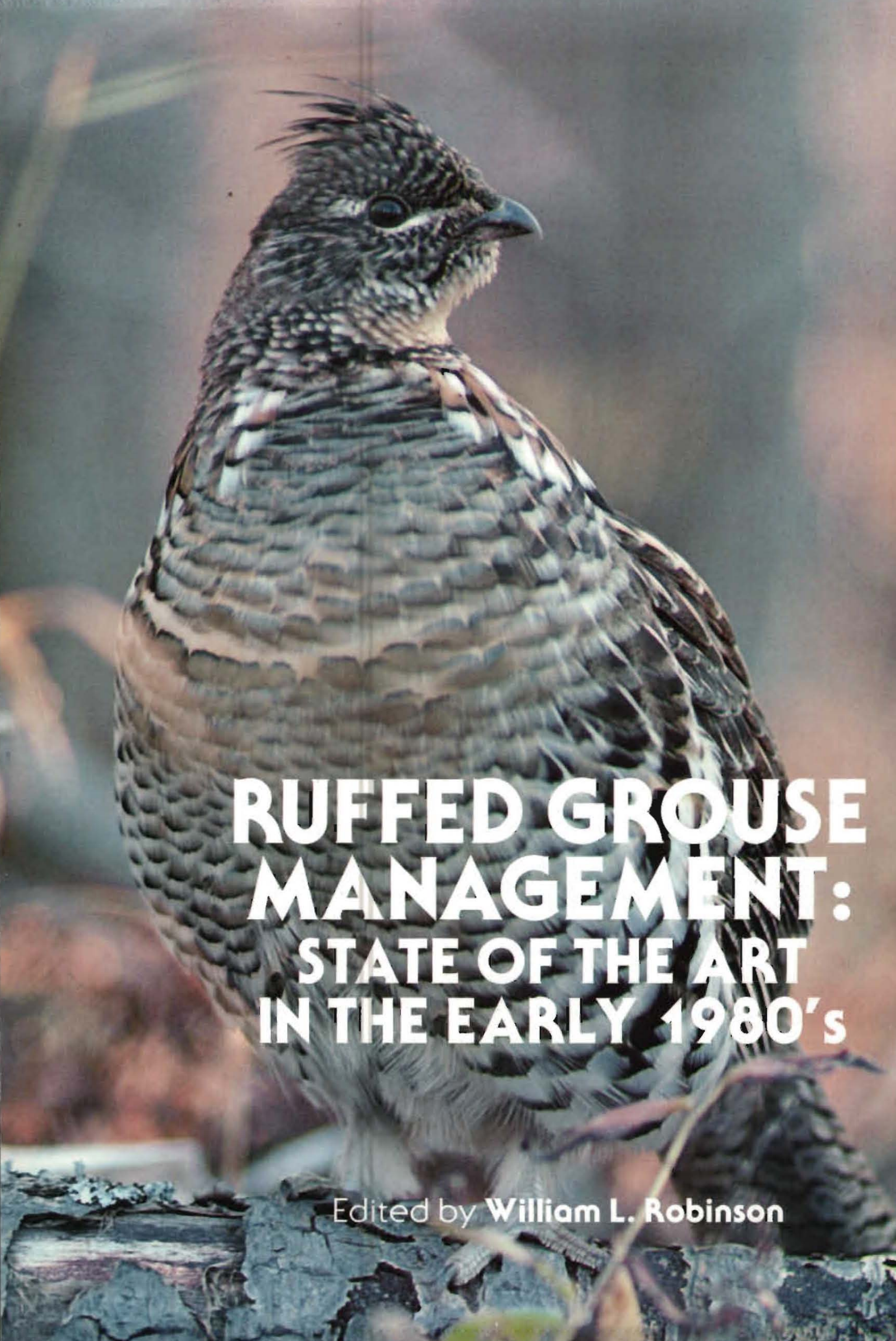

RUFFED GROUSE MANAGEMENT: STATE OF THE ART IN THE EARLY 1980's

Edited by **William L. Robinson**

Alan Crossley

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Edited by

William L. Robinson
Professor of Biology
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Proceedings of a Symposium
held at the 45th Midwest Fish and Wildlife Conference
St. Louis, Missouri
5-7 December 1983

1984

Sponsored by
The North Central Section of the Wildlife Society, and
The Ruffed Grouse Society

Cover Photo: Tom Martinson
Pen and Ink Drawings: John Wojciechowski

Library of Congress Catalog Card Number **84-62422**

Printed by
BookCrafters, Chelsea, Michigan

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FOREWORD

"Ruffed Grouse Management: State of the Art in the Early 1980's" is a symposium co-sponsored by the North Central Section of The Wildlife Society and The Ruffed Grouse Society of North America. The symposium was held on 6 December, 1983 at the 45th Midwest Fish and Wildlife Conference in St. Louis, Missouri. The North Central Section is committed to the biennial sponsorship of symposia on various wildlife management and research topics. Proceedings are published for use by research and management biologists, educational institutions and the public. This symposium adds to a growing list of excellent publications by the North Central Section of the Wildlife Society.

Symposium co-chairmen Decker Major and Gordon Gullion and editor William Robinson have done an outstanding job in assembling papers from some of the top grouse experts in the Midwest. Some of the major topics addressed by this symposium are: evaluating and monitoring ruffed grouse restoration in Missouri, Illinois and Indiana, comparing population indices between states, evaluating hunter harvest and seasonal mortality, grouse home range, dispersal and habitat selection, and beneficial grouse habitat management procedures.

I think everyone involved with this project is to be commended for shedding some light on the status of ruffed grouse management in the Midwest today.

H. Lee Gladfelter

Lee Gladfelter
President
North Central Section of The Wildlife Society

A Greeting from the Ruffed Grouse Society

Samuel R. Pursglove, Jr., The Ruffed Grouse Society, 1400 Lee Drive, Coraopolis, PA 15108

Good morning. It is my pleasure to welcome you to the Ruffed Grouse Symposium on behalf of the Ruffed Grouse Society. The Society is proud to be a cosponsor of this significant part of the Midwest Fish and Wildlife Conference, and we are extremely pleased to see so many taking advantage of the symposium.

As you've heard Gordon Gullion say, the ruffed grouse is looking toward a bright future in the Midwest and elsewhere, in stark contrast to what seems to be in store for many other game species.

For several years the Society has been working to help ensure that future for the ruffed grouse, and we plan to intensify our efforts in the years ahead, perhaps with the assistance of many of you here today.

I'm sure not all of you are familiar with the Society and the way we work, so I would like to take a few minutes to give you a little background.

The Society was formed in the fall of 1961 in Monterey, Virginia. It was incorporated as a non-profit, conservation organization under the laws of the Commonwealth of Virginia by a handful of sportsmen concerned with the future of ruffed grouse.

The Society has expanded into an international organization of conservationists dedicated to improving the environment for ruffed grouse, American woodcock and many other species of both game and nongame forest wildlife.

Our operating funds come from several sources, major ones being membership fees, grants, endowments and fund-raising projects. Our leading fund-raising effort is a series of Sportsmen's Banquets held on an annual basis in many states, as well as in Canadian provinces.

With the money it raises, the Society supports critical scientific research into habitat improvement methods and is currently expanding its commitment to a variety of habitat education projects.

At the present time, we are budgeting more than $115,000 annually to help support studies, such as the work being conducted by Gordon Gullion in Minnesota and habitat improvement research underway here in Missouri.

In cooperation with other conservation-oriented groups and agencies, the Society sponsors habitat improvement workshops. These workshop programs are extremely flexible. They can be tailored to the needs of professional foresters and wildlife biologists who are seeking the latest technical information available on habitat improvement and maintenance. They can also be designed to answer less technical questions for forest owners and sportsmen interested in what the layman can do to enhance habitat for forest wildlife.

Additionally, the Society is acting in partnership with conservation professionals in many key grouse-range states to develop ongoing habitat education projects. Through the use of publications, films, demonstration areas and several other teaching aids, these projects will bring habitat improvement methods to the widest possible audience of concerned landowners.

The Society also has the capability of working on an individual basis with private or corporate landowners interested in improving habitat for forest wildlife. The Society's regional directors are schooled in the latest forest habitat improvement techniques and will help woodland owners implement the best possible method to enhance wildlife habitat in a particular area of forest.

The Society has a wide selection of printed material for anyone interested in forest habitat improvement. The material available by contacting Ruffed Grouse Society national headquarters includes both works published at the Society's expense and those printed by other sources. This material has been carefully chosen for its conservation value.

Many of the activities of the Society are recorded in *The Drummer,* the official newspaper of the Ruffed Grouse Society. The paper is published six times a year and not only contains much conservation news but also covers several other topics of interest to a wide range of outdoor enthusiasts.

The Ruffed Grouse Society has come a long way since its beginnings 22 years ago in Virginia. Today there are close to 12,000 members in the United States, Canada and overseas.

We expect the growth of the Society to accelerate in the years just ahead as the importance of our work becomes apparent to an ever-widening circle of sportsmen and conservationists.

We look forward in the future to being deeply involved in many more programs with the impact of this symposium. And we also look forward to working with many of you here today to secure that bright future for the ruffed grouse and other forest wildlife species.

Introduction

P. Decker Major, Indiana Department of Natural Resources, Forest Wildlife Headquarters, Mitchell, IN 47446

Good morning and welcome to the 8th wildlife symposium held in conjunction with the Midwest Fish and Wildlife Conference. This symposium entitled: RUFFED GROUSE MANAGEMENT: STATE OF THE ART IN THE EARLY 1980's is cosponsored by the Northcentral Section of The Wildlife Society and The Ruffed Grouse Society.

Eleven papers will be presented today relating recent information concerning ruffed grouse *(Bonasa umbellus)* restoration, census techniques, grouse hunting pressure and related mortality, habitat manipulation and utilization, and brood habitat and foods.

Hopefully, this symposium will generate questions and challenges for biologists and managers throughout ruffed grouse range.

Several important topics relating to grouse management will be discussed today: As grouse hunting increases in popularity each year, what effect does this increased pressure, especially in intensively hunted areas, have on short and long term trends in grouse populations? Do later seasons affect reproduction? How important is aspen *(Populus* spp.*)* in the southern latitudes? What techniques exist for censusing production prior to fall hunting seasons? Do we need to manage specifically for brood habitat?

Of special interest to me, is the grouse restoration work in several midwestern states. What are the procedures involved in ruffed grouse trapping, holding, shipping, and restocking? What are the administrative costs involved? What kind of success can be expected? Wildlife professionals, with support of sportsmen and women, have done a tremendous job with the reintroduction of deer and wild turkeys in North America. We are now focusing our attention on ruffed grouse.

You will undoubtedly have additional questions. As we proceed today, please hold them until the end of each talk. Then, as you are recognized, please be sure to come to the nearest microphone and before stating your question, please give the audience your name and affiliation. We are ready to proceed.

Ruffed Grouse Population Indices from Iowa

Terry W. Little, Iowa Conservation Commission, Wildlife Research Station, Boone, IA 50036

Abstract: Little is known about long-term population trends or annual fluctuations of ruffed grouse *(Bonasa umbellus)* in the southern portion of their Midwestern range, because of their relatively minor status as a game bird. This paper describes spring and fall grouse population indices and hunter success in Iowa, and compares them to similar data from 4 grouse populations in Minnesota and Wisconsin. Spring roadside drumming indices (DI) from 10 routes in northeast Iowa averaged $1.6 \pm .08$ (SE) drums per stop for 1961-1978. DI's for northern Minnesota (1.9 ± 0.2), northern Wisconsin ($1.5 \pm .14$), southern Minnesota ($2.1 \pm .14$), and southern Wisconsin ($1.7 \pm .10$) were similar to Iowa's DI during the same years, but were more variable. Peak values of the DI were recorded in 1971-1973 in all regions, but the 10-year "cyclic" trends apparent from the other states were only weakly expressed in Iowa. A fall flushing index (FI) averaged 1.3 ± 0.1 flushes per hunter-hr and a productivity index (PI) averaged 1.7 juvenile hens per adult hen for 1969-1978, based on grouse wings and tails returned by cooperating hunters. Both fall indices varied substantially between years without apparent long-term trends. There were few significant correlations between spring and fall indices for 1969-1978, but peak values of the FI and PI preceded peak values of the DI. Few correlations were found between December-March precipitation, snow depths or temperatures and the following DI, FI or PI; or between April-August precipitation and temperature and the following FI or PI. The red color phase comprised 71% of all grouse tails returned by cooperators. Age ratios constructed from wings and tails indicated a 58% average annual mortality rate existed for 1969-1978. The relationships observed between population indices suggest that recruitment plays a greater role in determining fall population levels in Iowa than shifts in numbers of breeding grouse, and that overwinter survival is relatively stable.

Ruffed grouse have the most extensive distribution of any North American upland game bird, ranging from Alaska to the southern Appalachians, with the center of their current distribution in the Great Lakes states and southern Canada (Johnsgard 1973). In this region, their status as the most important upland game bird has resulted in extensive and intensive studies of population trends (e.g., Berg 1978, Gullion 1966, Kubisiak et al. 1980, Thompson and Moulton 1981), and dynamics (e.g., Dorney and Kabat 1960, Gullion 1970, Rusch and Keith 1971). Although the center of their original distribution was probably farther south (Leopold 1931), loss of habitat in the lower Midwest led to their extirpation or greatly reduced their numbers throughout Ohio, Illinois, Indiana, Iowa, Missouri, and elsewhere. They are of relatively minor importance to hunters in these states, and little is known of population trends or dynamics (Stoll 1980).

The Iowa Conservation Commission has conducted annual ruffed grouse breeding population surveys from 1961 through 1978 and hunter surveys from 1969 through 1978. This paper reports population indices derived from these surveys and compares them with population trends in more intensively studied northern populations in the Midwest.

This study was funded by the Iowa Conservation Commission and Federal Aid to Wildlife Restoration Project W-115-R. E. Klonglan, H. L. Gladfelter, and R. Sheets coordinated early survey efforts. D. Hackbarth, K. Varland, G. Zenner, and D. White processed survey materials. Most spring survey information was collected by wildlife biologists and conservation officers residing in grouse range. More than 400 individuals voluntarily returned fall survey materials. J. Kienzler and J. Strotman assisted with statistical analysis. S. Monen typed several drafts of the manuscript.

Iowa lies on the southwestern fringe of continguous ruffed grouse range in the upper Midwest (Johnsgard 1973:258). Ruffed grouse were once found throughout the State, but forest clearing and overgrazing eliminated them from most habitats by 1930 (Klonglan and Hlavka 1969). Except for an experimental transplant to southern Iowa (Little and Sheets 1982), remnant grouse populations are restricted to portions of 8 counties in the unglaciated northeast corner of the state.

Topography in the 3 extreme northeastern counties, which constitute primary grouse range, is characterized by deep, narrow, V-shaped stream valleys and long, narrow, angular ridges (Prior 1976). Maximum relief approaches 100 m. Ridgetops and flat alluvial valleys have been cleared for agriculture and timber is restricted to steep, rocky slopes.

Habitats within primary grouse range are not uniform in distribution or quality. Just 17% of these counties is forested; 85% of the forest land is in pole or sawtimber, dominated by oak-hickory (47%), elm-ash-cottonwood (27%) and maple-basswood (19%) forest types (Ostrom 1976). Aspen (1%), red cedar-hardwoods (2%) and unstocked shrublands (4%) are minor types found in restricted ecological situations. As a result, grouse tend to be patchily distributed and are associated primarily with early successional oak-hickory stands or field-forest edges (Porath and Vohs 1972, Polderboer 1940).

Grouse densities appear to be low as a result of overgrazing, advanced forest succession, and little management of habitat to benefit grouse on either public or private land. Klonglan and Hlavka (1969) estimated rangewide grouse numbers at 4000 in the spring and 12,000 in the fall based on extrapolations from spring surveys, but subsequent harvest information suggests this was conservative.

The first modern grouse hunting season was held in 1968. The season has gradually been lengthened from 18 to 116 days with a bag limit of 3 daily and 6 in possession. Current seasons run from early October to the end of January. In spite of liberal seasons, grouse hunting is not popular in Iowa. Less than 20% of the approximately 275,000 resident upland game hunters pursue grouse, and estimated annual harvests of 9000-24,000 grouse are less than 5% of the State's ring-necked pheasant kill (ICC unpublished data).

METHODS

Spring grouse populations were surveyed from 1961 to 1978 by roadside drumming counts (Petraborg et al. 1953). Ten permanently marked routes, spanning 80% of the primary ruffed grouse range, were surveyed once annually between 15 April and 10 May. The number of "drums" and individual grouse heard were counted in 4-min intervals at 15 stops spaced at least 0.8 km (0.5 mi) apart. Counts were begun 45 min before and completed 2 hr after sunrise on calm, clear mornings. These survey conditions were essentially the same as recommended by Rodgers (1981) for similar habitat and topography in southwestern Wisconsin. A weighted mean number of drums heard per stop was calculated as an annual drumming index (DI).

Intensive searches for drumming males were made on the 154 ha Little Paint Creek (LPC) study area in Yellow River State Forest from 1967 to 1978 as a check on the drumming index (Porath and Vohs 1972). The number of drummers on the study area was determined by checking known drumming logs in established activity centers and searching for actively drumming males (Gullion 1967).

A list of hunter cooperators was established by personal contacts and appeals through the media to obtain information on fall grouse populations and hunting conditions. From 1969 through 1978, each cooperator was supplied with leakproof, postage-paid envelopes, and was asked to return a wing and the tail from each grouse shot. A questionnaire on the envelope provided information on party size, grouse flushed and bagged, and hunter behavior. A flushing index (FI = mean grouse flushed per hunter-hr for all hunting parties) was calculated as an index to fall grouse populations.

Measurements of the central rectrix and 8th and 9th primaries (Gullion 1964) from hunter-shot wings were used to develop aging and sexing criteria for Iowa ruffed grouse (ICC, unpublished data). Using these criteria, the number of grouse in 4 age and sex groups was calculated annually — juvenile males and females (hatched the previous summer) and, adults of both sexes (at least 1½ yr old). A productivity index (PI = juvenile hens/adult hen in the wing and tail samples) was used to estimate annual variations in recruitment.

The color phase of each grouse tail returned by hunters was determined using a reference set supplied by G. W. Gullion (unpublished data). Grouse were assigned to 1 of 4 color phases ranging from primarily gray to nearly pure rufous. Gray, intermediate, brown and red tails are arbitrary classifications of a continuum in color and represent increasing proportions of red in the fields between bands.

I used ANOVA to test for annual differences in the 3 population indices, (DI, FI, and PI), and multiple regression to compare trends in DI's from Iowa with DI's from northern and southern regions of Minnesota (Berg 1978) and Wisconsin (Thompson and Moulton 1981). Log transformations were used to stabilize variances and reduce interactions in these analyses. Nonparametric tests for trend (Conover 1971) were used to examine trends in hunter-related variables and demographic parameters. Linear regressions were used to examine the relationship between population indices and the following standard weather parameters: winter (December-March) and summer (May-August) monthly and seasonal mean temperatures and total precipitation, departures of means and totals from 20-year normals, heating (winter) and cooling (summer) degree days, days with $\geq$ 2.5 cm (1 in) precipitation, and days with $\geq$ 2.5 cm snow cover and $\geq$ 18 cm (7 in) snow cover (minimal for snow roosting).

RESULTS AND DISCUSSION

Drumming Indices

The assumption implied in analyses of drumming indices is that changes in the indices reflect population changes. Population indices, their statistical properties and the assumptions involved have been discussed by Eberhardt (1978). He points out that models for most indices are not known, but are assumed by most authors to be linear (i.e., additive) without any evidence to substantiate this assumption. There is disagreement in the literature on the relationship of drumming activity to ruffed grouse population levels. Aubin (1972), Archibald (1976), and Rodgers (1981) have shown that stimulation between drummers can increase drumming frequency when densities of drummers is high (i.e., a multiplicative relationship can exist). Ammann and Ryel (1963) found little correlation between drumming and other indices in Michigan. Rodgers (1981) found, however, that drumming trends paralleled trends in total numbers of males in the population Gullion (1966) in Minnesota and Stoll (1980) in Ohio reported good correlations between drumming levels and grouse harvests, and Thompson and

Moulton (1981) reported drumming trends were correlated with several other population indices in Wisconsin. Gullion (1981) found that numbers of drumming and nondrumming males were directly proportional. Most information suggests that drumming counts are sufficiently sensitive to measure the major changes which occur in grouse breeding populations.

Not all drumming routes were surveyed every year and no surveys were conducted in 1966 because of continuously inclement weather. To minimize the impact of missing routes in some years, DI's were calculated for all routes and 6 "best" routes that were surveyed every year except 1966. The DI and number of individual drummers heard per stop were correlated ($\hat{p}<0.01$) for both sets, so only the DI was used in further analyses.

Table 1. Drumming index values (mean "drums" heard per stop) for ruffed grouse roadside drumming routes in northeast Iowa, 1961-1978.

Route	Drumming index	Years surveyed
Upper Iowa	2.2 ± 0.3^{b}	17
Highlandville	2.0 ± 0.2^{b}	17
Village Creek	2.0 ± 0.2^{b}	17
Yellow River Forest	2.0 ± 0.2^{b}	17
Yellow River-Sixteen	1.7 ± 0.4	13
Harper's Ferry	1.5 ± 0.2	14
Bloody Run	1.0 ± 0.2	15
Sny Magill	0.7 ± 0.1^{a}	17
Buck Creek	0.6 ± 0.1	13
Frankville	0.5 ± 0.1^{a}	17
All routes	1.6 ± 0.2	

[a,b]Means with common superscripts were not significantly different ($\hat{p}>.05$). Only the 6 routes surveyed each year were compared in this analysis.

There were significant differences in the weighted mean DI's for the 6 best routes pooled over 17 yr (Table 1). The 4 routes that averaged >2.0 drums/stop were about half as variable (CV = 99.7) as 2 routes which averaged <1.0 drums/stop (CV = 180.3). The between-route variation was presumably caused by quantitative and qualitative differences in habitats adjacent to routes, and topography, which affects the audibility of drumming (Rodgers 1981).

Similar annual changes were seen in the mean annual DI's for all routes and the routes run every year, but fluctuations were damped in the all-routes index (Table 2). The mean annual DI for the best routes ranged from 1.0 to 2.2 drums/stop, but substantial variation prevented the detection of significant differences between years ($\hat{p}>0.9$) when route effects were held constant. Large percentage changes in the DI between years appeared to be an artifact of small absolute index values. There were no detectable increasing or decreasing trends in annual DI's over the 17-yr. period ($\hat{p}>0.8$).

Table 2. Indices to spring breeding populations of ruffed grouse in northeast Iowa. Table values are the annual drumming index and the actual number of drumming males located on the Little Paint Creek Study Area.

	Drumming index				Drumming
Year	All routes	% Δ	Best routes[a]	% Δ	males
1961	1.2±0.2	—	1.3±0.2	—	—
1962	1.2±0.2	0	1.2±0.2	- 8	—
1963	1.6±0.2	+33	1.7±0.2	+29	—
1964	1.1±0.1	-31	1.2±0.2	-29	—
1965	1.6±0.2	+45	1.9±0.2	+58	—
1966	—	—	—	—	—
1967	1.3±0.2	—	1.8±0.2	—	13
1968	1.3±0.2	0	1.6±0.2	-11	11
1969	1.3±0.2	0	1.6±0.2	0	11
1970	1.4±0.1	+ 8	1.6±0.2	0	12
1971	1.3±0.1	- 7	1.5±0.2	- 7	13
1972	1.6±0.2	+23	2.0±0.2	+33	13
1973	1.9±0.2	+19	2.2±0.2	+10	12
1974	1.6±0.2	-15	1.9±0.2	-14	11
1975	1.2±0.2	-25	1.3±0.2	-32	9
1976	1.6±0.2	+33	1.5±0.2	+15	9
1977	1.2±0.2	-25	1.0±0.2	-33	9
1978	2.2±0.3	+83	1.8±0.2	+80	9

[a]Best route includes only the 6 routes on which counts were made every year.

Iowa's DI compares interestingly with similar indices for the northern and southern regions of Minnesota and Wisconsin during the same years (Fig. 1). Iowa's 17-yr. mean DI is similar to mean indices from both regions of Wisconsin, lower than DI's from both regions of Minnesota, and the least variable of all the DI's examined (Table 3).

Table 3. Descriptive statistics and regression parameter estimates for roadside drumming routes for 5 regions in the Midwest, 1961-78.

	N	Drumming			Parameter estimates[b]	
Region	(yrs)	index	SE	CV	Region	Year
Northern Minnesota	18	1.9	.198	.436	0.54	1.76
Northern Wisconsin	17	1.5	.140	.430	0.21	1.46
Southern Minnesota	18	2.1	.136	.451	0.70	1.10
Southern Wisconsin	17	1.7	.103	.251	0.50	0.42
Northern Iowa	17	1.6	.076	.197	0.45	0.26

[a]Drums per stop.
[b]Regression parameters which estimate the effect of area (additive) and year (multiplicative) on the regional drumming index.

A multiple regression model using transformed DI's from the 5 regions as dependent variables and year (1961-1978) and the 5 regions as independent variables confirmed these differences. No "cyclic" trend common to the 5 regions was detected ($\hat{p} = 0.23$) over the short time span involved (i.e., the DI could not be mathematically predicted from the previous year's DI when regions were pooled in the same model). The model detected differences in DI's between years and regions, but regional DI's changed at different rates between years (i.e., differences between years were multiplicative rather than additive). The regression parameters which estimated the relative annual response in DI's

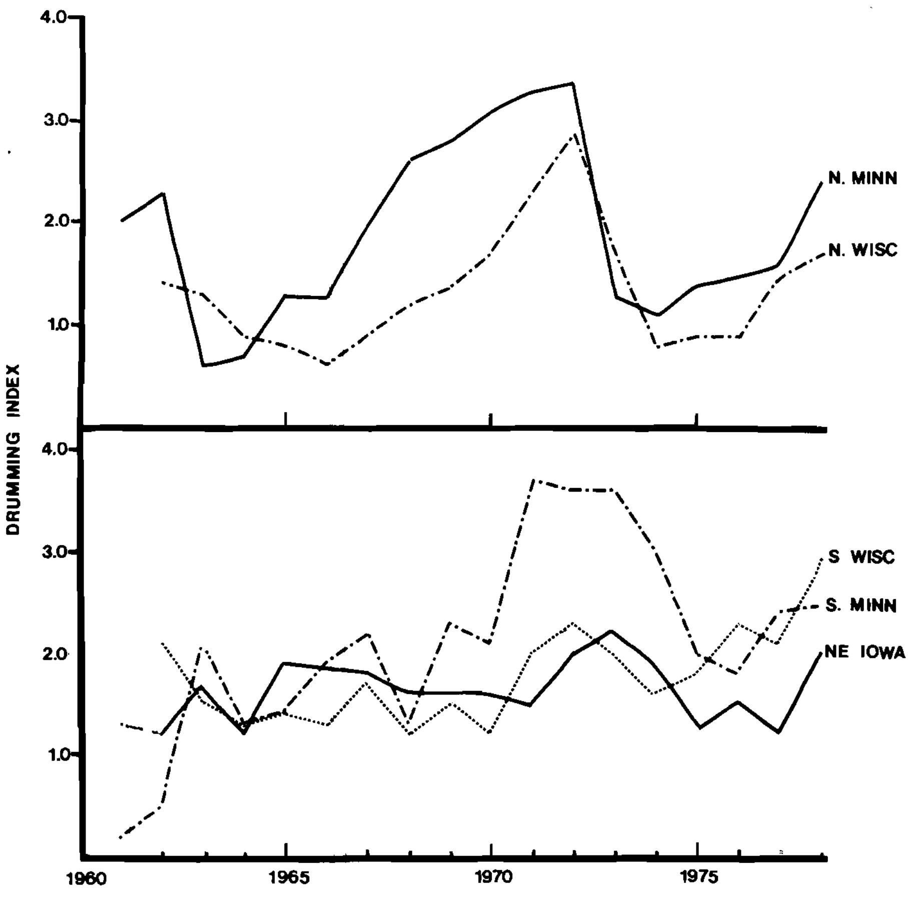

Fig. 1. Ruffed grouse drumming indices (drums/stop on roadside drumming routes) from northern and southern regions of Minnesota and Wisconsin, and from northeast Iowa, 1961-1978.

placed the regions in the same order as the graphical analysis (Fig. 1 and Table 3).

Iowa showed the smallest change between years, about 1/6 of that estimated for the 2 northern regions, with southern Minnesota and southern Wisconsin intermediate. Indices from both northern regions exhibited several years of increase to a peak, an abrupt decline, and then the start of a recovery. The 3 southern regions showed a longer period of variable annual indices, a shorter, rapid increase, and then 2 or 3 years of peak counts followed by less catastrophic declines. Although trends are weakly expressed in Iowa and southern Wisconsin, peak drumming indices were recorded in all regions in 1971-1973.

Densities of drumming males on the LPC area ranged from 5.8-8.5 drummers/100 ha (2.3-3.4 drummers/100 acres) and varied ≤25% between peak and low years (Table 2). The number of drummers found decreased from 1972 to 1978, due to circumstances unrelated to rangewide population trends. Several activity centers occupied from 1967 to 1971 no longer appeared suitable by 1975, because of secondary forest succession into poletimber stages. Less effort was spent on searches after 1972, when intensive studies were halted; since then only known activity centers have been checked. This reduced the chances that new activity centers would be found as old ones were abandoned. I think the apparent decline is an adjustment to the reduced searching effort and actually represents fairly stable numbers of drummers on this area. Even though the LPC area is smaller than recommended by Gullion (1966) for survey purposes, the relative stability in numbers of drumming males seems consistent with rangewide drumming indices.

Densities of drumming males on the LPC area were within the range of 2.2-10 drummers/100 ha (0.9-4.1 drummers/100 acres) summarized from several studies by Lewis et al. (1968), 1.3-10 drummers/100 ha (0.5-4.1 drummers/100 acres) in Wisconsin (Kubisiak et al. 1980) and 10-16.7 drummers/100 ha (4.1-6.8 drummers/100 acres) in Minnesota (Gullion 1969). Peak to low fluctuations of about 50% were much less than the 88-240% changes averaged from several northern populations (Keith 1963, Gullion 1970, Kubisiak et al. 1980).

Fall Indices

Problems associated with hunter-cooperator surveys are well known; only avid hunters participate, unsuccessful hunts tend to go unreported, and hunter effort and success are probably overestimated if the data are expanded to include all hunters. Data collected from the same sample of hunters should be useful in comparing annual fluctuations in parameters, however, if a constant bias is assumed.

Annual and 10-yr means for hunting related variables calculated from hunter questionnaires are presented in Table 4. The average party of 2.5 hunters hunted just 4.2 hr/day, flushed about 12 grouse, or 1.3 grouse/hunter-hr, and bagged 1

Table 4. Characteristics of ruffed grouse hunting trips and grouse bagged in Iowa, as reported by hunter cooperators. Table values are totals and mean values ±SE.

Parameter	Year 69	70	71	72	73	74	75	76	77	78	Total and average
Parties[a]	26	74	89	85	79	46	81	104	145	110	847
Hunter/party	3.2	1.4	2.8	2.3	2.7	2.0	2.4	2.4	2.1	2.2	2.5±.1
Hours hunted/day	4.1	4.1	4.3	3.8	4.5	3.7	4.6	5.6	3.8	3.7	4.2±.1
Flushes/party	12.4	8.2	15.1	15.4	12.4	12.4	11.5	11.4	10.2	9.8	11.9±.7
Flushing index[b]	1.1	0.9	1.2	1.9	1.2	1.5	1.1	1.0	1.5	1.2	1.3±.1
Grouse bagged/hunter	1.0	0.8	1.0	1.4	1.0	1.7	1.3	1.1	0.8	0.9	1.0±.1
Grouse bagged/hunter-hr	0.3	0.2	0.3	0.4	0.2	0.4	0.3	0.3	0.3	0.2	0.3±.02
Grouse bagged/flush	0.3	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.2	0.2	0.2±.01

[a]Number of parties providing information on all variables.

[b]Flushing index = Total flushes ÷ (No. of hunters x hours hunted).

Table 5. Characteristics of ruffed grouse bagged in Iowa, as reported by hunter cooperators. Table values are totals and mean values ±SE.

Age-sex composition	Year 69	70	71	72	73	74	75	76	77	78	Total and average
Number examined	52	91	167	175	137	113	179	193	40	131	1,278
Adult male (%)	21	24	18	17	24	23	24	21	20	18	22
Juvenile male (%)	17	21	19	26	21	27	23	24	23	32	24
Adult hen (%)	23	21	15	18	23	21	28	16	20	15	20
Juvenile hen (%)	38	34	30	40	32	29	25	39	38	35	34
Productivity index[a]	1.7	1.6	2.0	2.3	1.4	1.4	0.9	2.5	1.9	2.3	1.7

[a]Juvenile hens per adult hen.

grouse per hunter per day. About 5 flushes were required/grouse bagged. There were no detectable increasing or decreasing trends in any variable except party size, which tended to decrease. The only statistically significant change between years which could be detected for any variable was for the flushing index

Table 6. Composite tail color composition of hunter-shot ruffed grouse from northeast Iowa, 1968-78. Table values are the percentage of N in each color phase.

		Color phase[a]			
	N	Gray	Intermediate	Brown	Red
Male					
Adult	273	18	10	8	65
Juvenile	306	18	16	6	60
All males	579	18	13	7	63
Female					
Adult	199	20	6	1	73
Juvenile	348	20	8	3	69
All females	547	20	7	2	71
All grouse	1,126	19	10	5	66

[a]Split-phase females (hens with central rectrices darker than the rest of the tail) are included in the color phase group predominant in the entire tail.

($\hat{p}<0.0001$). The 1972 FI was greater than all years except 1974, but 1974 was not significantly different from all other years. The FI in 1972 was 26% greater than 1974; thus, this survey would seem to require more than a 26% difference before an annual change in populations could be inferred. Flushing rates also peaked in Ohio in 1972, with a similar increase of 25% over the next highest year (Stoll 1980). If the FI is an accurate trend indicator, fall grouse populations would seem to be as stable as spring populations appear to be.

Sex ratios of adults were not different from 50:50 (Table 5), but there were fewer juvenile males than expected and more juvenile females ($\hat{p}<0.01$). The PI appeared to increase from 1968 to 1972, decrease through 1975, and then increase from 1976 to 1978. Juveniles comprised 58% of all grouse returned by hunters, which should approximate the average annual fall-to-fall mortality rate if populations are stable and all segments are equally vulnerable to hunting. Dorney and Kabat (1960) found juveniles were more vulnerable to road hunting than adults, with little bias introduced when hunters walked in timber. Road hunting is virtually nonexistent in Iowa.

Major and Olson (1980) and Stoll (1980) reported 50-61% juveniles in hunter's bags in Indiana and 50-58% in Ohio, respectively. These authors cite several studies which show higher productivity in northern states (65-75% juveniles) than in southern grouse ranges (45-55% juveniles). The estimated survival rate of 42% is slightly lower than estimates of 44-50% for drumming males in northern populations (Theberge and Gauthier 1982, Kubisiak et al. 1980, Gullion and Marshall 1968, Dorney and Kabat 1960).

Composition of hunter-shot grouse showed a prevalence of red-phase birds (Table 6). Slightly more than 2/3 of all tails examined were in the red or brown phases; no differences could be detected between age-sex segments or years ($\hat{p}>0.1$). The ubiquity of red-phase grouse in Iowa agrees with the north-south cline in color phases from predominately gray to predominately red, described by Aldrich and Friedmann (1943) and Gullion and Marshall (1968).

Relationships Between Surveys

There were few obvious relationships between spring and fall population indices (Table 7). Linear correlations were weak between the DI and FI or PI from the same year, and between fall indices. The best correlation was between the FI and the next spring's DI. Similar trends were apparent in all 3 indices from 1969 to 1974, however, when values of the DI appeared to be increasing to a peak and then declining (Fig. 2). All correlations were stronger during this period, with the strongest between fall indices and the next year's DI. If these relationships are real, recruitment to fall populations would be independent of spring drumming activity, and overwinter survival should be relatively constant from year to year.

There is little evidence of relationships between weather parameters and population indices which might substantiate or refute this hypothesis. There was an

Table 7. Correlation matrices for ruffed grouse population indices from northeast Iowa. Table values are linear correlation coefficients (probabilities of a larger r) for the drumming (DI), flushing (FI), and productivity (PI) indices.

	1969-1978				1969-1974		
	FI	PI	DI (yr + 1)[a]		FI	PI	DI (yr + 1)
DI	.232	.038	—	DI	.515	.204	—
	(~0.5)	(>0.5)			(0.3)	(>0.5)	—
FI	—	.212	.564	FI	—	.543	.867
		(>0.5)	(.09)			(0.3)	(.05)
PI	—	—	.077	PI	—	—	.687
			(>0.5)				(0.2)

[a]Drumming index in the next spring

inverse relationship between February temperatures and DI's ($r = -0.489$, ($\hat{p} = 0.05$) and between July temperatures and PI's ($r = -0.590$, $\hat{p} = 0.07$). No other monthly or seasonal variables were remotely correlated with any index ($\hat{p}>0.2$).

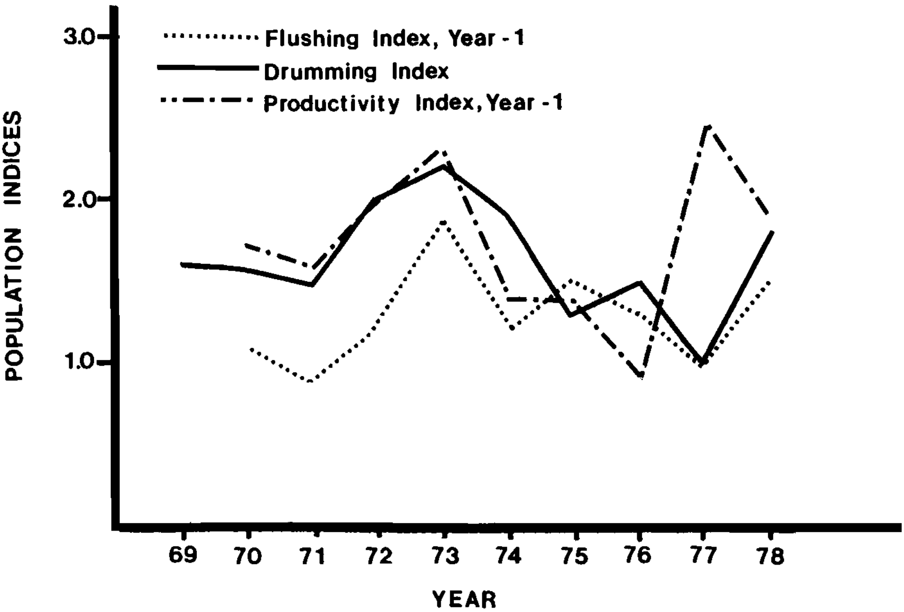

Fig. 2. Relationship between ruffed grouse population indices from northeast Iowa, 1969-1978. Fall flushing and productivity indices are compared to the following spring by shifting fall indices ahead 1 yr.

The lack of correlation between winter weather and spring DI's may not be surprising considering winter weather conditions in Iowa. An average of just 23 nights/yr. had sufficient snow depths for burrow roosting during the 17-yr. period (range = 0 - 72). Average maximum and minimum temperatures °C (°F), for northeast Iowa are, respectively, −3 and −12 (27.3 and 11.1) (January), −1 and −10 (30.2 and 13.8) (February), and 5 and −5 (40.6 and 23.2) (March) (Shaw and Waite 1964). Daily thawing and nighttime freezes are a common occurrence throughout much of the winter and hard snow crusts are often formed, reducing the quality of snow for roosting on many of the few nights sufficient depths are available. Above normal winter temperatures which cause poor snow roosting conditions have been associated with declining grouse populations in several northern studies (Larsen and Lahey 1958, Dorney and Kabat 1960, Gullion 1970, and Kubisiak et al. 1980), but no such relationship was found in my study.

Poor recruitment to ruffed grouse populations has usually been related to wet, cool summers (Bump et al. 1947, Ritcey and Edwards 1963, Dorney and Kabat 1960). I have no explanation why the inverse seemed to be true in Iowa, unless summers warm enough to stress chicks are more prevalent than the wet, cool springs which may reduce productivity in northern regions.

Placing results of Iowa's ruffed grouse population surveys in perspective with what is known of ruffed grouse ecology is difficult for several reasons. Results of short-term studies on widely fluctuating northern populations may be influenced by interactions between population levels and dynamics, while population data of any kind is sparse from southern grouse ranges. Extensive survey data, where available, often lacks the intensive research data needed to test assumptions; the inherent variability of indices generally makes statistical validation difficult or impossible; and comparing indices from different regions may be misleading if different index:parameter relationships exist.

Taken at face value, indices to population parameters for Iowa ruffed grouse tend to fall somewhere between what is known about northern and southern grouse populations. Long-term mean breeding populations seem similar to northern populations, but are more stable. A minor peak and decline in spring population indices from 1969 to 1974, corresponding to peaks in northern populations, was accompanied by more juveniles in the bag and more flushes per hunter-hour in the preceding fall, but trends were weakly expressed. Survival and productivity seem intermediate to northern and southern populations. Weather may play a different role in grouse ecology in southern environments than is generally understood for northern regions. The advantages of milder winters may be offset in part by the lack of suitable snow for burrow roosting in most years. Hot summers may have the same effect on recruitment that cool, wet summers have farther north. In light of the many problems just discussed, however, these statements should serve primarily as hypotheses to stimulate research rather than as a basis for management decisions.

LITERATURE CITED

Aldrich, J. W. and H. Friedmann. 1943. A revision of the ruffed grouse. Condor 45:85-103.

Ammann, G. A. and L. A. Ryel. 1963. Extensive methods of inventorying grouse in Michigan. J. Wildl. Manage. 27:617-633.

Archibald, H. L. 1976. Spring drumming patterns of ruffed grouse. Auk 93:808-829.

Aubin, A. E. 1972. Aural communication in ruffed grouse. Can. J. Zool. 50:1225-1229.

Berg, W. 1978. Ruffed grouse drumming survey, spring 1978. Minn. DNR Wildl. Res. Job Proj. Rpt. 11pp.

Bump, G., R. W. Darrow, F. C. Edminster and W. F. Crissey. 1947. The ruffed grouse: life history, propagation, management. New York State Conserv. Dept. Holling Press, Inc. Buffalo. 915pp.

Conover, W. J. 1971. Practical nonparametric statistics. J. Wiley and Sons, Inc., N.Y. 462pp.

Dorney, R. S. and C. Kabat. 1960. Relationship of weather, parasitic disease and hunting to Wisconsin ruffed grouse populations. Wisc. DNR Tech. Bull. 20. 64pp.

Eberhardt, L. L. 1978. Appraising variability in population studies. J. Wildl. Manage. 42:207-238.

Gullion, G. W. 1964. Evaluation of food, cover and other grouse management practices. Minn. Div. Game Fish, Quart. Prog. Rpt. 24:26-137.

_____. 1966. The use of drumming behavior in ruffed grouse population studies. J. Wildl. Manage. 30:717-729.

_____. 1967. Selection and use of drumming sites by male ruffed grouse. Auk 84:87-112.

_____. 1969. Aspen-ruffed grouse relationships. Unpubl. paper. Midwest Fish Wildl. Conf. St. Paul, MN

_____. 1970. Factors influencing ruffed grouse populations. N. Am. Wildl. Nat. Resour. Conf. Trans. 35:93-105.

_____. 1981. Nondrumming males in a ruffed grouse population. Wilson Bull. 93(3):372-382.

_____, and W. H. Marshall. 1968. Survival of ruffed grouse in a boreal forest. The Living Bird 7:117-167.

Johnsgard, P. A. 1973. Grouse and quails of North America. University of Nebraska Press. Lincoln. 553pp.

Keith, L. B. 1963. Wildlife's ten-year cycle. Univ. Wisconsin Press. Madison. 201pp.

Klonglan, E. D. and G. Hlavka. 1969. Recent status of ruffed grouse in Iowa. Ia. Acad. Sci. Proc. 76:231-239.

Kubisiak, J. F., J. C. Moulton and K. R. McCaffery. 1980. Ruffed grouse density and habitat relationships in Wisconsin. Wisc. DNR Tech. Bull. 118. 16pp.

Larsen, J. A. and J. F. Lehey. 1958. Influence of weather upon a ruffed grouse population. J. Wildl. Manage. 22:63-70.

Leopold, A. 1931. Report on a game survey of the north central states. Sporting Arms and Ammunition Manuf. Inst. Madison. 299pp.

Lewis, J. B., J. D. McGowan and T. S. Baskett. 1968. Evaluating ruffed grouse reintroduction in Missouri. J. Wildl. Manage. 32:17-30.

Little, T. W. and R. Sheets. 1982. Transplanting Iowa ruffed grouse. Ia. Acad. Sci. Proc. 89:172-175.

Major, P. D. and J. C. Olson. 1980. Harvest statistics from Indiana's ruffed grouse hunting seasons. Wildl. Soc. Bull. 8:18-23.

Ostrom, A. J. 1976. Forest statistics for Iowa, 1974. USDA For. Serv. Resour. Bull. NC-33. 25pp.

Petraborg, W. H., E. G. Wellein and V. E. Gunvalson. 1953. Roadside drumming counts, a spring census method for ruffed grouse. J. Wildl. Manage. 17:292-295.

Polderboer, E. G. 1940. The cover requirements of the eastern ruffed grouse, *Bonasa umbellus L.* in northeast Iowa. Unpubl. M.S. thesis. Ia. State Univ. Ames. 50pp.

Porath, W. R. and P. A. Vohs, Jr. 1972. Population ecology of the ruffed grouse in northeast Iowa. J. Wildl. Manage. 36:793-802.

Prior, J. C. 1976. A regional guide to Iowa land forms. Ia. Geol. Surv. Educa. Series 3. 72pp.

Ritcey, R. W. and R. Y. Edwards. 1963. Grouse abundance and June temperatures in Wells Gray Park, British Columbia. J. Wildl. Manage. 27:604-606.

Rodgers, R. D. 1981. Factors affecting ruffed grouse drumming counts in southwestern Wisconsin. J. Wildl. Manage. 45:409-418.

Rusch, D. H. and L. B. Keith. 1971. Seasonal and annual trends in numbers of Alberta ruffed grouse. J. Wildl. Manage. 35:803-822.

Shaw, R. H. and P. J. Waite. 1964. The climate of Iowa III. Monthly, crop season and annual temperature and precipitation normals for Iowa. Agric. and Home Ec. Expt. Sta. Spec. Rpt. No. 38.

Stoll, R. J., Jr. 1980. Indices to ruffed grouse hunting success in Ohio. Wildl. Soc. Bull. 8:24-28.

Theberge, J. B. and D. A. Gauthier. 1982. Factors influencing densities of territorial male ruffed grouse, Algonquin Park, Ontario. J. Wildl. Manage. 46:263-268.

Thompson, D. R. and J. C. Moulton. 1981. An evaluation of Wisconsin ruffed grouse surveys. Wisc. DNR Tech. Bull. 123. 14pp.

Ruffed Grouse Restoration in Missouri

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Abstract: Following near extinction in Missouri by the 1930's, and subsequent improvement of forest habitat, ruffed grouse *(Bonasa umbellus)* live-trapped in 7 other states were released in several locations in the state, beginning in 1959. Breeding densities of grouse populations descendent from released birds in the early 1980's ranged from 3.5-9.3/100 ha (1.3-3.7/100 acres). Best results were obtained when juvenile grouse stocked were >13 weeks old. Habitat regularly used by reestablished grouse consisted of stem densities averaging 11,051 ha (4472/acre) of woody plants >1m tall, with drumming log sites having slightly higher stem densities. Such stem densities resulted from old field invasion and selection cuts. Failure of grouse to become established in certain areas is attributable to inadequate habitat, specifically low stem densities. In 1983, the first hunging season on ruffed grouse in Missouri since 1905 resulted in the sale of 2917 permits with 1779 persons actually hunting, and a kill of 173 birds.

Missouri is on the southern periphery of the historical ruffed grouse *(Bonasa umbellus)* range in North America (Bump et al. 1947). Little is known of grouse populations prior to settlement, but they were probably limited to ecotones, and early successional areas created by natural and Indian-related disturbances (Hunyadi 1978).

Following settlement, grouse became locally abundant (Lewis et al. 1968) and in some areas populations erupted as mature forests were altered. The continuous process of clearing and abandoning homesteads created extensive grouse habitat. McKinley (1960:4) related a report by a Missouri pioneer who, in 1830, wrote that the "woods pheasant has followed the settlers, and multiplied greatly in the country within the last five years." Grouse were hunted commercially, and sold for $2.75 to $3.00 per dozen in St. Louis in 1878.

Shortly after the turn of the century, about half of Missouri's 32 million acres of forest lands had been cleared. Much of the remainder was burned regularly and severely overgrazed (Lewis 1971). Forest habitat was seriously depleted and grouse numbers declined drastically. Grouse hunting was prohibited in 1905, with little or no effect on grouse numbers. McKinley (1960:9) observed, "No animal the size of the ruffed grouse could be expected to persist among a rural population that was dense yet dispersed, universally armed, food-centered, and not naturally respectful towards laws."

Leopold (1931) reported grouse to be present in only 9 Missouri counties in the early thirties. Bennitt and Nagel (1937), in their resident game survey, estimated fewer than 100 birds statewide, in 1934. In spite of widespread habitat destruction and dangerously low numbers, some grouse did survive in small pockets of isolated habitat (Lewis et al. 1968).

Forest wildlife habitat in Missouri did eventually improve, as burning and grazing of forests were controlled, farms were abandoned for city life, and as forest lands came under professional management by the United States Forest Service (USFS) and the Missouri Department of Conservation (MDC). Consequently, the white-tailed deer *(Odocoileus virginianus)* and eastern wild turkey *(Meleagris gallopavo silvestris)* have been successfully restored in the state (Lewis 1971, Murphy 1965).

In response to the greatly improved forest habitat conditions, the Missouri Department of Conservation, following two earlier failures, began another experimental ruffed grouse release in 1959. This attempt was successful, and eventually resulted in a full-time grouse restoration project. The objectives of this paper are to review grouse restoration efforts in Missouri, methods of conducting releases, and results of the restoration program. I thank N. F. Giessman, J. B. Lewis, P. D. Major, W. R. Porath, and A. Woolf for reviewing this paper.

EARLY RESTORATION EFFORTS

A first attempt in 1940-43 to reestablish ruffed grouse in Missouri failed. Wild-trapped birds from central Wisconsin were released on three southern Ozark refuges; Indian Trail (26 birds), Deer Run (81), and Caney Mountain (57) (Lewis et al. 1968). The reasons for failure are unknown, as follow-up evaluations were not done. It is likely, however, that forest wildlife habitat had not yet recovered from the land abuse of the early 1900's.

Plans for a second restoration effort in the early 1950's were to release pen-reared chicks from wild-trapped brood stock. This project was conducted in cooperation with the Missouri Quail Hunters Association who provided their bobwhite quail *(Colinus virginianus)* rearing facilities. Many problems were encountered and no young birds were released. The project was terminated in July 1951, when the surviving 13 adult grouse, all in poor condition, were released in St. Charles County. These birds quickly disappeared (MDC, unpublished reports).

RUFFED GROUSE RESTORATION PROJECT

Ruffed grouse restoration was reinitiated in 1959. Experimental releases were

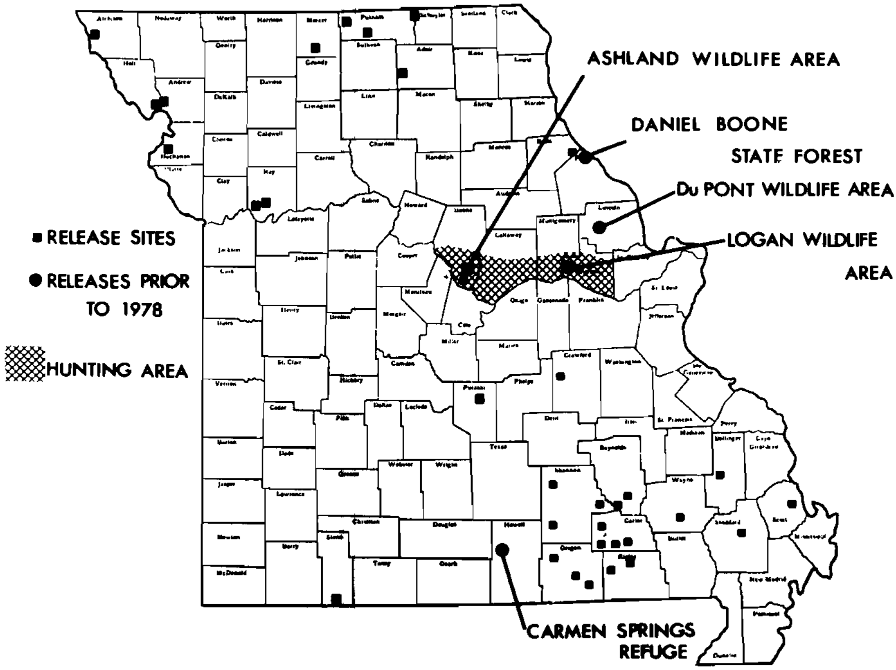

Fig. 1. Location of ruffed grouse releases and hunting area in Missouri.

made on the Daniel Boone State Forest, Warren County, and the Ashland Wildlife Area, Boone County (Fig. 1). Both areas, in the Missouri River hills are characterized by narrow ridges, steep slopes, and narrow drainages (Lewis 1971). One of the last authenticated records of grouse prior to the current restoration project was a grouse observed in 1956 on the Boone Forest (Lewis et al. 1968). Further references to the grouse restoration project refer only to those efforts beginning in 1959.

One hundred forty-three grouse were released on the Boone Forest, and 119 on the Ashland Area from 1959 to 1963 (Table 1). These birds were all obtained through wild turkey trades with Ohio and Indiana. Ohio provided all but the last 17 birds released on the Ashland Area.

Additional releases of 240 grouse from Indiana and Iowa were made on 3 other areas from 1963 to 1966 (Table 1). These releases were also experimental, in that insufficient time had elapsed to determine the success of the Boone Forest and Ashland Area releases.

Initial evaluation of grouse releases was by winter track counts, flushing records, roost locations, and annual surveys of drumming logs in the release vicinity. Lewis (1971) reported grouse had been successfully reintroduced, based

Table 1. Ruffed Grouse Releases in Missouri 1959-1983.

Area	County	Year	Number	Source
Daniel Boone State Forest	Warren	1959	18	Ohio
		1960	63	Ohio
		1961	62	Ohio
			143 Total	
Ashland Wildlife Area	Boone	1959	39	Ohio
		1962	63	Ohio
		1962	17	Indiana
			119 Total	
Carmen Springs Refuge	Howell	1963	70	Indiana
		1964	66	Indiana
			136 Total	
Logan Wildlife Area	Lincoln	1965	38	Indiana
		1966	26	Indiana
			64 Total	
DuPont Wildlife Area	Pike	1965	34	Iowa
		1966	6	Iowa
		1971	35	Minnesota
		1973	22	Minnesota
		1974	19	Minnesota
			116 Total	
Renner Wildlife Area	Boone	1973	15	Kentucky
		1974	18	Kentucky
			33 Total	
Anderson Wildlife Area	Pike/Ralls	1975	82	Wisconsin
		1976	116	Wisconsin
			198 Total	
Castor River State Forest	Bollinger	1978	37	Missouri
		1979	40	Missouri/Ohio/Indiana
			77 Total	
Cardareva (Current R.)	Shannon	1979	77	Missouri/Ohio/Indiana
Leatherwood (Jack's Fork R.)	Shannon	1979	87	Missouri/Ohio/Indiana
Pulltite (Current R.)	Shannon	1979	14	Missouri/Ohio/Indiana
		1980	62	Missouri/Indiana
			76 Total	

Panther Hollow (Eleven Pt. R.)	Oregon	1980	46	Indiana
Hackleton (Eleven Pt. R.)	Oregon	1980	55	Indiana
Becky Hollow (Eleven Pt. R.)	Oregon	1980	14	Indiana
			47	Indiana
			61 Total	
Brickyard Hill W.A.	Atchison	1980	47	Wisconsin
Monkey Mt. W.A.	Holt	1980	56	Wisconsin
		1981	11	Wisconsin
		1981	24	Indiana
			91 Total	
Honey Creek W.A.	Andrew	1980	39	Wisconsin
Rebel's Cove W.A.	Putnam/	1980	57	Wisconsin
	Schuyler	1981	56	Wisconsin
			113 Total	
Peck Ranch W.A.	Carter	1981	85	Indiana
Wappapello Lake	Wayne	1981	82	Indiana
General Watkins S.F.	Scott	1981	81	Indiana
Bluffwoods S.F.	Buchanan	1981	35	Indiana
		1981	21	Wisconsin
			56 Total	
Clearwater S.F.	Reynolds	1982	71	Indiana
White Oak Hollow	Carter	1982	70	Indiana
Compton Creek	Ripley	1982	70	Indiana
Dogwood Canyon	Stone	1982	60	Indiana
Ringer Hill	Stoddard	1982	20	Indiana
Sugar Creek S.F.	Adair	1982	68	Wisconsin
Weldon R.	Mercer	1982	43	Wisconsin
Crooked R.W.A.	Ray	1983	71	Wisconsin/Michigan/ Indiana

Millville	Ray	1983	50	Wisconsin/Michigan/ Indiana
Mineral Hills S.F.	Putnam	1983	77	Wisconsin/Michigan
Locust Creek	Putnam	1983	20	Wisconsin/Michigan
Big Piney R.	Pulaski	1983	70	Wisconsin/Michigan
Deer Run	Reynolds	1983	62	Indiana
Woods W.A.	Crawford	1983	61	Indiana
Cowards Hollow	Carter	1983	62	Indiana
Buffalo Creek	Carter	1983	71	Indiana
Big Barren Creek	Ripley	1983	24	Indiana

on evidence of reproduction and stable numbers of drumming males. The population levels were low, and range extension occurred slowly.

Ruffed grouse releases continued in the early 1970's, with 307 birds released on 3 areas from 1971 to 1976 (Table 1). These releases included birds from Minnesota, Wisconsin and Kentucky.

Research to determine population densities and habitat use was conducted during the 1970's on 3 of the release sites. They showed grouse populations to be increasing on the Daniel Boone Forest (Hunyadi 1978) and the Edward Anderson Wildlife Area (Kurzejeski 1979). On the Carmen Springs Refuge, Titus (1976) reported birds to be present in low numbers, but more common on adjacent Forest Service lands where timber sales had been conducted.

Interest in the ruffed grouse restoration project was also growing in the 1970's. In 1978, existing trades had been completed, and there appeared to be no new trading opportunities. An in-state trapping program was evaluated as a source of birds to continue the restoration program. One hundred one birds were captured from 1978-1980 on and adjacent to the Daniel Boone State Forest.

The ruffed grouse restoration program became a full-time project in 1978, with a goal to restore ruffed grouse to all parts of the native range in Missouri where suitable forest habitat can be found. Approximately 95 of 114 counties in the state (83%) are predicted eventually to have grouse populations.

Opportunities for turkey/grouse trades materialized again in 1979, and have continued. Since 1978, 2043 additional birds have been released, representing 72% of the total 2852 ruffed grouse released on 39 sites in 27 counties since 1959. Releases from 1980 to 1983 have averaged 451 birds per year.

METHODS

Obtaining Ruffed Grouse

Wild turkey/ruffed grouse trades with 7 states have supplied 96.4% of all birds released in Missouri, and is currently the most cost effective method of obtaining grouse. Exchange rates initially were 4 grouse/turkey, and presently are 3 to 1.

Trapping in grouse range within Missouri has proven dependable as a source of ruffed grouse. Traps were unbaited clover leaf (lily-pad) traps, which were checked once daily, near dusk. Trapping rates were one bird per 38.0 trap days in 1978, one per 49.4 days in 1979, and 1 per 23.5 days in 1980.

Six grouse production areas have been designated, which are being managed to create habitat that will provide cost-effective trapping operations. These areas are dispersed within the state, especially in regard to latitude, to minimize the effects of potential low reproduction caused by adverse spring weather.

Release Site Selection

Release site selection is based primarily on habitat quality as defined by 3 habitat evaluation studies (see Results — Habitat Quality). The amount of logging activity in the vicinity is a related selection criterion, as timber cutting is the main factor in creating and maintaining grouse habitat.

The extent of forest lands in the release vicinity, and therefore the dispersal potential, is another important factor in release site selection. All grouse release sites, for this reason, are selected along waterways, usually small rivers or permanent streams that do not dry up during summer. In many north Missouri counties, the only potential grouse habitat is in the remnant timber along streams. In parts of south Missouri, the drainages are equally important, as the uplands are xeric oak-hickory *(Quercus-Carya)* forests that contribute little to grouse habitat.

There are other non-site specific considerations involved in release site selection. Ruffed grouse from the northern states are released in north Missouri, to match ecosystems as closely as possible.

Many releases are spaced apart within a region in anticipation that dispersing grouse from different release sites will meet and establish area-wide populations more quickly. Usually releases are conducted no closer than 16 km (10 mi) from each other.

Release sites are primarily selected on public lands, both state and federal, although private releases are conducted in areas where there are no suitable public lands. The proportions of ruffed grouse released to date by land ownership follows: MDC — 45.5%, USFS — 23.3%, National Park Service — 8.4%, private — 6.8%, University of Missouri — 4.2%, and Corps of Engineers — 2.8%.

These percentages reflect the fact that there is very little federal land in north Missouri. USFS sites received 44.2% of all grouse released in south Missouri, while MDC lands received 29.1% and private ownerships represented 5.3%.

An excellent hypothetical release site in Missouri would occur in a forest compartment under even-aged management, with at least some of the cutting prescribed for the second 10-year period completed. The regeneration cuts would include stands with north and east aspects, and would be adjacent to a permanent stream with bottomland hardwood stands. Additional habitat diversity could be added by such things as timber stand improvement; direct wildlife habitat mangement; old fields in a stage of woody succession; utility right-of-ways; wind thrown trees; forest fires; abandoned homesteads, pastures, and orchards; and small conifer plantations of less than 1 ha (2.5 acres).

Conducting Releases

Ruffed grouse from other states are shipped to Missouri by commercial aircraft. MDC aircraft then transport the majority of the birds as close to the release site as possible, from where they are moved by automobile. Releases are made as early in the day as possible and air conditioned vehicles are used, if necessary, to avoid heat stress. Evening releases, which probably increase risk of predation, are avoided.

Normally 60-70 birds are distributed on 2-4 sites within a 1.6 km (1 mi) radius. Birds are aged, sexed, and banded with Missouri bands at the point of origin. This information, plus physical condition of each bird, as evaluated on site, is recorded at the time of release.

Evaluation of Ruffed Grouse Releases

Release success is monitored primarily by drumming routes and observations of grouse or grouse sign on each site. Drumming routes are done by walking 3.2 km (2 mi) established routes with 4 minute stops at 200 m (1/8 mi) intervals. Cooperators are asked to complete each route 3 times during the last 3 weeks of April.

One person on each release site, usually a local conservation agent, forester, or wildlife biologist, has the responsibility of collecting and plotting all reported sightings of grouse in the release vicinity.

Summer brood survey routes incorporating ruffed grouse chick distress calls (Healy et al. 1980) were also used to monitor releases for 2 years. Data from these surveys have been minimal. They are being continued on 3 release sites to further evaluate the technique.

RESULTS AND DISCUSSION

Ten of 11 releases of ruffed grouse in Missouri between 1959 and 1977 have been successful. The unsuccessful release on the Logan Wildlife Area in Lincoln County (1965-66) is one where follow-up evaluations were not done. (The possible reasons for failure will be discussed in the Conclusions Section.) All of the 28 releases since 1977 appear to be successful, although at least 3 to 5 years are required to evaluate the status of new releases.

Densities of Populations from Successful Releases

Spring breeding populations have been monitored by complete area counts of drumming males on the 1092 ha (2700 acres) Ashland Wildlife Area since 1963. The drumming counts were conducted so that all parts of the study area were visited at least 3 mornings each year. Population densities on the Ashland Area following the 1959-62 release showed an initial increase to 4.9 grouse/100 ha (2 grouse/100 acres) in 1964. The population declined to an average of 1.8 grouse/ 100 ha (0.7/100 acres) in the late 1970's. The spring population in 1983 was 3.5 grouse/100 ha (1.3/100 acres).

Population density was monitored since 1974 on a 259 ha (640 acres) study area of the Daniel Boone State Forest by complete area counts. Spring breeding populations decreased from 8.5 grouse/100 ha (3.5/100 acres) in 1975 to 3.9/100 ha (1.6/100 acres) in 1980. The breeding population then gradually increased to 9.3 grouse/100 ha (3.7/100 acres) in 1983.

Factors in Release Success

Following are the primary variables identified as determining success or failure or ruffed grouse releases in Missouri: release methods, numbers of birds released, condition of birds, sex ratios, age ratios, age of juveniles, origin of stock, and habitat quality.

Travel arrangements, time of day, and handling of grouse are planned to minimize transit time and stress. Releases are conducted as early in the day as possible to reduce the possibility of heat stress. Early releases also allow time for the birds to acclimate to the release area prior to roosting at night.

Grouse are shipped in cardboard poultry cartons with 4 compartments; 1 bird per compartment. The birds are removed by hand, examined, and placed into a dense thicket or loose brushpile, often causing them to run or walk off, rather than fly.

A release must include an adequate number of birds, but, for economic reasons, should be no more than necessary to ensure success. Releases may be conducted in one year, or be completed over several years.

All releases prior to 1978 were conducted over 2 or 3 years, and the majority were of >100 birds (Table 1). Currently, releases average 60-70 birds, and are completed in 1 year. Exceptions to completion of a release in 1 year occurred when enough birds to finish a release were not available, and 2 instances when releases were supplemented the following year.

If supplementing a release is desirable, early spring trapping may be the most advantageous method to do so. Spring releases of females that are or soon will be physiologically ready for breeding could be valuable in ensuring reproduction on a previous release, although this is speculative.

Ruffed grouse trade agreements stipulate that grouse will be in good physical condition at the time of release. Weak and injured birds are not accepted against the trade quotas, but are usually released. Severely injured birds are destroyed.

Approximately equal sex ratios are stipulated in the trade agreements. Sex ratios of trapped birds have been fairly consistent, approximating a 50-50 ratio with males averaging 51.2% of 1919 birds from 5 states.

Age ratios have varied considerably. Differences in year-to-year reproduction success contributes to the variation, but the main factor is the difference in trapping techniques. For example, one method of trapping concentrates on broods by moving traps in response to brood sightings. Also, earlier trapping allows more time for multiple captures of chicks prior to brood dispersal. Another method, by comparison, involves locating traps in good grouse habitat and seldom moving them. Adults shipped to Missouri trapped by the first method averaged 15% of 542 grouse from 1980-1983. The second trapping method, which does not depend upon brood sightings, produced 1142 grouse, which were 46.5% adults during the same 4 years. Releases containing high adult to juvenile ratios appear to be doing better, although currently we have no data to substantiate this.

Juveniles 13-14 weeks or older are stronger and appear to contribute more to successful releases. Although grouse chicks, by comparison, are much more independent than wild turkey poults at the same age (Healy, W. M., personal communication), I believe older juveniles have a better probability of surviving. For that reason, juveniles captured no earlier than September are more desirable.

Range description according to Aldrich (1963) indicates that all ruffed grouse released in Missouri were either *Bonasa umbellus monticola,* the Appalachian ruffed grouse, or *B.u. mediana,* the midwestern ruffed grouse. The ranges of these subspecies meet in Indiana and southern Michigan.

Ruffed grouse from Wisconsin, Minnesota, Michigan and Iowa have probably been *B.u. mediana,* and were of both red and gray color phases. Grouse from Indiana, Ohio, and Kentucky show differences in coloration and behavior, and are probably *B.u. monticola.* Grouse from these mid-latitude states have all been red phase birds. There have been no observations of gray phase birds among progeny of the Ohio, Indiana, and Kentucky grouse.

Most of the grouse releases in northern Missouri have been of lake state origin only. These releases, comprised of both color phases, will eventually provide the opportunity to investigate environmental selection of color phase.

Consistently used grouse habitat on 3 Missouri study areas averaged 11,051 woody stems (>1m tall) per ha (4472 stems/acre) (Hunyadi 1978, Kurzejeski 1979, Dacey 1983). Drumming log sites on the same study areas averaged 13,489 stems/ha (5459 stems/acre). Habitat that was largely avoided by grouse, as determined by clustering of observations over time, averaged 7345 stems/ha (2972 stems/acre) (Table 2).

Basal area and percent canopy cover increased through the sequence from drumming logs to general grouse habitat to infrequently used adjacent habitat (Table 2). Vegetation analysis on brood sites was conducted on one study only (Kurzejeski 1979). Brood habitat had a low basal area, 12.2 m^2/ha (53 ft^2/acre), and woody stem density of 13,967 stems/ha (5652 stems/acre).

Table 2. Means of woody stems, basal area, canopy, sub-canopy, and ground cover for drumming logs, general grouse habitat, and infrequently used habitat on three Missouri study areas.

	Stem Density Stems/ha (stems/acre)	Basal Area m^2/ha (ft^2/acre)	% Canopy	% Sub-Canopy	% Ground Cover
Drumming Logs					
Monkey Mountain W.A.	15,296 (6118)	19.0 (81.8)	65.7	77.9	72.5
Boone Forest	11,760 (4700)	12.2 (52.5)	53.0	80.0	51.0
Anderson W.A.	13,412 (5365)	17.8 (76.6)	63.0	66.0	47.4
Grouse Habitat (general)					
Monkey Mountain W.A.	14,364 (5746)	19.7 (84.8)	65.8	82.3	70.6
Boone Forest	8,123 (3249)	14.5 (62.4)	69.0	81.0	55.0
Anderson W.A.	10,042 (4016)	17.9 (77.0)	76.0	68.0	63.0
Infrequently Used Habitat					
Monkey Mountain W.A.	12,853 (5141)	27.8 (119.7)	83.9	47.8	67.9
Boone Forest	5,103 (2041)	19.1 (82.2)	92.0	62.0	43.0
Anderson W.A.	4,077 (1631)	26.1 (112.3)	93.0	62.0	42.8

Grouse on the 3 study areas used habitat with the highest stem densities available. Such vegetation was the result of past selection cuts and old field succession. There were no regeneration cuts on any of the areas; consequently stem densities were much lower than generally reported in the literature. Subsequent to these studies, regeneration cuts have been completed, which will make stands with much greater woody stem densities available to ruffed grouse.

Habitat used by grouse on these areas coincided with good timber sites characterized by shade-tolerant understories, particularly ironwood *(Ostrya virginiana)*, flowering dogwood *(Cornus florida)* and sugar maple *(Acer saccharum)*.

Habitat quality is one of the most important variables that determine success of ruffed grouse releases. Plant communities, moisture regime, topography, climate, percentage of forest lands, timber industry, and land use patterns vary tremendously in Missouri. The state's location on the southern periphery of the original ruffed grouse range (Aldrich 1963) also emphasizes the importance of habitat quality. Bump et al. (1947) suggest that habitat was marginal in the southern extremes of ruffed grouse range. The extent of xeric oak-hickory upland forests on poor sites with low plant species diversity in Missouri substantiates Bump's theory. These xeric sites, even given an ideal age and size class distribution of timber, would probably support grouse only in low densities.

Korschgen (1966) studied grouse food habits on the Boone Forest and the Ashland Wildlife Area. A majority of the food species he identified are associated with mesic sites on bottomlands and lower slopes with NNE to ESE aspects. Few are found on xeric sites. Suitable or potential grouse habitat is more restricted by moisture regime and site quality in Missouri than in states to the north and east with higher annual rainfall.

Some of the recent releases in southern Missouri are the most likely to establish a ruffed grouse population quickly, as they have shown the highest numbers of drumming males and brood observations. These releases, primarily on USFS lands, are characterized by even-aged management, with older selection cuts, salvage sales, and direct wildlife habitat plots. These disturbances are well dispersed by aspect and provide the necessary structural characteristics or ruffed grouse habitat.

Hunting Season

The ruffed grouse restoration program plan provided for the initiation of a hunting season when spring breeding populations of at least 6 grouse/100 ha (2.5/100 acre) have existed for at least 3 years over an area large enough to be hunted.

These conditions were met, and in 1983, a ruffed grouse season was set in portions of 4 central counties (Fig. 1). The open area totaled 3252 km^2 (1256 mi^2), with dates of 1 Oct.-10 Nov. (40 days), and a 2 bird daily limit (possession 4). It was the first grouse season in 78 years in Missouri. A ruffed grouse hunting permit ($1.00), for residents only and unlimited in number, was required in addition to a small game permit to take grouse; 2917 were sold.

A hunter record card was sent to each hunter, and envelopes for wings and tails were included with the first 2100 mailings. The envelopes included sex determination instructions for those who wished to keep the tail fan. Eighty-nine envelopes were returned, 41 (46%) of which included tails. The age ratio was 1:1 (50.6% adults). Males represented 62.1% of the sample, including the 48 returns that had hunter determination of sex. Sex determination of the 41 tails returned showed 58.5% males.

The hunter record card return rate was 71.7% (2091 returns). The survey showed that 39.0% (1138 permittees) did not hunt. The remaining 1779 hunters reported a harvest of 173 grouse. The harvest rate was one bird/62.1 hr, and each hunter averaged 6.0 hours afield. The flush rate was .33/hr.

Reasons for Local Failures

Ruffed grouse restoration in Missouri has been largely successful, as evidenced by established populations, and the recent ruffed grouse hunting season. In continuing the restoration program, it seems likely that replicating the methods of successful releases would repeat their success. This assumes that origin (genetic stock), numbers released, age and sex composition, condition of birds, release methods, and habitat quality are all replicable. Only habitat quality may not be entirely replicable, as there are extreme habitat differences throughout Missouri.

Habitat quality is probably the primary reason for failure in unsuccessful grouse releases. The failure of the early 1940's releases is thought to be due to inadequate early successional forest habitat. Some southern Missouri forest land, at that time, was still being grazed and burned regularly. Although the grouse releases were made on MDC lands that had been protected, there probably had ben insufficient time for these forest lands to recover.

Grouse habitat on the unsuccessful Logan Area release was limited to old field succession and field edges, which were marginal in extent and quality for ruffed grouse habitat.

The Carmen Springs release (1963-64) in Howell County is successful only because of suitable habitat created by timber cutting on adjacent USFS lands. Grouse habitat on Carmen Springs itself was lost to succession, as there had been no timber management since the release.

RECOMMENDATIONS AND CONCLUSIONS

The following guidelines appear to offer the greatest probability for successful ruffed grouse restoration in Missouri.

a. Releases consist of 60-70 grouse in good condition.
b. Adults comprise 40% or more of the release.
c. The sex ratio approximates 50-50.

d. Released birds are of the original subspecies from similar habitat and latitude.
e. Juveniles are at least 13 weeks old.
f. Releases are conducted early in the day.
g. Releases are conducted on areas that have been under timber management for 8 years or more.

Observations of recent releases indicate that origin of ruffed grouse, age ratio, and age of juveniles, in addition to habitat quality, are the most critical variables.

The separation and evaluation of any single variable is difficult, as they are all inter-related. Experimental releases, designed to investigate some of these variables have been conducted. These include a south Missouri release of northern birds, a release of 20 birds on a 109 ha (270 acre) island (isolated ridge) of good grouse habitat, supplemental releases on two north Missouri sites, mixing northern and Indiana birds on two north Missouri sites, and releasing variable numbers of ruffed grouse.

Research on ruffed grouse releases will continue, with greater emphasis on replicating and isolating variables to define combinations most successful in ruffed grouse restoration.

LITERATURE CITED

Aldrich, J. W. 1963. Geographic orientation of American Tetraonidae. J. Wildl. Manage. 27(4):528-545.

Bennitt, R., and W. O. Nagel. 1937. A survey of the resident game and furbearers of Missouri. Univ. Missouri Stud. 12(2):1-215.

Bump, G., R. W. Darrow, F. C. Edminster, and W. F. Crissey. 1947. The ruffed grouse: life history, propagation, and management. New York State Conserv. Dept. Holling Press Inc., Buffalo, New York, 915pp.

Dacey, K. W. 1983. Habitat utilization and food preferences of ruffed grouse in northwestern Missouri. M. S. Thesis. Northwest Missouri State Univ., Maryville. 143pp.

Healy, W. M., R.O. Kimmel, D. A. Holderman, and B. W. Hunyadi. 1980. Attracting ruffed grouse broods with tape-recorded chick calls. Wildl. Soc. Bull. 8(1):69-71.

Hunyadi, B.W. 1978. Analysis of ruffed grouse habitat in central Missouri. M. S. Thesis. Univ. of Missouri, Columbia. 145pp.

Korschgen, L. J. 1966. Foods and nutrition of ruffed grouse in Missouri. J. Wildl. Manage. 30(1):86-100.

Kurzejeski, E. W. 1979. Habitat utilization and survival rates of male ruffed grouse on the Edward Anderson Wildlife Area and surrounding private land. M. S. Thesis. Univ. of Missouri, Columbia. 151pp.

Leopold, A. 1931. Game survey of the north central states. Sporting Arms and Ammunition Manufacturers Institute. Madison, Wisconsin. 290pp.

Lewis, J. B. 1971. Ruffed grouse: an indicator of environmental change. Trans. N. Am. Wildl. Nat. Resour. Conf. 35:196-204.

Lewis, J. B., J. D. McGowan, and T. S. Baskett. 1968. Evaluating ruffed grouse reintroduction in Missouri. J. Wildl. Manage. 32(1):17-28.

McKinley, D. 1960. History of the ruffed grouse in Missouri. Bluebird 27(4):3-11.

Murphy, D. A. 1965. Effects of various opening days on deer harvest and hunting pressure. Proc. Annu. Conf. Southeastern Assoc. Game and Fish Commissioners. 19:141-146.

Titus, R. R. 1976. Habitat utilization of ruffed grouse in the Missouri Ozarks. M. S. Thesis. Univ. of Missouri, Columbia, 118pp.

Ruffed Grouse Restoration in Indiana

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Abstract: Ruffed grouse *(Bonasa umbellus subspp.)* historically occurred in all 92 counties in Indiana. By 1961, the range occupied by ruffed grouse was restricted to 14 counties in southcentral Indiana. Presently ruffed grouse occur in 41 counties. This paper describes ruffed grouse restoration, census techniques, harvest results, and habitat used in Indiana. Between 1961 and 1982, 1044 wild-trapped ruffed grouse were transplanted to 25 release sites in 21 counties. The best success occurred when a minimum of 60 birds at least 12 weeks of age were released at a site. Grouse trapping success has centered on the use of a modified "lily-pad" trap during September and October. Cost per grouse caught and shipped averages about $100. Population densities and trends have been determined using activity center counts, line transect drumming counts and harvest indices. Indiana's grouse densities are intermediate to those reported elsewhere and have similar trends. Standards used for determining successful reestablishment are 4 birds/40 ha for activity center counts and 0.5 drumming grouse/stop along roadside and walking transects. Grouse hunting presently occurs in 14 counties from mid-October through 31 January. Based on 18 years of data, hunters in Indiana averaged 1.8 (SE = 0.6) man-hours/grouse flushed and 13.4 (SE = 0.89) man-hours/grouse bagged. Juveniles comprised 57% of the harvest with 2.92 juveniles/adult hen. Hunter success and habitat used by ruffed grouse are similar to those of other states below 42°N latitude. Woody stem densities surrounding 64 active drumming logs averaged 35,000 stems/ha (14,000/acre) with differences in shrub densities separating used and unused logs ($p < 0.01$). Future grouse research needs to include continual refinement of survey techniques, identification of unoccupied suitable habitat, evaluation of release techniques, and monitoring of the effects of timber management on grouse populations.

While Indiana is not considered a major grouse state, the ruffed grouse investigation in Indiana spans over 30 years. This paper describes ruffed grouse restoration, survey techniques, harvests, and habitat use in Indiana. The restoration of ruffed grouse in Indiana is the result of the collective effort and dedication of

many wildlife research and management personnel. Much of the work reported herein has been supported by funds under Federal Aid in Fish and Wildlife Restoration Act; Wildlife Research Project W-26-R, and Forest Wildlife Project W-27-D Indiana. John S. Castrale, Robert D. Feldt, and P. Decker Major are kindly thanked for their constructive editorial comments.

HISTORIC RANGE AND NUMBERS

Ruffed grouse probably once occurred in all 92 counties in Indiana, which historically was almost 90% forested (Anonymous 1981). According to Aldrich (1963), two subspecies were represented; *B.u. mediana* in the northwest third of the state and *B.u. monticola* in the southeastern two-thirds. Populations of ruffed grouse initially benefited from early settlement because scattered openings were created throughout the hardwood forest. Ruffed grouse numbers in northern Indiana were considered similar to those of northern Ohio, Michigan, and Wisconsin (L. H. Haymond, in Butler 1897). As the timberlands were overexploited and agricultural land-use prevailed, grouse populations declined.

By 1856, ruffed grouse occupied only 58 counties and steadily declined to only 12 counties in 1931 (Leopold 1931). During the "Great Depression" of the 1930's, grouse populations began to increase in southern Indiana as the hilly, clay farmland was abandoned and allowed to revert to old field and early seral

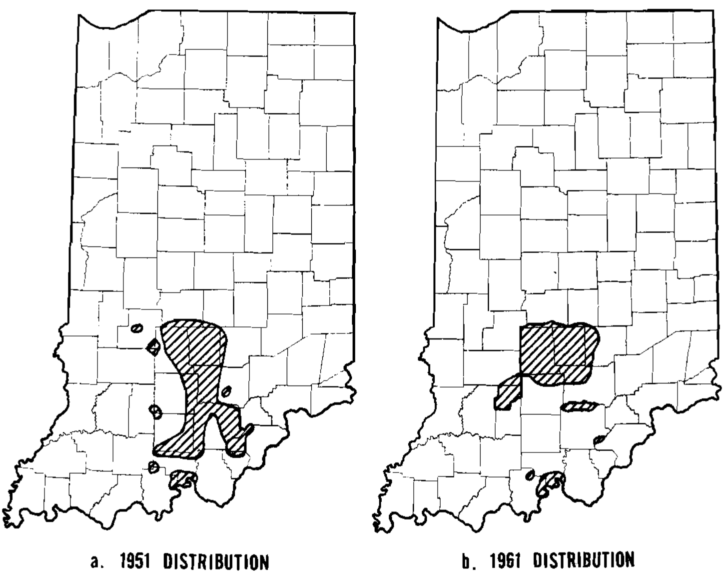

Fig. 1. Ruffed grouse distribution, release sites, and hunting range in Indiana (Adapted from Backs 1983).

stages of forest succession. Ruffed grouse were given extra security as natural resource agencies began to purchase abandoned farmland, primarily for reforestation (Mumford 1957).

By the 1940's and 1950's, grouse had disappeared from northern Indiana, but their populations had expanded to 18 counties in southcentral Indiana with major concentrations occurring primarily on publicly owned forests (Fig. 1a). Grouse densities were estimated at 0.4-4.4 birds/40 ha (100 acres) (Mumford 1957).

As more farmland reverted back to forest, grouse began to repopulate their former range and restocking was initiated to accelerate recovery. From 1952-60, 180 wild-trapped birds purchased from the Sandhill Game Farm in Wisconsin were released in southcentral Indiana. Records for 73 birds indicate three color phases were represented: 66% intermediate, 30% red, and 4% gray; (Mumford 1953). These birds represented a different subspecies *(B.u. mediana)* than was native to the area (Aldrich 1963). This difference may have contributed to the failure or limited success of these releases (Hamilton 1962a).

By 1961, ruffed grouse populations were again declining and their distribution was restricted to 14 counties (Fig. 1b) (Hamilton 1962b). However, isolated concentrations of grouse were abundant enough to allow trapping and transplanting of birds to other areas within the state. At present, ruffed grouse occur in 41 counties, their widest distribution since 1856 (Fig. 1c). This increased distribution resulted from the 1044 birds restocked in 21 counties between 1961 and 1982 as well as natural range expansion (Fig. 1d). Included were 126 grouse trapped in southern Michigan and released in northern Indiana. Legal grouse hunting presently occurs in 14 counties (Backs 1983).

TRAPPING AND RESTOCKING

Over the past 25 years, ruffed grouse trapping techniques improved through the efforts and experience of many field personnel of the Indiana Department of Natural Resources. Increased success has provided grouse for the restoration in Indiana as well as other states. Initially several types of traps were used but only variations of the modified shorebird or "lily-pad" trap (Liscinsky and Bailey 1955, Dorney and Mattison 1956, Chambers and English 1958, Gullion 1966b) proved successful in capturing grouse in sufficient numbers for restocking. The present lily-pad trap used is basically similar to Gullion's (1966b) design except for subtle modifications and structural materials used. A complete trap consists of 4 trap bodies with 1 trap body at each end of 2 lead fences, 15 m (50 ft) long. Two of the trap bodies are placed back-to-back to form a complete trap slightly over 30 m. A detailed description of this trap and general procedures are available in Backs et al. (in prep.).

The best trapping success occurs in association with the fall dispersal period. Traps are set out in late August and trapping begins soon after 1 September and extends until late October. Birds caught during this period are generally at least 12 weeks of age. Juveniles make up an average of 48% (SE = 7.5; n = 8 years) of the birds caught per year while sex ratios approach unity. The seemingly low percentage of juveniles captured may be an artifact resulting from difficulty in determining age by wing molt progression (Bump et al. 1947) during the latter half of the trapping period. The average weight of juveniles caught was 520g (n = 703) while adults averaged 540g (n = 269), indicating most juveniles are nearly fully grown. Annual trapping success averages 15.1 trap nights per bird (SE = 1.68; n = 8 years). The highest percentage of birds are caught from 29 September to 5 October which probably coincides with the peak of dispersal (Fig. 2). Bird losses in traps due to escapes, predator kills, and unknown causes account for approximately 9% of all birds captured.

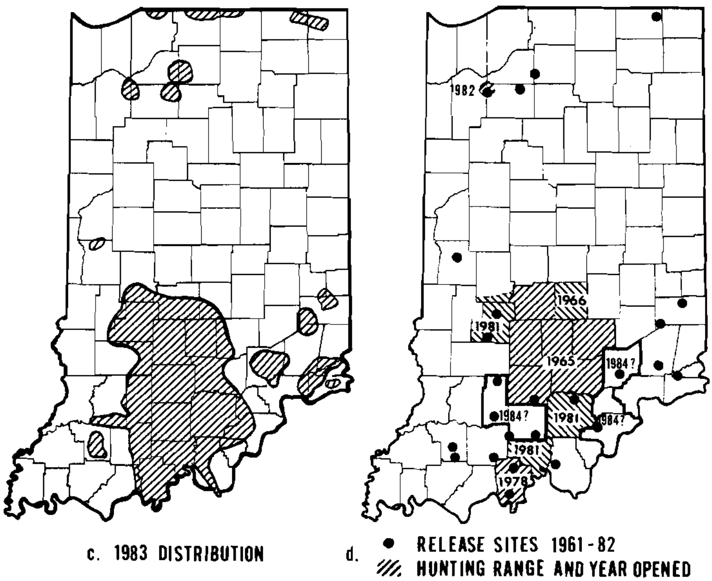

Fig. 2. Fall dispersal chronology of ruffed grouse in Indiana as depicted by trapping success, 1975-1983.

Captured birds are removed from traps each evening just before dark and held in semi-portable "grouse houses" (B. W. Hunyadi, Missouri Dept. of Cons.) adapted from holding facilities developed by the Wisconsin Department of Conservation. Grouse houses are designed to shelter captured grouse in an environment of minimal light but adequate ventilation. The size of the structures should be high enough (≥ 2 m; 6 ft) to allow personnel to walk in when handling birds and large enough to hold 10-20 birds at 0.12 m^2 (4 ft^2) per bird. Mortality in a house increases substantially over the normal 3-5% when birds are held at higher densities. Minnow seine netting (6 mm; .02 in) is suspended approximately 5 cm (2 in) from the inside walls and ceiling to protect flushing grouse from injury.

Food and moisture are provided ad libitum using autumn olive *(Elaeagnus umbellata)* and grape (*Vitis* spp.) fruit. Recently, slices of watermelon have also been used successfully. Captured grouse are held up to 4 days ($\bar{x}$ = 2) before being shipped in cardboard poultry boxes via air freight or motor vehicle. Although preliminary evaluation indicates 82% of the birds lose weight ($\bar{x}$ = 30g, SE = 2.6, n = 101, $p < 0.01$) while in a grouse house, this loss amounts to only 6% of total body weight. More detailed description and bird handling procedures are presented in Backs et al. (in prep.).

During 1980-82 trapping periods, 97% of the birds shipped (87% of birds captured) arrived at the release site in acceptable physical condition for release. Each bird shipped required 1.06 man-days (SE = 0.26, n = 4 years) trapping effort. The cost of each released bird is conservatively estimated to be $100. Efforts expended the cost per bird released fluctuate yearly depending on annual population levels.

Early restocking recommendations called for 5-8 pairs of grouse to be released on 200 ha of forested area. This recommendation assumed a normal production rate of 5 juveniles per adult hen by fall to produce a huntable population in 6 years established over 4,000 ha (10,000 acres). Many of these early releases failed to establish self-sustaining populations or resulted in a relatively long period of population development.

Eventually normal production in Indiana was determined to be only 3 juveniles per adult hen by fall, and relatively high initial mortality of birds and movement after release were more fully recognized. Excessive movement is especially important because releases are made during the fall dispersal period. In one release, mortality prior to the first breeding season was estimated between 38-77%, with juvenile birds dispersing up to 14.7 km (9 mi) from the release site (Paige 1975).

Present restocking recommendations call for a minimum of 60 birds to be released in a 400 ha (1000 acre) relatively contiguous forested area with a good interspersion of 20-25% mature sawlog timber, very little pole timber, 50-70% saplings at 37,500-62,500 stems/ha (15,200-25,400/acre), and 10% in field openings. This "ideal" release area should be surrounded by 5-8 km^2 (2-3 mi^2 of primarily forested cover types. This stocking rate is considerably higher than the 1 bird/2-3 km^2 (1/0.8-1.2 mi^2) recommended by Moran and Palmer (1963:613), but is necessary because of the relatively lower productivity of grouse in Indiana compared with Michigan. As noted by Moran and Palmer *(ibid)*, use of the appropriate subspecies is preferred.

Releases are made early in the day at a release site centrally located in the area to be restocked. The site itself is generally an open area or clearing which allows birds 30-60 m (30-70 yd) of flight before encountering obstructions. Birds are allowed to fly or walk from the transportation boxes without being coaxed (i.e. a passive type of release).

SURVEY TECHNIQUES

Most estimates of ruffed grouse densities and population trends rely on several techniques (Allison 1959, Ammann and Ryel 1963, Stoll 1980, Thompson and Moulton 1981). Techniques fall into 3 categories: direct counts, partial counts, and indices (Martinka and Swenson 1981). All three are used in Indiana to monitor established grouse populations and evaluate recent grouse releases, depending on the size of the area and available manpower.

Direct counts of "activity centers" of drumming male grouse (Gullion 1966a, 1967) are used to estimate spring breeding densities on study areas of at least 320 ha (800 acres). Assuming a 1:1 sex ratio and the existence of non-drumming males (Dorney et al. 1958, Gullion 1981), the number of drumming males counted is doubled to give a conservative, minimum spring density of birds of both sexes. Estimates of ruffed grouse density are expressed as birds/40 ha (100 acres).

Counts are conducted during the peak of drumming activity which traditionally occurs near 1 April in southcentral Indiana. Studies of drumming activity in Indiana (Johnson 1966) indicated the peak was independent of plant phenology, supporting Gullion's (1966a) suggestion that photoperiod is the primary controlling factor, as influenced by snow melt, temperature, and precipitation. Given these factors, drumming counts in northern Indiana are scheduled 7-14 days later than in southern Indiana. Generally, activity center counts (Gullion 1966a) require 5-12 observers systematically searching 300-600 ha (750-1500 acres) between 0530-0830 EST for 3-6 consecutive days. Experienced observers with favorable listening conditions (wind <15 km, no precipitation) can usually account for 90% of the activity centers in 3 days.

Using activity center counts, estimates of spring breeding densities have been determined on several areas in Indiana (Table 1). Data collected at Maumee Grouse Study Area (Maumee) is the most consistent, and best represents the average spring densities within the huntable range in southcentral Indiana. Compared to other states, southcentral Indiana falls midway in the range of estimates for spring densities (Table 2).

Using Maumee as a standard of comparison, other areas in Indiana are considered for opening to hunting when their spring densities approach 4 birds/40 ha. As an example, Jasper-Pulaski State Fish and Wildlife Area was stocked with 89 wild-trapped grouse in 1970-71. Spring densities leveled off at approximately 3 birds/40 ha (100 acres) in 1982 indicating the available habitat was becoming saturated. A hunting season was initiated that fall.

Partial counts, sampling a portion of a population and expanding to a total population estimate, are made by recording grouse flushes along transect lines. These census methods originated from the classic King census method (Leopold 1933). Line transects were initiated in 1975 because of their relative ease of implementation in the field and to provide additional estimates of grouse densi-

Table 1. Spring breeding densities of ruffed grouse within Indiana's huntable range estimated using activity center counts.

Study areas (ha censused)	Year stocked (no. birds)	$\bar{X}$ Activity centers	Minimum $\bar{X}$ density[a] birds/40 ha (SE) (birds/100 acres)	Density range birds/40 ha (birds/100 acres)	Year censused (n)
Maumee, Jackson-Brown Co. (336)	native	17	4.1 (0.26)	2.2-5.8	1969-73 1975-83 (14)
Geiger Ridge, Monroe Co. (340)	native	17	4.1 (0.91)	2.9-5.9	1966[b] 1968-69[c] (3)
Happy Hollow, Perry Co. (324)	1962-63 (49)	19	4.7 (0.30)	4.3-5.3	1977-79 (3)
J-P Fish and Wildlife Jasper-Pulaski Co. (440-1, 121)	1970 1971 (89)	10-13	2.2 (0.28)	0.9-3.1	1976[d]-83 (8)

[a]Assume 1M:1F and non-drumming males (Dorney et al. 1958, Gullion 1981).
[b]Data extracted from Thurman (1966).
[c]Data extracted from Muehrcke (1969), Muehrcke and Kirkpatrick (1969).
[d]Data extracted from Kelly (1977), Kelly and Kirkpatrick (1979).

Table 2. Spring densities of ruffed grouse in various parts of their range. (Figures corrected to birds/40 ha = birds/100 acres)[a].

Birds per 40 ha	State and Area	Observer	Census Method	Comments
1.0	Georgia: Union County	Hale et al. (1982:118)	Drumming count	1976
1.0	Michigan: Gladwin and Rifle River	Palmer and Bennett (1963:636)	Drumming count	At population low
1.7	Minnesota: Cloquet Forest Research Center	Gullion (1966:718)	Drumming count	1965 (Lowest count in 7-year period)
1.7	Wisconsin: Stone Lake	Thompson and Moulton (1981:12)	Drumming count	Mean 1968-80
1.7	Kentucky: Beaver Creek	Hardy (1950:21)	Drumming count	1950
2.0	Missouri: Ashland area	Lewis et al. (1968:23)	Drumming count	1965
2.2	Pennsylvania: Barrens	Bowers and Tanner (1947:7)	Drumming count	1946
3.3	New York: Adirondack	Bump et al. (1947:519)		Mean 1932-38
3.3	Ohio: Raccoon State Forest	Donohoe (1965:52)	Drumming count	Mean 1958-64
3.3	Pennsylvania: Stone Valley	Bowers and Tanner (1947:7)	Drumming count	1946
3.5	Central Alberta	Rusch and Keith 1971:420	Drumming count	Mean 1966-68
3.9	Wisconsin: Rusk County	Dorney (1958:98)	Drumming count corrected by fall sex ratio	1957

Table 2 (Cont.).

Birds per 40 ha	State and Area	Observer	Census Method	Comments
4.1	Indiana: Maumee	This publication	Drumming count	Mean 1969-83 (except 1974)
5.0	Minnesota: Cloquet Forest Research Center	Gullion (1966:718)	Drumming count	1961 (Highest count in 7-year period)
5.2	New York: Bull Hill	Bump et al. (1947:520)		1934
5.6	Northeastern Iowa	Porath and Vohs (1972:796)	Drumming count	1967
5.9	Wisconsin: Sandhill	Thompson and Moulton (1981:12)		Mean 1968-80
6.7	New York: Catskill	Bump et al. (1947:520)		Mean 1931-41 (except 1936)
7.3	New York: Pharsalia Game Refuge	Bump et al. (1947:520)		Mean 1932-37
7.4	New York: Connecticut Hill	Bump et al. (1947:519)		Mean 1939-42
8.1	Wisconsin: Dunn County	Dorney (1958:98)	Drumming count corrected by fall sex ratio	1957
8.4	Michigan: Gladwin	Palmer and Bennett (1963:635)	Drumming count	1953 (Highest count in 9-year period)
25.0	Northern Minnesota	King (1937:524)		Maximum during 7 years

[a]adapted from Lewis et al. (1968:23).

ties throughout the year, especially during the summer brood period (June-August). Line transect sampling followed the guidelines for motile or flushing populations prescribed by Anderson et al. (1976) and Eberhardt (1978a, 1981). The Hayne method is preferred because radial distances are more easily and accurately measured in the field. The Hayne method is also a more robust estimator and offers the best approach to working with animals that flush (Eberhardt 1978a).

Between 1975 and 1983, 147 grouse flushes were recorded over 920 km (560 mi) of transect lines covered primarily during the spring drumming season and summer brood periods. Transects were primarily restricted to study areas >300 ha (750 acres) where spring densities were determined using activity center counts. Recently, transect sampling has been restricted to the Maumee Study Area with 20-40 km (12-24 mi) traversed annually. Maumee has served as the primary study area for testing line transects as a technique for estimating Indiana grouse densities.

The major survey problem encountered using line transects is the low frequencies of grouse flushes, due to relatively low population densities and survey design. Burnham et al. (1980:35) recommended a minimum of 40 total objects or flushes (preferably 60-80 objects) in order to make reasonable estimates of density. The highest number of flushes recorded during a survey period on Maumee was 10, totaling 31 birds over 32 km (19 mi) of summer transects. With few flushes and the generally high variability inherent to transect methods (Eberhardt 1978b), it is doubtful that the great increase in manpower to conduct more transects could be justified to determine population estimates within acceptable confidence limits of even ±20 percent of the mean. Attempts were made to increase the number of grouse observed along summer transect lines using "chick distress calls" (Healy et al. 1980) but this did not prove successful. Density estimates determined by line transects theoretically show promise, but have not performed well in practical field applications with the resources available. Until improvements are made, data from line transects are better expressed as an index, i.e. grouse or broods flushed per km traveled (Allison 1963).

Indices of population density are generally easier to determine, less subject to bias, and are functionally capable of determining population trends and effects of management (Eberhardt 1978b). This is especially true when evaluating grouse populations on areas greater than 25 km^2 (64 mi^2). Indices from roadside drumming counts (Petraborg et al. 1953) are commonly used to determine population trends and were initiated in Indiana in 1953. Each route or roadside transect was 20-35 km (12-20 mi) with 15 4-minute listening stops not less than 0.8 km (0.5 mi) apart. Routes were recorded on topographic maps along county roads with stops near designated forest vegetation. Routes were run at least twice under acceptable weather conditions (wind <20 km (12 mi)/hr and no precipitation) in opposite directions starting 1/2 hr before sunrise. Observers recorded the number of drumming males and total drums heard. Somewhat contrary to Thompson and Moulton (1981), observers are able to distinguish individual drumming males due to the relatively low population levels. Because of extreme variability between route repetitions, only the route with the highest number of observations is used to calculate population indices, similar to Dorney et al. (1958). Under normal field conditions, these maximum counts tend to underestimate the number of drumming males present (Donahoe 1965, Gullion 1966a, Rodgers 1981).

Between 1953 and 1971, roadside drumming counts were used to monitor grouse populations within the remnant range. The only population index calculated for this period was the number of drumming males heard per stop which averaged 0.47 (SE = 0.03; Range = 0.16-0.78; n = 17) on three areas; Brown County State Park, Morgan-Monroe State Forest, Hickory Ridge in Brown and Jackson Counties.

Roadside counts were discontinued in 1972 but reinitiated in 1978. Results from 4 routes in the huntable range (Hickory Ridge, Jackson-Washington State Forest, Owen-Putnam State Forest, and Perry County) were used to monitor population trends and serve as controls to evaluate results from routes associated with release areas. During 1979-83, the mean number of drumming males heard per stop on the control areas was 0.65 (SE = 0.090; Range = 0.38-0.91) with a mean 1.08 drums heard per stop (SE = 0.138; Range = 0.78-1.55). Both means are greater than those reported in Ohio (Stoll 1975, Donohoe and Stoll 1982) while the mean number of drums per stop is less than that reported in Michigan (Ammann and Ryel 1963), Wisconsin (Thompson and Moulton 1981) and Minnesota (Berg 1982).

At present, the primary use of roadside drumming indices is to determine population levels for deciding what areas can be opened to hunting. Roadside counts are conducted in an area 3-6 years following a release. Using roadside indices from the 4 areas in hunted range as standards of comparison, other areas in Indiana are considered for inclusion into the hunting range when the number of drumming grouse heard per stop approaches 0.50.

Because roadside drumming routes cover relatively large areas, they are generally not sensitive enough to evaluate the initial population response following a release or habitat management. Occasionally road systems do not adequately traverse the area to be surveyed or are associated with too many disturbances which hamper observations. Activity center counts are an alternative (Gullion 1966a) but generally require more manpower than is available or justified. Drumming counts along walking 2-3 km (1-2 mi) routes in the immediate area of a release site or manipulated habitat often provide an efficient way to obtain needed information. Walking routes are conducted and analyzed similarly to roadside counts, except the observer listens at 17 stops every 200 m (220 yd) determined by pacing along low access trails or transect lines. Walking routes are usually set up in conjunction with roadside counts to provide supplementary data.

During 1980-83, the mean number of drumming males heard per stop on walking routes in the 4 control areas was 0.75 (SE = 0.125; Range = 0.43-1.04) with a mean 1.15 drums heard per stop (SE = 0.247; Range = 0.69-1.71). Comparisons between walking and roadside drumming indices, showed some consistency between the mean drumming males heard per stop over the 4 control areas combined by year (r = 0.913; df = 2) but was very low when individual areas were compared (r = 0.15; df = 13). The latter is probably related to differences in the relative amount of area censused by each method. Walking routes are very localized while roadside routes cover a much greater area and are less sensitive to or influenced by localized changes in population density. When the results from several walking routes are combined, the resulting index is more robust and comparable to roadside results. Walking routes provide very localized information and thus serve the purpose of evaluating initial population responses following a release or small scale habitat management. More regional coverage could be obtained by combining several routes into one in the analysis, similar to Allison (1963).

A common objective of grouse population surveys is to predict fall populations related to hunting or trapping success. Because of their more regional applications, roadside drumming indices have been correlated with hunter success in Michigan (Ammann and Ryel 1963), Wisconsin (Thompson and Moulton 1981), and Ohio (Stoll 1980). Based on limited data, the mean number of drumming males and drums heard per stop along roadside routes in the 4 control areas appears to be correlated with grouse flushes per gun-hour during the fall hunting season (r = 0.98 and 0.81; df = 2). The same roadside indices appear to be poor indicators of grouse trapping success (r = −0.10 and 0.21; df = 2). The small sample size and variability in trapping effort on different areas may confound any relationship.

HARVEST INDICES

Grouse harvest indices provide the most consistent means of determining trends in Indiana's grouse population and making comparisons with other states. Indiana's first modern ruffed grouse season occurred in 1965. The 12-day season in mid-November was restricted to 6 southcentral counties containing remnant native populations. Since 1965 the grouse season has been progressively lengthened and more counties included as the remnant population expanded naturally and through grouse transplant efforts. Presently, the season extends from mid-October to 31 January (15 weeks) and includes 14 counties with 5 additional counties projected to open in 1984 (Fig. 1c). The daily bag limit has remained at 2 birds since 1965.

In earlier years, grouse hunting in Indiana was viewed as a novel opportunity

Table 3. Indiana ruffed grouse hunting summary, 1965-82 (n = 18).

Category	$\bar{X}$	SE	CV[b] $\bar{X}$
No. of parties/year[a]	442	65.3	14.8
Hunters/party	2.2	0.04	1.8
Hours hunted/party/trip	4.2	0.08	1.9
Flushes/hour	1.3	0.06	4.6
Flushes/man-hour	0.56	0.020	3.6
Grouse bagged/flush	0.14	0.006	4.3
Grouse bagged/hour	0.18	0.012	6.7
Grouse bagged/man-hour	0.08	0.005	6.3
Percent juveniles[c]	57	1.4	2.5
Juveniles/adult hen[c]	2.92	0.203	7.0
Percent males[c]	52	1.3	2.5

[a]Compiled from area check stations, field checks, and cooperative hunters.

[b]Coefficient of the mean, $\frac{100SE}{\bar{X}}$

[c]n = 17

for northern bobwhite *(Colinus virginianus)* and ring-necked pheasant *(Phasianus colchicus)* hunters to exercise themselves and their dogs prior to the opening of the regular small game season. In recent years, interest in grouse hunting has increased as quail and pheasant populations declined. The effect of this change has resulted in more experienced and avid grouse hunters in Indiana today, whose success in finding grouse has also increased over time.

Annual grouse hunting statistics are derived from combined data collected from area check stations, field checks, and cooperating hunters who maintain a seasonal diary of their hunts (Major and Olson 1980). Several biases are inherent with these sources of data but they appear to be somewhat compensating. Data collected from cooperators, generally considered more avid and experienced, are probably compensated for by data collected from area check stations and opening day field checks, which are composed of many novice and incidental hunters who generally are less successful than the average cooperator.

A summary of 18 years of grouse hunting survey results in Indiana is provided in Table 3. Effort and success data are presented in 2 units of time for ease in comparing results with other states. "Flushes" includes all grouse flushed and reflushed. The average grouse hunting party consists of 2-3 hunters who generally spend 4.2 hours afield. During a full day's hunt, a party flushes 9 birds (0.56/gun-hr) but bags only 1 bird (0.14 grouse bagged/flush or 0.18 gun-hr). There is a 57% chance each bird bagged would be a juvenile and a 52% probability the bird would be a male. This success translates into an effort of 1.8 man-hours/flush and 13.4 man-hours/grouse bagged. In any given year ±8% change

Table 4. Ruffed grouse harvest indices from various states.

State	Flushes per hour	Year[a]	Juv. per adult hen	% Juv.	Year[a]	Source
MI So. Lower Penninsula	2.15	1950-82	—	—	—	Ammann and Ryel 1963 H. Johnson (1978 pers. comm.) W. Bronner (1983 pers. comm.)
MN	1.04	1969-75	7.85	75	1958-75	Gullion (1978 pers. comm.)
WI	1.14 (Sandhill)	1971-77	9.20	80	1948-75	Dorney and Kabat (1960) J. Kubisiak (1978 pers. comm.)
NH	—	—	5.7	67	1949-58	Allison (1959)
IO	1.33[b/]	1969-78	1.7	58	1969-78	T. Little (1983 pers. comm.)
			Above 42°N Latitude[b]			
			Below 42°N Latitude			
WV	1.6	1968-77	1.96	45	1962-76	J. Pack (1983 pers. comm.)
PA	1.4	1968-81	4.8	64	1977	Kriz (1979) Kriz and Liscinsky (1981)
OH	1.35	1974-82	2.7	53	1962-70	Davis and Stoll (1973) R. Stoll (1983 pers. comm.)
IN	1.33 0.56	1965-82 1965-82	2.92	54	1965-82	Major and Olson (1980) Project Reports (1977-82)
VA	1.2	1973-82	1.82	31	1973-82	J. Coggin (1977, 1981, pers. comm. 1983)
KY	0.64	1960-67	2.0	51	1958-67	H. Barber (1978 pers. comm.) Hardy (1967)

[a]Refers to the year in which the season began.
[b]States with major portion of grouse hunting range below 42°N latitude.

in flush rate and a ± 13% change in success are expected (95% confidence limits expressed as percentages of the mean). No correlation between flushes/man-hour and juveniles/adult hen ($r = 0.10$) or % juveniles in the harvest ($r = 0.05$; $df = 15$; $P < 0.05$) has been found, which agrees with Stoll's (1980) observations. The small variation from year to year could account for the lack of correlation between the age structure and flush rates.

Although grouse hunter effort and success provide a practical way to compare relative grouse densities between areas or states, major discrepancies exist beyond the biases pointed out by Ammann and Ryel (1963). The problems concern the lack of uniformity in reporting numbers of birds flushed or shot during a unit of time and the selective exclusion of data.

The first problem lies with the inconsistency in ways that flush data are recorded. Some reports are based only on initial flushes of grouse while others include reflushes. Because hunters cannot always differentiate between individual birds, the latter method would appear more consistent among observers.

The second problem concerns the unit of hunting time used, "hours" versus "man-hours". Many reports use hours to mean "party" or "cooperator-hours" which in effect does not differentiate between the effort of one person and the combined effort of 2 or more people. Surely the latter would result in a higher probability of flushing and shooting a grouse. Although the use of "hours" is common, it is misleading because it does not accurately define the total amount of effort expended by all hunters. The use of "man-hours", "hunter-hours", or "gun-hours" would account for the differences in effort and provide more consistent and accurate estimates of effort and success. Flushes/man-hour is also a better standard to compare hunting data to flush counts made on non-hunted areas or during non-hunting segments of the year, assuming both data are collected in a similar manner.

Finally, several reports exclude the results of hunters who hunt less than a specified number of times. This can only bias data upwards, and does not present an accurate account of the total effort expended or success.

Despite the problems with flushes/"hour", this parameter is widely used and a common means of comparing grouse hunting success and relative fall densities between areas or states. Indiana grouse hunting success and fall densities are similar to other states in southern latitudes (below 42°N) of ruffed grouse range (Table 4). Generally these densities are below those of northern states and probably reflect the relatively low productivity indicated by the number of juveniles/adult hen and % juveniles in the harvest. Reasons for this low productivity are uncertain in Indiana and elsewhere (Davis and Stoll 1973).

Although grouse hunting indices in Indiana show little variation, trends similar to those in other states occur (Fig. 3). Population highs as estimated by hunting indices occurred around 1971 and 1981 with lows around 1976. Hunting success in Indiana during 1971 and 1976 was significantly lower than all other

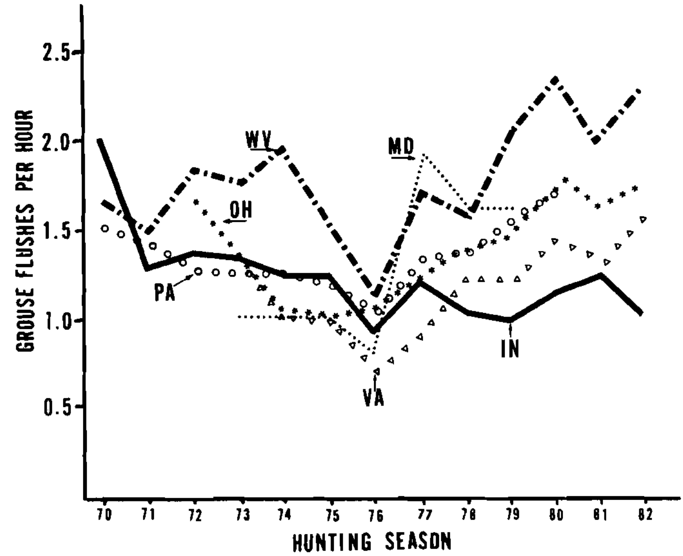

Fig. 3. Ruffed grouse flush rates during 1970-1982 hunting seasons in Indiana and several eastern states (Adapted from Kriz and Lang 1982).

years (Major and Olson 1980). Similar trends occurred in Wisconsin drumming indices (Thompson and Moulton 1981). Gullion (1978) pointed out that Minnesota's peaks usually occur in years ending in 1, 2, or 3, with lows occurring in years ending in 5, 6, or 7. While this regular fluctuation appears to occur in Indiana grouse populations, the amplitude of the oscillations is less than in more northern states (Bump et al. 1947, Keith 1963). The decreased variability may be due to the more complex ecosystem with which southern grouse are associated (Ricklefs 1974).

HABITAT

Early studies of grouse habitat in southcentral Indiana reflected more of what was available as the abandoned farmland reverted to early stages of forest succession characteristic of the central hardwood region. Thurman (1966) and Muehrcke (1969) reported ruffed grouse generally preferred hardwood thickets, old fields, and young pine plantations. Important tree and shrub species were oaks (*Quercus* spp.), hickories (*Carya* spp.), sumacs (*Rhus* spp.), sassafras (*Sassafras albidum*), flowering dogwood (*Cornus florida*), ironwood (*Ostrya virginiana*), grape (*Vitis* spp.), maples (*Acer* spp.), pines (*Pinus echinata,* and *P. strobus*), and yellow-poplar (*Liriodendron tulipifera*). Dominant ground cover species included grasses (*Graminae*), greenbriar (*Smilax* spp.), trefoils (*Desmodium* spp.), cinquefoils (*Potentilla* spp.), goldenrod (*Solidago* spp.), brambles (*Rubus* spp.), sassafras, virginia creeper (*Parthenocissus quinquefolia* spp.), lespedeza (*Lespedeza* spp.), and maples.

During summer months, grouse were found more often where the preferred habitat types were located in bottoms or ravines. Major and Wise (1977) suspected these areas of lower elevation were used during the summer months to escape the higher temperatures that occurred on the ridges. Broods were observed in hardwood thickets with woody stem (>10 cm, 4 in) dbh densities of 9000-10,000/ha (3700-4000/acre) (Muehrcke 1969). These stem densities probably represent a minimum because they do not include woody stems less than 10 cm (4 in) dbh and because broods are more likely to be seen in more open habitats than are actually used (Backs 1979).

During the fall months, birds showed less strict habitat preferences but tended to concentrate around available food sources. The food species utilized were generally the same as those reported in Korschgen (1966) and Stoll et al. (1980). In late fall and winter, birds preferred pine plantations and old field associations over other types, suggesting a greater need for cover.

No other aspect of seasonal habitat use by ruffed grouse has been studied more closely than habitat used by drumming males in the spring (Palmer 1963, Gullion 1967, Boag and Sumanik 1969, Stoll et al. 1979, Hale et al. 1982). Studies of habitat surrounding 64 drumming logs in Indiana showed birds using logs surrounded by mean woody stem densities of 35,000 stems/ha (14,000/acre). Differences in the shrub (<13 cm or 5 in dbh) densities separated used ($\bar{x}$ = 34,570 stems/ha; 14,000/acre) from unused logs ($\bar{x}$ = 20,775 stems/ha; 8300/acre) ($P<0.01$) (Kelly and Major 1979). These results are similar to those reported elsewhere, except for the low importance of aspen (*Populus* spp.), especially in southern Indiana where aspen makes up less than 2% of the forest ecosystem (United States Department of Agriculture 1976). Oaks were the most common trees occurring around used drumming logs in Indiana. Shrub species occurring at high frequencies around used drumming logs were cherry (*Prunus* spp.), brambles, flowering dogwood, sassafras, and greenbriar. Generally the species composition around drumming logs reflected the overall composition of the surrounding forest habitat.

CONCLUSIONS

Historically, the distribution of ruffed grouse in Indiana has fluctuated with changes in land-use practices. Through restocking and natural range expansion in response to more compatible land-use, ruffed grouse have the greatest distribution in modern times. Grouse trapping and restocking techniques continue to improve and be successful in providing birds for reestablishing populations elsewhere. Census techniques, primarily activity center and roadside drumming counts, provide satisfactory information for evaluating the grouse population response after releases or habitat management. Grouse densities in Indiana are comparable to those in other states of similar latitude. While line transects provide a theoretically efficient technique to determine grouse population densities, they have been unsatisfactory in field applications because of relatively low population densities. Harvest indices provide the most consistent means of monitoring grouse population trends. Grouse hunter success in Indiana is comparable to that of other states of similar latitude. Grouse populations in Indiana show some evidence of cyclic fluctuations but not of the magnitude recorded in more northern latitudes. Habitat used by drumming ruffed grouse in Indiana is structurally similar to that reported elsewhere but plant species of vegetation reflect what is available in the surrounding forest ecosystem.

The future of Indiana's ruffed grouse populations appears to be sound, but will continue to be influenced by contemporary land-use practices, especially timber management. Future research needs include the continual improvement of census techniques, identify unoccupied range with suitable habitat for restocking, evaluate release techniques, and monitor the effects of timber management on grouse populations.

LITERATURE CITED

Aldrich, J. W. 1963. Geographic orientation of American Tetraonidae. J. Wildl. Manage. 27:528-545.

Allison, D. G. 1959. Long line brood census and grouse fall age and sex study. New Hampshire Fish Game Dept. Pittman-Robertson Completion Rpt. W-9-R. 49pp.

_____, 1963. Basic features of the New Hampshire ruffed grouse census. 27:614-616. J. Wildl. Manage. 27:614-616.

Ammann, G. A., and L. A. Ryel. 1963. Extensive methods of inventorying ruffed grouse in Michigan. J. Wildl. Manage. 22:617-633.

Anderson, D. R., J. L. Laake, B. R. Cain, and K. P. Burnham. 1976. Guidelines for line transect sampling of biological populations. Utah Coop. Wildl. Res. Unit, Utah State Univ., Logan. 28pp.

Anonymous. 1981. Indiana forest resources management guide. Indiana Dept. Nat. Resour., Indianapolis. 191pp.

Backs, S. E. 1979. Characteristics of brood habitat of ruffed grouse in Grafton, Vermont. M. S. Thesis, Univ. of Vermont, Burlington. 65pp.

_____, 1983 (In press). The historic and present distribution of ruffed grouse in Indiana. Proc. Indiana Acad. Sci. 92:

Berg, W. E, 1982. Ruffed grouse drumming counts. *in* B. G. Joselyn, ed., Status of wildlife populations, fall 1982 and 1977-1981 hunting and trapping harvest statistics. Minnesota Dept. Nat. Resour., St. Paul, Unpublished Rep. 89pp.

Boag, D. A., and K. M. Sumanik. 1969. Characteristics of drumming sites selected by ruffed grouse in Alberta. J. Wildl. Manage. 33:621-628.

Bowers, G. L., and W. D. Tanner. 1947. Spring and summer populations of ruffed grouse in central Pennsylvania. Pennsylvania Game News. 17(12):6-7.

Bump, G., R. W. Darrow, F. C. Edminster, and W. F. Crissey. 1947. The ruffed grouse: life history, propogation, management. New York State Conserv. Dept. Holling Press Inc., Buffalo, N.Y. 915pp.

Burnham, K. P., D. R. Anderson, and J. L. Laake. 1980. Estimation of density from line transect sampling of biological populations. Wildl. Mono. No. 72. 202pp.

Butler, A. W. 1897. The birds of Indiana. Indiana Dept. Geol. Nat. Res., Ann. Rpt. 22:687-745 and 1172-1173.

Chambers, R. E., and P. R. English. 1958. Modifications of ruffed grouse traps. J. Wildl. Manage. 22:200-202.

Coggin, J. L. 1977. Checking on grouse. Virginia Wildlife. 38:13-14.

_____, 1981. Grouse cycles: ups and downs. Virginia Wildlife. 42:15-16.

Davis, J. A., and R. J. Stoll, Jr. 1973. Ruffed grouse age and sex ratios in Ohio. J. Wildl. Manage. 37:133-141.

Donahoe, R. W. 1965. Grouse drumming census study. Game Res. in Ohio. 3:51-55.

_____, and R. J. Stoll, Jr. 1982. Forest game. Pages 1.1-1.5 *in* Reasons for Seasons. Ohio Dept. Nat. Resour., Inserv. Doc. No. 74.

Dorney, R. S. 1958. Ruffed grouse roosts as a spring-census technique. J. Wildl. Manage. 22:97-99.

_____, and C. Kabat. 1969. Relation of weather, parasitic disease, and hunting to Wisconsin ruffed grouse populations. Wisc. Cons. Dept. Tech. Bull. Rpt. 20. 64pp.

_____, and H. M. Mattison. 1956. Trapping techniques for ruffed grouse. J. Wildl. Manage. 20:47-50.

_____, D. R. Thompson, J. B. Hale and R. F. Wendt. 1958. An evaluation of ruffed grouse drumming counts. J. Wildl. Manage. 22:35-40.

Eberhardt, L. L. 1978a. Transect methods for population studies. J. Wildl. Manage. 42:1-13.

_____, 1978b. Appraising variability in population studies. J. Wildl. Manage. 42:207-238.

_____, 1981. Comments on transect methodology. Pages 17-39 *in* F. L. Miller and A. Gunn, eds., Symposium on census and inventory methods for population and habitats. Forest, Wildlife, and Range Exp. Sta., Univ. of Idaho, Moscow. Contribution No. 217. 220pp.

Gullion, G.W. 1966a. The use of drumming behavior in ruffed grouse population studies. J. Wildl. Manage. 30:717-720.

_____, 1966b. Instructions for placing and operating traps for ruffed grouse. Forest Wildlife Relations Project, Univ. Minn. Forest Research Center, Cloquet, MN. Mimeo 14pp.

_____, 1967. Selection and use of drumming sites by male ruffed grouse. Auk 84:87-112.

_____, 1978. The ruffed grouse. Pages 33-47 *in* the Minnesota Volunteer, Minn. Dept. Nat. Resour. Sept.-Oct. 1978.

_____, 1981. Non-drumming males in a ruffed grouse population. Wilson Bull. 93:372-382.

Hale, R. E., A. S. Johnson, and J. L. Landers. 1982. Characteristics of ruffed grouse drumming sites in Georgia. J. Wildl. Manage. 46:115-123.

Hamilton, R. 1962a. Trapping and transplanting of ruffed grouse and observations of ruffed grouse broods. Indiana Dept. of Conser. Pittman-Robertson Wildl. Res. Rpt. W-2-R. 22:63-66.

_____, 1962b. Determination of occupied ruffed grouse range. Ind. Dept. of Conser. Pittman-Robertson Wildl. Res. Rpt. W-2-R. 22:72-74.

Hardy, F. C. 1950. Ruffed grouse studies in eastern Kentucky. Kentucky Div. Fish and Game. Pittman-Robertson Rpt. W-18-R. 26pp.

Healy, W. M., R. O. Kimmel, D. A. Holderman, W. B. Hunyadi. 1980. Attracting ruffed grouse broods with tape-recorded chick calls. Wildl. Soc. Bull. 8:69-71.

Johnson, G. 1966. Ruffed grouse roadside drumming counts. Ind. Dept. of Nat. Resour., Pittman-Robertson Wildl. Res. Rpt. 27:32-35.

Keith, L. B. 1963. Wildlife's ten-year cycle. Univ. of Wisconsin Press, Madison. 201pp.

Kelly, S. T. 1977. Evaluation of a ruffed grouse reintroduction in northern Indiana. M. S. Thesis, Purdue Univ., West Lafayette, Indiana 70pp.

_____, and C. M. Kirkpatrick. 1979. Evaluation of a ruffed grouse reintroduction in northern Indiana. Wildl. Soc. Bull. 7:288-291.

_____, and P. D. Major. 1979. Characteristics or ruffed grouse drumming sites in Indiana. Unpublished Rpt., Indiana Dept. Nat. Resour. 11pp.

King, R. T. 1937. Ruffed grouse management. J. Forestry. 35:523-532.

Korschgen, L. J. 1966. Foods and nutrition of ruffed grouse in Missouri. J. Wildl. Manage. 30:86-100.

Kriz, J. J. and S. A. Liscinsky. 1981. Pennsylvania's grouse hunting survey. Pages 26-30 *in* Pennsylvania Game News, Oct. 1981.

_____, and L. M. Lang. 1982. Why a longer grouse hunting season? Pennsylvania Game News, Vol. 53:42-43.

Leopold, A. 1931. Report on a game survey of the North-Central States. Sporting Arms and Ammunition Manuf. Inst. Madison, Wisconsin.

_____, 1933. Game management. Charles Schribner's Sons. New York. 481pp.

Lewis, J. B., J. D. McGowan, and T. S. Baskett. 1968. Evaluating ruffed grouse reintroduction in Missouri. J. Wildl. Manage. 32:17-28.

Liscinsky, S. A., and W. J. Bailey, Jr. 1955. A modified shorebird trap for capturing woodcock and grouse. J. Wildl. Manage. 19:405-408.

Major, P. D., and G. D. Wise. 1977. Effects of woodland habitat changes, summer temperature, and relative humidity on density and distribution of ruffed grouse. Ind. Dept. Nat. Resour. Pittman-Robertson Final Rpt. W-26-R. 58pp.

_____, and J. C. Olson 1980. Harvest statistics from Indiana's ruffed grouse hunting seasons. Wildl. Soc. Bull. 8:18-23.

Martinka, R. R. and J. E. Swenson. 1981. A review of census techniques for North American upland game birds. pp 158-180 *in* Symposium and Census and Inventory Methods for Populations and Habitats. F. L. Miller and A. Gunn, eds. Banff, Alberta, Canada. Forest, Wildlife, and Range Exper. Sta., Univ. of Idaho, Moscow. Contribution No. 217. 220pp.

Moran, R. J. and W. L. Palmer. 1963. Ruffed grouse introductions and population trends on Michigan islands. J. Wildl. Manage. 27:606-614.

Muehrke, J. P. 1969. Observations on ruffed grouse ecology and behavior in southeastern Monroe County, Indiana. M. S. Thesis. Purdue University, West Lafayette, Indiana 98pp.

_____, and C. M. Kirkpatrick 1970. Observations on ecology and behavior of Indiana ruffed grouse. Proc. Indiana Acad. Sci. 79:177-186.

Mumford, R. E. 1953. Ruffed grouse restocking. Ind. Dept. of Conserv. Pittman-Robertson Wildl. Res. Rpt. W-2-R. 14:67-70.

_____, 1957. Ruffed grouse. Pages 181-194 *in* J. M. Allen, ed. Indiana Pittman-Robertson Wilflife Restoration 1939-1955, Pittman-Robertson Bull. No. 3, Ind. Dept. of Conser. 240pp.

Paige, D. W. 1975. Ruffed grouse re-introduction, dispersal, and survival in northern Indiana. M. S. Thesis, Purdue Univ., West Lafayette, Indiana. 73pp.

Palmer, W. L. 1963. Ruffed grouse drumming sites in northern Michigan. J. Wildl. Manage. 27:656-663.

_____, and C. L. Bennett, Jr. 1963. Relation of season length to harvest or ruffed grouse. J. Wildl. Manage. 27:634-639.

Petraborg, W. H., E. G. Wellein, and V. E. Gunvalson. 1953. Roadside drumming counts: a spring census method for ruffed grouse. J. Wildl. Manage. 17:292-295.

Porath, W. R., and P. A. Vohs. 1972. Population ecology of ruffed grouse in northeastern Iowa. J. Wildl. Manage. 36:793-802.

Ricklefs, R. E. 1974. Ecology. Chiron Press, Inc., Neston, Mass. 861pp.

Rodgers, R. D. 1981. Factors affecting ruffed grouse drumming counts in southwestern Wisconsin. J. Wildl. Manage. 45:409-418.

Rusch, D. J. and L. B. Keith. 1971. Ruffed grouse vegetation relationships in central Alberta. J. Wildl. Manage. 35:417-429.

Stoll, R. J. 1975. Indices to ruffed grouse abundance and distribution in Ohio. Ohio Dept. Nat. Resour. Perf. Rpt. Pittman-Robertson Proj. W-105-R. 25pp.

_____, 1980. Indices to ruffed grouse hunting success in Ohio Wildl. Soc. Bull. 8:24-28.

_____, M. W. McClain, R. L. Boston, and G. P. Honchul. 1979. Ruffed grouse drumming site characteristics in Ohio. J. Wildl. Manage. 43:324-333.

_____, M. W. McClain, C. M. Nixon, D. M. Worley. 1980. Foods of ruffed grouse in Ohio. Ohio Dept. Nat. Resour., Ohio Fish and wildl. Rpt. No. 7 17pp.

Thompson, D. R. and J. C. Moulton. 1981. An evaluation of Wisconsin ruffed grouse surveys. Wisc. Dept. of Nat. Resour., Madison. Tech. Bull. No. 123. 13pp.

Thurman, J. R. 1966. Ruffed grouse ecology in southeastern Monroe County, Indiana M. S. Thesis, Purdue Univ., West Lafayette, Indiana 101pp.

United States Department of Agriculture. 1976. Forest Survey: 1976 Hoosier Nat. For., Indiana. U. S. For. Serv., (unpublished data).

Evaluation of Ruffed Grouse Reintroductions in Southern Illinois

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Abstract: Between 1955 and 1958, 171 ruffed grouse *(Bonasa umbellus)* from Michigan and Wisconsin were released in Pope county, southern Illinois to re-establish a resident population where this species has been absent in historical times. The restoration attempt failed, but 31 birds trapped in Ohio and released about 12 km (7 mi) east of the earlier effort has at least persisted; annual drumming surveys have found at least 1 bird in the area each year. In 1972 and 1973, a total of 55 grouse from Indiana were released in Alexander county. These releases failed; drumming surveys have not located any birds since 1981. During August-October 1982, 120 birds were trapped in Indiana and released in Union county about 15 km (9 mi) north of the 1973 attempt. Ten birds were fitted with solar-powered transmitters to monitor their movements and survival. The grouse displayed a strong affinity for the release sites; maximum distance recorded from a release site was 2.8 km (1.7 mi) Areas of home ranges of 9 radioed birds were from 26.9-226.2 ha (66-556 acres), and each included the small (<8 ha; 20 acre) clearcuts that were selected as release sites. One transmitter failed just after release and 7 birds died between release and 30 May 1983. The first mortality occurred 99 days after release; circumstances indicated that it was illegally killed. The first natural mortality occurred 104 days after release. Survival from release to the first breeding season was estimated at 25% based on the radioed sample. Extensive drumming surveys conducted in April yielded a minimum male survival estimate of 19%, but drumming routes and searches in a 2.6 km^2 (1 mi^2) intensive study area located 9 males where 20 were released reflecting a survival of 45%. Two juvenile females with functional radios at the onset of breeding both nested. One nest containing 6 eggs was lost to predation before hatching; 8 chicks hatched from the other clutch of 12 eggs in mid-May. Brood surveys using taped chick distress calls located 1 other brood. In the absence of good nesting success and survival of young the first year after release, the outcome of this restoration attempt appears to be in doubt unless it is supplemented. In spite of reported successful reintroductions with 60 or fewer birds released, it appears that several consecutive years of releases may be needed in a given area in order to be able to predict optimistically a successful restoration.

Illinois lies within the historic range of the ruffed grouse (*Bonasa umbellus*) with southern Illinois near the south edge (Bump et al. 1947). Historic population densities and distribution are largely unknown, but the last hunting season for grouse in Illinois was in 1899; few sightings in the southern part of the state have been reported since then. Seemingly, Illinois was not included among the few isolated pockets of grouse that remained in the midwest after the turn of the century. A population persisted in northeast Iowa (Klonglas and Hlavka 1969) and southcentral Indiana (Bump et al. 1947), but ruffed grouse were considered extirpated in Illinois and possibly Missouri by the early 1900's. Attempts to reintroduce grouse to former midwestern ranges were first undertaken in Ohio and Missouri in 1939-40. (Bump et al. 1947:19). Restoration efforts in Illinois began in 1955, but without clear success. Successful restoration in Missouri (Lewis et al. 1968) and an expansion of range in Indiana that was largely a product of trapping and transplant efforts between 1961 and 1982 (Backs 1984) have encouraged Illinois to persist in restoration efforts.

The objectives of this paper are to: 1) document ruffed grouse reintroductions in Illinois, 2) report on movements, survival, and reproduction of the grouse released in 1982, and 3) review aspects of midwestern grouse reintroductions. This study was conducted to provide a biological basis for making decisions and evaluating objectives with respect to future ruffed grouse management in Illinois.

The early efforts to restore grouse to Illinois began with a suggestion by Dr. T. G. Scott, former Head, Section of Wildlife Research, Illinois Natural History Survey; much of the early work reported was an effort of Survey staff. We thank Dr. Glen C. Sanderson, Head, Section of Wildlife Research, Illinois Natural History Survey, for access and permission to use unpublished data and reports in Survey files. Many former and present employees of the Illinois Department of Conservation continued the work, especially J. Calhoun, J. Garver, B. Hager, G. Hubert, and F. Loomis. The planning and conduct of grouse surveys in Pope and Alexander counties involved the efforts of both department employees and Dr. R. Andrews and his students at Eastern Illinois University. The current study benefited from the assistance and suggestions of J. Garver and other staff of the Illinois Department of Conservation; B. W. Hunyadi, Missouri Department of Conservation; P. Decker Major, Indiana Department of Natural Resources;

and M. Spanel, U.S. Forest Biologist, Shawnee National Forest. H. Godlevske, U.S. Forest Supervisor, Wayne-Hoosier National Forest, Indiana cooperated in trapping efforts.

This study is a contribution of Illinois Federal Aid Project W-63-R(SI) with portions contracted to the Cooperative Wildlife Research Laboratory, Southern Illinois University at Carbondale. However, the conclusions presented in this paper represent the personal views of the authors rather than of their agencies. Data were obtained as portions of a study conducted by R. Norris in partial fulfillment of the requirements for a Master's degree in the Department of Zoology, SIU-C.

METHODS

Capture, Handling, and Transport

Grouse to be released in Illinois in 1982 were captured in the Wayne-Hoosier National Forest, southern Indiana from August-October. Unbaited lily-pad traps were used; they were visited daily beginning in late afternoon and terminating at dusk. Captured birds were placed in a 35x25x21 cm (14x10x8 in) poultry box for transportation to a holding facility. Each was examined and age, sex, weight, condition, and capture date and location recorded. Aging was on the basis of feather development (Bump et al. 1947). Sex determination was based on the feather dot technique (Roussel and Ouellet 1975). Weights to the nearest gram were taken on a spring scale.

The holding house was a double-walled insulated structure 3.7x2.4 m (12x8 ft) with 1.2 m (4 ft) high walls; a pitched roof provided additional height. The interior was lined with 0.31 cm (0.1 in) mesh nylon netting suspended with turnbuckles and attaching wire so that the netting was held taut about 10 cm (2 in) from the walls and ceiling; the bottom was stapled to the plywood floor. Access was through zippered panels at the building entrance and a small side access door.

Ventilation was provided at floor level through a small door located centrally on 2 sides of the house; hardware cloth prevented entry of predators. Metal air vents were located at each roof comb; an externally mounted 8000 BTU air-conditioner further controlled temperature as necessary.

Autumn olive (*Elaeagnus umbellata*) branches bearing an abundance of ripe berries provided captive birds moisture, food, and cover. Once or twice a week, birds were either flown or driven to southern Illinois (no birds were held in captivity longer than 1 week) and released before early afternoon. Weights were again taken and the birds were grossly examined to assess physical condition and injuries that might adversely affect post-release survival.

Drumming Counts

Four drumming count routes to be run each year were established to monitor the 1967 Pope county release. In 1970, the number of routes was increased to 16 within a 65 km^2 (25 mi^2) area centered on the release site and they were run each year through 1979; only 6 routes were run from 1980-83. Drumming counts were generally conducted between the last week of March and mid-April. They began about 30 min before dawn and consisted of walking 5 min between 10 min listening stops. Each route in a given year was walked 1-3 times. Weather was not always ideal for the counts, but generally adequate conditions prevailed for at least 1 survey each year.

Following the 1972-73 Alexander county release, 12 drumming count routes totaling about 36 km (22 mi) were established around the release site, and counts were made under similar conditions as the Pope county routes. After 1980, only 5 routes were run until the monitoring terminated in 1982.

Eight routes totaling about 27 km (16.5 mi) were run 2-3 times each during 12-14 April 1983 to monitor the Union county release. These routes were supplemented by intensive searches for drumming logs and listening for drumming males from mid-March through April 1983 within a 2.6 km^2 (1 mi^2 intensive study area.

Radio-telemetry

Ten solar/nickel-cadmium powered transmitters (AVM Instrument Co., Ltd.[1]) were glued to vinyl "ponchos" as described by J. Monarch (Wildlife Biologist, Pittsburgh & Midway Coal, Denver, Co., pers. comm.). The complete packages ranged in weight from 15.5 to 16 g and averaged 3.4% of the weights of the birds at release. When the units are properly placed, the package rests on the bird's breast, neck and breast feathers are preened over the poncho to limit movement, and the "solar window" of the transmitter is the main portion left exposed. The antenna rests just lateral to the neck and rides over the bird's back.

Radio-locations by triangulation were made at random times during daylight hours using standard techniques. A minimum frequency of monitoring was twice weekly; visual location and/or flushing was done if 2 successive locations indicated that the bird had not moved. This procedure minimized disturbance to the birds yet insured that mortality could be detected within the 12 day full-charge battery life if the solar window became obscured. However, dead birds could not be detected soon enough to define causes of death with certainty.

All grouse locations were recorded on topographic maps or aerial photographs. Distances between locations were measured on a straight line to the nearest meter. Radio locations were also plotted on a grid overlay to the nearest 50 m (55 yd.) and assigned coordinates. Individual home ranges were calculated as the least-sided polygon encompassing all locations (Silvy et al. 1979) using a computer program called RANGE.

[1]Use of a brand name does not imply endorsement by the authors or their agencies.

RESULTS

1955-58 Pope County Releases

Unpublished Illinois Department of Conservation reports suggested that about 300 grouse were released between 1953 and 1958, but a review of records could only account for the release of 171 birds in the vicinity of Belle Smith Springs, Pope County, between November 1955 and October 1958 (Fig. 1, Table 1). The initial release was composed of 68 birds reportedly wild trapped in Wisconsin; subsequent releases were of birds obtained both from Wisconsin and Michigan, but specific origins are unknown.

Table 1. Documented releases of ruffed grouse in the area of Belle Smith Springs, northern Pope County, Illinois, 1955-58 (information compiled from unpublished Illinois Natural History Survey and Illinois Department of Conservation files).

Release Date		Males	Females	Total
11/02/55		18	18	36
11/10/55		3	3	6
1/26/56		6	2	8
2/08/56		2	8	10
3/02/56		0	1	1
3/09/56		3	2	5
3/28/56		1	1	2
	Subtotals	33	35	68
9/13/57		—	5	7[a]
9/16/57		2	7	9
9/18/57		4	3	7
9/20/57		5	3	9[a]
9/21/57		1	7	8
9/22/57		2	2	5[a]
	Subtotals	14	27	45[a]
8/30/58		5	3	8
9/03/58		3	6	9
9/06/58		1	1	2
9/11/58		4	3	7
9/14/58		3	3	6
9/21/58		2	4	6
9/27/58		5	5	10
10/01/58		1	5	6
10/03/58		3	2	5
	Subtotals	26	32	58
	Totals	73	94	171[a]

[a]Total includes undetermined sex.

Habitat in the area was about 50% wooded, predominantly oak-hickory (*Quercus-Carya*) forest; remaining areas consisted of pasture, cultivated fields, and old-field in varying successional stages. Scattered shortleaf pine (*Pinus echinata*) plantations had the densest understory and grouse were released in these plantations. In retrospect, it seems that the release site lacked well-distributed habitats of optimum structure to support grouse.

The first release was monitored through August 1956 by random and systematic searches for signs and sightings to document distribution, habitat use, survival, and reproduction. Hanson and Carter (1956, unpubl. Ill. Nat. Hist. Surv. rept., 19pp. mimeo) reported that at least 40% of the released birds survived through the end of the breeding season. Observations of the birds and their signs indicated little dispersal from the release site; 40% were within the 0.8 km (0.5 mi), all but 1 were within 2.2 km (1.3 mi). One bird was seen about 8 km (4.8 mi) northeast of the release site. In August 1956, 6 birds judged to be juveniles from 2 broods were sighted, providing the only evidence that reproduction occurred.

Follow-up studies were not conducted, but it is clear that the 3 years of releases failed to establish a viable breeding population. There were scattered sightings of ruffed grouse in 4 counties adjacent to and including Pope county through 1963, but no reports were received after that.

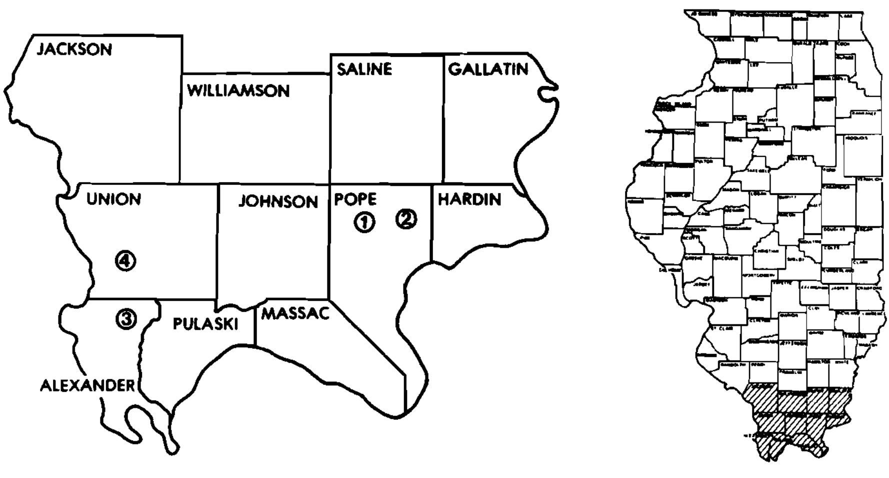

Fig. 1. Locations of ruffed grouse reintroductions in southern Illinois: 1. Belle Smith Springs, Pope county, 1955-58; 2. Lusk Creek Canyon, Pope county, 1967; 3. Alexander county, 1972-73; and 4. Union county, 1982.

1967 Pope County Release

Thirty-one grouse (20 males and 11 females; unknown age and condition) were trapped in southern Ohio and released in fall 1967 at Lusk Creek Canyon in northern Pope county about 12 km (7 mi) east of the 1955-58 releases (Fig. 1). The habitat in this area was 78% forest dominated by oak-hickory types. These stands were in late growth stages and generally lacked habitats with high stem densities in the understory. An evaluation of the release was made on the 65 km^2 (25 mi^2) study area from March-August 1968 (Hubert and Andrews 1968). Intensive searches led to a determination that a minimum of 9 grouse (29% of the release) survived until the following spring or summer. Reproduction was documented by finding 1 nest containing 11 eggs and twice sighting a brood of 6 chicks (Hubert and Andrews 1968).

The first drumming count in 1968 located 3 birds, and numbers increased each year through 1973 when 15 were heard (Fig. 2). Annual average dispersal distance from the release site over this period was about 0.8 km (0.5 mi) (Illinois Department of Conservation, unpubl. data), similar to that found with new releases in Missouri (Lewis et al. 1968) and Iowa (Little and Sheets 1982). Also, 85% of the drumming males were found less than 3.2 km (2 mi) from the release site over the first 5 years. Lewis et al. (1968) found that 92% of the grouse observed for 5 years following stocking in Missouri were less than 2.4 km (1.5 mi) from the initial release area. In Iowa, the first major extension of range was detected during the third spring. It appears from these data that the releases in Illinois, Iowa, and Missouri exhibited a common pattern, at least for the first few years after release.

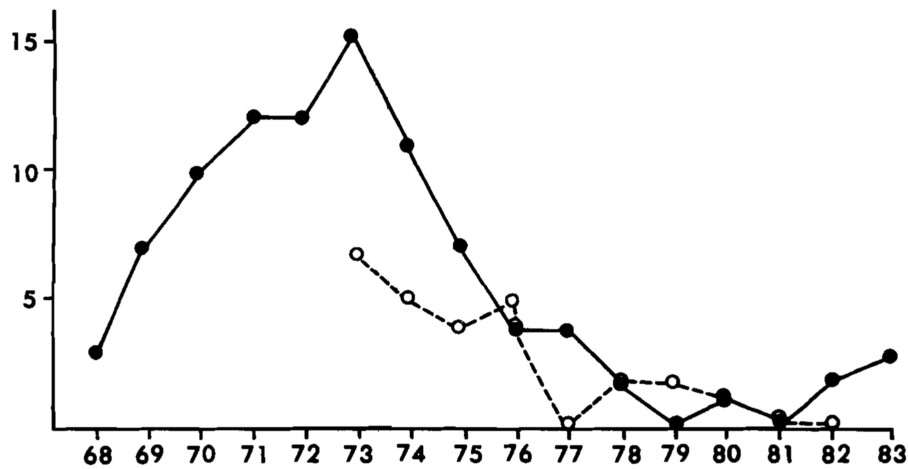

Fig. 2. Numbers of drumming grouse heard on Pope county routes, 1968-83 (●—●), and Alexander county routes, 1974-82 (○—○).

The drumming count index began a decline in 1974 that continued until none were heard in 1979. Although 1-3 drumming males have been heard each year since 1980 (Fig. 2), and unverified but seemingly valid reports of grouse sightings have been received, the release now appears to be a "straggling" failure. Both drumming males and reported sightings have been limited to the immediate vicinity of the release and no evidence exists to document successful dispersal. Apparently, the remnant population remaining is barely holding on.

1972-73 Alexander County Releases

In 1972, 42 grouse (23 males and 19 females) trapped in Indiana were released at a single site in northern Alexander County (Fig. 1). Habitat in the vicinity of the

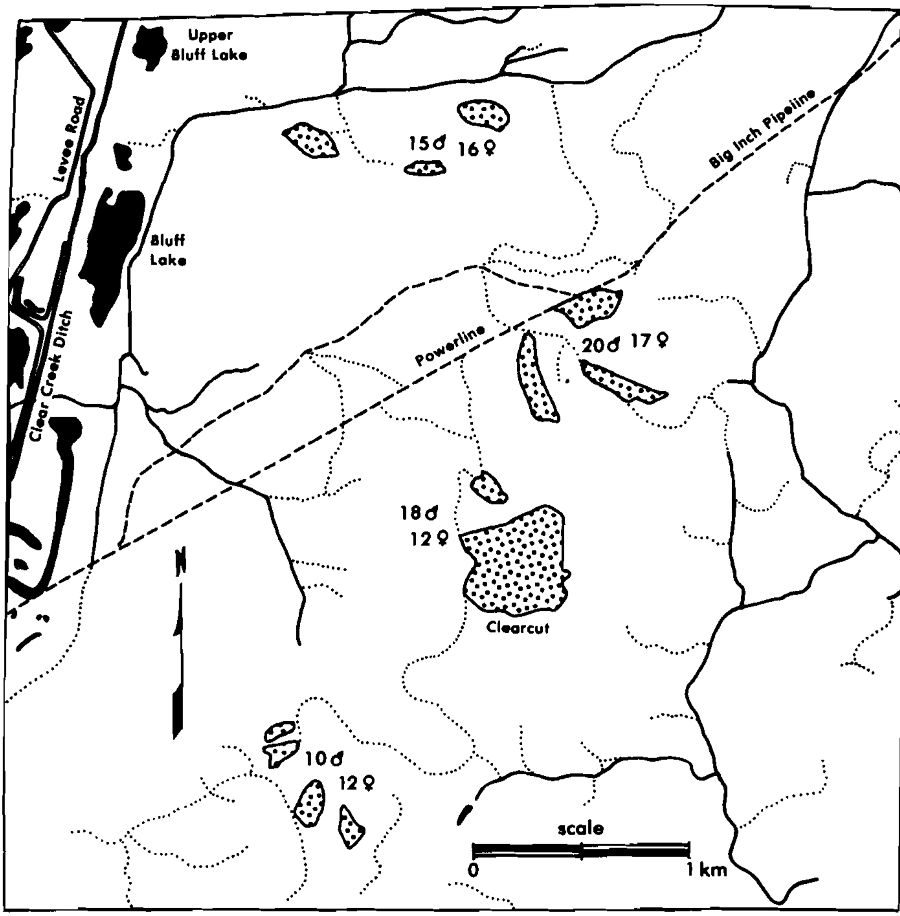

Fig. 3. Distribution of clearcuts and numbers/sex of ruffed grouse released at these sites in Union county, Illinois, August-October, 1982.

release was similar to that in Pope county, but was 81% woodland. An additional 13 birds from Indiana were released the following fall; 1 male and 4 females were released at the 1972 location and 4 of each sex were released about 8 km (5 mi) north. Seven drumming males were located the spring following the 1972 release suggesting a minimum survival of 30%. No birds were found farther than 2.5 km (1.5 mi) from the release site; most were much closer. The release seemed to be maintaining itself until 1976 as evidenced by the drumming counts (Fig. 2), but none were heard in 1977, only 1 or 2 through 1980, and none have been heard or sighted since then. The last drumming males located on the standard routes in 1979 and 1980 were all within 0.8 km (0.5 mi) of the original release site.

1982 Union County Release

Demographics and Condition

The August-October 1982 release in Union county (Fig. 1) differed from previous attempts in Illinois in that the initial release consisted of a large number of birds (120) from a similar latitude. Also, the birds were released at 4 sites along a 4.8 km (3 mi) north-south axis that were closely associated with regenerating clearcuts; each site was within dispersal distance of at least 1 other (Fig. 3). Surrounding habitat was dominated by late growth oak-hickory forest, but the clearcuts offered structurally ideal grouse habitat. The sex/age composition at each site of release was balanced as closely as possible (Table 2).

Of the 120 birds released, 16 were judged to be in poor condition on the basis of severe scalping, torn napes, or other injuries; their potential survival was doubtful. None of the birds had been held in captivity longer than 6 days prior to release; 78% were held 3 days or less. Weights at capture and release were recorded for a subsample of 46 birds; 7 maintained weight, 2 gained, and 37 lost

Table 2. Sex and age composition of the 1982 grouse reintroduction in Union County, Illinois.

Location		Male Adult	Male Juvenile	Male Total	Female Adult	Female Juvenile	Female Total
Lingle Creek		12	8	20	4	13	17
Harrison Creek	(east)	7	1	8	1	7	8
	(west)	2	5	7	5	3	8
Pine Knob	(north)	7	5	12	3	4	7
	(south)	2	4	6	3	2	5
Dogwood Flats		3	7	10	4	8	12
TOTALS		33	30	63	20	37	57

weight. The mean percentage of weight loss (5.6 ± 2.8 S.E.) was similar to the 6 ± 1% reported for the Iowa restoration attempt (Little and Sheets 1982).

Movements and Affinity to Release Sites

The radio-marked birds showed a strong affinity to the release locations; mean distance of all locations from release was 0.6 km (0.4 mi) while the maximum distance of any location was 2.8 km (1.7 mi) (Table 3). These post-release movements are similar to those documented in earlier Illinois releases as well as those

Table 3. Movements and home ranges of 9 ruffed grouse based on radio locations September 1982 - July 1983.

Band No.	Observation Period (n)	$\bar{X}$ Distance From Release, km (mi)	Maximum Distance From Release, km (mi)	Home Range Size ha (acres)
		MALES		
68	10/82- 3/83 (17)	0.3 (0.2)	0.6 (0.4)	42.5 (106)
108	9/82- 2/83 (24)	0.2 (0.1)	0.5 (0.3)	26.9 (67)
	$\bar{X}$ =	0.25 (0.15)	0.55 (0.33)	34.7 ± 11 (88 ± 28)
		FEMALES		
107	9/82- 7/83 (44)	0.7 (0.4)	1.6 (1.0)	226.2 (575)
109	9/82-12/82 (15)	0.5 (0.3)	0.8 (0.5)	54.9 (140)
125	9/82- 1/83 (16)	0.4 (0.2)	0.8 (0.5)	64.0 (160)
130	9/82- 4/83 (29)	1.1 (0.7)	1.7 (1.0)	88.4 (225)
134	9/82- 1/83 (13)	0.5 (0.3)	2.3 (1.4)	61.3 (156)
142	9/82- 5/83 (28)	1.0 (0.6)	2.5 (1.5)	153.5 (380)
150	9/82- 2/83 (12)	0.9 (0.5)	1.7 (1.0)	124.4 (310)
		0.7 (0.4)	1.6 (1.0)	110.4 ± 58 (273 ± 143)
BOTH SEXES	$\bar{X}$ =	0.6 (0.4)	1.4 (0.8)	93.57 ± 64 (231 ± 160)

in Missouri (Lewis et al. 1968) and Iowa (Little and Sheets 1982). Two females that survived to the breeding season showed some larger movements in spring 1983. This may be related to seeking mates and/or nesting locations; others have noted a similar increase in movements prior to nesting (Brander 1967, Maxson 1974). Females were more mobile than males throughout the monitoring period typifying the differential movements of sexes that was reported by Chambers and Sharp (1958) and Hale and Dorney (1963).

Home Ranges

The mean home range size of 34.7 ± 11 ha (85.3 ± 27 acres) for 2 radio-marked males reflected the generally sedentary nature of males in contrast to the 110.4 ± 58 (271 ± 143 acres) mean home range size of 7 females (Table 3). The largest home range of 226.2 ha (556 acres) can be attributed to successful nesting and movement to brood rearing habitat by #107. Female #142 had the next largest home range of 153.5 ha (378 acres). This size is accounted for by an ''errant'' movement of 2.8 km (1.7 mi) from release site to an isolated pocket of habitat; a similar movement then returned her to near the original release location where nesting occurred. None of the 5 other females survived past 7 April 1983; their mean home range size of 78.6 ± 25.6 ha (193 ± 63 acres) that did not encompass breeding and nesting activities was still more than double that of the 2 males. Nevertheless, the home ranges of both sexes reflected an overall tendency to remain close to the release locations.

Mortality

Each bird released was physically examined to assess probability of survivorship; 16 had injuries (from trapping/handling) that were judged severe. One of these birds was radio-collared to assess survival; it died within 12 days of release. Remains of 4 other birds also were found within a few days after release. In spite of the care taken during trapping, handling, and transport, we estimated that the birds experienced about a 13% mortality during the first few weeks after release.

Estimates of mortality from release until spring breeding were based on 3 independent measures. First, was the fate of 9 radio-marked birds (10 were initially marked, but 1 radio partially failed within a few days after release and we ended location attempts). The first radio-marked grouse died 99 days after release, with circumstances indicating that it was poached. The first natural mortality occurred 3 January 1983 (104 days afield); 5 others died from 19 January through 7 April (123 to 198 days after release). Excluding the transmitter failure and the illegal kill, 2 of 8 birds survived to the breeding season; a 75% mortality rate.

Two independent drumming surveys provided the other estimates of mortality. An extensive survey of the entire release area located 12 drumming males; 63 were released indicating a mortality rate of 81%. Poor weather conditions prevailed during the survey so this mortality estimate is considered high. A 2.6 km^2 (1 $mi.^2$) intensive study area where 20 males were released was repeatedly searched to locate drummers; 9 (45%) were found. Although this count ignored the effects of possible immigration or emmigration, the 55% mortality rate is comparable to those reported for Tennessee's reintroduction (White and Dimmick 1978) and also for established northern populations (Gullion and Marshall 1968).

We suspect that the fall to spring mortality experienced by this release is likely within the range of 55-75% as determined from the small radio-marked sample and the intensive study area drumming counts. Since this range of mortality was expected and has been frequently reported elsewhere, we conclude that the release has done as well as could be expected. If the immediate losses were discounted, fall to spring mortality experienced by this release is even better than indicated.

Reproduction

The 2 radio-marked females that survived to the breeding season both nested. One was found on a nest containing 12 eggs on 20 April; 7 chicks hatched on 17 May and 1 more the next day. The 4 remaining eggs were infertile. The other hen was found on a nest with 6 eggs on 3 May. This nest was destroyed by a predator 14 days later; no attempt was made to renest.

The hen with a brood was flushed on 20 July and at least 4 of the 8 chicks were still alive. Brood searches using a chick distress call tape (Healy et al. 1980) only located 1 additional brood; the size was not determined. These evidences of successful reproduction are analagous to those reported in earlier Illinois restoration attempts (Hubert and Andrews 1968, Hanson and Carter 1956, unpubl. Illinois Nat. History Surv. rept., 19pp. mimeo). It seems that although reproduction does occur, it does not occur at the high rates reported for reintroductions in prime northern grouse habitats (Moran and Palmer 1968). These findings illustrate the need to supplement initial restoration attempts with subsequent releases in the same area. Otherwise, "normal" fall to spring mortality is not being replaced by adequate reproduction, and although the release might persist for a period of time, a straggling type of failure is a more probable outcome.

DISCUSSION

Although the desire of public agencies to restore ruffed grouse to unoccupied historical ranges is seemingly a worthy concern, the feasibility of accomplishment and the techniques necessary to achieve success are subject to debate. For Illinois, the present state of the art has not yet defined all necessary ingredients for assured success as evidenced by grouse restoration attempts to date. Seemingly, early efforts failed except for a very low population in the vicinity of the 1967 release site in Pope county. It is too soon to judge the 1982 Union county release.

The monitoring of Illinois grouse reintroductions revealed some common findings. The fall to spring survival rates of 19% to 45% or greater are very similar to the 40% fall to spring juvenile survival rate reported by Gullion and Marshall (1968) for grouse in optimum northern habitats. Illinois survival rates exceed the 11% male survival in a southeast Iowa reintroducted population that has persisted (Little and Sheets 1982). In contrast, reintroduction that failed in Tennessee experienced an initial survival of about 45% (White and Dimmick 1978). Apparently survival at or near "expected" normal levels is not in itself a forecast of success. This initial survival so common to many reintroductions is usually coupled with some evidence, albiet scant, of successful reproduction in many cases; it was a common element in all Illinois efforts.

Apparently failures are not sudden, rather the releases persist for some time and then disappear. This happened not only in Illinois, but also in the early Missouri attempts (Lewis et al. 1968). Two Illinois releases even seemed to increase (Figure 1) then began a rather steep decline. Dispersal from the release sites was apparently not an adverse factor in Illinois; affinity to release sites was strong and similar to those dispersal rates reported for successful reintroductions in Missouri (Lewis et al. 1968) and Iowa (Little and Sheets 1982). White and Dimmick (1979) have been the only investigators to attribute a restoration failure to possible dispersal resulting in lack of breeding contact.

It may be difficult to partition out the interacting factors of genetic stock; habitat quality; size, composition, and condition of the release; and perhaps prevailing climatic condition, but these factors are likely central to the probability of success or failure. Regarding the genetic stock of birds, initial Illinois and Missouri releases were composed of birds from Michigan and Wisconsin. Likewise, the Tennessee release that failed was of birds from the same states. Several of the recent releases in portions of Missouri also consisted of birds from Wisconsin and these stockings may not be doing as well as those using Indiana birds (B. Hunyadi, Missouri Dept. Cons., pers. comm.). This is in contrast to successful reintroductions in the Ozarks of Missouri using birds from Indiana and Ohio (Lewis et al. 1968; B. Hunyadi, pers. comm.); and trap and transplant programs using resident birds in Indiana (Backs 1984), North Dakota (Schulz 1982), and Iowa (Little and Sheets 1982). Although birds from the northern states have demonstrated an ability to breed in the southern portions of grouse range, intuitively, one might assume that birds from a similar latitude and habitats would make better stock for reintroductions. Administrative considerations and expediency notwithstanding, we recommend that restoration programs limit the stock used to birds from similar latitudes and habitats.

Obviously, suitable habitat(s) must be selected to insure success. Bump et al. (1947) speculated that the southern limits of midwestern ranges may have been marginal habitats and this possibility should be considered. There is a good theoretical basis for assuming that at the limits of any species' range, climatic and edaphic conditions prevailing would produce less than optimum habitats. But this is not to say that suitable "patches" of habitat do not exist. In Indiana, there are spring densities of 6-33 grouse/100 ha (2.5-13/100 acres) (Kelley and Kirkpatrick 1977); the Missouri grouse range now supports average spring densities of 5-6/100 ha (2-3/100 acres) and densities of 12/100 ha (5/100 acres) exist in the best areas (Hunyadi, 1984). The very low spring density of 0.9/100 ha (0.4/100 acres) found 7 years after release in southeast Iowa was cited as evidence of the grouse's ability to exist "where little or no forest management has been undertaken to produce early seral stages" (Little and Sheets 1982:175).

In spite of the adaptability of grouse to habitats of various composition, requirements for suitable structure are well defined; the early releases in Illinois may have been doomed by poor habitat selection in terms of structure. Basically, the release areas of Pope and Alexander counties were composed of mature timber with relatively few patches of regenerating timber stands with high stem densities. To maximize success in the future, reintroductions should be made in areas where small block clearcuts have created a mosaic of habitat diversity within the known dispersal range of grouse. Forest management plans should exist and be implemented to insure that the release site and adjacent areas are maintained, or will become suitable habitat.

A final consideration is the size, composition, and pattern of release. Introductions in northern grouse ranges have resulted in spectacular successes; Moran and Palmer (1963) reported that stocking rates of 5 birds/2.6 km^2 (5/mi^2) reached maximum densities in 4 breeding seasons. The increase was described as "irruptive" and attributed mainly to excellent nesting success; overwinter mortality was "normal", about 70% of the fall population. More recently in North Dakota, a stocking of only 26 birds in about a 60 km^2 (22 mi^2) unit resulted in dispersal to all available areas after 3 years with an estimated spring population of 50-60 birds in the fourth spring.

It seems that these types of successes can only be expected in the prime grouse ranges; similar expectations may be unreasonable in the southern limits of historical ranges. The outcome of Missouri restoration efforts may be a more reasonable expectation. There, 3 releases totaling 143 birds were made between 1959-62 in 1 area and 2 additional releases totaling 119 birds were made in another area during 1959-63 (Lewis et al. 1968). These multiple releases slowly established and now comprise the core of a 4 county area in the Missouri River Hills that has a huntable grouse population. Additional grouse releases that have succeeded in Missouri totaled 50-70 birds in both single and multiple releases (Hunyadi 1984). The Illinois releases of "suitable" birds that failed (1972-73 Alexander county) or met with very marginal success (1967 Pope county) consisted of single releases of relatively few birds.

Consider that a reintroduction effort is essentially creating an "island" population with a set gene pool that initially must survive the rigors of trapping, handling, transport, and release in new surroundings, and cannot depend on immigration to enhance numbers. Moran and Palmer (1963:613) concluded that: "low density transplants composed largely of juveniles trapped and released in August and September have no difficulty adapting to suitable habitat and surviving the winter in the presence of natural predators." This conclusion is supported by the history of both successful and unsuccessful restoration attempts in southern midwestern ranges. A key difference, however, seems to be a lack of comparable reproductive success to that reported for northern releases. Although reproduction occurs, the net productivity is inadequate to offset the "normal" mortality experienced.

The size of an initial release should be adequate to withstand fall to spring mortality in the order of 70% and still have spring densities of 12/100 ha (5/100 acres) or better to maximize the probability of some brood production and survival. It would then be judicious in light of the restricted gene pool and apparent low productivity to "boost" the releases for 2-3 consecutive years. This would serve not only to supplement the initial survivals with "immigration", but may also offset any unfavorable climatic conditions that could impair brood production and survival in any single year.

We are optimistic that grouse can be successfully restored to former ranges in southern Illinois and elsewhere. An ecologically and physiologically suitable group of wild-trapped and carefully handled birds should be used; whether the birds are juveniles or adults is probably less important than the need to insure that releases are composed of a balanced sex ratio. The stocking rate should approximate or even somewhat exceed normal fall densities to insure that spring densities are adequate to maximize the probability of successful reproduction. Finally, the release sites selected must contain habitat components to meet year round needs, both at the time of release and also with some assurances of management to maintain a quality habitat in the future. If these conditions are met, success is still not insured. There must be a commitment to supplement the precarious initial transplant for 2 or more years to "weigh" the entire effort in favor of eventual success.

LITERATURE CITED

Backs, S. E. 1984. Ruffed grouse restoration in Indiana. pp. ??-?? *in* Ruffed Grouse Management: State of the Art in the Early 1980's (W. L. Robinson, ed.) North Central Section, The Wildlife Society, ?? pp.

Brander, R. B. 1967. Movements of female ruffed grouse during the mating season. The Wilson Bull. 79(1):28-36.

Bump, G., R. W. Darrow, F. C. Edminster, and W. F. Crissey. 1947. The ruffed grouse; life history, propagation, management. New York State Conserv. Dept. 915pp.

Chambers, R. E., and W. M. Sharp. 1958. Movements and dispersal within a population of ruffed grouse. J. Wildl. Manage. 22(3):231-39.

Gullion, G. W., and W. H. Marshall. 1968. Survival of ruffed grouse in a boreal forest. Living Bird 7:117-167.

Hale, J. B., R. S. Dorney. 1963. Seasonal movements of ruffed grouse in Wisconsin. J. Wildl. Manage. 27(4):648-656.

Healy, W., M. Kimmel, R. O. Holderman, D. A. and Wm. Hunyadi. 1980. Attracting ruffed grouse broods with tape-recorded chick calls. The Wildl. Soc. Bull. 8(1):69-71.

Hubert, G. F. Jr., and R. D. Andrews. 1968. Forest Game Investigations. Ill. P. R. Project W-63-R-11. Job 4. 33pp.

Hunyadi, B. W. 1984. Ruffed grouse restoration in Missouri. pp. ??-?? *in* Ruffed Grouse Management: State of the art in the early 1980's (W. L. Robinson, ed.) North Central Section, The Wildlife Society, ?? pp.

Kelley, S. T., and C. M. Kirkpatrick. 1977. Evaluation of a ruffed grouse reintroduction in northern Indiana. Proc. Indiana Acad. Sci. 87:173. (Abstract only)

Klonglan, E. D., and G. Hlavka. 1969. Recent status of ruffed grouse in Iowa. Proc. Iowa Acad. Sci. 76:231-240.

Lewis, J. B., J. D. McGowan, and T. S. Baskett. 1968. Evaluating ruffed grouse reintroduction in Missouri. J. Wildl. Manage. 32(1):17-28.

Little, T. W., and R. Sheets. 1982. Transplanting Iowa ruffed grouse. Proc. Iowa Acad. Sci. 89(4):172-175.

Maxson, S. J. 1978. Spring home range and habitat use by female ruffed grouse. J. Wildl. Manage. 42:61-71.

Moran, R. J., and W. L. Palmer. 1963. Ruffed grouse introductions and population trends on Michigan islands. J. Wildl. Manage. 27(4):606-614.

Roussel, Y. E., and R. Ouellet. 1975. A new criterion for sexing Quebec ruffed grouse. J. Wildl. Manage. 39(2):443-445.

Shulz, J. W. 1982. Ruffed grouse populations and management in North Dakota. Biennial Grouse Group Meeting. Traverse City, MI. Oct. 8-9.

Silvy, N. J., J. L. Roseberry, R. A. Lancia. 1979. A computer algorithm for determining home range size using Mohr's minimum home range method. pp.170-177 *in* Proc. Second International Confer. on Wildlife Biotelemetry. Laramie, Wyoming.

White, D. and R. W. Dimmick. 1978. Survival and habitat use of northern ruffed grouse introduced into west Tennessee. Proc. Southeast Assoc. Fish and Wildlife Agencies. 32:1-7.

Habitat Utilization by Ruffed Grouse Transplanted from Wisconsin to West Tennessee

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Abstract: Eighty ruffed grouse *(Bonasa umbellus)* trapped in southwestern Wisconsin were released in Benton County, Tennessee in an attempt to restore the bird to part of its historic range. Trapping, transporting and releasing were accomplished in late August and early September, 1981 and 1982. A total of 871 telemetry locations were made of 19 radio-equipped birds from September through December of both years. Seven of these birds were known to survive longer than 1 month after their release, including 1 which was alive at its last radio location almost 8 months later. Maximum dispersal was 4.0 km (2.5 mi). Home ranges of 10 grouse varied from 18 to 176 ha (45-447 acres). Habitat utilized was subjectively classified into 1 of 6 categories based upon permanent winter cover. The most intensively used habitats were dense stands of hardwood saplings and vines, found principally on lower slopes and stream bottoms. Also frequented were farkleberry (*Vaccinium arboreum*) thickets on dry ridges beneath overstories of pine (*Pinus* spp.) or mature oak (*Quercus* spp.). Mature upland oak and bottomland hardwood forests offered suitable habitat mainly during early fall when herbaceous and viny thickets provided cover in the understory. Home range sizes and dispersal movements were influenced by the quality of the habitat near the release site. Future restoration attempts should be conducted where proper forest management procedures can be assured.

Ruffed grouse in Tennessee live near the southern extremity of their range. Presently the bird occupies eastern Tennessee, with the western-most limit generally delineated by the western edge of the Cumberland Plateau (White and

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Dimmick 1979a). Ruffed grouse were formerly found on Tennessee's Western Highland Rim physiographic province, but were apparently extirpated from the region during the 1940's. Several states have had varied degrees of success in recent years in restoring ruffed grouse in their former range, including Missouri (McGowan 1966, Lewis et al. 1968), Indiana (Kelly and Kirkpatrick 1979), Arkansas (Pharris 1983) and Illinois (Woolf et al. 1984). Missouri's restocking program was successful enough to permit a hunting season on the bird in 1983, the first such season in Missouri since 1905.

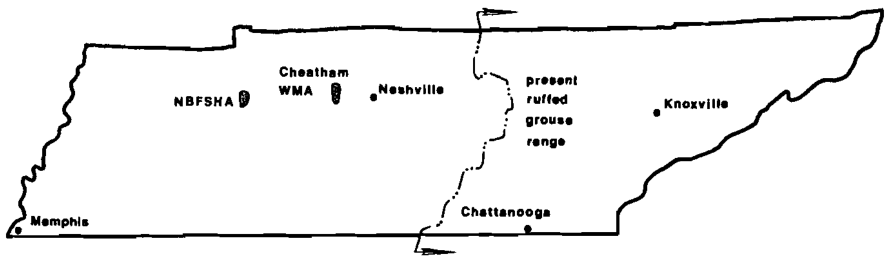

Fig. 1. Locations of release sites (Cheatham Wildlife Management Area) and Nathon Bedford Forrest State Historical Area for ruffed grouse restoration efforts in Tennessee.

Tennessee has had very limited success with 2 releases on the Western Highland Rim (Fig. 1). Eighteen Tennessee-trapped birds were released in Cheatham County in 1975 and 1976 (Jones 1979). In 1976 and 1977, 60 Wisconsin and Michigan grouse were released on Nathan B. Forrest State Historical Area (NBFSHA) in Benton County (White 1978). Ruffed grouse were observed on both areas as long as 2 years following the last release, but clear evidence of successful reproduction was never obtained. This paper describes a follow-up release and habitat utilization by grouse on the same area used by White.

STUDY AREA

Nathan B. Forrest State Historical Area occupies 1416 ha of hills and bluffs along the western shore of Kentucky Lake, some 200 km west of the present westernmost ruffed grouse populations in Tennessee. Topography of this highly dissected portion of the Western Highland Rim ranges from undulating stream terraces and uplands to steep, narrow-ridged hills with reliefs of up to 90 m (300 ft). Soils in the hilly areas are well to excessively well drained, cherty, weakly developed, leached and very acidic (Odum et al. 1953). Richer colluvial and alluvial soils in the valleys and hollows are limited in extent.

The vegetation is a mosaic of successional stages resulting from a history of repeated timber cutting and clearing of most level tracts for agriculture (White and Dimmick 1979b). Most of the area is wooded; uplands are dominated by oaks and hickories including chestnut oak (*Quercus prinus*), blackjack oak (*Q. mari-*

landica), white oak (*Q. alba*), post oak (*Q. stellata*) and shagbark hickory (*Carya ovata*). Thickets of farkleberry (*Vaccinium arboreum*) are often found on the ridges and upper slopes. Bands of mountain laurel (*Kalmia latifolia*) are also present on some of the steep south and east facing slopes. The moister bottomlands and hollows are mainly comprised of tulip poplar (*Liriodendron tulipifera*), sweetgum (*Liquidambar styraciflua*), maples (*Acer* spp.), beech (*Fagus grandifolia*) and mockernut hickory (*Carya tomentosa*). Shrub and ground layer vegetation is typically dense and more diverse in the bottomlands than in the uplands. Pines (*Pinus echinata, P. virginiana, P. strobus*) are interspersed throughout the area but are only dominant in one small portion of the park. Red cedars (*Juniperus virginiana*) are also scattered throughout NBFSHA but are rarely, if ever, dominant.

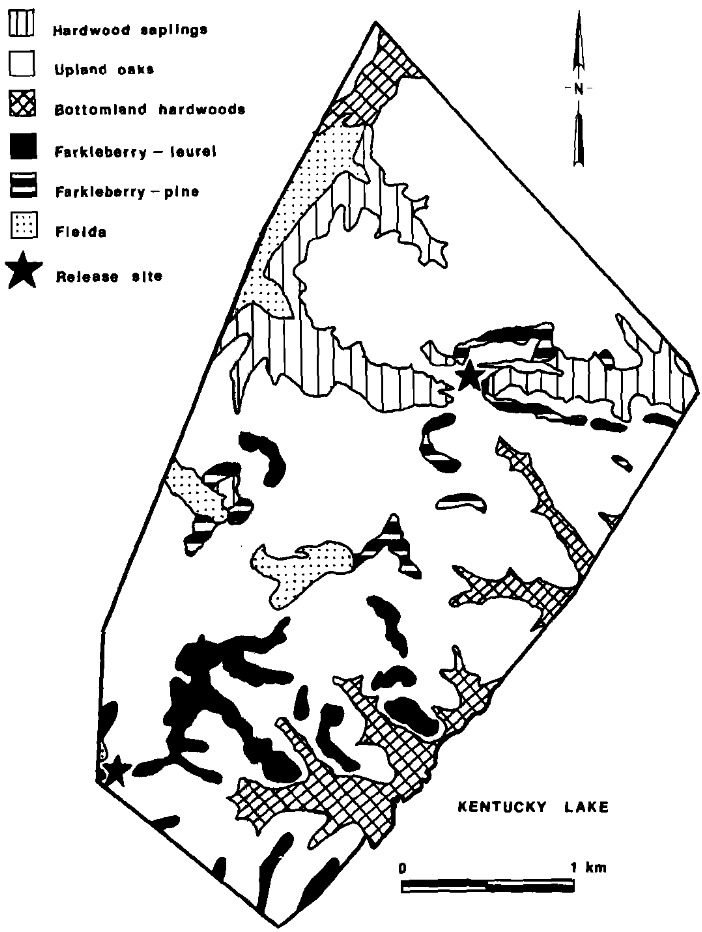

Fig. 2. Distribution of cover types on study area, NBFSHA, Benton County, Tennessee.

Six cover types were identified in the study area. They were classified according to their structural characteristics (Fig. 2). The resulting classification varied slightly from that presented by White and Dimmick (1979b) because different areas of the park were used by grouse, and habitat changes have occurred since their study was conducted. The 6 cover types are: (1) *Hardwood saplings:* dense stands of saplings (<4" dbh), (2) *upland oaks:* mature oak or oak-hickory woodlands with poorly developed understory, (3) *bottomland hardwoods:* mature, diversified mesic-site trees, with herbaceous understories varying from sparse to dense, (4) *farkleberry — laurel:* upland forest with dense shrubby understory of farkleberry and/or laurel, (5) *farkleberry — pine:* mature pine overstory with dense shrubby understory of farkleberry, (6) *fields:* principally agricultural crops including hay, pasture and row crops.

METHODS

Trapping and Handling

Grouse were trapped on the Fort McCoy Military Installation in southwestern Wisconsin in late August and early September of 1981 and 1982. Birds were captured using unbaited interception traps (Gullion 1965) consisting of 5x10 cm (2x4 in) welded wire catch boxes with funnel throats, connected by 9-27 m (30-90 ft) leads of 0.6 m (2 ft) high poultry wire. The birds were sexed according to rump feather dots (Roussell and Ouellet 1975), aged by feather growth and contour (Hale et al. 1954), leg banded, and placed in holding pens. They were fed locally gathered wild fruits and commercial game bird food pellets. Within 1 week of capture, the birds were either flown or driven to NBFSHA, where they were released at sites near favorable habitat.

Telemetry

Ten grouse in 1981 and 9 in 1982 were fitted with battery-powered radio transmitters (Telonics, Inc., Mesa, Arizona; wt. 30 g). Radio-tracking was conducted from time of release through mid-December of both years to monitor survival, movements and habitat use. Daily locations were calculated by triangulation from signals gathered by a receiver used in conjunction with a 4-element handheld antenna. Locations were generally made in either early morning (35.3% between 0700-0959 CDT) or late afternoon (36.6% between 1500-1759 CDT). About 58% of the time 2 locations were determined for a single bird on the same day. In 21% of the cases, the bird was flushed to determine survival or to delineate the habitat type used more specifically.

Analysis

Radio locations were recorded on USGS topographic maps overlaid by a grid of square 1 ha (2.5 acre) cells. Home range sizes were determined by delineating the area by means of a convex polygon; the area was calculated by a formula utilizing the UTM[2/] coordinates for the cells in which these locations were found (Jennrich and Turner 1969). Home range sizes were calculated excluding distinct dispersal and initial exploratory movements. The study area itself was determined by the birds' movements, and was delineated by a convex polygon containing the home ranges of all the radio-equipped birds. This totaled 1039 ha (2600 acres), including 323 ha (807 acres) outside NBFSHA boundaries.

A Chi-square test of utilization-availability data was used to determine preference or avoidance of the 6 cover types (Neu et al. 1974).

Maximum dispersal was measured as the straight line distance between the release site and the radio-location farthest from that point.

RESULTS

Eighty ruffed grouse trapped on Fort McCoy, Wisconsin (40 each in 1981 and 1982) were released on NBFSHA. In 1981, one-half of the birds were released at 1 site in the northern end of NBFSHA (Bethel Area) and the remainder at 1 site in the southern end (Pilot Knob Ridge). In 1982, all birds were released at the Bethel Area site, which appeared to be favored by grouse in the previous release.

Survival rate of radio-equipped grouse was very low. Only 6 of the 19 radio-equipped birds were alive 2 months after release, and only 1 survived beyond the life of its transmitters. The use of transmitters on grouse probably increases vulnerability to predation significantly (G. W. Gullion, 1982, per. comm.), and we concluded that the weight of the transmitters and length of the antennas reduced survival rates of our birds markedly. Cause of death could not be determined for all birds, but frequently it appeared to be predation, and commonly, predation was facilitated because the antenna became entangled in vegetation.

However, at least 3 drumming males were observed on the area in 1982 and 2 in 1983. An additional 4-6 birds were also flushed in the 1982 spring search. None of these carried transmitters.

A total of 871 locations was made for 19 radio-equipped grouse. Ten grouse survived a sufficient period of time to permit an analysis of their habitat use, home range, and dispersal movements. Seven hundred-ninety locations for these 10 grouse were used for the analysis.

Dispersal

The maximum distance travelled from the release site ranged from 936 to 4032 m (1020-4400 yd) (Table 1). Mean maximum distance was less in 1982 than in 1981 ($p < .0.20$). There were no distinct patterns of dispersal evidently related to sex or age.

Dispersal modes varied widely among those birds surviving a sufficient period of time to establish home ranges. Three birds occupied home ranges immediately

[2/]Universal Transverse Mercator system (Avery 1977).

Table 1. Home ranges and maximum dispersal of 10 ruffed grouse, each with 16 or more radio locations and surviving 3 weeks or longer.

Year	Bird No.	Sex	Age	No. Locs.	Survival (max. no. days)	Home Range, ha (acres)	Maximum Dispersal, m (yd)
1981	85	M	Juv.	96	92	176.0 (440)	1440 (1575)
	82	F	Juv.	86	86	165.5[b] (420)	3024 (3307)
	90	M	Juv.	112	234[a]	145.5[c] (370)	4032 (4409)
	86	F	Juv.	16	22	20.0 (50)	1296 (1417)
	84	M	Juv.	16	22	18.0 (45)	1536 (1680)
Mean						105.0 (267)	2266 (2478)
1982	145	M	Ad.	133	97	72.0 (183)	936 (1024)
	135	F	Juv.	37	25	25.5 (64)	2208 (2415)
	140	F	Juv.	129	87	33.5 (85)	1104 (1207)
	129	M	Ad.	64	44	31.0 (78)	1332 (1457)
	130	M	Juv.	101	69	29.5 (75)	1032 (1129)
Mean						38.3 (97)	1332 (1456)
Mean (all birds)						71.7 (182)	1799 (1967)

[a]Minimum survival: alive at last location

[b]Two distinct home ranges combined: 153.5 + 12.0 ha

[c]Two distinct home ranges combined: 99.0 + 46.5 ha; does not include 2 locations when the bird dispersed to a third area prior to 17 April 1982.

adjacent to the release site. All these birds were released in 1982 in an area which had been used successfully by birds released in 1981. Three birds established multiple home ranges, occupying them serially as summer progressed into fall and winter. The remaining 4 birds moved immediately from the release site, established small home ranges and remained there until their demise. Survival times were lowest for this last group of birds, averaging less than 1 month.

Home Range Characteristics

The size of home ranges varied from 18 to 176 ha (45-447 acres); area occupied was not consistently influenced by the life span of the occupant, nor by its sex. However, mean home range area of birds released in 1982 was only 46% of that of birds released in 1981 ($p<0.10$).

Seven grouse survived long enough to exhibit changes in their home ranges associated with seasonal changes in their habitat (Fig. 3). Two basic patterns were evident. A portion of the birds settled originally in habitat which was adequate for summer and late fall, but inadequate for winter. These birds initially maintained large home ranges, then dispersed to new areas more suitable for winter, decreasing their home range size drastically during the transitional period. A second segment initially occupied habitat suitable throughout the fall and winter. However, these birds increased their home ranges slightly during the transitional period as food and cover within this habitat type also diminished. Thus the released birds tended to seek out similar habitat as fall progressed and the home range sizes of the individual birds became increasingly similar.

Habitat Utilization

Seven of the 10 grouse utilized hardwood saplings as their primary cover type, all having 62% or more of their locations in this type. Two frequented upland oaks predominantly and 1 used bottomland hardwoods. These latter 3 birds were less faithful to a single cover type than birds using hardwood saplings. Only 46-50% of their locations were in their primary cover type. In contrast to the grouse released during 1976-77 (White and Dimmick 1976b), none of our radio-equipped birds used shrubby thickets of farkleberry or laurel as their primary cover type. These thickets appeared to be avoided (Table 2). Birds surviving longer than 1 month tended to increase their use of hardwood saplings as fall progressed (Fig. 4). This tendency was especially accentuated by 2 birds which, following dispersal from their initial ranges, increased their use of hardwood saplings twofold in one case and from no use to almost exclusive use in the other.

Upland oaks were frequented disproportionately less than their availability (70.3% of the study area), and were increasingly avoided as fall progressed (Fig. 4). Farkleberry-pine was a preferred cover type (Table 2), though only 1 bird used this cover type significantly. Use of this habitat occurred mainly during November. Bottomland hardwoods were used proportionate to their occurrence (Table 3). Fields were avoided.

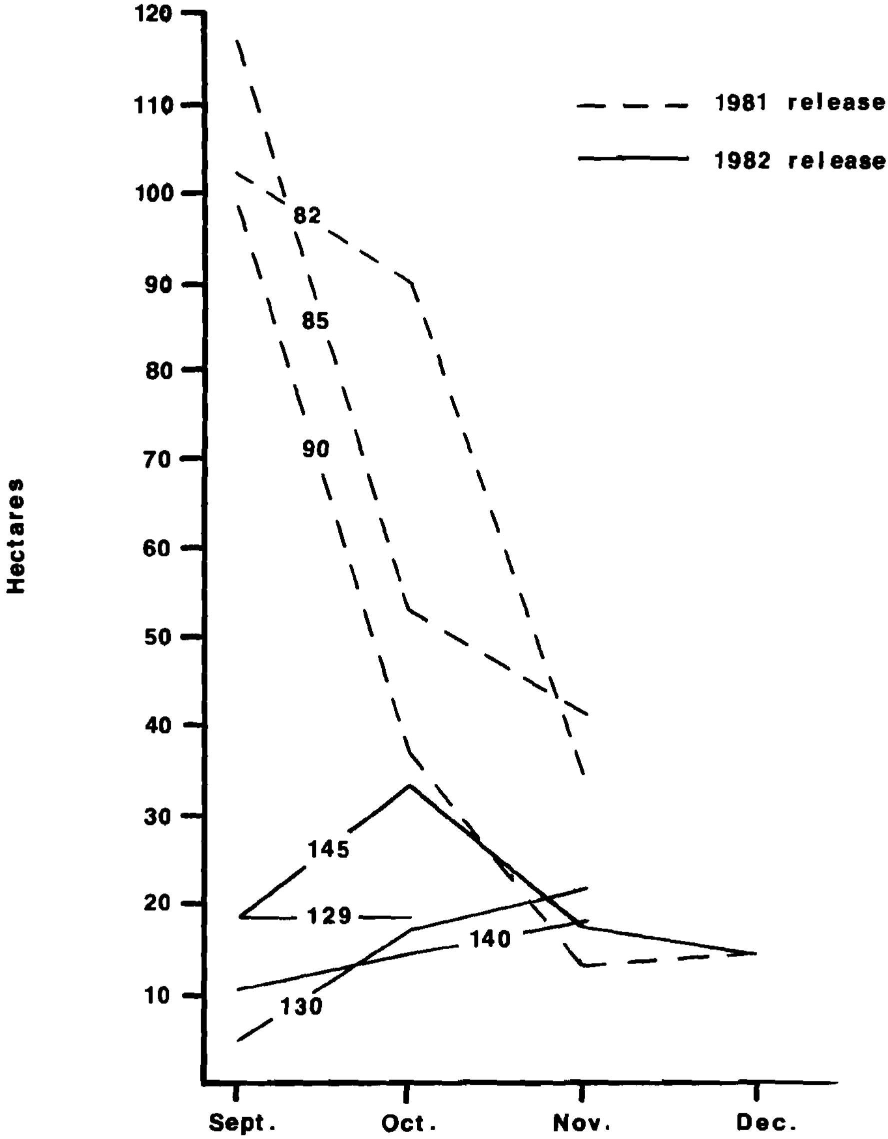

Fig. 3. Progressive changes in ruffed grouse home range size associated with seasonal habitat changes on NBFSHA, 1981-82.

Table 2. Cover type utilization and preference of 10 introduced ruffed grouse on NBFSHA, Benton Co., Tennessee, based on number and percentage of radio locations in each of 6 cover types.

Cover type	% availability	No. locs. observed	% utilization[a]	Pi[b]	99% Confidence interval	Preference[c]
Hardwood saplings	9.3	445	56.3	.093	$.603 \leq Pi \geq .523$	+
Upland oaks	70.3	210	26.6	.703	$.301 \leq Pi \geq .231$	–
Bottomland hardwoods	7.6	61	7.7	.076	$.099 \leq Pi \geq .055$	0
Farkleberry-laurel	5.3	28	3.5	.053	$.050 \leq Pi \geq .020$	–
Farkleberry-pine	2.5	33	4.2	.025	$.058 \leq Pi \geq .026$	+
Fields	5.0	13	1.7	.050	$.027 \leq Pi \geq .007$	–

[a]Based on percentage of total locations (N = 790)

[b]Theoretical proportion of occurrence (Neu et al. 1974)

[c]+ = used more than expected, – = used less than expected, 0 = used in proportion to occurrence on study area

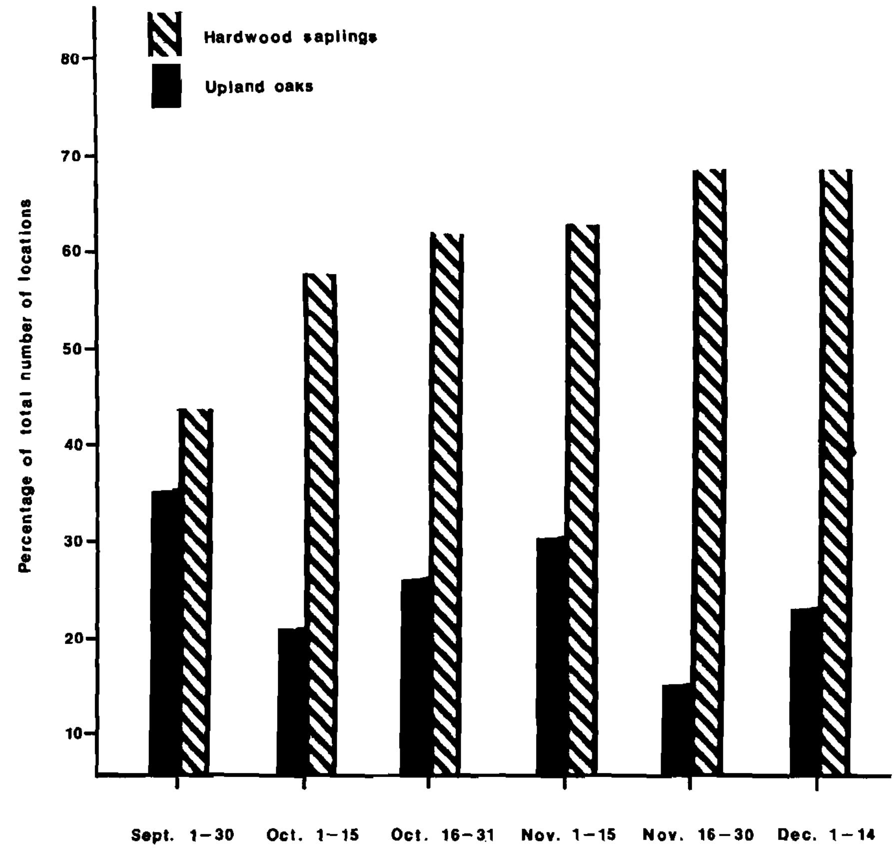

Fig. 4. Percentage of radio-locations in hardwood saplings vs. upland oaks, September-December, 1981 and 1982, NBFSHA, Tennessee.

Only 1 of the 7 birds surviving longer than 1 month exhibited no seasonal shift in habitat use. This bird utilized mainly hardwood saplings. All major shifts in habitat use occurred during late September to mid-October. Three birds shifted their primary use from upland oaks or bottomland hardwoods to extensive use of hardwood saplings, while another greatly increased its use of hardwood saplings beginning in October. In contrast, 1 bird shifted its primary cover type from hardwood saplings to upland oaks, and steadily increased its use of upland oaks thereafter. And one other grouse continued using upland oaks as its primary cover type, but shifted its secondary cover type from bottomland hardwoods to hardwood saplings.

DISCUSSION

Dispersal distances were well within limits of those reported for both native (Gullion and Marshall 1960, Godfrey and Marshall 1969, Rodgers 1980, Gullion 1982) and introduced grouse (Lewis et al. 1968, White and Dimmick 1979, Woolf et al. 1984).

Mean home range size was larger than reported for native northern grouse (Bump et al. 1947, Chambers and Sharp 1958, Schladweiler 1965, Archibald 1975, Bakke 1980). However, the 7 smallest home ranges of these introduced grouse were comparable to those of native Georgia birds (Harris 1981), and all were well within the range of those reported for introduced grouse (White and Dimmick 1979, Woolf et al. 1984). Harris (1981) postulated that better quality habitat was responsible for smaller home ranges of northern birds.

The quality of the habitat associated with the release site appeared to influence both dispersal and home range characteristics. In 1981, 2 of the birds released on Pilot Knob Ridge initially occupied large home ranges and had long daily movements. Later they dispersed northward to areas frequented by other grouse released in the Bethel Area. There they relocated into much smaller home ranges and greatly shortened their daily movements. This secondary dispersal may have reflected poor habitat quality in their initial home range, which afforded decreasing protection as leaf-fall progressed. Thus, birds released in 1981 served as indicators of habitat quality through their movements. In 1982 all birds were released in the Bethel Area; both the home ranges and dispersal movements of the radio-equipped birds were reduced markedly (Table 1).

High density stands of young deciduous trees, especially aspen, (*Populus* spp.), are highly regarded as critical habitat for northern ruffed grouse. In the southern Appalachian mountains, where aspen is seldom found, dense shrubby thickets of mountain laurel and rhododendron (*Rhododendron* spp.) appear to at least partially substitute for this habitat type. White and Dimmick (1979b) found thickets of laurel and farkleberry to be heavily used by northern grouse introduced on NBFSHA; forests with dense understories (similar to our hardwood saplings category) were also heavily utilized. Our results show hardwood saplings to be a highly preferred cover type, but shrubby thickets were avoided.

There were 2 possible reasons for this discrepancy. First, areas classified by White (1978) as open land or slashings have now grown into dense stands of hardwood saplings (about 9-12 years old), providing a greater extent of excellent habitat previously not available or as attractive. Second, White and Dimmick (1979b) released birds very close to shrubby thickets, and the birds apparently tended to use the closest adequate cover type. In contrast, we released a majority of birds near hardwood saplings and far from laurel thickets.

Gullion (1971) listed dense stands of 10-25 year old (aspen) saplings as being a factor critical to support of breeding grouse over winter. We feel that greater use of hardwood saplings significantly increased survival of birds without transmitters (Gudlin, M.S. thesis, in preparation) as compared to those released by White and Dimmick (1979b). Better quality habitat brought about shorter movements and smaller home ranges, decreasing vulnerability to predators.

Seasonal shifts in habitat use likely reflected changing cover requirements. In early fall (September-early October), upland oaks received much use. During this time grouse were often flushed from thickets of muscadine grape (*Vitis* sp.), which offered both cover and succulent fruits for food. As fall advanced, the deciduous shrub and ground cover in these habitat types gradually disappeared, and grouse increasingly used hardwood saplings. At this time the fruits of flowering dogwood (*Cornus florida*) had matured and birds were often flushed from or near these trees. As leaf cover declined, hardwood saplings and shrubby thickets offered the densest structural cover for protection. When dogwood berries became scarce, grouse increased their use of farkleberry thickets, where berries of this shrub persisted through November. Laurel thickets were seldom used, as they were somewhat limited in extent and are isolated from other adequate cover on NBFSHA. After leaf-fall, hardwood saplings provided the best protection from predators. As this cover type was located in the moister lowlands, it also contained the green leafy foods important to southern grouse (Stafford and Dimmick 1979, Smith 1977). Thus, seasonal changes in habitat narrowed the range of acceptable habitat, and resulted in more uniform habitat types comprising the home ranges of grouse on our study area.

Gullion (1977) observed that lack of the proper degree of forest disturbance poses the most serious threat to the continued abundance of grouse over some 29 million ha (73 million acres) of forest land in the northeastern United States. Increasing the quantity of clear-cutting also may be the key to restoring ruffed grouse to the Western Highland Rim. In this region, mature forest land is abundant, but young forested areas, which provide critical winter habitat, are limited. Clearcuts scheduled to provide regrowth in the 10-20 year old age class would be highly favored in areas selected for grouse restoration.

Acknowledgements

This project was supported with funds provided by the Tennessee Wildlife Resources Agency and the Federal Aid to Wildlife Restoration. We are grateful to the U.S. Army personnel at the Fort McCoy Military Installation, Sparta, Wisconsin, for permission to conduct our trapping efforts on the area, and especially to Kim Mello and Larry Capelle for their invaluable assistance during the trapping operations. Thanks to the Wisconsin Department of Natural Resources, notably Carl Batha for permission to capture grouse. The Tennessee Department of Conservation, Division of Parks provided permission and encouragement to use NBFSHA for the restorations attempt, and we are thankful to Superintendents Edwin Noble and Jennings Bunn for their cooperation and interest. We offer a special thanks to Ethlyn Dimmick, William G. Minser and Gary Tanner for their dedicated assistance throughout the trapping and release phases of this project.

LITERATURE CITED

Archibald, H. L. 1975. Temporal patterns of spring space use by ruffed grouse. J. Wildl. Manage. 39(3):472-481.

Avery, T. E. 1977. Interpretation of aerial photographs. Burgess Publishing Company, Minneapolis, Minnesota. 392 pp.

Bakke, E. L. 1980. Movements and habitat use of ruffed grouse in the Turtle Mountains, North Dakota. North Dakota State Game and Fish Dept., P-R Proj. W-67-R-20. 81 pp.

Bump, G., R. W. Darrow, F. C. Edminster and W. F. Crissey. 1947. The ruffed grouse: life history, propagation, management. New York State Conserv. Dept., Albany, New York. 915 pp.

Chambers, R. E., and W. M. Sharp. 1958. Movement and dispersal within a population of ruffed grouse. J. Wildl. Manage. 22(3):231-239.

Godfrey, G. A., and W. M. Marshall. 1969. Brood break-up and dispersal of ruffed grouse. J. Wildl. Manage. 33(6):609-620.

Gullion, G. W. 1965. Improvements in methods for trapping and marking ruffed grouse. J. Wildl. Manage. 29(1):109-116.

_____. 1971. Effects of logging upon ruffed grouse in Minnesota forests. Univ. Minn. Agric. Exp. Sta. Misc. Rept. 116:32-34.

_____. 1977. Forest manipulation for ruffed grouse. Trans. N. Am. Wildl. and Nat. Res. Conf. 42:449-458.

_____. 1982. The ruffed grouse. The Ruffed Grouse Society, Coraopolis, Pennsylvania. 4 p.

_____ and W. M. Marshall. 1960. Ruffed grouse management. Minnesota Conserv. Volunteer 23:51-55.

Hale, J. B., R. F. Wendt and G. C. Halazon. 1954. Sex and age criteria for Wisconsin ruffed grouse. Wisconsin Conserv. Dept. Tech. Wildl. Bull. No. 9, 24 p.

Harris, M. J. 1981. Spring and summer ecology of ruffed grouse in northern Georgia. M.S. thesis. The University of Georgia, Athens. 133 pp.

Jennrich, R. I., and F. B. Turner. 1969. Measurement of non-circular home range. J. Theoret. Biol. 22:227-237.

Jones, L. F. 1979. Evaluation of a ruffed grouse restoration attempt on the Western Highland Rim in Tennessee. M.S. thesis. The University of Tennessee, Knoxville. 64 pp.

Kelly, S. T., and C. M. Kirkpatrick. 1979. Evaluation of a ruffed grouse reintroduction in northern Indiana. Wild. Soc. Bull. 7(4):288-291.

Lewis, J. B., J. D. McGowan, and T. S. Baskett. 1968. Evaluating ruffed grouse reintroduction in Missouri. J. Wildl. Manage. 32(1):17-27.

McGowan, J. D. 1966. Ruffed grouse introduction in central Missouri. M.S. thesis. University of Missouri, Columbia. 121 pp.

Neu, C. W., C. R. Byers, and J. M. Peek. 1974. A technique for analysis of utilization-availability data. J. Wildl. Manage. 38(3):541-545.

Odum, L. E., R. M. Deere, M. H. Gallatin, and W. E. Cartwright. 1953. Soil survey of Benton County, Tennessee. U.S. Dept. of Agric. Soil Surv. Ser. 1941, No. 6. 171 pp.

Pharris, L. 1983. A different drummer for Arkansas. Arkansas Game and Fish 14(1):10-11.

Rodgers, R. D. 1980. Ecological relationships of ruffed grouse in southwestern Wisconsin. Wisc. Acad. Sci., Arts, and Letters. 68:97-105.

Roussel, Y. E., and R. Ouellet. 1975. A new criterion for sexing Quebec ruffed grouse. J. Wildl. Manage. 39(2):443-445.

Schladweiler, P. 1965. Movements and activities of ruffed grouse (*Bonasa umbellus*) during the summer period. M.S. thesis. The University of Minnesota, St. Paul. 107 pp.

Smith, A. F. 1977. Fall and winter food habits of the ruffed grouse in Georgia. M.S thesis. Univ. of Georgia, Athens. 76 pp.

Stafford, S. K., and R. W. Dimmick. 1979. Autumn and winter foods of ruffed grouse in the southern Appalachians. J. Wildl. Manage. 43(1):121-127.

White, D.W. 1978. Evaluation of a ruffed grouse restoration attempt in western Tennessee. M.S. thesis. The University of Tennessee, Knoxville. 85 pp.

_____ and R. W. Dimmick. 1979a. The distribution of ruffed grouse in Tennessee. J. Tenn. Acad. Sci. 54(3):114-115.

_____ and R. W. Dimmick, 1979b. Survival and habitat use of northern ruffed grouse introduced into west Tennessee. Proc. Ann. Conf. S.E. Assoc. Fish and Wildl. Agencies. 32:1-7.

Woolf, A., R. Norris, and J. Kube. Evaluation of ruffed grouse introductions in southern Illinois. pp. ??-?? *in* Ruffed Grouse Management: State of the Art in the Early 1980's (W. L. Robinson, ed.) North Central Section. The Wildlife Society.

Implications of Ruffed Grouse Brood Habitat Studies in West Virginia

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Abstract: Studies of the foraging behavior and cover use of 3 broods of human-imprinted ruffed grouse chicks were conducted in West Virginia to identify characteristics of forest openings that contribute to the survival of grouse during the early brood period. The diet of chicks up to 3 wk of age was found to consist of more than 90% invertebrates, particularly soft-bodied insects that would not be adequately measured through crop-gizzard or dropping analyses. Plant foods did not predominate in the diet until the chicks were 8 wk old. The vegetative structure of forest openings as it affects the availability of invertebrate foods could significantly influence chick survival. Habitat quality was related to differences in vegetative structure, particularly in the shrub layer, and its effect on ground temperature and humidity. Theoretical foraging times for chicks to meet necessary daily nutritional requirements on different habitat types were developed from observed feeding rates. Foraging times of 7.4-9.0 hr per day would be required in low quality brood habitat on reclaimed surface-mined land while foraging times of 3.7-5.1 hr per day were required on unmined land and a mined area planted to shrubs. Longer foraging times affect survival by making chicks more susceptible to predation and adverse weather conditions. Management aimed at improving brood habitat for ruffed grouse should be directed at creating small forest openings with a variety of understory plant species and a patchy shrub layer which provides a cool, moist microclimate for insects as well as ruffed grouse chicks.

Investigators throughout the range of the ruffed grouse (*Bonasa umbellus*) have stressed the importance of early succession habitats for ruffed grouse broods. In Virginia, Stewart (1956) found younger broods using forest edge habitats such as secondary roads and forest openings. Hein (1970) noted the use of logging roads by ruffed grouse broods in North Carolina. A similar use of openings by ruffed grouse broods has been reported in Idaho (Hungerford 1951), Wisconsin (Moulton 1968), and Iowa (Porath and Vohs 1972).

Why forest openings are important to ruffed grouse has often been a source of speculation. King (1937) noted that ruffed grouse broods are attracted to open areas for dry soil for dusting, succulent vegetation, and insects. More recent work with gray partridge (*Perdix perdix*) has indicated that insects as a food source for chicks may be the critical component of brood habitat (Southwood and Cross 1969). They found that 94% of the variation of breeding success of gray partridge could be explained primarily by variations in insect abundance and to a lesser extent by weather. Reduced insect numbers through modern pesticide use has been suggested as having adverse population effects through reduction of chick foods for ring-necked pheasants (*Phasianus colchicus*) (Messick et al. 1974, Warner et al. 1984), gray partridge (Potts 1977), and bobwhites (*Colinus virginianus*) (Stromborg 1982).

Insects are an important food source for juvenile ruffed grouse. Judd (1905) noted that young ruffed grouse, like the young of most gallinaceous birds, are more insectivorous than adults. Insects made up over 95% of the diet of 8 grouse chicks he examined, but the proportion of insect food to plant food decreased as the chicks aged. While there is general agreement that ruffed grouse chicks depend primarily on invertebrate food sources shortly after hatching, information on how long invertebrates make up a significant part of a grouse chick's diet is questionable. Bump et al. (1947) found that the proportion of insects fell to 30% of the diet by 3 wk after hatching. Studies by Stewart (1956), Hungerford (1957), and King (1969) have shown similar declines in the proportion of insects in the diet of grouse chicks as they aged, although the ages of the chicks they examined are not known.

Juvenile food habits similar to those reported for ruffed grouse have been noted for related species. Klebenow and Gray (1968) found insects in the diet of juvenile sage grouse (*Centrocercus urophasianus*) until 1 wk of age. Peterson (1970) reported that the proportion of insects in the diet of sage grouse drops to about 30% by 2 wk of age and to 5% by wk 3. Through crop examinations, he noted that hard-bodied insects were the most common food items. Stiven (1961) found that blue grouse (*Dendragapus obscurus*) switch from an insect to a plant diet after they are 2 wk old. May (1975) found that white-tailed ptarmigan (*Lagopus leucurus*) chicks eat mostly invertebrates until they are 3-4 wk old. Similar information has been noted for gray partridge (Weigand 1980), willow grouse (*Lagopus lagopus*) (Spidsø 1980), and the wild turkey (*Meleagris gallopavo silvestris*) (Hamrick and Davis 1971).

Traditionally, food habits data for gamebirds are obtained through examination of digestive tracts or droppings. Bump et al. (1947) questioned the reliability of crop-gizzard studies of ruffed grouse in summer because of differences in digestibility of many summer foods, but few subsequent studies have taken this into consideration. Biases related to digestibility have been recognized in waterfowl studies (Swanson and Bartenek 1970). Bailey et al. (1955) reported disadvantages for ruffed grouse food studies utilizing droppings, because identification of food items was related to digestibility.

The importance of insects in the diet of ruffed grouse chicks has serious implications for how we manage forest land for ruffed grouse brood habitat. The purpose of this study was to record food habits of juvenile ruffed grouse through direct observation of human-imprinted chicks. Foraging behavior and cover use in different habitat types were observed to identify characteristics of forest openings that contribute to the survival of grouse during the early brood period.

We thank W. Healy for assistance in project design and R. Whitmore for advice with the statistical analysis. G. Hockman, R. Johnson, and J. Messinger helped with field work and J. Lammers with typing. Ruffed grouse eggs were obtained with the cooperation of the West Virginia Department of Natural Resources. This research was supported by funds provided by the USDA Forest Service, Northeastern Forest Experiment Station Research Work Unit NE-1605 and by the West Virginia University Division of Forestry. Minnesota Department of Natural Resources provided logistic support in writing the manuscript.

METHODS

Three broods of ruffed grouse were obtained in northern West Virginia with the aid of the West Virginia Department of Natural Resources. Brood 1 consisted of 4 chicks captured from a wild brood on 21 May 1976 when they were 2 days old. Broods 2 and 3 were obtained as eggs from wild nests under incubation. Brood 2 (6 chicks) hatched 19 June 1976 and brood 3 (6 chicks) hatched 19 May 1977. Each brood was imprinted to humans by the investigators spending a minimum of 16 hr per day with the brood during the 1st wk after hatching (Kimmel 1982).

Feeding data were obtained by releasing a brood on a selected study area and observing individual chicks while actively feeding. Numbers of invertebrate and plant food items taken by chicks and food items that could be identified to taxonomic group were recorded during 5-min observation periods and expressed as feeding rates (food items/min). Six study areas were used; 4 were chosen to represent the spectrum of brood range available on reclaimed surface-mined lands, and 2 were non-mine sites representative of grouse brood range in northern West Virginia (Fig. 1). The 4 surface-mined areas were:

a) Autumn Olive — A 60x15 m (200x50 ft) area mined 25 yr earlier and planted with autumn olive (*Elaeagnus angustifolia*). The autumn olive was 4 m (13 ft) high with 100% canopy closure. The understory was sparse except at the edges of the planting.

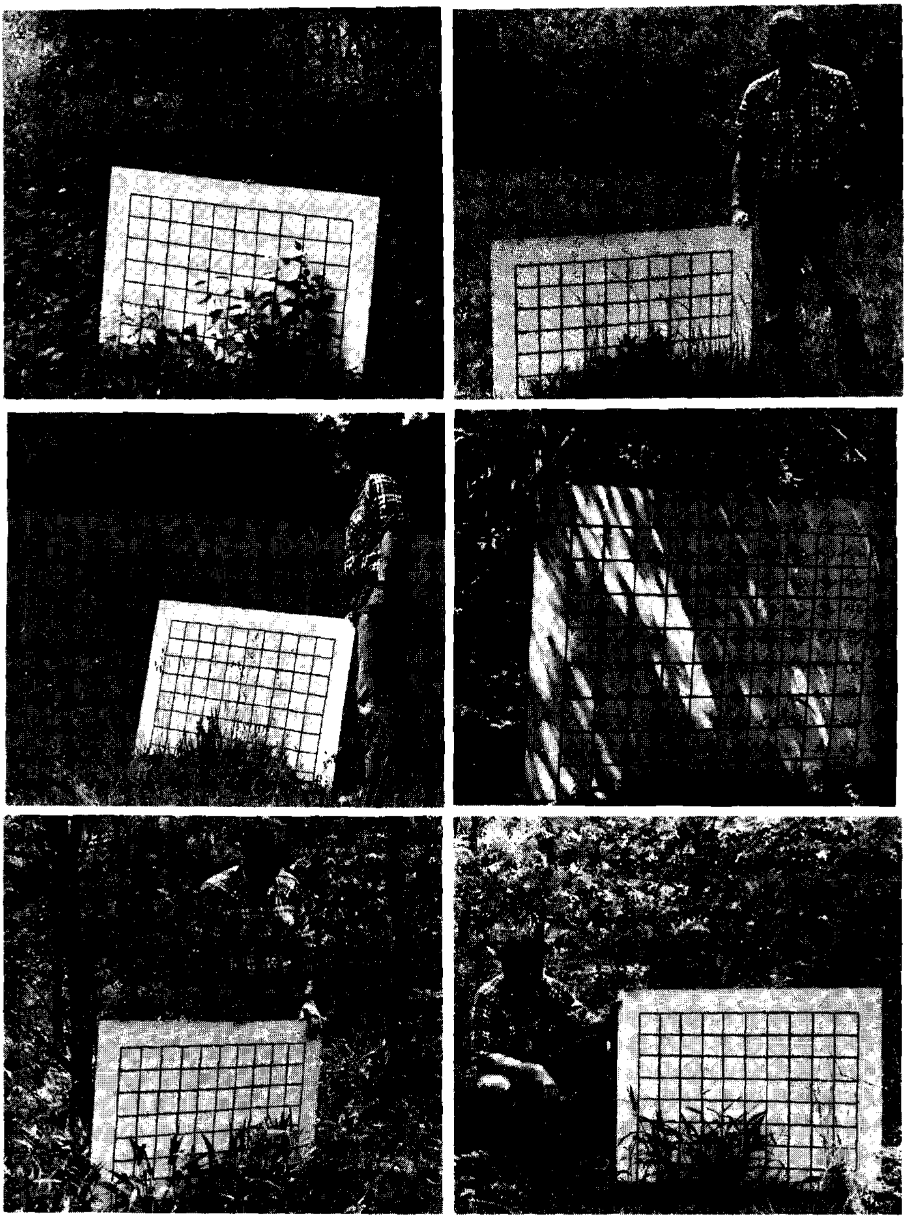

Fig. 1. Photographs of the study areas, W. Va., 1977. Foliage profile board contains 10 cm squares. Photos show Old Field (top left), Agricultural Clearing (top right), Grass-Legume (middle left), Autumn Olive (middle right), Locust I (bottom left), and Locust II (bottom right).

b) Locust I — A 20x20 m (66x66 ft) area mined 25 yr earlier and planted to black locust (*Robina pseudo-acacia*). The black locust trees averaged 5.7 cm (2.2 in) dbh and 7 m (23 ft) in height. Canopy closure was 50% and the understory was variable.
c) Locust II — An area similar to Locust I, but with trees averaging 4.8 cm (1.9 in) dbh and 6 m (20 ft) in height with a 25% canopy closure.
d) Grass-Legume — An area recontoured 2 years before the study and planted to birdsfoot trefoil (*Lotus corniculatus*) and Kentucky fescue (*Festuca spp.*).

Autumn Olive, Locust I, and Locust II were in Monongalia County, West Virginia. Grass-Legume was in Preston County, West Virginia. The non-mine areas were on the West Virginia University Experimental Forest in Preston County. Agricultural Clearing was a wildlife opening consisting of native grasses and herbaceous plants, maintained by the West Virginia Department of Natural Resources. The other (Old Field) was an abandoned orchard consisting of small openings, brushy thickets, and areas of young mixed hardwoods with a lush understory. All study areas except for Grass-Legume were used by wild grouse broods during the study.

A list of food items was obtained by pooling data from all 6 study areas. The proportion of plant to invertebrate items in the diet was determined on a weekly basis from the data collected on each of the study areas. These data were compared by week using paired t-tests.

Time spent feeding on invertebrates when the chicks were 2-4 wk old was used to develop theoretical foraging times for each study area. A standard linear regression analysis was used to predict when invertebrate feeding rates equaled plant feeding rates on each study area.

Suitability of protective cover was evaluated by visually locating all members of a brood, giving an alarm call (a trill) that immediately caused the birds to seek cover, then recording the percentage of the brood that was in sight of 2 observers 5 seconds after the call.

Plant availability was determined in 1977 for each study area using the line-intercept method (Giles and Toschik 1971). Foliage profile was measured in 1976 and 1977 using a grid board (Kimmel 1982).

Ground temperatures were recorded during 1977 by placing a recording thermometer under the ground litter on each study area. Humidity and air temperatures were recorded at ground level during the 1st feeding observation period each week on each study area.

Invertebrate availability was determined in 1977 by sweepnet sampling (Kretzschmer 1948, Hillhouse and Pitre 1974) and stickyboards (Southwood 1966).

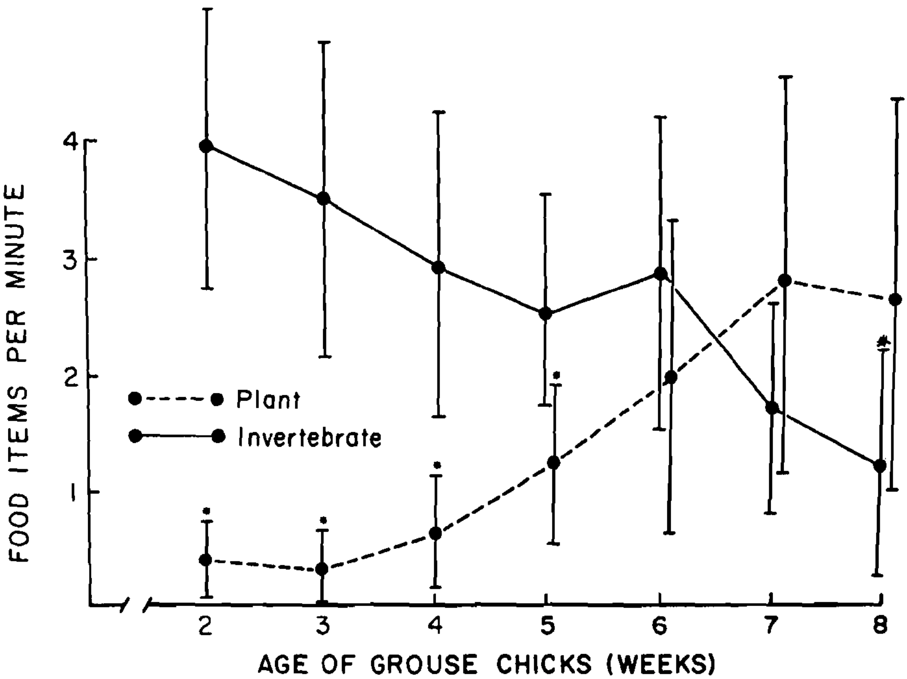

Fig. 2. Average number of food items taken per minute on unmined study areas by ruffed grouse chicks 2 to 8 wk of age, W. Va., 1976-77. Significant differences are indicated by *($P<0.01$). Solid vertical lines indicate SE.

RESULTS

Invertebrate food items (especially insects) were predominant in the diet of the grouse chicks for the 1st 5 wk ($P<0.01$) after hatching. Invertebrate consumption was the same as plant consumption during wk 6 and 7 ($P<0.01$). Plant food items predominated during wk 8 ($P<0.01$) (Fig. 2). The diet shift from a predominantly invertebrate to a predominantly plant diet for the combined broods occurred between wk 6 and 7. This diet shift fell between wk 6 and 7 for brood 1 and brood 2 and between wk 5 and 6 for brood 3.

The major invertebrate food items eaten were leafhoppers, ants, flies, aphids, and spiders (Table 1). Homopterans were the most frequently observed invertebrate food item in the diet of the grouse chicks on all of the study areas except Locust II (Table 2). Major plant food items were dry leaf parts, grass seeds, and ripe blackberries (Table 3). Dry litter was a common food item on all study areas (Table 4). The chicks occasionally rejected insects, particularly lady bugs, ants, and caterpillars, although they did eat these items during the study.

Ruffed grouse chicks under 4-wk old ate few plant food items, although they made frequent unsuccessful attempts to remove plant parts. We noted 2-wk-old birds having trouble removing small flower buds, and 3-to-4-wk-old birds trying unsuccessfully to remove birdsfoot trefoil leaves, sheep sorrel leaves (*Rumex acetosella*), and panic grass seeds. During wk 4 the birds first began to concentrate their feeding on leaves of more succulent plants such as jewelweed (*Impatiens spp.*).Birds 8 wk of age were not able to remove the seed pods from birdsfoot trefoil. When fruits were available (such as blackberries during wk 6-8 for brood 2, or autumn olive berries that became ripe after the study period) most brood members concentrated on these food items. Other times, they ate a wide variety of plant items.

Table 1. Identified invertebrate items eaten by ruffed grouse chicks 2-8 wk of age and number of observation periods item was noted, W. Va., 1976-77.

Food item	Taxonomic group	N observation periods
Insects		
Leafhoppers	Cicadellidae	34
Ants	Formicidae	29
Flies	Diptera	28
Aphids	Aphididae	25
Mosquitoes	Culicidae	11
Crickets	Gryllidae	10
Caterpillars	Lepidoptera	7
Moths	Lepidoptera	4
Daddy-long-legs	Phalangida	4
Inch worms	Geometridae	3
Lightning bugs	Lampyridae	3
Mites	Acarina	3
Spittle bugs	Cercopidae	3
Grasshoppers	Locustidae	2
Lady bugs	Coccinellidae	2
Unidentified beetle larvae	Coleoptera	1
Unidentified beetles	Coleoptera	1
Bumble bees	Apidae	1
Caddis flies	Trichoptera	1
Cicada shell parts	Cicadidae	1
Japanese beetles	*Popillia japonica*	1
Stinkbugs	Hemiptera	1
Thrips	Thysanoptera	1
Unidentified bugs	Hemiptera	2
Other invertebrates		
Spiders	Araneida	17
Earthworm parts	Oligochaeta	4
Grubs	Coleoptera	4
Snails	Gastropoda	2

Table 2. Percentage frequency of occurrence of insects in the diet of grouse chicks on 6 study areas in W. Va., 1976-77. Values are based on the number of observation periods an insect of an order was eaten.

	Unmined Areas		Surface-mined Areas			
	Old Field (N = 17)	Agricultural Clearing (N = 15)	Grass-Legume (N = 16)	Autumn Olive (N = 14)	Locust I (N = 14)	Locust II (N = 14)
Homoptera	88.2	100.0	68.8	78.6	64.3	28.5
Diptera	52.9	33.3	18.8	42.8	42.8	35.7
Hymenoptera	5.9	0.0	25.0	35.7	28.6	92.9
Lepidoptera	23.5	20.0	12.5	14.3	14.3	21.4
Coleoptera	11.7	33.3	18.8	0.0	14.3	7.1
Orthoptera	5.9	26.7	31.3	0.0	0.0	7.1
Hemiptera	5.9	0.0	6.3	0.0	14.3	0.0
Mecoptera	0.0	0.0	0.0	0.0	7.1	0.0
Others	41.2	20.0	25.0	42.9	14.3	7.1

Table 3. Identified plant items eaten by ruffed grouse chicks 2-8 wk of age and number of observation periods item was noted, W. Va., 1976-77.

Food item	Taxonomic group	N observation periods
Plants		
Unidentified dry leaf parts		41
Grass seeds	Gramineae	31
Blackberries	*Rubus* spp.	26
Mushroom parts		14
Grass blade parts	Gramineae	13
Clover leaf parts	*Trifolium* spp.	11
Autumn olive seeds	*Elaeagnus angustifolia*	8
Blackberry leaf parts	*Rubus eubatis*	8
Birdsfoot trefoil leaf parts	*Lotus corniculatus*	8
Unidentified green leaf parts		8
Cinquefoil leaf parts	*Potentilla canadensis*	7
Sedge seeds	Cyperaceae	6
Birdsfoot trefoil flower parts	*Lotus corniculatus*	6
Panic grass seeds	*Panicum* spp.	5
Panic grass leaf parts	*Panicum* spp.	4
Autumn olive sprouts	*Elaeagnus angustifolia*	4
Autumn olive leaf parts	*Elaeagnus angustifolia*	4
Bedstraw shoots	*Galium* spp.	4
Fern frond parts	Polypodiaceae	4
Moss parts		4
Unidentified seeds		4
Bedstraw seeds	*Galium* spp.	3
Mint flower parts	Labiatae	3
Ragweed leaf parts	*Ambrosia* spp.	3
Ragweed buds	*Ambrosia* spp.	3
Soldier lichen parts	*Cladonia christella*	3

On all of the study areas, chicks 3-wk old had higher invertebrate than plant feeding rates (t-test, $P<0.01$) (Fig. 3). On the different study areas the grouse chicks shifted from a primarily invertebrate diet to a primarily plant diet between 5.4 and 7.8 wk of age (Table 5).

The grouse chicks were able to find better escape cover on Old Field than any other habitat type (F-test, $P<0.01$) (Table 6). From lowest to highest percentage of birds visible after an alarm call, the areas ranked:

Old Field	Autumn Olive	Agricultural Clearing	Locust I	Locust II	Grass-Legume

Any 2 means not underscored by the same line are different (LSD test, $P<0.05$).

Table 4. Percentage frequency of occurrence of plant parts in the diet of ruffed grouse chicks on 6 study areas in W. Va., 1976-77. Values are based on the number of observation periods a plant was eaten.

	Unmined Areas		Surface-mined Areas			
	Old Field (N = 14)	**Agricultural Clearing (N = 16)**	**Grass-Legume (N = 20)**	**Autumn Olive (N = 18)**	**Locust I (N = 18)**	**Locust II (N = 14)**
Autumn Olive (*Eleagnus angustifolia*)	0.0	6.3	0.0	77.8	0.0	0.0
Bedstraw (*Galium* spp.)	35.7	0.0	0.0	0.0	0.0	0.0
Birdsfoot trefoil (*Lotus corniculatus*)	0.0	0.0	85.0	0.0	0.0	0.0
Blackberry (*Rubus* spp.)	7.1	0.0	15.0	22.2	66.7	35.7
Black locust (*Robina pseudo-acacia*)	0.0	0.0	0.0	0.0	0.0	21.4
Clover (*Trifolium* spp.)	7.1	18.8	40.0	0.0	0.0	0.0
Fern frond parts (Class Filicinae)	28.5	6.3	0.0	0.0	0.0	7.1
Grass (Family Gramineae)	35.7	37.5	60.0	38.9	22.2	28.6
Mint (Family Labiatae)	28.5	0.0	0.0	5.6	0.0	0.0
Panic grass (*Panicum* spp.)	7.1	0.0	0.0	0.0	33.3	21.4
Ragweed (*Ambrosia* spp.)	0.0	18.0	5.0	0.0	0.0	0.0
Miscellaneous spp.	35.7	62.5	20.0	16.6	11.1	28.5
Unidentified dry litter	28.5	25.0	25.0	44.4	33.3	92.9

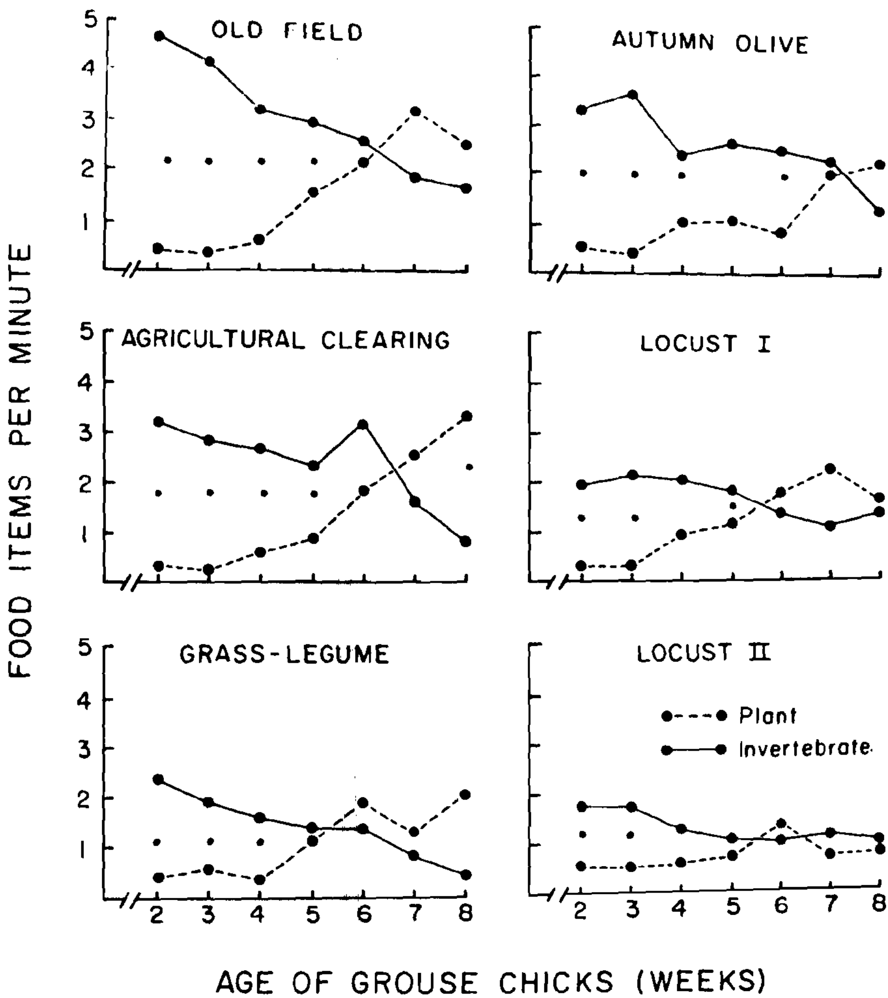

Fig. 3. Number of items per minute eaten by ruffed grouse chicks from 2-8 wk of age on 6 study areas, W. Va., 1976-77. Significant differences are indicated by *($P<0.01$). Solid line indicates invertebrate food items and broken line indicates plant food items.

Table 5. Age when ruffed grouse chicks shifted from a primarily invertebrate diet to a primarily plant diet as determined by standard linear regression analysis, W. Va., 1976-77. Blanks indicate that plant feeding curves did not exceed invertebrate feeding curves during the 8-wk period.

	Age of diet shift (wk)		
Study area	**Brood 1**	**Brood 2**	**Brood 3**
Old Field	6.4	7.5	6.1
Agricultural Clearing	5.8	6.2	6.6
Grass-Legume	6.4	6.1	5.6
Autumn Olive		7.8	5.9
Locust I	6.6	5.4	6.8
Locust II		5.9	

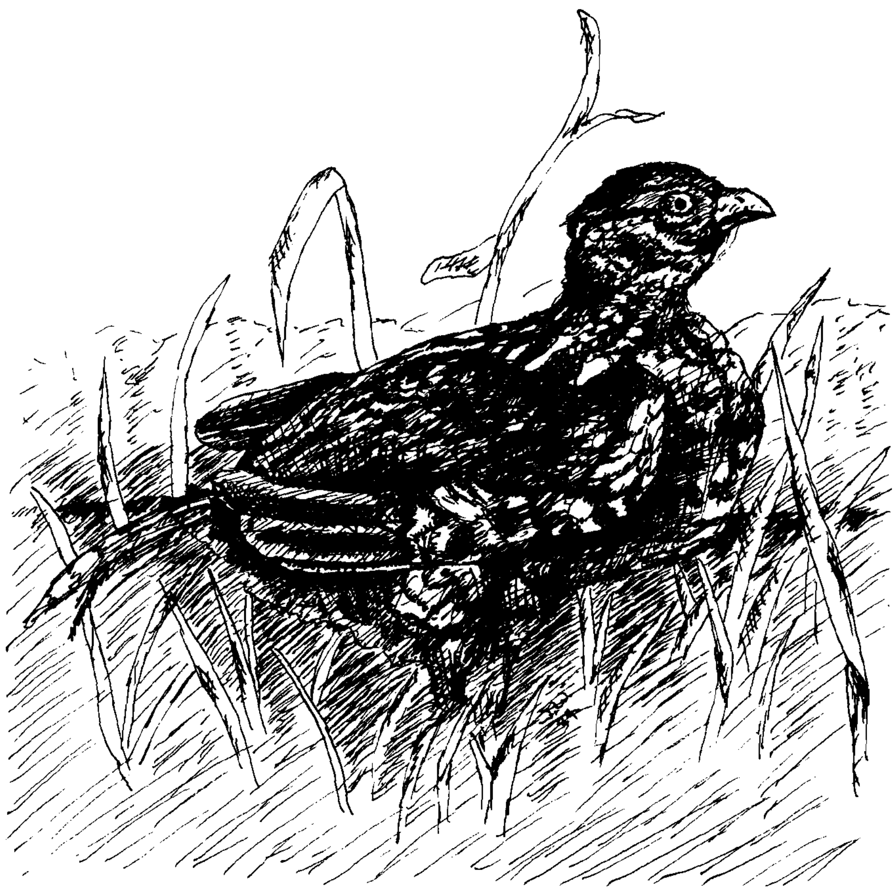

Table 6. Percent of human-imprinted ruffed grouse brood in sight on 6 study areas 5 seconds after investigator sounds an alarm call, W. Va., 1976-77.

Unmined Areas		Surface-mined Areas			
Old Field (N = 6)	Agricultural Clearing (N = 6)	Grass-Legume (N = 6)	Autumn Olive (N = 6)	Locust I (N = 6)	Locust II (N = 6)
$\bar{x} \pm SE$	$\bar{x} \pm SE$	$\bar{x} \pm SE$	$\bar{x} \pm SE$	$\bar{x} \pm SE$	$\bar{x} \pm SE$
6.7 ± 4.2	35.0 ± 9.6	72.2 ± 9.2	28.7 ± 6.0	36.2 ± 5.5	50.3 ± 6.9

DISCUSSION

Feeding data from human-imprinted ruffed grouse chicks showed that invertebrates, especially insects, were a major food item for 5 wk after hatching, a longer period of time than is suggested by other studies. The importance of soft-bodied insects in the diet of young ruffed grouse has been underrated by other authors because these species break down quickly in the digestive tract and are not as accurately represented in crop-gizzard or dropping analyses. W. M. Healy (pers. commun.) found that wild turkey poults retain food in the crop for only a few minutes, except during the evening feeding period, which occurs just before the birds go to roost for the night. Some poults that were killed while feeding actively had empty crops. Gizzards from the same birds usually contained more food than the crops, but the contents consisted of only the hard and fibrous items eaten during the preceding several hours.

Crop-gizzard and dropping analyses primarily monitor hard-bodied insects and fibrous plant parts (Bump et al. 1947). A list of most common food items of ruffed grouse chicks noted in this study (such as Table 1) would be different if we had utilized crop-gizzard or dropping analyses. Of the 10 most common insect items presented in Table 1, ants and crickets with a hard exoskeleton would be the most accurately represented. Soft-bodied insects such as leafhoppers, flies, aphids, and mosquitoes could go undetected. We suggest that this was the case in the crop-gizzard studies such as those of Bump et al. (1947), which reported heavy use of ants and beetles for the 1st 10 days after hatching.

Plant parts such as stems, leaves, and colored fruits would be accurately monitored by crop-gizzard and dropping techniques. Ruffed grouse chicks shifted from a primarily insect diet to a plant diet between wk 5 and 8. That was consistent for 6 different habitat types and for broods with more than 1 month between hatch dates. In a more recent study utilizing 1 brood of human-imprinted ruffed grouse in West Virginia, Rogers (1983) found this diet shift to occur between 8 and 9 wk of age.

A number of theories have been proposed as to why the young of most gallinaceous birds have adapted to a heavy use of insects early in life. Stiven (1961) noted that insects provide a higher protein source than plants. Hatchlings have higher protein requirements than adults of domestic fowl (Patrick and Schaible 1980) and bobwhites (Andrews et al. 1973). A 2nd theory suggests that digestive tracts of young birds do not contain bacteria for digestion of plant materials until the birds are a few wk old (Leopold 1953). We also suggest that young ruffed grouse chicks simply may not be physically able to remove most plant parts and thus they concentrate on invertebrate foods.

Upon release in the field, hatchling ruffed grouse are attracted to moving insects. We occasionally observed that chicks unsuccessfully attempted to remove a bud, leaf, or seed from a plant. By wk 4 there was more feeding on soft plants. By wk 6 plant use nearly equaled insect use. Eight-wk-old chicks ate more plant than insect foods, but still were not able to remove some plant parts.

Ruffed grouse chicks undergo a number of changes at approximately 6 wks of age. By this time the birds are almost completely feathered. Because of their size, 6-wk-old birds are not brooded efficiently by the hen, thus the chicks must maintain their own body temperatures. Lower environmental temperatures require an increase in carbohydrates available in plant materials (Patrick and Schaible 1980). Six-wk old ruffed grouse in this study showed an increase in use of plant foods (Fig. 2).

Poultry growth patterns lend insight into the diet shift observed in ruffed grouse. White-leghorn chickens undergo slow growth from 0-2 wk and then rapid growth through 8 wk of age (Carlotti 1971). This period of rapid growth is also reported for pheasant chicks and is related to the protein content in the diet during the 1st 8 wk after hatching (Norris et al. 1936). The diet shift of ruffed grouse could coincide with the end of this period of rapid growth.

The wide variety of food items eaten by young ruffed grouse in this study (Tables 1 and 3) suggests that they are opportunistic feeders; they may eat any available food item that they are physically able to secure. This was suggested by Bump et al. 1947. Edminster (1947), however, mentions grouse avoiding lightning bugs and lady bugs. We noted grouse eating these items, although at times chicks passed over such items as lady bugs and ants for other foods. Chicks frequently concentrated on certain foods, such as blackberries, autumn olive berries, and aphids, when these items were readily available in high numbers. Fluctuations in feeding curves for a brood were usually a result of heavily used foods that were not consistently present.

Spidsó (1980) found the proportion of invertebrate species in the crops of willow grouse chicks to be similar to those collected on the feeding areas by sweepnet. For ruffed grouse chicks, we noted that insects were not eaten in proportion to their availability (Kimmel 1982). The proportion of insects in the diet was not correlated with insect availability. There was a strong selection, particularly for Homopteran species (Table 2).

A number of factors could contribute to a bird's taking 1 food item over another. Spidsó (1980) found evidence suggesting that willow grouse chicks selected faster-moving insects. Healy (1978) found the size of an insect was not a significant factor in food selection by wild turkey poults. We noted occasional rejection of such items as spiders, caterpillars, lady bugs, lightning bugs, and ants, and suggest that color, shape, and softness are potential factors. The ruffed grouse chicks, particularly when young, ate more soft- than hard-bodied insects.

Johnson (1980) expressed caution in drawing inferences from food use and availability data because of biases associated with measurements of availability. Ruffed grouse chicks concentrate their feeding on a zone from ground level to approximately 40 cm high. We used different means of sampling to determine insect availability in this zone. Each technique does have inherent biases. For example, the sweepnet does not get to the ground layers, and faster insects may elude the net. The stickyboard only collects insects that move onto the board and measures availability at times when the birds are not feeding. Despite the apparent biases involved with measuring availability, a low correlation between insect use and availability indicates that ruffed grouse are not purely opportunistic feeders (Kimmel 1982). Given a variety of choices, ruffed grouse chicks select food items.

In general, the reclaimed surface-mined areas did not provide the quality of food and cover for grouse broods that unmined land provided. The Old Field study area was typical of grouse brood habitat in West Virginia: an abandoned farm with a variety of vegetation types, openings, thickets, and an almost continuous cover of herbaceous vegetation. Old Field had among the highest feeding rates on both plants and invertebrates and provided the best escape cover.

In other studies ruffed grouse broods were found to use openings in West Virginia that were created by surface mining for coal (Kimmel and Samuel 1978). We found feeding rates by grouse chicks lower on surface mines than on unmined land. On areas with lower feeding rates, a ruffed grouse chick must spend more time feeding to ingest its daily nutrient requirements. By increasing foraging time and decreasing available resting time, the bird expends more energy feeding, necessitating a higher daily caloric requirement than on areas providing more food per unit time. Increasing foraging increases exposure to predators and adverse weather conditions, lowering the chick's chances of survival.

Stiven (1961) calculated the amount of fresh invertebrates required daily by blue grouse chicks from hatch to 4 wk of age. We used Stiven's data to estimate how long a ruffed grouse chick must feed on each of our study areas in order to obtain this daily requirement of nutrients from fresh invertebrates. Weights of captive ruffed grouse in West Virginia are, by age group, approximately 50% of those Stiven (1961) reported for blue grouse (W. M. Healy, unpubl. data). However, ruffed grouse weights for an age group correspond closely to blue grouse weights for the age group 1 wk earlier. An average of the food requirements of blue grouse from 1 to 3 wk old (32.2 g/day) was used to provide an indication of ruffed grouse food requirements from 2 to 4 wk of age. Assuming an average fresh weight of 0.036 g/insect (Kimmel 1982) a ruffed grouse chick would have to ingest about 900 invertebrates/day to reach the required 32.2 g/day. Using invertebrate feeding rates for each study area, the required feeding time on each study area was estimated. Average invertebrate feeding rates of chicks 2 to 4 wk of age were used (Kimmel 1982). The estimated foraging times to ingest the required number of invertebrates on each study area are as follows:

Study area	N invertebrates eaten/min	Foraging time (hr)
Old Field	4.03	3.71
Autumn Olive	3.16	4.73
Agricultural Clearing	2.92	5.12
Locust I	2.03	7.37
Grass-Legume	2.01	7.44
Locust II	1.66	9.01

Assuming 14 hr of daylight during which a ruffed grouse chick can feed, in typical ruffed grouse brood habitat (e.g. Old Field) a chick need only spend about 27% of the daylight hours searching for food. Of the reclaimed surface-mined areas, only the Autumn Olive area had similar results with a required foraging time of 4.73 hr or about 34% of the daylight hours. All other surface-mined sites required foraging for more than 50% of the daylight hours.

While the foraging times are estimates and may actually be different, the relationships between these times are considered real; i.e., the required foraging time for Grass-Legume is more than twice that for Old Field, etc. A grouse chick raised on Old Field would have a better change for survival than a chick raised on the other areas.

The habitat types that provide better feeding areas for ruffed grouse chicks were openings with a diversity of herbaceous species associated with shrubs and/or small trees providing shaded areas. A canopy provides a cool, moist environment for both the chicks and insects on hot summer days. Berner and Gysel (1969) suggested that structure as well as composition are important components of ruffed grouse brood habitat. We stress that a shade-producing canopy is essential in order to provide the proper microclimate for both the grouse chicks and insects. Kimmel (1982) noted that areas producing higher grouse feeding rates had woody cover resulting in a lower average temperature and higher average humidity. Seastedt and Crossley (1981) found invertebrate populations decrease as temperature increases. Grouse chicks show signs of thermal stress when temperatures are above 25 C and insects move into thick vegetation seeking cooler conditions (Kimmel 1982).

Berner and Gysel (1969) conclude that brood range is the most important component of grouse habitat. Because grouse broods are unable to withstand unfavorable changes, and adults can easily survive on good brood range, they stressed brood habitat management as strong grouse management. Soft-bodied insects are the most important food item for a period lasting longer than the first month post-hatch, a time associated with highest mortality rates for ruffed grouse; therefore, habitat management for the early brood period should also be directed at creating the proper conditions for insects. Management with a goal of improving brood habitat for ruffed grouse should produce small forest openings with a diversity of herbaceous plants associated with patches of woody cover. Chambers and Sharp (1958) suggest managing clearings of less than 0.4 ha for ruffed grouse. Rogers (1983) suggests managing separate, adjoining blocks of habitat through burning rotations. One block would be managed for invertebrate foods for the early brood period and a separate block for plant foods for the late brood period.

Because ruffed grouse broods in West Virginia use low quality brood habitat on surface-mined land (Kimmel and Samuel 1978), we suggest that brood habitat may be of particular importance in the central Appalachians. Trimble et al. (1974) estimate that 75% of West Virginia is forested. This suggests that openings in this area may be at a premium. Improving low-quality openings on surface-mined land and ecologically sound maintenance procedures for other permanent openings such as gas and powerline rights-of-way for ruffed grouse broods may be a productive wildlife management program in the southern grouse range where food availability and survival in late winter may not be a problem.

LITERATURE CITED

Andrews, T. L., R. H. Harm, and H. R. Wilson. 1973. Protein requirement of the bobwhite chick. Poult. Sci. 52:2199-2201.

Bailey, W. J., Jr., W. M. Sharp, R. B. Hazel, and G. Davis. 1955. Food habit trends of ruffed grouse in the Centre County "barrens." Pennsylvania State Univ. Bull. 604. 18pp.

Berner, A., and L. W. Gysel. 1969. Habitat analysis and management considerations for ruffed grouse for a multiple use area in Michigan. J. Wildl. Manage. 33:769-778.

Bump, G., R. W. Darrow, F. C. Edminster, and W. F. Crissey. 1947. The ruffed grouse-life history, propagation, management. New York State Legislature, Albany. 915pp.

Carlotti, R. J. 1971. Manifestations of "metabolic bursts" during development of the cockerel. Ph.D. Diss. West Virginia Univ., Morgantown. 98pp.

Chambers, R. E., and W. M. Sharp. 1958. Movement and dispersal within a population of ruffed grouse. J. Wildl. Manage. 22:231-239.

Edminster, F. C. 1947. The ruffed grouse — its life story, ecology, and management. Macmillian Co., New York. 385pp.

Giles, R. H., and L. Toschik. 1971. Wildlife management techniques. Wildlife Society, Washington D.C. 633pp.

Hamrick, W. J. and J. R. Davis. 1971. Summer food items of juvenile wild turkeys. Proc. Southeast Assoc. Game and Fish. Comm. 25:85-89.

Healy, W. M. 1978. Feeding activity of wild turkey poults in relation to ground vegetation and insect abundance. Ph.D. Diss. West Virginia Univ. Morgantown. 177pp.

Hein, D. 1970. The ruffed grouse near the southeast edge of its range, J. Mitchell Soc. 1970:139-145.

Hillhouse, T. L., and H. N. Pitre. 1974. Comparison of sampling techniques to obtain measurements of insect populations on soybeans. J. Econ. Entomol. 67:411-414.

Hungerford, K. E. 1951. Ruffed grouse populations and cover use in northern Idaho. Trans. North Am. Wildl. Conf. 16:216-224.

_____. 1957. Evaluating ruffed grouse foods for habitat improvement. Trans. North Am. Wildl. Conf. 22:380-395.

Johnson, D. H. 1980. The comparison of usage and availability measurements for evaluating resource preference. Ecology 6:65-71.

Judd, S. D. 1905. The grouse and wild turkeys of the United States, and their economic value. U.S. Dep. Agric. Biol. Bull. 24. 55pp.

Kimmel, R. O. 1982. Ruffed grouse brood habitat on reclaimed surface mines in West Virginia. Ph.D. Diss. West Virginia Univ., Morgantown. 117pp.

_____, and D. E. Samuel. 1978. Ruffed grouse use of a twenty year old surface mine. Pages 345-351 *in* Surface mining and fish/wildlife needs in the eastern United States. U.S. Fish and Wildl. Serv., D. E. Samuel et al., eds. Off. Wildl. Serv. Publ. 78/81.

_____. 1983. Ruffed grouse brood habitat on reclaimed surface mines in West Virginia. In prep.

King, R. D. 1969. Spring and summer foods of ruffed grouse on Vancouver Island. J. Wildl. Manage. 33:440-442.

King, R. T. 1937. Ruffed grouse management. J. For. 35:523-532.

Klebenow, D. A., and G. M. Gray. 1968. Food habits of juvenile sage grouse. J. Range Manage. 21:80-83.

Kretzschmer, G. P. 1948. Soybean insects in Minnesota with special reference to sampling techniques. J. Econ. Entomol. 41:586-591.

Leopold, A. S. 1953. Intestinal morphology of gallinaceous birds in relation to food habits. J. Wildl. Manage. 17:197-203.

May, T. A. 1975. Physiological ecology of white-tailed ptarmigan in Colorado. Ph.D. Diss. Univ. Colorado, Fort Collins. 311pp.

Messick, J. P., E. C. Bizeau, W. W. Benson, W. H. Mullins. 1974. Aerial pesticide applications and ring-necked pheasants. J. Wildl. Manage. 38:679-685.

Moulton, J. C. 1968. Ruffed grouse habitat requirements and management opportunities. Wis. Dep. Nat. Resour. Rep. 36. 32pp.

Norris, L. C., L. J. Elmore, and R. C. Ringnose. 1936. The protein requirement of ring-necked pheasant chicks. Poult. Sci. 15:454-456.

Patrick, H., and P. J. Schaible. 1980. Poultry: feeds and nutrition. Avi Publishing Co., Inc., Westport, Conn. 668pp.

Peterson, J. G. 1970. The food habits and summer distribution of juvenile sage grouse in central Montana. J. Wildl. Manage. 34:147-155.

Porath, W. R., and P. A. Vohs, Jr. 1972. Population ecology of ruffed grouse in northeastern Iowa. J. Wildl. Manage. 36:793-802.

Potts, G. R. 1977. Population dynamics of the grey partridge: overall effects of herbicides and insecticides on chick survival rates. Cong. Game Biol. 13:203-211.

Rogers, R. E. 1983. Ruffed grouse brood use of oak-hickory stands managed with prescribed burning. MS Thesis. West Virginia Univ., Morgantown. 54pp.

Seastedt, T. R., and D. A. Crossley, Jr. 1981. Microarthropod response following cable logging and clear-cutting in the southern Appalachians. Ecology 62:126-135.

Southwood, T. R. E. 1966. Ecological methods: the measurement of association between species and the description of a fauna. Methuen and Co., London. 391pp.

_____, and D. J. Cross. 1969. The ecology of the partridge: III. Breeding success and the abundance of insect in natural habitats. J. Anim. Ecol. 38:497-509.

Spidsø, T. K. 1980. Food selection by willow grouse *Lagopus lagopus* chicks in northern Norway. Ornis Scandinavica 11:99-105.

Stewart, R. E. 1956. Ecological study of ruffed grouse broods in Virginia. Auk 73:33-41.

Stiven, A. E. 1961. Food energy available for and required by the blue grouse chick. Ecology 42:547-553.

Stromborg, K. L. 1982. Modern pesticides and bobwhite populations. National Bobwhite Quail Symp. 2:69-73.

Swanson, G. A., and J. C. Bartonek. 1970. Bias associated with food analysis in gizzards of blue-winged teal. J. Wildl. Manage. 34:739-746.

Trimble, G. R., Jr., J. H. Patric, J. D. Gill, G. H. Moeller, and J. N. Kochenderfer. 1974. Some options for managing forest land in the central Appalachians. U.S. Dep. Agric. For. Serv. Tech. Rep. NE-12. 42pp.

Warner, R. E. 1984. Effects of changing agriculture on ring-necked pheasant brood movements in Illinois. J. Wildl. Manage. 48: In review.

Weigand, J. P. 1980. Ecology of the Hungarian partridge in north-central Montana. Wildl. Monogr. 74. 106pp.

Manipulation of Habitat for Ruffed Grouse on the Wakopa Wildlife Management Area, North Dakota

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Abstract: Aspen (*Populus tremuloides*) constitutes the basic habitat resource for ruffed grouse (*Bonasa umbellus*) in the Turtle Mountains of North Dakota, and application of the proper management scheme could produce high quality ruffed grouse habitat. Aspen forests in the Turtle Mountains are deteriorating from old age and competition. To provide more suitable ruffed grouse habitat, a management plan was developed to set back succession and create forest openings by use of bulldozer. Bulldozing was done between 1976 and 1983 on 107 parcels totaling 122.4 ha (304 acres) in a 3200 ha (7900 acres) forest area. Aspen stem densities averaged 104,403 ± 33,555 stems/ha (42,268 ± 13,585/acre) and stem height average 0.92 ± .08 m (36.2 ± 3.1 in) the first growing season. Winter clearcuts produced higher stem densities in regenerating stands and more even distribution of aspen saplings. Ruffed grouse response to management is being monitored but significant response is not expected until the late 1980's. The cost of this management in the absence of commercial aspen markets is $210.00/ha ($85.00/acre) plus biologists' salaries, and may limit future management operations.

Aspen (*Populus tremuloides* and *P. grandidentuta*) has long been identified as an important habitat resource for many species of wildlife (Gullion 1977; Lyon and Jensen 1980, and many others). In the Turtle Mountains of North Dakota, these include ruffed grouse (*Bonasa umbellus*), snowshoe hare (*Lepus americanus*), white-tailed deer (*Odocoileus virginianus*), beaver (*Castor canadensis*) and various non-game species.

Perhaps the most notable relationship is the one between ruffed grouse and trembling aspen (*Populus tremuloides*). Studies in Minnesota (Gullion and Svoboda 1972) and North Dakota (Bakke 1980) have shown that aspen in various age classes can provide the spectrum of cover needs for ruffed grouse. This habitat diversity can be produced by proper management, specifically clearcutting in small patches to create the required habitat diversity (Gullion 1972). Clearcutting sets plant succession back to an earlier, pre-climax stage, from which succession again proceeds and different habitat conditions will appear then disappear until a climax forest once again occupies the site. Clearcutting may produce a continuum of habitats, from the disruptive stage through the climax stage.

METHODS

The Wakopa Wildlife Management Area, totaling 3200 ha (7900 acres), forms the basic study area. Wakopa is a publicly owned tract, located in northern Rolette County, North Dakota. The study area is contained within the Turtle Mountains, an oval shaped area of glaciated hills lying astride the international boundary between north central North Dakota and Manitoba (Fig. 1). The Turtle Mountains, on the American side, comprise 611 km^2 (240 mi^2). Prior to settlement the Turtle Mountains supported about 452 km^2 (175 mi^2) of forest. Since 1940, an estimated 228 km^2 (88 mi^2) of that forest has been cleared (Jakes and Smith 1982).

Vegetation of the study area consists of a complex of forest, wetland and grassland communities with forest predominating. Eighty-one percent of the trees are trembling aspen with the remaining 9 percent of the forest overstory paper birch (*Betula papyrifera*), bur oak (*Quercus macrocarpa*), American elm (*Ulmus americana*), green ash (*Fraxinus pennsylvanica*), balsam popular (*Populus balsamifera*), and box elder (*Acer negundo*) (Jakes and Smith 1982). The shrub layer is dominated by beaked hazel (*Corylus cornuta*). Other common shrubs are juneberry (*Amelanchier alnifolia*), chokecherry (*Prunus virginiana*), highbush cranberry (*Viburnum trilobum*), raspberry (*Rubus pubescens*), and rose (*Rosa sp.*) (Bakke 1980).

The aspen forest in Wakopa WMA is largely even-aged and mature (Fig. 2). In 1975, there was a marked scarcity of sucker and sapling stands under 25 years of age (Gullion 1975). The forest was evolving toward a hardwood climax dominated by bur oak, green ash and paper birch. In addition, white trunk rot, caused by the wood-rotting fungus *Phellinus igniarius*, is responsible for rapid decay and early mortality in mature trees. White trunk rot is often the cause of aspen death which determines the rotation time for cutting aspen. For these reasons, aspen management was needed to improve future habitat conditions for ruffed grouse.

The aspen management program on Wakopa WMA was initiated in 1976, with the objectives of (1) manipulating the aspen forest to improve habitat diver-

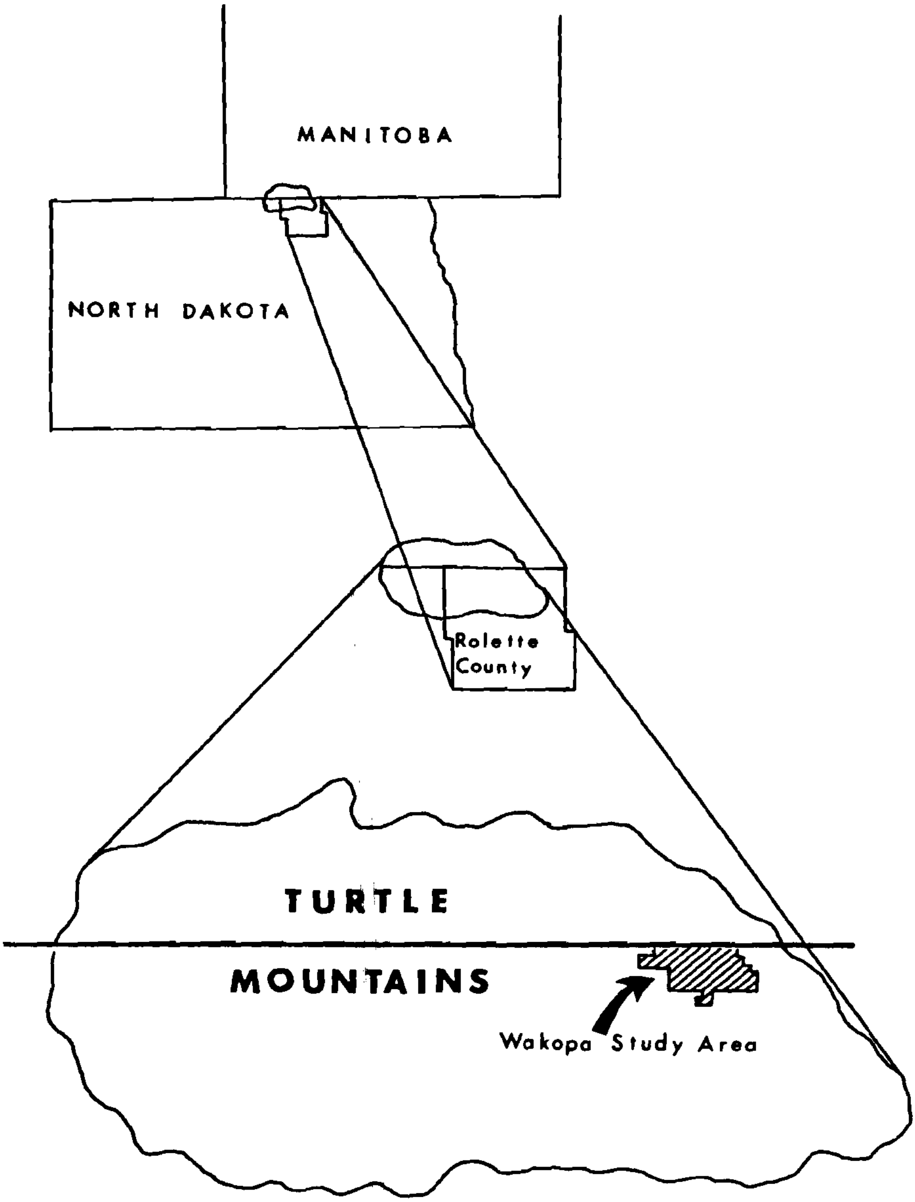

Fig. 1. Wakopa Wildlife Management Area and vicinity.

sity; and (2) comparing the numbers of ruffed grouse on manipulated areas with populations on control areas.

Forest habits were modified in summer and winter by using a bulldozer. Aspen downed by bulldozer was pushed into slash piles or fallen trees were left on the ground. Trees pushed into slash piles or those on the ground were left to decay and recycle naturally. Bulldozing was done during 1976-1983 on 107 parcels totaling 122.4 ha (304 acres) (Table 1).

Fig. 2. Overaged, understocked aspen, 40 to 60 years old.

The basis for most aspen habitat manipulation in the Great Lakes states is commercial logging, but since no commercial sawmills operate in the Turtle Mountains, clearing by bulldozer was used to regenerate aspen stands on the study area.

There are many clearing schemes developed for aspen management. We utilized a clearing scheme by which woodlands are surveyed into 16 ha (40 acres) tracts (Gullion 1972), with each tract divided into sixteen 1 ha (2.5 acres) cutting

Table 1. History of habitat manipulation on Wakopa WMA.

Year	Season cleared	Treatment	No. of plots cleared	Size range of plots ha	Size range of plots acres	Total area cleared ha	Total area cleared acres
1976	Summer	Bulldoze & windrow	3	1.6—3.0	4—7.5	7.0	17.5
1979	Summer	Bulldoze & windrow	7	1.0—1.6	2.5—4.0	8.8	22.0
1980	Winter	Bulldoze & windrow	10	1.0	2.5	10.0	25.0
1980	Winter	Bulldoze & leave	16	0.3—1.0	0.8—2.5	15.3	38.0
1982	Winter	Bulldoze & leave	37	0.7—1.0	1.8—2.5	36.7	90.0
1983	Winter	Bulldoze & leave	47	0.6—1.0	1.5—2.5	44.6	111.5
Total			120	0.3—3.0	0.8—7.5	122.4	304

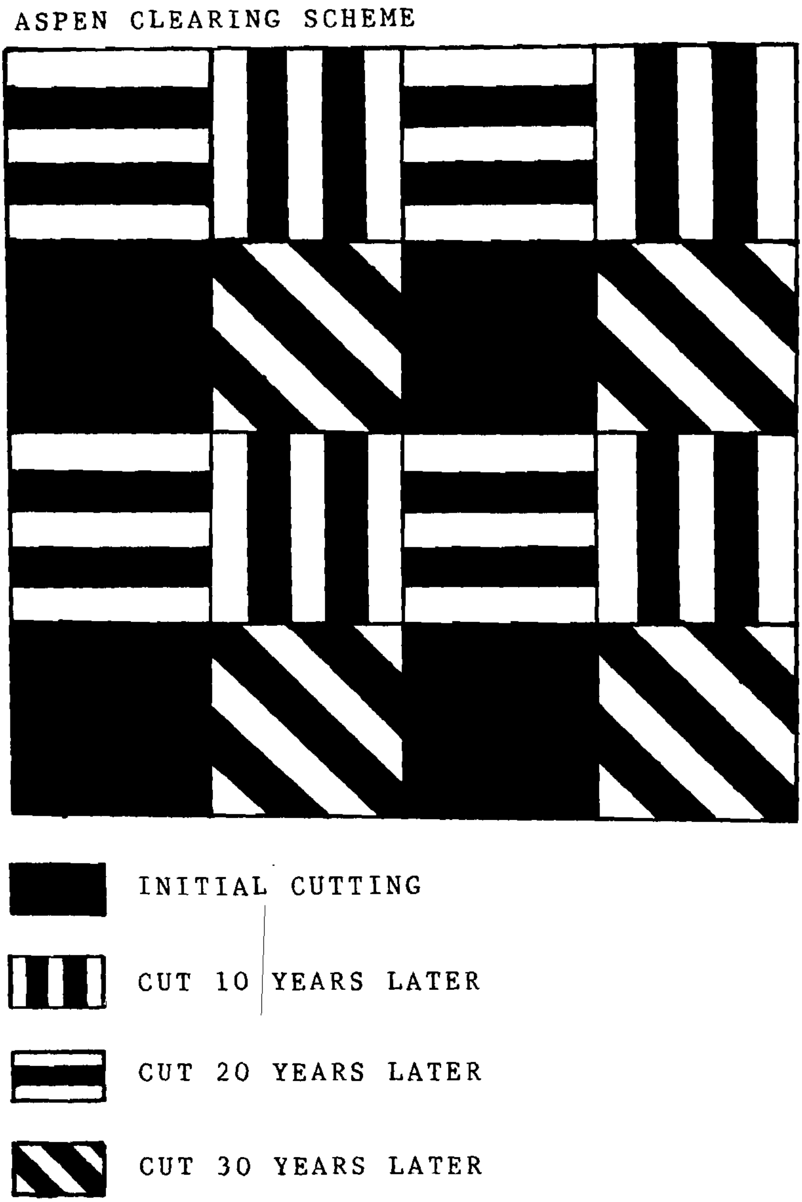

Fig. 3. Aspen management scheme used on Wakopa WMA.

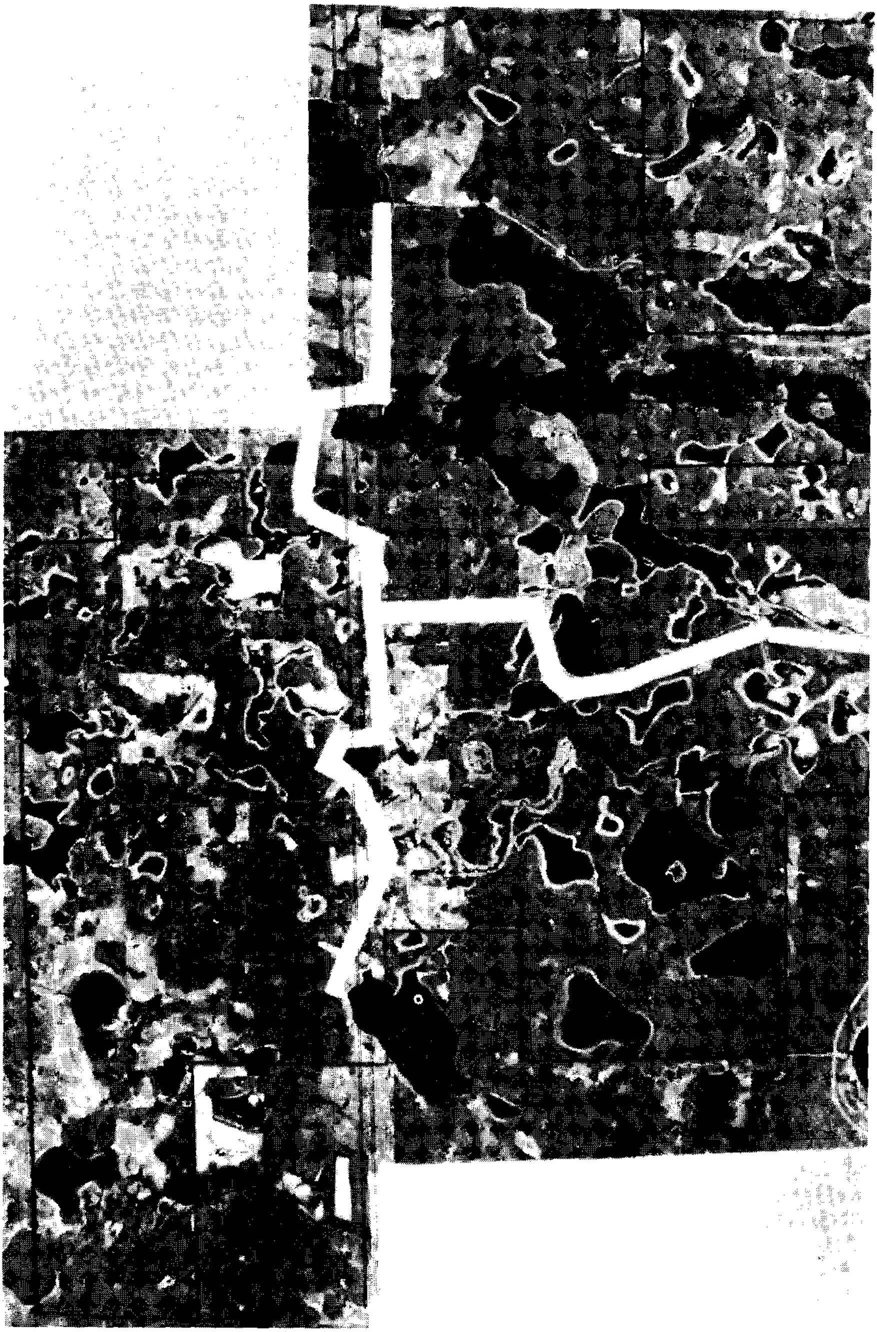

Fig. 4. Location of evaluation drumming route on Wakopa WMA.

Table 2. Aspen regeneration on selected clearcuts — Wakopa WMA.

Season	Method of clearing	1st growth season		2nd growth season		3rd growth season	
		Stems/ha	Mean ht. (m)	Stems/ha	Mean ht. (m)	Stems/ha	Mean ht. (m)
Summer	Bulldoze & windrow	67,992	1.15	47,995	1.99	40,313	2.23
Summer	Bulldoze & windrow	76,461	1.09	51,460	1.90	47,977	2.11
Summer	Bulldoze & windrow	77,906	0.86	53,930	2.01	50,292	2.16
Summer	Bulldoze & windrow	75,293	0.87	63,635	1.52	43,835	1.92
Winter	Bulldoze & windrow	202,234	0.84	99,025	1.80	93,079	2.13
Winter	Bulldoze & windrow	174,540	0.84	94,680	1.79	90,454	2.26
Winter	Bulldoze & windrow	121,141	0.98	90,656	1.61	87,463	2.32
Winter	Bulldoze & windrow	114,168	0.81	79,299	1.49	78,077	1.96
Winter	Bulldoze & leave	57,588	0.93	68,224	1.62	49,267	2.26
Winter	Bulldoze & leave	76,711	0.87	72,769	1.58	45,994	2.13
Mean and confidence interval		104,403 ± 33,555*	0.92 ± .08	72,167 ± 23,580	1.73 ± .12	62,675 ± 15,526	2.15 ± .05

*Confidence interval = x = T.05 (s_x)

blocks (Fig. 3). Every 10 years, 4 of the 1 ha (2.5 acres) blocks are cleared, resulting in a 40-year clearing rotation. Tracts larger than 1 ha (2.5 acres), however, were cleared when forest stands were rapidly deteriorating.

Aspen regeneration and growth was sampled following clearing. Sample clearcuts included winter and summer clearings with timber removed or left on the ground. Aspen regeneration was compared among different methods and different seasons. Stands were sampled systematically to determine density of aspen suckers using 2 8.2 x 1.2 m (27 x 4 ft) quadrats per ha (2.5 acres) of clearcut (Oosting 1956). All living aspens within each quadrat were counted and 10-30 stems/quadrat were radomly selected for mean height measurement. Clearcuts were sampled in August of each year. Confidence intervals were calculated for aspen density and mean height values (Snedecor 1961).

A route to survey drumming ruffed grouse was established in 1981 with 6 experimental listening stops adjacent to recent clearcuts and 6 control stops where no clearing is planned (Fig. 4). Drumming activity and drumming log occupancy were compared between control and experimental stops. Data between control and experimental stops were subjected to Chi-square analysis (Snedecor 1961).

RESULTS AND DISCUSSION

Vegetative Response

Stem densities the first growing season averaged 104,403 ± 33,555 stems/ha (42,268 ± 13,585/acre) (Table 2). Numbers of suckers dropped the second year to an average of 72,167 ± 23,500 stems/ha (29,217 ± 9546/acre). A drop in sucker numbers continued the third year averaging 62,675 ± 15,526 stems/ha (25,375 ± 6285/acre). Generally aspen regeneration for ruffed grouse habitat is considered adequate if sucker growth exceeds 30,000 — 37,000 stems/ha (12,145 — 14,980/acre), and reaches a height of more than 1 m (3 ft) in the first growing season (Gullion 1976). All sites produced sufficient suckers to regenerate the aspen stands (Fig. 5).

Suckering growth the first postcut year in North Dakota approximates that reported from other states. Smith et al. (1972) reported 74,000 to 124,000 stems/ha (30,000 — 50,000/acre) after clearcutting aspen in northern Utah. Jones (1975) found 35,000 stems/ha (14,000/acre) on aspen clearcuts in Arizona, and in southwestern Colorado, Hittenrauch (1976) found 37,500 — 62,500 stems/ha (15,000 — 25,000/acre). In Michigan, Beale (1960) reported first year sucker growth ranging from 15,250 to 50,330 stems/ha (6175 — 20,375/acre). Perala (1972) reported an average of 146,420 stems/ha (59,280/acre) for Minnesota.

Bulldozed plots produced adequate sucker regeneration, but there were differences in response between sample clearcuts. Denser sucker growth was found in winter bulldozed plots where trees were piled and the soil was exposed. Sucker densities averaged 153,000 stems/ha (61,952/acre). Ample vegetative response

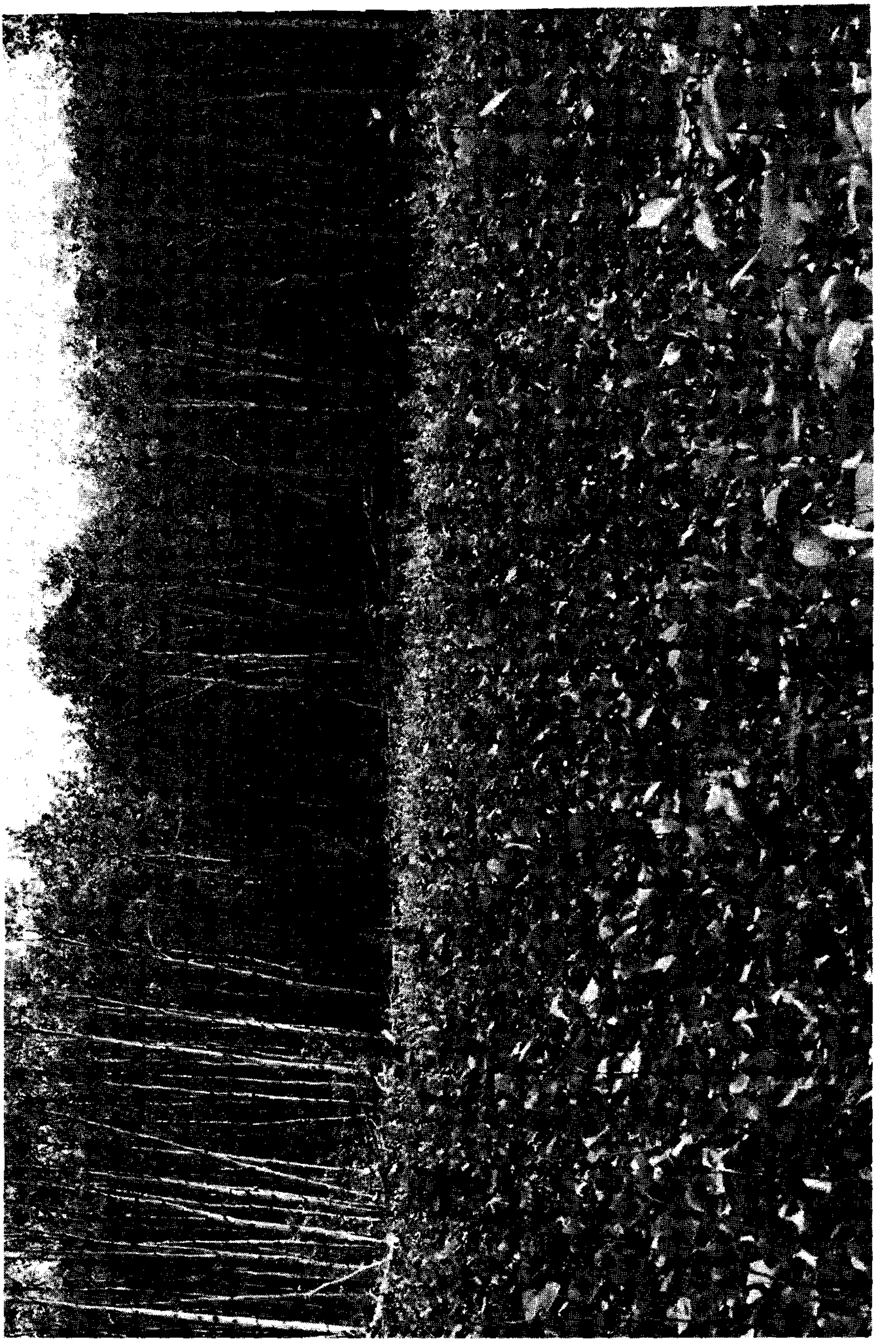

Fig. 5. Aspen saplings after one year of growth.

occurred on plots bulldozed in summer (74,413 stems/ha; 30,125/acre), but density of sucker production was only one-half that in winter-treated areas. Winter clearcuts where fallen trees were bulldozed and left on the ground averaged 67,150 stems/ha (27,185/acre) the first growing season.

Based on our observations, there may be several reasons for the differences in stem densities between summer and winter clearcuts: (1) aspen suckers originating after a winter clearcut get an equal start with competing understory vegetation; (2) winter clearing on frozen ground avoids destruction of parent aspen root systems from less uprooted trees, also resulting in a uniform distribution of suckers over the site; (3) in summer clearcuts, aspen suckers do not emerge until the following growing season, while understory vegetation gets a head start, and (4) nutrient storage in roots in winter promotes better sprout growth than in summer when more nutrients are in leaves and twigs.

Although evidence is conflicting, it is probably desirable to clear aspen during the dormant season especially where brush would compete with regeneration if it were cleared during the growing season (Stoeckeler and Macon 1956, Graham et al. 1963). Zehngraff (1946) reported less suckering in spring and summer-logged northern Minnesota aspen stands. Suckers produced later in the season were short and succulent, susceptible to frost, and less able to compete with brush. In Wisconsin, sucker numbers following late summer harvesting were about three-fourths of that following dormant season harvesting (Stoeckeler and Macon 1956). However, studies in Minnesota (Graham et al. 1963) and Michigan (Sandberg and Schneider 1953) showed that season of clearing had little effect on the number of suckers present after 2 growing seasons. The variability in reports on aspen suckering according to season cleared is probably tied closely to other variables such as genetic variation and the amount of understory and overstory competition left after logging.

Ruffed Grouse Response to Management

Although the major response by ruffed grouse is not expected until the late 1980's, data collected thus far permit a preliminary evaluation of the management effort. Drumming activity on the survey route averaged 1.92 drums per stop in 1982. The 6 stops adjacent to clearcuts averaged 2.17 drums per stop while the 6 control stops averaged 1.67 drums per stop. Eight and 5 birds were heard drumming at experimental and control stops, respectively (χ^2 = 2.28, $P>0.05$). No drumming logs were located in clearcuts, but 6 of the 8 birds located near experimental stops were occupying logs <40 m (130 ft) from the edge of 1 ha (2.5 acre) plots bulldozed in 1980. Minnesota studies suggest stands of regenerating aspen are first used by drumming grouse 8 to 12 years after cutting (Gullion 1970).

In 1983, drumming activity on the evaluation route averaged 1.33 drums per stop, a 31% decrease from 1982. The decrease coincided with an approximate 40% decline in drumming activity in the Turtle Mountains. The stops adjacent to clearcuts averaged 1.67 drums per stop compared to 1.00 drums per stop for control stops. Seven and 4 birds were active at experimental and control stops, respectively (χ^2 = 3.04, P>0.05). As in 1982, activity centers on experimental stops were not located in clearcuts but 5 of the 7 birds active near experimental stops were <40 m (130 ft) from the edge of clearcuts bulldozed in 1980.

Future Plans

Plans for 1983-84 include limited commercial logging by local farmers in 1 ha (2.5 acre) plots, firewood cutting for private use, and clearing 4 ha (10 acres) by bulldozer. Aspen management funding was nearly eliminated from the 1983-84 fiscal year budget of the North Dakota Game and Fish Department.

Aspen management is costly in North Dakota. As mentioned earlier, no large scale commercial logging takes place and firewood cutting is limited to private use. Bulldozing is the only method available to regenerate aspen stands for management of wildlife. The cost of bulldozing aspen averaged $210.00/ha ($85.00/ ''acre; range'' $185 — 235/ha; $75 — 95/acre), 1976 — 1983. Not included in these costs are salary and expenses of Game and Fish personnel who mark plots for clearing, record sucker growth and supervise bulldozer operators.

The original proposal was to clear up to 200 ha (500 acres) of mature and diseased aspen from tracts on Wakopa WMA from 1976 to 1986. If this goal is reached, we plan to bulldoze small isolated pockets of mature aspen until 1990, when considerable funding will be needed to initiate the second stage of clearing on the 16 ha (40 acre) blocks started in the 1979-1983 period.

LITERATURE CITED

Bakke, E.L. 1980. Movements and habitat use of ruffed grouse in the Turtle Mountains, North Dakota. M.S. Thesis. University of North Dakota. 81pp.

Beale, D. 1960. Evaluation of mechanical tree cutting. Michigan Dept. Cons. Rep. No. 2271. 8pp.

Gullion, G.W. 1970. Ruffed grouse investigations — influence of forest management practices on grouse populations. Minn. Game Res. Q. Prog. Rep. 30 (3):104-125.

_____ 1972. Improving your forested lands for ruffed grouse. The Ruffed Grouse Soc., Coraopolis, PA. 34pp.

_____ and F.J. Svoboda. 1972. Aspen — the basic habitat resource for ruffed grouse. In Aspen Symp. Proc., U.S. Forest Serv. Gen. Tech. Rep. NC-1. p. 113-119.

_____ 1975. Report on visit to the Turtle Mountains, October, 1975. Mimeo. 6pp.

——— 1976. Ruffed grouse habitat manipulation — Mille Lacs Wildlife Management Area, Minnesota. p. 97-121. Minn. Wildl. Res. Q. 36 (3), 1976.

——— 1977. Maintenance of the aspen ecosystem as a primary wildlife habitat. Proc. Internat'l Cong. Game Biol. 13:256-265.

Hittenrauch, H.R. 1976. Response of aspen to various harvest techniques. *In* Utilization and marketing as tools for aspen management in the Rocky Mountains; symposium proceedings. p. 41-44. USDA For. Serv. Gen. Tech. Rep. RM-29.

Jakes, D.J., and W.B. Smith. 1982. A second look at North Dakota's Timberland. Forest Service — USDA Bulletin NC-58. 8pp.

Jones, J.R. 1975. Regeneration on an aspen clearcut in Arizona. USDA For. Ser. Res. Note RM-285. 8 pp.

Lyon, L.J., and C.E. Jensen. 1980. Management implications of elk and deer use of clear-cuts in Montana. J. Wildl. Manage. 44:352-362.

Oosting, H.J. 1956. The study of plant communities. W.H. Freeman and Co., San Francisco. 440pp.

Perala, D.A. 1972. Regeneration: biotic and silvicultural factors. *In* Aspen symposium proceedings. Forest Service — USDA. p. 97-101

Sandberg, D., and A.E. Schneider. 1953. The regeneration of aspen by suckering. Univ. Minn. For. Notes. 24. 2pp.

Smith, A.D., P.A. Lucas, E.C. Beker, and G.W. Scotter. 1972. The effects of deer and livestock on aspen regeneration in Utah. Utah Div. Wildl. Res. 72-1. 32pp.

Snedecor, G.W. 1961. Statistical methods applied to experiments in agriculture and biology. 534p. The Iowa State University Press, Ames.

Stoeckeler, J.H., and J.W. Macon. 1956. Regeneration of aspen cutover areas in northern Wisconsin. J. For. 54. p. 13-16

Zehngraff, P.J. 1946. Season of cutting affects aspen sprouting, USDA For. Serv. Lake States For. Exp. Stn. Tech. Note. 1pp.

Status of Aspen in Northern Michigan as Ruffed Grouse Habitat

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Abstract: State and federal forest inventory data were used to determine the status of the aspen (*Populus tremuloides* and *P. grandidentata*) forest type in northern Michigan as ruffed grouse (*Bonasa umbellus*) habitat. Between 1966 and 1980 the aspen type in Michigan decreased from 1.7 to 1.4 million ha (4.2 to 3.4 million acres). In 1980, 39% of the aspen type was publicly owned with 46% owned by private individuals. In state and national forests in northern Michigan, 45% of the aspen is beyond the rotational age of 50 years. One-third of the aspen is less than 20 years old; however, only 12% is in the 20-39 year age class. Aspen on forest industry lands is younger than publicly owned aspen, while on private nonindustrial lands aspen tends to be older. Increased harvest of aspen, particularly on private nonindustrial forest land, is needed to prevent deterioration and conversion of overmature aspen and to better distribute age classes. Only 3.5% of the aspen type in state forests occurs in stands less than 4.2 ha (11 acres). The majority of the aspen (61%) is in stands exceeding 20.0 ha (50 acres). The stand size distribution of aspen less than 10 years old is the same as older aspen, indicating that recent management of aspen in state forests is not reducing stand sizes. Large stands of even-aged aspen result in poor interspersion especially for ruffed grouse. Smaller stand size will improve the distribution of young aspen for breeding cover and older aspen food resources. A habitat suitability model which includes interspersion is being evaluated by the Michigan Wildlife Division to improve the management of the aspen type for ruffed grouse.

The continental distribution of ruffed grouse and the distribution of the aspen forest type closely coincide, suggesting the dependence of ruffed grouse on the aspen type (Gullion and Svoboda 1972). It has also been shown that aspen forests are capable of fulfilling the basic life requisites of ruffed grouse. Young aspen stands (< 25 yr) with high stem densities provide protective fall-through-spring cover. High densities of breeding grouse have been recorded in young aspen stands in Minnesota (Gullion 1970), Wisconsin (Kubisiac et al. 1980) and Michigan (J. Hammill, unpubl. data). Young aspen is also preferred habitat for grouse broods during the summer (Muszkiewicz 1979). Aspen buds, catkins, and leaves provide a year-round food source for grouse (Edminster 1947). The flower buds of older aspen (> 25 yr) provide a critical food source for ruffed grouse during the winter (Gullion 1972). Older aspen also provides secure nesting cover for ruffed grouse.

The management of ruffed grouse habitat in the northern Lake States primarily involves management of the aspen forest type. The objectives of this paper are to describe the condition of the aspen forest type in northern Michigan and to discuss the future of this forest type particularly as it applies to ruffed grouse habitat.

We thank M. Anderson, R. Bertsch, N. Hussain, J. Thiede, and U. S. Forest Service personnel for their assistance in retrieving the forest inventory data used in this paper. We are also grateful to the American Can Corporation, Champion International Corporation, Keweenaw Land Association, and Packaging Corporation of America for allowing use of some of their forest inventory data. R. Moran provided helpful comments during the preparation of this manuscript. Assistance was also provided by E. Carlson and J. Terry.

DATA SOURCES

Several sources of information describing the status of aspen in Michigan are available. Four Michigan Forest Surveys (1935-1980) have been completed. These surveys were authorized by Congress in the Forest and Rangeland Renewable Resources Act of 1974, which was preceded by the McSweeney-McNary Forest Research Act of 1928. Data on aspen area, ownership, distribution, species composition, site index, growth, and removal were obtained from these surveys.

More detailed data are available for aspen in state and national forests. The most recent inventory of state forests began in 1976 and was 62% complete by 1983. From this inventory, data on stand age, stand size, site index, species composition, and conversion were obtained for the aspen forest type. Data on aspen stand age were obtained from inventories of national forests in northern Michigan.

Information concerning aspen on privately owned land is less readily available. Some data concerning aspen age-class distribution were obtained for forest industry lands. Information is generally lacking concerning the status of aspen on other privately owned forests.

HISTORY OF ASPEN IN MICHIGAN

The presettlement forests of Michigan were dominated by pines and northern hardwoods. Logging and subsequent fires produced conditions favorable for aspen. Recurring wild fires in northern Michigan kept most stands in the brush stage until the early twentieth century. By 1920, fire control had greatly improved and brushlands were able to develop into forest stands. By 1935 the aspen-birch type was the dominant forest type in Michigan.

During the period following the 1935 survey the amount of commercial aspen-birch forest land began to decrease (Fig. 1). The greatest decrease occurred between 1966 and 1980 when the area of commercial aspen decreased from 1.7 to 1.4 million ha (4.2 to 3.4 million acres). Much of this decrease is due to deterioration of aspen stands and natural succession to other forest types. Much of this conversion appears to be to red and white pine (*Pinus resinosa, P. strobus*) and northern hardwood forest types, both of which increased 17% between 1966 and 1980. Other land classes which showed substantial increases during this period were noncommercial forest land (+70%) and cropland (+27%).

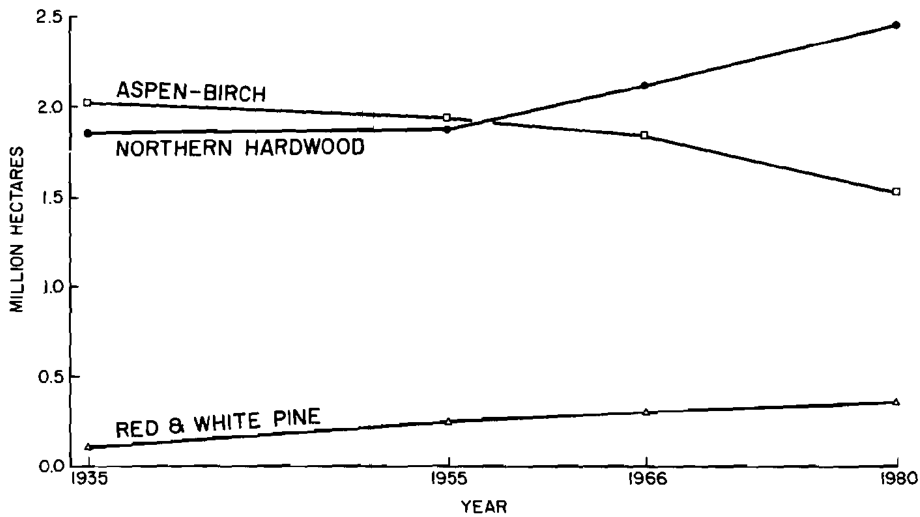

Fig. 1 Changes in the area of aspen and white birch, northern hardwood, and red and white pine forest types in Michigan between 1935 and 1980 (From Findell et al. 1960 and Raile and Smith 1983).

CURRENT STATUS OF ASPEN

Distribution and Ownership

The distribution of aspen varies within the state (Fig. 2). Ninety-five percent of aspen occurs in the northern two-thirds of the state. In both the northern Lower and Upper Peninsulas, approximately 15% of the land area contains aspen.

Fig. 2 Aspen distribution in Michigan, 1980 (From Raile and Smith 1983).

The ownership distribution of aspen also varies within the state (Table 1). Only 12% of the aspen is publicly owned in the southern Lower Peninsula, while 40% of the aspen is publicly owned in the northern two-thirds of the state. Private individuals, including farmers, are the largest ownership class in all three regions with 46% of the aspen in the state. The State of Michigan is the second largest landowner of aspen, with 29% of the aspen in the northern Lower Peninsula and 20% in the Upper Peninsula. Another 20% of the aspen in the Upper

Table 1. Area (thousand ha) of commercial aspen land by ownership class.

	Ownership Class						
	National Forest	State	Other Public	Forest Industry	Farmer	Misc. Private Corporation	Misc. Private Individual
Southern Lower Peninsula[a]	0.1	7.5	1.4		40.0		25.6
Northern Lower Peninsula[b]	67.2	212.0	6.8	9.3	119.0	61.2	260.4
Upper Peninsula[c]	115.8	117.7	6.9	75.8	66.1	60.5	125.9
Total State	183.1	337.2	15.2	85.2	225.1	121.7	411.9

[a]From Hahn (1982).
[b]From Jakes (1982).
[c]From Smith (1982) and Spencer (1982).

Peninsula occurs in national forests. Most of the aspen owned by forest industries also occurs in the Upper Peninsula.

Species Composition

Both bigtooth (*Populus grandidentata*) and quaking aspen (*P. tremuloides*) occur throughout the state; however, bigtooth is more abundant in the Lower Peninsula. This distribution pattern is not consistent across all forest areas in either peninsula. Graham et al. (1963) observed that in the northern Lower Peninsula, bigtooth aspen was dominant south of the 45th parallel and quaking aspen was dominant north of the 45th parallel. They attributed this difference to a predominance of well-drained sandy soils south of the 45th parallel and a large proportion of land with a high water table north of the 45th parallel.

Based on the volume of wood products harvested from the aspen type in state forests, aspen comprises 64% of these stands. In the fourth Michigan Forest Inventory, 54% of the commercial volume in the aspen cover type in northern Michigan was aspen (Jakes 1982, Smith 1982, Spencer 1982). Based on this inventory, other hardwoods comprise 30% of the volume in the aspen type. These hardwoods include soft maples (*Acer rubrum, A. saccharinum*), paper birch (*Betula papyrifera*), balsam poplar (*Populus balsamifera*), red oak (*Quercus rubra*), and hard maples (*Acer saccharum, A. nigrum*). Major softwood species in aspen stands include balsam fir (*Abies balsamea*), white cedar (*Thuja occidentalis*), white spruce (*Picea glauca*), white pine, and red pine.

Stand Age

In state and national forests in northern Michigan, 45% of the aspen is beyond the rotational age of 50 years (Table 2). In order to achieve an even age-class distribution, 20% of the aspen should be cut every 10 years. The only age class which comes close to this is the 10-19 year age class with 17.2% of the aspen. The greatest deficiencies exist in the 20-29 and 30-39 year age classes with 8.1 and 3.6% of the aspen, respectively.

The aspen harvest in state and national forests and the resulting age-class distribution differ across the three regions described in Table 2. During the past 10 years, aspen harvest has been greatest in the western Upper Peninsula. For the period 1954-1974 aspen harvest was highest in the northern Lower Peninsula. The poor aspen market in the eastern Upper Peninsula is shown in the low percentage of aspen less than 30 years old (25%) and high percentage of aspen beyond rotational age (58%).

Aspen owned by forest industry in northern Michigan has been harvested more intensively than publicly owned aspen. As a result, forest industry lands contain a higher percentage of younger aspen. The amount of aspen less than 20 years old of the four industrial forest owners contacted in the study ranged between 25 and 62%, with three of the four owners reporting greater than 50%

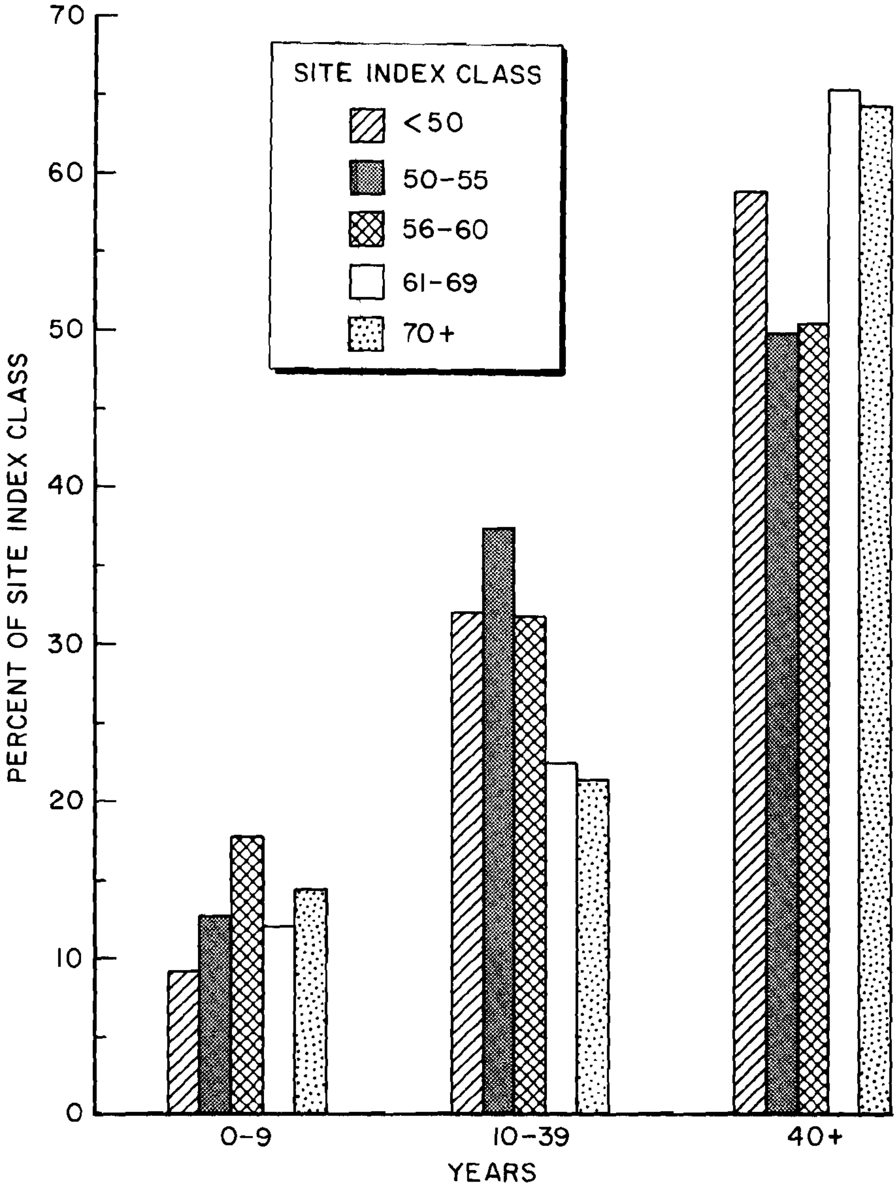

Fig. 3. Age class distribution of aspen in Michigan state forests by site index class.

of their aspen less than 20 years old. Although very little information is available for aspen on private nonindustrial lands, it is the consensus of land managers that less harvest of aspen is occurring on these lands than on publicly owned lands.

Site Index

The site index, height of dominant trees at age 50, of aspen stands in state forests is lower than aspen in other ownership in northern Michigan. Only 34% of the aspen in state forests has a site index greater than 60 as compared to 74% for aspen of all ownerships (Jakes 1982, Smith 1982, Spencer 1982).

During the period 1940 to 1970 there appears to have been a higher rate of cutting of poor quality aspen stands than of better quality stands in state forests. Of aspen in stands of age class 10-39 years, 34% is in areas with site indices less than 60, as compared to 22% for site indices greater than 60 (Fig. 3). During the past decade, however, cutting has been more uniformly distributed across all site index classes. In spite of the higher rate of cutting of poor quality stands between 1940 and 1970, more than 50% of the aspen on poorer sites is over 40 years old and has a high potential for being lost due to stand deterioration and conversion. Many of the stands with site indices less than 50 are noncommercial. These stands are cut primarily for wildlife management using deer range improvement funds collected through deer hunter licenses.

Stand Size

Only 3.5% of the aspen in state forests is in stands less than 4.2 ha (11 acres), the optimal size for ruffed grouse habitat (Gullion 1972). The stand size distribution for aspen less than 10 years old is almost identical to the distribution for all ages (Table 3). This indicates that recent management of aspen in state forests is not resulting in the reduction of stand sizes.

Aspen Harvest

Aspen comprised 35% of the total forest products harvested in northern Michigan in 1979 (Jakes 1982, Smith 1982, Spencer 1982). The demand for aspen forest products is not uniform throughout northern Michigan. Removal as a percentage of net annual growth was 146% for aspen in the western Upper Peninsula as compared to 92 and 79% for the northern Lower and eastern Upper Peninsulas, respectively (Table 4). Aspen removal increased 28 and 43% in the northern Lower and western Upper Peninsulas, respectively, between 1965 and 1979. However, during this period aspen removals decreased 13% in the eastern Upper Peninsula.

ASPEN MANAGEMENT

State Forests

In 1970 the Michigan Natural Resources Commission approved a policy for

Table 2. Aspen age-class distribution in state and national forests in northern Michigan.

Age Class	Western Upper Peninsula (%)	Eastern Upper Peninsula (%)	Northern Lower Peninsula (%)
0-9	16.2	11.5	14.4
10-19	12.7	8.7	23.0
20-29	5.7	4.9	10.7
30-39	4.0	3.6	3.5
40-49	13.0	13.6	10.4
50+	48.4	57.7	38.0

Table 3. Stand size distribution of aspen in Michigan state forests by age class.

Stand Size (ha)	All Ages (%)	Age Class (yr) 0-9 (%)	10-39 (%)	40+ (%)
0-2.0	0.7	0.6	0.7	0.8
2.5-4.0	2.8	3.1	2.6	2.9
4.5-7.5	7.5	7.3	7.0	7.7
8.0-20.0	27.8	27.9	23.7	30.0
20.5+	61.1	61.1	66.0	58.6

Table 4. Net annual growth and removal (thousand cubic meters) of aspen growing stock[a] on commercial forest land in northern Michigan, 1965[b] and 1979[c].

	1965		1979	
	Net Annual Growth	Removal	Net Annual Growth	Removal
Northern Lower Peninsula	664	1,002	1,392	1,280
Eastern Upper Peninsula	273	331	362	288
Western Upper Peninsula	594	520	508	744
Totals	1,531	1,853	2,262	2,312

[a]Trees with diameter 12.7 cm (5.0 in) or larger.
[b]From Chase et al. 1970.
[c]From Raile and Smith 1983.

managing Michigan state forest lands. This policy states that the Michigan Department of Natural Resources will manage state forests to "yield that combination of products and services which best meets the recreational, spiritual, and physical needs of all the people now and in the future." More specifically to the aspen forest type, the policy states that, "In general, the forest shall be managed to encourage intolerant forest types. As aspen is highly demanded for commercial purposes and is of equal importance to wildlife, it shall be perpetuated and expanded wherever feasible."

In its guidelines for deer range improvement, the Michigan Wildlife Division's stated objectives related to aspen are the following:

1. Not less than 65% of the upland area should be in a combination of aspen, oak, jack pine, upland brush and opening types.
2. Not less than 35% of the upland acreage should be in aspen type.
3. Not less than 25% of the upland acreage should be in seedling-sapling stage.

These policies and guidelines highlight the importance placed upon the aspen forest type by the Department of Natural Resources. Decisions on forest land management are made by interdisciplinary teams consisting of foresters, wildlife biologists, fisheries biologists, recreation specialists, fire officers, and conservation officers. Based on current management objectives for stands in state forests, 13,866 ha (34,249 acres) of aspen will convert to other cover types in 10 years. However, 32,820 ha (81,065 acres) of other forest types will convert to aspen, resulting in a net increase of 6% in the aspen type. Net losses from the aspen type will be primarily to red pine, white pine and forest opening types. Net gains will be primarily from northern hardwood, paper birch, spruce-fir and oak types.

National Forests

The U. S. Forest Service in this region does not have a specific policy for management of the aspen type. Aspen management is determined by the wildlife, timber, recreation, and aesthetic needs within individual forests as identified by forest planning teams. Within the Ottawa and Hiawatha National Forests in the Upper Peninsula, plans call for the maintenance of the aspen type with no large scale conversion of the type. For the Huron-Manistee National Forest in the northern Lower Peninsula, plans call for a 1% increase in the aspen type during the next decade.

Private Land

Since the intensity of aspen harvest on forest industry land is much greater than other ownerships, aspen loss due to natural succession should be minimal. However, some forest industry lands in the western Upper Peninsula are being converted to softwoods because of anticipated future shortages of softwood fiber.

Much of Michigan's privately owned forest land is held by individuals seeking amenities other than marketable wood fiber. Owning a parcel of land for the recreational and aesthetic values alone is important to many of these landowners. Forest management on these private holdings is further complicated by the small size of individual holdings, approximately two-thirds are less than 40 ha (100 acres) in size (Raile and Smith 1983). It has been estimated that one-third of the privately owned timber resources now harvestable in Michigan are being withheld from the market for various reasons (James et al. 1982). There is an obvious need to facilitate the coordination of timber production with other desired amenities on these lands. Although many landowners hold their properties for hunting and viewing wildlife, they often are unaware of the relationships between regulated timber harvest and production of wildlife species such as ruffed grouse.

DISCUSSION

The decline in Michigan's aspen forest lands since 1935 is resulting in a decreased carrying capacity for ruffed grouse. This successional trend is likely to continue, since the aspen age-class distribution is skewed toward stands beyond rotational age, that are now threatened with physiological breakup. Graham et al. (1963) found that in the Lower Peninsula of Michigan aspen should be cut prior to age 60. Beyond this age, decay and disease have reduced the commercial value of the species. However, Ohman and Ream (1971) found quaking aspen to be the dominant species in 100-year-old stands in northern Minnesota. Quaking aspen is considered to be more resistant to stand deterioration in more northerly latitudes (Kittredge 1938).

Most commonly, aspen is being successionally replaced by red maple, sugar maple, white pine, red pine, forest openings, and noncommercial forest land. These types are not conducive to ruffed grouse production and do not lend themselves to management that would satisfy this species' life requisites.

The problem of carrying a large inventory of mature aspen was recognized early by state forest managers. As a result, aspen cuts in state forests tended to be large, resulting in the poor interspersion of young and old age classes necessary to meet the habitat needs of ruffed grouse. Often the option of holdling portions of aspen stands for later cutting, and thereby increasing interspersion, was not viable because of impending stand breakup and excessive losses of quality and volume.

Aspen on poor quality sites is more vulnerable to deterioration and successional change than on good sites (Brinkman and Roe 1975). However, during the past decade, aspen harvest on state forests has been quite evenly distributed across all site index classes (Fig. 1). Larger cuts should be concentrated on poor quality sites and there should be an accelerated treatment of noncommercial stands. There should also be a more concerted effort to intersperse age classes on better sites where portions of stands can be held for at least another decade.

In addition to an overabundance of aspen beyond rotational age there is a shortage of middle-aged (20-39 yr) aspen stands. This shortage of middle-aged aspen appears to be common to all aspen ownerships. The current shortage of middle-aged aspen, combined with the loss of large areas of overmature aspen, may result in negative impacts in the future to both the aspen-dependent forest industry and wildlife. Forest industry may be forced to cut younger age classes of aspen and smaller tree diameters in order to obtain the needed volumes of aspen fiber. In addition, the potential shortage of mature aspen would result in a deficiency in aspen flower buds, the critical winter food source of ruffed grouse.

FUTURE MANAGEMENT

The Michigan Wildlife Division is currently developing a statewide ruffed grouse management plan. Guidelines are being developed to tailor the management of forest land to benefit ruffed grouse. The guidelines are designed to maximize ruffed grouse production with the practical and economic constraints imposed by the forest products industry. Forest management guidelines developed for ruffed grouse will center around the life requisites of fall-through-spring cover and winter food. These life requisites have been incorporated into a habitat model developed by the U. S. Fish and Wildlife Service (Western Energy and Land Use Team, Fort Collins, Colorado) and modified for Michigan conditions. The following variables are considered in this ruffed grouse habitat suitability model:

1. Winter food availability (percentage of area in mature aspen).
2. Fall-to-spring cover.
   a. Density and average height of deciduous trees and shrubs
   b. Density and average height of lowest live branches of coniferous trees.
3. Interspersion of winter food and fall-to-spring cover.

Preliminary tests of the model on areas with known densities of breeding ruffed grouse suggest that the model is accurate and has predictive capabilities (J. Hammill, unpubl. data). This model will be used to evaluate the cost effectiveness of ruffed grouse habitat management alternatives. The effects of increased management efforts or program reduction can also be predicted using this model. Based on the variables within the model, habitat management guidelines are being developed and will be used in areas where ruffed grouse production is an important consideration.

Without the development of significant aspen markets in the immediate future, we anticipate a continued decline of the aspen forest type. A study made for the Michigan Department of Natural Resources by Chas. T. Main, Inc. (MAIN 1982) concluded that there are sufficient timber resources, water, transportation, and skilled labor in northern Michigan to support two additional pulp and paper plants, each with a capacity of 726 t (800 tons) per day. The recently approved Statewide Forest Resources Plan (Michigan Department of Natural Resources 1983) sets a timber harvest target of 14.3 million m^3 (507 million ft^3) for the year 2000. This would be a 137% increase over the 6.0 million m^3 produced in 1977. It is important that additional aspen markets develop soon in order to better distribute the demand for the aspen resource as well as capture some of the losses now incurred due to overmature aspen.

An efficient assistance program for private land forest management is needed to recover the large volume of underutilized aspen present on nonindustrial forest lands. Such a program should 1) identify the landowners' desires and objectives for management, 2) be sensitive to aesthetic, timber, and wildlife considerations, and 3) assist in marketing forest products from these lands. Higher aspen prices through increased demand and wildlife management guidelines having predictive capabilities may be powerful tools for gaining access to these private aspen resources.

LITERATURE CITED

Brinkman, K. A. and E. I. Roe. 1975. Quaking aspen—silvics and management in the Lake States. U. S. Dep. Agric., Agric. Handb. 486. 52pp.

Chase, C. D., R. E. Pfeifer, and J. S. Spencer, Jr. 1970. The growing timber resource of Michigan, 1966. U. S. Dep. Agric., For. Serv. Resour. Bull. NC-9. 62pp.

Edminster, F. D. 1947. The ruffed grouse—its life story, ecology and management, Macmillan, New York. 385pp.

Findell, V. E., R. E. Pfeifer, A. G. Horn, and C. H. Tubbs. 1960. Michigan's forest resources. U. S. Dep. Agric., For. Serv., Lake States For. Exp. Sta. Paper 82. 46pp.

Graham, S. A., R. P. Harrison, Jr., and C. E. Westell, Jr. 1963. Aspens: phoenix trees of the Great Lakes Region. Univ. of Mich. Press, Ann Arbor. 272pp.

Gullion, G. W. 1970. Factors influencing ruffed grouse populations. Trans. N. Am. Wildl. and Nat. Resour. Conf. 35:93-105.

______. 1972. Improving your forested lands for ruffed grouse. Minn. Agr. Exp. Sta., St. Paul, Misc. Jour. Ser., Publ. 1439. 34pp.

______, and F. J. Svoboda. 1972. The basic habitat resource for ruffed grouse. Pages 113-119 *in* Aspen: symposium proceedings. U. S. Dep. Agr., For. Serv., Gen. Tech. Rep. NC-1. 154pp.

Hahn, J. T. 1982. Timber resource of Michigan's southern Lower Peninsula, 1980. U. S. Dep. Agric., For. Serv. Resour. Bull. NC-66. 119pp.

Jakes, P. J. 1982. Timber resource of Michigan's northern Lower Peninsula, 1980. U. S. Dep. Agric., For. Serv. Resour. Bull. NC-62. 120pp.

James, L. M., S. E. Heinen, D. D. Olson, and D. E. Chappelle. 1982. Timber products economy of Michigan. Mich. State Univ., East Lansing, Agric. Exp. Sta. Res. Rpt. 446. 24pp.

Kittredge, J., Jr. 1938. The interrelations of habitat, growth rate, and associated vegetation in the aspen community of Minnesota and Wisconsin. Ecol. Monogr. 8:151-246.

Kubisiac, J. F., J. C. Moulton, K. R. McCaffery. 1980. Ruffed grouse density and habitat relationships in Wisconsin. Wisc. Dep. Nat. Resour., Madison, Tech. Bull. 118. 16pp.

MAIN. 1982. Pulp and paper investment opportunities in Michigan. Chas. T. Main, Inc., Boston, Mass. 24pp.

Michigan Department of Natural Resources. 1983. Michigan's forest resources—direction for the future—a statewide forest resources plan. Mich. Dep. Nat. Resour., Lansing. 40pp.

Muszkiewicz, J. 1979. An analysis of ruffed grouse brood habitat in northern Michigan. M. S. Thesis, Univ. Mich., Ann Arbor. 55pp.

Ohmann, L. F. and R. P. Ream. 1971. Wilderness ecology—virgin plant communities of the Boundary Water Canoe Area. U. S. Dep. Agric., For. Serv. Res. Pap. NC-63. 55pp.

Raile, G. K. and W. B. Smith. 1983. Michigan forest statistics, 1980. U. S. Dep. Agric., For. Ser. Resour. Bull. NC-67. 101pp.

Smith, W. B. 1982. Timber resource of Michigan's eastern Upper Peninsula, 1980. U. S. Dep. Agric., For. Serv. Resour. Bull. NC-64. 103pp.

Spencer, J. S., Jr. 1982. Timber resource of Michigan's western Upper Peninsula, 1980. U. S. Dep. Agric., For. Serv. Resour. Bull. NC-60. 102pp.

Seasonal Harvest and Mortality of Ruffed Grouse in Wisconsin

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Abstract: The temporal distribution of harvest and mortality in ruffed grouse (*Bonasa umbellus*) has important implications for timing of hunting seasons and hypotheses of population control. We attempted to estimate these distributions from grouse population statistics in Wisconsin and published accounts from other areas. Distribution of harvest of ruffed grouse was estimated from recoveries of banded grouse in Shawano, Waushara and Marquette counties over 5 seasons (October-January) beginning in 1978-79, and by questionnaire responses from hunters throughout Wisconsin in 1981-82 and 1982-83. Seasonal patterns of mortality in these years were assessed from samples of brood size in late summer, from estimates of grouse density in fall and winter, and from deaths of radio-marked birds. In Shawano county about 58% of 172 band recoveries occurred in October, 19% in November and 23% in December, 1978-1981. In Waushara and Marquette counties, 13 bands were recovered in October and 9 in November, 1982. Although January hunting was allowed, no bands were recovered in January 1983, or December 1982. Mean band recovery rates were about 24% from study plots in these 3 counties, and bag per unit of effort apparently declined throughout the season on these heavily hunted areas. Nine hundred and thirty-eight respondents to 1526 questionnaires, sent to randomly selected hunters throughout Wisconsin, reported that of the 3900 grouse killed in the 1981-82 and 1982-83 seasons, 55% were taken in October, 26% in November, 13% in December and 6% in January. Respondents bagged an average of 0.7 grouse per trip; reported success declined slightly each month. The mean size of 44 broods

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captured and observed in July was 4.0. Brood sizes reported in the literature implied a chick survival rate of about 0.37 through September. Five paired indices to grouse density suggested that the decline averaged about 58% from October through December. These data imply that overall survival of juveniles and adults was about 0.16 from hatch to December. Assuming no overwinter losses, the production required to balance such mortality is a mean hatch of 10.2 chicks per hen. These estimates of summer and fall survival are generally lower than those published elsewhere. Preliminary data from 17 deaths of radio-marked grouse also indicated heavy fall mortality from hunters and other predators. Additional assessment of mortality patterns is needed in order to rationalize harvest strategies and better understand population fluctuations.

Ruffed grouse have long been considered to be an underutilized game species. Bump et al. (1947), Dorney and Kabat (1960), Fischer and Keith (1974) and several others have suggested that ruffed grouse could tolerate higher harvest rates. In apparent response to such beliefs season lengths for ruffed grouse in Wisconsin have grown steadily from 0-5 days in the 1930s to 138 days in 1983-84. Numbers of hunters have more than doubled in this interval (DeStefano and Rusch 1982). Similar trends are apparent in other midwestern and northeastern states. Research has yet to demonstrate convincingly any impact of harvest on subsequent numbers of ruffed grouse, but there is recent evidence of high harvest rates on some public lands (DeStefano 1982, Kubisiak 1984). Concern mounts about potential local effects of hunting, especially in winter (DeStefano and Rusch 1982, Gullion and Evans 1982).

The impact of high harvest rates in grouse depends in part upon the magnitude and temporal distribution of reproduction, movement and mortality in these populations. The seasonal distributions of hunting losses relative to losses from other causes are particularly relevant to calculation of allowable harvests and decisions on timing of hunting seasons. Data on temporal distribution of natural mortality also have obvious implications for hypotheses that strive to explain fluctuation, control or regulation in ruffed grouse populations.

The objectives of studies reported in this paper were (1) to estimate the temporal distribution of ruffed grouse harvest in Wisconsin, (2) to estimate seasonal distribution of mortality of ruffed grouse in Wisconsin, and (3) to evaluate these estimates and those from other studies as contributions to a potential life equation for ruffed grouse.

Our thanks to T. Bahti, G. Kloes, S. Miller, and T. Howard of the Wisconsin Department of Natural Resources (WDNR) and the members of the Navarino CETA crew for assistance and support in the field. D. Buehler, R. Draves, R. Longwitz, T. Moser, P. Tebbel, and D. White assisted with the fieldwork. J. Kubisiak and Doris Rusch offered many helpful suggestions throughout the preparation of the manuscript. Financial support was provided by the Bureaus of Wildlife Management and Research of the Wisconsin Department of Natural Resources through the Federal Aid to Wildlife Restoration Act under Pittman-Robertson Project W-141-R, and the Ruffed Grouse Society of North America.

STUDY AREAS

The 6542-ha (16,400-acre) Navarino Wildlife Area (NWA) in Shawano and Waupaca counties, Wisconsin (Fig. 1), is owned and managed by the Wisconsin Department of Natural Resources. About 55% (3600 ha; 9000 acres) is forested with 1800 ha (4500 acres) of aspen (*Populus tremuloides* and *P. grandidentata*), 1400 ha (3500 acres) of hardwoods, and 400 ha (1000 acres) of conifers (WDNR, unpubl. rep., NWA Master Plan Concept Elements, Madison, Wis., 1979). In addition, there are 800 ha (2000 acres) of brush, predominately speckled alder (*Alnus rugosa*) and willow (*Salix* spp.). Most of the vegetation types occur in relatively small and highly interspersed patches. The topography is flat except for several 10-15 m (30-50 ft) high sandy ridges separated by marshes of sedge (*Carex* and *Scirpus* spp.).

Navarino WA is about 75 km (47 mi) west of Green Bay and lies within a 128 km (80 mi) radius of over 0.5 million people. Access is good; a state and a county road bisect the area, and there are over 90 km (56 mi) of well-maintained hunter walking trails, all of which are gated and locked at the parking lots. Navarino WA and all of northern and southeastern Wisconsin had a 3-month hunting season for ruffed grouse in 1978-83, about 1 October to 31 December.

Public lands along various tributaries of the Fox River in Waushara and Marquette counties near Wautoma, Wisconsin, were also used as study areas in 1982 and 1983. These largely riparian woodlands are widely dispersed amongst croplands. Forest land comprises approximately 30% of these counties, with 40% in cropland, and 30% in pasture and marsh lands (WDNR, unpubl. rep., 1968). The primary grouse habitat along the streams is alder lowland and associated oak/birch uplands. These areas and southwestern Wisconsin had a 4-month hunting season in 1982-83, about 1 October to 31 January.

METHODS

Banding and Marking

Twenty to 40 lily-pad traps (Gullion 1965) were set in forested portions of Navarino WA and riparian woodlands in Waushara and Marquette counties from mid-summer to mid-fall, 1978-1982. Traps were checked once or twice each day. A brightly colored, numbered aluminum band was placed on 1 leg of each captured grouse and a silver or colored band inscribed with a number, our address, and a reward offer of $5, $10, or $20 was placed on the other leg. Color phase, weight (to the nearest 5 g), and juvenile molt progression of birds <17 wk old (Hale et al. 1954) were recorded. All grouse were released at the site of capture immediately after processing.

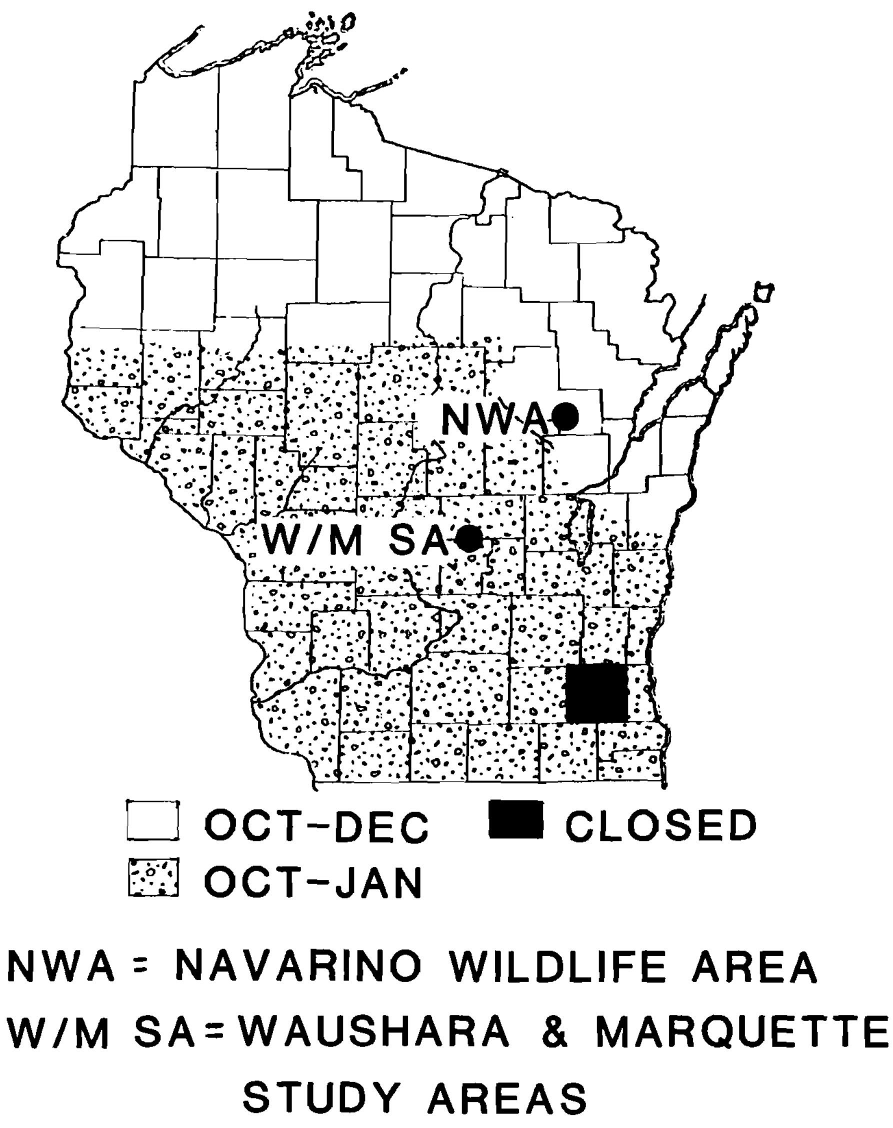


Fig. 1. Locations of areas where ruffed grouse were banded and studied in Wisconsin, and portions of the state with 3- or 4-month open seasons for ruffed grouse in 1982-83.

Recovery rates in 1978-83 were determined by the proportion of leg bands returned by hunters from ruffed grouse captured in lily-pad traps in July-September. Estimates of harvest distribution by month were calculated from these recoveries, with no corrections for nonreplacement sampling (grouse recovered in previous months). Thirty-five of the grouse trapped in Waushara and Marquette counties were fitted with radio transmitters mounted on ponchos (Amstrup 1980) or harnesses (Brander 1968). All radio-marked grouse weighed >375 g and bore $20 reward bands. Locations of radio-marked grouse were recorded at least every other day prior to 1 September and daily thereafter through December. Motion of grouse was monitored by activity sensors in the transmitters; immobile grouse were approached on foot until they were flushed or found dead. Cause of death was determined by examination of evidence on the carcass and at the site where it was found. Survival of radio-marked grouse was calculated by the method of Trent and Rongstad (1974).

Questionnaires to Hunters

The Wisconsin Department of Natural Resources provided us with a mailing list of all hunters that reported hunting ruffed grouse in 1981-82. These 1526 hunters were a portion of a random sample of license buyers that responded to a general small-game questionnaire mailed by WDN. Our questionnaire, mailed on 31 March 1983, asked hunters to provide data on the numbers of hunts and numbers of grouse bagged in each month October-January in 1981-82 and 1982-83. Hunters were asked to report unsuccessful trips and failures to remember data. Other questions on crippling loss, methods of hunting, and 3 counties most often hunted were also asked. A total of 938 (61.5%) questionnaires were returned; 786 reported hunts, 130 reported no hunts and 23 were bogus, incomplete or unusable. No follow-up contacts were made.

We suspect that some data from respondents were subject to memory, prestige, and other biases. Because of memory failure, fewer hunters (288) reported data from 1981-82 than from 1982-83 (349), but hunters reported similar distributions of effort and harvest in both years. We thus pooled years and assumed that bias did not vary among months and did not affect estimates of temporal distribution of harvest calculated from these reports.

Observations of Broods

At Navarino WA, mean brood size was estimated from numbers of ruffed grouse chicks in multiple captures in lily-pad traps in July and August. In Waushara and Marquette counties, mean brood size was estimated from observations of numbers of chicks accompanying radio-marked hens or siblings. Estimates of brood size reported in the literature were regressed on time in order to estimate a general mean survival rate for ruffed grouse chicks in summer.

RESULTS

Temporal Distribution of Band Recoveries

On Navarino Wildlife Area, 778 ruffed grouse were captured, fitted with reward bands and released in 1978 through 1981. Of these, 180 were shot by hunters during the 3-month ruffed grouse season and subsequently reported to us (Table 1). The majority of recoveries (58%) occurred in October (Table 2), but substantial proportions of recoveries were recorded in November (19%) and December (23%). Dates were not reported for 8 recoveries. Forty recoveries were recorded in December, 1978-1981, compared to 42 in November and 100 in October. The unexpectedly high proportion of recoveries in December was perhaps due, in part, to closure of about 10% of the area to grouse hunting during the waterfowl season (October-mid-December in 1978-1980). When the closed areas were opened to grouse hunting in December, these relatively unexploited grouse populations received considerable attention from hunters and produced 15 of the 37 December band recoveries in those years (DeStefano 1982).

In 1982, 73 grouse were banded in Waushara and Marquette counties. Radio transmitters were placed on 35 banded grouse. Twenty-two of the banded grouse were recovered, 13 (59%) in October and 9 (41%) in November. No recoveries were obtained in December 1982, or January 1983.

Data from both areas suggested that the majority of all band recoveries on ruffed grouse occurred in October, but significant numbers of grouse bands were recovered in other months as well. All 851 grouse were banded on public lands, and these banded grouse sustained minimum harvest rates (recovery rates) of about 24%.

Temporal Distribution of Harvest and Effort

A questionnaire to a random sample of small game hunters provided some data on grouse hunting activity and success in the entire state. A maximum of 725 hunters reported 11,762 trips in 1981-82 and 1982-83 (Table 2). Of the 7763 grouse bagged, 54% (4195) were taken in October, 27% (2126) in November 13%, (1000) in December and 6% (442) in January (Table 3).

In both years, 86% of the respondents hunted in October, 72% hunted in November, 38% hunted in December, and 19% hunted in January. Mean numbers of ruffed grouse bagged by hunters were 3.1 in October, 1.6 in November, 0.7 in December, and 0.3 in January. Mean numbers of trips varied in a similar manner; 4.3, 2.6, 1.2, and 0.6 in October through January, respectively (Table 4). In the sample, mean numbers of grouse per trip varied from 0.7 in October to 0.6 in November, December, and January (Table 5). These differences were significant ($t = 4.53$, $P < 0.001$), but the major decline in numbers of grouse bagged per month was due to major decreases in hunter activity rather than the

Table 1. Monthly distribution of recoveries of ruffed grouse banded 1) on the Navarino Wildlife Area, Wisconsin, 1978 to 1981; and 2) in Waushara and Marquette counties in 1982. All reported recoveries were of grouse shot during the hunting season.

	Number of grouse		Percent of recoveries in		
Years	Banded	Recovered	October[a]	November	December[b]
1978-81	778	180	58	19	23
1982	73	22	59	41	—
Weighted mean	—	—	55	20	25

[a]Hunting actually began 30 Sept 1978, 29 Sept 1979, 4 Oct 1980, 3 Oct 1981, and 2 Oct 1982.

[b]Season ended Dec 31 each year at Navarino and 31 Jan 1983 in Waushara and Marquette counties. No band recoveries occurred in January.

Table 2. Reported activity and bag of grouse hunters in the northern and southern parts of Wisconsin (Fig. 1) in 1981-82 and 1982-83. A total of 1526 questionnaires was mailed to randomly-selected hunters that reported grouse hunting to WDNR. A total of 915 responded; 786 of these hunted, but only 618-725 provided usable data in any one month.

	Number of hunters[a]		Number of grouse		Number of trips	
	N	SW	N	SW	N	SW
October 1981	282	334	1264	1014	1562	1231
November 1981	283	329	397	614	687	947
December 1981	286	333	127	340	231	500
January 1982	288	334	22	170	66	281
October 1982	349	376	1214	706	1789	1220
November 1982	348	376	570	545	936	954
December 1982	348	376	170	363	363	558
January 1983	349	376	46	204	111	326

[a]These are numbers of hunters that reported grouse hunting in 1981-82 or 1982-83. Totals are actually numbers of hunter reports rather than numbers of hunters. Many of the same hunters reported hunting in 1981-82 and 1982-83.

Table 3. Temporal distribution of bags of grouse reported by hunters in the northern and southwestern portions of Wisconsin in the 1981-82 and 1982-83 hunting seasons[a].

Area	Number of grouse reported	Percent reported in			
		October	November	December	January
N	3807	65	25	8	—
SW	3956	43	29	18	10
Both	7763	54	27	13	6

[a]Calculated from data in Table 2.

Table 4. Temporal distribution of grouse hunting trips reported by hunters in the northern and southwestern portions of Wisconsin in the 1981-82 and 1982-83 hunting seasons[a].

Area	Number hunter reports	Number of trips/hunter in			
		October	November	December	January
N	329	5.3	2.6	0.9	—
SW	376	3.5	2.7	1.5	0.9
Both	705	4.3	2.6	1.2	0.6

[a]Calculated from data in Table 2.

Table 5. Mean numbers of grouse per trip reported by hunters in the northern and southwestern portions of Wisconsin in the months of the 1981-82 and 1982-83 hunting seasons[a].

Area	Number trips reported	Number of grouse/trip in			
		October	November	December	January
N	5745	0.7	0.6	0.5	—
SW	6017	0.7	0.6	0.7	0.6

[a]Calculated from data in Table 2.

slight declines in hunter success. Northern hunters reported more trips (9.1) in the 3-month season than southern hunters reported (8.6) in a 4-month season.

Temporal Distribution of Mortality

Size of groups of chicks taken in lily-pad traps were used as estimates of brood size in July and August. Small samples pooled over 4 years (1978-1981) yielded

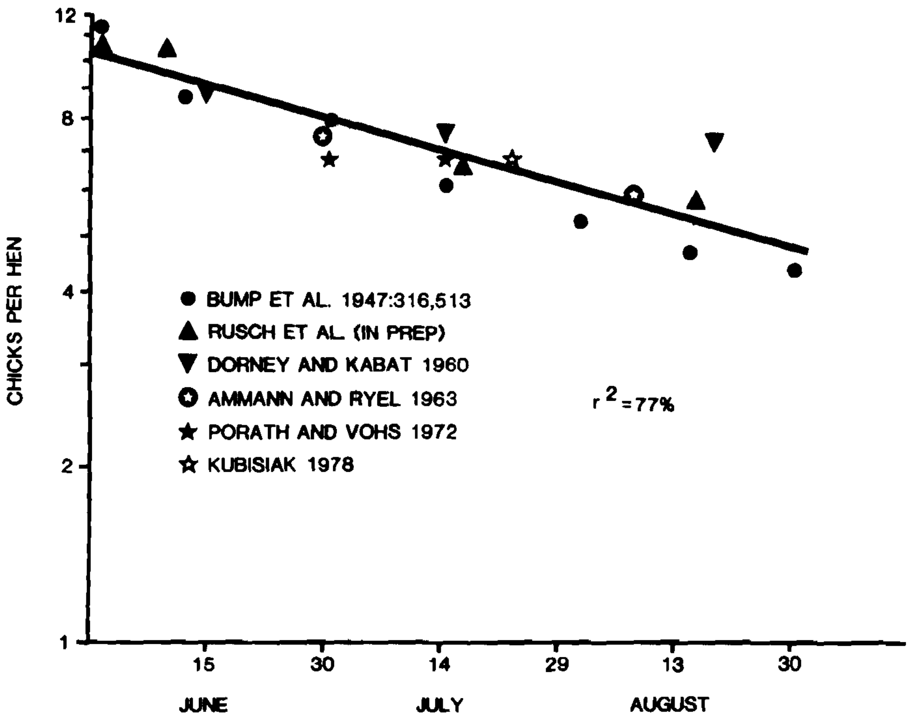


Fig. 2. Regression of log of mean chick numbers reported in the literature on mean date of observation. The appropriate equation of the regression line is log Y = 3.58919 — 00083X, where X is the Julian date of observation and Y is the expected number of chicks. Two earliest observations are means of clutch size (Bump et al. 1947) or mean number of chicks hatched (Rusch et al. in prep.).

means of 3.9 (n = 9, SD = 1.6) in July and 4.0 (n = 22, SD = 2.2) in August. Similar estimates, obtained from contacts with radio-marked broods in Waushara and Marquette counties were 4.1 (n = 8, SD = 1.1) in July, August, and early September. Brood size estimates from Waushara and Marquette counties and Navarino WA were similar but both were considerably lower than those collected and published by other observers (Fig. 2). Although we suspected some captured broods may have been incomplete, thus leading to biased estimates, there was little difference ($t = 0.18$, $P > 0.5$) in means of 3.5 chicks in 10 captures with hens versus 3.4 in 51 captures without hens. Published observations of mean brood size (4.9) and mean numbers of young hatched per nest (10.2) imply a loss of about 5 young per brood over June, July, and August, or a 92 day survival rate of about 0.47. We appreciate that mortality is probably heaviest in the first few weeks of life, that loss of entire broods would deflate survival, that not all chicks are necessarily seen in each brood (Godfrey and Marshall 1969), and that survival may be lower (or higher) during dispersal in September. We nonetheless accept 0.47 as a reasonable estimate of summer survival and extrapolate this survival rate to 1 October (the usual beginning of the hunting season) in order to calculate an expected number of survivors per brood of about 3.7 (if $s_{92} = 0.47$, then $s_{122} = 0.38$; $0.38 \times 10.2 = 3.7$).

Few data from Wisconsin or elsewhere are available for calculation of seasonal distribution of mortality in adult ruffed grouse or in juveniles after the broods separate in September. Juvenile ruffed grouse banded near Navarino and Wautoma were recovered at rates comparable to those of adutls of the same sex; 0.28 for males and 0.18 for females. In our view, recoveries of grouse banded in other studies in Wisconsin do not suggest markedly higher recovery rates for juveniles, even though Dorney and Kabat (1960) reported that juvenile grouse were 1.6 times more vulnerable to shooting than adults. Most of the difference they reported was due to the relatively low recovery of banded adult males which the authors attributed to poor access to territorial males by hunters that hunted mainly along roads. Although low vulnerability of adult males to the gun was no doubt a contributing factor to low recovery rates for this cohort, we surmised from their large samples of adult males and accompanying discussion that most adult males were probably trapped in the spring. We thus suggest that band recovery rates of adult males of 0.09 reported by Dorney and Kabat may also have been depressed by mortality of this banded cohort in spring and summer. At Navarino, the recovery rate of 57 adult males banded in the spring was 0.19, but the recovery rate of 50 adult males captured at Navarino and Wautoma in July-November was 0.28, identical to that of 352 juvenile males captured in the same trapping periods.

Age-specific estimates of fall and winter survival are not available to us, but changes in population estimates or indices to grouse density can give some indication of disappearance (mortality and net egress) of both juvenile and adult ruffed grouse in fall and winter. Two population estimates from Navarino WA suggest a disappearance rate of about 68% in 69 days in September through November (or 39% per month, Fig. 3). Data from December and January are insufficient for calculation of estimates of disappearance rates but hunter reports suggest relatively similar rates of bagging in December and January in Waushara and Marquette counties (0.10 grouse per hour).

The number of grouse flushed per hour and reported by hunters at Navarino

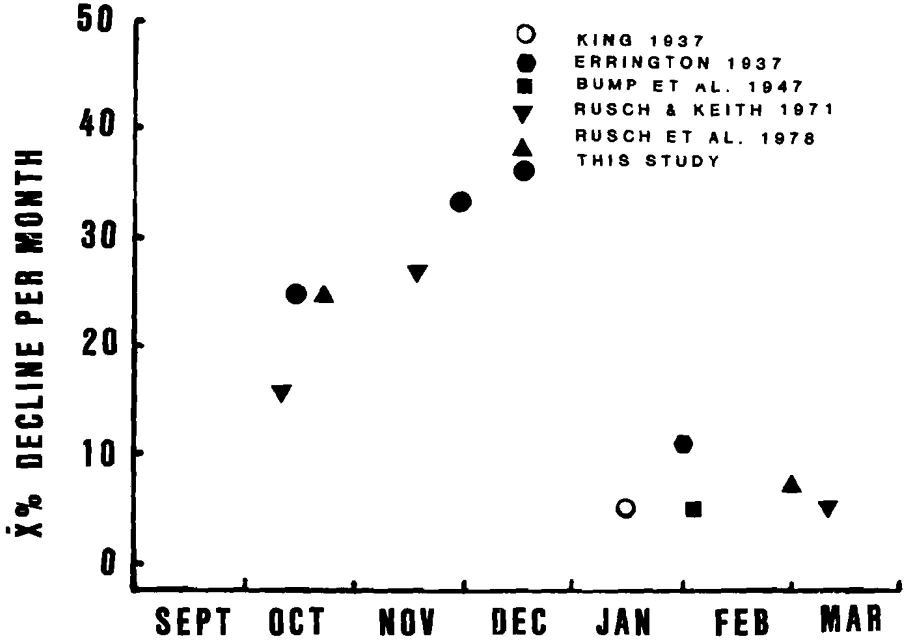


Fig. 3. Mean monthly rates of decline in numbers of grouse in Shawano and Waushara counties, Wisconsin and in other areas reported in the literature. All rates of decline were complements of survival rates calculated from pairs of population estimates or indices to numbers of grouse. Means were calculated from rates of decline in 2 or more years.

WA declined from 1.3 in October 1979 and 1980 to 1.0 in November-December 1979 and 1980. This gives an estimated decline of 23% in 30 days (Figure 3). Hunters in Waushara and Marquette counties reported bags per hour that declined from 0.3 per hour in October and November 1982, to 0.1 in December 1982, and January 1983; an estimated decline of 67% in 60 days. The average decline calculated from all of these estimates in Figure 3 was 58% from October 1 through December 31; the main portion of the decline apparently occurred in October and November.

DISCUSSION

Estimates of birth rates, age specific survival rates, unbiased fall age ratios, and/or size of ruffed grouse populations, lack the precision necessary for construction of a meaningful life equation for ruffed grouse in Wisconsin. Differential vulnerability of age-sex cohorts compounds the usual difficulties in interpretation of fall age ratios (Caughley 1974). Our preliminary data suggest that only about 37% of the chicks survived June-September and about 42% of the juveniles and adults present in September survived the hunting season (October 1 — December 31). The birth rate of ruffed grouse in Wisconsin is not known. However, if (1) estimates of mortality in summer and fall are reasonable; (2) no mortality occurred in winter-spring; and (3) no adults died in the summer, then the birth rate needed to balance the suggested mortality would be about 724 chicks per 100 hens, or 71% of hens successfully nesting and producing 10.2 chicks per nest. A birth rate of this magnitude is high but not unreasonable (Bump et al. 1947).

Bump et al. (1947:548) concluded that average overwinter loss was about 5% per month in stable populations in New York. Indices to numbers of grouse in other areas also suggest low overwinter losses (Fig. 3). Errington's (1937) estimates of grouse numbers in Wisconsin implied a monthly loss of about 11% in December-March. King's (1937) estimates in Minnesota indicated a mean monthly loss of about 5% in October-April. Population estimates for ruffed grouse in Alberta (Rusch and Keith 1971) and Manitoba (Rusch et al. 1978) indicated little or no decline in December-May and also a mean monthly loss of about 5%. We suggest that most mortality in these lightly hunted populations of ruffed grouse indeed occurred between June and December. High band recovery rates, the decline in population estimates and bag per unit effort statistics over the hunting season on our study areas suggest to us that mortality rates were relatively high in October through December, either due to hunting, natural causes, or both.

We believe that band recovery rates of 23-50% (this study and Kubisiak 1984), if sustained on large areas over 2 or more years, would have substantial negative impacts on numbers of breeding grouse. Indeed, data from Manitoba (Rusch et al. 1978), Minnesota (King 1937) and Alberta (Rusch et al. in prep.) all suggest that major cyclic declines in ruffed grouse were associated with unusually heavy mortality in summer and fall, although mainly from causes other than hunting.

We agree with Bump et al. (1947:539) that fall numbers of grouse twice those of spring numbers represents a good crop. This implies a maximum allowable harvest of 50% on the average. A realistic harvest rate objective would be somewhat less, depending on the timing of natural mortality in fall and winter and the compensatory or additive nature of hunting mortality in relation to subsequent natality and natural mortality. In spite of Bump et al.'s (1947:551) assertion to the contrary, we are not aware of evidence to suggest that low densities of breeders produce chicks at substantially higher rates. Chick production and chick survival are confounded in most studies. If there is indeed little natural mortality of grouse in winter in unhunted or lightly exploited populations, then low natural mortality in winter would not likely compensate for high hunting mortality in fall. Indeed, in a recent review, Bergerud (1983) concluded that evidence indicated that hunting was mostly additive mortality in several species of North American grouse.

Unfortunately, definitive statements on allowable harvest rates on ruffed grouse and the impacts of present harvest rates must be deferred until age- and time-specific survival rates and egress rates are better documented. We hope that some of these estimates will be obtained from radio-marked grouse in our current studies in central Wisconsin.

Although hunting pressure on ruffed grouse in January seems relatively light in Wisconsin, the potential impact of any significant late harvest on breeding populations is high. The magnitude and trend of recent harvest estimates in Wisconsin and other Lake States suggests need for continued study and surveillance, and a cautious approach to further liberalization of hunting seasons for ruffed grouse.

LITERATURE CITED

Ammann, G. A., and L. A. Ryel. 1963. Extensive methods for inventorying grouse in Michigan. J. Wildl. Manage. 27:617-633.

Amstrup, S. C. 1980. A radio-collar for game birds. J. Wildl. Manage. 44:214-217.

Bergerud, A. T. 1983. The additive effect of hunting mortality on the natural mortality rates of grouse. Symposium on game harvest management, Kingsville, Texas. (in press)

Brander, R. B. 1968. A radio-package harness for game birds. J. Wildl. Manage. 32:630-632.

Bump, G., R. W. Darrow, F. C. Edminister, and W. F. Crissey. 1947. The Ruffed Grouse: life history, propagation, management. New York State Conservation Department, Holling Press, Inc., Buffalo, New York. 915 pp.

Caughley, G. 1974. Interpretation of age ratios. J. Wildl. Manage. 38:557-562.

DeStefano, S. 1982. Harvest and distribution of ruffed grouse in northeastern Wisconsin. M.S. Thesis. University of Wisconsin, Madison. 107 pp.

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

Dorney, R. S., and C. Kabat. 1960. Relation of weather, parasitic disease, and hunting to Wisconsin Ruffed Grouse populations. Wisconsin Conservation Department, Tech. Bull. 20. 64 pp.

Errington, P. L. 1937. Winter carrying capacity of marginal ruffed grouse environment in north-central United States. Canad. Field-Naturalist 51 (3):31-34.

Fischer, C. A., and L. B. Keith. 1974. Population responses of central Alberta ruffed grouse to hunting. J. Wildl. Manage. 38:585-600.

Godfrey, G. A., and W. H. Marshall. 1969. Brood break-up and dispersal of ruffed grouse. J. Wildl. Manage. 33:609-620.

Gullion, G. W. 1965. Improvements in methods for trapping and marking ruffed grouse. J. Wildl. Manage. 29:109-116.

_____, and G. B. Evans. 1982. Are we overshooting late season grouse? (Interview by S. Smith). Wisconsin Sportsman 11 (6):18-23, 80.

Hale, J. B., R. F. Wendt, and G. C. Halazon. 1954. Sex and age criteria for Wisconsin ruffed grouse. Wisconsin Conservation Department, Tech. Wildl. Bull. 9. 24 pp.

King, R. T. 1937. Ruffed grouse management. J. Forestry 35(6):523-532.

Kubisiak, J. F. 1978. Brood characteristics and summer habitats of ruffed grouse in central Wisconsin. Wisconsin Department of Natural Resources Tech. Bull. 108. 11 pp.

_____, 1984. Impact of hunting on ruffed grouse populations in the Sandhill Wildlife Area. pp. . . . *in* Ruffed Grouse Management: State of the Art in the Early 1980's (W. L. Robinson, ed.) North Central Section. The Wildlife Society — pp.

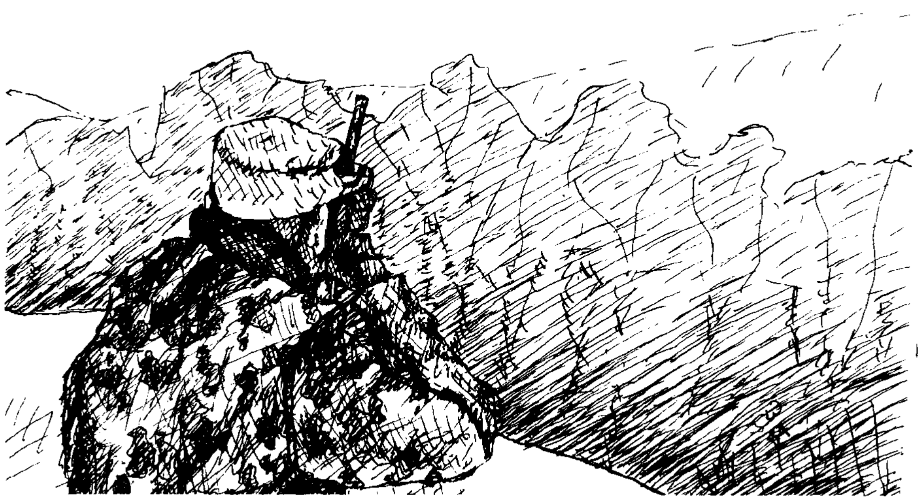
Porath, W. R. and P. A. Vohs, Jr. 1972. Population ecology of ruffed grouse in northeastern Iowa. J. Wildl. Manage. 36:793-802.

Rusch, D. H., and L. B. Keith. 1971. Seasonal and annual trends in numbers of Alberta ruffed grouse. J. Wildl. Manage. 35:803-822.

_____, M. M. Gillespie, and D. I. McKay. 1978. Decline of a ruffed grouse population in Manitoba. Canad. Field-Naturalist 92:123-127.

_____, L. B. Keith, P. D. Doerr, and C. A. Fischer. (in prep.). Demography of a ruffed grouse population in central Alberta. J. Wildl. Manage.

Trent, T. T., and O. J. Rongstad. 1974. Home range and survival of cottontail rabbits in southwestern Wisconsin. J. Wildl. Manage. 38:426-472.



The Impact of Hunting on Ruffed Grouse Populations in the Sandhill Wildlife Area

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Abstract: A study comparing harvests and population size of ruffed grouse (*Bonasa umbellus*) was conducted from 1968-82 on the Sandhill Wildlife Area in central Wisconsin. The south part of the 3706 ha (9150 acres) tract was opened to controlled hunting in 1971 while the northern portion remained closed to grouse hunting throughout the study. Harvest and hunter effort were measured by mandatory hunter checks. Grouse population trends were monitored by annual spring drumming counts. Fall grouse populations on the opening day of the hunting season were projected from spring counts of drumming cocks to determine the effect of known levels of hunter effort and kill on grouse populations. Hunter effort and fall harvests correlated ($P<0.01$) with drumming grouse populations of the preceding spring from 1971-79. During 1980-82, effort and harvests were magnified, in part, by a change in season structure in which Sandhill was the only area in Wisconsin open to grouse hunting two weeks prior to the statewide season. Most of the hunter effort and grouse kill occurred during the first 2-3 weeks of the hunting season irrespective of season structure or grouse populations. Estimated annual harvest rates expressed as a percent of the fall population were highly correlated ($P<0.01$) with cumulative hunter effort during the hunting season. Cumulative hunter-days required to achieve a 50% harvest rate averaged 43 hunter-days/km^2 (111/mi^2) for 7 high grouse years compared to 61/km^2 (158/mi^2) in low population years. Highest recovery rates of banded birds (49%) coincided with record harvests in 1980-81 and reduced breeding populations. In addition, grouse populations were lower ($P<0.01$) in the hunted area than in the unhunted area from 1971-82, further suggesting an impact by hunting. Although late-season hunting mortality was eliminated, Sandhill studies suggest that heavy early season hunting may be a major factor depressing grouse populations. However, Sandhill remains an exception to the

general pattern observed in most of Wisconsin where hunter effort and harvest rates are probably considerably lower. Cumulative hunting effort remains a concern only on similarly accessible areas in southern Wisconsin with extended seasons open to public hunting.

The ruffed grouse is the most important upland game bird in Wisconsin and is the most abundant of four native grouse species. Wisconsin also provides some of the finest ruffed grouse hunting in North America, rivaled only by Michigan and Minnesota. During the recent high grouse period in 1977-81, Wisconsin harvests averaged about 19 birds/km^2 (49/mi^2) of grouse range compared to 9/km^2 (24/mi^2) in Michigan and 8/km^2 (20/mi^2) in Minnesota. Management in Wisconsin has focused on refinement of annual hunting regulations and habitat manipulation, while population and harvest surveys have been continued to determine relative abundance and trends.

Hunter demand for ruffed grouse is expected to increase, while the supply may decline during the next 20 years in Wisconsin (Wisconsin Department of Natural Resources, 1979). There also has been a trend toward liberalized grouse regulations in Wisconsin and other states (DeStefano and Rusch 1982). This trend evolved from the attitude that sport hunting has no detrimental effect on grouse populations. This concept reflects the principle of compensatory mortality which was conceived in the 1930's. It implies that if we fail to harvest the annual surplus, game animals and birds will be lost to natural causes. In addition, more hunters are expected to concentrate on ruffed grouse as populations of other game birds, particularly ducks and pheasants, decline in proportion to demand.

In view of these developments, there is a need to determine acceptable limits of harvest while maintaining optimum numbers of breeding grouse. In Michigan, Palmer and Bennett (1963) suggested that breeding populations will not be adversely affected if grouse harvests do not exceed 50% of the fall population. Current regional estimates of grouse harvest rates in Wisconsin do not exceed 25% of the fall population, suggesting minimal hunting impact (Wisconsin Department of Natural Resources, 1979). Wildlife managers also agree that grouse harvests could be increased in northern Wisconsin and in some areas of central Wisconsin where hunter numbers and access are generally limited by terrain. However, we need to monitor harvests more closely in the remaining farmland and forested ranges, particularly where heavy hunting pressure occurs in isolated habitats or on small tracts of public land. Although the total impact of hunting may be obscured or alleviated by grouse movememts from adjacent lightly hunted or unhunted tracts, public wildlife areas or farmland woodlots in southern Wisconsin may be vulnerable to over-harvest (DeStefano and Rusch 1982). In addition, more research is needed to better assess the impact of late-season mortality occurring after fall dispersal. This information is essential for refining harvest strategies which will utilize this resource at optimum levels without adversely affecting populations.

In Wisconsin, the effect of current liberalized regulations on grouse populations was investigated since 1976 on four separate areas. Three areas studied by researchers from the University of Wisconsin are located within an extended season zone (Rodgers 1980, DeStefano and Rusch 1982, Rusch et al. 1984). Our studies were conducted on Sandhill, a heavily hunted wildlife area in central Wisconsin. The purpose of our study was to determine the effect of known levels of hunter effort and kill on grouse populations. Comparisons were made between grouse populations and hunter effort and kill in the fall, and between grouse populations on hunted and unhunted areas. Hunter effort, kill, and dog use was also related to changes in season structure and grouse populations. Recovery rates and movements of banded birds were also determined to further assess the impact of hunting.

Acknowledgements
We gratefully acknowledge the contributions of many individuals during the course of this study. Department of Natural Resources personnel (some retired) contributed to our investigation in many ways. Special thanks are due W. Creed and K. McCaffery of the Forest Wildlife Research Group at Rhinelander for advice and criticism throughout the study and preparation of this report. C. Kabat, K. Klepinger, J. Hale, J. March, R. Dumke, B. Hubbard, C. Smith, and J. Haug gave administrative assistance or support in the field. T. Moser, P. Ruesch, B. Knudsen, S. Kendall, J. Bronsdon, M. Zeckmeister, and J. Morton assisted with field work or data analysis. R. Hine and D. Rusch (Wisconsin Cooperative Wildlife Research Unit) provided helpful suggestions for preparation of the manuscript. D. Thompson, G. Lange, and M. Staggs provided statistical interpretations. This research was supported in part by the Federal Aid in Wildlife Restoration Act under Pittman-Robertson Project W-141-R.

STUDY AREA AND METHODS

Sandhill is a 3706 ha (9150 acres) tract of public land surrounded by a deer-proof fence, which provides an opportunity to manipulate hunting seasons and control hunter numbers. Uplands comprise 52% of the area and unforested wetlands, 48%. The upland forest is dominated by aspen (*Populus tremuloides* and *P. grandidentata*) and oak (*Quercus spp.*). Scattered stands of pine (*Pinus banksiana, P. strobus* and *P. resinosa*) occupy less than 1% of the uplands. Intensive habitat management has produced an interspersion of young and old forests. Stands of trees under 25 years old occupy about 43% of the upland forest, with the remainder in pole-sized stands older than 25 years (Kubisiak et al. 1980).

Grouse populations were monitored from 1968-82 and harvests from 1971-82. Controlled grouse hunting was permitted only on the 818 ha (2020 acres) of upland in the southern part of Sandhill, while the 1037 ha (2560 acres) northern uplands, hereafter referred to as the "unhunted area", remained closed thoughout the study. Maximum hunting pressure was limited to 75 hunters/day

(9/km^2; 23/mi^2), a level of pressure that was rarely attained. Hunters were required to report daily effort, success, and dog use. From 1971-79, hunting seasons began about October 1 and closed in early November, averaging 37 days. Grouse hunting seasons on surrounding ranges also opened about October 1, but continued through December 31 from 1971-79 and until January 31 thereafter. Beginning in 1980, a major change in season structure was initiated on Sandhill. Hunting seasons began in mid-September and averaged 56 days, while surrounding ranges remained closed until October 1. Thus, Sandhill attracted considerable publicity and hunter interest since it was the only area in Wisconsin open to grouse hunting prior to October 1.

Grouse population trends were measured on Sandhill by censusing drumming grouse (Gullion 1966). The census included 460 ha (1132 acres) on the southern part and 510 ha (1268 acres) on the unhunted area. The census was expanded in 1979 to include complete coverage of the 818 ha (2020 acres) of grouse range on the southern part and to 690 ha (1700 acres) which represents 66% of the unhunted area.

Fall grouse populations on the opening day of the hunting season were estimated by applying an expansion factor to spring counts of drumming cocks. We assumed 15% non-territorial cocks, 15% adult mortality over summer, an equal sex ratio, and 30% clutch loss with 10 chicks hatching per successful nest (Gullion 1981 and pers. comm.).

Average brood sizes were determined for nine 7-day intervals from July 1 - September 1 from 324 broods recorded on systematic searches (Kubisiak 1978) and reported incidentally by wildlife work crews from 1952-83 on the Sandhill-Wood County Wildlife Areas. These weekly average brood sizes were regressed against time to estimate the net number alive on the opening day of the hunting season. A brood was defined as 1 or more chicks $\geq$4 weeks old with or without a hen. Estimated brood size on the opening day of the hunting season was 5.5 on September 15 and 5.2 on October 1. The expansion factor applied to the number of drumming cocks was 6.4 for September 15 and 6.2 for October 1. An example of the procedure used to obtain the expansion factor follows: 1.0 drummer $\div$ 0.85 = 1.2 total males alive in spring + 1.2 hens x 70% nesting success rate = 0.8 hens producing chicks x 5.5 chicks/brood on September 15 = 4.4 chicks/hen + the 2 adults surviving to fall = 6.4.

In order to estimate grouse harvest rates, dispersal, and temporal distribution of the harvest, grouse were live-trapped and banded from 1978-82 using lily-pad traps both on Sandhill and on the nearby Wood County Wildlife Area. The Wood County tract comprises 7490 ha (18,483 acres) of similar habitat lying adjacent to Sandhill and is open to public hunting. All birds were marked with two numbered leg bands, one of which was labeled with the address of the Wisconsin DNR and a $5 reward notice.

Hunter effort and kill statistics were also obtained from 1971-78 on a 405 ha (1000 acres) portion of the 13,728 ha (35,555 acres) Wood County Forest located 3.2 km (2 mi) east of Sandhill. Hunters voluntarily reported results of their hunt on an area where hunting seasons opened about October 1 and concluded December 31.

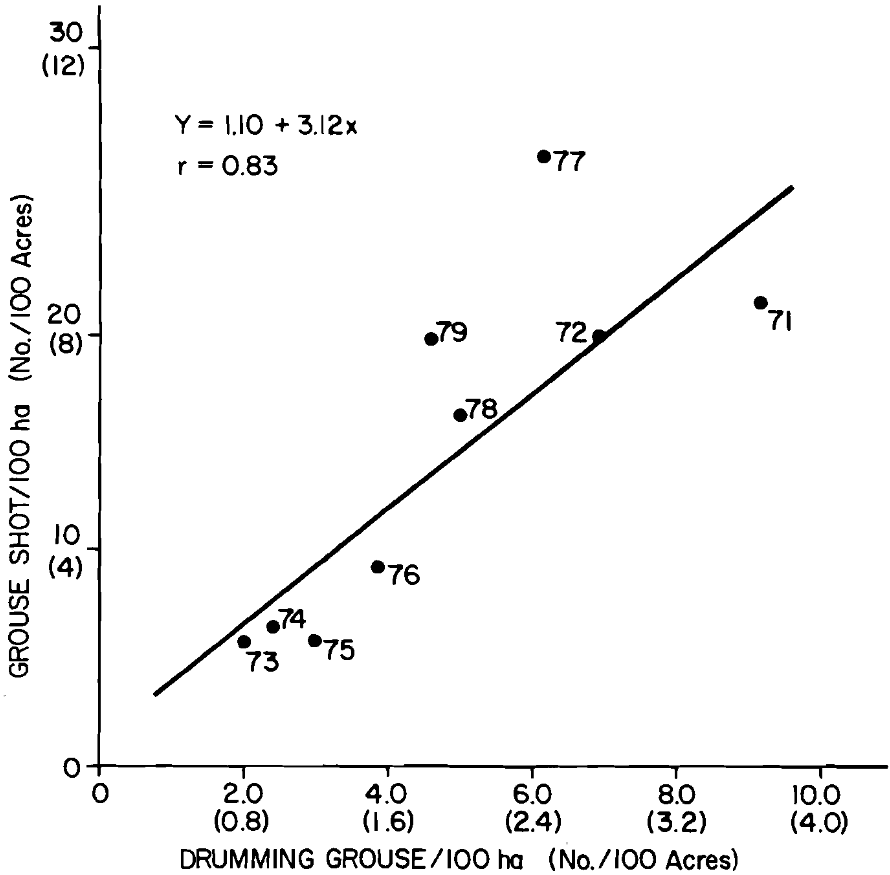


Fig. 1. Comparison of fall harvests and drumming grouse populations on the Sandhill Wildlife Area, 1971-79.

RESULTS AND DISCUSSION

Grouse Populations and Harvest

At Sandhill there was a good correlation ($r = 0.83$, $n = 9$, $P<0.01$) between fall harvests and drumming grouse populations of the preceding spring from 1971-79 (Fig. 1). Data after 1979 were effected by a change in season structure, the impli-

Table 1. Ruffed grouse population trends, hunter-days, and harvests on the Sandhill Wildlife Area, 1971-82.

Year	Drumming cocks/100 ha (No./100 acres)				Total hunter-days/km^2 (hunter-days/mi^2)		Reported harvest/100 ha (harvest/100 acres)	
	Unhunted Area 1037 ha (2560 acres)		Hunted Area 818 ha (2020 acres)					
1971	11.7	(4.7)	9.2	(3.7)	65	(167)	21.4	(8.7)
1972	10.7	(4.3)	7.0	(2.8)	77	(199)	19.9	(8.1)
1973	3.9	(1.6)	2.0	(0.8)	20	(53)	4.2	(1.7)
1974	3.7	(1.5)	2.4	(1.0)	28	(71)	4.6	(1.8)
1975	4.1	(1.7)	3.0	(1.2)	23	(60)	4.2	(1.7)
1976	7.4	(3.0)	3.9	(1.6)	15	(39)	7.6	(3.1)
1977	10.6	(4.3)	6.3	(2.6)	60	(154)	26.9	(10.9)
1978	11.7	(4.7)	5.0	(2.0)	62	(160)	16.6	(6.7)
1979	13.6	(5.5)	4.6	(1.8)	56	(145)	19.9	(8.1)
1980	13.6	(5.5)	5.6	(2.3)	130	(338)	47.9	(19.4)
1981	14.4	(5.8)	5.1	(2.1)	133	(345)	51.0	(20.6)
1982	6.1	(2.5)	2.0	(0.8)	62	(160)	6.2	(2.6)
Mean	9.3 (SE = 1.2)		4.7 (SE = 0.6)					

cations of which are discussed below. Thompson and Moulton (1981) also found drumming grouse surveys have consistently been a good indicator of changes in grouse abundance and subsequent fall harvests throughout Wisconsin, particularly in years with major changes in grouse populations.

Drumming surveys have also provided some evidence of the response of Sandhill grouse populations to hunting (Table 1). While recognizing that factors other than hunting contributed to "cyclic" declines in 1973 and 1982, Sandhill grouse populations have been consistently lower ($P<0.01$) in the hunted than in the unhunted area since 1971. However, drummer densities in either area may have been affected by movement of breeding birds after the hunting season, differential mortality, or habitat quality, among other factors. Although we have not attempted to assess the relative significance of these factors as they affect grouse populations, we have observed some relationships that suggest the overriding effect of hunting. Prior to hunting the southern part in 1971, mean drummer densities were not different ($P>0.05$) between the two areas. During this period (1968-71) drummer densities averaged 9.3/100 ha (SE = 1.4) (3.8/100 acres) on the hunted area and 7.6/100 ha (SE = 0.9) (3.1/100 acres) on the unhunted area. Since then, upland habitats have been maintained or improved proportionately on both areas. Thereafter, populations either declined or remained at considerably lower densities in the hunted area. This phenomenon appears to be related to moderate to high harvests prior to 1980, particularly in 1977-79. After hunting seasons began earlier in 1980, harvests increased dramatically while subsequent breeding grouse densities were substantially reduced, averaging 3.5 drumming grouse/100 ha (1.4/100 acres) in the hunted area compared to 10.4/100 ha (4.2/100 acres) in the unhunted area.

Grouse Populations, Hunter Effort, and Kill

At Sandhill, hunter effort as measured in hunter-days, was also positively correlated ($r = 0.82$, $n = 9$, $P<0.01$) with drumming grouse populations of the previous spring from 1971-79. Thereafter, hunter effort increased considerably as a result of the special season, averaging 887 hunter-days/season compared to 413 prior to 1980 (Table 1). During the same period, grouse harvests were also much higher, averaging 35.0 grouse shot/100 ha (14.2/100 acres) compared to 13.9/100 ha (5.6/100 acres) prior to 1980. While effort and kill increased proportionately since 1980, drumming grouse populations remained at lower densities or declined.

Most of the hunter effort at Sandhill occurred during the first 2-3 weeks of the hunting season irrespective of changes in season structure or grouse populations (Figs. 2 and 3). Seventy-five percent of the total hunter effort was achieved in the first 22-27 days, whether the season was short or long or whether grouse harvest was high or low, although, short seasons tended to concentrate effort into a shorter period. Hunters also bagged 75% of the season kill in the first 15 to 18 days before and after season structure changes in 1980, and in years with low and

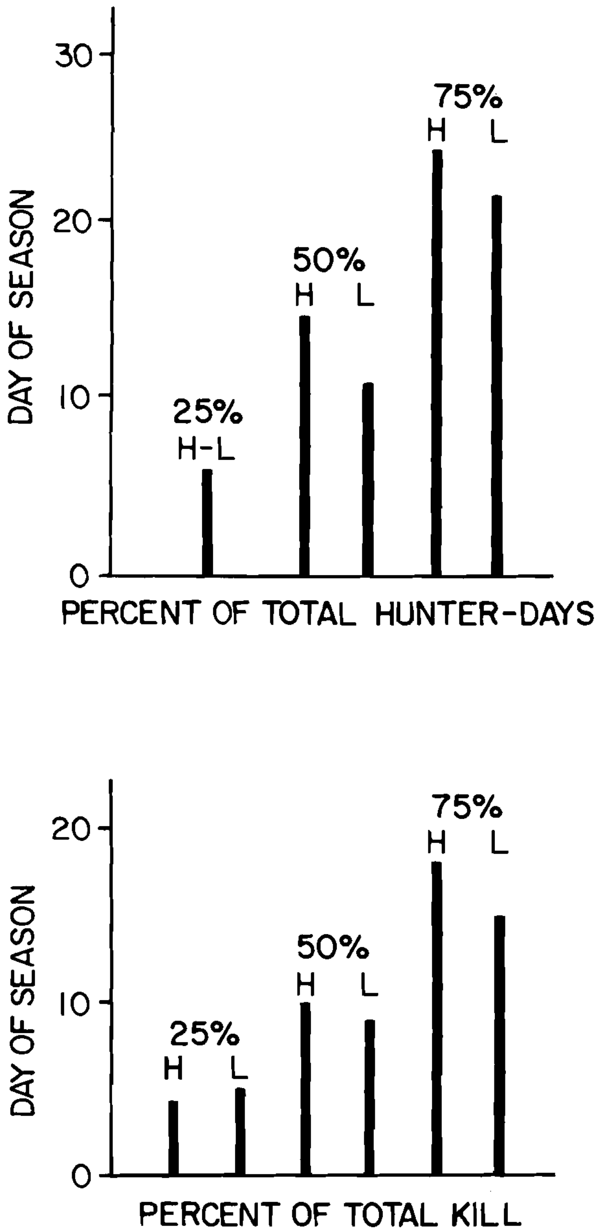
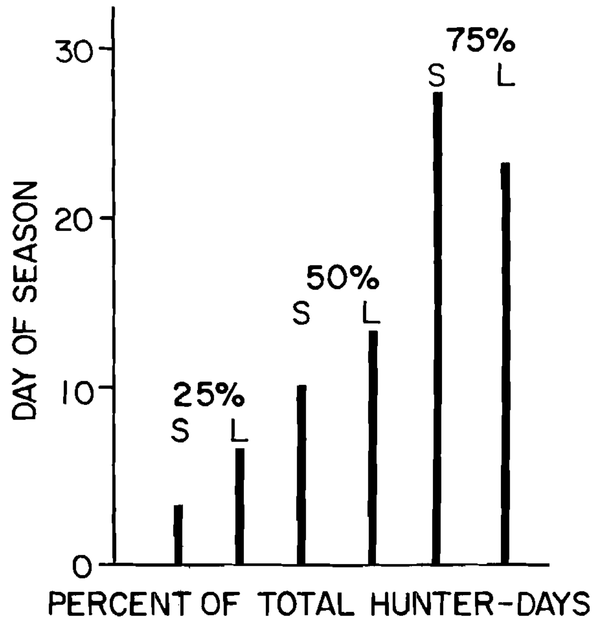


Fig. 2. Comparison of the number of days required to attain 25, 50, and 75% of the total hunter-days and grouse kill between years with high (H) grouse harvests (1971-72, 1977-81) and low (L) grouse harvests (1973-76, 1982) on the Sandhill Wildlife Area.



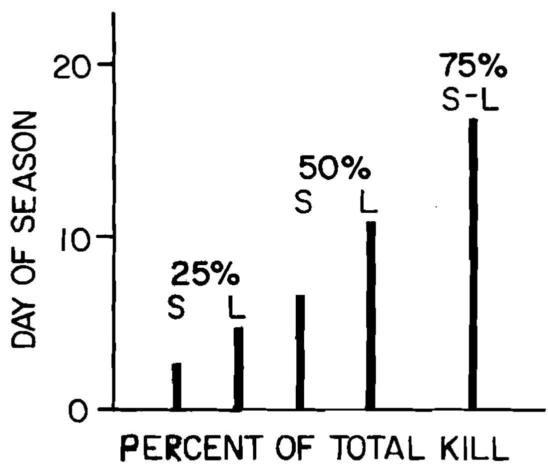


Fig. 3. Comparison of the number of days required to attain 25, 50, and 75% of the total hunter-days and grouse kill between years with short (S) hunting seasons (1971-79) and long (L) hunting seasons (1980-82) on the Sandhill Wildlife Area.

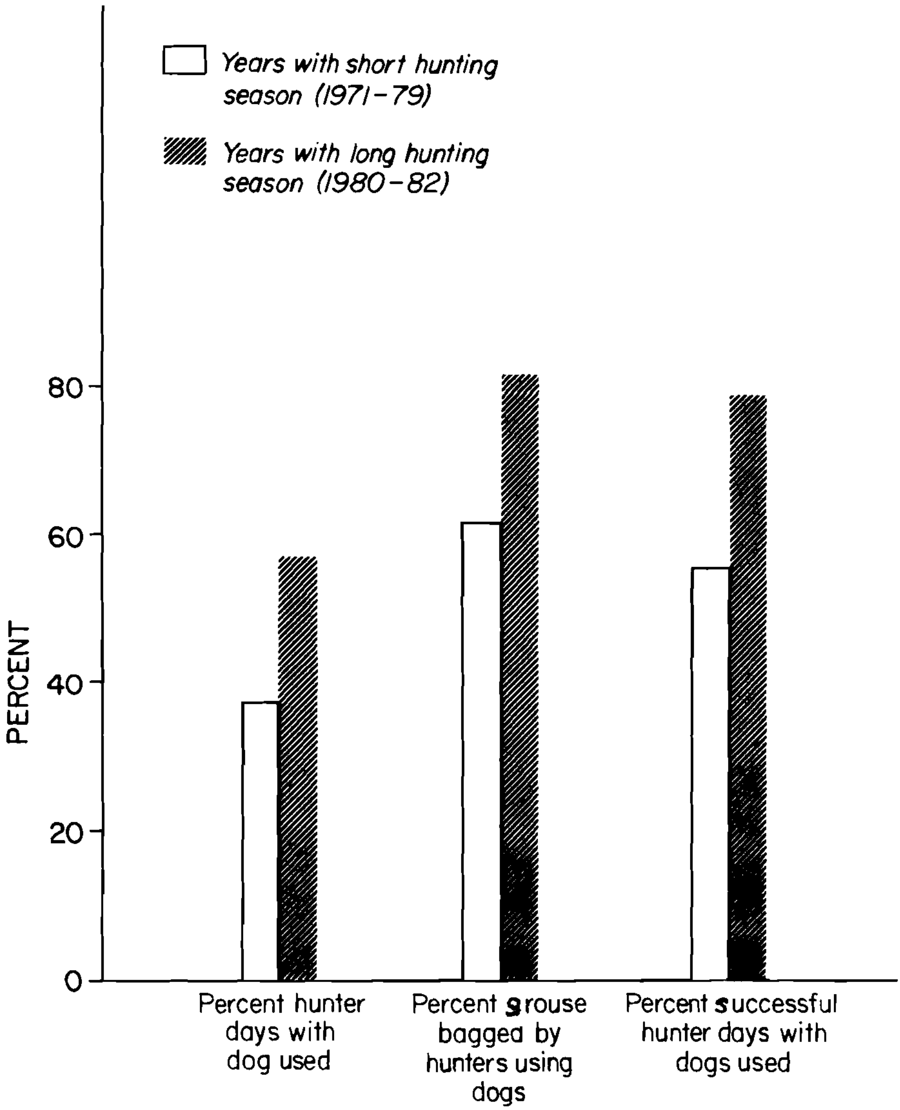


Fig. 4. Hunter effort and success relative to dog use and season structure on the Sandhill Wildlife Area.

high grouse kills. In comparison, grouse hunters required 34 days to achieve 75% of the total hunting effort and season bag on the Wood County Forest. Only 7% of the total hunter effort and 11% of the total grouse bagged were reported after November 30.

The temporal distribution of band recoveries on Sandhill also indicates most grouse were bagged early in the season. Of 266 banded birds shot on Sandhill from 1978-82, 75% were taken within 14 days after the season opened. In contrast, band recoveries were more evenly distributed through the hunting season from 1978-82 on the Wood County Wildlife Area. Of 121 banded birds shot on the Wood County Wildlife Area and surrounding lands, 75% were taken by October 30 (within 30 days after the season opened). Only 5% were bagged after November 30 (60+ days after the season opened).

High early season harvests also occurred on the Rifle River Area in Michigan where 75% of the grouse kill was achieved during the first 15 days with an October 1 opening date, according to Palmer and Bennett (1963). Those authors found that high early season kills were greater in high grouse years in Michigan, while in low years, the kill was spread more evenly throughout the season. Hunter effort and grouse kill was more evenly distributed throughout the season in Minnesota, according to a hunter postcard survey conducted from 1969-79 (Gullion pers. comm.). Minnesota hunters required 35-40 days to achieve 70% of the hunter effort and season bag during hunting seasons which opened in mid-September.

Dog Use

Higher grouse harvests at Sandhill since 1980 may be due, at least in part, to use of dogs by hunters. Most hunters used dogs, and a greater proportion of the grouse were bagged by hunters using dogs since 1980 (Fig. 4). Fifty-eight percent of the hunters used dogs and bagged 82% of the grouse since 1980. In comparison, 38% of the hunters used dogs and bagged 62% of the grouse from 1971-79. Of the successful hunters (those bagging at least 1 grouse), 79% used dogs since 1980 compared to 56% from 1971-79.

Harvest Levels and Movement

Higher grouse harvests since 1980 may also be attributed to movement of juveniles. Since 1980, the Sandhill hunts have coincided with brood dispersal which is well underway by mid-September (Godfrey and Marshall 1969; DeStefano 1982). With surrounding ranges closed to hunting until about October 1, dispersing juveniles provided considerable potential for adding to the kill on Sandhill, even though the proportion of juveniles in the bag was not different ($\chi^2 = 0.714$, df = 1, $P > 0.25$) before and after season structure changes in 1980. During the first 3 weeks of the hunting season juveniles comprised 79% of the bag in years with a mid-September opening compared to 82% in years with an October 1 opening date.

Of, 1141 birds live-trapped from 1978-82 on the Sandhill-Wood County Areas, 476 were banded on the Sandhill hunted area, 428 on the Sandhill unhunted area, and 237 on the nearby Wood County Wildlife Area (Table 2). Recovery rates of banded birds averaged 42% (SE = 5.9) on Sandhill and 29% (SE = 2.9) on the Wood County Wildlife Area. In 1980-81, when high grouse harvests occurred, recovery rates averaged 49% (n = 289) on Sandhill and 32% (n = 158) on Wood County.

Recovery rates in 1980-81 at Sandhill were higher than any reported in the literature and they coincided with reduced or declining breeding populations, further emphasizing the likely impact of hunting on grouse populations.

The highest recovery rates previously reported in Wisconsin were observed from 1978-81 on the Navarino Wildlife Area, a 6460 ha (15,954 acres) tract of public land in northeastern Wisconsin (DeStefano 1982). There, hunters recovered an average of 23% (18-31) of the banded birds on an area where seasons opened about October 1 and closed December 31. This area provided good road access and is located within 50 miles of several large cities. At this level of harvest, drumming grouse populations remained stable, suggesting that hunting season removals were within acceptable limits.

Recovery rates at Navarino translated to an estimated harvest rate of 38% (28-48) after adjusting for mortality of banded birds before the hunting season, unrecovered cripples, and lost or non-reported bands (DeStefano 1982). Mortality of banded birds before the hunting season on Navarino was estimated from 10-day interval survival rates using mark-recapture data (Seber 1973: 196-232). Recovery rates at Sandhill were also affected by the same factors in addition to movement of birds into the Sandhill unhunted area or other lands which were either closed to public hunting or remained inaccessible.

Recoveries of banded birds off the areas where they were originally trapped has provided additional evidence of grouse movement contributing to higher harvests on Sandhill since 1980 (Table 2). The proportion of birds trapped and banded on Wood County and recovered on the Sandhill hunted area was higher (χ^2 = 4.01, df = 1, $P<0.05$) than the proportion of birds banded on Sandhill and subsequently recovered on Wood County. Since 1980, 7% of 170 birds banded on Wood County were subsequently recovered on Sandhill, while 3% of 320 birds banded on Sandhill were recovered on Wood County. Although the probability of birds moving into either area was not appreciably different, higher recoveries of banded birds on Sandhill may reflect both higher reporting rates by hunters and greater probability of banded birds being shot.

In addition, the probability of recapturing banded birds in live-traps was considerably greater on Sandhill where trapping effort was nearly twice as great as in

Table 2. Recovery of banded ruffed grouse on the Sandhill-Wood County Wildlife Areas, 1978-82.

		Recovery Rate During Hunting Season on Area Where Trapped		Recovery Off Area Where Trapped			
Area	No. Birds Banded	No. Shot	Percent ± SE	No. Shot	No. Recaptured or Found Dead	Total	Percent ± SE
Sandhill Hunted	476	200	42 ± 5.9	21	0	21	4 ± 1.3
Wood County	237	68	29 ± 2.9	15	5	20	8 ± 4.0
Sandhill Unhunted	428	—	—	46	2	48	11 ± 2.8

Wood County. However, only 4 of 20 recoveries from Wood County on the Sandhill hunted area were trapping season recaptures. If it is assumed that hunters reported at lower rates from Wood County, recovery rates were underestimated. However, we feel a high proportion of the hunters were willing to report banded birds shot, given the reward incentive and the overall recovery rates observed. DeStefano (1982) also found no difference ($\chi^2 = 0.245$, df $= 1$, $P > 0.50$) in the recovery rates of $5 and $10 reward bands at Navarino. In addition, of hunters surveyed at Navarino, 98% would return a band for a $2 reward.

Hunter Effort and Harvest Levels

As expected, estimated annual harvest rates expressed as a percent of the fall population shot on Sandhill since 1971 was also correlated ($r = 0.92$, $n = 12$, $P > 0.01$) with total hunter effort as measured in hunter-days/km². During years with moderate to high kills prior to 1980, estimated harvest rates averaged 56%

Table 3. Comparison of harvest levels with estimated grouse populations on the opening day of the hunting season on the Sandhill hunted area, 1971-82.

Year	Estimated Population/100 ha[1]	(Per 100 acres)	Percent of Population Shot
1971	56.6	(22.9)	38
1972	43.0	(17.4)	47
1973	12.3	(5.0)	34
1974	15.3	(6.2)	29
1975	19.0	(7.7)	23
1976	22.7	(9.2)	31
1977	39.8	(16.1)	68
1978	30.6	(12.4)	54
1979	27.7	(11.2)	72
1980	36.3	(14.7)	132
1981	33.1	(13.4)	154
1982	12.6	(5.1)	51

[1]Expansion factor of 6.2 applied to drumming cocks in 1971-79 and 6.4 in 1980-82 using brood size regression ($y = 6.65 - 0.10x$, $r = -0.52$).

(38-72), compared to 29% (23-34) in low kill years (Table 3). In 1980-81, estimated harvest rates exceeded 100% of the projected fall population. This suggests ingress into the hunted area, underestimation of the living population, or both. Although hunter effort and kill in 1982 dropped considerably below 1980-

81 levels, they far surpassed those of the previous low years. This level of hunter effort and kill illustrates the carry-over effect of two successive hunts in 1980-81 during which Sandhill acquired a reputation as an area with prime grouse habitat and excellent hunting opportunities.

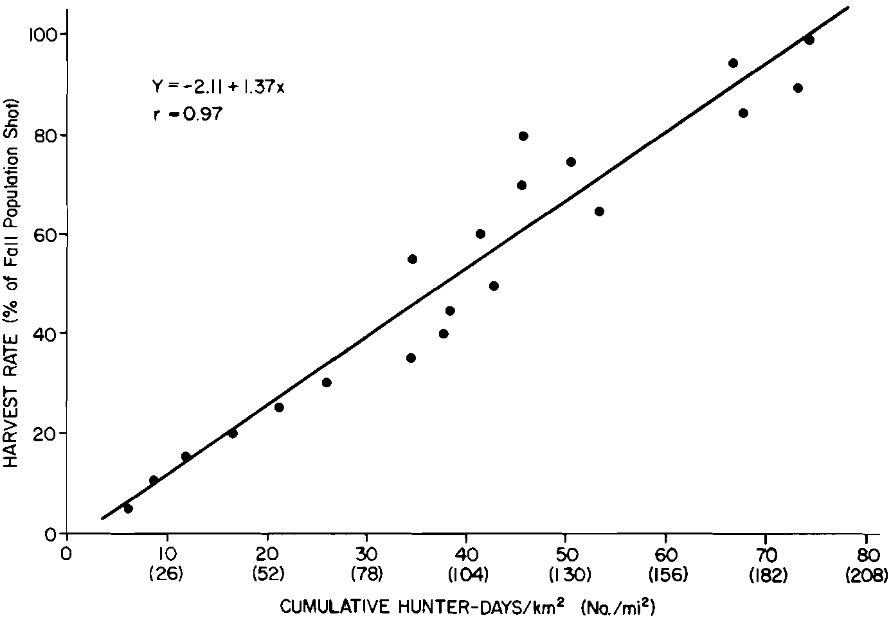


Fig. 5. Comparison of cumulative hunter effort means and estimated fall harvest rates on the Sandhill Wildlife Area, 1971-82.

The proportion of the estimated fall population shot, plotted in increments from 5-100%, was highly correlated (r = 0.97, n = 20, $P<0.01$) with mean cumulative hunter-days/km^2 during all seasons (Fig. 5). These results suggest that cumulative hunter-days should not exceed 38/km^2 (98/mi^2) to achieve a theoretical maximum allowable harvest of 50% of the fall population. Although means obscure between-year differences in hunter effort during the hunting season, variation caused by poor hunting conditions or other factors which affect hunter effort is reduced. Means of hunter effort were also regressed against estimated harvest rates plotted in 5% increments from 5-50% since no data above the 50% level were available for low years. To achieve a 50% harvest rate, cumulative hunter-days should not exceed 43/km^2 (111/mi^2) in high years and 61/km^2 (158/mi^2) in low years. NOTE: The regression formulas were: $y = -3.29 + 1.25x$ and $y = -8.10 + 0.69x$ for high and low years, respectively.

In comparison, statewide grouse hunter effort in Wisconsin averaged about 25 hunter-days/km^2 (65/mi^2) in 1980, and is expected to exceed 27/km^2 (70/mi^2) by 1990 (Wisconsin Department of Natural Resources 1979). Although these statewide estimates of hunter effort are considerably below those at Sandhill, hunter effort is unquestionably higher on certain tracts with good grouse potential which are accessible to public hunting in southern Wisconsin.

The potential application and impact of a prescribed level of hunter effort on any area is related to several factors. These include the average time spent hunting and the number of grouse bagged/hunter-hr. relative to dog use,. the proportion of hunters making repeat trips to an area, hunter knowledge of areas with good grouse potential, party size, and skill of the hunter, among others. At Sandhill, hunters averaged 3.1 hr/hunter-day, but hunters using dogs averaged 4.0 hr/hunter-day compared to 1.9 hr by hunters without dogs. Hunters using dogs were also more efficient, averaging 14 grouse bagged/100 hr afield compared to 6/100 hr by hunters without dogs. In addition, 57% of the hunter-days involved only one trip to Sandhill during the hunting season, and only 15% exceeded 3 trips/season. One or more grouse were bagged on 21% of 5975 total hunter-days, and 60% of the total effort occurred on weekends. For this calculation, a party of 2 hunters bagging 1 grouse in a day would count as 1 successful hunter-day; and the same party of 2 hunters bagging 3 grouse would count as 2 successful hunter-days if both hunters bagged birds. Of the total grouse bagged, 57% were taken on weekends. Data on the composition and size of hunting parties, hunter proficiency and knowledge of potential grouse hunting areas as it affected hunter effort were not gathered.

Our studies illustrate the impact of given levels of hunter effort on grouse populations on an area where hunting seasons ended in early November, and where late-season hunting mortality was eliminated. Gullion *in* Smith (1982 observed similar results on the Mille Lacs Wildlife Area, a heavily hunted accessible tract in northern Minnesota. Hunting seasons opened in mid-September and closed December 31 resulting in high grouse harvests and declining breeding populations. Depressed breeding populations on that area were related to high cumulative hunting effort, but late-season hunting mortality and accessibility of good habitat to hunters, among other factors, were also considered important.

Although our studies at Sandhill suggest that hunting may be a potential major factor depressing grouse populations, it should be emphasized that this is what occurred on an area with excellent road access, exceptionally high hunter effort, high harvest rates, and a high proportion of hunters using dogs, particularly since 1980. Thus, Sandhill remains an exception to the general pattern observed in most of Wisconsin. Generally, hunter effort and grouse harvest rates are somewhat lower, or considerably below the level observed at Sandhill. In the Oak

Coulee country of southwestern Wisconsin, Rodgers (1980) found that recovery rates of banded grouse were less than 5%. These results were observed on privately owned woodlots interspersed with crop fields where hunting seasons began about October 1 and closed January 31. However, vulnerability of grouse populations to hunting remains a concern wherever the potential for a locally heavy harvest exists on similarly accessible areas open to public hunting (Smith 1982).

Although the potential exists for over-harvest of the next season's breeding grouse during extended (December-January) seasons, there are several compensating factors which reduce the vulnerability of grouse to hunting. Most grouse have been removed by mid-November so hunters have to work harder to find birds. In addition, hunting is usually hampered at temperatures below −18°C (0°F), or by precipitation, or poor snow conditions. For hunters who can go afield only on weekends, hunting opportunities are even further diminished. Interest in other forms of recreation also reduces the number of people who hunt ruffed grouse seriously after the November deer season.

Finally, extended hunting seasons with closures on or after December 31 have been in effect for several years throughout most of the grouse range and there does not appear to be any detectable widespread impact on grouse populations in these areas. In Wisconsin, Minnesota, and Michigan, it does not appear that regional grouse populations were suppressed where hunting seasons have closed by December 31 or January 31 during the past decade. Although there does not now appear to be any adverse regional impact by hunting, we need to continue monitoring grouse populations relative to changes in season structure and hunter effort.

LITERATURE CITED

DeStefano, S. 1982. Harvest and distribution of ruffed grouse in northeastern Wisconsin. Univ. Wis., Madison, M.S. Thesis. 107 pp.

_____ and D. H. Rusch 1982. Some historical aspects of ruffed grouse harvests and hunting regulations in Wisconsin. Trans. Wis. Acad. Sci., Arts and Lett. 70:27-35.

Godfrey, G. A. and W. H. Marshall 1969. Brood break-up and dispersal of ruffed grouse. J. Wildl. Manage. 33:609-20.

Gullion, G. J. 1966. The use of drumming behavior in ruffed grouse population studies. W. Wildl. Manage. 30(4):714-29.

_____ 1981. Non-drumming males in a ruffed grouse population. Wilson Bull. 93(3):372-82.

Kubisiak, J. F., J. C. Moulton and K. R. McCaffery 1980. Ruffed grouse density and habitat relationships in Wisconsin. Wis. Dep. Nat. Resour. Tech. Bull. No. 118. 15 pp.

_____ 1978. Brood characteristics and summer habitats of ruffed grouse in central Wisconsin. Wis. Dep. Nat. Resour. Tech. Bull. No. 108. 11 pp.

Palmer, W. L. and C. L. Bennett, Jr. 1963. Relation of season length to hunting harvest of ruffed grouse. J. Wildl. Manage. 27(4):634-39.

Rodgers, R. D. 1980. Ecological relationships of ruffed grouse in southwestern Wisconsin. Trans. Wis. Acad. Sci. Arts and Lett. 68:97-105.

Rusch, D. H., S. DeStefano, and R. J. Small 1984. Seasonal harvest and mortality of ruffed grouse. pp. *in* Ruffed Grouse Management's State of the Art in the Early 1980's. (W. L. Robinson, ed.) North Central Section, The Wildlife Society, pp.

Seber, G. A. F. 1973. The estimation of animal abundance and related parameters. Hafner Press, N. Y. 506 pp.

Smith, S. 1982. Are we over-shooting late season grouse? Wis. Sportsman 11(6):18-23, 80.

Thompson, D. R. and J. C. Moulton 1981. An evaluation of ruffed grouse surveys. Wis. Dep. Nat. Resour. Tech. Bull. No. 213. 11 pp.

Wisconsin Department of Natural Resources 1979. Fish and Wildlife comprehensive plan. Madison, Wis. 62 pp.

Ruffed Grouse Management — Where do We Stand In The Eighties?

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Abstract: The long trend of shrinking range and declining numbers of ruffed grouse (*Bonasa umbellus*) in the Midwest appears to have been reversed. Missouri, by transplanting 2288 wild-trapped grouse, has re-established a population warranting the first hunting season in 78 years. Indiana has also successfully restocked long vacant coverts, while the success of restocking in Illinois and western Tennessee is still questionable. Ruffed grouse today are nearly as widely distributed as they were a century ago. Work in West Virginia has shown that herbaceous openings with brush cover in mature forest settings provide the necessary abundance of insects for chicks. Population indices and hunting successes in Iowa are similar to those in similar habitats in adjacent states. Studies of habitat preferences continue to refine our knowledge of grouse-habitat relationships, giving wildlife managers increasing precision in developing grouse management programs. Structure of the early seral forest is more important than species in providing secure cover for ruffed grouse. In northern forests aspen is most dependable for this structure, but farther south other species regenerating after clearcutting provide similar, adequate cover. A breeding pair of ruffed grouse per 4 to 5 ha seems to be a reasonable goal for management. In Lakes States forests the increasing commercial interest in aspen is accelerating the pace of regeneration of this resource, markedly improving the outlook for ruffed grouse. In Michigan some 258,000 ha (637,500 acres) of public lands has been favorably affected by logging in recent years, but size of cutting blocks has diminished the value of this treatment to a marked degree. North Dakota has embarked upon an aspen management program designed to improve the quality of ruffed grouse habitat in the Turtle Mountains. Two studies dealing with the harvesting of grouse on public hunting areas in Wisconsin indicate that breeding populations are suppressed by harvests taking upwards of 50% of the population, at a pressure averaging 50 hunter-days/km^2 (130 hunter-days/mi^2). Random fall dis-

persal of young grouse does not replace all the birds removed by harvest, resulting in an "accumulative depletion" of breeding stock. Under this condition breeding populations may decline in a few years to 50% or less of probable "carrying capacity" in excellent habitats. Further exploration of the impact of heavy pressure on public hunting areas and under prolonged seasons appears to be an important need for future research.

At a time when a shrinking wildland base is seriously endangering the future of wildlife associated with farmlands and our North American waterfowl population, one bright spot is the future of ruffed grouse in the central part of the continent. Here properly planned intensified timber harvesting practices are providing a basis for a reversal in the long-term decline, and encourage an outlook for improved ruffed grouse populations in the years to come. Aldo Leopold (1931:160) prophesied this more than 50 years ago when he wrote, "Sportsmen should realize that a wood-burning gas plant for farms, or even an efficient wood-burning furnace, would do more to keep woodlots, and hence grouse, on the map of rural America than many new laws or sermons on conservation."

Perhaps of most significance is the understanding we now have concerning the habitat requirements of ruffed grouse. There is a considerable volume of evidence, presented at this symposium and elsewhere that describes the rather narrow habitat tolerances of these birds.

Based on an intensive study in Minnesota which has now spanned 28 years, it is possible to describe fairly precisely the quality of habitat that ruffed grouse prefer. This is based on the histories of more than a 1000 activity centers, many of which have been in cutover areas, that we have been able to monitor from the time they first became occupied until they were deserted 10 to 15 years later.

Although densities of initial regeneration in secondary hardwood succession are often in the range of 49,000 to over 100,000 stems/ha (20,000 to 50,000 stems/acre), ruffed grouse seldom use these stands until they have thinned to total densities of less than 37,000 stems/ha (15,000 stems/acre). When ruffed grouse have a choice, use usually ceases when total density declines below 17,000 stems/ha (6900 stems/acre). They will use lower densities in areas where cover is poorer, but grouse densities there are lower, too. The preferred range for hardwood saplings is between 7000 and 17,000 stems/ha (2800 to 6900 stems/acre), and for brush species, 7000 to 24,000 stems/ha (2800 to 9700 stems/acre). It is a varying number of brush and hardwood saplings that together comprise the total preferred stem densities. Canopy height for preferred cover ranges from 7.3 to 10.7 m (22 to 32 ft) (Gullion 1983, and unpublished data).

For whatever it may be worth, we also know the dimensions of acceptable drumming logs (Gullion 1984a). Drumming logs can be "made-to-order", with a high rate of prompt acceptance when other habitat qualities develop properly.

Although ruffed grouse have long been considered inhabitants of forest edges, we now know that they quickly abandon edge situations when they have suitably sized blocks of uniform habitat available elsewhere (Gullion 1970, 1983). In preferred habitats the density of cover is quite uniform over a major portion of the activity center. There is little difference between stem densities around drumming logs and at sites 20 to 40 m (60 to 130 ft) distant. Persistent use of edge situations by ruffed grouse is a strong indicator of inadequate habitats. Grouse concentrated at edges or in pockets of more dense vegetation are especially vulnerable to predation (Gullion unpubl. data). This is the reason that knowledgeable grouse hunters concentrate their effort along forest edges.

Blocks of suitable habitat should be not less than 0.4 ha (1.0 acres), and may be as large as 4.0 ha (10 acres) in size. Where this habitat quality can be provided with suitable interspersion through forested areas, breeding pairs of ruffed grouse can be expected at a spacing of about 136-145 m apart (440-480 ft), providing a spring breeding density of about 30 grouse/100 ha (12 grouse/100 acres) (Gullion 1984b). Densities decline sharply where conifers are present, to 2 or 3 grouse/100 ha (0.8-1.2/100 acres), or less (Gullion and Alm 1983).

It is also possible to predict about when ruffed grouse will commence occupying a regenerating forest habitat on a year-long basis, and when they will find it no longer suitable for occupancy. Timing of occupancy is a function of the growth rates of the plants providing cover, and this varies according to species and environmental factors. In Minnesota, for example, on the Mille Lacs study area, new ruffed grouse habitat begins to be occupied when it is 4 to 6 years old, but its occupancy declines 10 years later (Gullion 1983). At Cloquet, 115 km (90 mi.) to the northeast, few new converts are acceptable in less than 10 years, but having a slower rate of growth, they remain usable for about 15 years. Forests that have not been significantly disturbed for more than 30 years are unlikely to provide much acceptable cover for ruffed grouse (Gullion 1970).

The best opportunities for productive ruffed grouse management appear to be in those regions where aspens (*Populus tremuloides; P. grandidentata*) are an important part of the forest composition. When the inter-relationships between the aspens and ruffed grouse are examined and understood, it becomes apparent that it is not a coincidence that the range of the most widely distributed resident gamebird in North America correlates closely with the range of the most widely distributed forest tree on the continent (Gullion and Svoboda 1972, Gullion 1984b). Nor is it coincidence that over 90% of the continental harvest of ruffed grouse occurs in the regions where aspen is an important part of the forest composition (Gullion 1977a). Ruffed grouse needs can be satisfied when aspen constitutes no more than 12 to 14% of the forest composition (Gullion 1983).

This knowledge provides a sound basis for prescribing forest management activities that are most likely to develop productive ruffed grouse habitats. This information is already being used to improve the outlook for ruffed grouse over a broad area.

One strong indicator of this trend was the 1970 decision by the Michigan Natural Resources Commission to manage state forest lands "to encourage intolerant forest types" (Hammill and Visser 1984). That policy states, "As aspen is highly demanded for commercial purposes and is of equal importance to wildlife, it shall be perpetuated and expanded wherever feasible."

However, conversion of forest types in Michigan is resulting in a net loss of aspen volume due to natural breakup of stands. Although aspen harvest exceeds growth on the western part of the Upper Peninsula, this is not the case elsewhere in Michigan.

Recent trends in Minnesota's forest industries should be indicative of the future for aspen and ruffed grouse habitat development in Michigan, elsewhere in the Lakes States, and in New England. In the past few years three new aspen processing plants have come on-line in Minnesota, and the capacity of a fourth plant was doubled. These four mills have an aggregate annual demand of 1.2 million cubic meters (475,000 cords) of aspen, which means harvesting from an additional 12,000 ha (29,700 acres) of forest land annually. Shortly before this symposium convened, the start of another aspen processing plant in northern Minnesota was announced. This plant will use another 181,000 to 217,000 cubic meters (50,000-60,000 cords) of aspen annually. Foresters in Minnesota expect demand to reach a sustained yield of 4.2 million cubic meters (1.6 million cords) annually within the next few years. This should mean harvesting of an additional 40,470 ha (100,000 acres) of aspen annually.

North Dakota has undertaken a significant aspen management program, designed to improve habitat for ruffed grouse in the Turtle Mountains along the Canadian border (Schulz 1984). Lacking a commercial market for aspen, the North Dakota Game and Fish Department undertook a modest program of aspen regeneration. The goal was to treat 202 ha (500 acres) of mature aspen by mechanical methods between 1976 and 1986. By 1982 there was some evidence of an increase in the ruffed grouse populations in sections treated early in this program (Schulz 1984).

Also, the U.S. Forest Service has undertaken an extensive aspen management program in the Black Hills of South Dakota (Riley 1983). This program has been tailored to improving the quality of habitat available to ruffed grouse in the Black Hills (Gullion 1979).

While aspen dominated forests have the greatest potential for sustaining high density ruffed grouse populations, grouse dependent upon aspens tend to exhibit more severe periodic fluctuations, or "cycles" than do grouse populations less dependent upon aspen. It appears probable that changes in aspen chemistry play an important role in affecting grouse population trends in northern areas (Gullion 1982, 1984b). There is substantial evidence, however, that the severity of these fluctuations can be dampened by maintaining the proper intermixture of forest age classes (Gullion and Alm 1983).

Not only is the pace of habitat deterioration being slowed or reversed in the primary ruffed grouse states in the upper Midwest, but a combination of land abandonment and increased timber harvesting has improved the habitat for ruffed grouse in the states farther south. Transplanting birds to restock vacant coverts has re-established ruffed grouse in several areas where they were greatly reduced in numbers or extirpated by the clearing of forests and hunting following the settlement of those regions in the 1800s (McKinley 1960).

The most significant success has been in Missouri. There the release over 2800 grouse wild-trapped and moved from Ohio, Indiana, Iowa, Kentucky, Minnesota, Michigan and Wisconsin, and within Missouri has re-established a widespread population (Hunyadi 1984). Releases have been made at 39 sites scattered across the state. Now ruffed grouse populations in some formerly depleted Missouri coverts probably exceed the density in many of the classic ruffed grouse ranges in the New England states. The size of this population was believed sufficient to permit in 1983 the first hunting season for Missouri ruffed grouse in 78 years.

By wild-trapping and moving mostly native birds Indiana has expanded the range of ruffed grouse from 14 counties in 1961 to 41 counties by 1982 (Backs 1984). This has involved transplanting 1044 birds. Commencing in 1965, Indiana has had annual hunting seasons, expanding from 6 counties in 1965 to 14 counties currently.

Illinois has released at least 380 ruffed grouse wild-trapped in Michigan, Wisconsin, Ohio, and Indiana in several forested sites in the southern portion of the state since 1955 (Woolf et al. 1984). To date the success of these releases has been questionable, but the most recent release of 123 grouse from Indiana, made in an area where there has been recent clear-cut logging, appears to be persisting.

Recent transplants from Wisconsin to western Tennessee also show promise of success, but it is still too early to be certain of establishment (Gudlin and Dimmick 1984).

Ruffed grouse trapped in Virginia and Minnesota were recently released in Arkansas, but the success of this release is uncertain (Pharris et al. 1983). This year Kansas has also moved wild-trapped grouse from Wisconsin into wooded areas in the northeastern part of the state. Kansas plans to bring in about 100 birds annually for the next 4 years (Anon. 1983).

On a continent-wide basis, with ruffed grouse firmly established as an exotic species in Newfoundland and Nevada, on some islands in Lake Michigan and in the Killdeer Mountains in North Dakota, their range is more extensive than it was when white man arrived on this continent. Among the states where ruffed grouse were native then, the only state remaining without a population, or not attempting to re-establish this bird is Nebraska.

A region-wide aspen management program in the Central Rocky Mountains Region of the U.S. Forest Service is creating many areas of potential ruffed grouse habitat in Colorado and south-eastern Wyoming. An emphasis was placed on maintaining aspen as an important habitat resource for wildlife in this region, and much of the effort was directed towards creating optimum coverts for ruffed grouse (Gullion 1977b). It is expected that transplants of these grouse into those treated areas will result in a substantial expansion of the range of ruffed grouse into a region where they are not native (Hoffman and Braun 1978).

Based on examination of several areas, I believe there are significant opportunities for the establishment of exotic populations of ruffed grouse in the northern mountainous parts of Arizona and New Mexico.

In several papers presented in this symposium discussing transplants from one region to another, the authors have expressed concern about the adaptability of grouse from distant regions to the new environments into which they were released. While there may be problems associated with releasing northern, gray-phased grouse in southern forests, it is my opinion that origin of birds should probably be of little concern, though it is always wise to acquire planting stock from habitats as similar as possible to the release areas. When one closely examines the precise habitats where ruffed grouse prosper across the continent, a structural homogeneity of occupied coverts becomes apparent. Good ruffed grouse habitat in Utah, Oregon, Tennessee, Missouri, and West Virginia is structurally identical to good ruffed grouse habitat in Minnesota, Maine, Vermont, Wisconsin, and North Dakota.

Evidence of this selection for habitat structure is reinforced by Hunyadi's studies in Missouri (Hunyadi 1978), by the shifts to better coverts by grouse transplanted into west Tennessee (Gudlin and Dimmick 1984), by the quality of cover used in Indiana (Backs 1984), and by the response to the development of regenerated coverts in North Dakota (Schulz 1984). Where forest habitats have been allowed to persist in Iowa, ruffed grouse abundance and hunter success is equivalent to that in habitats of similar quality in states having more extensive forests (Little 1984). While there are differences in the plant species involved all habitats are structurally similar. Outside of the zone where winter-long snow cover is an important ecological feature, ruffed grouse diets are sufficiently catholic that a scarcity of adequate food resources does not appear to be a problem.

I do not believe ruffed grouse can be considered to be an "adaptable" species. The success of transplants has not been the result of birds adapting to new habitats. Success has occurred when grouse have been released, by intent or accident, into situations that suited their rather narrow habitat tolerances. This has been the result of placing "round pegs in round holes."

The most successful transplanting in the several states has involved capturing grouse in late summer and early fall, and moving them rapidly (overnight, or within 3 or 4 days) to the release site. Early morning releases of 60 to 70 birds at each site has appeared to provide the highest assurance of success.

However, Newfoundland's most successful release involved 38 grouse released in the fall of 1956 (Inder 1967). Twelve years later this nucleus population had expanded to occupy 9300 km^2 (3600 mi^2). Nevada's successful establishment in a new region involved only 13 birds released in 1963 — and they began hunting ruffed grouse 7 years later (Foree 1983). If an area is really suitable for these grouse the release of only two or three dozen should be all it takes to provide the needed nucleus population. As we should have learned from long experiences with releasing thousands of chukars (*Alectoris chukar*) in many parts of the country 30-40 years ago, and the massive release program for *Coturnix* quail (*Coturnix coturnix*), birds cannot be made to survive in unsuitable habitats by loading those sites with large numbers of individuals.

Particularly interesting have been the post-release studies of grouse movements made in Indiana, Illinois, and Tennessee (Backs 1984; Woolf et al. 1984; Gudlin and Dimmick 1984). Even though grouse had been moved considerable distances from their original habitats, their tendency to disperse was similar to that occurring in resident populations.

A study using imprinted grouse in West Virginia has reinforced our earlier information concerning the importance of invertebrates as a food resource for young grouse and has again shown the need for an early successional forest composition adjacent to mature forest habitats (Kimmel and Samuel 1984). In the West Virginia situation this early forest succession represented revegetation following strip surface-mining. These data suggest that current reclamation procedures are not beneficial to ruffed grouse and probably not to other forest wildlife species. The grass and herbaceous cover which is being produced by conventional reclamation procedures does not provide the habitat resources needed by these animals.

Most of the success in maintaining ruffed grouse populations and in restoring them to depleted coverts has occurred on public lands. The encouraging habitat management programs in Michigan, Minnesota, and Wisconsin are occurring almost exclusively on state and federally owned forest land (Hammill and Visser 1984; Gullion 1981a). Several counties in Minnesota also have beneficial programs underway. The best prospects for ruffed grouse in North Dakota remain on public lands (Schulz 1984), and the South Dakota management effort is on National Forest land (Riley 1983). Successful restoration in Indiana and Missouri has been on public lands, and the current efforts in Illinois, Tennessee, and Arkansas are on public lands (Woolf et al. 1984; Gudlin and Dimmick 1984; Pharris et al. 1983).

In Iowa, where most of the forest land is in private ownership there appears to be little opportunity for productive management, and populations remain at low levels (Little 1984), comparable to the scarcity of grouse on private lands on similar, privately-owned forestlands in southwestern Wisconsin (Rogers 1980).

There is a widespread but inaccurate conception among the private sector (when there is any concern at all) that woodlands will support grouse so long as the trees are protected from disturbance.

It is also evident that the maintenance of viable ruffed grouse populations is dependent upon the cooperation of those responsible for forest management, and an economic demand for forest products. This is demonstrated by the high cost of management of 202 ha (500 acres) in North Dakota where there is no demand for the timber. By contrast, commercial timber harvesting in recent years has beneficially affected some 258,000 ha (637,500 acres) in Michigan, more than 40,500 ha (100,000 acres) in Wisconsin, and is currently affecting an estimated 38,400 ha (95,000 acres) annually in Minnesota (Gullion 1981a). In the discussion following his paper Hunyadi (1984) emphasized that restoration success in Missouri has been closely related to timber harvesting activities.

The importance of the attitude of forest managers in maintaining forest grouse populations is particularly apparent when we compare the relatively optimistic outlook for ruffed grouse in the Midwest with their plight in New England, and particularly with the very grim outlook for forest grouse in European forests. The latter is reflected by several papers presented at a recent symposium in Scotland (Lovel 1981). In Europe, under increasingly intensive use of forestlands for wood production and recreation, many forest grouse populations have declined dramatically in recent years. Some countries have grouse populations that number only in the hundreds of birds, fewer grouse than Missouri and Indiana have transplanted in recent years to restock depleted coverts. In some European countries, especially West Germany, due to the lack of opportunity to manipulate forest habitats in a favorable manner, game managers are turning to artificial propagation as a means of maintaining stocks of forest grouse. The European equivalent of our ruffed grouse, the hazel grouse (*Bonasa bonasia*) has become scarce across most of Europe. This is not surprising when one examines the structure of the long and carefully managed central European forests. In the 1960's, for example, Finnish foresters were intent on eliminating aspen (*Populus tremulus*) as a component of Finland's forests by 1970. Ironically, the Finns were attempting to establish North American beavers (*Castor canadensis*) as a fur-bearer at the same time they were eliminating aspen as a forest component.

The one unsettling note provided by this symposium is the realization that we do not know as much about the impact of hunting on a ruffed grouse population as we believed we knew. For many years we had accepted the conclusions of the pioneering studies by Gardiner Bump and his group in New York (Bump et al. 1947), and Walt Palmer's long study in the Rifle River area of Michigan (Palmer 1956). Both of these studies showed that a month of hunting in October did not have a significant impact upon ruffed grouse breeding populations under the pressures exerted at that time. So it is disturbing to find now that a season lasting only 6 weeks from the middle of September to the end of October is suppressing a breeding population on the Sandhill Area in Wisconsin to a level of about one-third that of a protected refuge population in adjacent, similar coverts (Kubisiak 1984). This was under a hunting pressure of approximately 2.5 hours of hunting per ha (1 hr/acre).

Another Wisconsin study has also shown a very high level of harvest of a grouse population (Rusch et al. 1984). This study has not been underway long enough to show an effect on breeding populations. But this study, together with Fisher's (1939) and Palmer and Bennett's (1963) work in Michigan, and studies in Alberta, Canada (Rusch and Keith 1971) tell us that most of the annual surplus of ruffed grouse has been dissipated by late November or early December. If we look at the rates of population loss indicated by these four studies, it is apparent that grouse were lost at a rate of about 1% of the population per day during the period of fall dispersal. This is not surprising when we understand the dispersal patterns of young grouse. During this season, most young grouse are moving considerable distances through often unsuitable habitat at a time when there is a concerted movement of northern raptors towards southern wintering regions.

The results of these 2 Wisconsin studies are supported by a Minnesota study where a hunting pressure of about 3.49 to 3.59 hunter hr per ha (1.41 to 1.45 hr/acre) depressed a population to about 1/3 the carrying capacity of an area where intensive habitat management has been underway for nearly 15 years (Gullion 1981b). Harvests have approximated 1 grouse/2.1 ha (1 grouse/5.2 acres) on the most heavily harvested area. Hunting success has varied from 11.7 to 16.0 hr of hunting for each grouse bagged. This study has suggested an "accumulative depletion" of breeding populations in accessible coverts, which include all areas within a 1 1/2 km (0.9 mi) radius of vehicle access. This depression is the result of very high levels of harvest upon vulnerable populations and the failure of dispersing replacement birds to reach depleted coverts (Gullion 1983). The random nature of the fall dispersal of young grouse is such that only a small proportion of the dispersing birds from "refuges of inaccessibility" move into depleted coverts. The majority of the birds dispersing in these situations remain within the "refuge of inaccessibility."

As managers charged with the maintenance of a wildlife resource we need to re-examine what constitutes the allowable harvest of ruffed grouse populations, and how regulations affect that harvest. It probably does not matter that there is a secure, largely unhunted population 2 km (about 1.4 mi) or more from vehicle access, or on private lands where access is limited. The population we should be concerned about is the population accessible to and subject to harvesting by the majority of ruffed grouse hunters.

Birds in the "refuge of inaccessibility" are apparently not adequately replacing grouse lost to extended seasons, or where harvesting is especially heavy. Fall dispersal from the more remote areas does little more than replace birds departing from hunted areas through normal fall dispersal. This ingress by dispersing young grouse from more remote areas probably seldom compensates for excessive losses to hunter kill, especially losses that occur after the period of normal fall shuffle.

The fact that fall dispersal in sourthern Indiana occurs at the same time as it does in northern Minnesota is especially significant (Backs 1984). In both regions, dispersal begins in mid-September and by mid- or late-October most of the young grouse have reached the coverts where they will spend the remainder of their life.

Since losses from November to April amount to only about 10% of the population, this means that perhaps 8 out of 10 ruffed grouse shot after the end of November would otherwise be a part of next year's breeding population following most winters. In Minnesota, by late November, the age ratio among harvested birds has declined to less than 2 young/adult. During a 12-year period from 1968 to 1979 the mean age ratio among harvested grouse in Minnesota was 2.7 young/adult statewide, and for the past 4 years on the Mille Lacs Project it has averaged 3.5 young/adult. Early in the season at Mille Lacs the ratio is about 6 young/adult, but it declines to 2.2 young/adult by the end of October.

It may be that the low young/adult ratios often found among hunter-killed grouse in states having late seasons simply reflects the loss of many young grouse during dispersal prior to the hunting season.

While there is good evidence of this harvest impact upon heavily hunted populations on public hunting areas such as Wisconsin's Sandhill Area, the areas studied by Rusch and his students, and the Mille Lacs area in Minnesota, I believe that we cannot rule out the possibility that the same thing occurs throughout the ruffed grouse range in corridors along persistently hunted roadways. This effect may be especially true in regions where satisfactory grouse habitat occurs as small, isolated coverts.

Our conventional extensive population trend techniques will not alert us to this fact. The technique most often used for region-wide monitoring of ruffed grouse populations is the road-side drumming count (Petraborg et al. 1953). This inventory is made after the fact, sampling the depleted population after depletion has occurred.

While we have tended to blame this depletion upon hunter harvest, it seems prudent to consider the possibility that this depression in breeding grouse numbers in accessible areas may be more the consequence of disturbance — increasing predation losses by pushing birds out of secure coverts. Cover providing adequate security for ruffed grouse when they are dealing with predators on a one to one basis is not secure cover when those birds have to cope with a "team of predators", *i.e.* hunters with their dogs. Even if not shot, a bird pushed from a secure covert becomes exceedingly vulnerable to predation, and this may be the most important factor confronting us. On our Minnesota area I have problems believing that the light hunter harvest we measure in December can be responsible for the observed depression in the grouse breeding population. Yet we know that this depression occurs, and that it is significantly related to distance from hunter parking areas.

Perhaps we have too long, too conveniently blamed scarce grouse populations upon inadequate habitats. While insufficient habitat surely compounds this problem, and is the problem in many areas, we must be careful about where we lay the blame in areas where habitats are adequate. Too much hunting can suppress ruffed grouse populations in even the best coverts.

Acknowledgements: This is paper number 14,119 of the Miscellaneous Journal Series, Minnesota Agricultural Experiment Station. The Forest Wildlife Relations Project is project 83H of the University of Minnesota Agricultural Experiment Station, with additional support from the Minnesota Department of Natural Resources, Division of Fish and Wildlife, The Ruffed Grouse Society, and J.O. Matschulat of New York.

LITERATURE CITED

Anonymous. 1983. Kansas attempts re-introduction of ruffed grouse. The Drummer, 9 (5):19.

Backs, S. E. 1984. Ruffed grouse restoration in Indiana. Pp. *in* Ruffed grouse management; state of the art in the early 1980's (W. L. Robinson, ed.) North Central Section The Wildlife Soc., pp.

Bump, G., R. W. Darrow, F. C. Edminster, and W. F. Crissey. 1947. Ruffed grouse: life history-propagation-management. New York Conserv. Dept., Albany, 915 pp.

Fisher, L. W. 1939. Studies of the eastern ruffed grouse in Michigan. Mich. State Ag. Expt. Sta., Tech. Bull. 166, 46 pp.

Foree, S. 1983. Ruffed grouse trapping, introduction, transplanting and monitoring exotic and nonresident game bird releases and investigations. Nevada Dept. of Wildlife, Job Prog. Report, Proj. W-48-R-14, 3 pp.

Gudlin, M. J., and R. W. Dimmick. 1984. Habitat utilization by ruffed grouse transplanted from Wisconsin to west Tennessee. Pp. *in* Ruffed grouse management; state of the art in the early 1980's (W. L. Robinson, ed.) North Central Section. The Wildlife Soc., pp.

Gullion, G. W. 1970. Ruffed grouse investigations-influence of forest management practices on grouse populations. Minn. Div. Game & Fish, Game Res. Quart. Repts. 30(2):104-125.

Gullion, G. W. 1977a. Forest manipulation for ruffed grouse. Trans. 42nd No. Amer. Wildl. & Nat. Resources Conf., p. 449-458.

Gullion, G. W. 1977b. Review of ruffed grouse habitats — central Rocky Mountains. Report submitted to Div. Range & Wildlife, Region 2, U.S. Forest Service, Denver, August 25, 1977, 5 pp. (unpubl.)

Gullion, G. W. 1979. Aspen management activity report — 1979. Report submitted to Div. Range & Wildlife, Region 2, U.S. Forest Service, Denver, Nov. 21, 1979, 31 pp. (unpubl.)

Gullion, G. W. 1981a. Integration of wildlife production in Great Lakes states forestry programs. P. 28-35 *in* (H. C. Black, ed.), Effects of Forest Practices on Fish and Wildlife Production, Soc. Amer. Foresters, Washington, D. C., 52 pp.

Gullion, G. W. 1981b. Rejuvenation and maintenance of forest habitats for the American ruffed grouse. P. 11-25 *in* Proceed. 2nd Internatl. Symposium on Grouse, (T.W.I. Lovel, ed.), Edinburg, Scotland, 255 pp.

Gullion, G. W. 1982. Plants poison grouse. Outdoor Life, p. 37, 88-89, December 1982.

Gullion, G. W. 1983. Ruffed grouse habitat manipulation — Mille Lacs Wildlife Management Area, Minnesota. Minn. Div. Fish & Wildlife, Job Progress Report, 76 pp. (unpubl.)

Gullion, G. W. 1984a. Managing northern forests for wildlife. The Ruffed Grouse Society, Coraopolis, PA. (in press).

Gullion, G. W. 1984b. Grouse of the North Shore. Willow Creek Press, Oshkosh, WI. 144 pp.

Gullion, G. W., and A. A. Alm. 1983. Forest management and ruffed grouse populations in a Minnesota coniferous forest. Journ. Forestry, 81(8):529-531, 536.

Gullion, G. W. and F. J. Svoboda. 1972 Aspen: the basic habitat resource for ruffed grouse. P. 113-119 *in* Aspen Symposium Proceedings, U.S.D.A. Forest Service, Gen. Tech. Report NC-1, 154 pp.

Hammill, J., and L. Visser. 1984. Status of aspen in northern Michigan as ruffed grouse habitat. Pp. *in* Ruffed grouse management: state of the art in the early 1980's (W. L. Robinson, ed.) North Central Section, The Wildlife Soc. pp.

Hoffman, R. W., and C. E. Braun. 1978. Characteristics and status of ruffed grouse and blue grouse in Colorado. Western Birds, 9:121-126.

Hunyadi, B. W. 1978. Analysis of ruffed grouse habitat in central Missouri. Univ. Missouri-Columbia, M.S. thesis, 145 pp. (unpubl.)

Hunyadi, B. W. 1984. Ruffed grouse restoration in Missouri. Pp. *in* Ruffed grouse management: state of the art in the early 1980's (W. L. Robinson, ed.) North Central Section, The Wildlife Soc. pp.

Inder, J. 1967. Introduction of ruffed grouse into Newfoundland. Newfdl. Dept. Mines, Agric. and Resources, St. Johns, 11 pp. (unpubl.)

Kimmel, R. O. and D. E. Samuel 1984. Implications of ruffed grouse brood habitat studies in West Virginia. Pp. *in* Ruffed grouse management: state of the art in the early 1980's (W. L. Robinson, ed.) North Central Section, The Wildlife Soc. pp.

Kubisiak, J. F. 1984. The impact of hunting on ruffed grouse populations in the Sandhill Wildlife Area. Pp. *in* Ruffed grouse management: state of the art in the early 1980's (W. L. Robinson, ed.) North Central Section, The Wildlife Soc. pp.

Leopold, A. 1931. Report on a game survey of the North Central States. Sport. Arms & Ammun. Manuf. Instit, Madison, Wisconsin. 299 pp.

Little, T. W. 1984. Ruffed grouse population indices from Iowa. Pp. *in* Ruffed grouse management: state of the art in the early 1980's (W. L. Robinson, ed.) North Central Section, The Wildlife Soc. pp

Lovel, T.W.I. (ed.) 1981. Proceedings of the Second International Symposium on Grouse. World Pheasant Assn., Edinburgh, Scotland. 255 pp.

McKinley, D. 1960. History of the ruffed grouse in Missouri. The Bluebird, 27 (4):3-11.

Palmer, W. L. 1956. Ruffed grouse population studies on hunted and unhunted areas. Trans. 21st No. Amer. Wildl. Conf., p. 338-345.

Palmer, W. L., and C. L. Bennett, Jr. 1963. Relation of season length to hunting harvest of ruffed grouse. J. Wildl. Manage. 27 (4) 634-639.

Petraborg, W. H., E. G. Wellein, and V. E. Gunvalson. 1953. Roadside drumming counts, a spring census method for ruffed grouse. J. Wildl. Manage. 17 (3):292-295.

Pharris, L. D., S. Chaney, and M. Cartwright. 1983. Preliminary evaluation of ruffed grouse restoration efforts in Arkansas. Proceed. SE Assn. Fish & Wildlife Agencies, (in press)

Riley, T. 1983. Ruffed grouse habitat management in the northern Black Hills, South Dakota. Paper presented 45th Midwest Fish & Wildl. Conf., 4 pp. (unpubl.)

Rogers, R. D. 1980. Ecological relationships of ruffed grouse in south-western Wisconsin. Trans. Wisc. Acad. Sci., Arts & Letters, 68:95-105.

Rusch, D. H., and L. Keith. 1971. Seasonal and annual trends in numbers of Alberta ruffed grouse. J. Wildl. Manage. 35 (4):803-822.

Rusch, D. H., S. DeStefano, and R. J. Small. 1984. Seasonal harvest and mortality of ruffed grouse. Pp. *in* Ruffed grouse management: state of the art in the early 1980's (W. L. Robinson, ed.) North Central Section, The Wildlife Soc. pp.

Schulz, J. W. 1984. Manipulation of habitat for ruffed grouse on the Wakopa Wildlife Management Area, North Dakota. Pp. *in* Ruffed grouse management: state of the art in the early 1980's (W. L. Robinson, ed.) North Central Section, The Wildlife Soc. pp.

Woolf, A., R. Norris, and J. Kube. 1984. Evaluation of ruffed grouse reintroductions in southern Illinois. Pp. *in* Ruffed grouse management: state of the art in the early 1980's (W. L. Robinson, ed.) North Central Section, The Wildlife Soc. pp.