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Ecology and Management of Ruffed Grouse

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INTRODUCTION

The ruffed grouse (Bonasa umbellus Linn.) has been shot, snared, hunted for market, and even bountied since early colonial times in North America. Despite this level of exploitation and resulting broad interest, research into the natural history of this species was not begun until the early 1900's. Subsequent research has been conducted principally in the eastern and north-central states which form the core of the species' range in the United States. These studies have documented a strong association of this bird with hardwood forest communities.

This report summarizes literature published through July 1980 on the ecology and population dynamics of the ruffed grouse with emphasis on habitat utilization. Current research and management techniques are discussed.

The intent of this report is to provide a readily available source of information on this species. While data presented should suffice as a basis for making initial appraisals of the impact of habitat alterations on the ruffed grouse and in the formulation of preliminary management plans for this species, pertinent literature should be reviewed before impact analyses or management plans are finalized. A listing of literature is presented at the end of the manuscript.

A version of this report which includes more complete in-text literature citations is available from the Intermountain Forest and Range Experiment Station - USDA, Ogden, Utah.

Drumming and Breeding Behavior

Drumming behavior exhibited by the breeding male segment of the population acts as a low-cost, high benefit territorial display which results in a stable spatial organization of a restricted number of breeding males. Boundaries of drumming territories are delineated by natural features and the location of other drumming males, with density of breeding males dependent both on quality of habitat and social tolerance. Areas where male home ranges overlap are used at different times by neighboring males and apparently do not contain any important resources which are unavailable in the exclusive portions of the individual home ranges.

Spring drumming, which generally peaks between mid-April and mid-May, also serves to attract females for breeding. In Utah, drumming begins in late April to early May and peaks in mid-May while in Minnesota, the peak generally occurs within 3 days of 29 April. While Gullion (1966) felt that the peak in drumming activity was probably independent of plant phenology in Minnesota, the peak in drumming coincided closely with elongation of willow (*Salix* spp.) catkins in Idaho and aspen and chokecherry (*Prunus virginianus*) leaf sprouting in Utah. Low temperatures and heavy rainfall may restrict drumming activity, and an early snowmelt and temperatures ranging from 26°F to 36°F may stimulate drumming.

Individual males are generally closely associated with their drumming logs throughout the spring, and more loosely associate with them in the summer and fall. Fall densities of males associated with drumming logs may approach that of the breeding season. Juvenile males may become associated with a drumming log as early as their first fall or the following spring.

Gullion (1967) found that non-drumming and subdominant drumming males were occasionally found associated with sites of drumming logs occupied by dominant males. Additionally, some non-drumming males are not associated with any definite centers of drumming activity. Although little is known about densities of non-breeding males in the spring, research in Alberta indicated that between 23 percent and 42 percent of males did not establish territories. Thirty-three percent of males in Wisconsin and 50 percent of male ruffed grouse in Minnesota do not breed. The proportion of non-breeding females in a population was estimated to be 25 percent in New York and 50 percent in Alberta. Doerr et al. (unpub. in Fischer and Keith 1974) reported that over a 6-year period, 22 percent to 29 percent of females did not breed.

Adult females actively seek out drumming males at drumming activity centers and form a transitory pair-bond which seldom lasts longer than a few hours. Since the males continue drumming after copulating with a female and hens have been recorded in the territories of several drumming males prior to egg laying, it is assumed that the breeding pattern is promiscuous.

Nesting and Dispersal

Female reproductive activity begins 3 to 7 days before the first egg is laid. Estrus lasts 3 to 5 days in individual hens with the peak of estrus synchronized with the peak of drumming. Two eggs are laid every 3 days, allowing 17 days for completion of an average clutch of 11.5 eggs. Eggs are laid at intervals of 25 to 30 hours, and the hen remains at the nest site only for the period required to lay the egg. Incubation starts after the last egg is laid and continues for 23 to 24 days. Hatching generally occurs between late May and early June. As incubation progresses, the female becomes increasingly attentive to her nest, ultimately spending over 95 percent of her time on the nest. Toward the end of the incubation period, she leaves only for feeding 2 or 3 times per day for less than 18 to 24 minutes at a time.

Home Range and Movement Patterns

During mating and nest building, the hen travels within an area 5.8 ha to 22.9 ha in size ($\bar{x}$ = 12.1 ha). During egg laying, her activities are restricted to an area averaging 8.4 ha in size. Her mobility is further curtailed during incubation to an area averaging 0.9 ha. Archibald (1975) reported home range size prior to hatching to be 16.5 ha.

Hens and broods cover the major portion of their summer home range during the first 10 days after hatching. As the summer progresses, hens with broods concentrate movements in smaller, well defined portions of their summer home range. Habitat conditions generally dictate the mean size of home ranges used by individual hens with broods. Small home ranges are characteristically found in areas with localized, widely separated patches of suitable habitat, or in areas with highly interspersed habitat types. Patterns of brood movement are related not only to the quality of the habitat but to physiographical features as well. Probability of encountering broods in particular areas is directly related to the frequency with which the area is utilized, and, therefore, frequency of encounters should indicate relative preference for certain habitat types. Godfrey (1975a) and Bump et al. (1947:259) suggested that lack of competition from neighboring hens and broods at low population densities would result in utilization of only preferred habitat. However, observations by Kubisiak (1978) indicated that population level did not affect patterns of habitat use.

The average summer home range size for hens and broods ranges from 12.9 ha to 16 ha. Godfrey (1975a) in Minnesota noted some spatial but no temporal overlap of home ranges. However, intermingling of broods was reported in New York, Wisconsin, Pennsylvania, and Minnesota. It is possible that orphaned broods will attach themselves to another brood.

Home range size for breeding males was reported to be 6.7 ha during the breeding season and between 8.9 ha and 16 ha during the entire spring period.

Brood breakup and dispersal generally begins during the first week of September, peaks in mid-September, and ends by the second week of October. During brood break-up, juveniles may aggregate in non-sibling groups for short periods of time just prior to dispersal. Dispersal is assumed to be independent of population densities and was recorded by Godfrey and Marshall (1969) to occur in synchronized patterns by widely separated individuals prior to unstable weather conditions. Dispersal consists of a series of rapid, linear, diurnal movements, generally totalling at least 1.6 km in length. Following dispersal, all age classes of grouse become attached to definite home ranges for the fall and winter.

Survival and Mortality Factors

Annual natural mortality rates of ruffed grouse have been estimated to be slightly greater than 70 percent. However, the various sex and age classes are differentially vulnerable to seasonal mortality factors. Mortality is greatest for hens and chicks in early summer, drumming males in the spring, and juveniles following dispersal in the fall. Numbers stabilize in favor of males during the winter but sex ratios probably equalize following the drumming season.

Total overwinter mortality was estimated by King (1937) to be between 17 percent and 20 percent, but later studies placed the figure between 40 percent and 66 percent (Palmer 1956, Svoboda and Gullion 1972, Doerr et al. 1974). In 10 years of study in Minnesota, only once was the overwinter loss substantially greater than 55 percent. The major controlling factor for winter survival in Minnesota apparently is the suitability of snow for snow burrowing.

Chick mortality appears to be directly proportional to population density but independent of brood size. King (1937) estimated that 75 percent of chicks were lost within 30 days of hatching. In Alberta, annual chick mortality averaged between 66 percent and 79 percent, with summer losses totaling 49 and winter mortality varying between 33 percent and 58 percent. Higher mortality rates for hens during the early brood period is believed to result from increased activity of hens and displays of aggressive behavior during brood defense.

Drumming males, especially males using previously utilized drumming logs, may be more vulnerable to predation in the spring because repetitive patterns of behavior make them more obvious to predators. However, Doerr (1973) found that annual survival rates for drumming males averaged 45 percent, while that for non-territorial, non-drumming males was only 16 percent. Similarly, Boag (1976) found that the annual survival rate of males on continuously used logs was almost twice as high as drumming males on sporadically used, marginal logs.

Predation, especially by raptors, is the dominant proximal cause of mortality, but it is not a limiting factor. In Minnesota, nesting goshawks were reported to have effectively removed most of a ruffed grouse population within 1/2 mile of the nest. However, both complete and selective predator control in New York did not reduce brood mortality, despite reducing nest losses, and adult mortality was actually higher in the controlled area.

Fall hunting has no appreciable effect on the proportion of the ruffed grouse population alive the following spring. Hunting refuges and season closures generally have no positive long-term effect on fall and winter population size. A Michigan study indicated that both hunted and unhunted populations declined 50 percent between late September and mid-December. Although generally 33 percent of a population is removed by fall hunting, up to 50 percent can be removed without negative effects. In Michigan, 75 percent of grouse killed are harvested during the first 15 days of the season, and 95 percent taken during the first 30 days.

A spring hunt, concentrating on drumming males, would probably be additive to other mortality in the spring, but not to overall annual mortality. Females would be incubating during the drumming season, and 20 percent of the males harvested would probably be replaced by non-drumming males in the population.

Density

Spring densities are dependent on rates of annual mortality, habitat quality, and diversity, and intrinsic population fluctuations. However, King (1937) and Bump et al. (1947:331) believed that a density dependent saturation point was reached at 25 birds per 40 ha. Gullion (1970) more recently suggested that a "good" population consisted of a breeding pair per 4 to 6 ha of forested land. Spring densities of 47 birds per 40 ha in Alberta and 55 birds per 40 ha of suitable habitat in New York have been reported. In Utah, Phillips (1965) calculated a spring density of 10 grouse per 40 ha of woodland habitat and the Utah Division of Wildlife Resources estimated 6.7 to 12.7 grouse per 40 ha. In northern Idaho, densities of 11.1 and 21.3 birds per 40 ha were reported by Hungerford. Most density estimates are calculated from either spring census or surveys of drumming males and, as a result, estimates may not be comparable because assumptions regarding the proportion of drumming males present in the population, sex ratios, and suitability of all vegetation types included in the calculations are seldom stated and probably differ.

Population Dynamics

Cycles in numbers apparently occur in some ruffed grouse populations but the causes of these rhythmic fluctuations have not been determined. Lack (1954) and more recently Rusch and Keith (1971b) and Rusch et al. (1978) suggested that cycles were a product of predator-prey relationships. This argument, however, has been rebutted by other researchers. Dorney and Kabat (1960) suggested that cycles were caused by an interplay of inclement weather and parasitic diseases. Hoffman (1958) and Gullion and Marshall (1968) reported that cyclic lows were characterized by a small proportion of highly visible juveniles in the population. They hypothesized that the lack of replacement stock was the result of a large proportion of females failing to nest, a high degree of nesting failure, and inferior stamina of the chicks. More recently, Svoboda and Gullion (1974) suggested that the production cycle of male aspen flower buds may be an important factor contributing to population cycles.

Weather can affect seasonal population densities. Temperatures above the average maximum for April can result in a large population the following spring, while low April and May temperatures often put additional stress on hens during incubation. Temperatures consistently above winter daily maximums cause snow to crust, preventing the use of snow burrows.

Diet

Foods used by ruffed grouse differ with the season, geographical region, and among sex and age classes in the same area. During incubation, hens use catkins and leaves of sexually mature male and female quaking aspen almost exclusively. Trees utilized by incubating hens are generally located 28 m to 185 m from the nest. Hens generally feed shortly before daylight and after dark, although some sporadic feeding may occur during the day. As incubation progresses, morning activity may be delayed by as much as 4 to 5 hours if increasing growth of vegetation decreases light intensity at the nest. Male ruffed grouse also feed chiefly on sexually mature male aspen flower buds and catkins in the spring and usually select drumming logs with such trees in sight. With the abscission of aspen catkins in early May, catkins and leaves of other species such as hophornbeam (*Ostrya virginiana*), willow, and balsam popular (*Populus balsamifera*) become more common in the diet. Leaves from herbaceous evergreen plants such as wild strawberry (*Fragaria* spp.) and wintergreen (*Gaultheria* spp.) are also used.

Chicks feed heavily on insects from hatching to about the first week in July. The final transition by chicks to a typically adult diet of vegetable matter occurs during the fifth to seventh week of life (Kimmel and Samuel 1978). For approximately the first 3 weeks after hatching, chicks generally feed in mid-morning and late afternoon and do not assume a crepuscular feeding schedule similar to adult birds until later in the summer.

Few studies have addressed food habits of ruffed grouse during the summer, but leaves, fruits, and seeds, particularly those of clover (Trifolium spp.), bunchberry (Cornus canadensis), and sedges (Carex spp.) appear to be important.

In the fall, the diet gradually changes from fruits, nuts, and leaves to flower buds of sexually mature aspen trees. In Utah, rose hips (Rosa woodsii), aspen leaves, and the fruit of the meadowrue (Thalictrum fendleri) are major items in the fall diet.

The winter diet for all sex and age classes is dominated by buds and twigs of sexually mature aspen trees. Chokecherry, rose hips, and other winter berries, nuts, buds, and twigs are very important components of the winter diet in some areas.

The nutrient content of seasonally available aspen components is apparently sufficient to maintain ruffed grouse throughout the year. Grouse use the leaves, flower buds, vegetative buds, catkins, and the current year's twigs of aspen at some time during the year. Aspen is highest in protein during the early spring and decreases in value gradually during the summer, fall, and winter. During winter and early spring, upper canopy flower buds and catkins contain the highest levels of protein. Crude fat levels, particularly from buds in the upper canopy, are highest in the winter when energy requirements for maintenance and survival are greatest. Nutritionally, flower buds are of greater value than vegetative buds because they are four times heavier but contain only 10 percent more moisture than vegetative buds. Vegetative buds, however, contain proportionally more calcium and lignin than flower buds at this time. New twigs have more calories of metabolizable energy per gram than flower buds but less nitrogen, potassium, and iron than summer leaves. Both male and female leaves are high in protein, energy, and lignin and have proportionally more protein than either staminate flower buds or catkins. Male catkins have more protein, crude fat, and calcium than male buds, but less protein than female catkins.

Although containing less fat and fiber, willow buds have more protein and carbohydrates than aspen and provide an excellent winter nutrient supplement. Woods rose hips, which have a low crude fiber and lignin content and a high proportion of nitrogen-free extract, may also be a valuable source of digestible energy in winter.

Characteristics of Habitat

A high degree of diversity both within a habitat type and among proximal habitat types increases the number of grouse potentially capable of being supported on a given area. Brood cover is the single most important component of grouse habitat.

Activity centers of breeding males in the spring are generally located in habitats consisting of well-stocked stands of pole-sized aspen with mature aspen in the area as a food source. Overhead canopy closure is generally less than 60 percent, resulting in a moderately dense understory of woody shrubs and young trees allowing the drumming male to survey the area for ground predators. The dense shrub layer characteristic of drumming sites provides protection from avian predators. A Utah study found that all drumming logs were within clones of male aspen.

Nesting habitat generally consists of stands of 10 to 25 year-old sexually mature aspen with a moderately dense ground cover which reaches about 20 cm in height by hatching. A well developed understory of young aspen may increase the quality of a site for nesting. Losses to predators may be greater in areas with very low density of ground cover. In optimum habitats, mature female and male aspen trees are often found within 9 m of the nest site.

Optimum brood habitat includes the proper interspersion of three principle components: (1) a good source of summer foods; (2) suitable cover for loafing; and (3) suitable cover for roosting. From hatching to early July, feeding habitat consists of young dense stands of sapling aspen less than 10 years old, which are often located near streams.

The open overstory canopy structure in these sapling stands results in a highly diverse and dense ground cover of herbaceous vegetation 40 to 76 cm tall. Broods loaf in dense thickets during the day, often in the vicinity of streams and roost in dense clumps of young conifers. Broods either move down slope as the summer progresses or up to drier ridges which support berry-producing species and bare ground for dusting. A study in Pennsylvania indicated that most hens with broods preferred open clearcuts when available, but that a small proportion of hens would use unmanaged areas. In Utah, family groups spend much of the day in open stands of aspen which included dense clumps of chokecherry and willow.

Solitary adults in the central states spend the spring and summer in alder thickets (Alnus spp.) or well-stocked stands of pole-sized hardwood trees with moderately dense shrub and sapling layers.

Fall habitat of all sex and age classes is generally similar to that used by breeding males with the exception that the understory canopy and ground cover vegetation are less dense. Stands of mixed hardwoods and mixed aspen-hardwoods with brushy overgrown edges are important. Although Svoboda and Gullion (1972) found mature male aspen to be the major food item at this time of the year, Robertson (1976) found no grouse in pure aspen stands. Robertson hypothesized that grouse may select for greater aspen abundance until a threshold is reached at which time they may select for greater diversity.

During the winter, ruffed grouse roost in deep, soft snow in sexually mature stands of pole-sized aspen, whenever possible. Sapling and shrub density in this cover type is the lowest of all seasonal habitats. When the snow is crusted or less than 30 cm deep, grouse will roost in hardwoods or at the base of trees. Although the use of conifers was formerly thought to be critical to survival, studies in Minnesota indicated that use of conifer stands, particularly those composed of self-pruning species, may lead to increased predation from avian predators which use the conifers for hunting perches. Phillips (1965) found no use of conifers for winter cover in Utah.

The general consensus of managers and researchers in the east and mid-west is that the manipulation of aspen communities can result in increased grouse production. It is not known, however, the extent to which aspen manipulation procedures will increase the quality of habitat for ruffed grouse in the Intermountain West. Areas that lack a good distribution of aspen or that support an abundance of conifers generally respond poorly to management attempts. The preliminary considerations for planning any management strategy for ruffed grouse are: (1) determine the desired composition and structure of the plant communities for the most beneficial habitat; (2) choose sites which already have good potential for ruffed grouse production; and (3) select the most practical and economical methods for achieving the desired conditions. Diversity is one of the major characteristics of good ruffed grouse habitat and should be a major concern in the development of any management scheme.

Gullion (1977) and Berner and Gysel (1969) recommend managing areas 16 ha in size by cutting blocks, circles, or strips 4 to 5 ha in size within each management unit on a 10 to 20 year rotating cutting cycle. They felt this procedure would provide the proper interspersion of specific vegetation types for year-round requirements of ruffed grouse. The following are specific vegetation types and abundance that should be planned for: (1) 5 percent to 10 percent of the area should consist of open canopy sucker aspen stands less than 10 years old with dense understory vegetation and food shrub borders for brood cover and feeding habitat; (2) 40 percent to 45 percent of the area should consist of 10 to 25 year old aspen stands for wintering, nesting, and drumming habitat; (3) 40 percent to 45 percent of the area should consist of mature aspen stands greater than 25 years old for feeding in the fall, winter, and spring. This schedule would result in 25 percent to 33 percent of each activity unit providing one of the three habitat requirements. Food trees and shrubs other than aspen may be retained in moderate densities as supplementary food sources as long as they do not inhibit aspen sucker growth. During clearcutting operations, the understory should be removed or broken to increase light intensity at the soil surface to stimulate suckering. Heavy machinery should be used carefully to avoid damaging aspen root systems. Controlled burning may be a viable alternative for removing slash and shrubs, but it must be done within two years of cutting to be effective without damaging aspen regeneration. Aspen, however, is characteristically difficult to burn without optimum conditions. All brush piles should be removed to eliminate predator cover.

Food and cover conditions are optimal for grouse broods approximately 3 to 5 years after clearcutting when aspen regeneration is about 80 to 100 cm tall. At this rate of growth, suckers rapidly outgrow browsing pressure, reducing the need for buffer browse species. Production of herbaceous vegetation is also greater under aspen stands than in open areas with direct solar radiation. Within 8 to 10 years following cutting, aspen stands are too dense for brood cover, but adequate for breeding, winter feeding, and cover.

Heavy grazing by livestock in early spring and summer may remove food and cover required by broods for survival. Light to moderate grazing or grazing in the late summer and fall does not affect as greatly the quality of vegetation stands for brood use.

Specific strategies for achieving the desired interspersion and quality of habitat are discussed fully in the literature (Bump et al. 1947:605666, Edminster 1955, Hale and Dorney 1963, Sharp 1963, Gullion 1968, Berner and Gysel 1969). Some approaches worth noting, however, are: (1) use drainage patterns and soils as indicators of potential brood range; (2) use brood habitat as the focal point; (3) use some pattern of clear-cutting to maintain an interspersion of various age classes in even-aged blocks; (4) use a cutting cycle which will maintain younger and older aspen stands in close proximity; and (5) maintain dense shrub borders in small openings and along trails.

In many areas of ruffed grouse range, management of the aspen resource for timber and for ruffed grouse can be planned simultaneously because of the commercial value of aspen in these areas. However, in the Intermountain West, aspen currently has very little commercial value. As a result, the full cost of aspen manipulation would have to be borne by the managing agency. Fire-wood cutting programs in the vicinity of urban areas may prove to be a useful tool.

MANAGEMENT AND RESEARCH TECHNIQUES

Capture Techniques

Several techniques, each aimed at exploiting differential vulnerability due to sex and/or season of year, have been used to capture ruffed grouse. The lily-pad, or clover-leaf, trap is most successful during late summer and fall when birds are most mobile or during the winter with bait. The principle of this trap is to either lead a walking bird to the entrance using a wire lead placed securely on the ground or to attract the bird into the trap using dyed corn. The grouse enters the trap through a one-way opening and is held for processing.

Drumming males can be caught on their drumming log using a trap which exploits their aggressive territorial defense behavior. The mirror trap is a cage with a mirror at one end in which the territorial male sees a "rival." When the male enters the trap to attack the bird in the mirror, a trip mechanism shuts a trap door on the other end. Obviously, this trap is most effective during the spring drumming period, but it has been used successfully as a bait trap in the winter for capturing both sexes.

Fischer (1974) described a net placed over the drumming log that is pulled tight by an observer when the drumming male is centered on the net. This same technique was reported by Bendell and Fowle (1950), using a net, and Bump et al. (1947:717), using a wire cage, for capturing hens on nests. Coulter (1958) described a nest net tripped by the bird itself which has been used successfully for ruffed grouse.

An effective procedure for capturing any sex or age grouse that will sit in a tree is described by Zwickel and Bendell (1967). An expandable fishing pole, 20 feet long, is fitted with a small noose on the end which is slipped over the bird's head. This technique is commonly used for both ruffed grouse and blue grouse (*Dendragopus obscurus*).

Huempfner et al. (1975) developed a portable nightlighting system for catching birds with transmitters in a snow roost or tree roost. Healy et al. (1980) used a recording of chick distress calls to locate hens with broods. He found he could save, on the average, 11.6 man hours per brood located using this tape.

Marking and Radio Telemetry

Several methods have been used successfully to mark individual ruffed grouse for future identification. Each method has advantages and disadvantages depending on field conditions and research objectives. Leg-banding, backtagging, and feather dyeing are contrasted by Gullion et al. (1962). They found that dyeing the feathers of hens and juveniles provided the best method of short-term field identification during July and August because the birds could be identified by observation, presence of molted dyed feathers, or the remains of feathers at a predator kill. Banding with eight colors of aluminum leg bands in combinations of four allowed over 4,000 different combinations and did not mutilate the legs. However, bands were often ingested by raptors as they consumed the grouse thus precluding identification of the individual grouse. Backtagging was effective for field identification by observation and at raptor kills, but may increase the vulnerability of marked birds. The rate of population turnover was twice as high in areas where backtagging was used as a marking technique than it was in areas where only colored leg bands were used. However, the authors felt that backtagging was a useful technique for short-term studies. The durability of different materials used for backtags is discussed by Labisky and Mann (1962).

The use of radio telemetry has proven to be an effective method for identifying individual grouse and monitoring their movements and activities. Boag et al. (1973) found no difference in the ability of backtagged and radio-tagged red grouse (Lagopus lagopus) to establish territories or produce chicks. Survival of radio-marked birds was no different than that of backtagged birds. Laboratory studies on the effect of radio-marking on red grouse, however, found that radio-marked birds showed lower levels of activity and food intake for the first week subsequent to marking. Studies by Lance and Watson (1977) indicated that fitting a red grouse hen with a radio transmitter early in breeding apparently impaired her ability to successfully produce chicks. Results of this study also suggested that radioed birds in a flock flushed later and slower than unmarked birds. Research by Herzog (1979) indicated that spruce grouse (Canachites canadensis) readily adapted to radio-marking and that the movements and rates of mortality of marked and unmarked grouse were not significantly different. Three incubating, radio-tagged, females found dead on or near a nest showed signs of renal gout, but the authors did not know if there was a relationship between this condition and radio-marking.

Different attachment designs for radio transmitters are discussed by Marshall and Kupa (1963), Brander (1968), Anon. (1979), and Amstrup (1980).

Sex Determination

No criterion for determining sex of ruffed grouse other than internal examination is infallible. Several established methods when used together, however, can provide satisfactory results.

From age 13 weeks, grouse can be sexed with only 0.3 percent error using the number of dots on the distal end of the rump feathers. The pattern of the terminal band of the tail and the length of the plucked middle rectrix can be used with slightly greater error to determine sex. Sex specific measurements of the middle rectrix, however, appear to vary geographically. Additional characteristics which can be used to sex adults are: (1) ventral shaft pigmentation of the middle rectrix; (2) shape of the distal end of the rectrices; (3) length of the central rectrix compared to the length of the ninth primary; (4) length of the middle toe; (5) lengths of primaries 8 and 9; (6) calamus diameter of the middle rectrix; (7) length of the middle rectrix barbs; and (8) distinctive behavior.

Sex determination of ruffed grouse less than 13 weeks of age is based on color of the eyepatch, amount of peeping when handled, and comparative feather development. A listing of seasonally significant sexing criteria is found in Table 1.

TABLE 1. Criteria for Determining the Sex of Ruffed Grouse.

Criteria	Female	Age in weeks	Male	Authority
Winter to Spring				
(1) Dots on rump feathers	1 dot (circular, arrow, transverse)		2-3 dots vertically	Roussel & Quellet 1975
Summer				
(1) Dots on rump feathers (adults)	1 dot		2-3 dots	Roussel & Quellet 1975
(2) Eye patch and feather development (chicks)	eye patch colorless peeps more when handled, lag in feather develop	8-10	eye patch bright red peeps very little when handled feather develop ahead	Palmer 1959
	same as above small ruff	10-12	same as above larger ruff	
	same as above adult character- istics (rump feather dot)	12-14	same as above adult characteristics (rump feather dots)	
Fall				
(1) Dots on rump feathers (greater than 13 weeks old)	1 dot		2-3 dots	Roussel & Quellet 1975
(2) Tail terminal band pattern	obscured (blotched- sex unk)		clear or fuzzy	Gullion 1964
(3) Plucked, mid-rectrix length	less than 14.9 cm		greater than 15 cm	Hale, et al. 1954
(4) Mid-rectrix shaft pigmentation	1-2 long narrow stripes		irregular transverse bands	Hale, et al. 1954

Age Determination

Aging criteria are generally based on characteristics and condition of feathers associated with the various molts. Chicks up to age 17 weeks can be aged using the wing and body feather development charts and descriptions in Bump et al. (1947:7990). Since ruffed grouse juvenile primaries have pointed tips and juvenile primaries 9 and 10 are not molted until spring following hatching, the condition of the tips of primaries 9 and 10 can be used as general aging criterion from fall through spring. The molt chronology of the primaries can also be used from fall to spring to separate juveniles from adults. Quantitative criteria using characteristics of the primaries and rectrices have been developed in several states but the applicability of these criteria to other geographical areas is unknown. A listing of seasonally significant aging criteria is found in Table 2.

Population Sampling Techniques

The most commonly used method of estimating ruffed grouse abundance and population size is counts of males heard drumming. This technique involves the establishment of "listening stops" 0.25 miles apart on usable roads through ruffed grouse habitat. At dawn and dusk during good weather, the number of grouse heard drumming in 4 minutes at each station is recorded. While this is a relatively simple technique, field personnel changes from season-to-season reduce its effectiveness. Although the actual relationship between numbers heard drumming and number of grouse in the breeding population is assumed to be weak, a high correlation has been shown to exist between the survey and subsequent fall harvest level and winter flush counts. If done consistently, this technique may provide an index to general population trends.

The total census of drumming males, by locating drumming logs, provides the best estimate of density of breeding males. This approach, however, should not be used in areas much smaller than 400 ha. Apparent changes in population size based on a census of drumming males in an area as large as 256 ha in size may indicate changes in only one or two activity clusters of male grouse and be independent of general population trends.

The King Strip Census, with modifications discussed by Hayne (1949), was developed as a population estimator for flushing species. It requires that individual birds not move in relation to the observer before they flush. The closely related line transect sampling technique assumes, in addition, that individuals be counted only once, all sightings be independent, clusters of flushing individuals be tight and enumerated, and that the observer stay strictly on the straight line transect. The advantages of these two techniques is that the results can be analyzed statistically if the assumptions are carefully met. For a more complete discussion of the methods, advantages, and assumptions of strip census and line transect sampling in relation to ruffed grouse, see Hayne (1949), Palmer and Eberhardt (1955), Gates et al. (1968), Eberhardt (1968), Wilbur and Landwehr (1974), Robinette et al. (1974), Eberhardt (1978), and Anderson et al. (1978).

TABLE 2. Criteria for Determining the Age of Ruffed Grouse.

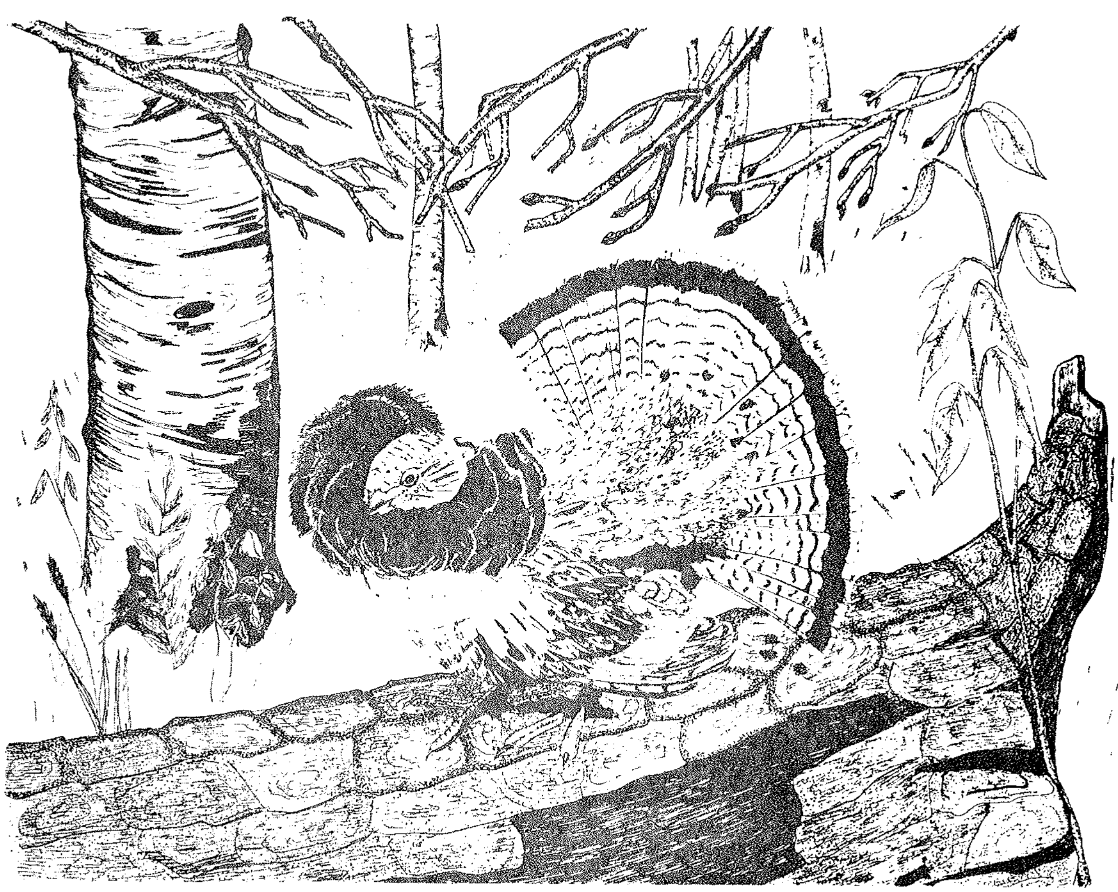
Criteria	Juvenile[a]	Adult[a]	Authority
Spring			
(1) Sheathing on P8[b] to P10	sheath only on P8	sheath on P8 to P10	Dorney and Holzer 1957
(2) Contour of P9 and P10	pointed tips	rounded tips	Dorney and Holzer 1957
(3) Bursa of Fabricius	open (not used)	closed	Dorney and Holzer 1957
Summer			
(1) Chick primary molt	key to primary molt		Bump et al. 1947
Fall (mid-July to mid-November			
(1) Sheathing on P7 to P10	only on P8 after 13 weeks	on P9 to P10; if P9 blood quill with rounded tip and P10 hard with pointed tip - 1-1/2 yrs; if P10 rounded - 2-1/2 yrs.	Hale et al. 1954
(2) Contour of P9 to P10	pointed tips	rounded tips	Hale et al. 1954
(3) Bursa of Fabricius	greater than 6mm	less than 6mm	Hale et al. 1954
Winter			
(1) Sheathing on P8 to P10	sheath only on P8	sheath on P9 and P10	Hale et al. 1954
(2) Contour of P9 to P10	pointed tips	rounded tips	Hale et al. 1954
(3) Bursa of Fabricius	open (closes 1 Mar. Bump et al. 1947)	closed	Hale et al. 1954

[a] Adult rectrices fully grown by 15 weeks of age; replacement of seventh primary complete by 13 weeks of age (Rusch and Keith, 1971b).
[b] Primary

Summer counts of ruffed grouse broods may give a reasonable index of fall population levels but research in Minnesota indicated that counts of brood size underestimated the true brood size in the early summer by 54 percent and later in the season by 40 percent.

More subjective sampling methods include winter flush counts conducted during winter deer research and mail carrier surveys conducted seasonally by mail carrier. Opinion surveys mailed to knowledgeable people who spend a great deal of time in the field, kill records from hunting clubs, and hunting season check stations provide some data on population trends.

Ruffed grouse hens with broods can be attracted to a tape-recording of chick distress calls. Healy suggested walking or driving transect lines and playing the tape for 4 to 5 minutes at each station which are located at least 150 m apart. Since the call is audible for approximately 65 m, the number of hens with broods per unit area can be calculated.



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