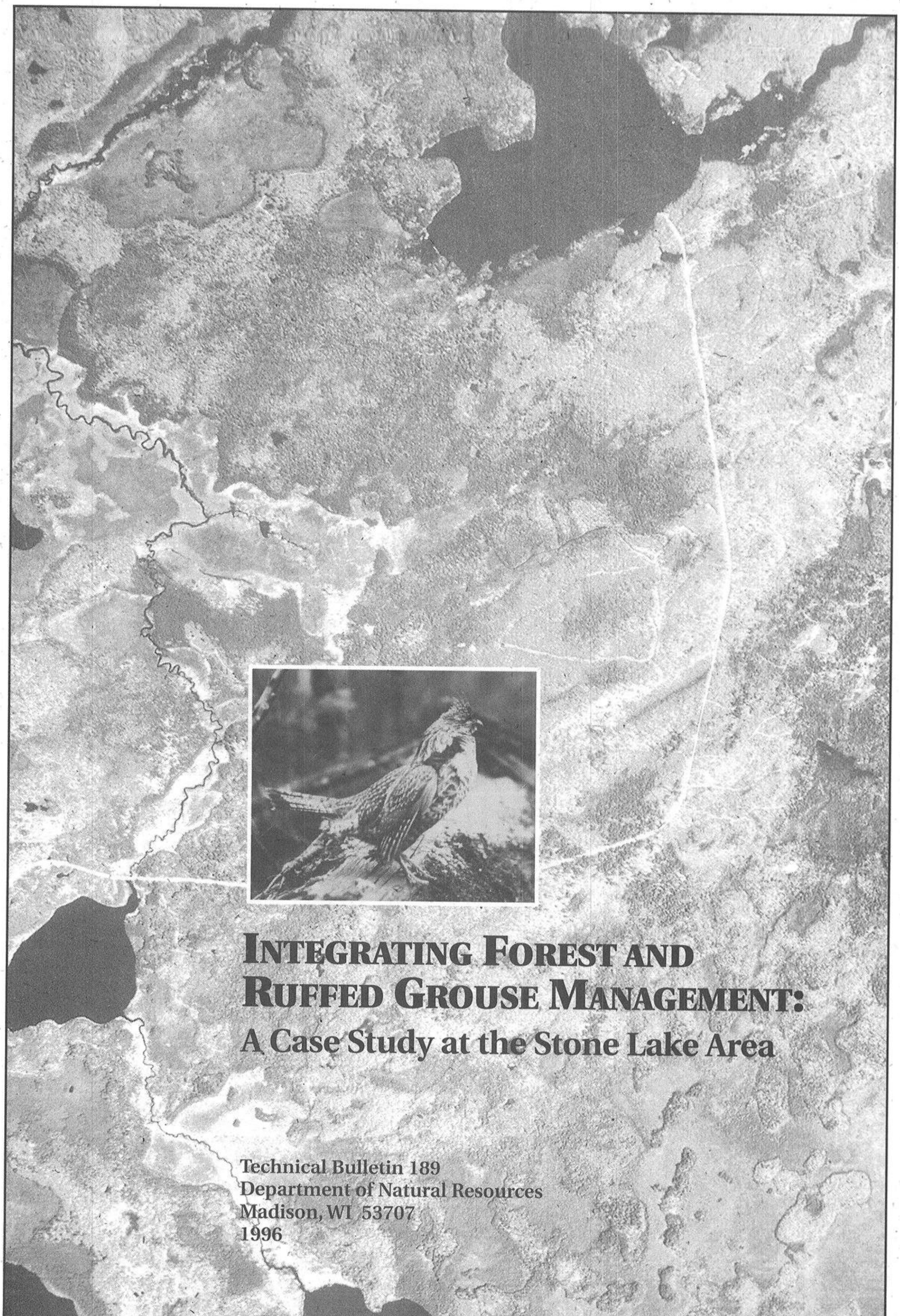
Integrating forest and ruffed grouse management: a case study at the Stone Lake area. No. 189 1996

McCaffery, Keith R.; Ashbrenner, James E.; Creed, William A.
Madison, Wisconsin: Wisconsin Department of Natural Resources, 1996



INTEGRATING FOREST AND RUFFED GROUSE MANAGEMENT:

A Case Study at the Stone Lake Area

Technical Bulletin 189
Department of Natural Resources
Madison, WI 53707
1996

Cover photo credits: DNR archives

ABSTRACT

The primary objective of this study was to demonstrate and evaluate responses of ruffed grouse populations to habitat management during a coordinated forestry-wildlife habitat management program. Additional data were gathered on some grouse and hunter behaviors. The 4,200-acre Stone Lake Experimental Area was chosen because it was State Forest land, had forest types typical of northern Wisconsin, and had a dead-end road that facilitated hunter checks. The primary land use was pulpwood production. The area was composed of 5 forest compartments, 2 of which were being harvested by large-scale clear-cutting at the inception of the study. Three demonstration compartments were clear-cut in patches averaging 22 acres during 3 cutting periods to improve aspen age-class interspersion. The study began in 1967 with patch cuttings beginning in 1974. Grouse population monitoring continued through 1994. About 14 miles of hunter walking trails were developed as timber sales progressed. Ruffed grouse responses were determined by a near-complete spring drummer census. Highest densities of drumming ruffed grouse were found in 8- to 24-year-old aspen saplings and small poles. Of 11 other forest habitats, drumming ruffed grouse densities were highest in swamp conifers (with white-cedar) and balsam fir. Pine habitats ranked lowest. During the first 20 years following cutting, grouse densities on the large-scale clear-cuts and specially managed demonstration areas (small-scale clear-cuts) were similar. Overall grouse densities will likely be higher in the future on the demonstration compartments as prime-age aspen habitats continue to be available, while maturing aspen will have lost its attractiveness in the traditionally cut compartments. Hunter exploitation of grouse averaged about 28% of the estimated fall population when hunting effort averaged about 215 hours/mile^2. Exploitation appeared to be disproportionately higher during years when walking trails were seeded with clover and mowed.

INTEGRATING FOREST AND RUFFED GROUSE MANAGEMENT: A Case Study at the Stone Lake Area

By Keith R. McCaffery, James E. Ashbrenner, William A. Creed, and Bruce E. Kohn

Technical Bulletin 189
Department of Natural Resources
P.O. Box 7921
Madison, WI 53707
1996

CONTENTS

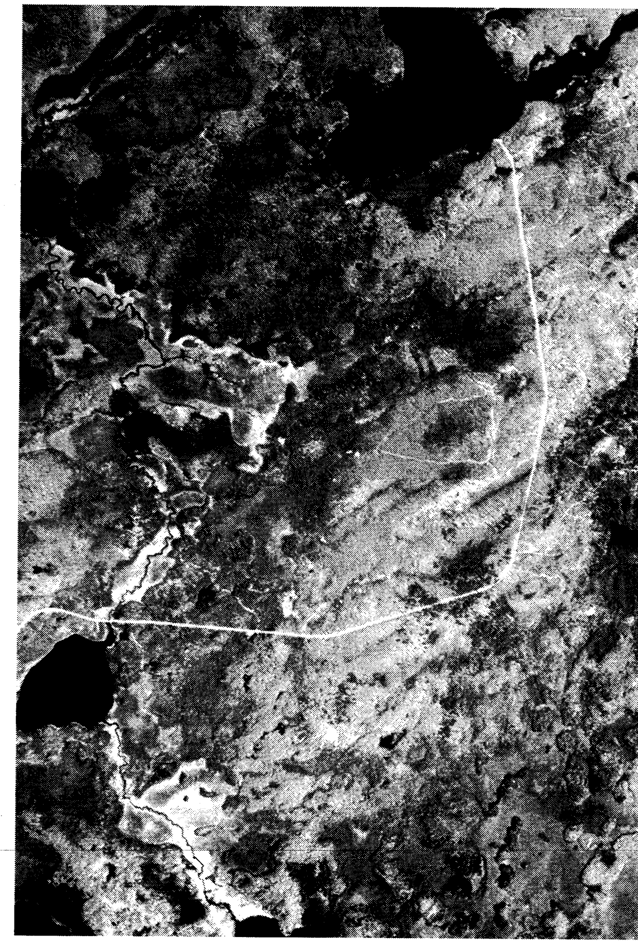
INTRODUCTION

A number of studies have been conducted on ruffed grouse habitat relationships in the Lake States region (King 1937, Grange 1948, Dorney 1959, Hale and Dorney 1963, Berner and Gysel 1969, Gullion 1972, 1977*a*, 1983, Kubisiak et al. 1980). Until 1970, only one study area (Cloquet Forest in Minnesota) had been monitored sufficiently long to track grouse population responses through an entire 10-year cycle.

Habitat management recommendations to maximize ruffed grouse production were made following these earlier studies, most notably Gullion (1972). These recommendations called for frequent clear-cutting of small tracts of 1 to 5 acres in a systematic pattern to provide a continuous supply of 5- to 25-year-old aspen saplings (Gullion 1977*a*). These recommendations were mainly theoretical applications of research findings. While this small-tract cutting would no doubt be possible for use on private woodlands or wildlife management properties where ruffed grouse might be a primary objective, this intensity of management exceeds what can be reasonably practiced extensively in large public forests devoted primarily to timber production.

Prior to 1972, it was common practice on public forests in Wisconsin to schedule all merchantable timber in a management compartment (500 to 1,000 acres) to be cut (clear-cut or thinned) in one sale. This procedure was most efficient administratively, and most stands were of similar age as a result of exploitative logging and fires earlier in the century. These larger sales and higher sale values also permitted allowances for road-building and other specifications that might be written into the sale contract. Cutting smaller tracts of 5 or fewer acres would be impractical within this timber management framework. Thus, a need existed for a long-term demonstration and evaluation of habitat management for grouse in the context of commercial forestry operations.

Three other evaluations were initiated to look at more intensive application of habitat recommendations. The most intensive management involved a systematic 1-acre "checker-board" cutting being demonstrated and evaluated in Pennsylvania starting in 1985 (G. Storm, pers. comm. 1993; study area described by Yahner 1990). A range of management intensities was being evaluated at Mille Lacs Wildlife Management Area in Minnesota beginning in 1976 (Gullion 1983). And an intermediate intensity of habitat management had been implemented for evaluation on the Sandhill Wildlife Area where timber sales averaged 17 acres (Kubisiak et al. 1980 and Kubisiak 1985*a*). The Stone Lake Experimental Area (SLA) study was designed to evaluate the impact of a lower intensity of habitat management where cut tracts would be kept below 40 acres in size. Though not replicates, these evaluations of various levels of management intensity should eventually provide excellent information on the relative effectiveness of these management practices.



DNR PHOTO

The 4,200-acre Stone Lake Experimental Area was chosen for study because it was mostly State Forest land, was serviced by a dead-end road, and had timber types typical of much of northern Wisconsin. The study area is bordered by Indian Creek and marshes to the west, Stone Lake to the north, and Oatmeal Lake to the south.

The Stone Lake study began in 1967. The primary objective of this study was to demonstrate and evaluate responses of ruffed grouse populations and harvests in relation to habitat management during the first 20 years of a coordinated forestry-wildlife habitat program. Some data on grouse and hunter behavior were also gathered during the study and reported here. Most habitat measurements ended in 1988, but grouse population monitoring continued through 1994.

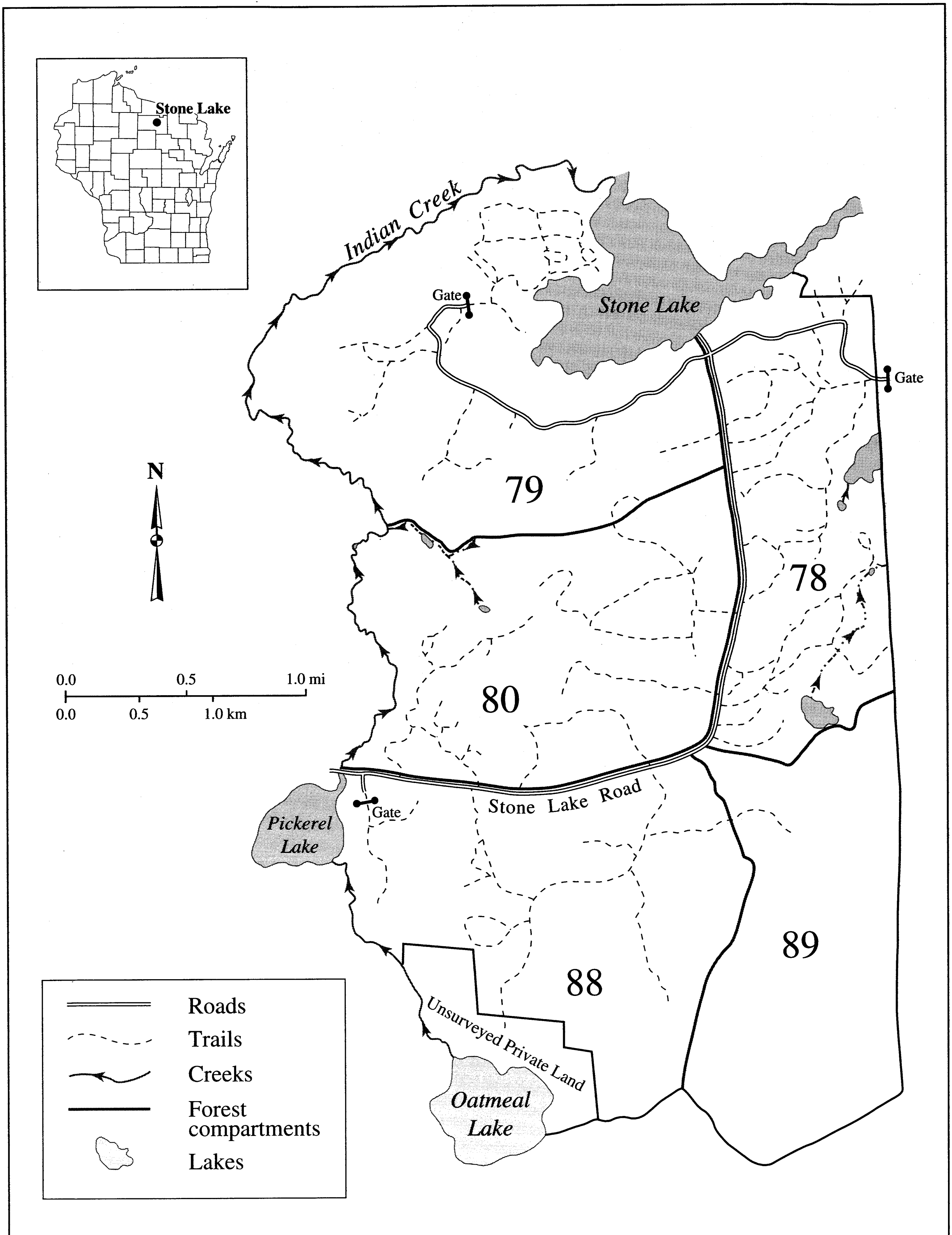
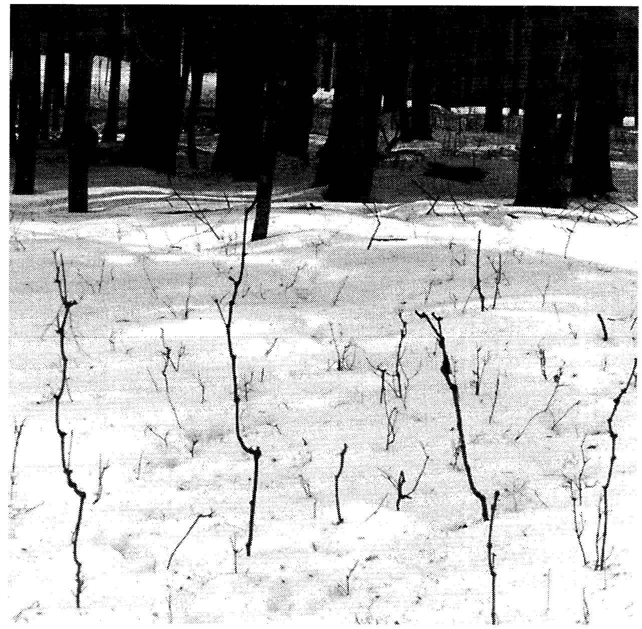


Figure 1. *Stone Lake Area forest compartments, roads, and trails, 1979 to 1994. All walking trails were gated in addition to gates shown on driveable roads.*

Study Area

The SLA includes 4,200 acres of the American Legion State Forest in north-central Wisconsin (Figure 1). The area lies above Latitude 45°45′, and grouse there are clearly impacted by northern raptors and population cycles (Keith and Rusch 1989). The area was chosen in part because it was serviced by a dead-end road, which facilitated gathering information from hunters. It was also chosen because it was state-owned property that had forest types typical of northern Wisconsin. Overall habitat quality for ruffed grouse was considered mediocre in 1968 because much of the area was composed of older age classes (pole-size and larger) of timber. The area is surrounded by open wetlands and lakes that are not insurmountable obstacles to ruffed grouse, but may limit some amount of grouse ingress and egress. Upland soils are predominantly Keweenaw sandy-loams. The glaciated topography is gently rolling. Much of the upland would fall into the ATM (Acer-Tsuga/Maianthemum), TMC (Tsuga/Maianthemum-Coptis), or PMV (Pinus/Maianthemum/Vaccinium) habitat types as described by Kotar et al. (1988).

The primary land-use objective was economical production of pulpwood. The area was composed of 5 timber management compartments (Figure 1). A variety of forest types typical of northern Wisconsin were present as shown by the 1981 inventory (Table 1). Uplands made up 62% of the area and were forested mainly with aspen, white birch, balsam fir, and northern hardwoods. Compartments ranged in size from 637 acres to 1,077 acres. The amount of potential grouse range (excluding only stagnant black spruce, water, marsh, and muskeg) varied by compartment from 384 to 838 acres and totalled 3,307 acres.



K. McCAFFERY

The Stone Lake Area has a long history as a winter deer yard. Sugar maple seedlings deformed by deer browsing are in the foreground with a dense hemlock grove in the background.

Table 1. *Forest composition (acres) by compartment on Stone Lake Area in 1981.*

	Compartments						
Forest Type	**78**	**79**	**80**	**88**	**89**	**Total**	**Percent**
Aspen	227	311	323	239	127	1,227	29.3
Birch	36	179	5	69	70	359	8.6
Balsam fir	71	105	61	74	38	349	8.3
Northern hardwoods	143	6	80	86	8	323	7.7
Hemlock	16	1	26	39	7	89	2.1
Red and white pine		70	8	39	10	127	3.0
Jack pine		36	23		1	60	1.4
White spruce	7	1		7		15	0.4
Grass	3	9	10	5	1	28	0.7
Upland brush	15	10				25	0.6
Swamp hardwoods	7		19	20		46	1.1
Black spruce	7	42	26	52	74	201	4.8
Swamp conifers	6	18	52	24	8	108	2.6
Tamarack		1	21	4	3	29	0.7
Lowland brush	52	49	127	59	37	324	7.7
Stagnant spruce		33	14	65	52	164	3.9
Muskeg	28	204	109	96	261	698	16.6
Water	19	2	1			22	0.5
Total	637	1,077[a]	905	878[b]	697	4,194	100.0
Potential grouse habitat[c]	589	838	781	715	384	3,307	78.9

[a] Includes 184 acres of private land.
[b] Includes 35 acres of private land.
[c] Excludes stagnant spruce, muskeg, and water.

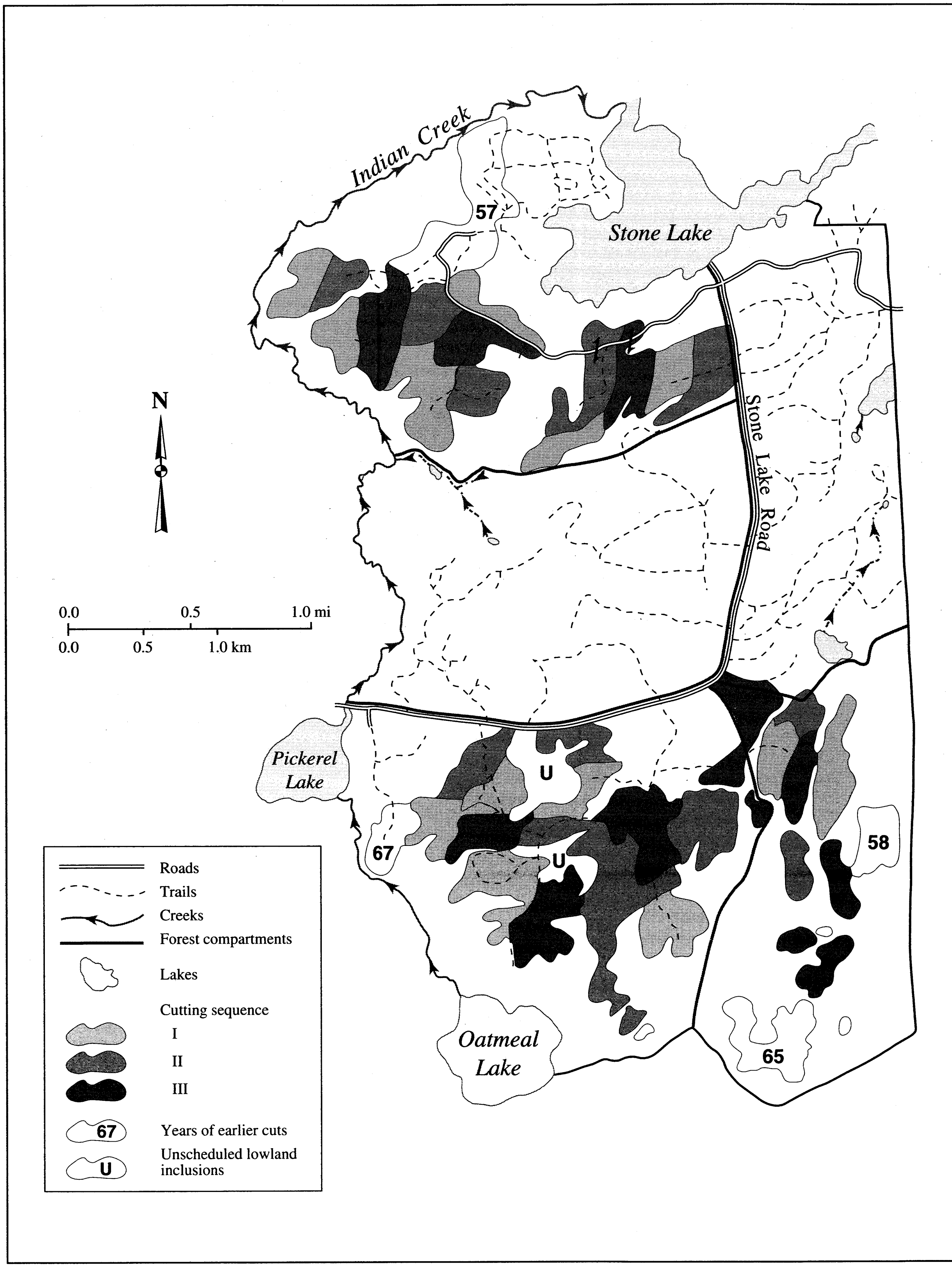


Figure 2. *Original cutting plan for demonstration compartments.*

Two of the compartments (Comp. 78 and 80) were being commercially harvested at the time this study began. Both compartments contained some amount of northern hardwood that was thinned and pines that were not cut. Most of the remaining upland portions of the 2 compartments were commercially clear-cut (all merchantable stems containing 2 or more 8-ft pulp sticks were removed). These 2 cutover compartments provided a comparison for 3 other compartments (Comp. 79, 88, 89) managed with demonstration patch cutting. Patch cutting began in 1974, and our evaluation extended to those patches cut as recently as 1988. Hunter access to the cutover compartments was high as a result of logging roads. Hunter access to the remaining compartments was more limited prior to cutting, with one compartment (Comp. 89) being relatively inaccessible to hunters throughout the study.

Pulp stumpage values were low during the early part of this study, so cutting specifications in these cutover compartments had evidently been lenient. Cutters were required only to harvest trees containing 2 or more pulp sticks. This "2-stick limit" resulted in considerable uncut residual, causing some stands to revert from having a major aspen component to stands dominated by balsam fir, white birch, and/or maple. A portion of these stands (mostly in Comp. 80) were cleared using bulldozers with tree-cutting blades to improve aspen regeneration. Conifers were often left for deer thermal cover. Less than half of the potential grouse range in these cutover compartments was actually cut heavily enough to regenerate well-stocked aspen stands.

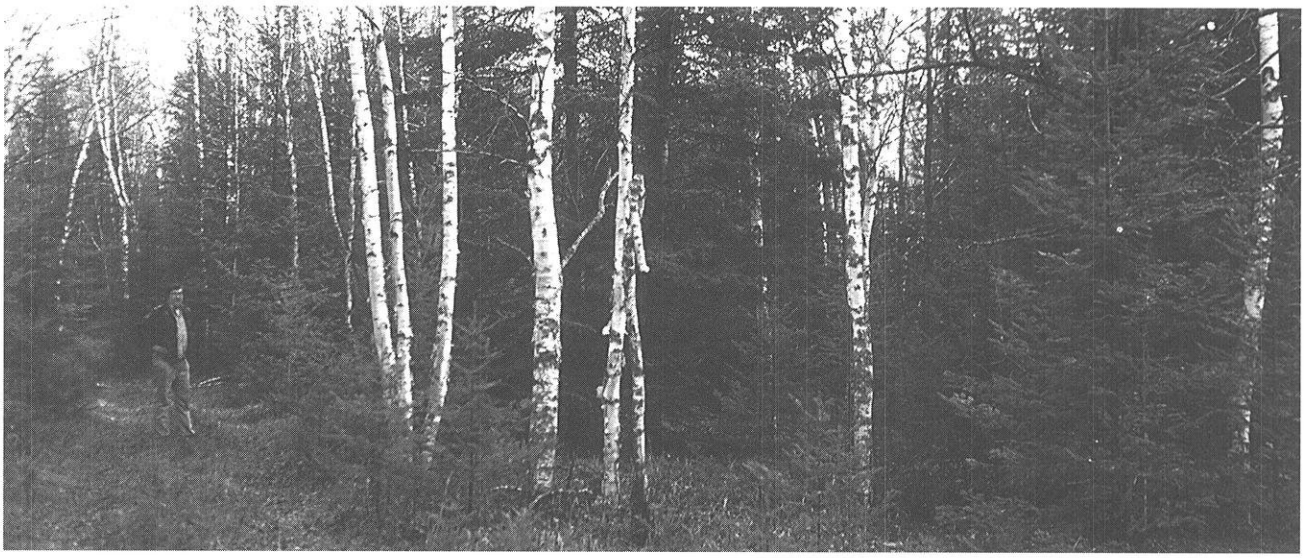
The SLA has been and continues to be a wintering area for deer. Stands of hemlock, swamp conifers, and balsam fir provide attractive winter cover. The long history of deer use is evident by old browse lines on conifers and the "brooming" of understory hardwood browse species. Frequent timber-cutting activity also attracted wintering deer throughout the study period.

METHODS

Habitat Management

"Experimental design" was less than ideal. We worked with what we had. Timber in 2 compartments (Comp. 78 and 80) was already sold, and cutting was nearing completion. Thus, these 2 compartments became the "controls" representing "traditional" large-tract cutting. These larger cuttings were interspersed with lowland types and some pine and hardwood types that were not clear-cut. The remaining 3 compartments (Comp. 79, 88, and 89) provided an opportunity for modified timber sales and became the "demonstration" compartments.

The primary modification to "traditional" forest management practices was to reduce the size of tracts set up for clear-cutting in the remaining 3 compartments and to spread the timing and spacing of cuts. Thus, areas dominated by aspen, birch, and/or balsam fir were subdivided into tracts of fewer than 40 acres (mean = 22.4 acres) using natural boundaries and stand divisions (Figure 2). Optimally, aspen resulting from this schedule would have 4 age classes with a 10-year difference between adjacent stands. However, most stands on the SLA were


J. KUBISIAK

Much of the upland forest was composed of aspen, birch, and balsam fir in variable mixtures or in nearly pure stands.

Most of the aspen forest was at maturity at the time the study began. Understory shrub development was generally poor in most upland forest types.

Swamp conifers normally had patches of alder brush interspersed in the stand. The high density of alder stems combined with the taller cover provided by swamp conifers resulted in this being a favored drumming habitat prior to the availability of sapling aspen stands.

already near or beyond rotation age (approximately 50 years), so only 3 periods of cutting were planned, and the scheduled intervals between cuts spanned a maximum of only 12 years. Some of the aspen stands originated in the years 1913 and 1916. Cutting of stands on better sites was delayed longest. Those on poorer sites were scheduled earliest to minimize losses to stand breakup. Timber sales were planned by research personnel but were administered by State Forest personnel. Departures from the planned schedule were necessary to salvage windthrow areas and to accommodate fluctuating market conditions. As the study progressed, the 12-year cutting plan, in actuality, was extended to more than 20 years.

The cutting contracts specified cutting noncommercial stems to < 30 ft^2/acre of basal area or < 15% canopy coverage to promote dense aspen regeneration. Field observations suggested that these requirements were easily met.

Many logging trails were leveled and widened for hunter walking trails after timber sales. These trails were gated against vehicular travel, seeded with clover, and mowed prior to the hunting season. Later in the study, the presence of clover declined, but trails continued to be mowed in most years.

A few grassy openings were also maintained on the area. Additional openings ranging in size from 0.5 to 1.5 acres were constructed to supplement the relict openings. This latter practice was recognized to benefit deer and deer hunters (McCaffery and Ashbrenner 1981); in most cases, new openings subtracted potential aspen habitat for grouse.

Habitat Measurements

Forest composition of the SLA was updated at about 5-year intervals from 1960 to 1975. Forest inventory data from a 1963 compartment reconnaissance was used as the basis for these adjustments. In most cases, the 1963 map data were biased toward aspen because forest typing favored the timber management objective rather than indicating the predominant species in the stand.

The 1981 inventory was a completely new and detailed inventory based on different definitions and smaller stand sizes. Stands were mapped from both winter and summer aerial photography to insure inclusion of conifer understories. A composite map was prepared using a sketchmaster to rectify scale differences. Initial typing was done stereoscopically from aerial photos with corrections made during ground reconnaissance. Habitats were classified by the tree species having the greatest impact on the stand; normally this species represented the plurality of stems. Up to 3 other tree species were indicated in the order of their effect on the physiognomy of the habitat.

Estimates of shrub and tree-stem densities in regenerating clear-cuts were made using randomized milacre plots. When counting shrub (≥ 6 ft tall) densities at drumming sites, a circular 0.004-acre plot was used that was centered on the drumming stage. Counts of tree saplings (1-4 inches dbh) and poles (5-9 inches dbh) were made on 0.01-acre circular plots.

Ruffed Grouse Measurements

Active drumming males were censused annually using procedures described by Gullion (1966). The entire study area was surveyed at least twice between 20 April and 10 May. A person was assigned to each management compartment. Four of the 5 compartments were surveyed by the same individual for the entire study period. The near-complete census was conducted by walking to known points within each compartment and listening for drumming grouse. Drumming sites that were active in the prior year were also examined for current sign. Activity centers occupied by drumming grouse were marked by paint, plastic flagging, and a metal, numbered tag. Drumming sites were also pinpricked on aerial photos and described in field notes. Forest composition within 0.1 acre of the drumming site was recorded as was the immediate cover at the drumming site. The drumming stage was described (log, boulder, etc.), and the length, diameter, and azimuth of drumming logs were noted. Drummer use of habitats was compared with the availability of habitats by calculating the number of drummers per 100 acres of available habitat. Drummer distribution and density were assumed to be an expression of year-round habitat preference by both sexes (Gullion 1977*a*, Thompson et al. 1987).

This spring drummer census was compared with regional indexes of grouse abundance, which served as a control. The primary index was roadside drumming transects run by management personnel in northern Wisconsin. This and other grouse indexes were described and evaluated by Thompson and Moulton (1981).

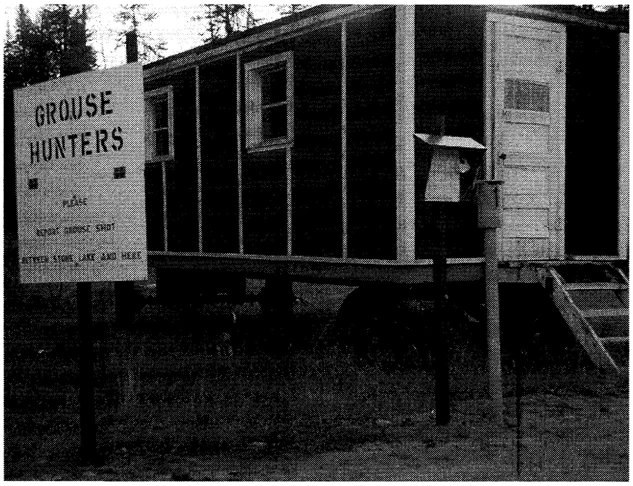
Estimates of fall grouse populations were made by multiplying the spring count of drummers by 6. This is similar to the expansion factors of 5.7 calculated by Gullion (1981*a*) and 6.4 by Kubisiak (1984). Though requiring a number of assumptions, these population estimates permitted crude approximations of hunting exploitation when compared with the reported harvest.

Because snow-roosting conditions are believed to improve overwinter grouse survival (Gullion 1970), the number of days with ≥ 7 inches of loose snow was recorded each winter. Survival data were not available for individual grouse on the study area, so the numbers of snow-roosting days per year were compared with spring counts of drumming males and calculated rates of increase from the close of one hunting season to the beginning of the next.

Incidental observations of avian predators (mainly horned and barred owls and, rarely, goshawks) were noted on field data sheets, but no systematic surveys of predator abundance were conducted. Major predator impacts on grouse population were assumed to coincide with the occasional migrations of northern raptors into the northern U.S. (Keith and Rusch 1989). Mammalian predator populations, except for fisher, were believed to be fairly stable. Regional fisher populations increased during the study period. However, radio tagging of grouse in northern Wisconsin indicated that mammalian predation was a minimal factor in a recent grouse population decline (D. H. Rusch, UW-Madison, pers. comm. 1994; Lauten and Balzer 1994).

K. McCAFFERY

Drumming grouse were censused by listening and searching throughout the study area at least twice each spring. Drumming sites were marked in the field with plastic flagging and paint, and locations were pinpricked onto aerial photographs. The adjacent habitat was also described in field notes.



J. MOULTON

A check station was located at the entrance of the study area. Most years it was unattended and we relied on voluntary reports by hunters who completed a card and deposited it in a small lock box. A pneumatic traffic counter recorded vehicle passage.

Hunter and Harvest Measurements

Grouse hunting seasons began the Saturday nearest 1 October and ended in mid-November from 1968 to 1975. The seasons were extended to 31 December beginning in 1976 and opened on a mid-September Saturday starting in 1983. The bag limit was 3/day until 1970 when it increased to 4 and then to 5 starting in 1971. The possession limit was 2 times the daily bag. Sunday hunting was permitted.

A voluntary check station was maintained at the entrance of the SLA each year from the start of the season until mid-November. A sign instructed hunters on procedures for reporting the date and number of grouse flushed and bagged. Cards were deposited into a locked box designed for timber scale slips. A pneumatic traffic counter was also maintained at the site. The check station was visited once or twice weekly on Monday and Friday from the week before grouse season in September until the week before the firearm deer season in mid-November. In some cases, report cards were obviously falsified, and these were omitted from the totals. There was no attempt to correct for nonreporting by hunters.

A hunter check station was staffed from 1967 to 1976 and in 1982 to determine traffic volume, hunting effort/success, and attributes of hunters, and to calibrate/validate the voluntary check. The station was staffed full days on the opening weekend and, thereafter, on alternating mornings and afternoons until closure of the hunting season before the firearm deer season in mid-November. Hunters were briefed on the purpose of the study and procedures before entering the area. The number of auto occupants and the primary activity of each occupant were recorded (grouse or deer hunting, fishing, etc.). On leaving the area, they were asked to report game seen and bagged and method of hunting (road-hunting from a vehicle, hunting with a dog, walking). If grouse were bagged, sex and age were determined. The total time each hunter spent on the study area was also recorded (see also Appendix B).

The exit interviews determined the proportion of total vehicles that contained grouse hunters and the average number of hunters per vehicle. A pneumatic traffic counter was also operated during the hunter checks; from this information we calculated approximate hunting effort on the area.

Results and Discussion

Habitat Composition and Changes

Forest overstory composition on the SLA was compiled for 1960, 1963, 1970, 1975, and 1981. The first 4 inventories were based primarily on the 1963 forest reconnaissance, with adjustments made based on cutting activity. Only the 1963, 1975, and 1981 inventories are presented (Table 2). Direct comparison between the 3 inventories is difficult because of differences in forest-type map resolution and habitat-type definition. The 1981 inventory is the most accurate measure of habitats. Mapping was done to a much finer detail, and typing was based on the predominance of species affecting the physiognomy of each habitat. The 1981 inventory is the most representative of habitats available from 1976 to 1988.

The principal differences between the habitat inventories during the study included an apparent reduction in what had been classified as aspen acreage. Much of this difference may have been due to classifying the mixed types as aspen during the earlier inventories

Table 2. *Forest type composition (percent) of Stone Lake Area as shown by three inventories.*

	Percent Composition		
Forest Type	**1963**	**1975**	**1981**
Uplands			
Aspen	41.3	40.3	29.3
Birch	7.3	4.8	8.6
Balsam fir	1.8	1.8	8.7
Northern hardwoods	2.6	7.1	7.7
Red, white, and jack pine	7.1	7.0	4.4
Hemlock	3.8	3.5	2.1
Grass and upland brush	0.6	0.9	1.3
Lowland			
Black spruce and tamarack	6.5	6.5	5.5
Swamp conifers	3.2	2.7	2.6
Swamp hardwoods	0.5	0.5	1.1
Marsh and muskeg	16.6	16.4	16.6
Lowland brush	7.2	7.4	7.7
Stagnant black spruce	1.6	1.1	3.9
Water	–	–	0.5
Total	100.1	100.0	100.0

even though these stands were dominated by other species. Often aspen was emphasized on forest reconnaissance maps due to ease of regeneration and operability. Although some aspen dominance may have been lost due to poor cutting practices prior to 1970, the actual amount of aspen habitat should have increased as mixed stands dominated by birch, fir, and red maple were regenerated to aspen by clear-cutting.

Major gains were shown for white birch and balsam fir between the last 2 inventories. The birch was no doubt present during the earlier inventory and classified with aspen. However, the predominance of birch may have increased in some stands as over-mature aspen broke up. Clearly balsam fir is increasing on the SLA despite significant mortality of older fir caused by a spruce budworm infestation in 1980. However, the amount of increase may be exaggerated because some fir-dominated habitats were likely classed as aspen stands in the early inventories. In the absence of fire, the trend for more fir is expected to continue. The decrease in the amount of hemlock acreage was due to tighter mapping standards (hemlock vs. hemlock-hardwood) that were applied during the 1981 mapping.

Lowland types remained relatively stable. The proportion of lowland increased slightly because small areas formerly included with upland types were delineated in the 1981 survey. Also, some areas formerly classified as commercial black spruce were reclassified as stagnant spruce.

During the 1981 inventory, forest stands were classified into 17 primary types. However, when secondary types were considered, a total of 82 "habitats" were recognized (Table 3). These habitats are shown to provide better perspective on the nature of the forest types discussed later (see also Appendix C). Of the 4,194 acres on the study area, only 3,307 were considered to be potential ruffed grouse habitat. Acreages of stagnant (nonproductive—slow growing and sparsely stocked) black spruce, marsh, muskeg, and water were excluded. For some analyses, aspen age 0-4 years was excluded as grouse habitat.


K. McCAFFERY

Timber cutting was already underway in 2 of the 5 management compartments at the time of study. The primary product was pulpwood.

Table 3. *Habitat composition (acres) of the Stone Lake Area in 1981.*

Component Species[b]	Primary Habitat Species[a]																		Total
	A	B	F	M	H	R	J	G	UB	SH	S	SB	SC	T	LB	Sx	K	LM	
Minor	549	45	68	103	40	58	28	25	4	5	1	198	85	3	301	164	698	25	2,400
A		28	85	26		3	3					3			1				149
AB			21	55		7													83
AF		57		21		8					2				14				102
AM		32	39																71
ABM			11				2		7										20
B	119		49	90		11			5										274
BF	179			20		5								1					205
BM	34		14																48
BMF	23								6										29
F	169	52		8	14	18				22	12				2				297
FM	30	59			1	6													96
FMA		30																	30
M	113	53	12		34				3										215
S	6		46			4	32												88
SB	2	3	4			5								4	6				24
LB										19			23	21					63
Total acres	1,224	359	349	323	89	127	63	25	25	46	15	201	108	29	324	164	698	25	4,194
Percent	29.2	8.6	8.3	7.7	2.1	3.0	1.5	0.6	0.6	1.1	0.4	4.8	2.6	0.7	7.7	3.9	16.6	0.6	100.0

[a] A = Aspen; B = White birch; F = Balsam fir; M = Northern hardwoods; H = Eastern hemlock; R = Red (and white) pine; J = Jack pine; G = Upland grass; UB = Upland brush; SH = Swamp hardwoods; S = White spruce; SB = Black spruce; SC = Swamp conifers; T = Tamarack; LB = Lowland brush; Sx = Stagnant black spruce; K = Marsh grass and muskeg; LM = Small lakes and ponds

[b] Component species comprise 20% or more of the stems or cover.

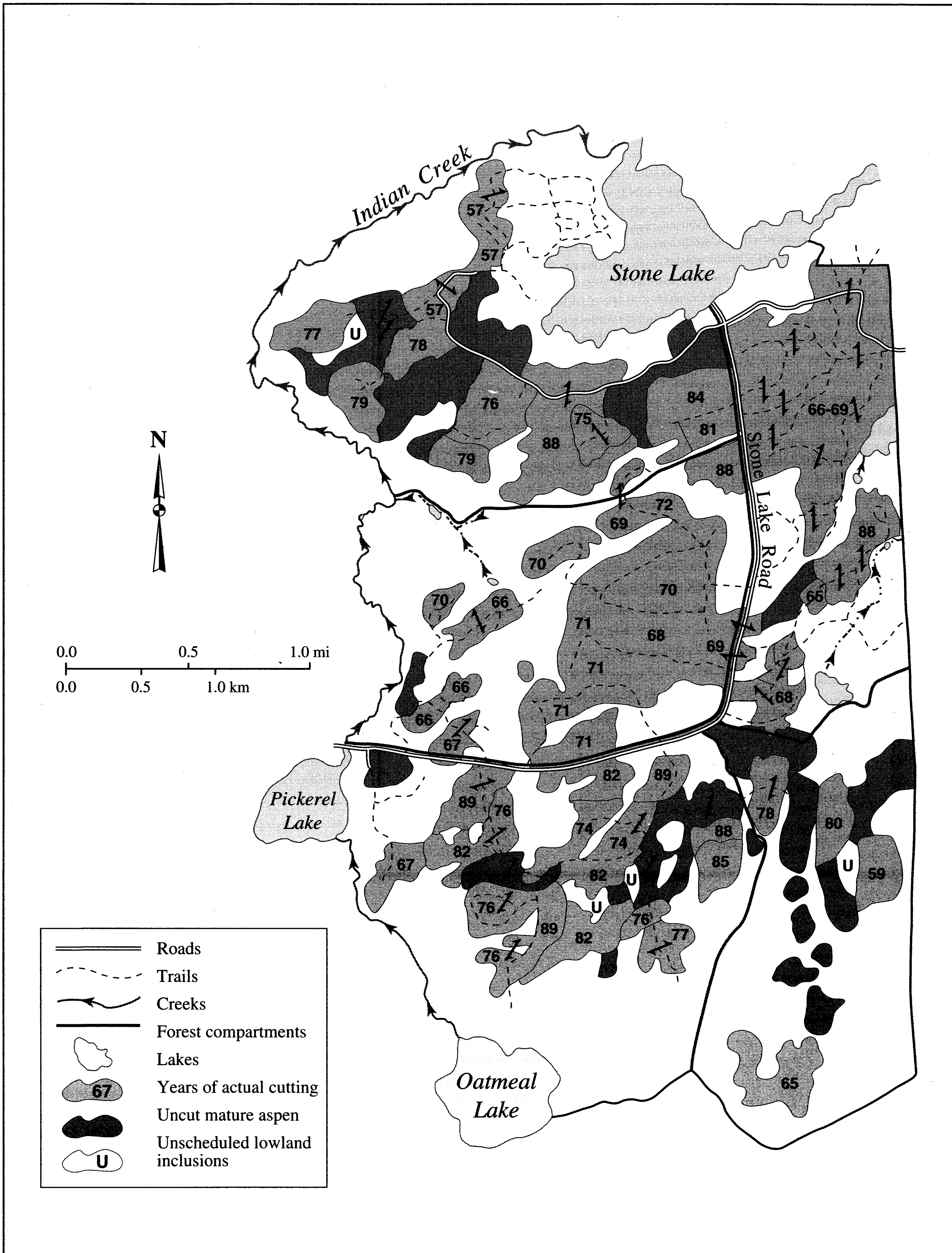


Figure 3. *Years of actual cutting from 1974 through 1989-90 on the Stone Lake Area.*

Table 4. *Acreages of aspen regeneration by treatment, compartment, and year of origin on the Stone Lake Area.*[a]

	Traditionally Cut		Demonstration-Cut			Total
Year Cut	78	80	79	88	89	Acres
1957			28			28
1958					10	10
1965	7				8 (2)	15 (2)
1966	79 (7)	19				98 (7)
1967	46	13 (2)		3		62 (2)
1968	26	8 (9)				34 (9)
1969	16	42 (15)	3			61 (15)
1970		40 (44)				40 (44)
1971		71 (54)				71 (54)
1974				20 (17)		20 (17)
1975			14			14
1976			47 (8)	39 (3)		86 (11)
1977			13	10		23
1978			31 (10)		13 (4)	44 (14)
1979			11 (10)			11 (10)
1980					19 (7)	19 (7)
1981			9 (5)			9 (5)
1982				50 (29)		50 (29)
1984			29 (13)			29 (13)
1985				10		10
1988	30	18	62	15		125
Total acres	204 (7)	211 (124)	247 (46)	147 (49)	50 (13)	859 (239)

[a] Poorly stocked aspen is shown in parentheses. Stocking evaluations have not yet been made for cuttings after 1984.

Timber Sales and Postsale Treatments

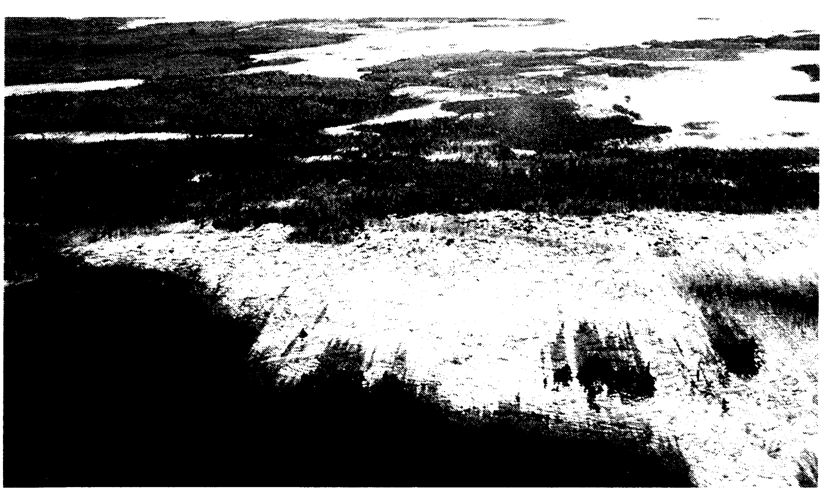
Timber sales were conducted on 498 acres within the 3 demonstration compartments between 1974 and 1988 (Table 4). Eight sales averaged 62 acres, but these sales were divided into cutting units that averaged only 22 acres. The cutting schedule had to be modified repeatedly to accommodate fluctuating market conditions and to salvage occasional windthrow. Thus, there were differences between the plan (Figure 2) and the resulting cutting pattern (Figure 3). Many adjacent cuts were 7 to 8 years apart.

Some additional administrative cost was necessary to accommodate the spacing of tracts to be cut. Small tracts resulted in more time and expense per acre for planning, cruising, and scaling. However, accurate dollar amounts were not recorded, and these additional costs were believed to be small. The main cost was for additional sale

A. LOOMANS

Unmerchantable stems remaining after harvest were removed from many of the early cuttings by using a bulldozer with a tree-cutting blade. This practice encouraged better reproduction of aspen stems. Improved timber prices allowed for requiring loggers to remove residual stems as part of the timber sale contract in later years.

B. KOHN



A portion of a clear-cut in Compartment 80 during postsale treatment. Bulldozer tracks are visible in the foreground. This clear-cut was the largest patch cut during the study.

perimeters that had to be marked. No loss of stumpage value was believed to have resulted from employing the smaller tracts.

Timber sale contracts prior to 1971 did not specify clear-cutting standards other than the 2-stick limit, so residual basal area in 24 cut stands ranged from as low as 7 to as high as 78 ft^2/acre and averaged 32 $\pm$ 18 (SD) ft^2. Species composition of the residual averaged 54% maples (mostly red maple), followed by white birch, aspen, and fir. The stand with 78 ft^2/acre was subsequently managed as a northern hardwood (maple-dominated) stand.

Several areas with excessive deciduous residual basal area (mostly > 30 ft^2) were subsequently sheared from 1965 to 1971 under special contract or with state bulldozers equipped with tree-cutting blades. Normally, shearing was done within one year of the completion of a sale. Most of the postsale treatment was done in Compartment 80 with only a limited amount occurring in Compartment 78. Basal areas of sheared stands averaged 40 $\pm$ 11 (SD) ft^2, and treatment averaged 2.1 $\pm$ 0.8 (SD) acres/hour. Acreage treated ranged from 1.0 to 3.6 acres/hour and was correlated (r = -0.64, n = 13, $P < 0.01$) with residual basal area. Cost of postsale shearing averaged $12.63/acre (1968-72 dollars).

Two years after shearing, tree and shrub stem densities averaged 14,840 $\pm$ 4,800 (2 SE)/acre. Aspen and maple were the dominant tree species and averaged 7,900 and 2,300 stems/acre, respectively. Spot checks 11 years after treatment indicated that stem densities had declined to fewer than 5,000/acre, and fewer than 1,500 stems were of tree species. About two-thirds of the tree stems were aspen, and one-third was maple. This latter composition is similar to the composition of initial regeneration and is likely the approximate composition of the stand prior to timber cutting. Gullion (1983) also reported that 15 years after cutting stands had a composition similar to preharvest despite postsale treatment to "remove" competing residual stems. The main advantage of the postsale treatment was to preserve a high representation of aspen in the subsequent stand that might otherwise have been shaded out by competing hardwoods.

K. McCAFFERY

Smaller patch cutting was practiced in 3 demonstration compartments in an effort to intersperse aspen stands of different age classes. Here, a young aspen stand is surrounded by uncut stands. Young aspen is preferred drumming and brood habitat. Mature aspen is favored for nesting and winter feeding.

Aspen Age-Class Distribution

Timber cutting was completed in Compartments 78 and 80 prior to 1969, but postsale treatments resulted in spreading the year of origin for some stands from 1965 to 1971 (Table 4). Of the 514 acres of aspen treated or cut within the study area from 1965 through 1971, 381 acres regenerated satisfactorily (> 2,000 aspen stems/acre plus stems of other woody species as determined from winter aerial photography and ground inspection) for ruffed grouse habitat. The remaining 133 acres (26%) contained sparse regeneration due mainly to poorly drained soils.

An additional 421 acres were cut in the 3 demonstration compartments from 1974 to 1985. Of this amount, 106 acres (25%) regenerated poorly. The most recent cuts beginning in 1988 were not evaluated for adequacy of stocking. Considerably more acreage was set up for earlier sale, but poor markets in some years deferred cutting.

Much of the "traditional" aspen cutting that took place during the prestudy period occurred in patches similar to the specially planned cuttings in Compartments 79, 88, and 89 (Figure 3). These patches were caused mainly by interspersed lowlands but were all cut in a matter of a few years. Though some aspen trees were present in uncut forest types and as residual in the cutover areas, there was no deliberate effort made to leave residual aspen stands as in the demonstration cuttings. Two clumps of mature aspen, totalling fewer than 30 trees, were reserved from postsale treatment in Compartment 80. However, most of these blew down during the first summer after adjacent trees were cut.

In the demonstration compartments from 1974 to 1988, there were 23 tracts cut that averaged 22 acres. Each tract abutted stands of mature aspen. The expectation was that this practice would promote higher densities of grouse and that spreading the cutting activity over a longer period would sustain higher grouse populations throughout the aspen rotation.

Management and Demonstration Costs

Early in the study, detailed records were maintained on the cost of conducting various types of management. Monetary inflation since many of these treatments were conducted makes these costs meaningful only in a relative sense.

About 14 miles of walking trails were mowed most years, and 18 wildlife openings were constructed (Figure 4). Walking-trail mowing and renovation averaged about \$50-60/mile during the mid-1980s. Trails were very popular with hunters and decreased the proportion of hunters who hunted from vehicles (see "Hunting Patterns and Harvest Exploration" section of this report). However, trail mowing alone cost an average of about \$13/grouse bagged on the area in 1984 and 1985. Clearly the benefits of trail management must be weighed in light of multiple uses and hunter satisfaction rather than birds bagged.

Opening construction cost about \$300/acre in 1982 and 1986. Openings were developed primarily to benefit deer and probably negatively affected grouse because most openings were constructed within recently cut aspen stands.

Records of sales administration costs became blurred during the study. The smaller sales and spaced cuttings in the demonstration compartments were expected to add administrative costs to timber sales. However, the early part of the study period coincided with heightened sensitivity to public concerns about large clearcuts and aesthetics. Aesthetic strips and smaller cutting tracts became a common practice on the American Legion State Forest. Therefore, the costs of cutting scattered tracts were similar to administrative costs for smaller routine sales elsewhere on the forest. Advantages of the smaller sales included opening the bidding process to additional timber operators and more timely completion of sales.

Grouse Population Trends

The number of active drumming ruffed grouse counted on the SLA ranged from a low of 16 in 1975 to highs of 62 in both 1972 and 1986 and 78 in 1990 (Figure 5). The relative magnitude of the population peaks may be underestimated by our drummer census in that nondrumming males are believed to be more prevalent during population highs (Gullion 1981*b*). Results of the drummer census correlated very well with the regional drumming index for the first 13 years of the study (r = 0.96,

W. CREED

Logging trails were gated and managed for hunter walking trails. Greatest use and hunting success occurred when trails were seeded with clover and mowed. Harvest success diminished as clover disappeared and was lowest when trails were not mowed prior to the hunt.

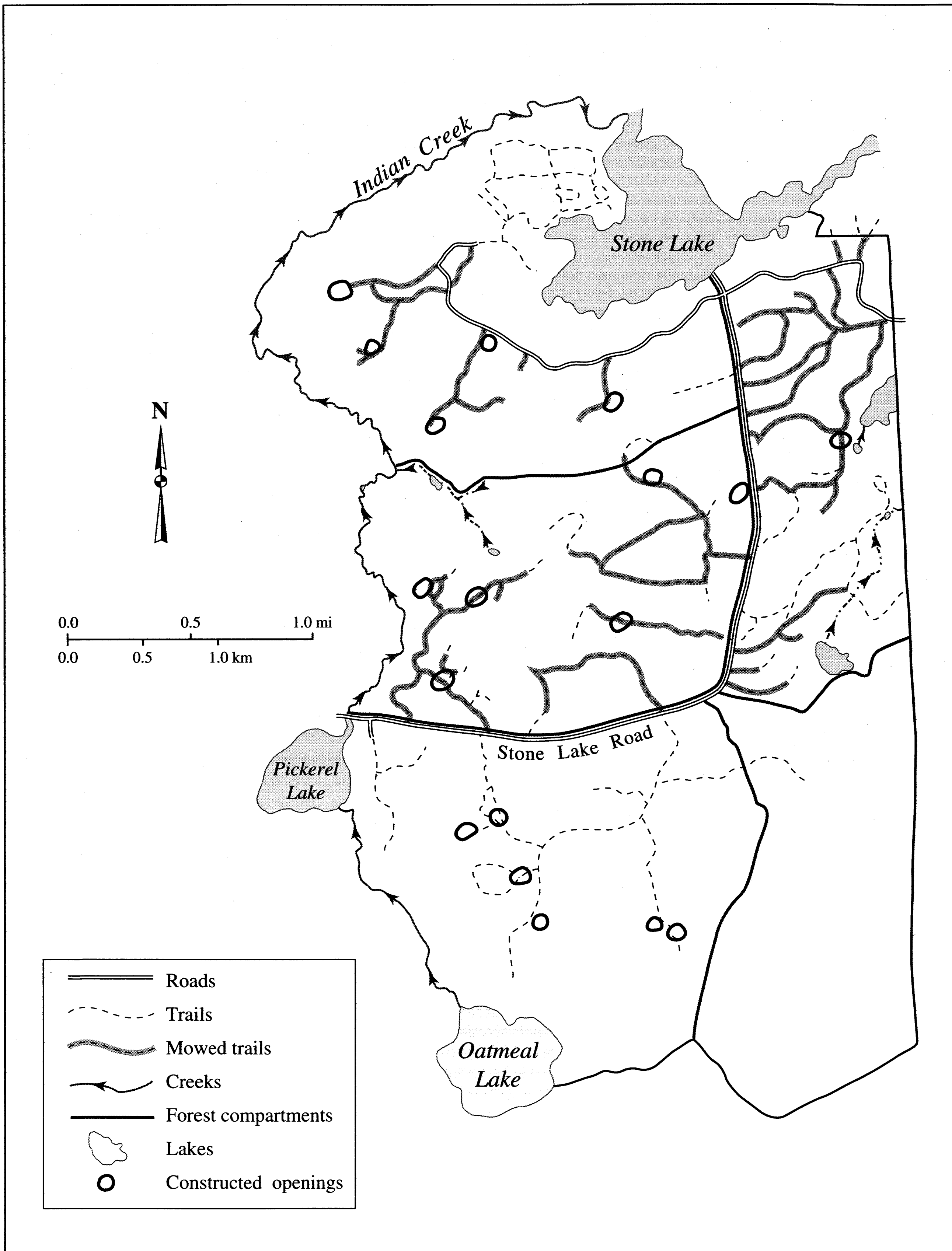


Figure 4. *Constructed openings and access on the Stone Lake Area as existed from 1979 to 1994.*

P = 0.001). Thereafter, the indexes appeared to diverge beginning in 1981. The increased availability of aspen saplings (5 to 24 years old) on the study area was believed to be the major reason for the disproportionate abundance of drummers on the SLA after 1981.

Beginning in 1987, grouse populations began a 2-year decline on the SLA despite a continued increase in the regional index. Reports of hunting success in the vicinity of the SLA tended to corroborate a locally depressed population. The SLA population recovered to a peak in 1990 and then joined in the regional "crash" following 1990.

Cyclic Influences

The 1972 peak in drumming ruffed grouse numbers on the SLA area (Figure 5) coincided with a cyclic high that was also reported in the early 1970s in Minnesota and central Wisconsin (Kubisiak et al. 1980). The precipitous decline in drummers on the area following 1972 was also matched by regional changes in grouse abundance (Rusch et al. 1978). This decline coincided with a 2-year invasion of goshawks as reported by Mueller et al. (1977) and Keith and Rusch (1989).

A second peak in the cycle may have occurred regionally during 1978 to 1981 as shown by drumming counts in Minnesota (Dexter 1991) and Wisconsin (Kubisiak and Dhuey 1991). Neither index suggests a well-defined peak here, but the decline following 1981 again coincided with a reported 3-year invasion of goshawks (Keith and Rusch 1989). A third peak in the regional cycle seems to have occurred from 1988 to 1990 in Wisconsin and Minnesota, with Wisconsin peaking somewhat earlier (Kubisiak and Dhuey 1991, Dexter 1991). The sharp decline of drummers on the SLA in 1987 and 1988 may have been the result of an apparent local abundance of owls noticed during the drummer census in spring 1988. It was the single biggest departure from trends shown by the regional index. We believe the 1990 peak in drummer numbers on the SLA exceeded previous peaks as a result of greater availability of prime grouse habitat on the area. The regional decline following 1990 again coincided with an invasion by boreal goshawks that began in 1989 and peaked during fall of 1992 as reported by Lauten and Balzer (1994).

Winter Impacts

The presence of loose snow for burrow roosting is believed to improve overwinter grouse survival (Gullion 1970). Snow cover should provide insulation for energy conservation and also protect against avian predators. The number of snow-roosting days per year on the SLA averaged 47 $\pm$ 26 (SD)/year (Table 5). Although we did not have data on survival of individual grouse, we found that availability of roosting snow, alone, did not correlate ($r = 0.06$, $n = 24$, $P = 0.78$) with subsequent numbers of drumming grouse (Figure 6). An attempt to correlate calculated postseason to preseason population changes ($Lambda_2$) with available snow-roost days produced a correlation coefficient of only 0.20 ($n = 24$, $P = 0.36$). Excluding years of population crashes did not improve these correlations. The presence of roosting snow also correlated weakly with trends in drumming grouse at the Sandhill Wildlife Area (Kubisiak et al. 1980).

Thompson and Fritzell (1988) indicated that conifers (redcedar) were used by grouse for roosting in the absence of snow in Missouri. Energy (heat) loss was almost twice as great in conifers as in snow roosts, but was nearly one-third as great as in deciduous cover. The high amount of conifers (especially balsam fir and swamp conifers) on the SLA may have compensated somewhat for poor snow-roosting conditions. We did not attempt to analyze the impact of subzero or subthermalneutral temperatures on grouse when roosting snow was absent.

Harvest Impacts

No attempt was made to obtain estimates of harvest by compartment because of the difficulty of obtaining such specific effort and success information from hunters, especially at a voluntary check station. However, hunter use of the SLA was known to be disproportionately heavy in Compartments 78 and 80 because of the abundance of access trails. Road and trail densities averaged 7.2/mile^2 of habitat in these compartments compared to 3.9 in the demonstration compartments (see Figure 4). The most remote and least-hunted compartment was


J. MOULTON

Snow roosting by ruffed grouse is believed to improve their survival. Soft snow deeper than 7 inches provides insulation from cold temperatures and concealment from avian predators. Here there is an entrance hole (upper) where the grouse dived into the snow and exit hole where it flushed.

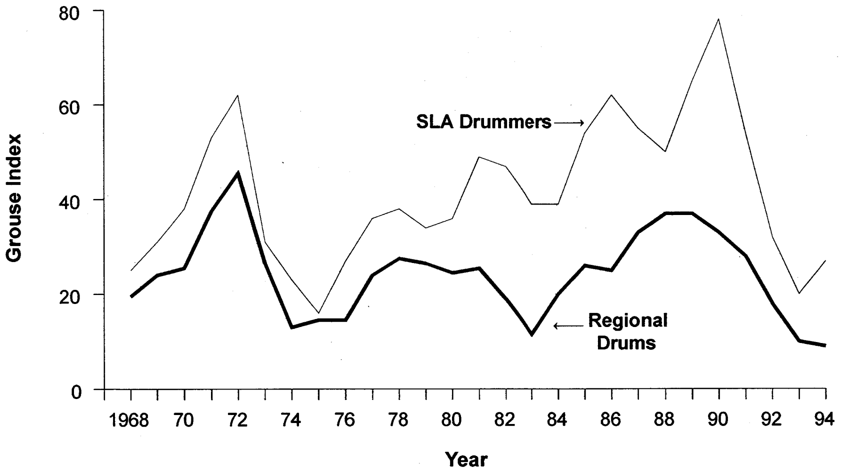


Figure 5. *Comparison of ruffed grouse population indexes from the Northern Forest (regional index in drums/transect) and the Stone Lake Area drummer census.*

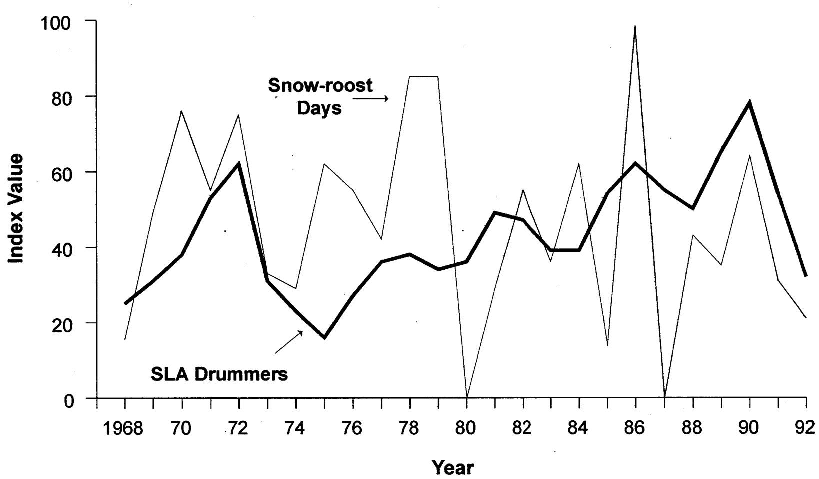


Figure 6. *Comparison of spring drummer census and snow-roosting days on the Stone Lake Area.*

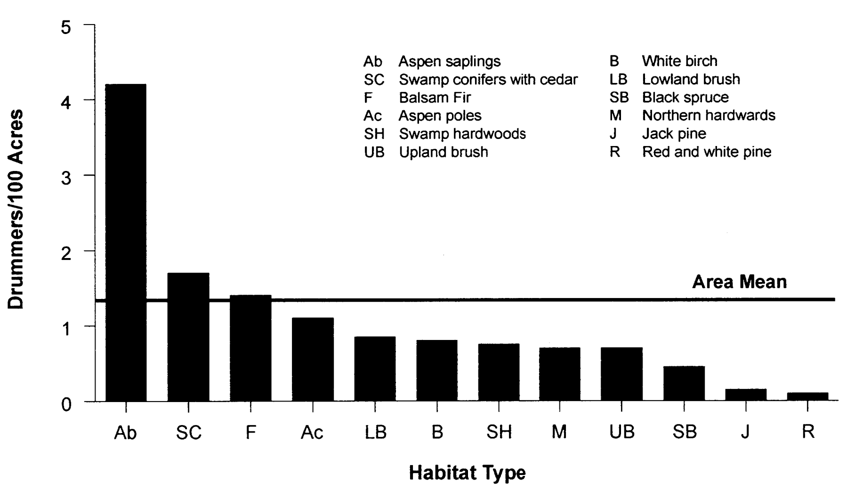


Figure 7. *Mean densities of drumming grouse by habitat on the Stone Lake Area (1976-87).*

Compartment 89, which had no trail access until 1979 and thereafter had only 0.4 mile of trail (0.7/mile^2 of habitat). Despite these differences in hunting effort and access, it is doubtful that harvest exploitation caused any major differential in subsequent drummer densities.

The trends in the grouse population on the SLA matched or exceeded regional trends, which suggests that hunting on the area did not have an overall depleting effect. Overall, average estimates of harvest exploitation of grouse by hunters peaked at 35% from 1972 to 1975 (see "Hunting Patterns and Harvest/Exploitation" section of this report). Even in the most vulnerable compartments, we suspect that replacement birds would move in from lightly hunted adjacent land. Therefore, we don't think that the population responses shown by the drummer census were affected significantly by differential hunting in the compartments.

Grouse Densities by Habitat Type

Drummer densities on the SLA averaged 1.3/100 acres of habitat from 1976 to 1987. Aspen sapling habitat (aged 5 to 24 years) was by far the most heavily used type (Figure 7). Of 11 other habitats rated, only swamp conifers and balsam fir attracted above-average drummer densities. All other habitats, including older aspen habitat, were below the overall study area average. Pine habitats had the lowest intensity of use by drumming grouse.

Generally, upland timber types of pole and larger size classes had poor representation of deciduous (tall shrubs and tree regeneration) understory. Balsam fir seedlings and saplings were an increasing component of many stands during the study period. In some maturing aspen stands, the growth of balsam within the stand appeared to sustain higher drumming grouse densities than were present in similarly aged stands without fir.

Swamp conifer habitats were composed mostly of white-cedar with small breaks occupied by alders. Conifers apparently provided the preferred height (20+ ft), while the alders provided the necessary stem density (Cade and Sousa 1985). This structure is similar to that found on upland-lowland edges where upland overstory trees provide height and lowland alders provide stem density.

Balsam fir was especially important at drumming stages where fir seedlings or saplings provided supplemental cover to deciduous stems. It was also, no doubt, valuable for winter roosting sites (Thompson and Fritzell 1988). The relative importance of balsam fir in this analysis is biased by situations where fir occurred on the upland-lowland edge in conjunction with alders. Alders apart from nearby taller trees were little used by drumming grouse, presumably because they are less than 15 ft tall (Cade and Sousa 1985).

Habitat types shown in Figure 7 are classed according to the dominant tree (cover) species in the stand. See Table 3 and Appendix C for a more detailed description of these habitat classes.

Aspen Age Classes and Drummer Use

Male ruffed grouse reoccupied young aspen sapling stands when regrowth was 5 to 10-years-old (Figure 8). The intensity of use in young aspen remained high through the 24th year. Relatively few stands were older than 25 and younger than 50 years on the SLA, so the decline in use after age 24 may be less precipitous than shown in Figure 8.

Table 5. *Number of days with 7 or more inches of roosting snow, December 1 through March 31 at Rhinelander.*

Year	Dec	Jan	Feb	Mar	Total
1967-68	0	16	0	0	16
1968-69	19	14	16	0	49
1969-70	24	31	21	0	76
1970-71	6	31	18	0	55
1971-72	4	31	29	11	75
1972-73	16	0	16	1	33
1973-74	11	17	1	0	29
1974-75	12	13	23	14	62
1975-76	0	30	9	14	53
1976-77	0	29	9	4	42
1977-78	16	31	28	10	85
1978-79	31	31	23	0	85
1979-80	0	0	0	0	0
1980-81	1	25	3	0	29
1981-82	4	31	20	0	55
1982-83	0	21	15	0	36
1983-84	21	31	10	0	62
1984-85	4	0	6	4	14
1985-86	31	31	28	8	98
1986-87	0	0	0	0	0
1987-88	13	30	0	0	43
1988-89	0	18	0	17	35
1989-90	18	27	13	6	64
1990-91	0	19	12	0	31
1991-92	0	0	13	8	21

White birch stands were lightly used as drumming habitat as were stands of northern hardwoods and pines.

K. McCAFFERY

Upland-lowland edges were preferred drumming sites when aspen sapling habitat was scarce. Dense alders in the lowland plus taller trees on the upland combined to provide favorable drumming habitat. Alders away from overstory trees were not used for drumming.

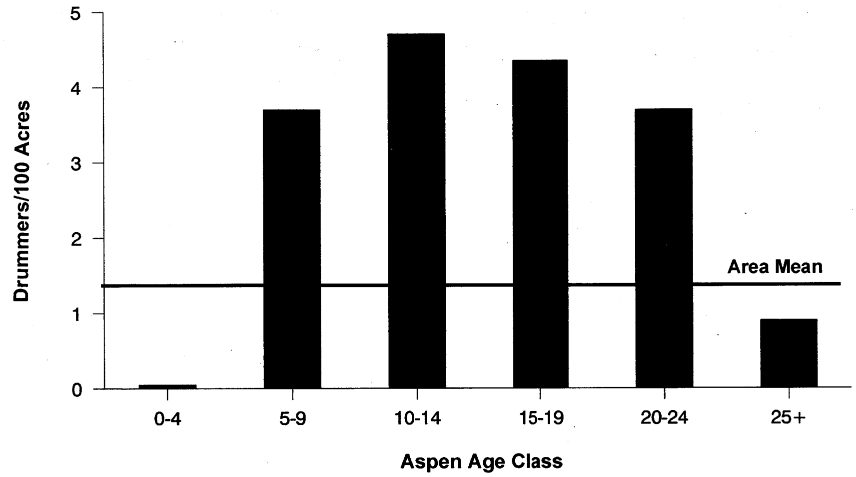


Figure 8. *Mean densities of drumming grouse by aspen age class on the Stone Lake Area (1976-87).*

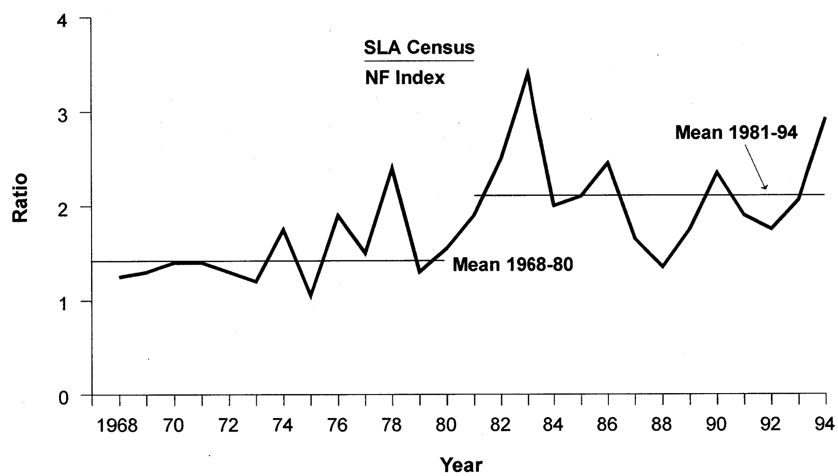


Figure 9. *Trend in ratio of Stone Lake Area drummer census and Northern Forest index, which suggests higher than expected grouse numbers on the Stone Lake Area beginning after 1980.*

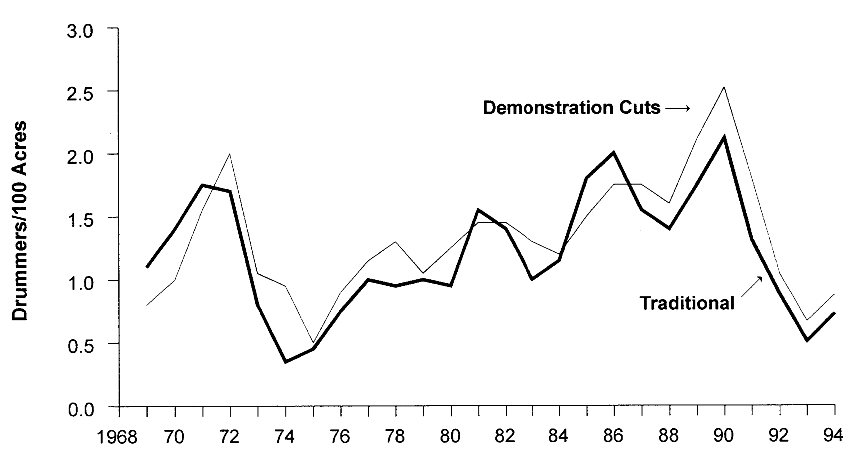


Figure 10. *Annual drummer densities on demonstration Compartments 79, 88, and 89 compared with traditional management in Compartments 78 and 80. Densities are based on potential grouse habitat including recently clear-cut aspen (0-4 years old).*

Kubisiak (1985*a*) reported that use by drumming grouse peaked during the 6- to 10-year age class of aspen in central Wisconsin with use tapering off as aspen stands matured. The presence of alder in some aspen understories resulted in higher drummer densities in these stands than observed at the SLA. However, in the absence of an alder understory, drummer densities were only slightly higher in aspen habitats in the central Wisconsin areas than on the SLA (Kubisiak 1985*a*).

Highest drummer densities on the SLA occurred in 8- to 24-year-old stands. Thereafter, stem densities apparently declined below the desirable threshold. The length of time an aspen stand is used by drumming grouse seems to vary with the site index and, perhaps, the habitat class (Kotar et al. 1988). Parker and Hardin (1990) reported that the mean for years of drumming by individual birds was longer for sites classed as PMV (Pinus/Maianthemum-Vaccinium) than for sites classed as TMC (Tsuga/Maianthemum-Coptis) or ATM (Acer-Tsuga/Maianthemum). PMV occurs on drier, less rich soils and typically has more hazel brush than TMC and ATM (Kotar et al. 1988). The presence of some balsam fir also seemed to prolong grouse use in some aspen stands. On the central Wisconsin study areas, use by drumming grouse was clearly prolonged in aspen pole stands that contained an alder understory (Kubisiak 1985*a*).

Grouse Population Responses to Cuttings

One of the main hypotheses of this study was that small clear-cuts (spaced temporally and geographically) in aspen would produce more grouse than larger timber sales. Interspersion of aspen age classes insures close proximity of year-round life requirements of grouse. Dense saplings are preferred drumming and brood habitat, and mature trees are a preferred winter food source and spring nesting habitat (Gullion 1977*a*). Gullion (1988*a*) indicated that drummer densities can be expected to decline rapidly as the size of aspen clear-cuts exceeds 2.5 acres.

Compartments 78 and 80 had been harvested in the traditional fashion during 1965 to 1971 when virtually all upland timber was set up under one sale and commercially clear-cut except for northern hardwoods (which were thinned), pine, and hemlock. However, less than half of these 2 compartments were cut heavily (cleanly) enough to promote good aspen regeneration. Some balsam fir understories were left because there was interest in preserving winter deer cover. Portions of these 2 compartments (especially Comp. 80) were mechanically cleared of residual stems in deciduous stands following timber harvest to insure good aspen regeneration. Little thought was given to the effect this activity might have on the study design. The main focus was on having relatively large ("traditional") cuts to compare to the demonstration cuts and to determine the efficacy of postsale aspen treatments. (The latter became a significant habitat maintenance activity across northern Wisconsin during the 1970s, in part as a result of demonstrations at the SLA.)

Compartments 79, 88, and 89 were scheduled for a "demonstration" patchwork of cuttings over a 12-year period. The actual cutting period was extended because of fluctuating markets. A limited amount of cutting took place in the latter compartments prior to the study, but these sales were relatively insignificant to the total area and on a compartment scale may have been significant only in Compartment 89.

Responses by Study Area

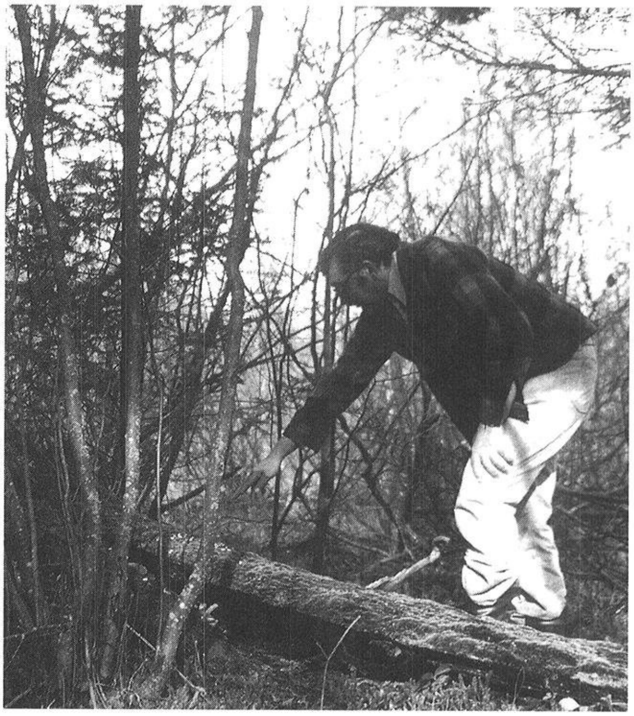
The divergence of the drummer census trend on the SLA from the regional roadside drumming index (Figure 5) suggests that timber harvest activities on the study area resulted in increased grouse population densities on the SLA. During the first 13 years of the study, the ratio between the drummer count on the study area and the roadside index averaged 1.4 (Figure 9). After 1981, the ratio averaged 2.1, suggesting that the greater availability of prime aspen habitat on the SLA in these latter 14 years resulted in disproportionately more ruffed grouse than the regional average.

Responses by Treatment

Treatment-wide grouse response to deliberate age-class interspersion of aspen was not clearly evident at Stone Lake during the early half of this aspen rotation. Overall grouse densities and trends in the traditionally cut compartments were similar to those on the demonstration compartments (Figure 10). Drummer densities for the entire study period averaged 1.31/100 acres of potential grouse habitat on the demonstration-cut compartments (Comp. 79, 88, and 89) and 1.20/100 acres on the traditionally cut compartments (Comp. 78 and 80) (Table 6).

Ruffed grouse densities were similar in both treatments during "cyclic high" populations in the early and late 1980s. During 1980 to 1982, drummer densities averaged 1.38 and 1.27/100 acres, respectively, on the demonstration-cut and traditionally cut compartments. These densities were not significantly different ($t = -0.66$, 3 df, $P = 0.56$) (Table 7). During the high populations of 1988 to 1990 when treatment effects should have been most noticeable to date, drummer densities on the demonstration compartments averaged 2.08/100 acres, which was not significantly different from an average of 1.75/100 acres found on the traditionally cut compartments ($t = -1.75$, 3 df, $P = 0.18$).

Expectations were that drummer densities would be lower during the early 1970s in the traditionally cut compartments because large areas of cutover aspen would be too young to be attractive to drummers. From the mid-1970s to mid-1980s, higher densities might have been expected in the traditionally cut compartments because of the greater availability of prime-age aspen saplings, even though not deliberately interspersed with mature aspen stands. After the mid-1980s, it was expected that the grouse densities in the demonstration compartments would begin to exceed those in the traditionally cut compartments. However, almost the opposite was found during the first 20 years of the study (Figure 10). The traditionally cut compartments outperformed the demonstration compartments from 1969 to 1971, but then underperformed in all but one year from 1972 through 1984. In 1987, the densities of drummers in the



A typical grouse drumming stage on an alder edge with boughs of taller balsam fir providing immediate cover for the stage.

Table 6. *Density of drumming grouse per 100 acres by treatment and compartment on the Stone Lake Area.*

	Traditionally Cut			Demonstration-Cut				SLA
	78	80	Mean	79	88	89	Mean	Overall Mean
Year	(589 acres)[a]	(781 acres)	(1,370 acres)	(838 acres)	(715 acres)	(384 acres)	(1,937 acres)	(3,307 acres)
1969	1.5 (9)[b]	0.8 (6)	1.1	0.8 (7)	0.7 (5)	1.0 (4)	0.8	0.9 (31)[c]
1970	2.0 (12)	0.9 (7)	1.4	1.3 (11)	0.4 (3)	1.3 (5)	1.0	1.1 (38)
1971	1.9 (11)	1.7 (7)	1.8	1.8 (15)	1.0 (7)	2.1 (8)	1.5	1.6 (54)
1972	1.5 (9)	1.8 (14)	1.7	1.8 (15)	2.1 (15)	2.3 (9)	2.0	1.9 (62)
1973	0.8 (5)	0.8 (6)	0.8	1.3 (11)	0.8 (6)	0.8 (3)	1.0	0.9 (31)
1974	0.7 (4)	0.1 (1)	0.4	0.7 (6)	0.8 (6)	1.6 (6)	0.9	0.7 (23)
1975	0.5 (3)	0.4 (3)	0.4	0.7 (6)	0.3 (2)	0.5 (2)	0.5	0.5 (16)
1976	1.0 (6)	0.5 (4)	0.7	0.8 (7)	0.4 (3)	1.8 (7)	0.9	0.8 (27)
1977	1.5 (9)	0.6 (5)	1.0	0.6 (5)	1.4 (10)	1.8 (7)	1.1	1.1 (36)
1978	1.5 (9)	0.5 (4)	0.9	0.5 (4)	1.5 (11)	1.8 (7)	1.1	1.1 (38)
1979	1.5 (9)	0.6 (5)	1.0	1.1 (9)	0.8 (6)	1.3 (5)	1.0	1.0 (34)
1980	0.8 (5)	0.9 (7)	0.9	1.1 (9)	1.3 (9)	1.6 (6)	1.2	1.1 (36)
1981	1.4 (8)	1.7 (13)	1.5	1.0 (8)	1.8 (13)	1.8 (7)	1.4	1.5 (49)
1982	1.4 (8)	1.4 (11)	1.4	1.0 (8)	1.7 (12)	2.1 (8)	1.4	1.4 (47)
1983	1.2 (7)	0.9 (7)	1.0	1.1 (9)	1.3 (9)	1.8 (7)	1.3	1.2 (39)
1984	1.0 (6)	1.3 (10)	1.2	1.2 (10)	1.7 (8)	1.3 (5)	1.2	1.2 (39)
1985	1.4 (8)	2.2 (17)	1.8	1.4 (12)	1.3 (9)	2.1 (8)	1.5	1.6 (54)
1986	1.7 (10)	2.3 (18)	2.0	1.9 (16)	1.7 (12)	1.6 (6)	1.8	1.9 (62)
1987	1.5 (9)	1.5 (12)	1.5	1.7 (14)	1.8 (13)	1.8 (7)	1.8	1.7 (55)
1988	1.4 (8)	1.4 (11)	1.4	1.4 (12)	1.8 (13)	1.6 (6)	1.6	1.5 (50)
1989	1.5 (9)	1.9 (15)	1.8	1.8 (15)	2.2 (16)	2.6 (10)	2.1	2.0 (65)
1990	2.0 (12)	2.2 (17)	2.1	2.3 (19)	2.9 (21)	2.3 (9)	2.5	2.4 (78)
1991	1.0 (6)	1.5 (12)	1.3	1.7 (14)	2.4 (17)	1.0 (4)	1.8	1.6 (53)
1992	0.5 (3)	1.2 (9)	0.9	1.2 (10)	0.8 (6)	1.0 (4)	1.0	1.0 (32)
1993	0.3 (2)	0.6 (5)	0.5	0.6 (5)	0.3 (2)	1.3 (5)	0.7	0.6 (20)
1994	0.7 (4)	0.8 (6)	0.7	0.8 (7)	0.8 (6)	1.0 (4)	0.9	0.8 (27)
Mean	1.23	1.17	1.20	1.22	1.31	1.58	1.31	1.27

[a] Acres of grouse habitat—excludes stagnant black spruce, marsh, and muskeg.
[b] Actual number of drumming grouse in parentheses.
[c] Total number of drumming grouse in the SLA.

demonstration compartments did indeed begin to slightly exceed that in the traditionally cut compartments.

One possible reason for the similarity in treatment-wide responses during the first half of this aspen rotation is that the traditionally cut areas were not totally without mature aspen trees for a source of winter food. Considerable noncommercial residual aspen remained in some cutover stands (especially in Comp. 78), and the largest contiguous block of "clean" clear-cut was only about 0.25 mile wide (in Comp. 80). The natural interspersion of upland and lowland soils cause a "patchiness" even in the traditionally cut compartments, and some aspen trees remained uncut in these lowlands and adjacent stands. Other possible explanations for the similarity of results from the 2 treatments become apparent when grouse trends are examined by individual compartment.

Responses by Compartment

Ideally, drumming grouse counts should have begun prior to any cutting in these compartments because the compartments have inherent differences other than timber-cutting patterns. Pretreatment measurements would have illustrated these differences and strengthened interpretations of subsequent grouse responses to the modified cutting schedules. Beyond these possible intrinsic differences, there were some obvious differences in how individual compartments were treated.

Closer evaluation seems to reveal that combining results for Compartments 78 and 80 as representative of "traditional" cutting obscured significant differences that may have management implications. One of these findings is the relatively high density of drummers found in aspen saplings in Compartment 80 (Table 8). Drummer densities in aspen saplings in Compartment 80 were not greatly different from those found in the demonstration compartments during peaks in the grouse population during the 1980s. Only when results from Compartments 78 and 80 are combined does there appear to be a significant difference between traditional and demonstration cutting. This difference is caused only by the low drummer densities found in what was classified as "good" (well-stocked) aspen saplings in Compartment 78.

Timber cutting in Compartment 78 was most nearly like "traditional" cutting in that most of the cutting was not followed by postsale treatments to remove excessive overstory as was the case for many deciduous stands in Compartment 80. "Traditional" in Compartment 78 meant not only a large sale area, but application of the 2-stick limit, which resulted in high residual in the compartment.

"Traditional" in Compartment 80 meant only large sale area in that most of the deciduous stands were subsequently mechanically cleared of residual standing trees in an attempt to enhance aspen regeneration (a "new" rather than a "traditional" practice). The cleaner cuts in Compartment 80 also permitted repeated aerial evaluation for poorly stocked aspen areas, which were subtracted from some of our analyses. Some poor sapling stocking that developed was likely obscured in Compartment 78 by overstory residual trees. This likely resulted in underestimating the drummer density in the well-stocked aspen saplings in Compartment 78.

Overall grouse responses in Compartments 78 and 80 appeared to complement each other in a compensatory way during the study period (Figure 11). The high amount of residual in Compartment 78 seemingly sustained higher drummer densities or caused grouse to occupy cut areas sooner than areas in compartment 80 that had been cut "cleaner"; when combined, these counts compensated for the high proportion of mechanically sheared areas in Compartment 80 that were unattractive to grouse for at least 4 years after shearing. Beginning in 1980, Compartment 80 appeared to outperform Compartment 78. Likely this was due to the increased availability of prime-aged aspen in Compartment 80. Aspen stem density in Compartment 78 may have already begun to decline, hastened by excessive overstory residual and sandy soils.

In Compartment 80 most deciduous residual trees were mechanically removed from clear-cut areas in the eastern portion. However, the largest contiguous block of "clean" clear-cut was only about 0.25 mile wide in the southeast portion of Compartment 80 (see Figure 3). This clear-cut area also included considerable land that was characterized by poor internal drainage; good aspen regeneration occurred only on the better drained soils. Here, the maximum drummer density recorded was about 7 to 8 drummers/100 acres of well-stocked aspen saplings (137 acres) in 1985 and 1986 or 4.5 drummers/100 acres of

Table 7. *Drummer densities by compartment and treatment during two periods[a] of high grouse population on the Stone Lake Area.*

Compartment and Treatment	Potential Range (acres)	Total Drummers 1980-82	Total Drummers 1988-90	Drummers/100 Acres/Year 1980-82	Drummers/100 Acres/Year 1988-90
Traditional					
78	589	21	29	1.19	1.64
80	781	31	43	1.32	1.84
Total	1,370	52	72	1.27 (avg)	1.75 (avg)
Demonstration					
79	838	25	46	0.99	1.82
88	715	34	50	1.59	2.33
89	384	21	25	1.82	2.16
Total	1,937	80	121	1.38 (avg)	2.08 (avg)

[a] These periods were chosen because they seemed to coincide with regional high populations and gave some temporal spread between periods shown. An "intercyclic" high population on the SLA in 1985 and 1986 exceeded densities found in 1980-82.

Table 8. *Drummer densities in prime-aged aspen by compartment and treatment during two periods[a] of high grouse populations on the Stone Lake Area.*

Compartment and Treatment	Aspen Sapling Acreage 1980-82	Aspen Sapling Acreage 1988-90	Total Drummers 1980-82	Total Drummers 1988-90	Drummers/100 Acres/Year 1980-82	Drummers/100 Acres/Year 1988-90
Traditional						
78	174 (12)[b]	174 (22)	19	15	3.64	2.87
80	193 (10)	193 (21)	27	36	4.66	6.22
Total	367 (11)	367 (21)	46	51	4.18 (avg)	4.63 (avg)
Demonstration						
79	62 (9)	167 (10)	10	39	5.38	7.78
88	52 (7)	119 (11)	15	31	9.62	8.66
89	29 (21)	32 (10)	6	9	6.90	9.38
Total	143 (11)	318 (10)	31	79	7.23 (avg)	8.28 (avg)

[a] These periods were chosen because they seemed to coincide with regional high populations and gave some temporal spread between periods shown. An "intercyclic" high population on the SLA in 1985 and 1986 exceeded densities found in 1980-82.

[b] Average age of aspen sapling stands in parentheses.

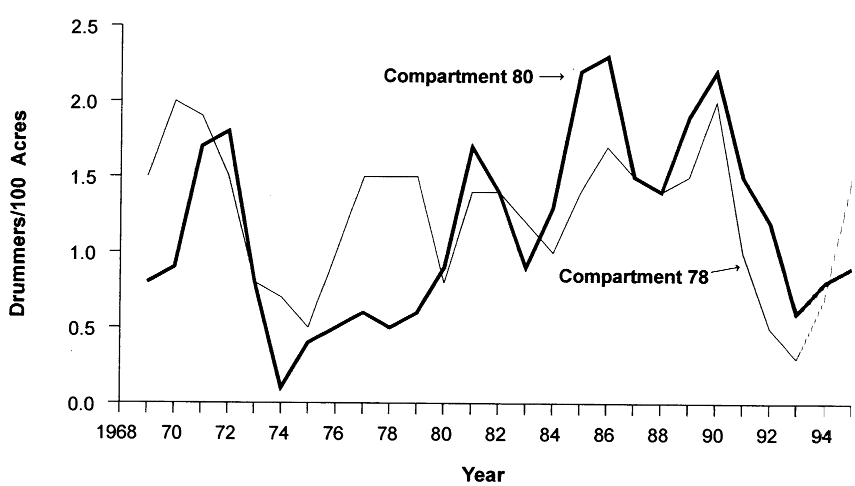


Figure 11. *Annual drummer densities in the 2 "traditionally cut" compartments. Densities are based on potential grouse habitat including recently clear-cut tracts.*

total clear-cut (243 acres). Despite the size of this cutover area, these densities compare favorably with the patch-cut results in the demonstration compartments (Table 8).

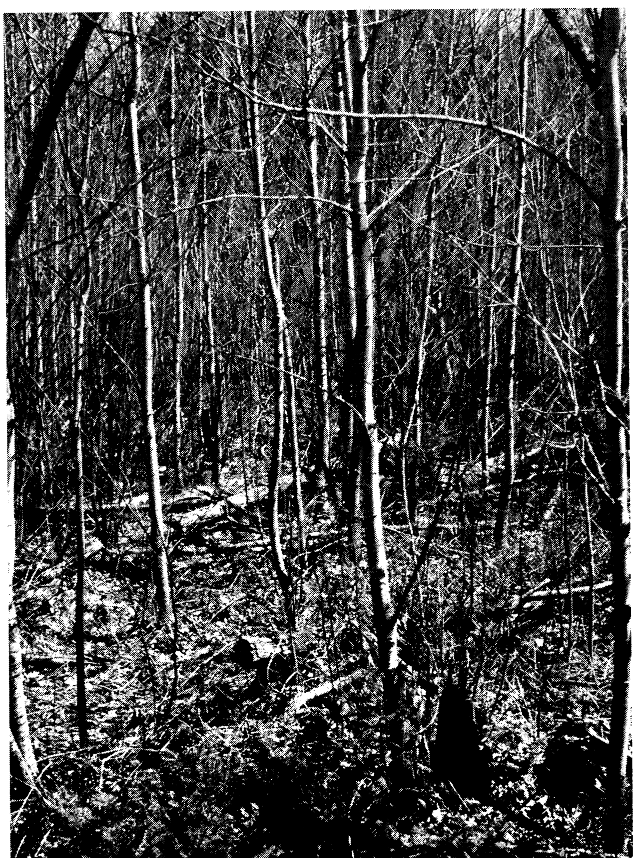
A missing piece of vital information is the effect of the postsale residual on subsequent aspen stocking trends in Compartment 78. Aspen stem densities here were likely depressed initially compared to stem densities in other cuts and may have lost stem density earlier. If so, "cleaner" cuts in Compartment 78 may have produced higher aspen stem densities and higher grouse populations for 5 to 24 years following harvest than we documented. However, grouse use may also have been lower than what we found immediately following cutting if there had not been the taller cover provided by the residual trees. In the future, "poor" cutting practices during the 1960s in Compartment 78 may favor grouse as residual trees from the earlier cut become merchantable and cutting activity is reinstated long before what would have been possible if stands had been cut "cleaner."

Drummer density trends for Compartments 79, 88, and 89 showed relatively minor differences (Figure 12). Compartment 79 seemed to lag in performance compared to the other 2 compartments, especially during the early 1980s. The generally lower performance is likely because 184 acres of the 838 acres of potential grouse habitat occurred on private land where active cutting did not take place between 1940 and 1993. This private land also contained significant acreage of mature (> 15 inches dbh) red and white pine, which contributed to the documentation of extremely low use in this habitat type by drumming ruffed grouse.

Compartment 88 trends encompassed both the highest and lowest densities of grouse found by compartment during the study period. The low in 1993, along with other recent lows in all other compartments, suggests that grouse populations will crash to very low densities despite the increased availability of prime aspen sapling habitat.

Compartment 89 trends appeared to outperform most other compartments in most years. Two cuts conducted in 1958 and 1965 appear to have contributed significantly to the number of drummers recorded on this area during the early portion of the study. More recent cutting activity beginning in 1978 should preserve the productivity of this compartment in future decades. This was the most remote and least hunted of the 5 compartments, yet trends in drummer density tended to follow that of other more heavily hunted compartments.

K. McCAFFERY



Young aspen stands 8 to 20 years old were the most highly preferred drumming habitats in the Stone Lake Area. High stem density and suitable overstory height appear to be necessary prerequisites.

Grouse Preference for Aspen Saplings

Gullion (1983) indicated that grouse would favor aspen sapling habitat over alder and lowland edges when given a choice. This appeared to be the case on the SLA where there was a strong orientation of drummers to prime age (5-24 year) aspen habitats following cutting. During the earlier years of this study, drumming grouse were oriented to balsam fir, swamp conifers, and alder (Figure 13). As aspen sapling habitat became available, there was a profound shift of drummers into the aspen habitat. The amount of prime aspen sapling habitat increased gradually from less than 7% of the total habitat during 1969 to 1972, to 14% by 1980, and to 21% by 1989. The acreage of alder and swamp conifer was relatively unaffected by cutting, and the amount of balsam fir increased during the study period. The quality of alder habitat, however, deteriorated somewhat as stem density declined with age during the 27 years of observation. Area-wide, 130 (67%) of 193 drummer observations were in well-stocked aspen saplings during the recent high population (1988-90) when prime-aged aspen habitat comprised only 21% (685 of 3,307 acres) of the potential grouse range on the SLA.

Drummer distribution in Compartment 79 serves as a specific illustration. During the peak 3 years of grouse population in the early 1970s prior to planned aspen cutting, the majority of drumming centers were oriented to lowlands, lowland edges, and balsam fir. Of 19 activity centers in Compartment 79, only 2 occurred within areas presently dominated by prime-aged aspen habitat. Seven were on alder edges, 3 were in swamp conifer, and most were influenced by the presence of sapling balsam fir. Of 24 activity centers located during 1988 to 1990, 18 were found in aspen saplings aged mainly 8 to 15-years-old. Two additional drummers alternated between saplings and uncut areas. Drummer densities in the aspen saplings of this compartment averaged 7.8/100 acres during 1988 to 1990.

Implications

The demonstration-cut areas were deliberately planned to retain mature aspen stands adjacent to newly cutover stands to insure mature aspen trees as a source of flower buds for winter food. The responses to this food and cover plan were not yet apparent in the treatment-wide comparisons. The treatment-wide effect of planned interspersed cutting on the SLA may become evident as the stands in the traditionally cut compartments mature. Few new sapling habitats will develop there during the remainder of the aspen rotation, particularly in Compartment 80, and grouse densities will likely decline.

In the demonstration compartments, continued cutting of small tracts insures continuous availability of aspen sapling habitat throughout the aspen rotation. These compartments will likely sustain higher densities of grouse during the remainder of this aspen rotation. The deliberate interspersion of young and old stands in the demonstration compartments tended to produce somewhat higher densities of grouse per unit area treated than the larger cuts, even in the short term. However, the most expansive clear-cut on the area (243 acres) resulted in drummer densities that were not much lower than the smaller patch cuttings. In view of the mix of upland and lowland types on the SLA, it appears that insuring good aspen regeneration was paramount to deliberate interspersing of aspen age classes in the short term (the first 25 years of this aspen rotation). However, interspersed smaller cuts will help insure a continuous supply of young aspen throughout longer periods of time and should result in higher average grouse densities in the long term (50+ years).

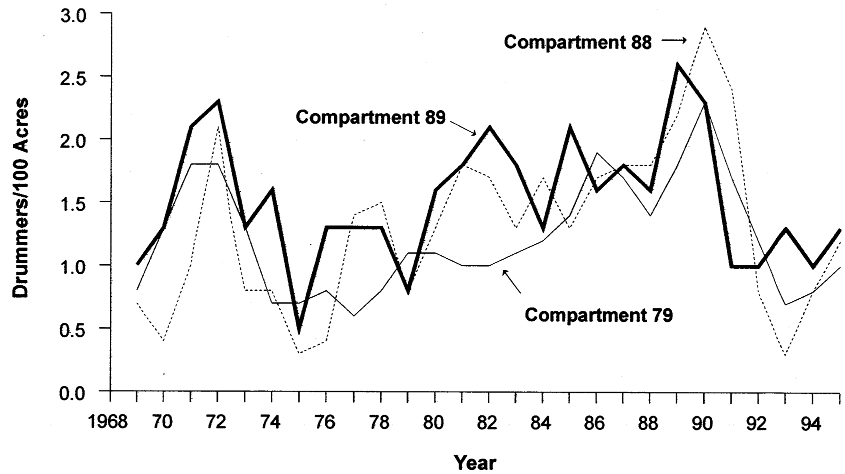


Figure 12. *Annual drummer densities in the 3 "demonstration-cut" compartments. Densities are based on potential grouse habitat including recently clear-cut tracts.*

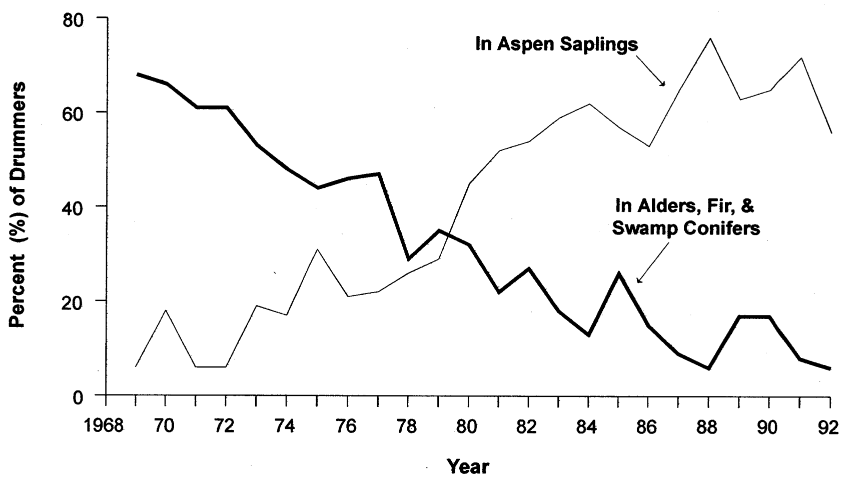


Figure 13. *Change in proportion of drummers located in prime aspen habitat compared to drummers found in alder, balsam fir, or swamp conifers at the Stone Lake Area. Aspen sapling habitat availability increased from 7% of the SLA in 1969-72 to 21% by 1989.*

Drummer Site Selection

The literature is replete with descriptions of drumming stages, logs, and centers (Palmer 1963, Boag and Sumanik 1969, Stoll et al. 1979, Hale et al. 1982, Thompson et al. 1987). It was not the intent of this study to replicate them. The purpose of this section is to further characterize the study area and to show similarities to other descriptions of drumming sites.

Cover Density at Logs

Early in the study when aspen sapling habitat was rare, site characteristics at drumming logs were compared with measurements at random points throughout the SLA. Only 3 of the 8 attributes recorded at each site were markedly different between occupied sites and random locations (Table 9): Drumming sites tended to have more balsam fir in the overstory than random sites; the nearest conifer was much closer to drumming sites than random points; and mature aspen trees were more often near drumming sites than at random points. It was during this time that balsam fir and alder habitats were the most intensively used drumming habitats on the SLA (Kubisiak et al. 1980).

Thompson and Fritzell (1989) suggested that habitats that are deficient in hardwood understory will be enhanced by the presence of conifer cover (redcedar in Missouri). Moulton (1974), studying large areas of 10 to 15-year-old aspen, found a positive correlation between drummer density and the abundance of mature (≥ 5 inches dbh) male aspen trees in large clear-cuts (Figure 14).

In 1984, we measured stem densities at 51 recently active drumming logs in aspen saplings. Woody stem densities (> 6 ft tall) averaged 8,200 stems/acre with stems taller than 15 ft comprising 2,600 of this average. Equivalent Stem Densities (ESD), as defined by Cade and Sousa (1985), averaged 5,580 ± 570 (2 SE) stems/acre. ESD values at individual sites ranged from 1,900 to 10,200, but only 3 drumming sites had ESD values lower than 3,000. All 3 of the latter sites were influenced by the presence of fir seedlings in the understory that were too short (< 6 ft tall) to be included in the ESD measurements. These ESD measurements seem to corroborate the contention that there is a threshold stem density below which drumming grouse will normally not be found in the habitat (Cade and Sousa 1985).

Movement of Drummers to Alternate Logs

Grouse were not banded during the study, so it was not possible to determine with certainty that birds seen in different places were necessarily the same individual. However, there were occasions when it appeared that the same drummer used drumming sites that were widely spaced. As an example, one bird (activity center #7947) drummed from a rock pile as a primary stage and was subsequently heard drumming successively on 2 logs, 5+ chains to the west. The latter logs became primary drumming stages for 2 and 3 years, respectively. This same bird appeared to use these 3 widely spaced sites as alternate stages during this period. A second bird (activity center #7955) drummed one year from a stage on a large boulder, but also drummed on a birch log 4 chains away and on elevated points between. The birch log became the primary stage for the next 5 years.

In 2 other cases, drumming sites were disturbed by logging or windthrow, and drumming resumed nearby. Logging activity displaced one bird (activity center #8830) from a pine/hazel ridge to the edge of a spruce swamp. The move was about 4 chains. Another bird (activity center #8828) was drumming on the root of a lone spruce in a narrow alder draw. The spruce blew down, and the bird seemed to relocate about 6 chains away in dense hazel under mature aspen. A third bird (activity centers #7969-7970) was displaced from a site in sapling aspen when a grassy opening was constructed. The latter bird appeared to set up again in similar habitat about 4 chains away.

Choice of Drumming Stage

Over three-quarters of the drumming stages were logs or downed tree boles; most were in varying states of decay, but some were newly fallen trees (Table 10). Another 13% were large rocks or boulders, some of which provided stages more than 6 ft above local datum. Other stages were roots of standing trees or stumps, earth mounds, tipped-up root masses, and other elevated locations. At no time did it appear that the availability of suitable drumming stages limited the location and number of displaying drummers.

Work done on blue grouse in Alberta indicates that breeding territories are chosen based on habitat quality and prior use (Lewis 1988). Perhaps ruffed grouse operate similarly when choosing drumming sites.

Maximum Drummer Densities

The highest density of drumming grouse encountered during the study occurred when 5 drummers occupied a single 21-acre 12-year-old aspen sapling stand (Stand 207, Comp. 88, 1989). The second highest density occurred in a 13-year-old aspen stand where 7 drummers were located on 52 acres (Stand 179, Comp. 79, 1989). Area-wide the mean density in young aspen (5-24 years) from 1988 to 1990 was 6.3 drummers/100 acres, but in the demonstration compartments mean density averaged 8.3 (see Table 8). This compares with a maximum of 8 to 15.3 drummers/100 acres in young

Table 10. *Objects chosen by grouse for drumming stages on the Stone Lake Area.*

Stage	Percent	Number
Logs	77	310
Boulders	13	52
Rooted roots	4	15
Earth mounds	2	9
Tip-up roots	2	9
Stumps	1	4
Pulp piles	<1	2
Total	100	401

Table 9. *Comparison of selected site characteristics between primary logs and random locations in 1972 on the Stone Lake Area.*

Site	Basal Area (ft²)	Percent Balsam, Fir and Spruce: Overstory	Percent Balsam, Fir and Spruce: Understory	Mature Aspen Tree (percent)[a]	Distance to Nearest- Clover Trail (chains)	Distance to Nearest- Logging Road (chains)	Distance to Nearest- Forest Type Edge (chains)	Distance to Nearest- Conifer (ft)
Primary log	69 (110)[b]	47 (117)	53 (117)	91 (109)	36 (119)	15 (119)	2 (119)	9 (116)
Random location	63 (139)	19 (139)	44 (139)	66 (139)	29 (140)	13 (140)	2 (140)	18 (139)

[a] Percent of the locations where a mature aspen tree is within two chains.
[b] Numbers in parentheses are numbers of site measurements.

aspen (5-15 years) reported by Gullion (1990*b*). Gullion (1990*a*) also reported that a stand on the Cloquet Forest had 16.3 drummers/100 acres in 1989 and believed that this density probably approached breeding saturation.

It was not uncommon to find active drumming males within 4 chains of each other on the SLA. These situations most commonly occurred in sapling aspen habitat and only in years with very high grouse populations. Gullion (1990*a*) reported active drummers within 3 chains of each other at Cloquet.

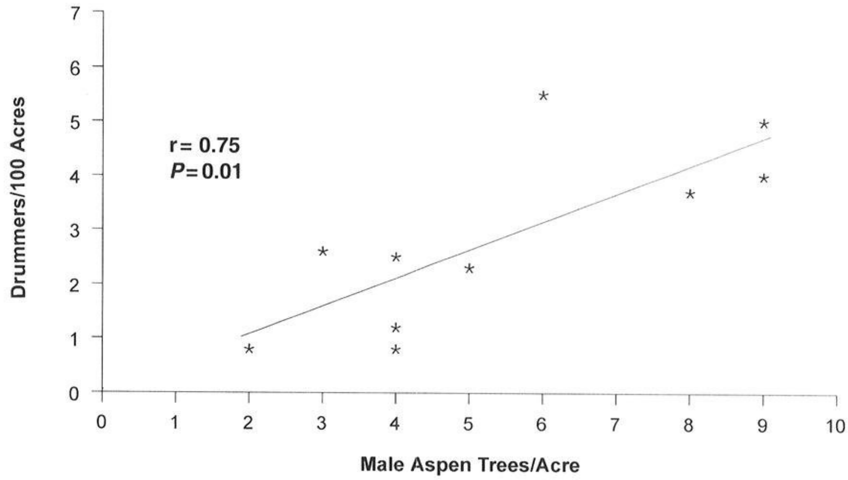


Figure 14. *Correlation between the number of mature male aspen trees per acre of sapling aspen and the density of drummers in extensive sapling stands of western Oneida County (from Moulton 1974).*

Hunting Patterns and Harvest Exploitation

Harvests and Grouse Populations

Estimates of harvest from the voluntary check station correlated positively with the spring drummer census (Figure 15). Traffic volumes that were recorded by a pneumatic counter indicated that hunting effort may have varied considerably from year to year. Adjusting the harvest by traffic volume did not improve the correlation (r = 0.49, n = 25, P = 0.02). Traffic volume was influenced in some years by a number of factors unrelated to grouse hunting (archery deer hunting, logging, road construction). Kubisiak (1984) also found that voluntary harvest reports correlated quite well (r = 0.83, n = 9, P < 0.01) with spring drummer census at the Sandhill Wildlife Area.

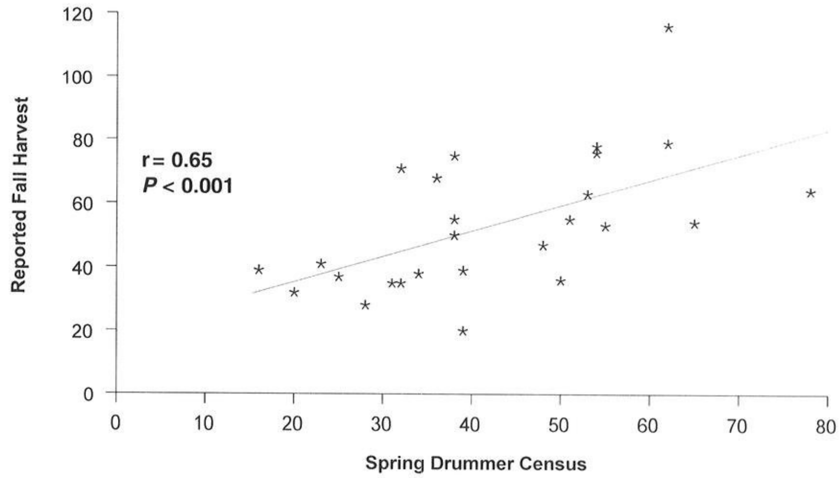


Figure 15. *Correlation between spring drummer census and reported harvest in the fall at the Stone Lake Area.*

Hunting Methods

Exit interviews during the first 10 years of the study indicated what proportion of hunters "hunted" from a moving vehicle. Hunting (not shooting) grouse from a moving vehicle was legal. To shoot, hunters had to step out of the vehicle, uncase and load the gun. The proportion of road-hunters was high (43-45%) during the first 2 years, then ranged from 5 to 20% during 1969 to 1976 (Table 11). This decline in road-hunting was believed to be the result

A light mixture of balsam fir seemed to complement drumming habitat and prolong its use as the trees matured. Dense balsam fir was not preferred for drumming habitat.

Table 11. *Trends in hunting methods on the Stone Lake Area.*

Year	No. Hunters[a]	Hunting Method (percent) Road Hunter[b]	Hunting with Dogs[c]	Hunting without Dogs[d]
1967	93	43	14	43
1968	124	45	11	44
1969	187	16	22	62
1970	255	21	18	61
1971	240	13	23	64
1972	286	15	23	62
1973	307	5	26	69
1974	172	15	27	58
1975	164	20	28	52
1976	147	20	15	65
1982	250	10	42	48

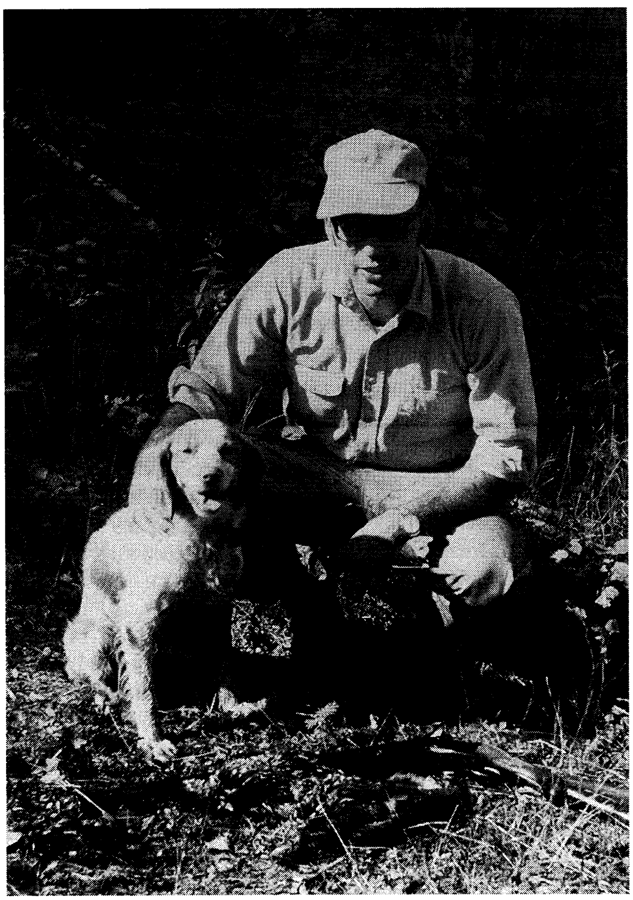
[a] Number of hunters contacted at entry. Exit interviews were conducted with as many hunters as possible.

[b] Percent of hunters that traversed the main roads without leaving their vehicle.

[c] Percent of hunters entering study area with a bird dog.

[d] Percent of hunters that hunted from walking trails or brush without dog.

J. ASHBRENNER



Hunters with and without dogs flushed similar numbers of grouse but hunters with dogs bagged a much higher proportion of their flushes. (Project leader John Moulton and Buffy.)

of increased availability of walking trails on the area. The trails seemed to provide an incentive for hunters to go into the woods, especially when trails were seeded with clover and mowed.

The popularity of hunting with dogs seemingly increased during the study. During 1982, interviews were conducted with 126 hunting parties that included 252 hunters (Table 12). Dogs were used by 42% (107) while only 10% (24) were road-hunters. The "flush rate" (grouse seen per hunter/hour) for road-hunting cars averaged only 0.14 grouse/hour. Flushing rates for hunters with and without dogs were similar, averaging slightly more than 0.5/hour. At Sandhill, the use of dogs increased from 38% of the hunters during 1971 to 1979 to 58% during 1980 to 1982 (Kubisiak 1984), but then averaged 48% during 1983 to 1992 (Kubisiak unpubl.).

Hunting parties with dogs tended to bag a higher proportion of their flushes on the SLA. Fifty-six hunting parties with dogs (32 individuals, 20 pairs, 4 trios) flushed 58 birds (0.50/hour) and bagged 14 grouse (0.12/hour) during 115.4 hours of "party" hunting. Fifty-six hunting parties without dogs (28 individuals, 20 pairs, 8 trios) flushed 65 birds (0.57/hour) but bagged only 3 birds (0.03/hour) during 114.5 hours of "party" hunting time. The unusually low bagging rate for hunters without dogs may have been caused in part by grouse flushing from trails well ahead of hunters. Dogs may have led hunters from trails to grouse in cover that "held" for better shooting opportunities. Dogs would also have likely increased recovery of downed birds. These bagging rates were similar to those found at Sandhill where hunters with dogs bagged 0.14 grouse/hour compared to 0.06/hour without dogs (Kubisiak 1984).

Bag Limits

The average number of birds bagged by hunters was most accurately determined during exit interviews. The reported bag per hunter-trip on the SLA during 1982 was 0.09. Hunters with dogs averaged 0.16 grouse/hunter-trip. In no year during exit interviews from 1967 to 1976 did the average bag exceed 0.19/hunter. At Mille Lacs, the highest number of birds bagged per hunter during 1979 to 1982 was 0.32 birds/hunter (Gullion 1983). A questionnaire survey of Wisconsin hunters during the winter of 1981-82 revealed that the reported average daily bag was 0.7 birds or fewer (Rusch et al. 1984). There may be considerable prestige or memory bias present in the latter figure. Kubisiak (1984) found that only 21% of the hunts resulted in one or more grouse being bagged at Sandhill. Only 31 (11%) of 284 hunters checked during 1972 were successful on the SLA, and in 1982, only 17 (7%) of 235 hunters were successful. In both of these years there were above-average grouse populations on the SLA.

It would seem that reducing bag limits (e.g., from 5 to 3) would have a very limited effect on the overall exploitation of the grouse population on these areas. On the SLA, only 1 of 519 hunters had bagged more than 2 grouse during the checks in 1972 and 1982. A reduced bag might have a counter-intuitive effect of increasing exploitation if hunters with 1 or 2 birds exerted additional effort in the hope of being able to boast of getting a limit of 3.

Effort Lagtime

During the period of intensive bag checks (1968-76), the number of birds bagged each year tended to match the trends in spring drummer census (Figure 16). Hunter numbers also tended to rise with an increasing grouse population. However, there appeared to be a one-year lag in hunter response to a declining grouse population following 1972. Seemingly, it took one fall of hunters experiencing lower success before hunter interest in grouse declined. The drop in hunter numbers following the grouse population decline tends to support the argument that hunters are somewhat self-regulating in the face of declining grouse abundance.

This lag time was not especially apparent on the SLA during the 1980s based on traffic counter data (Table 13). However, there was not a clear peak and crash in grouse numbers on the SLA during this decade, and any response could have been masked by the variability of traffic counter data. In the early 1990s, there again may have been evidence of a delayed hunter response to declining grouse numbers on the SLA, because there was an increased volume of traffic recorded in 1991, one year after the peak grouse population. This one-year lag time in hunter response was also apparent in Minnesota data for grouse population crashes following 1980 and 1989 (Berg 1995).

Seasonal Pressure

The greatest intensity of hunting effort and harvest occurred during the first week of the 7-week early season (late-September to mid-November) (Figure 17). Almost 75% of the effort occurred by the end of the third week. This can be attributed, in large part, to the "opening day" effect. However,

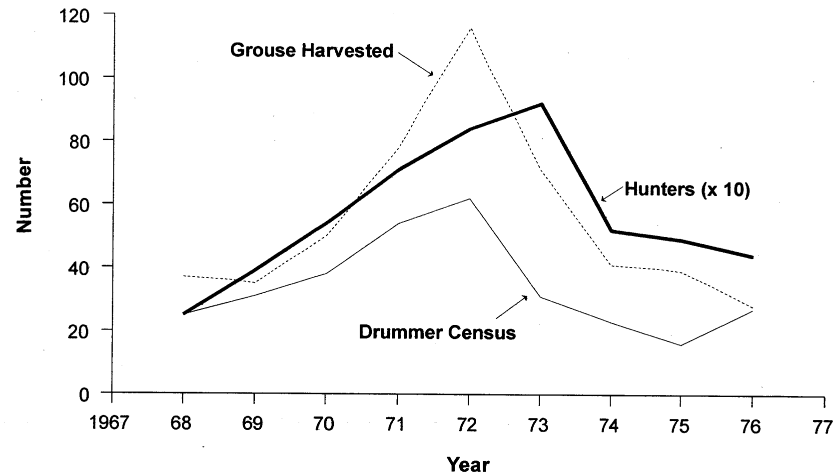


Figure 16. *Relationship between grouse harvest, drummer census, and number of hunters on the Stone Lake Area during a period of grouse population change.*

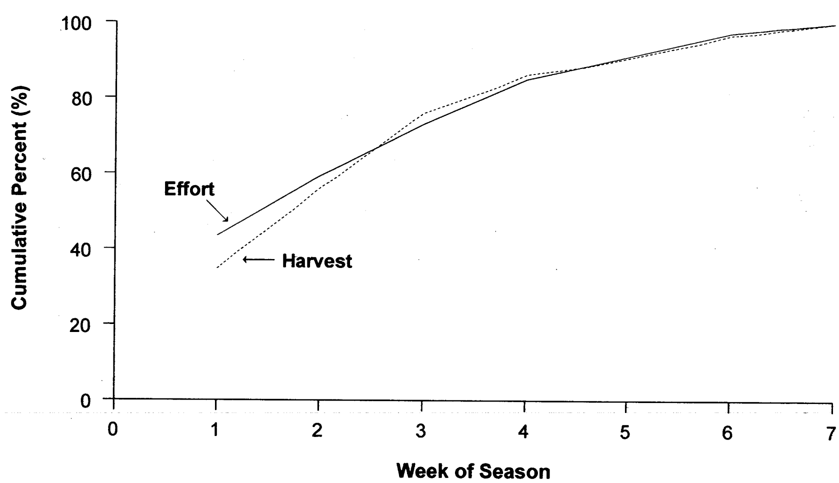


Figure 17. *Cumulative percent of the grouse harvest and hunting effort during the 7-week early hunting season at the Stone Lake Area (1971-76, 1982).*

Table 12. *Relative success of hunters by hunting method in 1982 on the Stone Lake Area.*

Method of Hunt	No. of Parties	Cumulative Hours Hunted	Flushes/Hour[a]	Birds Bagged
Road hunting	14	7.4	0.14	0
Without dogs:				
Single hunters	28	47.4	0.55	0
Pairs	20	49.0	0.61	2
Trios	8	18.0	0.50	1
With dog:				
Single hunters	32	60.0	0.52	4
Pairs	20	45.0	0.51	9
Trios	4	10.7	0.37	1

[a] Grouse seen and/or flushed per party-hour.

Table 13. *Grouse population data, hunter harvest, and measures of hunting effort on the Stone Lake Area.*

Year	Drummer Census	Fall Grouse Population[a]	Reported Harvest	Percent Exploitation	Traffic Counter Tally	Hunter Numbers[b]	Hours/ Hunter	Hours Hunted[c]	Huntable Area (mile²)[d]
1967	–	–	44	–	635	229	2.0	448	–
1968	25	150	37	25	766	252	1.8	463	4.6
1969	31	186	35	19	655	391	1.5	571	4.6
1970	38	228	50	22	1,052	537	1.4	759	4.5
1971	54	324	78	24	868	707	1.5	1,083	4.5
1972	62	372	116	31	878	844	1.8	1,496	4.6
1973	31	186	71	38	1,197	921	1.8	1,625	4.7
1974	23	138	41	30	889	516	(1.7)[e]	(877)[e]	4.7
1975	16	96	39	41	655	487	(1.7)	(828)	4.9
1976	27	162	28	17	710	444	(1.7)	(755)	4.9
1977	36	216	68	31	1,131	–	–	–	–
1978	38	228	55	24	810	–	–	–	–
1979	34	204	38	19	838	–	–	–	–
1980	36	216	75	35	1,294	–	–	–	–
1981	49	294	55	19	1,478	–	–	–	–
1982	47	282	47	17	725	560	2.0	1,120	4.9
1983	39	234	20	9	659	–	–	–	–
1984	39	234	39	17	860	–	–	–	–
1985	54	324	76	23	998	–	–	–	–
1986	62	372	83	22	1,378	–	–	–	–
1987	55	330	53	16	968	–	–	–	–
1988	50	300	36	12	995	–	–	–	–
1989	65	390	54	14	1,064	–	–	–	–
1990	78	468	64	14	1,052	–	–	–	–
1991	53	318	63	20	1,347	–	–	–	–
1992	32	192	35	18	839	–	–	–	–
1993	20	120	32	27	846	–	–	–	–

[a] Populations projected by simply multiplying drummer census by 6 similar to Gullion (1981*a*) and Kubisiak (1984).
[b] Hunter visits projected by Moulton (1977) and from McCaffery and Ashbrenner (1983).
[c] Hours for: (1) 1967-71 are from Moulton (1972), (2) 1972-73 are based on hours/kill reported by Moulton (1974), (3) 1974-76 are projected assuming an average hunt of 1.7 hours, and (4) 1982 is projected from intensive October bag check.
[d] Area of grouse range (5.17 mile²) minus clear-cut stands less than 5 years old.
[e] Values in parentheses assume average of 1.7 hours hunted per hunter.

the opportunity to hunt other species contributed to the decline in grouse hunting pressure later in the hunt. Normally, pheasant and waterfowl hunting seasons opened after the grouse season opened. These later openings drew some hunters away from grouse hunting, particularly during years of low grouse numbers. The archery deer season opened prior to the grouse season, but if hunters experienced low flush rates, interviews suggested that many grouse hunters resumed deer hunting. Hunting effort during the late (December) season was very light on the SLA.

Cumulative harvest during the season closely matched cumulative effort. The first week harvest may have been depressed somewhat by reduced visibility since leaves had not yet fallen in most years. During 1971 to 1976 and 1982, over half of the harvest occurred by the end of the second week, and 86% of the harvest occurred by the end of the fourth week (Figure 17). A similar pattern of harvest was found on the Mille Lacs Wildlife Management Area in Minnesota where Gullion (1983) found that about 68% of the harvest occurred in the first 4 weeks of a 14-week season. Kubisiak (1984) found that three-quarters of the effort occurred within the first 3 to 4 weeks whether the season was short (37 days) or long (56 days) and that 75% of the harvest occurred within the first 2 to 3 weeks on the Sandhill Wildlife Area. These studies suggest that the hunting season would have to be dramatically shortened to achieve a measurable reduction in current harvest levels. A shortened season would likely concentrate additional effort into the shorter time period.

Concern has been expressed regarding the effect of extended hunting seasons and late-season harvests on grouse exploitation (DeStefano and Rusch 1982, Gullion 1988*b*). Part of this concern is that late-season harvest may be purely additive mortality as it occurs after fall dispersal of young birds (mid-September to mid-November) and the associated high natural mortality. However, it appears that overharvest documented on the Mille Lacs and Sandhill areas already occurred in the early part of the hunting season. While late season harvests may be mostly additive mortality, they seem only to have exacerbated a problem of excessive early harvest in these examples.

Trail Development

Harvest exploitation appeared to be related to the quality of maintained walking trails on the SLA (Figure 18). Years when walking trails had clover present, the exploitation rate was higher per unit of effort than when clover was nearly absent. The "clover-baited" trails seemed to have had the effect of making SLA birds as vulnerable as on the Sandhill Wildlife Area, which is a more huntable area (better access and fewer conifers). On Sandhill, about 300 hours of hunting/mile^2 of habitat exploited about half the grouse population (Kubisiak 1984). It appeared as though the SLA with mowed trails, but no clover seeding, could absorb about one-third greater hunting effort to achieve the same grouse mortality rate as at Sandhill.

Trails were not mowed during 1983 and 1988 to 1992 as a result of equipment breakdown and personnel shortage. Traffic counts suggested an average of 709 hunters/year in these years. Assuming 1.7 hours/hunter, cumulative hunting pressure would have averaged about 233 hours/mile^2 of habitat. The estimated exploitation of grouse during these 6 years based on voluntary reports averaged only 14.5%. This rate of exploitation/effort suggests that considerably more hunting effort could potentially be accommodated on the SLA when trails are not maintained; i.e., if 40% harvest mortality is a threshold, a maximum of about 220 hunting hours/mile^2 could be accommodated when trails are clover-seeded and mowed, about 300 hours when trails are only mowed, and perhaps more than 500 hours when trails are not maintained. However, much of the hunting effort in years when trails were not maintained may have reverted to road-hunting from vehicles as was the case prior to trail development. No exit interviews were conducted in these latter years. Stoll and Culbertson (1995) presented exploitation/effort data that suggest that under Ohio conditions hunters could expend about 600 hours/mile^2 before Ohio ruffed grouse would be harvested at the 40% level.

Trail and road densities on the SLA averaged 5.6 miles/mile^2 of habitat and ranged from 0.7 in Compartment 89 to 8.2 in Compartment 78 (see Figure 4). These totalled 29 miles of access including 5.5 miles of roads that were driveable by cars. Of the remaining 23.5 miles, about 14 miles were mowed walking trails, or 2.5 miles/mile^2 of habitat. "Saturation," or the maximum density of trails, will vary from one area to another. However, the amount of trails provided should be inversely related to anticipated hunting pressure on the area.

On the Sandhill Wildlife Area, there were 3.9 miles of "driveable" roads/mile^2 of habitat. Here, ruffed grouse were proportionally exploited out to beyond 800 m from access roads (Kubisiak 1985*b*). Gullion (1983) reported that grouse living within 1,000 m of road or trail lived only 9.1 months compared to 16.3 months for grouse farther from access. These high removals of grouse occurred under excessively heavy hunting pressure. These experiences suggest that developments should be planned so that refugia may be preserved beyond the radius of high exploitation to insure against overexploitation. Managers must balance developments that improve hunter success and satisfaction with the potential for overexploiting grouse. In some cases, it may be advisable to withdraw developments (close access, remove parking areas, etc.) if hunting pressure begins to exceed tolerable limits.

Nonhunting Uses of the Area

During the 10 years that interviews were conducted at the entrance to the SLA, an average of only 41% of the vehicle occupants were there for the primary purpose of hunting ruffed grouse (Table 14). An additional 10% of those entering the area were considered to be secondary ruffed grouse hunters, such as archers who also had a shotgun along in the event of encountering a grouse. An average of 14% of all entrants were bowhunting for deer, 22% were merely sightseeing, 8% were hunting other game or going fishing, and 7% were working on the area (mainly logging).

The proportion and number of grouse hunters were lowest at the inception of the study and peaked during the years of highest grouse population in 1971. Thereafter the proportion of grouse hunters remained at a much higher level than during the early years of the study. Likely this was due to the publicity surrounding the study and the local availability of maps of the study area.

Other activities that varied considerably from year to year were bowhunting and working. The amount of bowhunting on the study area in any given year was affected by the size of the acorn crop in some oak stands located west of the SLA. The number of workers entering the area was affected by timber cutting and road-building activity in some years. A significant "other" use was mushroom picking during some wet autumns.

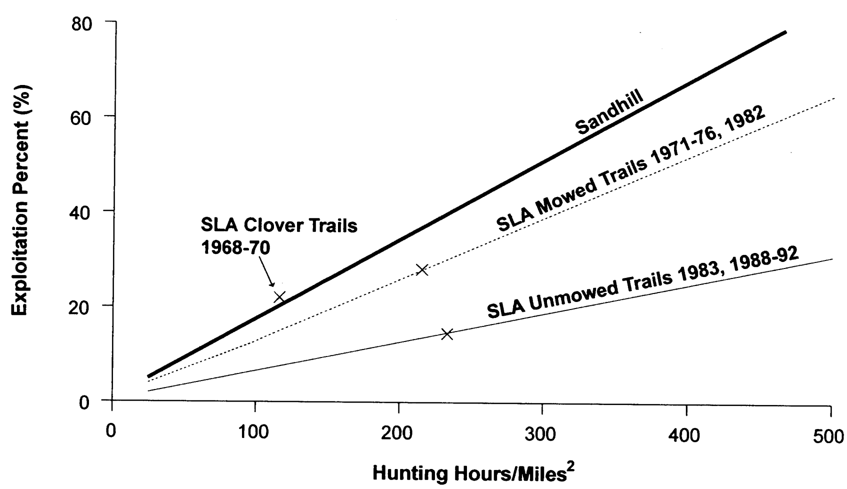


Figure 18. *Hunter effort and grouse exploitation relationships at the Stone Lake Area were affected by trail management practices compared with exploitation documented by Kubisiak (1984) at the Sandhill Wildlife Area. The dashed line and the thinner solid line are based on one mean sample point.*

Table 14. *Primary activities by year of interviewees exiting the Stone Lake Area.*

Activity	Percent by Year										
	68	69	70	71	72	73	74	75	76	82	Mean
Ruffed grouse hunting	21	26	24	57	57	49	39	44	40	53	41
Archery deer hunting	42	22	19	11	2	7	9	11	13	6	14
Other hunting	4	5	4	7	1	6	6	12	9	3	6
Fishing	4	2	3	T	1	5	2	T	1	2	2
Sightseeing	19	27	31	18	23	17	32	15	26	14	22
Working	8	15	17	3	3	3	1	3	8	6	7
Other	2	3	3	3	13	13	11	14	3	15	8
Total	100	100	101	99	100	100	100	99	100	99	100
Secondary grouse hunter[a]	21	15	13	9	5	3	8	9	12	2	10

[a] Interviewees that had a shotgun in the car for use if a grouse is seen while pursuing primary activity.

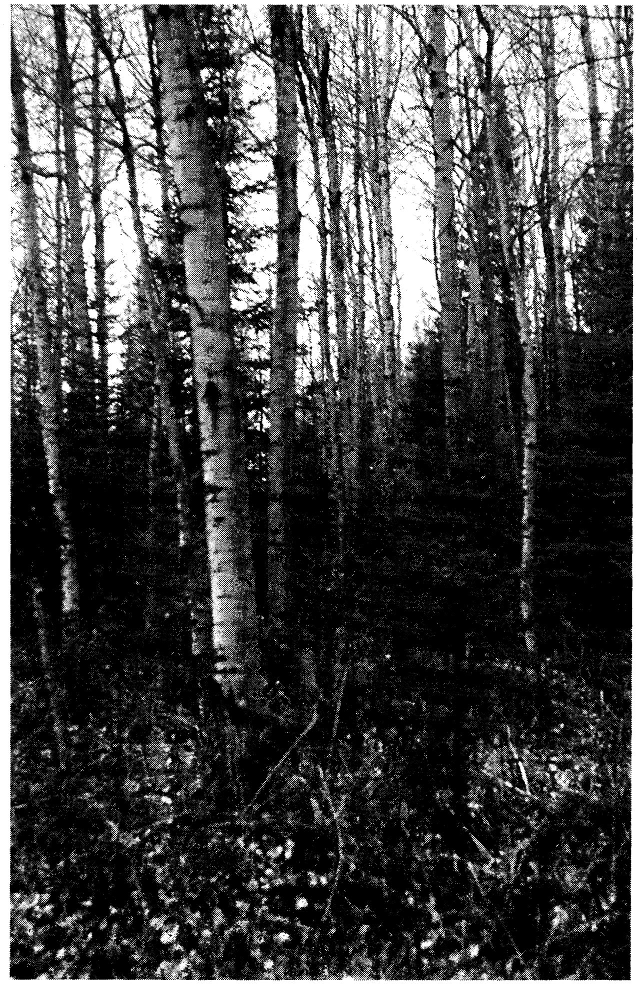
MANAGEMENT IMPLICATIONS AND RECOMMENDATIONS

Habitat Management

The presence of aspen-sapling habitat is clearly a key to ruffed grouse abundance in northern Wisconsin. Aspen acreage has declined from 5.12 million acres in 1936 to 3.26 million in 1983 (Spencer et al. 1988). The average annual rate of loss seems to have slowed over this time period, but aspen continues to be lost to human developments, natural succession, and forced conversion. To the extent that aspen acreage continues to decline, carrying capacity for ruffed grouse will also decline. High priority should be placed on identifying aspen stands for maintenance.

Aspen saplings and small poles (age 5-24 years) consistently have the highest density of drumming grouse. Patch cutting (about 20-acre clear-cuts) tended to produce higher densities of drumming grouse per area cut than large-scale cuts on the SLA. However, a 243-acre clear-cut also produced relatively high densities of drummers during the first half of the aspen rotation. Patch cutting is expected to maintain higher grouse populations throughout the aspen rotation because of the continuous availability of aspen saplings in a relatively small area. This intensity of patch cutting was totally compatible with the primary forest management objective of pulpwood production and seemed to address some of the aesthetic concerns expressed by the public.

Gullion (1972) indicated that maximum grouse densities can be achieved by 1 to 2.5-acre clear-cuts, but suggested that 10-acre cuts may be necessary where wood products are the primary objective (Gullion 1983). Though possibly obscured by differential hunter exploitation, grouse densities on 10-acre block cuts were not different from densities on 20-acre blocks at the Mille Lacs Wildlife Management Area (Gullion 1990*b*). If 10 drummers/100 acres is a standard by which to measure optimum grouse habitat (Gullion 1990*b*), we seem to have achieved 83% of the potential that might have been realized on the SLA had we employed 10-acre patch cutting rather than 22-acre patches.



K. McCAFFERY

The balsam fir component increased during the study period. In the absence of fire, balsam fir is likely to continue to increase in dominance of many forest stands.

Hunter Management

The maximum amount of hunting opportunity that can be provided is determined by the area of huntable coverts and the efficiency of hunters. Maintaining huntable coverts (suitable grouse habitat accessible to public hunting) is paramount to maintaining hunting opportunity. Already, huntable cover is much less than the 22,000 $miles^2$ of commercial forest area (Smith 1986) commonly reported as an expression of grouse hunting opportunity in the state. More likely, it approaches 14,000 $miles^2$ when poor hunting habitats (northern hardwoods, pine plantations, black spruce, tamarack, etc.) are deducted. To the extent that even-aged silviculture is discouraged and aspen acreage is lost, grouse populations and grouse hunting opportunities will decline.

Hunter efficiency is determined by habitat types, access, personal skills, and hunting method. Grouse exploitation can be regulated most easily by controlling management activities that increase grouse vulnerability (trail seeding and/or mowing) and hunter access (ATVs, trails, and parking). Exploitation is less easily controlled by bag limit or season length. Closing trails and other access may be an important part of future management plans if hunting pressure increases or if grouse exploitation needs to be reduced.

Research Needs

More information is needed on harvest exploitation of ruffed grouse within Wisconsin. The total supply of grouse hunting has not been well defined. Huntable populations of grouse probably occur on less than 14,000 $miles^2$ of forest land. Estimates further indicate that there are about 150,000 to 200,000 ruffed grouse hunters in Wisconsin (A. J. Rusch 1987, DNR unpublished report). Mean hunting effort reported by hunters from 1978 to 1982 was 1.7 million hunter-days, or 77 hunts/$mile^2$). At the Sandhill Wildlife Area, 90 to 100 hunts/$mile^2$ imposed a 50% mortality rate on the grouse population (Kubisiak 1984). If current estimates of effort are realistic, there are likely areas in Wisconsin where grouse are being overhunted, especially in the southern two-thirds of the state (Rusch et al. 1984, Small 1985, Small et al. 1991). Better regional information is needed on the total amount of huntable grouse covert, the number of hunters, and their effort and harvest.

Replicate studies are also needed to determine the relationship of hunting effort and exploitation in habitats dissimilar to Sandhill. Data from this study suggests that habitats similar to the Stone Lake Area can withstand 40% greater hunting effort than at Sandhill. An efficient method for detecting regional overharvest should be defined.

More information is needed on the impacts of intensive aspen management on other plant and animal species. There are a number of wildlife species that benefit from aspen (Gullion 1977*b*, Yahner 1990). Recent findings suggest that most interior bird species are not negatively affected by clear-cutting within a forest matrix (Thompson et al. 1992). However, additional surveys are needed to increase understanding of the impact of deliberate aspen age-class interspersion on interior species (Howe et al. 1992).

The potential impact of succession to balsam fir on ruffed grouse populations and hunting should be studied. In the absence of fire, balsam fir is inexorably increasing in a variety of forest types. This trend appears irreversible despite occasional mortality of older trees caused by spruce budworm. Some amount of fir seems to improve some habitats for grouse. Also, some fir makes birds less vulnerable to hunting and may increase the ability of the grouse population to absorb additional hunter days of recreation. Too much fir may reduce grouse populations to unhuntable densities or impair success rates to the discouragement of hunters.

Continued monitoring of drumming grouse trends on the Stone Lake Area is advised. Overall grouse densities on demonstration and traditionally cut compartments have not been markedly different during the first half of the current aspen rotation. A greater difference is expected during the second half of the rotation. Furthermore, the long population database has served as a supplementary index to regional grouse populations and may provide a foundation upon which to pursue future grouse research on this area.

The potential for producing huntable densities of ruffed grouse in red pine stands should be explored. The supply of grouse hunting is directly related to the available acreage of huntable grouse covert (and difficulty of extracting grouse from the habitat). Perhaps subtle decreases in pine stocking and the reduced use of herbicides would increase overall stem densities of understory and midstory woody vegetation so that huntable grouse habitat could be maintained even on sites converted to pine.

SUMMARY

- The primary objective of this study was to demonstrate and evaluate responses of ruffed grouse populations and harvests in relation to habitat management during the first 20 years of a coordinated forestry-wildlife habitat program. Data were also gathered on some grouse and hunter behaviors.
- The Stone Lake Experimental Study Area included 3,307 acres of potential ruffed grouse habitat on a gross land area of about 4,200 acres. There were 17 primary forest types that were typical of much of northern Wisconsin. However, when secondary timber species and understories were considered, a total of 82 "habitats" were recognized. Pulpwood production was the primary timber management objective.
- The study area was composed of 5 forest compartments, 2 of which were being harvested using large-scale clear-cutting at the inception of the study and 3 that were to be clear-cut in patches averaging 22 acres to improve aspen age-class interspersion.
- Ruffed grouse population and distribution were determined by a near-complete spring drummer census.
- Highest densities of drumming ruffed grouse were found in 8- to 24-year-old aspen saplings and small poles. Of 11 other forest habitats, drumming ruffed grouse densities were highest in swamp conifers and balsam fir. Pine habitats ranked lowest.
- Area-wide, 130 (67%) of 193 drummer observations were in well-stocked aspen saplings during the recent high population (1988-90). Prime aspen habitat comprised only 21% (685 of 3,307 acres) of the potential grouse range on the study area.
- During the first 20 years following cutting, grouse densities and trends on the traditional (large-scale clear-cuts) and demonstration areas (small-scale clear-cuts) were similar. However, grouse densities will likely be higher in the future on the demonstration compartments as prime-age aspen habitats continue to be available, while maturing aspen will have lost its attractiveness in the traditionally cut compartments.
- Hunter exploitation of grouse averaged about 28% of the estimated fall population when hunting effort averaged about 215 hours/mile^2. Exploitation was disproportionately higher during years when walking trails were seeded with clover and mowed.
- The proportion of hunters who "hunted" from a moving vehicle declined from more than 40% in 1967-68 to as low as 5% in 1973. This decline in road-hunting was believed to be the result of increased availability of walking trails on the Stone Lake Area. About 14 miles of trails seemed to provide an incentive for hunters to get into the woods, especially when trails were seeded with clover and mowed.
- Controlling grouse exploitation by hunters might better be accomplished by the amenities provided (parking, walking trails) than by restrictions of bag limit or season length. On the Stone Lake Area, only 1 of 519 hunters had bagged more than 2 grouse during exit interviews in 1972 and 1982 despite high grouse populations.
- The presence of aspen is clearly the key to ruffed grouse abundance in northern Wisconsin. To the extent that aspen acreage continues to decline, carrying capacity for ruffed grouse will also decline. High priority should be placed on identifying aspen stands for maintenance.

Appendixes

Appendix A. *Scientific Names of Animals and Plants*

Animals	
Deer	*Odocoileus virginianus*
Dog	*Canis lupus familiarus*
Fisher	*Martes pennanti*
Goshawk	*Accipiter gentilis*
Owl, barred	*Strix varia*
Owl, horned	*Bubo virginianus*
Pheasant	*Phasianus colchicus*
Ruffed Grouse	*Bonasa Umbellus*
Spruce budworm	*Choristoneura fumiferana*
Plants	
Alder (speckled)	*Alnus rugosa*
Aspen	*Populus tremuloides* (Some *P. grandidentata*)
Balsam fir	*Abies balsamea*
Birch, white	*Betula papyrifera*
Cherry	*Prunus* spp.
Clover	*Trifolium hibridum* (Some *T. repens*)
Fir (balsam)	*Abies balsamea*
Hazel (beaked)	*Corylus cornuta*
Hemlock (eastern)	*Tsuga canadensis*
Holly	*Ilex verticillata*
Juneberry	*Amelanchier* spp.
Leatherleaf	*Chamaedaphne calyculata*
Maple, red	*Acer rubrum*
Maple, sugar	*Acer saccharum*
Oak, northern red	*Quercus borealis*
Oak, northern pin	*Quercus ellipsoidalis*
Pine, jack	*Pinus banksiana*
Pine, red	*Pinus resinosa*
Pine, white	*Pinus strobus*
Redcedar	*Juniperus virginiana*
Spruce, black	*Picea mariana*
Spruce, white	*Picea glauca*
Tamarack	*Larix laricina*
Willow	*Salix* spp.
White-cedar	*Thuja occidentalis*

RUFFED GROUSE HUNTER INTERVIEW CARD
Form 8100-37

Department of Natural Resources

155

FILL ON ENTRY

District	Date
Stone Ck	10/1/72

Car Lic. No.	Time entered	Time Left
C25006	8:03	10:38

Primary Activity

- [x] Ruffed Grouse
- [ ] Deer
- [ ] Other Game
- [ ] Driving
- [ ] Fishing
- [ ] Sightseeing
- [ ] Work
- [ ] Other ______

[ ] R.G. -Secondary -Activity

FILL ON LEAVING

No. of Deer		No. of Grouse	
____ Seen	____ Killed	8 Seen	1 Killed

Hunting Method
[ ] Drive [x] Walk [x] Dog

Time Hunting (est. of $\frac{1}{2}$ hr.) ______

Trails Hunted (list) 26,

or Area(s) 88-8F, 1K

Remarks

(OVER)

No.	Sex (Cock, Hen)	Age (Juv., Adult)	Where Shot: Road	Where Shot: Walking Trails	Where Shot: Brush	Crop Contents
20	♀	Juv.		✓		empty

Rev. 9-70

Aspen:
Occurring in nearly pure stands or more often mixed with birch, fir, and/or maple in varying proportions.

Balsam fir:
Often mixed with maple, aspen, birch, and/or white spruce in varying proportions.

Birch (white):
Often mixed with aspen, fir, and/or maple in varying proportions.

Brush, upland:
Predominantly beaked hazel, cherry, willow, and Juneberry.

Brush, lowland:
Predominantly alder, but often mixed with holly and/or willow.

Fir:
Balsam fir.

Grass, upland:
Areas less than 10% stocked with trees and dominated by native and introduced cool-season grasses.

Hardwoods, northern:
Predominantly sugar maple and associated red maple, white ash, and basswood with occasional aspen, birch, and oak.

Hardwoods, swamp:
Predominantly black ash, but often mixed with fir and with an understory of lowland brush.

Jack pine:
Occasionally contains some amount of aspen, birch, and/or fir.

Maple:
Red maple or sugar maple.

Maple, sugar:
Usually the dominant species in northern hardwood habitats.

Maple, red:
Often a component of northern hardwood, aspen, fir, and birch habitats.

Muskeg:
Open wetlands dominated by leatherleaf, sedges, and *Vaccinium* spp.

Red pine:
Often containing variable mixes of fir, red maple, and/or aspen.

Spruce, black:
Most often in nearly pure stands with little shrub understory.

Spruce, stagnant:
Stunted black spruce trees usually on muskeg-type substrate.

Spruce, white:
Often contains some amount of fir.

Swamp conifers:
Habitat dominated by white-cedar, but often containing variable amounts of fir, black spruce, and/or black ash. Most stands contain breaks dominated by lowland brush (mostly alder).

Tamarack:
Most stands contain some amount of black spruce and lowland brush.

Literature Cited

Berg, B.
1995. Minnesota grouse and hares, 1995. Survey Report. Minnesota Department of Natural Resources, Grand Rapids, MN. 4 pp.

Berner, A., and L. W. Gysel
1969. Habitat analysis and management considerations for ruffed grouse for a multiple use area in Michigan. *Journal of Wildlife Management* 33:769-78.

Boag, D. A., and K. M. Sumanik
1969. Characteristics of drumming sites selected by ruffed grouse in Alberta. *Journal of Wildlife Management* 33:621-28.

Cade, B. S., and P. J. Sousa
1985. Habitat suitability index models: Ruffed grouse. U.S. Fish and Wildlife Service Biological Report 82. 31 pp.

DeStefano, S., and D. H. Rusch
1982. Some historical aspects of ruffed grouse harvests and hunting regulations in Wisconsin. *Transactions of the Wisconsin Academy of Sciences, Art and Letters* 70:27-35.

Dexter, M. H., compiler
1991. Status of wildlife populations, fall 1991 and 1981-1990 hunting and trapping harvest statistics. Minnesota Department of Natural Resources, St. Paul, MN. 136 pp.

Dorney, R. S
1959. The relationship of ruffed grouse to forest cover types in Wisconsin. Wisconsin Conservation Department Technical Bulletin 18. 32 pp.

Grange, W. B.
1948. *Wisconsin grouse problems.* Wisconsin Conservation Department. 318 pp.

Gullion, G. W.
1966. The use of drumming behavior in ruffed grouse population studies. *Journal of Wildlife Management* 30:717-29.

1970. Factors influencing ruffed grouse populations. *Transactions of the North American Wildlife and Natural Resource Conference* 35:95-105.

1972. Improving your forested lands for ruffed grouse. Publication No. 1439, Miscellaneous Journal Series, Minnesota Agricultural Experiment Station. 34 pp.

1977*a*. Improving your forested lands for ruffed grouse. Ruffed Grouse Society of North America, Coraopolis, PA. 34 pp.

1977*b*. Maintenance of the aspen ecosystem as a primary wildlife habitat. *Proceedings of the International Congress of Game Biologists* 13:256-65.

1981*a*. An investigation concerning length of ruffed grouse hunting seasons. Study Proposal. University of Minnesota Agricultural Experiment Station. 17 pp.

1981*b*. Non-drumming males in a ruffed grouse population. *Wilson Bulletin* 93:372-82.

1983. Ruffed grouse habitat manipulation—Mille Lacs Wildlife Management Area, Minnesota. *Minnesota Wildlife Resource Quarterly* 43:25-98.

1988*a*. Aspen management for ruffed grouse. Pp. 9-12 *in* T. W. Hoekstra, ed. *Integrating forest management for wildlife and fish.* USDA Forest Service NC-122. 63 pp.

1988*b*. Effect of hunting on a ruffed grouse population. Paper presented at 50th Midwest Fish and Wildlife Conference. Columbus, Ohio. 31 pp.

1990*a*. Ruffed grouse use of conifer plantations. *Wildlife Society Bulletin* 18:183-87.

1990*b*. Management of aspen for ruffed grouse and other wildlife—an update. Pp 133-43 *in* R. D. Adams, ed. *Aspen Symposium '89 Proceedings.* USDA Forest Service General Technical Report NC-140. 348 pp.

Hale, J. B., and R. S. Dorney
1963. Seasonal movements of ruffed grouse in Wisconsin. *Journal of Wildlife Management* 27:648-56.

Hale, P. E., A. S. Johnson, and J. L. Landers
1982. Characteristics of ruffed grouse drumming sites in Georgia. *Journal of Wildlife Management* 46:115-23.

Howe, R. W., S. A. Temple, and M. J. Mossman
1992. Forest management and birds in northern Wisconsin. *Passenger Pidgeon* 54:297-305.

Keith, L. B., and D. H. Rusch
1989. Predations role in the cyclic fluctuations of ruffed grouse. *Acta XIX Congressus Internationalis Ornithologici*:699-732.

King, R. T.
1937. Ruffed grouse management. *Journal of Forestry* 35:523-32.

Kotar, J., J. A. Kovach, and C. T. Locey
1988. Field guide to forest habitat types of northern Wisconsin. University of Wisconsin and Wisconsin Department of Natural Resources, Madison. Looseleaf.

Kubisiak, J. F.
1984. The impact of hunting on ruffed grouse populations in the Sandhill Wildlife Area. Pp 151-68 *in* W. L. Robinson, ed. *Ruffed grouse management: State of the art in the early 1980s.* North Central Section, The Wildlife Society. 181 pp.

1985*a*. Ruffed grouse habitat relationships in aspen and oak forests of central Wisconsin. Wisconsin Department of Natural Resources Technical Bulletin 151. 22 pp.

1985*b*. Ruffed grouse harvest levels and population characteristics in central Wisconsin. Wisconsin Department of Natural Resources Research Report 136. 24 pp.

Kubisiak, J. F., and B. Dhuey
1991. Ruffed grouse drumming survey, 1991. Pp 5-7 *in Wisconsin Wildlife Surveys: August 1991*. Wisconsin Department of Natural Resources. 82 pp.

Kubisiak, J. F., J. C. Moulton, and K. R. McCaffery
1980. Ruffed grouse density and habitat relationships in Wisconsin. Wisconsin Department of Natural Resources Technical Bulletin 118. 15 pp.

Lauten, D. J., and C. C. Balzer
1994. Harvest and cycles of ruffed grouse in northwest Wisconsin. Pp 10-15 *in Wisconsin Grouse Symposium Proceedings*. Wisconsin Department of Natural Resources, Madison. 80 pp.

Lewis, R. A.
1988. Effect of previous occupancy on recruitment to territorial sites of male blue grouse. *Wilson Bulletin* 100:310-12.

McCaffery, K. R., and J. E. Ashbrenner
1981. Forest opening construction and impacts in northern Wisconsin. Wisconsin Department of Natural Resources Technical Bulletin 120. 41 pp.

Moulton, J. C.
1974. Grouse distribution in young aspen stands. Wisconsin Department of Natural Resources. Final Report Study 206, Pittman-Robertson Project W-141-R-9. 14 pp.

Mueller, H. C., D. D. Berger, and G. Allez
1977. The periodic invasions of goshawks. *The Auk* 94:652-63.

Palmer, W. L.
1963. Ruffed grouse drumming sites in northern Michigan. *Journal of Wildlife Management* 27:656-63.

Parker, L. R., and J. W. Hardin
1990. Relationship between wildlife values and the Kotar forest habitat classification system. Wisconsin Department of Natural Resources Report. Rhinelander. 27 pp. + App.

Rusch, D. H., M. M. Gillespie, and D. I. McKay
1978. Decline of a ruffed grouse population in Manitoba. *Canadian Field-Naturalist* 92:123-27.

Rusch, D. H., S. DeStefano, and R. J. Small
1984. Seasonal harvest and mortality of ruffed grouse in Wisconsin. Pp 137-50 *in* W. L. Robinson, ed. *Ruffed grouse management: State of the art in the early 1980s*. North Central Section, The Wildlife Society.

Small, R. J.
1985. Mortality and dispersal of ruffed grouse in central Wisconsin. M.S. Thesis, University of Wisconsin. Madison. 56 pp.

Small, R. J., J. C. Holzwart, and D. H. Rusch
1991. Predation and hunting mortality of ruffed grouse in central Wisconsin. *Journal of Wildlife Management* 55:512-20.

Smith, W. B.
1986. Wisconsin's fourth forest inventory: Area. USDA Forest Service Resource Bulletin NC-97. 48 pp.

Spencer, J. S., Jr., W. B. Smith, J. T. Hahn, and G. K. Raile
1988. Wisconsin's fourth forest inventory, 1983. USDA Forest Service Resource Bulletin NC-107. 158 pp.

Stoll, R. J., Jr., M. W. McClain, R. L. Boston, and G. P. Honchul
1979. Ruffed grouse drumming site characteristics in Ohio. *Journal of Wildlife Management* 43:324-33.

Stoll, R. J., Jr., and W. L. Culbertson
1995. Ruffed grouse hunting pressure and harvest on an Ohio public hunting area. Ohio Department of Natural Resources Fish and Wildlife Report 12. 15 pp.

Thompson, F. R. III, D. A. Freiling, and E. K. Fritzell
1987. Drumming, nesting, and brood habitats of ruffed grouse in an oak-hickory forest. *Journal of Wildlife Management* 51:568-75.

Thompson, F. R. III, and E. K. Fritzell
1988. Ruffed grouse winter roost site preference and influence on energy demands. *Journal of Wildlife Management* 52:454-60.

1989. Habitat differences between perennial and transient drumming sites of ruffed grouse. *Journal of Wildlife Management* 53:820-23.

Thompson, F. R. III, W. D. Dijak, T. G. Kulowiec, and D. A. Hamilton
1992. Effects of even-aged management on breeding bird densities. *Journal of Wildlife Management* 56:23-30.

Thompson, D. R., and J. C. Moulton
1981. An evaluation of Wisconsin ruffed grouse surveys. Wisconsin Department of Natural Resources Technical Bulletin 123. 13 pp.

Yahner, R. H.
1990. Nongame response to ruffed grouse habitat management in Pennsylvania. Pp 145-53 *in* R. D. Adams, ed. *Aspen Symposium '89 Proceedings*. USDA Forest Service General Technical Report NC-140. 348 pp.

Acknowledgments
John C. Moulton began this project in 1967-68 and continued as the project leader for 10 years prior to going into private employment. His planning and early efforts led to the product now in hand. Special thanks are due to forester Hal Berndt for his assistance in selecting the study area and to forester Bill Wood (American Legion State Forest) for his close cooperation in conducting forest management activities; to the late Alf Williston and Art Larson and their families for permitting us to survey grouse on lands owned by them within the study area; to DNR wildlife personnel Arlyn Loomans, Phill Vanderschaegen, Ron Eckstein, Fred Johnson, and Chet Botwinski for maintaining and providing records of wildlife management activities on the study area; to the late Gordon Gullion (University of Minnesota) for advice and encouragement during the study; and to John Kubisiak, Gerald A. Bartelt, Dr. Don Rusch (University of Wisconsin), Dan Dessecker (The Ruffed Grouse Society), and an anonymous reviewer for reviewing the manuscript and providing comments that improved this report. This study was funded in part under the Federal Aid to Wildlife Restoration Act, Pittman-Robertson Project W-141-R. This document represents the final report for Study 202.

Dedicated In Memorium
Three dads crossed The River during the study period.

Philip McCaffery (1912-91), Stanley WI, Standard Oil agent, educator and conservationist, who given the choice between hunting pheasants and ruffed grouse by his sons, would always choose "partridge" hunting.

Edward Ashbrenner (1906-1983), Merrill WI, dairy farm operator and logger for the Rib Lake Lumber Company. He raised a family in the rural setting and taught them appreciation for the land. He was always ready to listen after asking, "How was your day?"

Nyole "Bunk" Creed (1907-1988), Unity WI, Postmaster, Boy Scout leader, and occasional chaser of grouse at Stone Lake. He maintained a great interest in the activities of our little group of researchers.

About The Authors
Keith McCaffery has been a research biologist with the Wisconsin DNR since 1963. Most of his work has been on deer and ruffed grouse habitat relationships and deer population monitoring. He attended St. Olaf College and received B.S. and M.F. degrees in forest resources management from the University of Minnesota. He assumed leadership of the Stone Lake Grouse Study in 1978.

James Ashbrenner has worked for the Wisconsin DNR since 1960. He received an Associate Degree in Technical Agriculture from North Central Technical Institute and completed a military stint in Korea as a firefighter in crash rescue. He has been a primary investigator for the entire duration of the Stone Lake Grouse Study.

William A. Creed began with the Wisconsin DNR in 1953. He has a B.S. in conservation and biology from the University of Wisconsin-Stevens Point and a M.S. in forestry-wildlife from Penn State University. He assisted with planning, conducting, and supervising the Stone Lake Grouse Study until his retirement in 1991 and has been a volunteer on the project since.

Bruce Kohn received B.S. and M.S. degrees in wildlife management from the University of Minnesota prior to joining Wisconsin DNR in 1970. Although his primary research assignments have involved bears, furbearers, and wolves, he has assisted with the annual grouse census at Stone Lake since 1970.

The first three authors are natives of Wisconsin. Bruce Kohn grew up in Cloquet, MN. All four authors currently live in the Rhinelander area.

Production Credits
Wendy M. McCown, Managing Editor
Patricia Allen Duyfhuizen, Editor
Michelle E. Jesko, Layout/Production

TECHNICAL BULLETINS (1989-1996)

No. 163 Mercury levels in walleyes from Wisconsin lakes of different water and sediment chemistry characteristics. (1989) Richard C. Lathrop, Katherine C. Noonan, Paula M. Guenther, Therese L. Brasino, and Paul W. Rasmussen

No. 164 Water quality and restoration of the lower Oconto River, Oconto County, Wisconsin. (1989) Richard A. Rost

No. 165 Population dynamics of smallmouth bass (*Micropterus dolomieui*) in the Galena (Fever) River and one of its tributaries. (1989) Anne M. Forbes

No. 166 Bibliography of fishery investigations on large salmonid river systems with special emphasis on the Bois Brule River, Douglas County, Wisconsin. (1989) Robert B. DuBois

No. 167 Wisconsin recreation survey-1986. (1989) Linda J. Penaloza

No. 168 A postglacial vegetational history of Sauk County and Caledonia Township, Columbia County, South Central Wisconsin. (1990) Kenneth I. Lange

No. 169 A review of fisheries habitat improvement projects in warmwater streams, with recommendations for Wisconsin. (1990) John Lyons and Cheryl Courtney

No. 170 Ecosystem responses to growth and control of submerged macrophytes: a literature review. (1990) Sandy Engel

No. 171 The sport fishery for, and selected population characteristics of, smallmouth bass in Pallette Lake, Wisconsin, 1956-1984. (1990) Michael H. Hoff and Steven L. Serns

No. 172 Restoration of canvasback migrational staging habitat in Wisconsin: a research plan with implications for shallow lake management. (1991) Rich Kahl

No. 173 Evaluation of a catch and release fishery for brown trout regulated by an unprotected slot length. (1991) Robert L. Hunt

No. 174 Boating pressure on Wisconsin's lakes and rivers: results of the 1989-1990 Wisconsin recreational boating study, phase 1. (1991) Linda J. Penaloza

No. 175 Distribution and relative abundance of fishes in Wisconsin. VIII. Summary report. (1992) Don Fago

No. 176 Electric fencing for duck and pheasant production in Wisconsin. (1992) Ronald C. Gatti, James O. Evrard, and William J. Vander Zouwen

No. 177 Population biology and management of the walleye in western Lake Superior. (1992) Stephen T. Schram, Terry L. Margenau, and William H. Blust

No. 178 A survey of the aquatic insects of the Lower Wisconsin River, 1985-1986, with notes on distribution and habitat. (1992) Richard A. Lillie and William L. Hilsenhoff

No. 179 Evaluation of trout habitat improvement structures in three high-gradient streams in Wisconsin. (1992) Robert L. Hunt

No. 180 Boater attitudes and experiences: results of the 1989-1990 Wisconsin recreational boating study, phase 2. (1992) Linda J. Penaloza

No. 181 The fishery of the Yahara lakes. (1992) Richard C. Lathrop, Susan B. Nehls, Clifford L. Brynildson, and Karen R. Plass

No. 182 Aquatic macrophyte ecology in the Upper Winnebago Pool Lakes, Wisconsin. (1993) Rich Kahl

No. 183 The fisher in Wisconsin. (1993) Bruce E. Kohn, Neil F. Payne, James E. Ashbrenner, and William A. Creed

No. 184 Chemical and biotic characteristics of two low-alkalinity lakes in northern Wisconsin: relation to atmospheric deposition. (1993) Katherine E. Webster, Joseph M. Eilers, James G. Wiener, Gary E. Glass, Paul J. Garrison, and Mark D. Johnson

No. 185 Aquatic insects of the Bois Brule river system, Wisconsin. (1993) Robert B. DuBois

No. 186 Restoring Rice Lake at Milltown, Wisconsin. (1994) Sandy Engel and Stanley A. Nichols

No. 187 Bibliography of fire effects and related literature applicable to the ecosystems and species of Wisconsin. (1995) Richard A. Henderson and Sandra H. Statz

No. 188 Plant species composition of Wisconsin prairies: an aid to selecting species for plantings and restorations based upon University of Wisconsin-Madison plant ecology laboratory data. (1995) Richard A. Henderson

No. 189 Integrating forest and ruffed grouse management: a case study at the Stone Lake Area. (1996) Keith McCaffery, James E. Ashbrenner, William A. Creed, and Bruce E. Kohn

Printed on recycled paper.

Copies of the above publications and a complete list of all technical bulletins in the series are available from the Bureau of Research, Department of Natural Resources, Box 7921, Madison, WI 53707.

PUBL-RS-189-96

Department of Natural Resources
RS/G3
Box 7921
Madison, WI 53707

DO NOT FORWARD
ADDRESS CORRECTION REQUESTED
RETURN POSTAGE GUARANTEED