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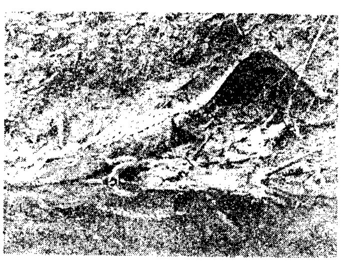

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RUFFED GROUSE (*Bonasa umbellus*)

Section 4.1.1, US ARMY CORPS OF ENGINEERS WILDLIFE RESOURCES MANAGEMENT MANUAL

by

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A wildlife species account for the ruffed grouse (*Bonasa umbellus*) is provided as Section 4.1.1 of the US Army Corps of Engineers Wildlife Resources Management Manual. The account is developed as a guide to provide the Corps District or project biologist with basic information on the biology, ecological requirements, and management technology for the ruffed grouse.

Major topics covered include status, characters and measurements, population attributes, habitat requirements, management, and census and sampling. The importance of the ruffed grouse as a game species is discussed, and the present and historic range of the species is described. Diagnostic characters are presented, including criteria for sex and age determination. The section on population attributes includes details on densities, movements, breeding biology, and mortality factors. Food and cover requirements are treated

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from a regional perspective, and principal foods are listed by region in tabular form. Techniques for managing ruffed grouse habitat and estimating grouse populations are described, and major sources of information are provided.

PREFACE

This work was sponsored by the Office, Chief of Engineers (OCE), US Army, as part of the Environmental Impact Research Program (EIRP), Work Unit 31631, entitled Management of Corps Lands for Wildlife Resource Improvement. The Technical Monitors for the study were Dr. John Bushman and Mr. Earl Eiker, OCE, and Mr. Dave Mathis, Water Resources Support Center.

This report was prepared for the US Army Engineer Waterways Experiment Station (WES) by Dr. John A. Crawford, Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oreg., under Contract No. DACW39-82-M-1856. Mr. Chester O. Martin, Team Leader, Wildlife Resources Team, Wetlands and Terrestrial Habitat Group (WTHG), Environmental Laboratory (EL), was principal investigator for the work unit. Review and comments were provided by Dr. Wilma A. Mitchell and Dr. Thomas H. Roberts, WTHG, and Dr. Kenneth T. Ridlehuber, Department of Wildlife and Fisheries Sciences, Texas A&M University. The report was prepared under the general supervision of Dr. Hanley K. Smith, Chief, Wetlands and Terrestrial Habitat Group, EL; Dr. Conrad J. Kirby, Chief, Environmental Resources Division, EL; and Dr. John Harrison, Chief, EL. Dr. Roger Saucier, WES, was Program Manager, EIRP. The report was edited by Ms. Jessica S. Ruff of the WES Publications and Graphic Arts Division.

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NOTE TO READER

This report is designated as Section 4.1.1 in Chapter 4 -- WILDLIFE SPECIES ACCOUNTS, Part 4.1 -- GAME BIRDS, of the US ARMY CORPS OF ENGINEERS WILDLIFE RESOURCES MANAGEMENT MANUAL. Each section of the manual is published as a separate Technical Report but is designed for use as a unit of the manual. For best retrieval, this report should be filed according to section number within Chapter 4.

RUFFED GROUSE *(Bonasa umbellus)*

Section 4.1.1, US ARMY CORPS OF ENGINEERS
WILDLIFE RESOURCES MANAGEMENT MANUAL

The ruffed grouse is an upland game bird inhabiting forested areas of much of North America above 34° N latitude. The species occurs from South Carolina to Newfoundland, across the Canadian provinces to western Alaska, south to northern California, and through the northern United States except in the Great Basin and most of the Great Plains (Fig. 1).

Ruffed grouse are associated primarily with 3 major forest regions: the Boreal Forest, Northern Mixed Forest, and Temperate Deciduous Forest. The most extensively inhabited region is the Boreal Forest, much of which is dominated by aspen and pines in early to midseral stages and by spruce and fir in later stages (Gullion 1971). Spruce, pine, fir, birch, maple, and aspen characterize the Northern Mixed Forest within the range of ruffed grouse (Bump et al. 1947). Temperate Deciduous Forest regions inhabited by ruffed grouse

* Scientific names of plants referenced in the text are given in the appendix at the end of this account.

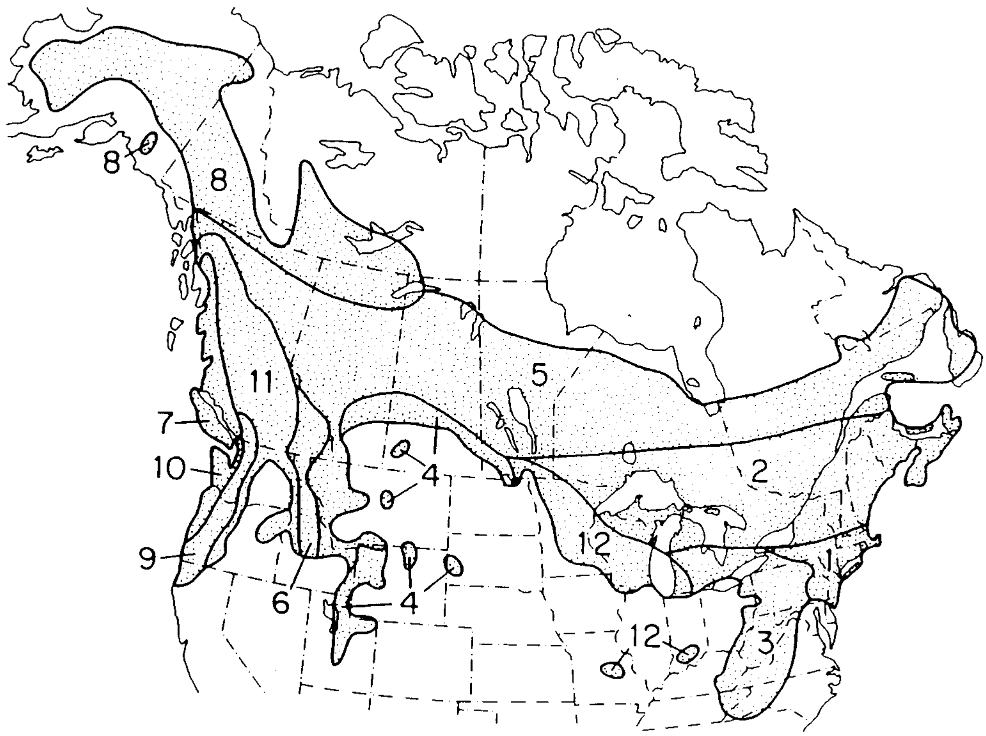

Figure 1. Current distribution of the ruffed grouse by subspecies (from Aldrich and Duvall 1955, American Ornithologists' Union 1957, and Johnsgard 1973. *B. u. affinis* and *B. u. mediana* are not recognized by the American Ornithologists' Union). Subspecies are coded numerically as shown below

1. *B. u. umbellus*	5. *B. u. umbelloides*	9. *B. u. sabini*
2. *B. u. togata*	6. *B. u. phaia*	10. *B. u. castanea*
3. *B. u. monticola*	7. *B. u. brunnescens*	11. *B. u. affinis*
4. *B. u. incana*	8. *B. u. yukonensis*	12. *B. u. mediana*

are composed predominantly of oak, hickory, beech, birch, maple, and pines (Edminster 1954).

STATUS

The ruffed grouse is of considerable importance as a game bird and is the third most heavily harvested galliform in North America (Johnsgard 1975). Approximately 4 million birds were harvested annually during the 1950's, and nearly 2 million hunters accounted for 20 million recreation hours each year

(Edminster 1954). The annual harvest increased to approximately 6.0 million birds in the 1970's (Gullion 1977). Ruffed grouse are especially important game birds in Minnesota, Michigan, New York, Pennsylvania, and Wisconsin; these states account for approximately 70% of the total United States harvest (Johnsgard 1973).

During the past century the species was virtually extirpated from Indiana, Missouri, and Illinois, and populations were greatly reduced in Kentucky, Ohio, Tennessee, and portions of Montana, Saskatchewan, and Alberta (Edminster 1954, Aldrich and Duvall 1955). Ruffed grouse were reintroduced into Missouri (Lewis et al. 1968) and Indiana (Kelly and Kirkpatrick 1979), and populations were established in Nevada (McColm 1970), Newfoundland (Tuck 1968), and part of Michigan (Moran and Palmer 1963).

No subspecies of ruffed grouse is considered endangered or has been assigned any special status by the Federal Government. However, populations are limited and protected from hunting in Colorado, Illinois, Missouri, Nevada, and South Dakota.

CHARACTERS AND MEASUREMENTS

Description

The plumage of the ruffed grouse is mottled brown, tan, and white with gray or rusty red on the tail and tail coverts. The tail is heavily barred and has a prominent, black subterminal band. The ruff, composed of specialized neck feathers, is black to reddish-brown. Two color phases occur; the red phase is typical of birds in southern latitudes and low altitudes, whereas the gray phase predominates in northern latitudes and at high altitudes. Both phases occur in most races (Johnsgard 1973), and different phases may be found within a brood (Edminster 1954).

Adult ruffed grouse range from 38 to 48 cm in length (Edminster 1954) and weigh from 500 to more than 650 g (Nelson and Martin 1953). Tail length ranges from 11.4 to 19.0 cm; the wingspan is approximately 60 cm (Edminster 1954).

Chicks are covered with natal down when hatched. The postnatal molt begins almost immediately after hatching, and juvenile contour feathers begin to replace natal down. The postjuvenile molt (the replacement of juvenile plumage and remaining natal down by the first-winter plumage) begins at approximately 7 weeks of age (Bump et al. 1947). The postjuvenile molt is complete at 18 to 20 weeks of age, and immatures resemble adult birds except for minor differences such as the appearance of the 2 outermost primaries (Bump et al. 1947). Thereafter, birds have only 1 complete annual molt, which occurs after the breeding season.

Sex Determination

Sexes are superficially alike, but they differ in weight and several anatomical characters. Adult males weigh from 604 to 654 g, whereas adult females weigh from 500 to 587 g (Bump et al. 1947). The ruff and supraorbital combs are more prominent in males than in females (Johnsgard 1973).

Characteristics of rump and tail feathers are reliable means of distinguishing the sexes. Length of the central tail feather (plucked) usually exceeds 15 cm in males (Palmer 1959) and is 1 to 2 cm less in females (Johnsgard 1973). Tail feather measurements are 99% accurate for sex determination (Davis 1969), but ranges of tail lengths should be determined for local populations because of regional variability. The pattern of rump feathers can also be used to determine sex. Rump feathers adjacent to upper tail coverts typically possess 1 "dot" in females and 2 or more "dots" in males (Fig. 2). The accuracy of this method was reported as 99.7% (Roussel and Ouellet 1975).

The sex of 8- to 14-week-old chicks can be determined by the appearance of the supraorbital comb. Combs of males are red to orange, whereas female combs have little or no color (Palmer 1959).

Age Determination

Only immature and adult age classes can be determined for ruffed grouse. Characteristics of wing feathers are the most useful and reliable indicators of age. The outer 2 primaries (numbers 9 and 10) are pointed and lack sheathing material in immatures, whereas in adults they are rounded and possess sheathing material during the early fall (Fig. 3) (Hale et al. 1954, Davis 1969). The ratio of the diameter of the calamus (the proximal portion of the feather shaft) of primary 9 to primary 8 can be used to distinguish ages of both sexes. A ratio of more than 0.89:1.00 (P9:P8) indicates an adult, and a ratio of less than 0.89:1.00 (P9:P8) is characteristic of immatures (Rodgers 1979).

Age in weeks may be determined for birds 2 to 17 weeks old by the sequential replacement of primary feathers (Bump et al. 1947). The first primary erupts and begins to grow approximately 2 weeks after hatching; thereafter,

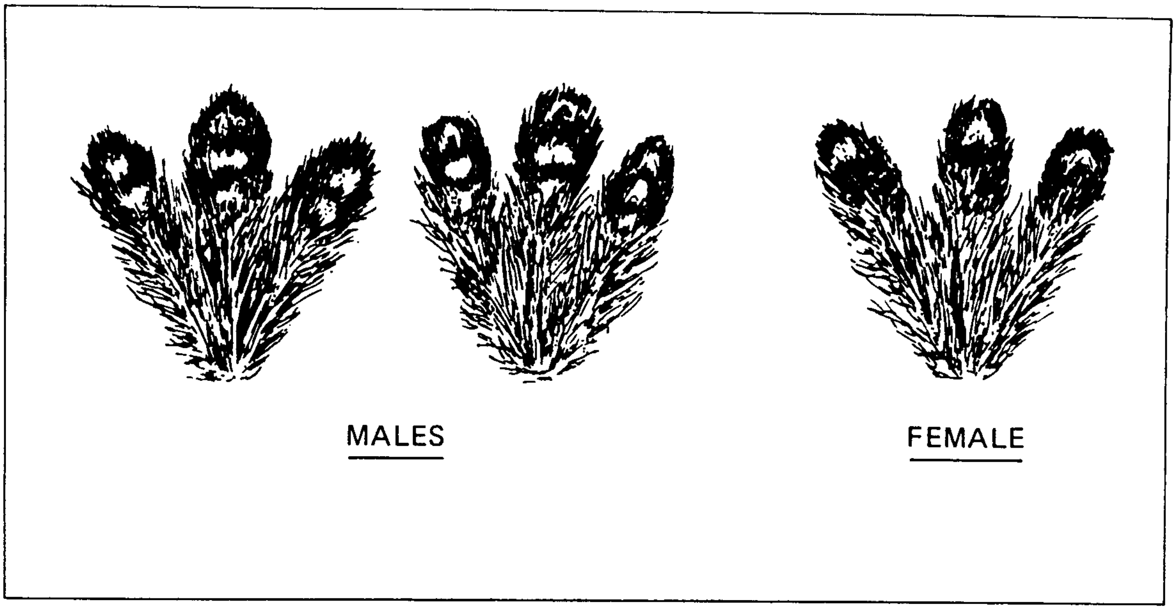

Figure 2. Dot configuration on rump feathers of male and female ruffed grouse (from Roussel and Ouellet 1975)

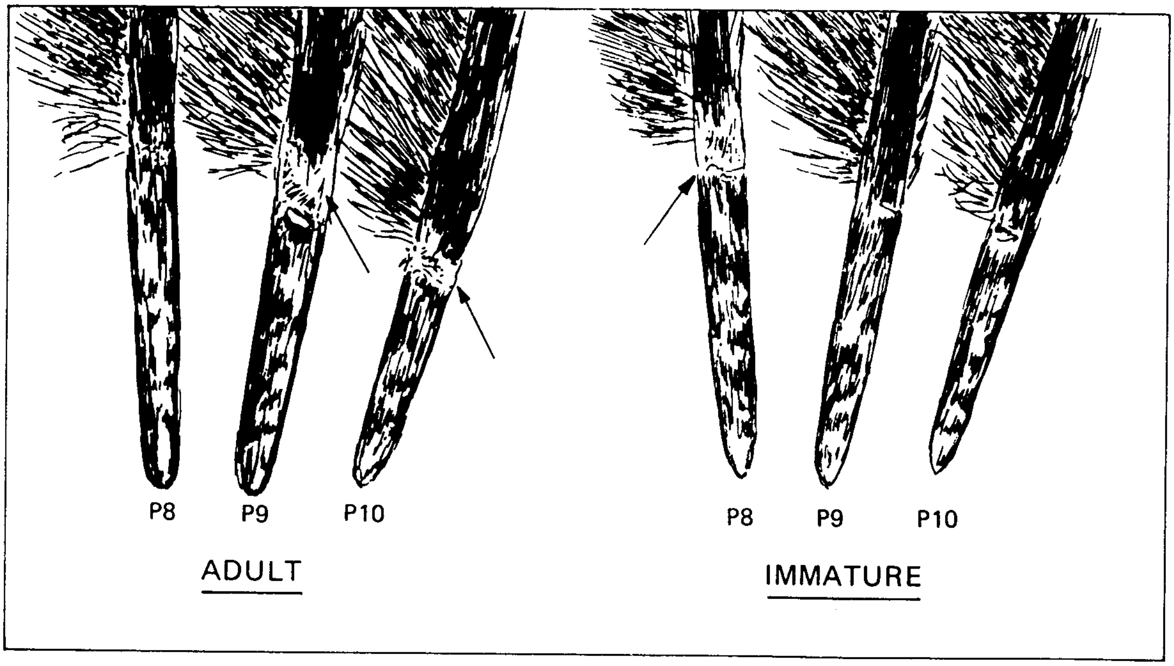

Figure 3. Primary feathers 8 through 10 of adult and immature ruffed grouse. Sheathing material (indicated by arrows) is present on primaries 9 and 10 of adults; sheathing is absent on these primaries in immatures but is present on primary 8 during fall (from Davis 1969)

growth of the other primaries is initiated sequentially at intervals of 7 to 13 days. Growth of primaries is complete 29 to 44 days after feather eruption. Analysis of feather development can be used to determine dates of hatching, initiation of incubation, laying, and breeding times (Table 1).

Table 1. Chronology of primary feather replacement in immature ruffed grouse (from Bump et al. 1947)

	Age (days)	
Primary Feather*	Initiation of growth	Completion of growth
1	14	45
2	20	49
3	27	63
4	35	68
5	42	77
6	49	83
7	61	98
8	74	119

* Primaries 9 and 10 are not replaced.

POPULATION ATTRIBUTES

Population Densities

Densities of ruffed grouse vary temporally and spatially because of differences in habitat quality and quantity. These differences result from climatic and other environmental influences and land use practices. Population numbers also fluctuate annually because of the cyclic nature of most ruffed grouse populations.

Regional variations. The highest ruffed grouse densities occur in the Boreal Forest region (Gullion 1969). Typical densities in this region range from 1.4 to 10.0 birds/40 ha* (100 acres) in spring (Table 2); maximum breeding densities may approach 22 to 25 birds/40 ha (King 1937, Gullion 1969). The greatest density reported for any portion of the Boreal Forest was 55.5 birds/40 ha during the fall in Minnesota (King 1937).

Average breeding densities in the Northern Mixed Forest range from 2.2 to 7.4 birds/40 ha (Table 2). The maximum breeding density reported in this

* All densities are hereafter expressed as the number of birds/40 ha.

Table 2. Comparison of ruffed grouse densities in major forest regions

	Density (birds/40 ha)			
Forest Region	Spring	Fall	Location	Reference
Boreal Forest	4.4-6.4		Alberta, Canada	Rusch and Keith 1971a
	3.1-8.4	25.0-30.0*	Michigan	Palmer 1956
	3.8-5.0	6.0	Michigan	Moran and Palmer 1963
		29.0-55.5*	Minnesota	King 1937
	1.4-10.0		Minnesota	Gullion 1966, 1969, 1971
Northern Mixed Forest	3.3-7.4	4.9-20.0	New York	Bump et al. 1947
	2.2-3.3		Pennsylvania	Bowers and Tanner 1947
		8.3	Pennsylvania	Chambers and English 1958
		19.1-28.6*	Pennsylvania	Keith 1963
Temperate Deciduous Forest	3.0**		Indiana	Kelly and Kirkpatrick 1979
	5.6		Iowa	Porath and Vohs 1972
	2.0**		Missouri	Lewis et al. 1968
	2.0-4.0		Ohio	Davis 1968

* Peak densities.
** Recently reestablished populations.

region was 12.5 birds/40 ha (Edminster 1954). Fall densities may range from 4.9 birds/40 ha during a population low (Bump et al. 1947) to 28.6 birds/40 ha at the peak population size (Keith 1963). The Deciduous Forest region generally supports slightly lower densities of breeding birds, 2.0-5.3 birds/ 40 ha, than other regions. Data on fall densities in this region are unavailable. Porath and Vohs (1972) estimated July densities at 14 and 21 birds/40 ha in 1966 and 1967, respectively, in a deciduous forest in northeastern Iowa.

Grouse densities also differ among seral stages within a forest region. Gullion (1971) found that the greatest breeding densities in a Boreal Forest region in Minnesota occurred in hardwood and coniferous stands that were 10 to 20 years old. Thereafter, population densities decreased as stand age increased, and no birds were present in stands over 80 years old. The aspen-dominated stage in Boreal Forest succession supports the highest breeding densities of that sere; however, midseral stages of aspen and coniferous vegetation also receive some use (Gullion 1971).

Cyclic fluctuations. Ruffed grouse populations normally follow relatively synchronous cycles at approximately 10-year intervals (Fig. 4); however, noncyclic populations have been reported in Boreal and Mixed Forest regions (Graham and Hunt 1958, Keith 1963, Theberge and Gauthier 1982). The precise cause of population cycles is unknown, but Keith (1963) hypothesized that changes in ruffed grouse densities were related to predator density. Factors that disrupt cycling have not been identified. The amount of continuous habitat, vegetative composition, and habitat manipulation have been hypothesized as factors influencing stationary populations (Graham and Hunt 1958, Keith 1963). During low periods in the cycle, densities may decline 67% to 94% from the peak density and usually drop by more than 80% (Keith 1963). Cyclic fluctuations apparently account for much of the variation in reported densities.

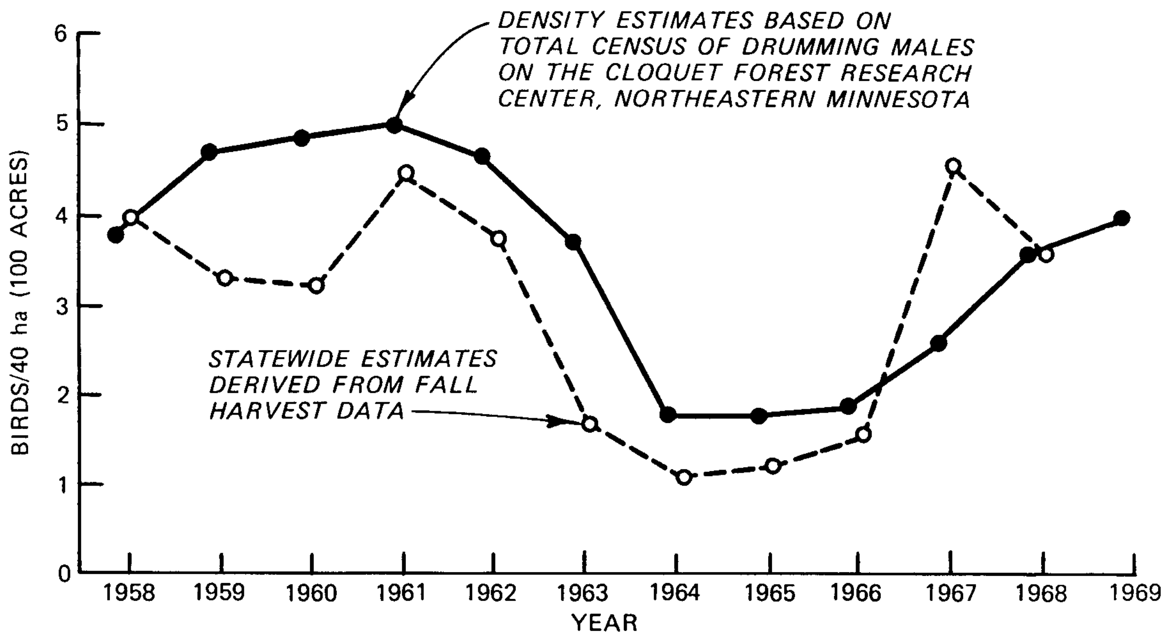

Figure 4. Example of cyclic fluctuations in ruffed grouse populations in Minnesota, 1958 through 1969 (modified from Gullion 1971)

Home Range and Movements

Home range. Home range and territory size are closely related for ruffed grouse. Adult males have a home range of 2.3 to 4.5 ha (5.7 to 11.1 acres), whereas immature males occupy 1.7 to 4.2 ha (4.2 to 10.4 acres) (Archibald 1975). The home range sizes for females are related primarily to breeding activities. Females occupy approximately 12 ha (30 acres) prior to nesting, 7 to 8 ha (17.3 to 20 acres) during laying, and 1 to 2.5 ha (2.5 to 6.2 acres) while incubating (Archibald 1975, Maxson 1978b). Hens with broods use an area of 6.3 to 18.9 ha (15.6 to 46.7 acres), averaging 12.9 ha (31.9 acres), during summer (Godfrey 1975b). After brood breakup and dispersal, and throughout winter, the female's home range declines to approximately 3 to 10 ha (7 to 25 acres) (Brander 1967).

Territory. Only male ruffed grouse are territorial. Immature males may establish territories during their first fall (Gullion 1967), but this does not commonly occur until winter (Eng 1959) or spring (Boag 1976a). Some males do not have a territory until their second fall (Boag 1976a), and others never occupy a permanent territory (Gullion 1966). The number of males able to establish and defend territories is related to habitat quality and quantity and to density of the grouse population (Gullion 1966). The distribution of territories is a function of habitat (Gullion 1966) and social interactions, such as aggressive displays among neighboring males (Boag 1976a).

Territory sizes average 4.1 ha (10.1 acres) (Stoll et al. 1979). Territories of adults range from 2.2 to 4.5 ha (5.4 to 11.1 acres) and average 0.4 ha (1 acre) larger than those of immatures, which are 1.7 to 4.2 ha (4.2 to 10.4 acres) (Archibald 1975).

Movements. Ruffed grouse are not migratory, but juveniles may undertake unidirectional movements of 3.2 km (2 miles) or more during fall (Chambers and Sharp 1958). These movements, sometimes called "crazy flights," are associated with brood breakup and dispersal and may result in the occurrence of birds in atypical habitats (Godfrey and Marshall 1969). Brood dispersal begins in early fall and continues for 2 to 5 weeks (Godfrey and Marshall 1969). Average daily movements of immatures increase from approximately 0.38 km (0.24 mile) (Godfrey 1975b) to 0.92 km (0.57 mile) during dispersal (Godfrey and Marshall 1969). Most immatures move less than 1.6 km (1 mile), but dispersal distance may average as much as 2 km (1.2 miles) (Godfrey and Marshall 1969). The cause of variations in the magnitude of fall dispersal is unknown but is apparently unrelated to population density (Hale and Dorney 1963).

Females are more mobile than males during winter (Hale and Dorney 1963), largely because territorial males are very sedentary (Gullion and Marshall 1968). Nonterritorial males, most often immatures, move greater distances than males with established territories (Archibald 1975); consequently, juvenile movements during winter have occasionally been reported to exceed those of adults (Hale and Dorney 1963, Rusch and Keith 1971a).

Movements during spring and summer are governed by reproductive activities. Territorial males, the most sedentary segment of the population year-round, move least during the peak of drumming, and females restrict their movements the most during laying, incubation, and early brood-rearing (Archibald 1975).

Breeding Biology

The breeding season extends from March through July. The timing of all breeding activities is related to photoperiod (Gullion 1966), latitude, and climatic conditions (Petraborg et al. 1953). Birds in the southern part of their range breed earlier than those in northern regions. Mating occurs within the territories of males. Males, however, are promiscuous and play no role in incubation, nest defense, or brood rearing (Edminster 1954, Brander 1967). Ruffed grouse characteristically have high reproductive and mortality rates.

Drumming. Reproductive activities begin with the onset of drumming by males, which is influenced by the melting of snow (Petraborg et al. 1953, Rusch and Keith 1971a) and possibly by the amount of moonlight (Archibald 1976). The peak of drumming, however, is apparently related to photoperiod (Gullion 1966), which is a function of latitude. For example, peak drumming occurs during mid-March in Missouri (Lewis et al. 1968), early April in Indiana (Major and Olson 1980), and late April in Minnesota (Archibald 1976). Two drumming peaks, separated by an interval of 2 to 3 weeks, are sometimes observed. The second peak may reflect mating for renesting attempts (Archibald 1976) or late breeding by inexperienced birds (Porath and Vohs 1972). Drumming declines to a low level by June (Archibald 1976). Copulation takes place during the peak drumming period (Archibald 1976).

Nesting and clutch size. Females begin laying from 3 to 7 days after copulation (Bump et al. 1947) and produce 1 egg every 25 to 30 hours (Maxson 1977). The average clutch size is 11.5 eggs, with a range of 4 to 19 (Bump et al. 1947, Porath and Vohs 1972). The date of first eggs ranges from April 7 (Lewis et al. 1968) to May 10 (Brander 1967).

Incubation and hatching. Incubation begins after the clutch is completed and continues for 23 to 24 days until the chicks hatch (Edminster 1954). Hatching takes place during May and June, and the dates are related to the chronology of other breeding activities. For example, the first peak of hatching occurs during late May in Iowa (Porath and Vohs 1972), whereas the peak is approximately 2 weeks later in Minnesota (Godfrey 1975b).

Renesting. Ruffed grouse are single-brooded, but females sometimes make second nesting attempts if initial nests are abandoned or destroyed (Maxson 1977). As many as 25% of unsuccessful hens may attempt to renest (Edminster 1954). Second nests typically are initiated in May (Archibald 1976, Maxson 1977).

Nest and hatching success. Nest success ranges from 52% to 61% and averages approximately 60% (Bump et al. 1947). Predation, primarily by foxes (*Vulpes vulpes* and *Urocyon cinereoargenteus*), accounts for 90% of all nest losses (Edminister 1954). The effect of vegetative characteristics at the nest site on nest success is not clear. Maxson (1978a) found that 89% of nests in mixed hardwoods were successful compared to only 25% in oak woodlands in Minnesota. The greater structural diversity of the mixed hardwood habitat (Godfrey 1975b) presumably decreases predator efficiency. By contrast, Bump et al. (1947) found no relationship between habitat structure and nest success in the mixed forests of New York. Hatchability usually exceeds 95% for successful, initial nests and is approximately 92% for subsequent nests (Bump et al. 1947).

Brood size and success. Brood size decreases slightly from north to south within the species range. For example, broods in Iowa range from 5.5 to 6.6 chicks (Porath and Vohs 1972), whereas those in Wisconsin and Alberta vary from 6.7 to 7.4 chicks (Dorney and Kabat 1960, Rusch and Keith 1971a, Kubisiak 1978). Brood size remains relatively constant through the cyclic fluctuations of grouse populations. High mortality rates for chicks are normal throughout the range. Between 33% and 50% of the chicks die during their first month of life, and by fall, chick mortality reaches 60% to 80% (Edminster 1954, Rusch and Keith 1971a).

Breeding age and longevity. Both males and females attain sexual maturity within the first year of life. From 75% to 100% of first-year females attempt to breed (Bump et al. 1947). The maximum longevity recorded for a ruffed grouse is 7.8 years (Gullion and Marshall 1968). However, the effective population turnover period is 6.8 years (Johnsgard 1973), and birds older than 5 years are uncommon (Bump et al. 1947). The mean life span is 8.6 months for immatures and approximately 2 years for adults; annual survival rate for adult males is 47% (Gullion and Marshall 1968).

Sex ratios. Sex ratios differ between adults and immatures. The immature sex ratio is approximately equal, whereas 55% to 61% of adults are males (Dorney 1963, Davis and Stoll 1973, Major and Olson 1980).

Recruitment rates. Recruitment of young into the fall population varies annually and differs among regions. Large-scale population declines and slow recovery during cyclic lows result from extremely low recruitment of young (Gullion 1971). Cyclic increases are associated with rates as high as 80% (Dorney 1963). Typical recruitment rates range from 42% to 75% and average 53% (Davis and Stoll 1973). Lower fall recruitment occurs in southern parts of the species range due to smaller brood sizes. Fall populations are composed of 39% to 57% immatures south of latitude 42°3' N, whereas young comprise 63% to 78% of northern populations (Davis and Stoll 1973).

Mortality Factors

The annual mortality rate of adult ruffed grouse averages 50% and ranges from 30% to 60%. Although predation and hunting cause most deaths (Edminster 1954), these factors do not necessarily limit the size and distribution of populations.

Predation. Foxes, goshawks (*Accipiter gentilis*), and great-horned owls (*Bubo virginianus*) are the major predators of ruffed grouse (Bump et al. 1947, Edminster 1954). Predators may account for as much as 80% of the losses in a grouse population. However, predation typically is density dependent (Bump et al. 1947) and rarely acts as a limiting factor to populations (Gullion 1971). Deaths from predation are generally influenced by environmental stress, habitat inadequacies, and social interactions such as the territorial spacing of individuals (Gullion 1971). Intensive predator control has been found to have virtually no effect on the mortality rates of ruffed grouse (Edminster 1947).

Hunting. Legal harvest may account for 25% to 30% of the mortality in ruffed grouse populations, yet hunting is not typically a significant limiting factor. Healthy populations may be able to withstand a 50% harvest without spring densities being affected (Palmer and Bennett 1963). Hunting appears "self-limiting," density dependent, and compensatory with other mortality factors in most populations (Edminster 1954, Gullion and Marshall 1968). However, hunting may depress grouse numbers on areas that receive intensive pressure (Kubisiak 1984).

Environmental stress. Environmental stress is most severe during the winter breeding season. In the North, snow depth and quality are possibly the most important factors affecting annual population fluctuations (Gullion 1971). Winter snow depth of less than 10 to 15 cm (4 to 6 in.) precludes use of snow burrows for roosting and escape cover and may result in increased mortality from severe weather and predation (Bump et al. 1947, Doerr et al. 1974). An ice layer over snow or very soft snow also inhibits burrowing and may reduce survival (Gullion 1971). Cold, wet weather in May and June reduces nesting success and may cause high losses among broods (Edminster 1954).

Parasites and diseases. Diseases that most frequently result in mortality of ruffed grouse include ulcerative enteritis (quail disease), histomoniasis (blackhead), and aspergillosis (Bump et al. 1947). Ruffed grouse are also known to harbor 43 species of helminth and protozoan parasites (Braun and Willers 1967, Davidson et al. 1977) and 16 types of ectoparasites (Edminster 1954). The roundworm *Dispharynx spiralis* occurs in grouse in mixed forest habitats and may cause death by impairment of digestion. The caecal roundworm *Heterakis bonasae* commonly parasitizes grouse in mixed and deciduous forests (Davidson et al. 1977), but it apparently has no effect on survival (Edminster 1954).

Most parasites and diseases afflict chicks and immature birds more frequently, and with greater severity, than adult grouse (Bump et al. 1947, Edminster 1954, Davidson et al. 1977). Nevertheless, parasites and diseases are usually not considered serious limiting factors of ruffed grouse, and their effects are typically density dependent (Edminster 1954).

HABITAT REQUIREMENTS

Throughout its range the ruffed grouse is closely associated with deciduous vegetation. Early seral stages of the Boreal Forest, especially those dominated by aspen, provide essential food and cover, but only limited use is made of coniferous stands in this region (Gullion 1969, 1971; Rusch and Keith 1971b). The deciduous component is also most important in the Northern Mixed Forest; however, coniferous vegetation is apparently of greater value to grouse in this region than in others (Edminster 1954). Many of the early and midseral stages of the Deciduous Forest region provide food and cover, whereas coniferous vegetation is restricted in distribution and rarely utilized (Edminster 1954).

Habitat Components

Basic components of ruffed grouse habitat include open areas, brush, hardwoods, conifers, and mixed woodlands (Edminster 1954). Use of a stand is related to the age and structure of the vegetation, as many habitat requirements of the grouse are similar in all forest regions.

Open areas. Bare ground, roads, meadows, and some types of agricultural land provide areas for sunning and dusting activities (Edminster 1954). Openings also enhance the value of adjacent cover by increasing light penetration and providing some important grouse foods such as clover (Bump et al. 1947, Edminster 1954). Openings are also essential for providing insects during the brood-rearing period.

Brush. Brush species often invade an area after logging or burning and represent a very important seral stage for ruffed grouse. Broods require brush for food and cover throughout the summer; use begins within 1 or 2 years after the brushy area is established and continues until the stand is 7 to 10 years old (Bump et al. 1947, Sharp 1963, Gullion 1977). Brood use of a forest site may increase as much as 3.5- to 7-fold during the 5 to 7 years after the beginning of secondary succession (Sharp 1963). Brushy areas also provide some food and foraging cover during fall, winter, and spring (Edminster 1954).

Hardwoods. Hardwood stands are the most important habitat for ruffed grouse throughout their range. They are used extensively for breeding activities, foraging, and loafing (Bump et al. 1947; Gullion 1971, 1977).

Early hardwood stages are critical in the Boreal Forest (Gullion 1971), where they represent the highest vegetative diversity and are preferred habitat (Godfrey 1975b). The greatest use of aspen begins when a stand is 4 to 12 years old, with stem densities from 14,000 to 20,000/ha (5666 to 8094/ acre). Use continues until the stand is approximately 25 years old and has stem densities of less than 5000/ha (2023/acre) (Gullion 1977). Stands of mature aspen consisting of 30- to 45-year-old trees are required for winter feeding (Gullion 1971, Svoboda and Gullion 1972).

In mixed and deciduous forest regions ruffed grouse utilize both seral and mature hardwood stands for nesting and feeding (Bump et al. 1947, Edminster 1954). Early stages, 10 to 20 years old, are preferred for breeding activities (Gullion 1971).

Conifers. Conifers provide important escape and roosting cover, especially during winter, in the Northern Mixed Forest (Bump et al. 1947). Conifer stands are used for roosting cover in the Boreal Forest (Godfrey 1975b), but these areas are of less importance than hardwood sites for roosting and other activities (Rusch and Keith 1971b).

Mixed woodlands. Forest stands composed of both coniferous and deciduous vegetation are important to grouse in the Northern Mixed Forest (Bump et al. 1947; Edminster 1954; Gullion 1971, 1977). However, mixed woodlands are inferior to deciduous sites in the Boreal Forest; this possibly relates to the higher rate of predation on grouse that occurs where spruce or pine are interspersed with aspen (Rusch and Keith 1971b, Gullion 1977).

Food Habits

Immature and adult ruffed grouse are largely herbivorous; 93% to 97% of the diet is composed of plant parts (Bump et al. 1947, Martin et al. 1951). A variety of grasses, sedges, forbs, and berries are consumed during summer; birds rely on buds, catkins, leaves, fruits, and acorns from fall through spring (Edminster 1954).

Chicks consume 44% to 75% animal matter, primarily insects, for the first month of life (Edminster 1954, King 1969); ants, bees, beetles, grasshoppers, and worms are the most common animal foods in their diet (Bump et al. 1947, Stewart 1956). The amount of plant material consumed by young birds increases during summer and by fall their diet is similar to that of adults (Edminster 1954).

Principal foods. Diets of ruffed grouse differ among the major forest regions with regard to the plant species consumed. However, many of the principal food items throughout grouse range are taxonomically related, and the parts consumed are similar among regions. Aspen and willow constitute major food items through much of the species range; and hophornbeam, hazelnut, and birch are commonly used where available. Plants belonging to the rose family are important foods in many areas. Parts consumed are given in Tables 3 through 5.

Aspen is the primary fall and winter food in the Boreal Forest (Table 3); both quaking aspen and bigtooth aspen are consumed (Svoboda and Gullion 1974). Rose and willow contribute significantly to the fall and winter diets (Phillips 1967, McGowan 1973, Doerr et al. 1974). Fall is a time of food abundance, which is reflected in the diversity of ruffed grouse diets. Clover and other green leafy material and the fruits of *Arctostaphylos*, cranberry, and meadow rue contribute to the fall diet (Beer 1948, Hungerford 1957, Phillips 1967, McGowan 1973). Hazelnut, chokecherry, and juneberry supplement aspen and other foods during winter (Marshall 1946, Phillips 1967, Doerr et al. 1974). Marshall (1946) also noted winter use of *Phacelia* and maple. Salal, willow, dandelions, and ferns were reported in the spring diet of grouse in the southwestern portion of the Boreal Forest (King 1969). The summer diet of ruffed grouse in the Boreal Forest has not been studied extensively, but sedges, salal, and clover are locally important components of the diet (Hungerford 1957, King 1969).

Food habits in the Northern Mixed Forest (Table 4) are similar to those of the Boreal Forest, but seasonal variations in diet are better known. Aspens provide the most important food items from fall through spring (Brown 1946, Bump et al. 1947, Stollberg and Hine 1952). Clover, hazelnut, hawthorn, and apple also contribute to the fall diet (Brown 1946, Bump et al. 1947, Stollberg and Hine 1952). Cherry buds are consumed during winter; birches provide winter and spring food; and blackberry and raspberry are important summer foods (Bump et al. 1947).

Acorns, greenbrier, and hophornbeam are the principal foods (Table 5) from fall through spring in the Deciduous Forest region (Nelson et al. 1938, Gilfillan and Bezdek 1944, Korschgen 1966, Stafford and Dimmick 1979). Other important fall and winter foods include grapes, tick trefoil, Christmas fern, multiflora rose, cherry, sheep sorrel, mountain laurel, and aspen. Leaves and

Table 3. Principal foods of the ruffed grouse in the Boreal Forest region (seasonal importance in the diet is indicated by percent volume and frequency of occurrence)

Food Item	Parts Consumed	Season	Volume (%)	Frequency (%)	Location	Reference
Aspen	Buds, catkins	Fall	23	30	Utah	Phillips 1967
	leaves, twigs		--	16	Alaska	McGowan 1973
		Winter	35	68	Alberta*	Doerr et al. 1974
			--	55	Alaska	McGowan 1973
			--	42	Utah	Phillips 1967
Rose	Fruit	Fall	--	65	Alaska	McGowan 1973
			29	15	Utah	Phillips 1967
		Winter	--	27	Alaska	McGowan 1973
			5	14	Alberta*	Doerr et al. 1974
Willow	Buds and twigs	Fall	--	18	Alaska	McGowan 1973
		Winter	--	61	Alaska	McGowan 1973
			29	48	Alberta*	Doerr et al. 1974
Clover	Leaves	Fall	--	25-75	Idaho	Hungerford 1957
			12	5	Montana	Beer 1948
			--	47-93	Idaho	Hungerford 1957
Arctostaphylos spp.	Fruit	Fall	49	14	Montana	Beer 1948
			--	8	Alaska	McGowan 1973
Cranberry	Fruit	Fall	--	31	Alaska	McGowan 1973
Meadow rue	Fruit	Fall	12	22	Utah	Phillips 1967
Chokecherry	Fruit	Winter	--	92	Utah	Phillips 1967
Juneberry	Fruit	Winter	5	10	Alberta*	Doerr et al. 1974
Hazelnut	Catkins	Winter	4	12	Alberta*	Doerr et al. 1974
Sedges	Seeds	Summer	--	11-63	Idaho	Hungerford 1957
Unidentified plants	Leaves	Fall	--	16-59	Idaho	Hungerford 1957

* Alberta, Canada.

Table 4. Principal foods of the ruffed grouse in the Northern Mixed Forest region (seasonal importance in the diet is indicated by percent volume and frequency of occurrence)

Food Item	Parts Consumed	Season	Volume (%)	Frequency (%)	Location	Reference
Aspen	Buds, catkins, leaves	Fall	29	49	Wisconsin	Stollberg and Hine 1952
		Winter	55	70	Maine	Brown 1946
			16	--	New York	Bump et al. 1947
		Spring	71	74	Maine	Brown 1946
			20	--	New York	Bump et al. 1947
		Summer	12	--	New York	Bump et al. 1947
Birch	Buds, catkins	Winter	14	--	New York	Bump et al. 1947
		Spring	16	--	New York	Bump et al. 1947
Clover	Leaves	Fall	21	78	Wisconsin	Stollberg and Hine 1952
			13	50	Maine	Brown 1946
Hawthorn	Fruit	Fall	12	--	New York	Bump et al. 1947
			11	11	Maine	Brown 1946
Hazelnut	Buds, catkins	Fall	15	30	Maine	Brown 1946
Apple	Fruit	Fall	11	13	Maine	Brown 1946
Cherry	Buds	Winter	17	--	New York	Bump et al. 1947
Rubus spp.	Fruits	Summer	29	--	New York	Bump et al. 1947

Table 5. Principal foods of the ruffed grouse in the Temperate Deciduous Forest region (seasonal importance in the diet is indicated by percent volume and frequency of occurrence)

Food Item	Parts Consumed	Season	Volume (%)	Frequency (%)	Location	Reference
Oak	Acorns	Fall	21	66	Missouri	Korschgen 1966
			11	--	Ohio	Gilfillan and Bezdek 1944
		Spring	11	37	Missouri	Korschgen 1966
Greenbrier	Fruits and leaves	Fall	16	--	Virginia	Nelson et al. 1938
		Fall/winter	20	--	Tennessee North Carolina	Stafford and Dimmick 1979
		Winter	15	62	Ohio	Gilfillan and Bezdek 1944
Hophornbeam	Buds and catkins	Winter	24	27	Missouri	Korschgen 1966
		Spring	17	29	Missouri	Korschgen 1966
Grape	Fruit	Fall	26	--	Missouri	Korschgen 1966
Tick trefoil	Seeds	Fall	19	59	Missouri	Korschgen 1966
Cherry	Leaves, buds, and twigs	Fall	12	23	Pennsylvania	Kuhn 1940
Sheep sorrel	Leaves	Fall	12	45	Pennsylvania	Kuhn 1940
Mountain laurel	Leaves, buds	Fall/winter	15	--	Tennessee North Carolina	Stafford and Dimmick 1979
Christmas fern	Fronds	Fall/winter	11	--	Tennessee North Carolina	Stafford and Dimmick 1979
Multiflora rose	Fruit	Winter	20	28	Missouri	Korschgen 1966
Aspen	Buds, catkins	Winter	14	29	Ohio	Gilfillan and Bezdek 1944
Ladies' tobacco	Leaves, flowers	Spring	14	27	Missouri	Korschgen 1966
Sedges	Seeds	Summer	10	75	Missouri	Korschgen 1966
Unidentified plants	Leaves	Spring	17	32	Missouri	Korschgen 1966
		Summer	58	82	Missouri	Korschgen 1966

flowers of ladies' tobacco and other leafy material complement other spring foods; sedges and a variety of leaves compose the bulk of the summer diet (Korschgen 1966).

Critical and preferred foods. Information pertaining to the critical foods and dietary preferences of ruffed grouse is available primarily for the Boreal Forest region. Survival of ruffed grouse populations throughout much of the Boreal Forest apparently is vitally related to the winter availability of the staminate buds and catkins of aspen (Gullion 1969). Changes in abundance or quality of bud production may influence densities and may be related to cycles of grouse populations (Svoboda and Gullion 1974). Availability of birch, alder, and hazelnut buds and catkins may also influence grouse population levels (Gullion 1969).

Ruffed grouse prefer clones of male aspens over female aspens and other hardwood species for winter foraging, and quaking aspen is selected at a 2:1 ratio over bigtooth aspen (Svoboda and Gullion 1972). Chokecherry is a locally preferred winter food (Phillips 1967).

Nutrition. Korschgen (1966) determined that ruffed grouse select forage based upon their physiological needs. Foods high in protein (18% to 22%) and mineral content, such as green leafy material and sedge seeds, are selected during summer when protein and mineral needs are greatest for growth and molting. Catkins and buds of hophornbeam, rose fruits, and acorns supply fats and carbohydrates for energy needs and are consumed in greatest quantities in winter when energy requirements are highest (Korschgen 1966).

Aspens provide a highly nutritious winter food (Svoboda and Gullion 1972), and staminate buds are richer in nutrients than vegetative buds (Huff 1970, 1973). Furthermore, ruffed grouse select staminate buds that are larger and higher than average in protein and potassium (Doerr et al. 1974). Willow buds, a common food of grouse in the Boreal Forest, are higher in protein content than aspen, but aspen provides more secure feeding perches, which increases foraging efficiency (Doerr et al. 1974). Consequently, willow is a secondary food, although it has a greater nutrient content than aspen.

Water. Water is available to ruffed grouse in the forms of free-standing water, dew, and succulent vegetation (Bump et al. 1947). No work has demonstrated that grouse must have free water; apparently all water requirements are met by the consumption of dew and foods, many of which are composed of 40% to 70% water (Bump et al. 1947).

Cover

The most critical types of cover for ruffed grouse are those used for foraging, reproduction, and roosting. Breeding cover includes areas suitable for drumming, nesting, and brood rearing. Some cover requirements change seasonally and are related to vegetative composition of the plant community. Many cover needs are similar among grouse populations in all major forest regions.

Foraging cover. Cover types selected for foraging are directly related to the quality and quantity of food items available within a habitat. Three major foraging strata are used by ruffed grouse throughout their range: grasses/forbs, shrubs, and trees. The grass/forb and shrub strata are used most often during summer (Bump et al. 1947, Korschgen 1966), while arboreal feeding begins in fall and continues through spring (Bump et al. 1947, Svoboda and Gullion 1972). Changes in use of foraging cover may be related to availability of buds and catkins (Svoboda and Gullion 1972) or to the covering of herbaceous vegetation by snow (Doerr et al. 1974).

Two classes of hardwoods are used for foraging cover in the Boreal Forest. Aspens, 30 to 45 years old and averaging 12.5 m (approximately 40 ft) in height, are the preferred foraging habitat during fall, winter, and spring throughout much of the region (Gullion 1969, 1971; Svoboda and Gullion 1972; Doerr et al. 1974). Brushy areas of young aspen 1 to 10 years old and up to approximately 8.3 m (27 ft) in height (Gullion 1969, 1971), or mature alder ranging from approximately 3 to 6 m (10 to 20 ft) high (Godfrey 1975b), are used for foraging by broods.

The midseral stages of hardwoods, consisting of species such as aspen and birch, and mixed woodlands provide foraging cover from fall through spring in the Northern Mixed Forest region (Bump et al. 1947, Edminster 1954). The value of hardwood foraging areas is enhanced by the presence of a few conifers, which are used for roosting and escape (Brown 1946, Bump et al. 1947). The primary foraging habitats during summer are the grass/forb stratum of fields, meadows, and orchards, that contain abundant insects and seeds, and the shrub layer of brushy areas and woodlands that provides berries, especially *Rubus* spp. (Brown 1946, Bump et al. 1947, Edminster 1954).

Shrub and tree strata of greenbrier, hophornbeam, and mountain laurel are important foraging areas during fall, winter, and spring within the Temperate Deciduous Forest (Korschgen 1966, Stafford and Dimmick 1979). Oak stands are used when acorns are available (Korschgen 1966), and areas with abundant Christmas fern provide food and excellent foraging cover (Korschgen 1966, Stafford and Dimmick 1979).

Drumming cover. The drumming area is the focal point for breeding activities. Males use drumming platforms for display behavior that serves to establish territories and attract females for mating (Johnsgard 1973). Important aspects of drumming cover are the platform and the adjacent vegetation.

Logs are commonly selected as drumming platforms, but rocks, stumps, or mounds of soil may also be used (Bump et al. 1947, Schemnitz 1976). Species of drumming logs reflect local availability. For example, oaks comprise up to 65% of all drumming logs in deciduous forests (Stoll et al. 1979), whereas 75% of drumming logs in the Boreal Forest may be spruce (Boag and Sumanik 1969). Males may use several drumming logs or platforms within their territories (Bump et al. 1947, Gullion 1967).

The essential features of a drumming platform are a level stage for performance of drumming displays and a position above the ground that affords the male good visibility (Boag and Sumanik 1969, Stoll et al. 1979). Height of the platform above the forest floor averages 0.43 to 0.55 m (1.4 to 1.8 ft) and ranges from 0.30 to 0.64 m (0.98 to 2.1 ft) (Schemnitz 1976, Hale et al. 1982). Diameters of drumming logs average 29.5 to 39.8 cm (11.6 to 15.7 in.) but may be as large as 98 cm (39 in.) (Palmer 1963, Boag and Sumanik 1969, Schemnitz 1976, Stoll et al. 1979). An adequate stage is apparently provided by logs with a diameter of 12.5 to 18.8 cm (4.9 to 7.4 in.) (Palmer 1963, Boag and Sumanik 1969). Drumming logs range from 1.7 to 20.0 m (5.6 to 65.6 ft) in length (Palmer 1963, Hale et al. 1982).

The vegetative characteristics around the platform influence the selection of the drumming site and are more important than the platform itself (Boag and Sumanik 1969; Boag 1976a, 1976b; Stoll et al. 1979). Species composition of a forest stand is seemingly less critical than vegetative structure of shrubs and trees (Boag and Sumanik 1969, Hale et al. 1982). Males typically select sites that are open below but have relatively dense cover at 0.5 to 1.0 m (1.6 to 3.0 ft) or more above the ground (Palmer 1963, Gullion 1972, Hale et al. 1982). Removal of this layer will virtually eliminate use of a site for drumming (Boag 1976b).

Hardwoods, such as aspen and alder, and young conifers compose the most important cover at drumming sites in the Boreal and Northern Mixed Forests

(Bump et al. 1947, Boag and Sumanik 1969, Gullion 1972). Stem densities of woody vegetation 60 cm (24 in.) or more in height range from 50 to 200 within a 4-m (13-ft) radius of the platform (Palmer 1963, Boag and Sumanik 1969, Gullion 1972). Aspen is a common canopy tree within drumming cover (Boag and Sumanik 1969, Gullion 1972), but the amount of canopy coverage is quite variable. Schemnitz (1976) found that males selected drumming sites with more canopy cover (77%) than adjacent areas (65%); by contrast, Boag and Sumanik (1969) stated that males selected sites of 28% canopy cover compared to an average of 40% for the forest stand. A "guard" object such as a tree trunk within 4 m (13 ft) of the platform is a common feature of drumming sites in the Boreal Forest region (Gullion 1972).

Shrubs, especially species of the heath family, provide the required cover of dense vegetation in the 0.5- to 4.0-m (1.6- to 13.1-ft) layer above ground level for drumming sites in the Deciduous Forest region (Hale et al. 1982). Densities of shrubs >1 m (3.3 ft) in height at perennially used drumming sites may exceed those of infrequently used areas by more than 50%, 68 and 41 stems/40.5 sq m (436 sq ft), respectively (Stoll et al. 1979). Drumming cover commonly has little or no high-canopy vegetation, and the presence of aspen stands and guard objects is much less important in the Deciduous Forest region than in the Boreal and Mixed Forests (Stoll et al. 1979). Logs are frequently located on slopes of 25% to 30% in deciduous forest habitats (Stoll et al. 1979, Hale et al. 1982).

Nesting and brood cover. Nests consist of a hollowed-out area on the ground and often are located at the base of a tree or near a rock, stump, or brushpile (Bump et al. 1947, Edminster 1954). Standing water near the nest is a feature common to many nesting sites (Bump et al. 1947), and as much as 43% of the area within 100 sq m (1076 sq ft) of the nest may be covered with water (Maxson 1978a). Midseral stands of hardwoods and conifers are the cover types most frequently used for nesting (Bump et al. 1947, Gullion 1969, Maxson 1978a), although nests have been found in habitats ranging from open fields to mature forest (Bump et al. 1947). Nests are commonly located within 30 m (98 ft) of a habitat edge such as a field or open area (Bump et al. 1947).

Broods make greatest use of early seral, brushy areas (Bump et al. 1947, Stewart 1956, Sharp 1963, Kubisiak 1978), with the exception of broods in Iowa that most frequently used 20- to 50-year-old hardwood stands (Porath and Vohs 1972). Second-growth areas from 1 to 15 years old and overgrown pastures and fields provide the necessary food and cover for broods and are preferred to mature stands in most areas (Bump et al. 1947, Gullion 1972, Kubisiak 1978). In some Boreal Forest regions, broods are often closely associated with aspen stands, which have greater stem densities, more shrub cover, and a larger number of food plants than other habitats (Kubisiak 1978). Berry (*Rubus* spp.) thickets receive heavy use by broods in the Northern Mixed Forest (Bump et al. 1947).

Roosting cover. Roosting cover is most critical for ruffed grouse during winter; birds may seek shelter in trees, especially conifers, or in snow burrows (Bump et al. 1947, Godfrey 1970, Gullion 1971). Burrows, which may be in as little as 10 cm (4 in.) of snow, provide a thermoregulatory advantage over arboreal roosts in areas characterized by winters with heavy snowfall and cold temperatures (Gullion 1971). Snow burrows may be as much as 30° C warmer than surface temperatures of the snow, and burrows in hardwood stands are warmer than those in conifers (Gullion 1971).

Ruffed grouse roost in coniferous or hardwood trees, on logs, or on the ground during spring, summer, and fall (Bump et al. 1947, Edminster 1954). Coniferous trees are commonly sought for roosting cover during extreme heat or heavy precipitation (Edminster 1954).

Other cover needs. Conifers such as hemlock, pine, spruce, and Douglas fir are preferred as escape cover, but brushpiles or dense stands of shrubs may be used (Bump et al. 1947, Edminster 1954). Snow burrowing is also a means to escape or avoid predators (Gullion 1971).

Bare ground or decaying logs may be used for dusting (Bump et al. 1947). Fields, meadows, roads, and brushy habitats in recently burned or logged areas are most frequently selected for sunning and dusting activities (Edminster 1954).

Birds typically loaf in hardwoods or conifers, either in or under the trees, but hardwoods are preferred during spring and summer (Edminster 1954). Factors affecting selection of loafing habitat are obscure (Bump et al. 1947), but they possibly relate to habitats used for other seasonal activities such as breeding or foraging.

MANAGEMENT

Throughout its range the ruffed grouse is dependent on several early and midseral stages of forest succession (Bump et al. 1947, Edminster 1954, Gullion 1977, Stoll et al. 1979). Ruffed grouse management, therefore, is closely related to forestry practices. The principles of grouse management are similar for all forest regions because of the relationship of ruffed grouse to habitat structure.

The goal of management should be to maintain the proper quality, quantity, and interspersion of seral stages through the manipulation of plant succession. The manager must identify those requirements that are available in least supply and determine the vegetative trends of an area. Corrective measures in the form of manipulating forest succession should then be taken. Techniques such as cutting, burning, and grazing may be used to set back or retard succession. Plantings and selective thinning of trees are useful to advance the successional stage of an area.

The Management Unit

Ruffed grouse inhabit areas ranging from woodlots surrounded by agricultural lands to extensive forests. In some areas, such as small woodlands or managed forests, it may be necessary to provide for only a few habitat needs if surrounding areas provide the other essentials. Management for all habitat requirements may be needed in unmanaged forests and on small areas if adjacent vegetation is unsuitable. The size of the management unit depends upon the nature and size of the management area and the types of habitat needs that must be fulfilled.

One of the most important principles of grouse management is the optimization of edge effect. Intensive management of all habitat requirements should be guided toward providing all necessary seral stages within the minimum-sized management unit. For the management of total food and cover needs of ruffed grouse, the minimum unit size should be 10 to 16 ha (25 to 40 acres) (Edminster 1954, Gullion 1977). Management of extensive tracts of forest may be based on management units of 64 ha (160 acres) spaced 4.8 to 6.4 km (3 to 4 miles) apart (Hale and Dorney 1963). Minimum sizes of management units for specific habitat requirements range from 0.1 ha (0.25 acre) for brood foraging habitat to 2.4 to 4.0 ha (6 to 10 acres) for drumming habitat of territorial males (Sharp 1963, Gullion 1977).

Habitat management expressly for ruffed grouse may be beneficial to many other early and midseral species of birds and mammals. Some components of ruffed grouse habitats are utilized by moose (*Alces alces*), elk (*Cervus* *elaphus*), white-tailed deer (*Odocoileus virginianus*), black bears (*Ursus americanus*), gray wolves (*Canis lupus*), beavers (*Castor canadensis*), and snowshoe hares (*Lepus americanus*) (Gullion 1977). Woodcock (*Philohela minor*) and a variety of forest-dwelling passerines may also be managed in conjunction with ruffed grouse (Gullion 1977).

Management Practices

Management techniques for ruffed grouse primarily involve methods to manipulate plant succession. Common practices such as cutting, planting, burning, and grazing may be integrated with other aspects of forest management. The following practices may be used to manage for the total cover needs of ruffed grouse, or they may be applied to the management of specific requirements, such as maintenance of brood habitat.

Cutting. Timber cutting may be in the form of (1) selective harvest or (2) rotational clearcutting of blocks or strips of woody vegetation (Edminster 1954). Both extensive cutting of more than 16 ha (40 acres) and total protection of a forest area from cutting are detrimental to ruffed grouse (Bump et al. 1947, Gullion 1977).

Gullion (1977) recommended several alternative cutting schemes, based on 16-ha (40-acre) management units, for aspen-dominated sites in the Boreal Forest. These include: (1) rotational cutting of 4 ha (10 acres) every 10 to 15 years; (2) cutting of a 1-ha (2.5-acre) block in every 4-ha (10-acre) area every 10 to 12 years; and (3) a 0.4-ha (1-acre) cut every year. All of these alternatives provide a 40-year rotation. No more than 5% to 10% of the canopy should remain after cutting, and brush, slash, and other debris should be removed or burned to encourage regeneration of vegetation and to reduce predator cover (Gullion 1977).

Mixed and deciduous forests may be harvested on a 50- to 150-year rotation (Bump et al. 1947, Edminster 1954). Small clearcuts should be made on about 10% of an area every 10 to 15 years; cuts should be spaced approximately 366 to 488 m (1200 to 1600 ft) apart (Bump et al. 1947). In uniform forest stands, strips of trees 4.6 to 9.2 m (15 to 30 ft) wide may be cut to provide early seral stages adjacent to woody cover (Edminster 1954). Shrub thickets should be protected during the cutting (Bump et al. 1947, Hale et al. 1982).

Cutting may be used specifically to enhance brood habitat and food production. Selective thinning of oak stands can extend the crown canopy and result in increased acorn production (Korschgen 1966). Brushy cover can be developed by cutting trees along a 7.6- to 9.2-m-wide (25- to 30-ft-wide) border where fields or pastures adjoin woodlots. Continued cutting is often required because of persistent resprouting by some hardwoods (Edminster 1954). Brood habitat may be developed in extensive forest stands by clearcutting blocks of 0.1 to 0.4 ha (0.25 to 1.0 acre); 4 to 6 openings/100 ha (250 acres) should be made each year, and sites should be recut every 7 to 8 years (Sharp 1963).

Plantings. The production of desirable plant species for grouse is generally achieved by manipulation of succession, but plantings may be used to advance the successional stage of an area or to provide one or more essential elements of cover that are lacking.

Legumes, especially clover, and grasses are commonly seeded in openings created by cutting or burning to provide food (King 1937, Stollberg and Hine 1952, Hungerford 1957, Korschgen 1966). Plantings of species such as multiflora rose, hawthorn, hazelnut, rose, and grape may be used to create brushy areas adjacent to woodland habitats (Edminster 1954, Korschgen 1966). Shrubs should be planted approximately 0.6 to 1.2 m (2 to 4 ft) apart in 4 or 5 rows (Edminster 1954).

Plantings of pines and spruces are often compatible with ruffed grouse management in the Northern Mixed Forest. However, extensive areas of even-aged conifer stands are of little value to grouse. Plantings of coniferous species should be no more than 183 m (600 ft) wide and should comprise no more than 40% of an area (Bump et al. 1947). Hardwoods such as oaks or maple should be planted among the coniferous species, and hardwood stands approximately 90 m (300 ft) wide should adjoin the strips or blocks of conifers (Bump et al. 1947, Edminster 1954). A full discussion of procedures used for plant selection, seedling preparation, planting, and maintenance is provided in Bump et al. (1947).

Burning. Controlled burning of small areas is an inexpensive method of creating openings in a forest stand to increase edge. Burning results in abundant regrowth of vegetation, improves nutrient quality of plants, and reduces litter on the forest floor (Gullion 1971). Fire is best used to manipulate early seral stages because young trees are more susceptible to fire damage (Gullion 1977). Burning should be conducted on areas of 4 ha (10 acres) or less and need be repeated only every 20 to 25 years in Boreal

Forest regions (Gullion 1971). Bump et al. (1947) and Edminster (1954) recommended protection of mature forest stands from burning.

Grazing. The effects of livestock grazing on the quality of ruffed grouse habitat vary with intensity of utilization. Moderate grazing may be used to create openings in thickly vegetated herbaceous stands and to maintain brushy stages by retarding forest succession (Bump et al. 1947).

Heavy grazing may greatly reduce herbaceous and brushy vegetation (Edminster 1954) and may alter the composition of shrub species (Weatherkill and Keith 1969). Destruction of brushy cover, especially along riparian zones, may eliminate critical brood habitat and is the most detrimental aspect of heavy livestock use (Hungerford 1957, Edminster 1954). Brushy and woodland habitats should be fenced and protected from heavy grazing where these areas compose a relatively small amount of the cover available to ruffed grouse (Bump et al. 1947). Fencing of brushy areas, particularly in riparian habitat, may be used to protect brood cover; Hungerford (1957) suggested 4 or 5 fenced enclosures of 25 sq m (270 sq ft) for each 2.6 sq km (1 sq mile).

Grazing apparently has the least effect on drumming habitat. Weatherkill and Keith (1969) found that heavy grazing reduced the amount of herbaceous vegetation and resulted in the replacement of hazelnut and dogwood with willow and alder, but these changes had little influence on the density of drumming males. Elimination of woody vegetation, however, would probably render sites useless for drumming activities (Boag 1976b).

Other methods. Some other techniques to slow or set back succession include bulldozing, application of herbicides, and girdling of trees. Bulldozing has been recommended as a means to increase herbaceous foods and some types of shrub cover (Korschgen 1966). However, Gullion (1977) found very poor regeneration of aspen after bulldozing experimental plots and did not suggest this technique for Boreal Forest areas. Poisoning and girdling are inexpensive techniques that may be used to kill trees. The chief drawback of these methods is that dead trees are left in place, which inhibits the response of saplings (Bump et al. 1947, Gullion 1977). In addition, herbicides may be detrimental to some components of grouse cover and other species of forest wildlife (Edminster 1954, Gullion 1977).

CENSUS AND SAMPLING

Information about population trends and habitat variables is essential for proper grouse management. Censusing furnishes estimates of size, structure, and distribution of grouse populations. These data may be used to set harvest regulations and make other management decisions. Data collected from vegetation sampling provide the basis for determining suitability of sites for ruffed grouse, evaluating effects of habitat management programs, and predicting impacts created by habitat manipulation.

Population Estimates

Inventory data, such as the number and distribution of birds and the size and number of broods, provide information about grouse abundance and population trends and can be used to predict fall populations. Methods such as drumming-male censuses and roadside-drumming counts indicate annual and long-term grouse density and abundance, respectively, whereas brood counts reflect both population size and productivity. Recommended methods differ according to the size of the area to be censused.

Census of drumming males. A census of drumming males provides the best estimate of size of the breeding population on areas of 400 to 4000 ha (1000 to 10,000 acres) and may be used on smaller units (Gullion 1966). Locations of drumming males are determined by a thorough search of the area with at least 4 replications (Bump et al. 1947). Physical sign, such as piles of droppings near logs, can be used to identify sites of male activity (Gullion 1966). The census should be conducted on calm, rain-free days over a period of approximately 4 weeks during peak drumming (Gullion 1966). The best time of day for censusing is during the 2 periods of most intense drumming: (1) 2 hours before sunset, and (2) from 30 minutes before sunrise until 2 hours afterward (Hungerford 1953, Petraborg et al. 1953, Gullion 1966). The breeding population size is commonly estimated by doubling the number of drumming males on an area; however, the spring sex ratio and the number of non-drumming males should be determined to increase the accuracy of this procedure (Gullion 1966).

Roadside drumming counts. Counts of drumming males along established road transects have been used extensively as indices to abundance but cannot be used for density estimates (Hungerford 1953, Petraborg et al. 1953, Dorney et al. 1958, Gullion 1966). This method is best applied as a regional or statewide index and may be inaccurate on areas smaller than 4000 ha (10,000 acres) (Gullion 1966). The procedure involves morning and evening counts of drumming males at stations located approximately 0.8 km (0.5 mile) apart along a road transect. One to 3 counts should be made on calm, clear days during peak drumming (Hungerford 1953, Petraborg et al. 1953, Gullion 1966). After the arrival of an observer at a station, 3 minutes should be allowed before counting is initiated (Petraborg et al. 1953, Hungerford 1953). Males should be counted for 4 minutes at each station.

Other measures of abundance and density. Spring mail-carrier counts, hunting reports by cooperators, and hunting kill estimates from mail surveys are the most accurate and efficient means to survey large areas for ruffed grouse (Ammann and Ryel 1963). Reports of numbers of birds flushed by squirrel hunters have been found to serve as a reliable index to grouse abundance (Stoll 1980). Strip censuses (King 1937) were previously used to determine densities but are now considered too time-consuming for use on large areas, and the error is unacceptable to some workers (Amman and Ryel 1963).

Brood counts. Complete searches for broods by 2 or more field workers (aided by trained dogs) should be conducted during June, July, and August (Edminster 1954). Brood size and number of broods should be recorded. Approximately 20 ha (50 acres) per day can be searched by each worker. Brood counts may underestimate the population; therefore, observations should be correlated to densities recorded for an area. Godfrey (1975a) suggested that correction factors should be developed for specific areas; he used a multiplier of 1.9 to estimate brood sizes for a study area in Minnesota.

The efficiency of brood counts may be increased 4-fold with the use of tape-recorded distress calls of chicks (Healy et al. 1980). This method involves use of census stations located 150 m (492 ft) apart, at which distress calls are played for 4 to 5 minutes and numbers of chicks and hens sighted are recorded (Healy et al. 1980).

Trapping and Marking

Trapping and marking of ruffed grouse may be used to estimate sex and age ratios of the population, to obtain an indication of grouse abundance, and to provide information about mortality rates, movements, and habitat use. Methods appropriate for analysis of mark-recapture data include the Lincoln Index and Schnabel, Schumacher-Eschmeyer, and Jolly techniques.

Three methods were designed or adapted specifically for the capture of these birds. A cage trap containing a mirror opposite the entrance and placed on the drumming platform is an efficient method for capturing territorial males (Chambers and English 1958). A lift net placed over the drumming platform and operated by an observer may also be used to catch males during the breeding season (Fischer 1974). All sex and age groups may be caught with "cloverleaf" traps from fall through spring (Gullion 1965).

Tagging with colored, anodized aluminum leg bands is one of the best methods for marking grouse, and as many as 4 bands per bird may be used without impeding activity (Gullion 1965). Back tags are not recommended because they may reduce survival by as much as 50% (Gullion et al. 1962). Use of coloring agents is an effective, although short-term, technique to mark chicks (Gullion et al. 1962). Radio telemetry methods to mark and study grouse were adapted for grouse research by Marshall and Kupa (1963).

Habitat Variables

Composition and structural characteristics of shrubs and trees greatly affect the quality of habitat for foraging, drumming, nesting, brooding, roosting, and escape. Features of herbaceous vegetation influence foraging and brood cover. Vegetation sampling is necessary to determine whether the proper food plants and cover requirements occur within an area and to identify inadequate habitat components. Attributes of woody and herbaceous vegetation that should be ascertained include species composition, age, stem density, height, and percent cover.

SOURCES OF INFORMATION

Major books dealing exclusively with the ruffed grouse are The Ruffed Grouse: Life History, Propagation, Management (Bump et al. 1947) and The Ruffed Grouse: Its Life History, Ecology and Management (Edminster 1947). Extensive summaries of the biology of the species are contained in American Game Birds of Field and Forest (Edminster 1954) and Grouse and Quails of North America (Johnsgard 1973). More than 500 references for the ruffed grouse are contained in a bibliography by Moulton and Vanderschaegen (1974). Another important reference is Ruffed Grouse Management: State of the Art in the Early 1980's , edited by Robinson (1984).

Reports made by state biologists for programs funded under the Federal Aid in Wildlife Restoration Projects, Pittman-Robertson funds, are summarized in bibliographies available from:

Denver Public Library
Fish and Wildlife Reference System
3840 York Street
Denver, CO 80205

Information contained in each citation includes: author(s), title, subtitles, publisher, date and length of publication, Federal Aid Project number, key words, and geographic location of work. Bibliographies may be obtained by U.S. Fish and Wildlife Service offices without charge and are available to other agencies for a nominal fee. Copies of the reports may be obtained from the authors or agencies conducting the work.

The private organization most highly involved in the management of the ruffed grouse and dissemination of information about the species is:

The Ruffed Grouse Society
1400 Lee Drive
Coraopolis, PA 15108

This organization will assist in consultations about specific management procedures.

LITERATURE CITED

Aldrich, J. W., and A. J. Duvall. 1955. Distribution of American gallinaceous game birds. U.S. Fish and Wildl. Serv. Circ. 34. 23 pp.

American Ornithologists' Union. 1957. Check-List of North American Birds. Port City Press, Baltimore. 691 pp.

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

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

__________. 1976. Spring drumming patterns of ruffed grouse. Auk 93:808-829.

Beer, J. R. 1948. Notes on the food habits of some western grouse. Murrelet 29:18-20.

Boag, D. A. 1976a. Influence of changing grouse density and forest attributes on the occupancy of a series of potential territories by male ruffed grouse. Can. J. Zool. 54:1727-1736.

__________. 1976b. The effect of shrub removal on occupancy of ruffed grouse drumming sites. J. Wildl. Manage. 40:105-110.

__________, 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. Pa. Game News 17:6-7.

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

Braun, C. E., and W. B. Willers. 1967. The helminth and protozoan parasites of North American grouse (family: Tetraonidae): A checklist. Avian Dis. 72:241-245.

Brown, C. P. 1946. Food of Maine ruffed grouse by seasons and cover types. J. Wildl. Manage. 10:17-28.

Bump, G., R. W. Darrow, F. C. Edminster, and W. F. Crissey. 1947. The Ruffed Grouse: Life History, Propagation, Management. New York State Conserv. Dep., Albany. 815 pp.

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

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

Davidson, W. R., G. L. Doster, S. R. Pursglove, Jr., and A. K. Prestwood. 1977. Helminth parasites of ruffed grouse (*Bonasa umbellus*) from the Eastern United States. Proc. Helminthol. Soc. Wash. 44:156-161.

Davis, J. A. 1968. The postjuvenal wing and tail molt of the ruffed grouse (*Bonasa umbellus monticola*) in Ohio. Ohio J. Sci. 68:305-312.

__________. 1969. Aging and sexing criteria for Ohio ruffed grouse. J. Wildl. Manage. 33:628-636.

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

Doerr, P. D., L. B. Keith, D. H. Rusch, and C. A. Fisher. 1974. Characteristics of winter feeding aggregations of ruffed grouse in Alberta. J. Wildl. Manage. 38:601-615.

Dorney, R. S. 1963. Sex and age structure of Wisconsin ruffed grouse populations. J. Wildl. Manage. 27:599-603.

__________, and C. Kabat. 1960. Relation of weather, parasitic disease, and hunting to Wisconsin ruffed grouse populations. Wis. Conserv. Dep. Tech. Bull. 20. 64 pp.

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

Edminster, F. C. 1947. The Ruffed Grouse, Its Life History, Ecology and Management. MacMillan, New York. 385 pp.

__________. 1954. American Game Birds of Field and Forest. Castle Books, New York. 490 pp.

Eng, R. L. 1959. A study of the ecology of male ruffed grouse (*Bonasa umbellus* L.) on the Cloquet Forest Research Center, Minnesota. Ph. D. Thesis. Univ. of Minn., Minneapolis. 119 pp.

Fischer, C. A. 1974. A lift net for capturing male ruffed grouse. J. Wildl. Manage. 38:149-151.

Gilfillan, M. C., and H. Bezdek. 1944. Winter foods of the ruffed grouse in Ohio. J. Wildl. Manage. 8:208-210.

Godfrey, G. A. 1970. Snow roosting behavior of immature ruffed grouse. Auk 87:578-579.

__________. 1975a. Underestimation experienced in determining ruffed grouse brood size. J. Wildl. Manage. 39:191-193.

__________. 1975b. Home range characteristics of ruffed grouse broods in Minnesota. J. Wildl. Manage. 39:287-298.

__________, and W. H. Marshall. 1969. Brood break-up and dispersal of ruffed grouse. J. Wildl. Manage. 33:609-620.

Graham, S. A., and G. S. Hunt. 1958. A non-cyclic ruffed grouse population near Ann Arbor, Michigan. J. Wildl. Manage. 22:427-432.

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

__________. 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. Proc. Midwest Wildl. Conf. 31. 7 pp.

__________. 1971. Factors influencing ruffed grouse populations. Trans. N. Am. Wildl. and Nat. Resour. Conf. 35:93-105.

Gullion, G. W. 1972. Effect of logging upon ruffed grouse in Minnesota forests. Minn. Agric. Exp. Sta. Misc. Rep. 116:32-34.

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

__________, R. L. Eng, and J. J. Kupa. 1962. Three methods for individually marking ruffed grouse. J. Wildl. Manage. 26:404-407.

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

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

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

__________, R. F. Wendt, and G. C. Halazon. 1954. Sex and age criteria for Wisconsin ruffed grouse. Wis. Conserv. Dep. Tech. Wildl. Bull. 9. 24 pp.

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

Huff, D. E. 1970. A study of selected nutrients in browse available to ruffed grouse. M.S. Thesis. Univ. of Minn., St. Paul. 72 pp.

__________. 1973. A preliminary study of ruffed grouse-aspen nutrient relationships. Ph. D. Thesis. Univ. of Minn., St. Paul. 160 pp.

Hungerford, K. E. 1953. A ruffed grouse drumming count technique for northern Idaho conditions. Univ. of Idaho For., Wildl., and Range Exp. Sta. Res. Note 10. 3 pp.

__________. 1957. Evaluating ruffed grouse foods for habitat improvement. Trans. N. Am. Wildl. Conf. 22:380-394.

Johnsgard, P. A. 1973. Grouse and Quails of North America. Univ. of Nebr. Press, Lincoln. 553 pp.

__________. 1975. North American Game Birds of Upland and Shoreline. Univ. of Nebr. Press, Lincoln. 183 pp.

Keith, L. B. 1963. Wildlife's Ten Year Cycle. Univ. of Wis. Press, Madison. 201 pp.

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

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.

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

Kubisiak, J. F. 1978. Brood characteristics and summer habitats of ruffed grouse in central Wisconsin. Wis. Dep. Nat. Resour. Tech. Bull. 108. 11 pp.

Kubisiak, J. F. 1984. The impact of hunting on ruffed grouse populations in the Sandhill Wildlife Area. Pages 151-168 In W. L. Robinson, ed. Ruffed Grouse Management: State of the Art in the Early 1980's. North Central Section, The Wildl. Soc. 181 pp.

Kuhn, T. M. 1940. Fall foods of the ruffed grouse in Pennsylvania. Pa. Game News 11:4-5,31.

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

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

Marshall, W. H. 1946. Cover preferences, seasonal movements, and food habits of Richardson's grouse and ruffed grouse in southern Idaho. Wilson Bull. 58:42-52.

__________, and J. J. Kupa. 1963. Development of radio-telemetry techniques for ruffed grouse studies. Trans. N. Am. Wildl. Conf. 28:443-456.

Martin, A. C., H. S. Zim, and A. L. Nelson. 1951. American Wildlife and Plants. McGraw-Hill, New York. 500 pp.

Maxson, S. J. 1977. Activity patterns of female ruffed grouse during the breeding season. Wilson Bull. 89:439-455.

__________. 1978a. Growth and behavior of ruffed grouse chicks. Loon 50:106-112.

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

McColm, M. 1970. Ruffed grouse. Nev. Outdoors 4:27.

McGowan, J. D. 1973. Fall and winter foods of ruffed grouse in interior Alaska. Auk 90:636-640.

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

Moulton, J. C., and P. V. Vanderschaegen. 1974. Bibliography of the ruffed grouse. Wis. Dep. Nat. Resour. 31 pp.

Nelson, A. L., T. E. Clarke, and W. W. Bailey. 1938. Early winter food of ruffed grouse on the George Washington National Forest. U. S. Dep. Agric. Circ. 504. 37 pp.

__________, and A. C. Martin. 1953. Gamebird weights. J. Wildl. Manage. 17:36-42.

Palmer, W. L. 1956. Ruffed grouse population studies on hunted and unhunted areas. Trans. N. Am. Wildl. Conf. 21:338-344.

__________. 1959. Sexing live-trapped juvenile ruffed grouse. J. Wildl. Manage. 23:111-112.

__________. 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 hunting harvest of 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.

Phillips, R. L. 1967. Fall and winter food habits of ruffed grouse in Utah. J. Wildl. Manage. 31:827-829.

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

Robinson, W.L., ed. 1984. Ruffed Grouse Management: State of the Art in the Early 1980's. North Central Section, The Wildl. Soc. 181 pp.

Rodgers, R. D. 1979. Ratios of primary calamus diameters for determining age of ruffed grouse. Wildl. Soc. Bull. 7:125-127.

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

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

__________, and __________. 1971b. Ruffed grouse-vegetation relationships in central Alberta. J. Wildl. Manage. 35:417-429.

Schemnitz, S. D. 1976. Characteristics of Maine ruffed grouse drumming sites. Res. Life Sci. 23:1-6.

Sharp, W. M. 1963. The effects of habitat manipulation and forest succession on ruffed grouse. J. Wildl. Manage. 27:664-671.

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

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

Stoll, R. J., Jr. 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.

Stollberg, B. P., and R. L. Hine. 1952. Food habits of ruffed grouse, pheasant, quail and mink in Wisconsin. Wis. Conserv. Dep. Tech. Bull. 4:6-12.

Svoboda, F. J., and G. W. Gullion. 1972. Preferential use of aspen by ruffed grouse in northern Minnesota. J. Wildl. Manage. 36:1166-1180.

__________, and __________. 1974. Techniques for monitoring ruffed grouse food resources. Wildl. Soc. Bull. 2:195-197.

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

Tuck, L. M. 1968. Recent Newfoundland bird records. Auk 85:304-311.

Weatherkill, R. G., and L. B. Keith. 1969. The effect of livestock grazing on an aspen forest community. Alberta Dep. Lands For. Tech. Bull. 1. 31 pp.

APPENDIX A: COMMON AND SCIENTIFIC NAMES OF PLANTS MENTIONED IN TEXT

Common Name	Scientific Name
Alder	*Alnus* spp.
Apple	*Malus* spp.
Aspen	*Populus* spp.
Bigtooth aspen	*P. grandidentata*
Quaking aspen	*P. tremuloides*
Beech	*Fagus* spp.
Birch	*Betula* spp.
Blackberry	*Rubus* spp.
Cherry	*Prunus* spp.
Chokecherry	*P. virginiana*
Christmas fern	*Polystichum acrostichoides*
Clover	*Trifolium* spp.
Cranberry	*Viburnum edule*
Dandelion	*Taraxacum* spp.
Dogwood	*Cornus* spp.
Douglas fir	*Pseudotsuga menziesii*
Fir	*Abies* spp.
Grape	*Vitis* spp.
Greenbrier	*Smilax* spp.
Hawthorn	*Crataegus* spp.
Hazlenut	*Corylus* spp.
Hemlock	*Tsuga* spp.
Hickory	*Carya* spp.
Hophornbeam	*Ostrya virginiana*
Juneberry	*Amelanchier alnifolia*
Ladies' tobacco	*Antennaria* spp.
Maple	*Acer* spp.
Meadow rue	*Thalictrum fendleri*
Mountain laurel	*Kalmia latifolia*
Oak	*Quercus* spp.
Pine	*Pinus* spp.

(Continued)

APPENDIX A (Concluded)

Common Name	Scientific Name
Raspberry	*Rubus* spp.
Rose	*Rosa* spp.
Multiflora rose	*R. multiflora*
Salal	*Gaultheria shallon*
Sedge	*Carex* spp.
Sheep sorrel	*Oxalis* spp.
Spruce	*Picea* spp.
Tick trefoil	*Desmodium* spp.
Willow	*Salix* spp.