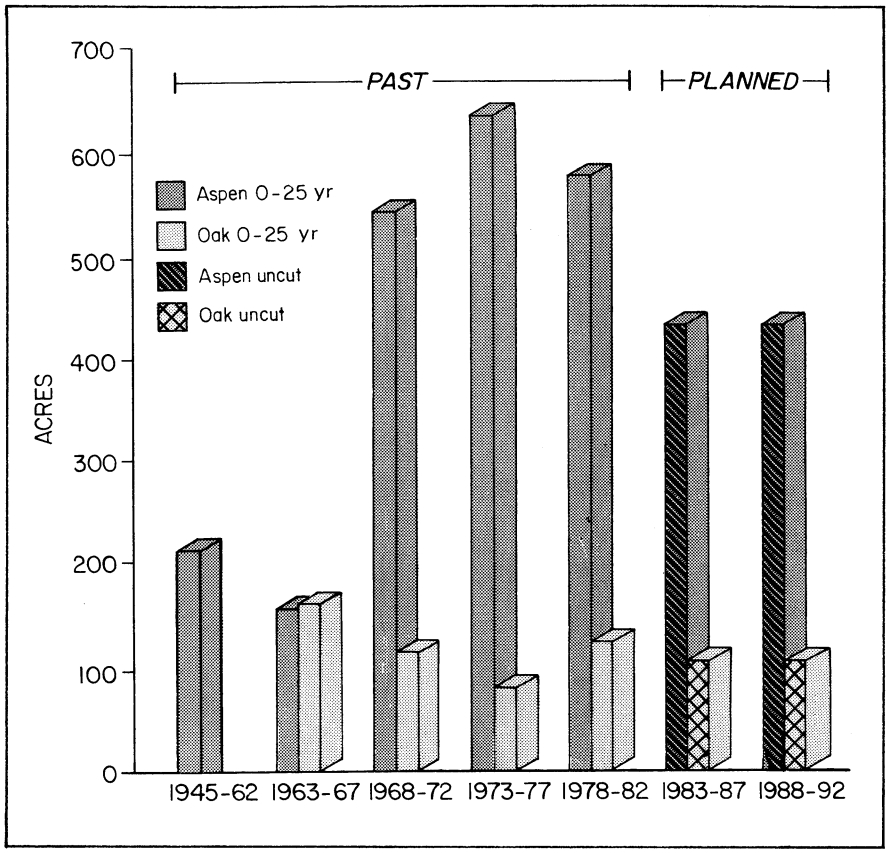

FIGURE 4. *Past and planned timber sales and shearing in aspen and oak forest types on the Sandhill Wildlife Area, 1945-92.*

GROUSE RESPONSE TO HABITAT MANAGEMENT

Density Changes in Response to Management

Drummer densities were similar on both tracts at the beginning of the study, averaging 2.9 grouse/100 acres on the managed area, and 3.0 on the unmanaged area (Fig. 5). This occurred even though stands under 26 years old comprised 27% of the unmanaged area, compared to only 13% of the managed area. Following the low grouse years of 1973-76, grouse densities increased and remained higher on the managed area, demonstrating a response to habitat management. After 10 years of habitat management (1978), drummer densities were 1.6 times higher on the managed area than on the unmanaged, and after 12 years (1981), drummer densities more than doubled on the managed area. During this time, the proportion of upland forest in 0- to 25-year-old stands steadily increased from 13% to 55% on the managed area.

Furthermore, during the low years (1973-76), densities were higher on the managed area (2.2 grouse/100 acres) than on the unmanaged (1.7). Densities were also somewhat higher on the managed area during the low in 1982 (2.8 grouse/100 acres) than during the previous low (2.2).

Highest densities on the managed area in 1979-81 (6.4 drummers/100 acres) project to a breeding pair/12 acres, assuming about 15% non-drumming males (Gullion 1981) and an equal sex ratio. Highest breeding densities on the managed area approach the optimum goal of a breeding pair/10-12 acres suggested by Gullion (1984). However, in less productive habitats dominated by "off-site" aspen or large (greater than 30-40 acres) monotypic stands of conifers or hardwoods (oak, red maple, white birch, and others), grouse potential is considerably lower (breeding pair/60+ acres). Exceptions occur in these latter habitats on better sites where dense understory woody vegetation, aspen, and other intolerant types are present.

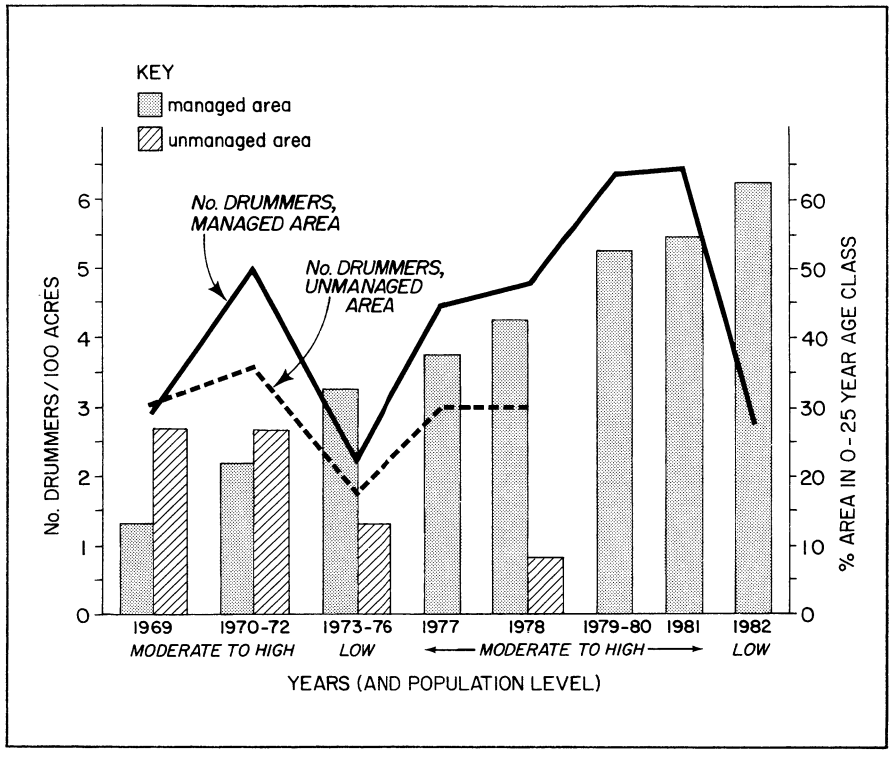

FIGURE 5. *Drumming grouse densities relative to habitat management on 1,000-acre managed and unmanaged tracts on the Sandhill-Wood County study areas, 1969-82.*

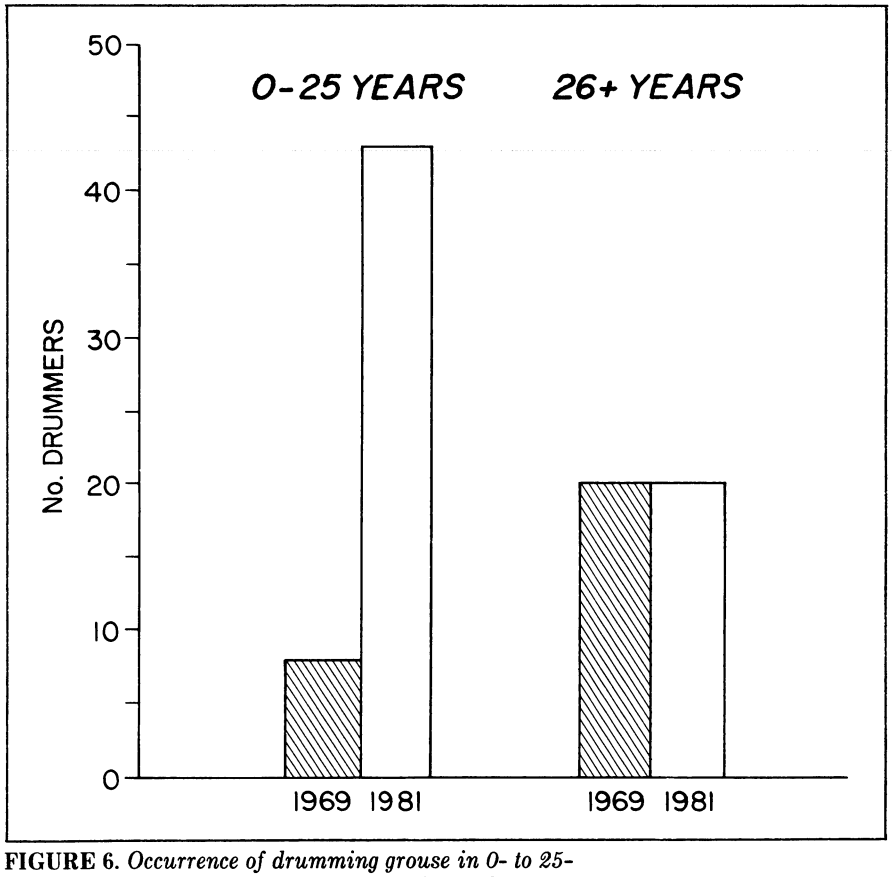

FIGURE 6. *Occurrence of drumming grouse in 0- to 25-year-old and 26+-year-old aspen and oak stands on managed tracts.*

Grouse Use of Aspen Under 26 Years Old

Occurrence of drumming grouse in 0- to 25-year-old aspen and oak stands provided additional evidence of the response of grouse populations to habitat management (Fig. 6). Drummers in these stands increased considerably on the managed area, while remaining the same in stands 26 years and older.

Thus, habitat management resulted in considerable redistribution of drummers into regenerating habitats under 26 years old between 1969 and 1981 on the managed area. Use of most of the remaining stands 26 years and older by drummers on the managed area occurred where alder and winterberry provided the principal understory shrub cover. However, a combination of hazel-nut, gray dogwood, chokeberry, service-berry, cherry, or red maple also provided suitable understory cover at many sites in stands 26 years and older.

Densities By Habitat and Aspen Age Classes

Drumming grouse were not randomly distributed among aspen and oak habitats on the Sandhill-Wood County study areas (Table 3). Grouse exhibited a strong preference for aspen, a relationship also observed by Kubisiak (1978) and Kubisiak et al. (1980). Mean density was 4.1 grouse/100 acres in aspen and 0.8 in oak from 1968-82. Lower densities in oak habitats on the study areas were related to poor interspersion of various oak age classes, inadequate understory woody cover, or insufficient mixtures of oak with other habitat components important to grouse. More than 85% of the oak type occurs in large (more than 20 acres) pole-sized stands with a sparse shrub understory. High densities (7,000+ stems greater than 2 ft tall/acre) of hazel-nut, dogwood, or other tall (over 5 ft in height) shrubs occupy a small proportion of the understory of most oak habitats (Table 4). In contrast, the average density of woody stems greater than 2 ft tall was higher ($P < 0.05$) at drumming sites, exceeding 15,000/acre.

Grouse were also highly selective for aspen-alder over other habitats (Table 3). Mean annual densities were 11.1 grouse/100 acres in aspen-alder of all ages and 2.2 in aspen stands of all ages devoid of alder. Drummer densities were considerably higher wherever alder was dominant in the understory, regardless of stand age. Within 0- to 25-year-old aspen stands, mean annual density was also higher in aspen-alder,

TABLE 3. *Distribution of drummers in aspen and oak habitats on the Sandhill-Wood County study areas, 1968-82.*

	Aspen-Alder			Aspen Without Alder*				
	0- to 25-year-old Stands	Stands 26 Years and Older	All Ages	0- to 25-year-old Stands	Stands 26 Years and Older	All Ages	Avg. Aspen	Avg. Oak
No. drummers/100 acres	11.2	11.0	11.1	4.4	0.8	2.2	4.1	0.8
Avg. no. drummers located/year (n = 1,466)	15	36	51	29	8	37	88	10
(percent)	15	37	52	30	8	38	90	10
Avg. acres surveyed/year	134	326	459	664	1,034	1,698	2,157	1,257
Percent of grouse census area in habitat type	4	10	14	19	30	49	63	47

*Stands with upland brush and saplings.

averaging 11.2 grouse/100 acres compared to 4.4 in stands devoid of alder. However, in aspen stands devoid of alder, drummer densities were considerably higher in stands under 26 years, indicating a response to habitat management. Although upland aspen-alder habitats have the most potential for producing higher grouse densities, the remaining uplands also provide a good opportunity for habitat management, particularly where aspen or other woody species important to grouse occur. In areas where aspen-alder habitats only occupy a small proportion of the upland forest as occurs at Sandhill, habitat management in aspen-alder must be complemented by manipulation of the remaining forested lands.

Drummer densities exceeded the long-term mean of 4.1 grouse/100 acres in most aspen age classes, suggested that grouse can adapt to a broad range of aspen habitats (Fig. 7). Lowest densities occurred in the 0- to 5-year class, indicating a substantial decline occurs after older pole-sized stands were cut. Mean annual densities were only 1.7 grouse/100 acres in stands under 6 years old compared to 3.6 in mature stands beyond 25 years. However, after 6 growing seasons, grouse densities increased considerably and numbers remained at higher levels through age 25. High grouse densities in the 6- to 25-year class ("prime-age aspen") supports the contention that a breeding pair/10-12 acres appears to be a reasonable management goal (Gullion 1984).

The presence of reasonably good numbers of breeding birds in aspen stands 26 years and older also indicates these habitats remain very productive for grouse, where suitable understory woody cover is present. This finding contrasts with Gullion and Svoboda (1972) and Gullion (1984) who found that aspen stands beyond 25-30 years old are unlikely to provide much acceptable cover for ruffed grouse.

TABLE 4. *Woody stem densities at drumming sites and random locations in selected age classes of aspen and oak on the Sandhill Wildlife Area.*

Habitat Type/ Age Class	No. Samples	No. Stems Greater Than 2 ft/acre (SE) Drumming Sites		Random Locations	
Aspen 0-5 years	20	14,090	(1,431)	15,950	(2,067)
Aspen 6-15 years	65	7,248	(741)	5,328	(590)
Aspen 16-25 years	25	10,291	(824)	8,516	(659)
Aspen 26 years+	40	14,580	(1,107)	9,550	(680)*
Oak 26 years+	40	15,670	(1,621)	6,058	(456)*

*$P < 0.05$.

Higher grouse densities can be sustained where good vertical cover is present--i.e., where a high density of woody stems greater than 5 ft tall/acre occur. Maintenance of aspen and a continuous supply of dense vertical cover throughout a management area should be the top priorities of grouse habitat management.

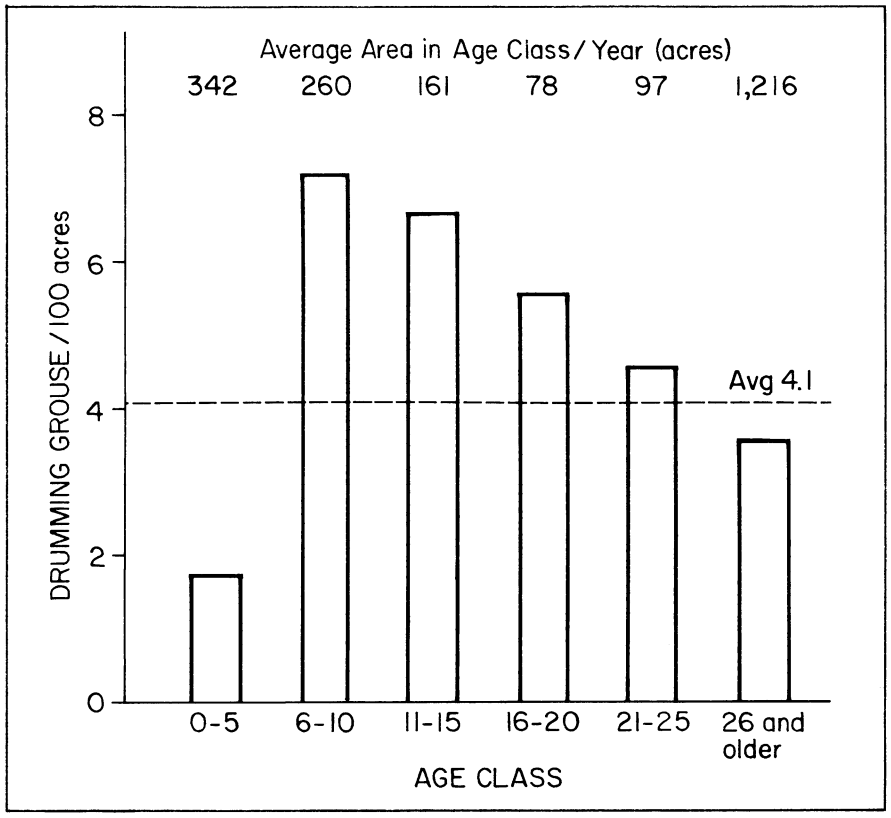

FIGURE 7. *Density of drumming grouse by aspen age class on the Sandhill-Wood County study areas, 1968-82.*

New Occupancy in Stands Under 26 Years Old

New drumming sites were established with highest frequency in 6- to 10-year-old aspen (45%) (Fig. 8). Gullion (1984) also found drummers began occupying 4- to 6-year-old stands on the Mille Lacs Wildlife Area, but drummer densities dropped considerably after stands were 14-16 years old. New drummers did not occupy aspen stands until 10 years after clear cutting at Cloquet, Minnesota, but these habitats supported drummers until stands were 25 years old. On our study areas, new occupancy in sapling-sized stands over 10 years old was considerably less, but grouse established new drumming sites in these habitats, provided suitable understory shrub cover was present. These results provide additional evidence of the dynamic relationship existing between grouse populations and habitat quality, emphasizing the need to achieve good age class interspersion wherever it is practical as suggested by Kubisiak et al. (1980).

Drummer densities in regenerating aspen under 6 years old averaged 1.7 grouse/100 acres. Occupancy of these habitats usually occurred where alder, winterberry, and other tall shrubs (greater than 5 ft in height) complemented the aspen to provide good overhead cover at the drumming log.

Drummer densities gradually decline in aspen stands beyond 15 years of age as natural thinning reduces the stocking of aspen. Thereafter reasonably good numbers of breeding birds occupy these habitats, provided suitable understory woody cover is present.

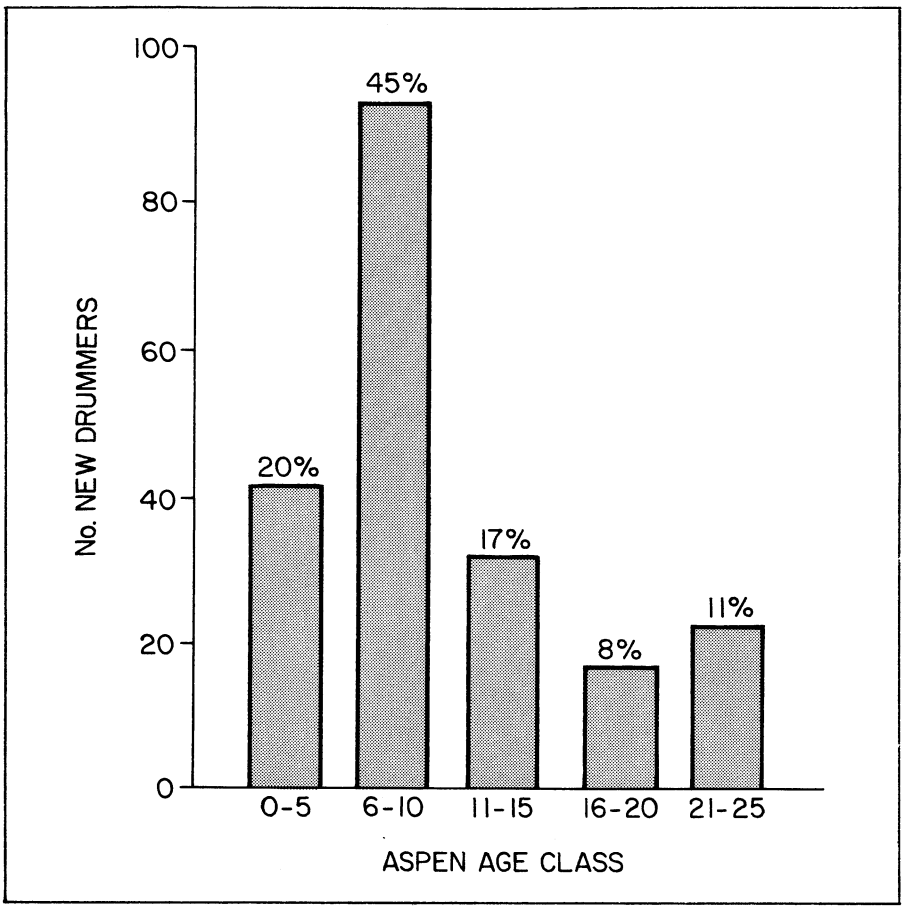

FIGURE 8. *New occupancy by drummers in 0- to 25-year-old aspen on the Sandhill-Wood County study areas, 1968-82.*

FACTORS INFLUENCING SELECTION AND DISTRIBUTION OF DRUMMING SITES

Vertical Cover

The dramatic response of grouse populations to habitat change occurring in regenerating aspen, particularly during the 6- to 25-year period, is related to several factors. Prime among these is vertical cover, which is considered a vital element determining selection of drumming sites and grouse survival (Gullion 1970, 1972; Gullion and Svoboda 1972; Brewer 1980). High quality vertical cover is characterized by high densities of woody stems (6,900-15,000 stems/acre) that provide good overhead cover and an open ground layer with little slash or horizontal debris (Gullion 1984). This is usually not achieved until after 6 growing seasons following a clear cut. Prior to this time, stocking is usually too dense, and residual slash or debris creates impenetrable ground layer horizontal cover which may inhibit grouse movement on the ground. After 6 years, the potential for maintaining high grouse densities will depend on the composition, density, and structure of woody and herbaceous species, particularly as natural thinning of aspen occurs.

Woody Stem Densities

At Sandhill, woody stem densities were not different ($P > 0.05$) at drumming sites and random locations in aspen stands under 26 years and averaged between 5,000 and 16,000 per acre (Table 4). In contrast, stem densities were higher ($P < 0.05$) at drumming sites in pole-sized aspen and oak (15,000-16,000/acre) in comparison to stands without sites (6,000-10,000/acre). Thus, stem densities alone did not appear to be a primary factor influencing drumming site selection within 0- to 25-year-old aspen at Sandhill. However, grouse were selective for sites with higher stem densities within pole-sized aspen and oak. In these stands, adequate understory cover was generally lacking or localized in dense clumps along type edges or in forest openings. Woody stem densities at drumming sites in all stands ranged from 6,900-15,000 stems greater than 2

ft/acre. This exceeds the range identified by Gullion (1984) as optimum for grouse at the Mille Lacs Wildlife Area. On that area, grouse preferred stands with densities of woody stems which ranged from 6,900-15,000 stems greater than 1 ft/acre. However, these densities would translate to a lower figure if measured at the 2 ft level.

Key Woody Species

Irrespective of stem densities, certain key understory woody species (shrubs greater than 5 ft tall) were predominant at drumming sites on the Sandhill-Wood County study areas (Tables 5-7). These included alder, winterberry, and hazel-nut. Although densities of sapling-sized trees varied considerably at drumming sites and random locations in the 0- to 25-year class, aspen was the most common tree species. Several other woody species also provided cover, but densities, with a few exceptions, were not different ($P > 0.05$) at drumming sites and random locations. Species in this category were oak, red maple, cherry, service-berry, and chokeberry. Individually these species were not important as cover, but could provide suitable understory cover where they are either aggregated or occur in combination with tall shrubs. Other species were present on plots, but provided little cover. These included blackberry, gray dogwood, red osier dogwood, hardhack, huckleberry, meadow-sweet, ninebark, raspberry, rose, white birch, and witch hazel. Boag (1976) and Boag and Sumanik (1969) also suggested that selection of drumming sites by male grouse is not random, but depends primarily on the density, frequency, and canopy coverage afforded by certain species of plants in the shrub layer. Gullion et al. (1962) also observed a strong preference for shrub cover and low use of closed canopy conifer stands by drumming males. In Minnesota, beaked hazel, alder, and service-berry were the most prevalent woody species at drumming sites (Eng 1959). In Michigan, Palmer (1963) found drumming grouse concentrated where alder was predominant, and where woody vegetation over 8 ft was more abundant. Brewer (1980) observed that the structure of ground cover and the shrub stratum were key factors in drumming habitat selection in Washington, implying that certain species provide better cover. Stocking of shrubs greater than 5 ft tall is also one of several factors used to determine a Habitat Suitability Index to assess habitat quality for grouse in Michigan (Hammill and Visser 1984; Cade and Sousa 1985). Thus, the composition and density of certain tall shrub understories are important factors influencing habitat quality and subsequent management opportunities for grouse, especially in stands with inadequate stocking of trees.

TABLE 5. *Stem densities of common species providing cover for grouse at drumming sites and random locations in 0- to 25-year-old aspen stands on the Sandhill Wildlife Area.*

	No. Stems Greater Than 2 ft/acre by Age Class					
	0-5 (n = 20)		6-15 (n = 65)		16-25 (n = 25)	
Species	Drumming Site	Random Loc.	Drumming Site	Random Loc.	Drumming Site	Random Loc.
Aspen	2,730	6,040*	1,905	2,526	972	1,376*
Alder	4,075	850*	1,645	276*	64	0
Winterberry	301	104	635	291	264	168
Hazel-nut	190	150	1,998	447*	1,524	520

*$P < 0.05$.

TABLE 6. *Stem densities of other common species providing cover at drumming sites and random locations in 0- to 25-year-old aspen stands on the Sandhill Wildlife Area.*

	No. Stems Greater Than 2 ft/acre by Age Class					
	0-5 (n = 20)		6-15 (n = 65)		16-25 (n = 25)	
Species	Drumming Site	Random Loc.	Drumming Site	Random Loc.	Drumming Site	Random Loc.
Oak	560	760	692	478	624	696
Cherry	950	570	955	459	932	368
Red maple	1,545	1,550	240	533	256	128
Service-berry	280	120	762	239	524	136
Chokeberry	410	1,070	542	1,100	248	208

TABLE 7. *Stem densities of common species providing cover for grouse at drumming sites and random locations in aspen and oak stands 26 years and older on the Sandhill Wildlife Area.*

	No. Stems Greater Than 2 ft/acre by Age Class			
	Aspen (n = 40)		Oak (n = 40)	
Species	Drumming Site	Random Loc.	Drumming Site	Random Loc
Aspen	120	725*	158	125
Alder	7,853	142*	0	0
Winterberry	3,492	917*	0	0
Hazel-nut	480	634	10,780	1,916*
Oak	218	667*	535	758
Cherry	575	408	450	482
Red maple	520	1,800*	248	475
Service-berry	3,332	317	868	1,000
Chokeberry	288	442	710	108

*$P < 0.05$.

Aspen Food Source

Most drumming grouse selected sites where aspen more than 25 years old was present in the immediate vicinity of the drumming log (Table 8). Average distance from the drumming log to aspen larger than 5 inches dbh was less than 1 chain (66 ft) at all sites. Distance to the nearest aspen larger than 5 inches averaged only 10.2 ft in aspen stands more than 25 years old, compared to 33.5 ft in 0- to 25-year-old aspen, and 55.6 ft in oak. The number of aspen larger than 5 inches dbh within 100 ft of the drumming log averaged more than 12 at all sites, which represents about 17 trees/acre. In addition, 56% of 530 drumming sites had more than 25 aspen larger than 5 inches within 100 ft of the primary drumming log.

Mature uncut aspen far exceeded the minimum 3 trees/acre required to sustain a pair of breeding grouse (Gullion 1972) at most drumming sites, suggesting that older aspen occurred throughout the study areas. Even at drumming sites where mature aspen was relatively scarce, stocking exceeded 3 trees/acre, assuming 50% of the trees produced staminate buds. An

TABLE 8. *Selected parameters at drumming sites in aspen and oak habitats on the Sandhill-Wood County study areas, 1968-82.*

Parameter	Habitat Type: Aspen — 0- to 25-year-old Stands (n = 250)		Range	Aspen — Stands 26 Years and Older (n = 215)		Range	Oak — All Ages (n = 65)		Range
Avg. distance (ft) from drumming log to aspen larger than 5 inches dbh (SE)	33.5	(3.3)	2-330	10.2	(0.6)	2-35	55.6	(4.6)	7-200
No. of sites with more than 25 aspen larger than 5 inches dbh within 100 ft of the drumming log	66			215			18		
Avg. no. of aspen larger than 5 inches dbh (SE) within 100 ft of the drumming log	13.8	(0.7)	0-40	more than 25			12.2	(1.2)	0-35
Distance (ft) from drumming log to forest type edge or age class - mean (SE)	92.8	(4.6)	33-660	92.8	(6.2)	33-528	74.1	(4.6)	33-198
Distance (ft) from drumming log to upland-lowland edge - mean (SE)	131.6	(7.6)	33-726	128.3	(11.8)	33-594	155.6	(21.0)	33-1,122

adequate food supply (i.e., mature aspen clone with about 60 trees) within 100 ft of good year-round woody cover is considered an essential component of good grouse habitat (Gullion 1966; Gullion and Svoboda 1972; Svoboda and Gullion 1972; Vanderschaegen and Moulton 1975). It has also been used as a key element in determining the Habitat Suitability Index (Hammill and Visser 1984; Cade and Sousa 1985).

Forest Type or Age Class and Upland-Lowland Edge

Distance to the nearest forest type or age class was the same in both sapling and pole-sized aspen and somewhat lower in oak, and averaged less than 100 ft in all habitats (Table 8). Although distance to the nearest upland-lowland edge was somewhat greater in all habitats, 60% of the drumming sites were situated within 100 ft and 83% within 200 ft of a lowland edge. The close proximity of drumming sites to upland-lowland edges is influenced in part by the natural interspersion of forest types and upland and lowland habitats throughout the study areas. This has been complemented by intensive habitat manipulations, which have produced a good mixture of various age classes, particularly on Sandhill. The concentrated distribution of drumming sites along upland-lowland edges was also observed by Eng (1959), Meslow (1966), and Berner and Gysel (1969).

In contrast, Rusch and Keith (1971) found a generally even distribution of drumming sites in upland aspen stands in Alberta. However, Gullion (1984) suggested that persistent use of edge situations by ruffed grouse is a strong indicator of inadequate habitats and birds in these habitats are especially vulnerable to predation. On our study areas, edges provided some of the best cover for grouse, especially where shrubs or tree saplings occurred on sites with good exposure to sunlight.

Drumming Logs

Although grouse used various surfaces for drumming, logs of aspen, oak, and pine (remnants of old blowdowns and trees cut before 1930) accounted for 97% of all drumming sites used be-

Logs, stumps, or root hummocks of aspen, oak, and pine, occurring throughout most upland habitats, accounted for 97% of all drumming sites used.

tween 1968-82. Since mature conifers are virtually absent on the study areas, pine logs will decline in importance as drumming surfaces in the future. In addition, logs of white birch, cherry, ash, ground hummocks, ditch banks, old building foundations, rocks, and an old wooden sleigh frame were also used. Most logs averaged 10-15 inches in height, and acceptable logs occurred in most habitats (Table 9). Suitable drumming logs occurred in most habitats, and this did not appear to limit site selection by drummers. Most drumming logs were greater than 10 inches in height and diameter, suggesting a preference by grouse for logs in this size class. Smaller logs under 6 inches in diameter were used infrequently and were usually situated on a large hummock or other substrate which provided a suitable drumming stage. Similar log sizes were reported in Michigan (Palmer 1963) where the mean height was 11.0 inches (range 7-21) and mean diameter was 13.0 inches (range 8-21). Of 40 logs measured in that study, 34 were pine.

TABLE 9. *Measurements of selected primary drumming logs in aspen and oak habitats on the Sandhill-Wood County study areas, 1968-82.*

Drumming Logs		Avg. (SE)				Range	
Species	No.	Ht.*		Diam.*		Ht.*	Diam.*
Aspen	370	10.6	(0.2)	8.5	(0.2)	2-30	2-36
Oak	90	16.0	(0.6)	13.6	(0.4)	4-34	5-22
Pine	60	10.7	(0.4)	12.6	(0.6)	4-23	3-18

*Inches.

MANAGEMENT OPTIONS

Aspen Type

Aspen is commonly regenerated by clear cutting to stimulate sucker or sprout growth. Aspen seedlings will also invade areas disturbed by logging, fire, or other habitat manipulations, providing favorable conditions are present. Success of aspen sucker regeneration depends on several factors including soil moisture and aeration, stocking of the parent stand, and amount of residual stocking left after a commercial sale (Brinkman and Roe 1975, Perala 1977). Best sucker regeneration occurs on well-drained soils where stocking of the parent stand exceeds 50 trees/acre. A complete clear cut is essential to insure optimum growth and survival, since as little as 10-15 ft^2 of residual basal area will retard sprout growth by 35-40% (Perala 1977). Winter logging produces more vigorous sucker growth, but cutting may be done in any season if a complete clear cut is made (Brinkman and Roe 1975).

Size, Shape, and Distribution of Cuts

Size and shape of a cutting area is an important consideration in grouse management, but some flexibility may be required to incorporate tract size, land ownership, arrangement of forest types and age classes, topography, and other factors. From our experience at Sandhill, cutting prescriptions to encourage grouse include the following: (1) Cuts approaching 20 acres are most practical and potentially as beneficial to grouse as smaller cuts. (2) Smaller cuts of 5-15 acres are also desirable, but access, marketability, and other considerations may take precedence. Smaller cuts under 3 acres are usually not practical and success of aspen regeneration may be inhibited by inadequate sunlight or air circulation (Graham et al. 1963). Exceptions occur on small islands surrounded by marsh or areas with good exposure to sunlight. (3) Larger cuts up to 40 acres may be an acceptable alternative providing their shape closely replicates rectangular strips. Spacing between strips of the same age should not exceed 15 chains (990 ft) and cuts should be about 5-10 chains (330-660 ft) wide. Strips should be oriented with the longest sides on a north-south axis to obtain maximum exposure to sunlight. Retention of older aspen clones in these strips may not be necessary if older aspen occur throughout adjacent stands. Assuming this situation prevails, distance from the interior of the cut to the nearest older aspen would not exceed 300 ft. (4) If larger cuts (greater than 40 acres) are the only alternative, clones of 50-60 mature aspen should be retained in every 20 acres. Leaving 30-60 ft uncut strips along upland-lowland edges or small aspen clones or stands on poorer sites (site index less than 50) may also be feasible in both large and small cuts. (6) Finally, whatever the size or shape of cuts, adjacent cuts should be scheduled at no closer than 4-5 year intervals.

Somewhat similar cutting prescriptions were proposed by Berner and Gysel (1969); they suggested 10- to 20-acre clear cuts conducted at 10-year intervals under a 40-year rotation to maintain even age stands of various age classes in close proximity. In a related approach to grouse habitat management, Hale and Dorney (1963) recommended cutting units of 160 acres located 3-4 miles apart to provide drumming, nesting, brood, and winter cover. Habitat recommendations proposed by Gullion (1972) concentrated on providing the year-round requirements of grouse in a 6- to 10-acre covert by using various combinations of 2.5- to 10-acre clear cut blocks. While Gullion has recommended that cuts be kept at 10 acres or less, he concedes that larger cuts are acceptable if clones of older male aspen (including 30-50 trees) are left standing in every 10-acre cut. The importance of retaining older aspen in large clear cuts was also confirmed by Moulton (1974) in northern Wisconsin. He found drummers ap-

peared to prefer sites within 600 ft of older aspen greater than 5 inches dbh in 10- to 15-year-old clear cuts which averaged 143 acres (range 82-308). The density of older aspen averaged 5 trees/acre (range 2-9) in 11 clear cuts surveyed, and cuts with a higher density of male trees generally supported a higher density of grouse.

Other Management Options in Aspen

Several other options may also be appropriate where maintenance of aspen and associated intolerant types is a primary management goal. In habitats where alder and other woody vegetation dominate the understory, clear cutting or shearing treatments should be arranged to obtain a continuous supply of dense vertical sprout growth under 20 years of age throughout an area, as suggested by Sepik et al. (1981). Exceptions occur where the post-sale stocking of alder is less than 15 ft^2 basal area, permitting good aspen-alder sprout growth and survival. On wetter sites, particularly in "off-site" stands, clear cutting or shearing of aspen-alder may be cost-prohibitive, and prospects for obtaining adequate regeneration is reduced. Leaving uncut upland-lowland edges or stands of older aspen may be the best alternative on these sites.

Other management options include shortening the rotation age of aspen, and prescribed burning to improve habitat quality. Management of aspen at shorter rotations of 25-30 years should be encouraged wherever practical, particularly where utilization by whole tree harvesting is feasible. Prescribed burning should be considered to reduce slash or litter, regenerate woody vegetation, stimulate establishment and growth of succulent herbs, and recycle mineral nutrients (Sharp 1971; Gullion 1972). Burning may be a suitable alternative to cutting in areas where aspen stands will convert to conifers or low-grade hardwoods if not managed. Prescribed burning may also be effective in minimizing conversion of aspen or oak to white pine on sandy soils and balsam fir, sugar maple, red maple, or white birch on loamy soils, particularly where succession to large stands with little species diversity is likely.

Intermediate commercial and/or noncommercial cutting and hybrid aspen reforestation (Lindberg and Hovind 1983) may also be considered to either encourage understory sprout growth or establish new stands, but these practices should be restricted to better sites (site index greater than 70).

Deterioration or loss of aspen habitats must be minimized wherever practical. Aspen habitats need to be maintained for grouse and other forest wildlife, and conversion to sedge marsh or other noncommercial types should be avoided.

Noncommercial thinning of high quality aspen at 10 years of age will produce sawbolts and veneer products at maturity while stimulating new sprout growth (Perala 1977). Further thinning at 25-30 years will encourage better growth of the overstory aspen while resulting in some additional sprout growth. Hybrid aspen can also be planted on high quality, but poorly stocked sites following a commercial clear cut. Hybrids outgrow native suckers and can be harvested after 20 years, reducing the rotation age considerably. While these practices constitute viable management options, the benefit to grouse has yet to be demonstrated, and their application on a broad scale may be limited.

Oak Type

Oak is considered another important habitat type for grouse, and management is influenced by site index and the species composition of overstory and understory vegetation. From our experience at Sandhill, management of oak habitats for grouse should include the following: (1) Conduct shelterwood cuts or clear cuts of 20 acres or less, leaving designated groups or scattered oaks (residual basal area less than 20 ft^2) with potential as mast-bearers or den trees. Larger cuts up to 40 acres are acceptable if in linear strips. (2) Encourage habitat diversity where oaks occur in mixed stands with aspen, pine, or other hardwoods. In oak with small scattered aspen clones, clear cuts of 20 acres or less should be designed to permit good aspen sprout growth. Where aspen is a dominant species in oak stands, complete clear cuts are necessary, but scattered small groups (8-10 trees/group) of mature oaks should be left uncut. In oak-pine, merchantable trees should be clear cut to maintain the type. Scattered mature oaks (8-10 trees/group) and advance reproduction of oak and/or pine should be left to perpetuate oak and pine while maintaining habitat diversity. (3) Conifer planting may be considered in sparsely stocked oak (basal area less than 50 ft^2) on poorer sites (site index less than 50), or in large stands (greater than 30 acres). Short-term benefits may accrue to certain wildlife species in conifer plantations under 20 years old, but the quality of understory and ground layer food and cover is considerably lower. Habitat quality is further reduced where competing vegetation is treated with herbicides. Thus, plantings should be designed to maintain habitat diversity while retaining dense shrub understories or regenerating tree seedlings and saplings. Size of plantings should be restricted to 10 acres or less, spaced at least 10 chains (660 ft) apart. Conifer cover should not exceed 30% of a stand or tract being managed for grouse. Given these options, grouse

Oaks, particularly young sapling reproduction, retain their leaves throughout most of the winter providing good insulating cover for grouse. These habitats should be encouraged to maintain diversity and improve understory cover.

habitat quality may also be reduced while vulnerability of grouse to predators may be increased if conifers are encouraged (Gullion 1972). In addition, while conifer planting has often been justified to improve habitat diversity or cover for other wildlife species, a long-term positive impact on grouse populations has not been demonstrated. Gullion and Alm (1983) also found grouse densities were considerably lower (0.8-1.0 drummers/100 acres) on an area dominated by conifer cover (more than 80% pine, spruce-fir, and tamarack) at Cloquet, Minnesota. In comparison, high grouse densities (7-11 drummers/100 acres) have been documented on our study areas where conifers constitute less than 1% of the upland forest, suggesting that conifers are not required to improve grouse survival. (4) Prescribed burning (preferably in spring) may also be an effective tool in selected oak stands to stimulate sprouting of understory woody vegetation, reduce dead slash, and encourage oak, aspen, or jack pine.

While these guidelines provide a broad framework, management of oak will vary somewhat among the forests of northern, central, and southern Wisconsin. In addition, establishment of advance oak reproduction is a key factor affecting perpetuation of the oak type, particularly on heavier soils where the site index exceeds 65 (Sander 1977). In contrast, oak can be successfully regenerated on average and poorer sites (site index 40-65). Clear cuts are recommended with scheduling designed to distribute various age classes throughout a compartment or tract, while maintaining 40-60% of an area in stands of mast-bearing age. Although small clear cuts are impractical for most situations, Sharp (1963) found small 1/4- to 1-acre clear cuts encouraged ground layer vegetation attractive to grouse in oak habitats in Pennsylvania. But benefits were short term (7 years or less) and principal grouse use was restricted to the summer brood period.

HABITAT COMPOSITION GUIDELINES

Broad compositional guidelines were recently prescribed for deer in Wisconsin and these provide a management framework for grouse and other forest wildlife. Where fall density goals exceed 30 deer/mile^2, intolerant upland types should constitute 65% of the forest canopy. In addition to these goals, our experience at Sandhill shows a need to maintain 30-35% of the aspen type in sapling-sized stands under 26 years old to produce higher sustained yields of grouse. Maintaining 30-35% of the aspen type in sapling-sized stands appears to be a realistic goal since seedlings and saplings under 20 years old constituted 35% of the aspen forest type in Wisconsin in 1968 (Spencer and Thorne 1972). However, this proportion has probably changed somewhat since 1968, varies by region within the state, and is considerably lower on non-industrial private lands. With the distribution of regenerating aspen skewed to public and industrial forest lands, a projected shortage of aspen timber appears imminent in central and northern Wisconsin after the year 2000 (Lueschner 1972). Although marketability of aspen is improving with prospects of chipping in central Wisconsin, inferior wood quality and feasibility of logging have historically suppressed

Maintenance of the aspen type in central Wisconsin is complicated in some areas by conversion to white pine or low-grade hardwoods. Poor wood quality where high water tables exist has also affected marketability of aspen.

the demand for aspen pulpwood in this area.

Habitat guidelines prescribed for grouse by other investigators differ from those suggested above, and may not necessarily be attainable. In the aspen type, Berner and Gysel (1969) recommended maintaining 40-45% sapling-sized stands under 20 years old, 40-45% pole-sized or mature trees, with the remainder in grass-upland brush openings or poorly stocked stands. Gullion (1972) suggested that 50% of the aspen type occur in stands 20 years old or less, with cuts spaced no more than 20 years apart. This approach would achieve nearly equal proportions of four age classes (0-10, 11-20, etc.) in a tract. While these proportions may not be attainable on large blocks of public land, they may provide a useful framework for small private parcels. Habitat guidelines prescribed for deer in Michigan (Hammill and Visser 1984) are more practical and correspond closely to Wisconsin criteria. They include maintaining 65% of the upland forest in intolerant types, with aspen comprising 35% and seedling-sapling aspen stands at least 25% of this total. Habitat guidelines for grouse (Mich. Dep. Nat. Resour. 1984) also emphasize maintenance of aspen by clear cutting (all stems over 2 inches dbh removed) along existing stand boundaries with cuts up to 10 chains in width. Exceptions to clear cutting include stands where oak is scarce or where concerns about road access or maintenance of uncut corridors for aesthetic reasons occur. Aspen stands not capable of being left uncut up to 10 years should be cut expediently to maintain aspen to avoid loss or deterioration of the type. In larger cuts (more than 10 chains wide), retention of clones of about 60 mature aspen in every 20-acre cut is also recommended.

RESEARCH NEEDS

More information is needed to better assess grouse population changes relative to intensive and extensive habitat management. Several studies are underway in parts of the grouse range to monitor grouse populations on intensively managed tracts using various combinations of small cuts of 10 acres or less. Ongoing research at the Stone Lake Experimental Area in northern Wisconsin will provide an evaluation of the grouse response to large clear cuts which have averaged 50 acres. However, more work is needed to define the upper limits of the size and shape of cuts which are compatible with timber management on public and private forests, and the maintenance of higher grouse densities. Thus, further work is needed to refine the ability to predict grouse numbers with various levels of habitat management (small versus large; strip versus block cuts).

The impact of conifers on habitat quality is another concern since a projected softwood fiber shortage has created considerable interest in converting aspen, oak, and other intolerant types to pine, particularly red pine (Lindberg and Hovind 1983). Thus, we need to better define the upper limits of conifer cover (land area, species composition, age class distribution, and proportion of natural and artificial regeneration) which is compatible with established overwinter deer goals and desired grouse densities.

SUMMARY

Grouse populations were monitored on Sandhill from 1968-82. The census covered 2,400 acres of upland from 1968-78 and was expanded to 3,720 acres in 1979. Comparative information on grouse densities was also obtained on a 1,000-acre portion of the Wood County Forest from 1969-78 and combined with Sandhill data.

Management of Sandhill as a state-owned wildlife area began in 1963, but habitat manipulations through timber sales or shearing were not accelerated until 1968. Habitat treatments averaged 138 acres/year from 1968-82 compared to 65 acres/year before 1968. Eighty-nine percent of these manipulations occurred in the aspen type where total treatments have averaged 117 acres/year since 1968. Timber sales have accounted for 79% of the areas treated, while shearing by dozers or chain saw crews constituted the remainder. Generally, size of timber sales and shearing treatments have been kept small, averaging less than 20 acres since 1963. The proportion of upland forest lands treated by timber sales or shearing increased from only 5% in 1962 to 15% in 1968 and 48% in 1982.

A comparison of separate 1,000-acre managed and unmanaged tracts from 1969-82 demonstrated grouse response to habitat management. Drummer densities were similar on both areas at the beginning of the study, but after 10 years (1978), densities were 1.6 times higher on the managed area than on the unmanaged area, and after 12 years (1981) densities more than doubled on the managed area. During this time, the proportion of upland forest in 0- to 25-year-old stands steadily increased from 13% to 55% on the managed area, while declining on the unmanaged area. In addition, the occurrence of drummers in 0- to 25-year-old stands increased considerably between 1969 and 1981 on the managed area.

Drumming grouse were not randomly distributed, exhibiting a strong preference for aspen instead of oak and aspen-alder habitats compared to aspen stands devoid of alder. Mean density was 4.1 grouse/100 acres in aspen and 0.8 in oak from 1968-82. In comparison, densities averaged 11.1 grouse/100 acres in aspen-alder and 2.2 in aspen of all ages devoid of alder. In aspen stands devoid of alder, drummer densities were considerably higher in regenerating stands under 26 years old, indicating a positive response to habitat management. Drummer densities exceeded the long-term mean of 4.1 grouse/100 acres in most aspen age classes, suggesting that grouse can adapt to a broad range of habitats. Exceptions occurred in stands under 6 years old and mature stands beyond 26 years where densities were lower. Densities peaked at 7.2 grouse/100 acres in the 6- to 10-year class, and averaged 6.4 in 6- to 25-year old stands. New occupancy of previously unoccupied drumming sites also corroborated the response to habitat change brought about by management practices.

Factors influencing the selection and distribution of drumming sites included the composition, density, and structure of woody species, and the presence of certain shrubs greater than 5 ft tall, particularly alder, winterberry, and hazel-nut. In addition, most drumming grouse were selective for sites where older aspen were present near the drumming log, and most birds were situated along an upland-lowland edge.

Management efforts which achieve greater age class interspersion while maintaining aspen and aspen-alder habitats should be encouraged wherever practical. Habitat prescriptions may vary among investigators, but we feel it is essential to maintain a continuous supply of dense sapling (0- to 25-year-old) stands by timely clear cuts of 5-20 acres throughout a management area. Larger cuts up to 40 acres may be acceptable if adjustments in their configuration and distribution are made. It is also vital to maintain some mature aspen as a food source to stands under 26 years or within large clear cuts. We also need to avoid, discourage, or minimize conversion of aspen, oak, or upland brush habitats to conifers.

Other management options include shortening the aspen rotation age, intermediate thinning in aspen, hybrid aspen reforestation, regenerating alder, prescribed burning, and conifer planting.

Broad compositional guidelines have been prescribed for deer and these currently provide a suitable management framework for grouse and other forest wildlife. In Wisconsin, where fall deer densities exceed 30/mile^2, intolerant types should constitute 65% of the forest canopy. In addition, higher grouse densities can also be expected if 30-35% of the aspen type occurs in well-distributed sapling-sized stands under 26 years old.

Maximum size and configuration of cutting areas and the upper limits of conifer composition compatible with desired grouse densities are areas needing further research.

APPENDIX A. Scientific Names of Plants Cited.*

Alder (*Alnus rugosa*)
Ash (*Fraxinus* spp.)
Aspen, large-toothed (*Populus grandidentata*)
Aspen, trembling (*P. tremuloides*)
Beech (*Fagus grandifolia*)
Birch, bog (*Betula pumila*)
Birch, white (*B. papyrifera*)
Birch, yellow (*B. lutea*)
Blackberry (*Rubus allegheniensis*)
Blueberry (*Vaccinium angustifolium* and *V. brittonii*)
Cat-tail (*Typha latifolia* and *T. angustifolia*)
Cherry, black (*Prunus serotina*)
Cherry, choke (*P. virginiana*)
Cherry, pin (*P. pensylvanica*)
Chokeberry (*Aronia melanocarpa*)
Dogwood, gray (*Cornus racemosa*)
Dogwood, red osier (*C. stolonifera*)
Fir, balsam (*Abies balsamea*)
Hardhack (*Spiraea tomentosa*)
Hazel-nut (*Corylus americana*)
Hazel, beaked (*C. cornuta*)
Hickory (*Carya* spp.)
Huckleberry (*Gaylussacia baccata*)
Service-berry (*Amelanchier laevis, A. sanguinea,* and *A. spicata*)
Maple, red (*Acer rubrum*)
Maple, sugar (*A. saccharum*)
Meadow-sweet (*Spiraea latifolia*)
Ninebark (*Physocarpus opulifolius*)
Oak, northern pin (jack-oak) (*Quercus ellipsoidalis*)
Oak, northern red (*Q. borealis*)
Oak, white (*Q. alba*)
Oak, black (*Q. velutina*)
Pine, jack (*Pinus banksiana*)
Pine, red (*P. resinosa*)
Pine, white (*P. strobus*)
Raspberry (*Rubus strigosus*)
Rose (*Rosa* spp.)
Sedge (*Carex* spp.)
Sedge, wool grass (*Scirpus cyperinus*)
Spruce (*Picea* spp.)
Sweetfern (*Myrica asplenifolia*)
Tamarack (*Larix laricina*)
Willow (*Salix* spp.)
Winterberry (*Ilex verticillata*)
Witch hazel (*Hamamelis virginiana*)

*Plant Reference: Gleason and Cronquist (1963).

APPENDIX B. Upland habitat types found on the Sandhill-Wood County study areas.

Habitat Type	Description
Aspen	Upland stands dominated by trembling or large-toothed aspen with scattered white birch, red maple, or oak in the overstory. Understories are dominated by hazel-nut and chokeberry. Oak, red maple, and white birch saplings occur in varying densities.
Aspen-alder	Trembling aspen on upland and wet sites with alder and winterberry understories.
Oak	Principally northern pin (jack-oak), white, and northern red oak with scattered black oak, large-toothed aspen, white birch, or pine in the overstory and hazel-nut or scattered pine in the understory.
Pine	Natural and planted stands of jack, red and white pine.
Upland brush	Mixture of hazel-nut, beaked hazel, chokeberry, sweet fern, huckleberry, blueberry, blackberry, or raspberry.

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