GROUSE AND PTARMIGAN IN ALASKA

THEIR ECOLOGY AND MANAGEMENT

ALASKA DEPARTMENT OF FISH & GAME
Juneau, Alaska

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JUNEAU, ALASKA

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by

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cover by R. T. Wallen: blue grouse chicks

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GROUSE AND PTARMIGAN IN ALASKA

Four species of grouse and three species of ptarmigan live in Alaska. These birds, all in the family Tetraonidae, are the large blue grouse of southeastern Alaska (Dendragapus obscurus); the widespread spruce grouse, or fool hen (Canachites canadensis); the ruffed grouse (Bonasa umbellus), drummer of the Interior woodlands; the sharp-tailed or pintail grouse (Pedioecetes phasianellus); the willow ptarmigan (Lagopus lagopus), official state bird of Alaska; the smaller rock ptarmigan (Lagopus mutus); and the pigeon-sized white-tailed ptarmigan (Lagopus leucurus). There is hardly a land area in the State that supports plant growth that does not also harbor grouse or ptarmigan.

Historically, these species may have contributed more to the food supply of Alaskans than any other avian group, primarily because of their wide distribution, occasional abundance, and year-round availability. For the same reasons, ptarmigan and grouse now afford an increasing amount of recreation to hunters and other outdoorsmen.

This report summarizes past and current efforts to discover facts about upland game birds in Alaska. It reviews the pattern of human use of the resident game bird resource, and describes in general terms how human activities are influencing the birds. Finally, it suggests what we must know if we are to maintain some control over interactions between people and upland game birds in the future.

A SKETCH OF RESEARCH IN ALASKA

In a sense, a lot of people have studied grouse and ptarmigan for a long time. With natural curiosity spurred by necessity, Alaska's indigenous people observed wild creatures frequently and shrewdly. Their combined observations, amassed over centuries, probably would constitute a clearer picture of the lives of ptarmigan and grouse than is available in scientific literature today. It is our loss that their observations were unorganized, that they had no tradition of

experimentation, and especially that they did not keep written records.

The accumulation and permanent storing of knowledge about grouse and ptarmigan in Alaska began with the coming of modern civilization and science. The first organized, prolonged observations were made just after World War II. Since then there have been no long gaps in the over-all attempt to learn about grouse and ptarmigan, although individual projects have waxed and waned irregularly. These projects, concerned with general biology, population phenomena, and utilization, will be discussed briefly in chronological order.

General Biology

Laboratory of Zoophysiology

Dr. Laurence Irving and associates have studied ptarmigan and other birds in northern Alaska since 1947. These investigations were carried out under the auspices of three agencies: (1) Arctic Research Laboratory, Barrow (1947-49); (2) Arctic Health Research Center, Anchorage (1949-62); (3) Laboratory of Zoophysiology, University of Alaska (1962-64). During the first decade, information was obtained on the natural history of willow ptarmigan, particularly on migrations and winter behavior of the species at Anaktuvuk Pass, Brooks Range. In 1959 the specimen collection program was intensified to make more data available on the sex, age, and feeding habits of migrating ptarmigan in the Brooks Range. Simon Paneak, a cooperator of the project, began banding willow ptarmigan at Anaktuvuk Pass in the spring of 1961. Dr. George West joined Dr. Irving and Leonard Peyton at the Laboratory in 1963, to begin experimental and field studies of the fat reserves, fat mobilization, food consumption, and energy requirements of wintering ptarmigan.

Some of the early reconnaissance work has been published (Irving, 1953 and 1960; Irving and Paneak, 1954).

Arctic Health Research Center

The Zoonotic Disease Section of this agency, under the

direction of Dr. Robert L. Rausch, collected ptarmigan in the late 1940's and early 1950's. These birds, including 191 willow ptarmigan, 45 rock ptarmigan, and 56 white-tailed ptarmigan, were examined for helminth parasites by Bert Babero (Babero, 1953). Babero also collected and examined grouse specimens for parasites, but the results of this work never were published. The parasitic worms found by Babero in ptarmigan are listed in Appendix I of this report.

Alaska Cooperative Wildlife Research Unit

Unit Leader Dr. John Buckley and two graduate students turned their attention to ptarmigan between the years 1950 and 1954. The students, Salvatore DeLeonardis and Harvey Roberts, summarized Alaskan literature on the population fluctuations, distribution, and breeding biology of rock and willow ptarmigan. They also carried out some field work in summer and autumn, and analyzed crops from 393 ptarmigan. Rock ptarmigan were banded one summer at Eagle Summit.

The work of DeLeonardis and Roberts appeared only in quarterly progress reports of the Unit, and in theses filed at the Univeristy of Alaska (DeLeonardis, 1952; Roberts, 1963).

The Unit and the Department of Wildlife Management at the University assigned a study of winter ecology of ptarmigan to a student in 1964. Field work will begin in 1965.

University of British Columbia

The Arctic Institute of North America supported a study of ptarmigan in Alaska and British Columbia from 1956 to 1958 (Weeden, 1959). Habitat preferences of the three species of ptarmigan were described, and comparisons of these habitats were made in areas having all species as well as in localities where only one or two species occurred. Information was obtained regarding territorial behavior, breeding schedule, nesting, and brood-rearing. The studies were carried out primarily at Eagle Summit, central Alaska (the site of earlier research by DeLeonardis and Roberts), and at Chilkat Pass in northwestern British Columbia.

Alaska Department of Fish and Game

The Alaska Department of Fish and Game was organized in 1957. It expanded in 1959 to meet the responsibilities imposed by statehood; studies of grouse and ptarmigan by the Department began in that year. Although upland game birds are recreational and nutritional resources of value to the State, the annual, natural replacement of the resource is believed to be far ahead of utilization at present. During this "breathing spell" before intensive management measures have to be applied to grouse and ptarmigan, it seemed logical to undertake detailed studies of the most abundant species, and to take stock of the distribution and abundance of upland game birds throughout the State. Rock and willow ptarmigan were selected for initial study because they are the most abundant, most widespread, and perhaps the most heavily utilized of Alaska's grouse-like birds.

The primary aim of the intensive study is to describe population changes among ptarmigan living on a particular area, and to analyze the processes by which the observed changes are brought about. The research is scheduled to continue until 1970. The main study area is at Eagle Summit, 105 miles northeast of Fairbanks along the Steese Highway. Secondary study areas are at Harrison Summit (8 miles east of Eagle Summit), Mount Fairplay (mile 33 Taylor Highway), and at mile 13 Denali Highway, west of Paxon.

The Department is compiling past and current records of grouse and ptarmigan distribution. Data come from published and unpublished reports, from interviews, and from observations made by many field men of the Department of Fish and Game. The Department hopes to be able to draw range maps for each species of upland game bird, and to distribute them to Alaskan sportsmen and other interested people.

The Alaska Department of Fish and Game began basic studies of the life cycle and population dynamics of spruce grouse in August 1963. Spruce grouse currently are scarce in interior Alaska; initial life history studies were carried out near Dillingham (Bristol Bay) in 1964, and will be continued on the Kenai Peninsula in coming years.

Population Phenomena

Bureau of Animal Population, Oxford

In 1931-32 the Bureau of Animal Population began sending questionnaires to people in Canada and United States, asking for current assessments of the numbers of small game, especially snowshoe hare. Few or no comments on grouse or ptarmigan were obtained from the handful of Alaskan cooperators until 1951-52. For the next six years, members of the Alaska Game Commission and United States Fish and Wildlife Service were asked to report their impressions of local grouse populations. Except for brief mention of the replies for 1951-52 by Williams (1954), none of this information has been published.

Alaska Cooperative Wildlife Research Unit

Buckley (1954) presented a paper at the 19th North American Wildlife Conference describing historic changes in numbers of Alaskan grouse and ptarmigan. He had compiled information from published accounts, from harvest records maintained by the Alaska Game Commission and United States Fish and Wildlife Service, from personal interviews, and from questionnaires mailed in 1951 to about 100 selected Alaskans. Williams (1954) repeated many of Buckley's conclusions and much of the supporting evidence. He also compared the Alaskan data with changes in grouse abundance occurring in Canada in the same span of time.

Alaska Department of Fish and Game

Each November since 1960, 150 to 300 questionnaires have been sent by the Department to registered guides, sportsmen, biologists, and others thought to have an interest in game bird populations. Cooperators are asked whether particular species of grouse or ptarmigan currently are at high, moderate, or low levels of abundance, and whether there are more, the same number, or fewer than in the previous year. A gridded map of Alaska on one side of the card enables the respondent to show areas with which he is familiar. The mailing list is enlarged and revised yearly to cull out those who died, moved, or did not respond. The questionnaire suffers the well-known

shortcomings of most questionnaires, the main one being that the replies are wholly subjective. At present, however, it seems the only practical way to obtain an impression of the numbers of upland game birds throughout the entire State.

An annual spring count of courting sharp-tailed grouse in east-central Alaska is a minor phase of game bird studies by the Alaska Department of Fish and Game. The study is an experiment to determine if roadside counts are practical and provide meaningful population data. The first count was made in 1961 after a reconnaissance in 1960. The same sections of road, totalling about 30 miles, are systematically cruised three times each spring.

Utilization

United States Fish and Wildlife Service

The Service made a concerted effort to get information on the harvest of wildlife by Alaskan natives between 1954 and 1957. Field men of the Branch of River Basin Studies (Bureau of Commercial Fisheries) and Game Management Agents of the Bureau of Sport Fisheries and Wildlife interviewed natives in 61 villages, mostly in western Alaska. The people were asked to estimate how many of various game species they took in a particular period. Heads of families were interviewed when possible. The average harvest by the families interviewed was multiplied by the number of families present to obtain village totals. This kind of survey, especially when conducted by "game wardens" in country where traditional methods of getting food conflict with game regulations, is fraught with difficulties. However, mail surveys are even less likely to be fruitful in these areas.

A summary of this survey was included in a recent paper on ptarmigan management (Weeden, 1963).

Alaska Game Commission

Until 1961 every person applying for an Alaskan hunting license was required to record, on the application, game killed

the previous year. These records were kept from 1925 to 1953. From 1959 to 1960 the Alaska Department of Fish and Game continued the system. All reports were tabulated for the years 1925 to 1938, inclusive, and from 1942 to 1943. Apparently no records were tabulated in 1939, 1940, 1941, or 1944. In the years from 1944 to 1952, the kill reported by part of the hunters was extrapolated to an estimated harvest by all licensees. Buckley (1954) published the harvest data up to 1952-53; after that, information on license applications was not compiled.

The Alaska Department of Fish and Game sent a questionnaire to a large sample of hunters in 1962, asking for harvest information for 1961. The calculated harvest that year was about 45,000 each of ptarmigan and grouse. The questionnaire was not repeated.

SUMMARY OF KNOWLEDGE ABOUT PTARMIGAN AND GROUSE IN ALASKA

Achievements of Alaskan upland game bird studies to date range from a partial listing of worms found in ptarmigan intestines to guesses about the abundance of spruce grouse thirty years ago. With exceptions, investigations have been superficial. Most investigators have chosen a broad problem; found out enough to reach the state of puzzlement marking the point when real progress can be made; then left for other projects or other places.

This review of present knowledge of Alaska's upland game birds is divided into six phases: (1) techniques used to get information on these birds; (2) distribution; (3) life cycles; (4) foods; (5) population dynamics; (6) utilization.

Techniques for Field Studies

The purpose of this section is to describe methods that have been used in Alaska to obtain information about grouse and ptarmigan in the field. It is not an over-all review of study techniques. Methods for catching, marking, and locating game birds in general have been described in many publications, and

are too well known to be reiterated here. The same is true of laboratory methods, such as crop content analysis, fat deposition measurement, and gonad examination.

Techniques discussed here apply mostly to rock and willow ptarmigan, as these are the only species of upland game birds that have been studied in detail in Alaska.

Identification

Species: Standard references such as Birds of Alaska (Gabrielson and Lincoln, 1959) and Field Guide to Western Birds (Peterson, 1961, revised edition) give adequate descriptions of Alaskan grouse and ptarmigan that will not be repeated here.

One point does deserve mention, however. Concerning the identification of rock ptarmigan in winter, Gabrielson and Lincoln (1959) say that males have a black loral stripe, or eyestripe, whereas females do not have this stripe. At the other extreme, Peterson (1961) states that rock ptarmigan can be distinguished from willow ptarmigan in winter by the presence of the black stripe from the bill to and behind the eye in the former species. My studies have shown that rock ptarmigan of interior Alaska (race Lagopus mutus nelsoni) do not agree with the descriptions of either author. I examined 116 male and 84 female rock ptarmigan in winter plumage from 1959 to 1964. All of these birds were examined internally to determine sex. All males had a complete eyestripe. Most of the hens (65) lacked an eyestripe, but one had a complete eyestripe identical to that of males, and 18 had incomplete stripes easily distinguished from the typical markings of males. Thus, any ptarmigan with a black loral stripe in winter is a rock ptarmigan, and probably is a male. A ptarmigan without a loral stripe could not be identified as to species without further study of tail color, size, calls, and bill shape.

Age and Sex: Because of a peculiar pattern of wing feather loss and replacement, the outer primaries of most young upland game birds differ in color or shape from those of adult birds that have completed the post-nuptial molt. Among ptarmigan, differences in color seem more useful for age determination than differences in shape. Examination of the color or shape of individual outer primaries proved to be too inaccurate to be a

useful indication of age of Alaskan rock ptarmigan (Weeden, 1961). However, studies in Newfoundland (Bergerud, Peters, and McGrath, 1963) show that the age of about 97 per cent of all willow ptarmigan can be determined throughout autumn, winter, and spring by comparing the amount of dark pigment on the eighth and ninth primaries (counting outward along the wing). Young birds normally have more pigment on the ninth than on the eighth primary; the situation is reversed among adults that have completed the molt of wing feathers late in their second summer (when yearlings) or subsequent summers. This technique has not been tested adequately on willow ptarmigan in Alaska, nor on rock ptarmigan anywhere. The Alaska Department of Fish and Game and the Laboratory of Zoophysiology, University of Alaska, have data on the subject which will be pooled and analyzed in the near future.

Bergerud, et al (1963) outlined four ways to tell the sex of willow ptarmigan in Newfoundland by external means. In order of increasing accuracy, the methods are (1) color of tail, (2) wing length, (3) length of tail feathers, (4) wing and tail-feather length combined. Females have shorter wings and tails than cocks, and the tail feathers of hens have more brown pigment. Preliminary work in Alaska suggests that these methods may be useful here as well, but available data have not been examined fully.

Tracks: Track measurement in snow may show what kinds of ptarmigan have been in a given area----a technique of value where any one of the three species of ptarmigan might be encountered. On firm snow, the tracks left by rock ptarmigan usually are narrower than footprints of willow ptarmigan. Measurements made by the Department of Fish and Game showed a width ranging from 40 to 49 millimeters for rock ptarmigan (51 measurements; mean 44 mm.), and from 48 to 59 mm. (mean 53 mm.) for 93 footprints of willow ptarmigan. Duplicate measurements of prints from the same bird were avoided as much as possible.

The feet of white-tailed ptarmigan are slightly smaller than those of rock ptarmigan, raising the possibility that the tracks of the former species may be identifiable. This possibility has not yet been tested.

Capturing Ptarmigan

Light, portable traps are necessary for catching ptarmigan in summer when the birds are encountered sparingly over wide stretches of land. Both thrown and hand-held nets have been used in Alaska for this purpose. The Alaska Cooperative Wildlife Research Unit used hoop nets very effectively in July, 1953, when Unit personnel caught 312 rock ptarmigan by throwing nets over them when they were on the ground or in flight. Juveniles apparently were easier to catch than adults, judging from the 25:1 ratio of young to adults in the catch. The quick motion used in throwing a net often frightens adult ptarmigan. A hoop net on a long handle has proven more efficient for catching mature birds. The hoop, about 2 1/2 feet in diameter and made of 1/2-inch aluminum tubing, is welded to a handle of 1-inch or 3/4-inch aluminum tubing about 9 feet long. Short braces from the handle to the hoop lengthen the life of the net. The netting, with mesh about 1 inch, has little slack; it pins, rather than entangles, the bird. Nets made in Fairbanks have cost $18 to $20 each and last for one to two years under continual usage in summer.

A length of gill netting with 1-inch or 1 1/2-inch mesh can be used to catch ptarmigan in summer. The netting is hung loosely between shrubs or between temporary stakes, and the birds are driven into it. This method sometimes is successful with molting adults, which often are hard to approach close enough to catch in a hand-held net.

Few attempts have been made to catch ptarmigan in winter. At Anaktuvuk Pass, the staff of the Laboratory of Zoophysiology has trapped several hundred willow ptarmigan in winter since 1961, mostly in snares. A brush "fence" is erected in the snow in an area of willow thickets where ptarmigan feed; the snare loops are hung in small openings at intervals along this partial barrier. Few ptarmigan are killed or hurt if the snares are checked frequently.

The Laboratory staff also is experimenting with wire traps of various sizes, all built with a pair of long leads with a combined trap and holding pen. Few ptarmigan have been caught in these traps thus far.

Banding and Marking

Two types of numbered bands have been used on Alaskan ptarmigan. One, a self-piercing tag of monel metal applied with special pliers to the leading edge of the wing, was used in 1960 in limited numbers on rock ptarmigan by the Alaska Department of Fish and Game. The wing tags can be placed on young chicks whose legs are too small for leg bands. However, mortality rates of very small chicks are quite high, resulting in the quick disappearance of tagged birds before information is gained. The Department now uses leg bands exclusively. The bands are butt-end style, made of aluminum, with baked enamel finishes in red, blue, and yellow. Size 10 of the series manufactured by National Band and Tag Company (Newport, Kentucky) fits both rock and willow ptarmigan. The bands can be placed on ptarmigan when the birds are four weeks old or older, and seem to last as long as ptarmigan do.

The Laboratory of Zoophysiology uses standard aluminum bands (size 6), obtained from the U. S. Fish and Wildlife Service, on willow ptarmigan caught at Anaktuvuk Pass.

The white wings of ptarmigan make convenient carriers for colored dyes for marking birds individually in summer. (Any part of the bird can be dyed successfully in winter.) The Alaska Department of Fish and Game has used felt marking pens in five or six contrasting colors to mark breeding rock ptarmigan for close study. The Laboratory of Zoophysiology dyed a number of willow ptarmigan at Anaktuvuk Pass in winter, obtaining data on their subsequent movements as long as the birds stayed close to human settlements.

Miscellaneous Field Techniques

Locating nests: Ptarmigan nests, like those of other grouse, are not easy to find. Experience is the best instructor. Trained dogs also help. By covering additional ground, dogs make the chances of finding nests much greater. Some dogs, particularly breeds developed specifically for hunting upland game birds, will find nests occasionally by tracking a hen to the nest on which it is sitting.

Incubating hens deposit a peculiar type of dropping known as a "clocker" dropping when they leave the nest to feed. These droppings, much larger than other types of ptarmigan feces, usually are deposited within 50 feet of rock ptarmigan nests. They seem to be concentrated in moist sites. When these droppings are found, the area in which one might hope to find a nest is narrowed considerably. On a few occasions I have searched intensively but fruitlessly in an area where clocker droppings were abundant, suggesting that some hens move much further than 50 feet from the nest to feed.

Detection of predator species: Piles of white feathers, the last visible remains of ptarmigan, are found frequently in alpine or arctic areas where ptarmigan live. Sometimes it is possible to tell what kind of predator killed (or ate) the bird by the characteristics of the remains. Avian predators, of which gyrfalcons are the most common in areas familiar to me, leave chalky, white droppings at some of their kills. Most kill sites have a number of wing quills or tail feathers; the primaries and tail feathers invariably are pulled out by the hawks, and the shafts are unbroken. Gyrfalcons typically leave the feet of the dead ptarmigan, broken off just below the ankle joint, at the kill. Varying amounts of the skeleton, particularly the head and keel, usually are left. If the ptarmigan had a full crop when killed, the whole crop or its contents often are found at the kill site.

Foxes, often implicated in ptarmigan predation in central Alaska, leave quite different evidence behind them. First, they usually eat almost everything except feathers. Bone fragments rarely are left at the kill. Further, when a fox gets ready to eat a ptarmigan, it bites off the primary feathers, and sometimes tail feathers as well, leaving quills with broken shafts. Foxes also habitually defecate at the site where they killed and ate a ptarmigan.

Distribution

The distribution of grouse and ptarmigan can be thought of on two planes: the local distribution of species in terms of the terrain and vegetation utilized (habitat preference),

and the geographic extent of ranges, determined by the existence of the right habitats and the birds' opportunity to reach them. In Alaska, little detailed work on the habitat preferences of ptarmigan has been done, although some general aspects are known. No formally reported studies of grouse have been made in this regard. As for geographic aspects of distribution, we are able to circumscribe the outer limits of the range of most upland game birds; knowledge of distribution within these boundaries is limited.

Habitat Preferences of Ptarmigan

Ptarmigan are adapted to the treeless country beyond timberline. Nearly all ptarmigan live in treeless arctic or alpine areas in summer, although a few willow and rock ptarmigan dwell at the upper or outer edge of forest. Because each species has different habitat preferences, the three kinds of ptarmigan occupy different parts of the tundra. This is true even when all three live on one mountain. Distinctions in habitat become less obvious in winter, when ptarmigan feed on buds and twigs of a few species of shrubs which, themselves, have overlapping ranges. Mixed flocks of two or three species of ptarmigan are not rare in winter in southcentral and southeastern Alaska.

An investigation of ptarmigan habitat preferences was undertaken in 1956 and continued through 1958 (Weeden, 1959). I attempted to describe and compare the summer habitats of the three species, emphasizing gross appearance of vegetation and terrain. Table 1 summarizes the year-round habitat preferences of ptarmigan as I understand them. The comments apply particularly to the Alaska Range, Tanana Hills, and physiographically similar parts of southwestern Yukon and northern British Columbia.

Table 1. Summary of habitat preferences of ptarmigan in central Alaska.

	Willow Ptarmigan	Rock Ptarmigan	White-tailed Ptarmigan
SUMMER (May-September)			
Terrain	Level ground with minor relief features, or gentle to moderate mountain slopes and terraces. Frequently at bottom of valleys.	Moderately sloping ground in hilly country; middle slopes of mountains.	Steep slopes and ridges, often around cirques and high, stony benches; ledges, cliffs and rocky outcrops common.
Vegetation (General)	Luxuriant growth of plants over most of ground; shrubs usually 3-8', scattered in variable quantities through areas dominated by grasses, sedges, mosses, dwarf shrubs and low herbs.	Vegetative cover nearly complete, but sparse on driest and highest exposed sites. Shrubs 1-4' concentrated in shallow ravines, on soil-creep lobes, in hollows, etc. Most plants less that 1'. Creeping woody plants, rosette plants, sedges, lichens abundant and dominant over wide areas.	Plants rarely form continuous cover over ground, except in most protected, moist sites. Shrubs almost absent, except for dwarf forms. Wide variety of plants present in small quantities.
Relation to Timberline	Usually at upper edge of timber, among widely scattered trees. Sometimes slightly below true timberline where expanses of treeless areas exist because of poor drainage, cold microclimate, etc.	Lowest breeding birds at extreme upper fringe of trees. Most birds from 100-1000' above local timberline.	Above timberline. Occasionally within 100-200' (vertical) of last trees, usually 500-2000' above forest.

Table 1. (Continued)

	Willow Ptarmigan	Rock Ptarmigan	White-tailed Ptarmigan
Territories (Males)	Include shrubby and "open" vegetation types (with plants less than eyelevel to ptarmigan). Cocks habitually use elevated points (rocks, trees, hummocks) during courtship. Males rest during day in small clumps of shrubs at edges of open areas.	Higher proportion of "open" vegetation than in willow ptarmigan territories; some contain no shrubs. Cock sits on rock, knolls, etc. with no overhead vegetation during active courtship periods and occasionally in rest of day.	Unknown
Nests	Protected by vegetation (usually shrubby) from above and side. One open side bordering open area. In the males' territory.	Concealing vegetation usually present over nest, but small proportion of nests with no overhead concealment. Site very similiar to those selected by willow ptarmigan.	Unknown. In Rocky Mtn. areas, usually on ledge or in rocky areas beside a boulder. Few nests in vegetation tall enough for concealment.
Broods	Habitat similiar to nest sites. Young chicks tend to use areas of very low vegetation. Older broods use thickets for escape cover. Moist areas preferred, with great floral diversity.	Similiar to nest sites. Broods tend to congregate in moist swales on ridges and upper slopes. Dense shrubs avoided. Young escape primarily by flying out of sight over knolls.	Poorly known. Broods seem to prefer most moist areas, especially near snowpatches; Chicks hide among rocks, and broods rarely seen in places without large rocks and ledges.

Table 1. (Continued)

	Willow Ptarmigan	Rock Ptarmigan	White-tailed Ptarmigan
WINTER (October-April)	Willow thickets along watercourses, areas of tall shrubs and scattered trees at timberline; burns, muskegs, and river banks below timberline.	Shrubby slopes at timberline. Rarely in riparian willows. In large openings of forest where shrubs (especially birch) are scattered and project above snow. Often in windier areas than willow ptarmigan, where snow is shallower.	Most stay above timberline. Apparently feed on steep cliffs, ridgetops, benches where wind blows snow away, or on shrub-strewn slopes.

Characteristic habitats of ptarmigan are pictured in Figures 1 and 2b.

Habitat Preferences of Grouse

The four kinds of grouse found in Alaska select different types of climate, topography, and vegetation for their life activities. Spruce grouse and blue grouse are closely associated with evergreen timber vegetation which, barring major disturbance by people or natural forces, remains essentially unchanged for centuries. Ruffed and sharp-tailed grouse, in contrast, flourish when their habitats are rejuvenated periodically by fire, river action, land clearing, frost action, and other disturbances. Without such rejuvenation these vegetation types, containing high proportions of deciduous trees and shrubs, would be replaced on most sites by self-perpetuating evergreen forests.

No investigations of habitat preferences of Alaskan grouse have been made, so that we have only a superficial knowledge of the subject. A new project of the Alaska Department of Fish and Game will, in time, make information available on the requirements of spruce grouse.

Like others interested in grouse, I have a general notion of where each species is most likely to be found. This notion was formed slowly after many trips afield, after reading numerous casual references to grouse, and after talking with other hunters.

Figure 1. Habitat preferences of ptarmigan in interior Alaska.

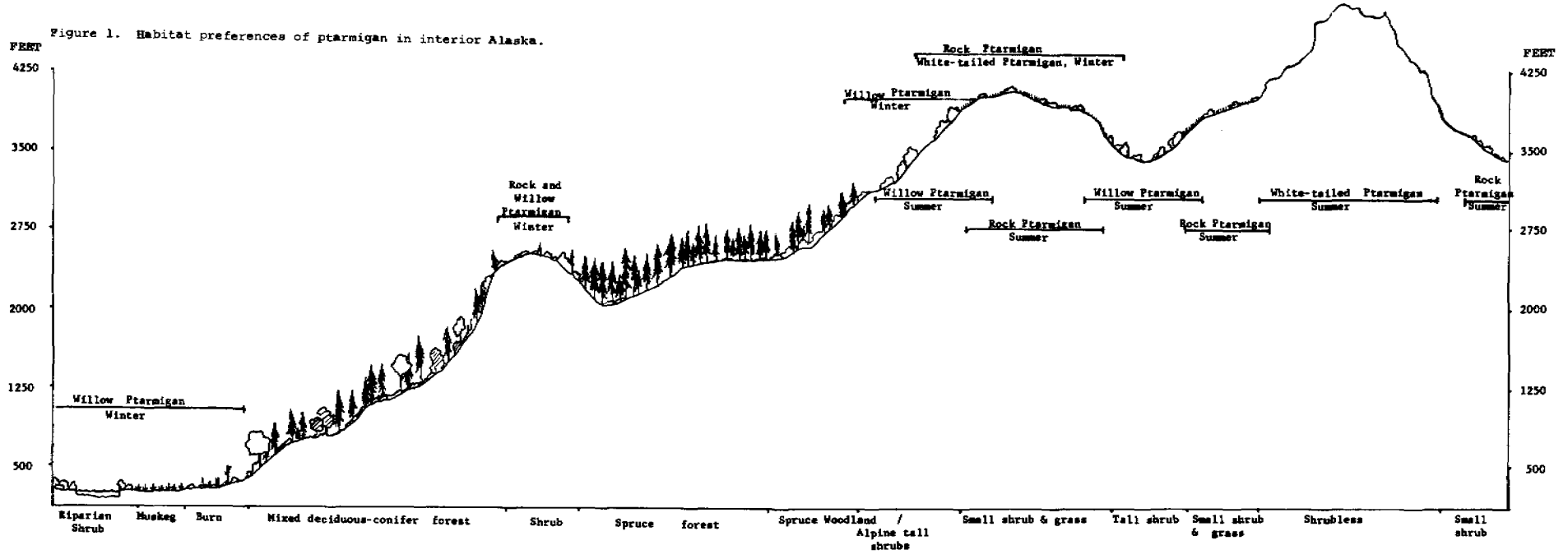


Figure 2a. Habitat preferences of grouse in interior Alaska.

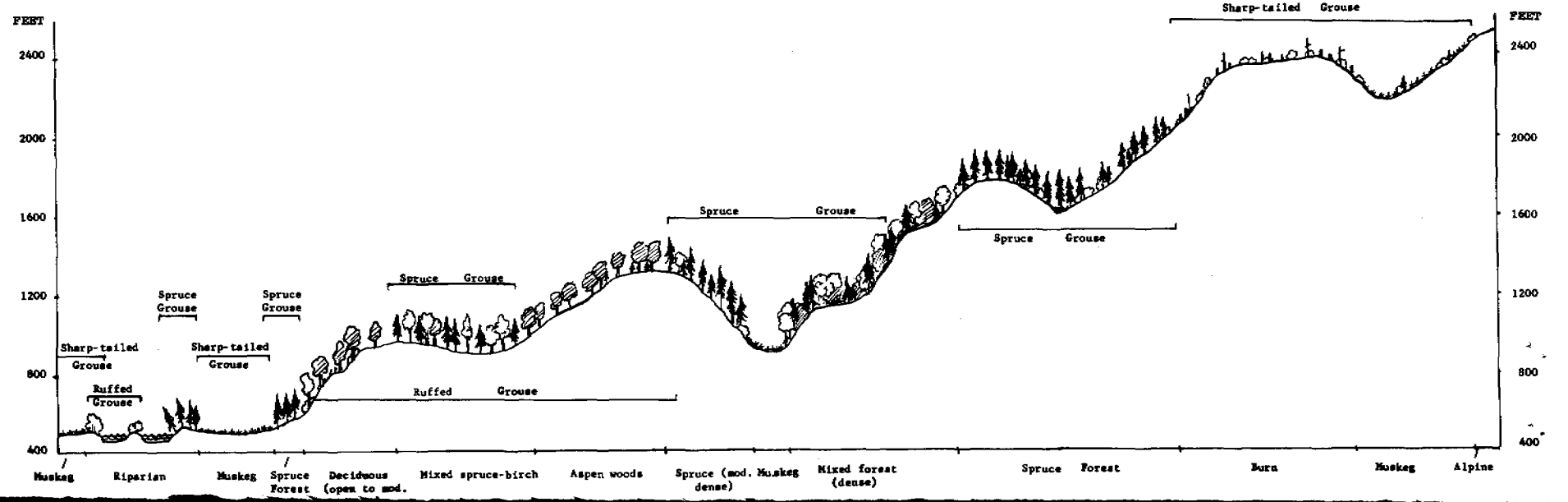
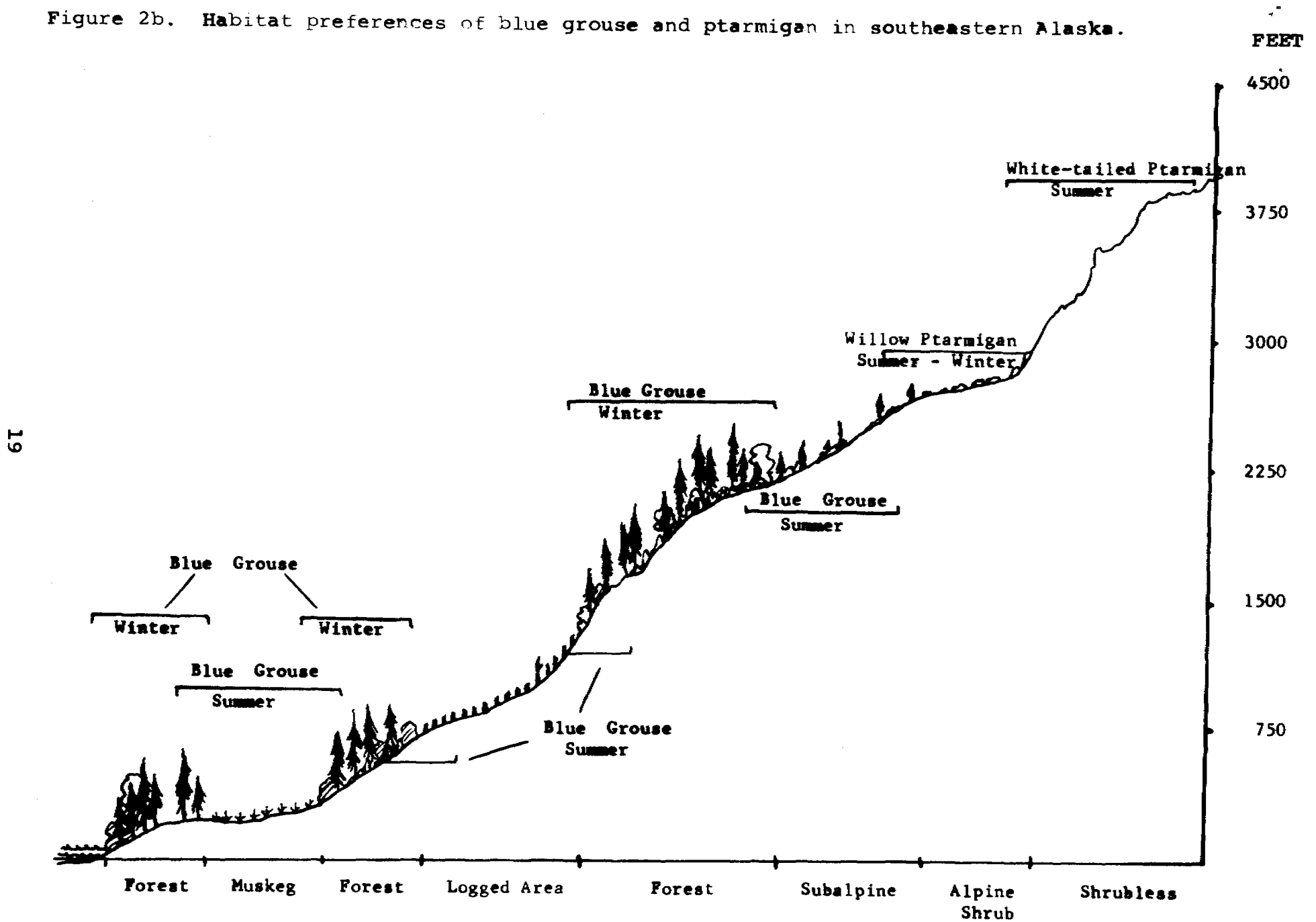


Figure 2b. Habitat preferences of blue grouse and ptarmigan in southeastern Alaska.



The following general description of grouse habitats is only a starting point for more useful studies (see Figure 2a).

Ruffed grouse: In interior Alaska, ruffed grouse often are found in stands of timber containing large amounts of aspen (see Appendix II for scientific names of plants). Such stands usually contain white spruce and white birch as well. Common understory and forest edge plants are highbush cranberry, soapberry, rose, and Labrador tea. Bearberry and cranberries are found in most areas, carpeting the ground in dry openings. Dwarf dogwood, monkshood, wintergreen, louseworts, and twinflower are common.

The ranges of ruffed and spruce grouse sometimes overlap. However, ruffed grouse seem more dependent on the younger stages of forest succession; they frequent woodland edges, shrubby ravines, and other woodland openings. The local Alaskan name "willow grouse" indicates a habitat preference of this species.

Spruce grouse: Spruce grouse seem to prefer upland situations where the forest contains mature evergreen and hardwoods, with white and black spruce making up from 30 to 90 per cent of the whole stand. Extensive pure stands of spruce do not seem to be attractive nor do forests with only a scattering of evergreen trees. Spruce needles are important foods of these grouse in late fall and winter. Relatively dense clusters of spruce are used for escape coverts, and possibly for roosting in winter. Cranberries, crowberry, Labrator tea, and dwarf dogwood are frequent components of the ground cover, as are mosses and lichens.

Spruce grouse occur in a few coastal areas where Sitka spruce and western hemlock are dominant conifers, and where the proportion of birch, aspen, and poplar is less than in the interior. Nothing is known about the use of various forest types by spruce grouse where they occur in these coastal areas (such as Valdez, Cordova, and Prince of Wales Island).

Sharp-tailed grouse: In Alaska, sharp-tailed grouse live in burned land not yet reforested, in extensive muskegs with

islands of trees, in thin stands of aspen growing on gravelly or sandy soil, and in spruce woodlands near timberline.

Burned areas that have begun to produce low shrubs, especially willows, soapberry, rose, and birch, often have populations of sharp-tailed grouse. Ground-level plants like lupines, bearberry, twinflower, and wintergreen are common in such areas. Grasses may be important constituents of the vegetation also. Frequently, moist pockets and margins of ponds in these old burns have residual stands of low black spruce and larch.

"Muskeg" is a term used for a variety of northern habitats with certain features in common: the soils are cold and wet, the surface of the ground is hummocky, several sedges and other grasslike plants form tussocks ("niggerheads") over wide areas, and low woody plants such as Labrador tea, bog rosemary, cranberry, blueberry, and cloudberry are common and widely distributed. Alder, dwarf birch, and low willows usually are present in small quantities in wetter areas, and in larger amounts where the ground is drier. Occasionally, small "islands" of white birch or larch grow on raised hummocks. Stunted black spruce and larch occur sparsely throughout the muskeg.

Another kind of habitat that supports sharp-tailed grouse is found on gravelly or sandy soils originally laid down by the action of large rivers. These old river bars and terraces usually are relatively dry in summer, and a park-like stand of aspen often develops on them. Fire may have a part in the development of this plant community. Grasses are abundant beneath the thin-crowned aspen and in open glades. Roses, soapberry, and bearberry are abundant constituents of the lower levels of the vegetation. Young white spruce often are present.

Rolling hills and ridges close to climatic timberline in sections of central Alaska are covered with a monotonous-looking forest of black spruce. The forest canopy is not closed; the trees are well spaced, and openings are common. Under the spruce and in these openings is a fairly uniform flora characterized by lichens, mosses, many heath-family species, and dwarf birch. Aspen and white birch trees are found on drier sites, particularly on south-facing bluffs near creeks. Treeless swales up to 1/2 square mile in extent occur commonly,

often resembling muskegs in their lower, wetter parts. The higher ground of the swales usually supports clustered willows from four to six feet high, in a matrix of grasses, tussock-forming sedges, mosses and lichens, Labrador tea, crowberry, and blueberries. Sharp-tailed grouse often have communal courtship grounds in these areas.

Blue grouse:[1] In Alaska, blue grouse are found on the islands and mainland south of latitude 59° N. However, no blue grouse have been reported from Prince of Wales and some other southern islands. The climate of the area is mild and wet. The average annual temperature is about 45°F and the average precipitation is 100 inches. At Petersburg there are approximately 160 days between the last frost of spring and the first frost of fall.

Blue grouse habitat (Figure 2b) can be classified into three major types: climax forest, muskeg, and subalpine forest. Grouse are in the climax forest in winter and early spring, spending most of their time in the branches of spruce and hemlock trees. About mid-March the males betray their positions by hooting, and usually can be located by diligent search. In summer most birds are seen along roads, in muskegs, and in the fringe between forest and muskeg. From August through October they seem to move up and are seen most often in subalpine areas near the edge of the forest.

The climax forest extends from sea level to about 2,000 feet. Dominant trees are Sitka spruce and western hemlock. At the upper limits there is a transition to mountain hemlock and yellow cedar. South of Sumner Strait, western red cedar is common. The edges of climax forest and muskeg are transitional in nature, containing scrubby spruce and hemlock with a mixture of yellow cedar and lodgepole pine. Red and Alaska alder are common along the beaches and stream borders.

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1 Section contributed by Harry Merriam, Game Biologist, Alaska Department of Fish and Game, Petersburg.

In heavy timber the ground may be bare except for moss and dead wood. Where there is an opening in the canopy, or in transition zones to muskegs or subalpine forests, shrubs and forbs become more abundant. The most common forest shrubs are blue huckleberry, devil's club, buckbush, black currant, and salmonberry. Blue huckleberry becomes dense and red huckleberry is present under the open canopy of forest-muskeg transitions. Of the forbs, ground dogwood, trailing bramble, and goldthread are most common. The entire forest floor normally is covered with a carpet of mosses. Ferns of various sorts are common to abundant.

The ground cover of muskegs is predominantly mosses and sedges which may accumulate as a layer of peat several feet deep. The ground is saturated with water and small pools are plentiful. Lodgepole pine, yellow cedar, and occasionally mountain hemlock are characteristic muskeg trees, occurring as scattered individuals, in clusters, or in strips. They usually are surrounded by dense growths of blue huckleberry. Red huckleberry and mountain cranberry also occur on better-drained sites. Much of the open ground is covered with a complex mixture of Labrador tea, swamp laurel, bog rosemary, crowberry, bog cranberry, bog blueberry, burnet, deer heart, marsh marigold, cloudberry, and nagoon berry.

The subalpine zone actually is a transition zone between climax forest and alpine tundra types. Vegetation is similar to that of muskegs, but the soil is better drained and more species of heaths and berries are present. The abundance of berries probably attracts blue grouse to this zone in late summer and fall. It is semi-open with clumps of mountain hemlock and yellow cedar surrounded by dense growths of blue huckleberry and copperbush. Most open ground is covered with heaths, low-bush blueberries, and forbs. Large, lush patches of deer heart and marsh marigold occupy areas where the soil is moist. On dryer sites, crowberry, bell heather, mountain heath, partridge foot, mountain azalea, low-bush blueberries, and sedges are common. Many other less plentiful species are present.

The Ranges of Grouse and Ptarmigan

Figures 3 through 9 summarize our present knowledge of the

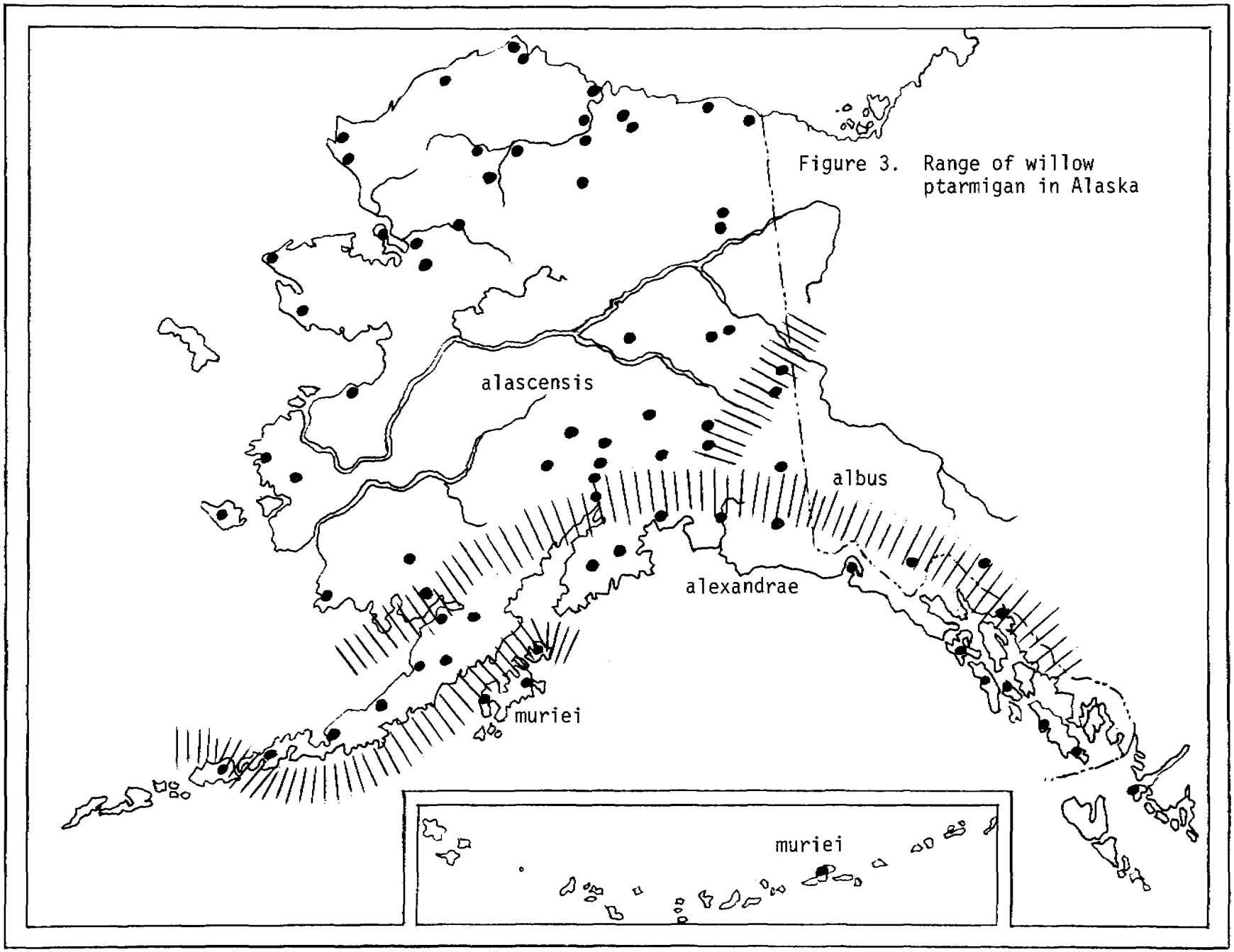


Figure 3. Range of willow ptarmigan in Alaska

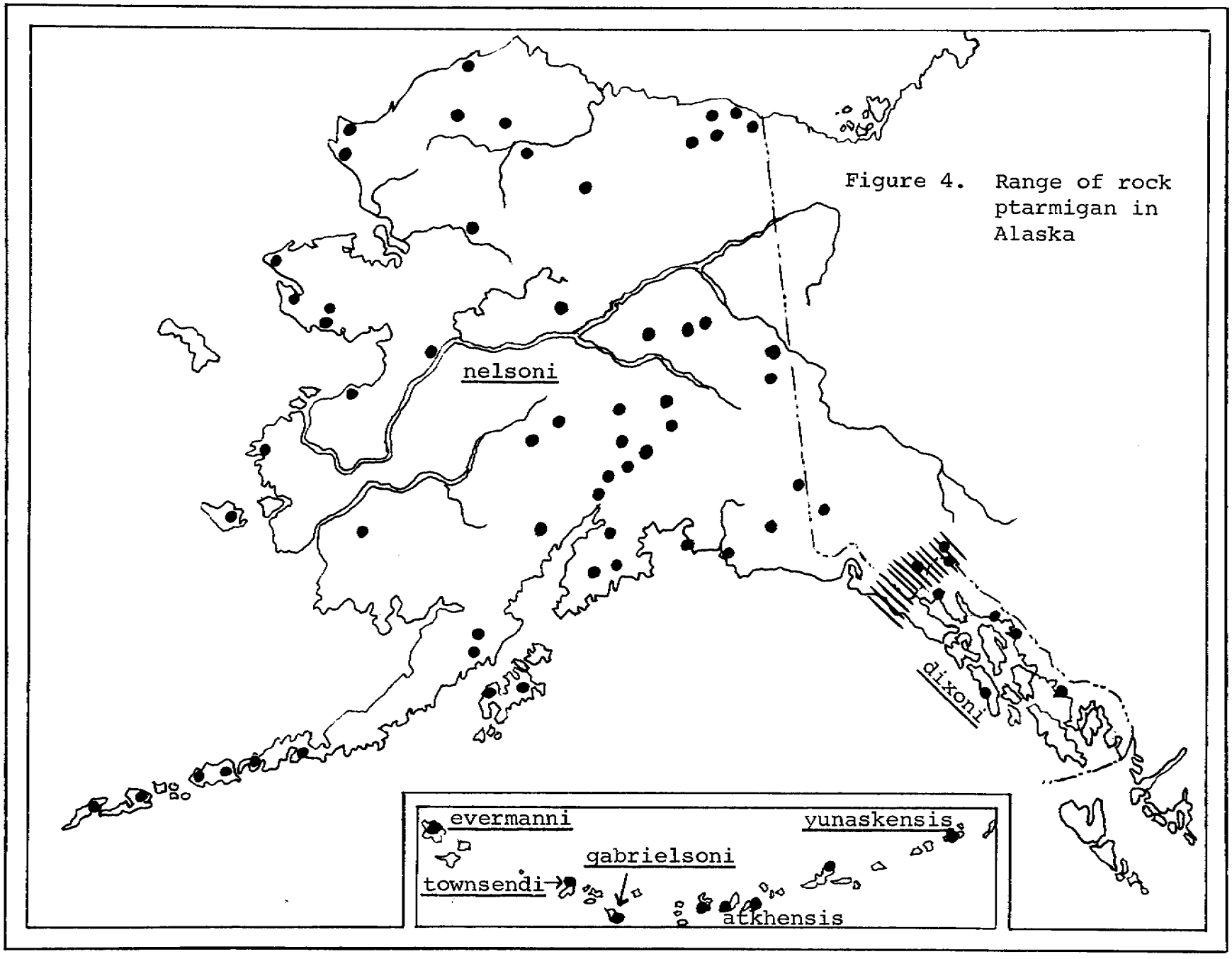


Figure 4. Range of rock ptarmigan in Alaska

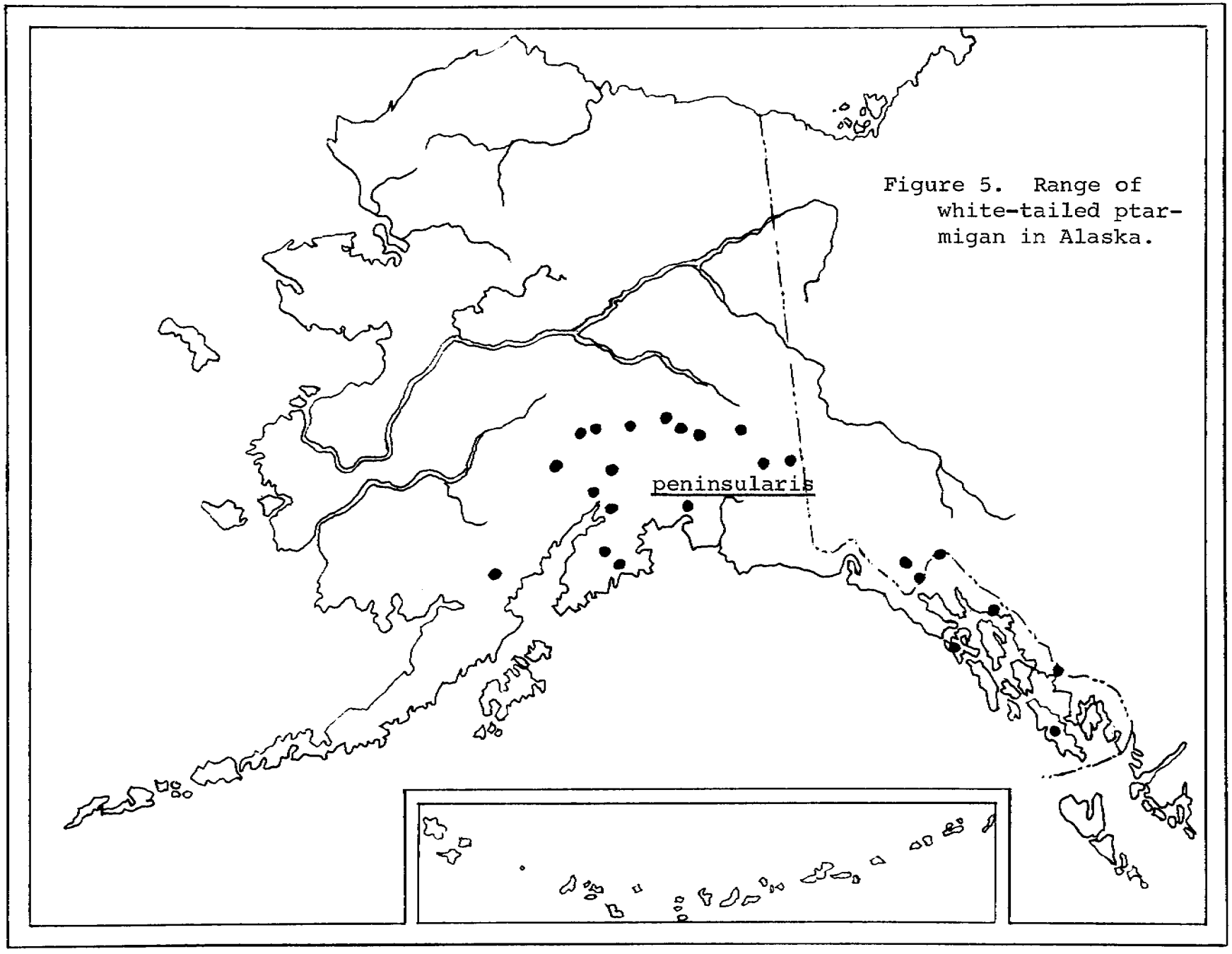


Figure 5. Range of white-tailed ptarmigan in Alaska.

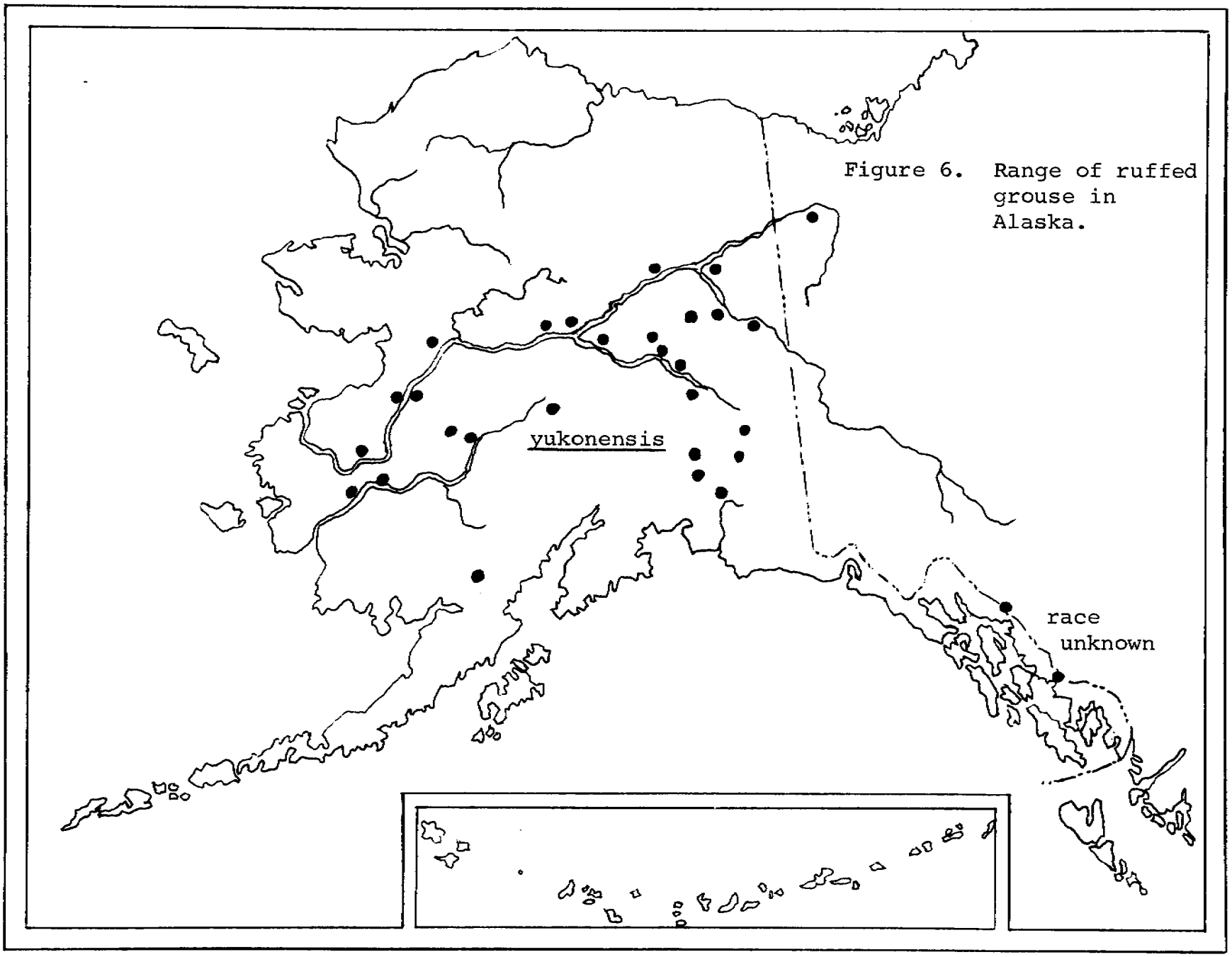


Figure 6. Range of ruffed grouse in Alaska.

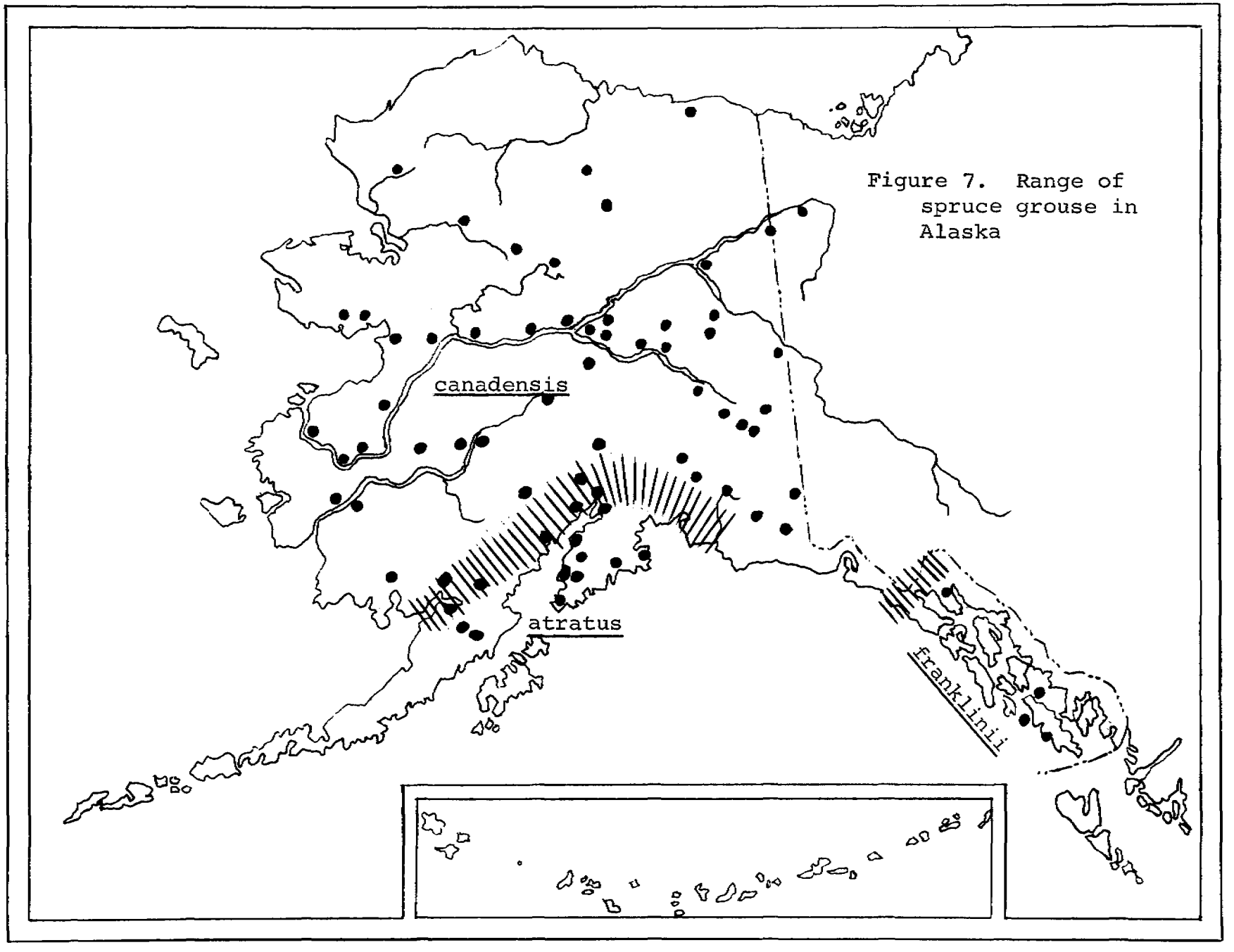
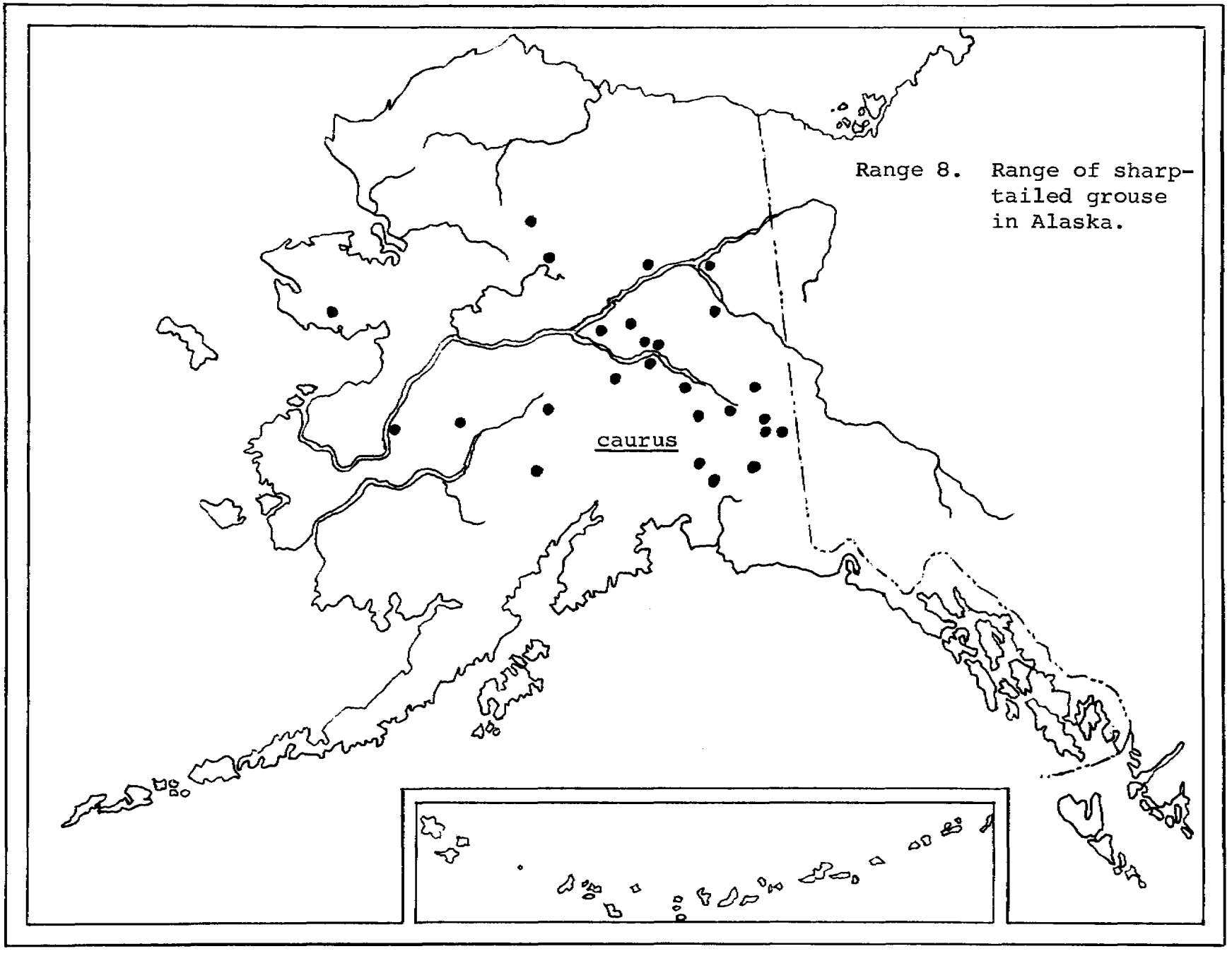


Figure 7. Range of spruce grouse in Alaska



Range 8. Range of sharp-tailed grouse in Alaska.

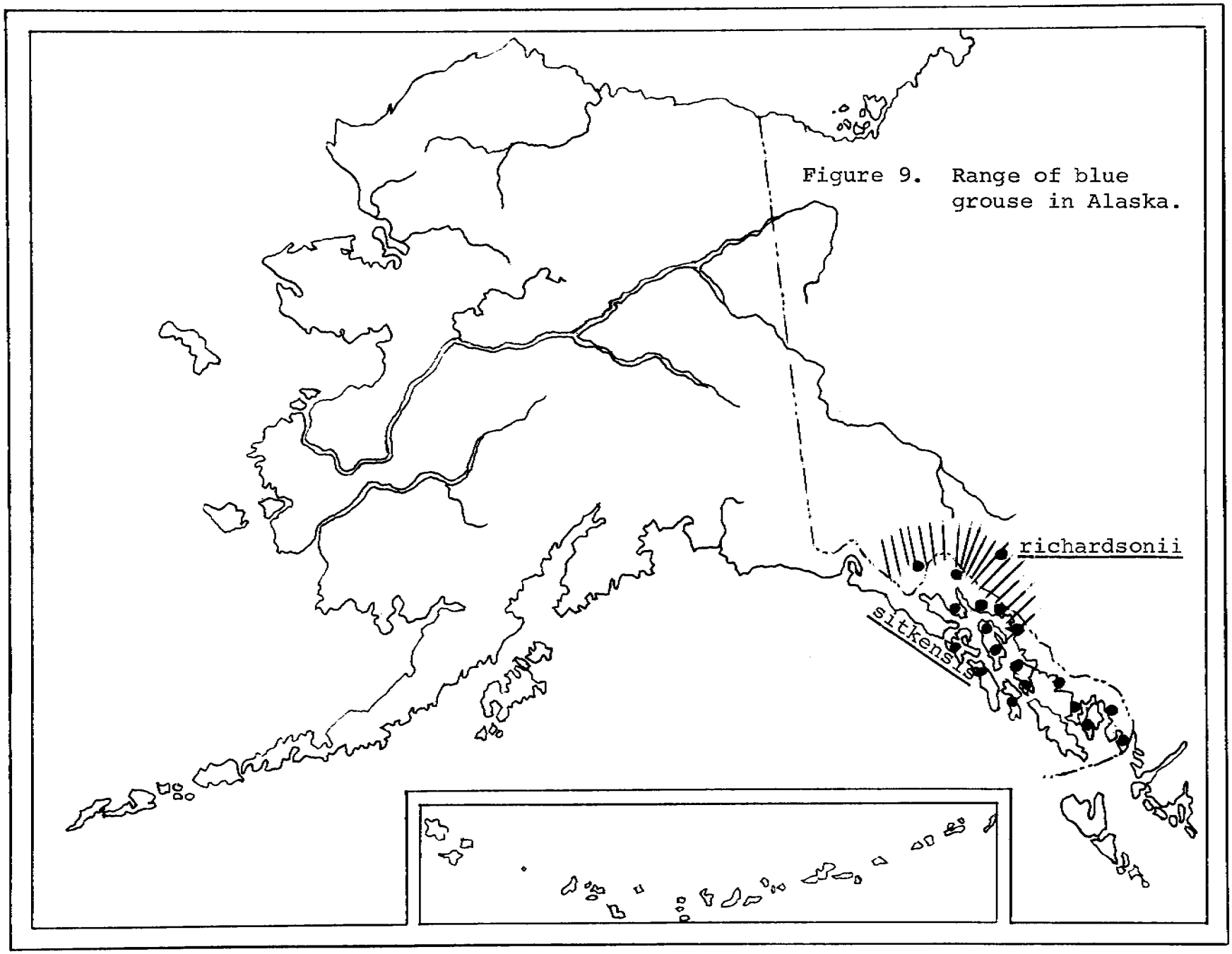


Figure 9. Range of blue grouse in Alaska.

current ranges of Alaskan upland game birds. Many of the records come from publications by Aldrich and Duvall (1955), Aldrich (1963), and Gabrielson and Lincoln (1959), whereas a number of others are from the files of the Alaska Department of Fish and Game.

Alaskan grouse and ptarmigan seem to have populated nearly all of the suitable range in the State. However, a few possibilities for range expansions may exist. Large blocks of range in the Prince William Sound area might be suitable for blue grouse if the barrier of distance from present range were overcome. Many people have speculated that ruffed and sharp-tailed grouse might survive in the upper Cook Inlet area, where no populations occur naturally. Rock ptarmigan might find small expanses of favorable country on some presently unoccupied islands in southeastern Alaska; again, the distance from present range is quite great.

Life History

To reduce the overlap of information presented here and in the section on numbers, only the main events in the life cycle, the scheduling of these events relative to the calendar, and behavior patterns, are included as "life history." Only the rock and willow ptarmigan are discussed here, as the lives of grouse and white-tailed ptarmigan have not been studied in Alaska.

Rock Ptarmigan

This species has been studied intensively in central Alaska since 1950. The life cycle as described probably is similar to that of the species in other regions.

The main events in the life of rock ptarmigan, and their chronological relationships, are shown in Figure 10.

Winter habits: In winter (the period when feeding is restricted largely to shrubby material by snow conditions, or from about October 10 to May 10), rock ptarmigan are scattered over

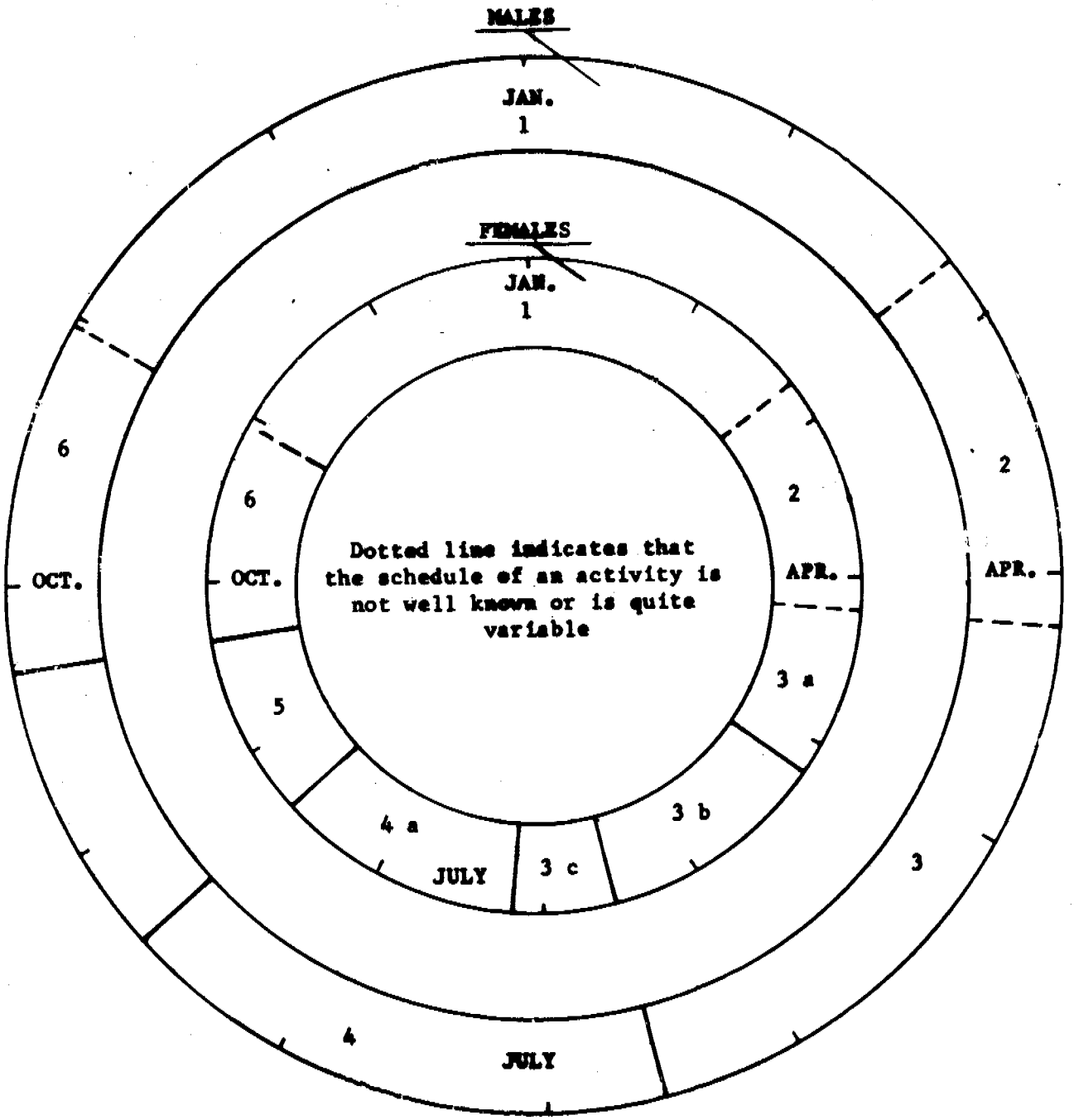


Figure 10. Outline of annual activities of rock ptarmigan in Alaska.

Figure 10. Explanation

1. Birds in flocks, with some tendency toward sex segration.

2. Spring period of greatest movement to breeding areas.

3. Males territorial. Flocks occur up to first of May, rarely after.

3a. Pairing period.

3b. Hens nesting.

3c. Peak of hatching.

4. Males molting; solitary or with other cocks. Rarely with broods.

4a. Brood-rearing.

5. Flock formation. Males join family groups. Calling and displaying among males.

6. Period of greatest movement away from breeding area.

a wide variety of habitats in interior Alaska. Some are high in the hills, usually at the lower edge of summer habitats along the upper fringe of timber. Most birds in these situations are males (Weeden, 1964). Other rock ptarmigan, primarily females, are found at lower elevations where there are extensive shrubby openings in the coniferous forest. These low-altitude wintering areas may be only a mile or two from breeding habitats, although many (such as those close to Fairbanks) are a minimum of 10, and probably 15-20, miles from the nearest alpine areas. No banding studies have been made to determine how far the birds in low-altitude winter ranges actually travel to get there, or to find out whether extensive movements occur among birds found in alpine-fringe areas.

No really intensive work on ptarmigan has been done in winter; this is one of the biggest gaps in current knowledge of the species. We know, for example, that rock ptarmigan live almost exclusively on buds and catkins in winter, especially of dwarf birches. We do not know how much food is consumed in one day, or when the most food is consumed, or whether feeding habits change with changing day length, or why birch is selected in preference to other common species. Our knowledge is equally superficial for other aspects of winter behavior. Nothing is known about roosting, except that rock ptarmigan usually roost at night and during storms in shallow holes in the snow just deep enough to cover the body of the bird. The terrain, types of snow, and vegetation preferred for roosting are unknown.

In the case of predation and predator evasion, we know little more than the kinds of animals that kill ptarmigan. In central Alaska, gyrfalcons (Falco rusticolis) and red foxes (Vulpes fulva) seem to be the most common winter predators of rock ptarmigan. Other known predators of less importance include marten (Martes americana), horned owls (Bubo virginianus), snowy owls (Nyctea scandiaca), and golden eagles (Aquila chrysaetos). I have seen two of these species, golden eagles and gyrfalcons, hunting or killing ptarmigan.

Many casual observers of ptarmigan have suggested that these birds are quite nomadic in winter. My own studies indicate that in the altitudinally lower parts of the wintering range, rock ptarmigan appear and disappear in an unpredictable

fashion. Work done in March and April on breeding grounds, however, showed that the movements of ptarmigan were quite limited. Flocks of rock ptarmigan used two or three main feeding areas, separated by distances of up to one-half mile, for a month or more, visiting each area for varying periods at least partly in response to weather conditions. Much more study of this aspect is needed.

Spring migration, territoriality, and courtship: Rock ptarmigan disappear from forest openings at low altitudes in March and April. In 1962, the first incoming migrants, (females), arrived at Eagle Creek on March 29. This migration, which probably involved transient birds as well as birds ending their travels on the study area, continued through April. By May 1 many rock ptramigan were paired, and the last flock was seen on May 11 during a snowstorm. By May 15 the birds were scattered over the entire breeding grounds in pairs, in groups of three containing one cock, or (in the case of a few cocks) as single birds.

Rock ptarmigan are basically monogamous, although two hens sometimes mate with one cock. Pair bonds last for one season. The pairs each occupy a piece of ground in which the hen nests and which the cock defends from other males. Cocks establish and defend these areas even in the absence of hens. In 1961, for example, five males set up territories in a small tributary vallev of Eagle Creek, and defended these territories while males elsewhere were also territorial, although no hens were seen in the valley until August. In March and April, 1962, I observed that male rock ptarmigan began "parcelling out" the breeding habitat in advance of the immigration of hens. The presence of females, however, noticeably increased the intensity and frequency of display activities by cocks.

Rock ptarmigan have a spectrum of displays associated with courtship of females and defense or advertizement of territories. Courtship displays I have seen include strutting (with fanning of the tail and drooping or dragging of wings), courtship flights, with males following closely behind females, and a head-jerking display given rather rarely. When other males approach the boundaries of a piece of ground claimed by a cock, several display patterns occur. The "running-in-line" display is very common, during which the males run parallel

to each other in short bursts, first one running and then the other. Both cocks, but especially the territory owner, usually give low, growling calls during this display. Sometimes the two males face each other a few feet apart, and jump into the air (simultaneously or in quick succession) towards each other. Males often put intruding cocks to flight, following behind the fleeing bird for as much as one or two miles before returning to the territory. Males advertize their territory by calling. Sometimes the calls are given from the ground when the cock is on its habitual resting place in the territory. More often, however, the croaking challenge is given at the end of a distinctive type of flight in which the bird gains altitude slowly, then rises sharply, "stalls," and flutters to the ground.

Many important aspects of territoriality and mating remain conjectural. In particular, studies are needed to determine how females select their mates or nesting grounds, whether yearlings play a role different from birds with previous reproductive experience, whether territory defense and territory size vary with environmental conditions or population density, and what importance territoriality has to the species.

Nesting: In central Alaska female rock ptarmigan begin laying eggs in the second, third, or fourth weeks of May. I have found few nests before the beginning of incubation, and therefore know little about the length of intervals between egg depositions. According to studies by Westerskov (1956), eggs are laid at intervals greater than 24 hours. As a rule-of-thumb, I consider the egg-laying period (in days) to be equal to the clutch size plus one day. The nests of ptarmigan are shallow, often seeming little more than depressions caused by the weight and movements of the sitting hen. Grass blades wound spirally around the inside of the nest occur in some cases, and a sparse accumulation of feathers from the incubating hen often is present. Nests are used only once.

Hatching occurs after an incubation period of about three weeks. The precise period is rarely determined for individual nests, because nests are not found early enough. However, I consider the average incubation period to be 21 days when calculating egg-laying dates. The error inherent in this assumption probably is not great.

Chicks usually begin pecking at the shell about 12 to 16 hours before hatching. This process ("pipping") seems to consume a lot of energy, judging from the fact that a large percentage of fertile eggs left in ptarmigan nests contain chicks that died while attempting to break out of the egg. Perhaps the tendency of hens to leave nests rather quickly after most chicks hatch contributes to this loss, as cooling of the hatching chick undoubtedly would kill it rapidly.

Hatching times: By watching nests and estimating ages of chicks found within two weeks after hatching, it is possible to amass data on the hatching schedule of ptarmigan. This was done at Eagle Creek in 1956 and each year from 1960 to 1963. The results are in Figure 11. These records show that rock ptarmigan living on the study area were well synchronized in their breeding activities. A majority of broods (75 per cent of those found) hatched in a period of 5 to 7 days each year.

Furthermore, the data show that there was little variation from year to year in the calendar dates of hatching peaks. If we determine the day each year at which point 50 per cent of all broods observed had hatched, we find that the dates are June 18 (1956), June 19 (1960), June 19 (1961), June 23 (1962), June 19 (1963). The year 1962 was recognized throughout interior Alaska as having a very late spring. Even that year, ptarmigan nested only a few days later than in other years.

The tightness of the hatching peaks suggests that rock ptarmigan did not renest very often. Only two or three cases were recorded, out of 219 hatching dates from 1956 to 1963, where very young chicks were found late in the season (Figure 11). Nest destruction and subsequent renesting could occur in the egglaying period without showing on the hatching curves as isolated, late records.

Data collected by Harvey Roberts in 1953 differ considerably from information for 1956 and later years. He found a brood at Eagle Creek that apparently hatched as early as May 27 (Figure 12) and 8 that hatched as late as July 8. His data show that there were three clusters of hatching dates within this long period; 16 broods were thought to have hatched between June 5 and June 13, 57 between June 20 and June 27, and 31 between July 3 and July 8. In view of the close synchrony of nesting

Figure 11. Hatching of rock ptarmigan at Eagle Creek in 1956 and 1960-63.

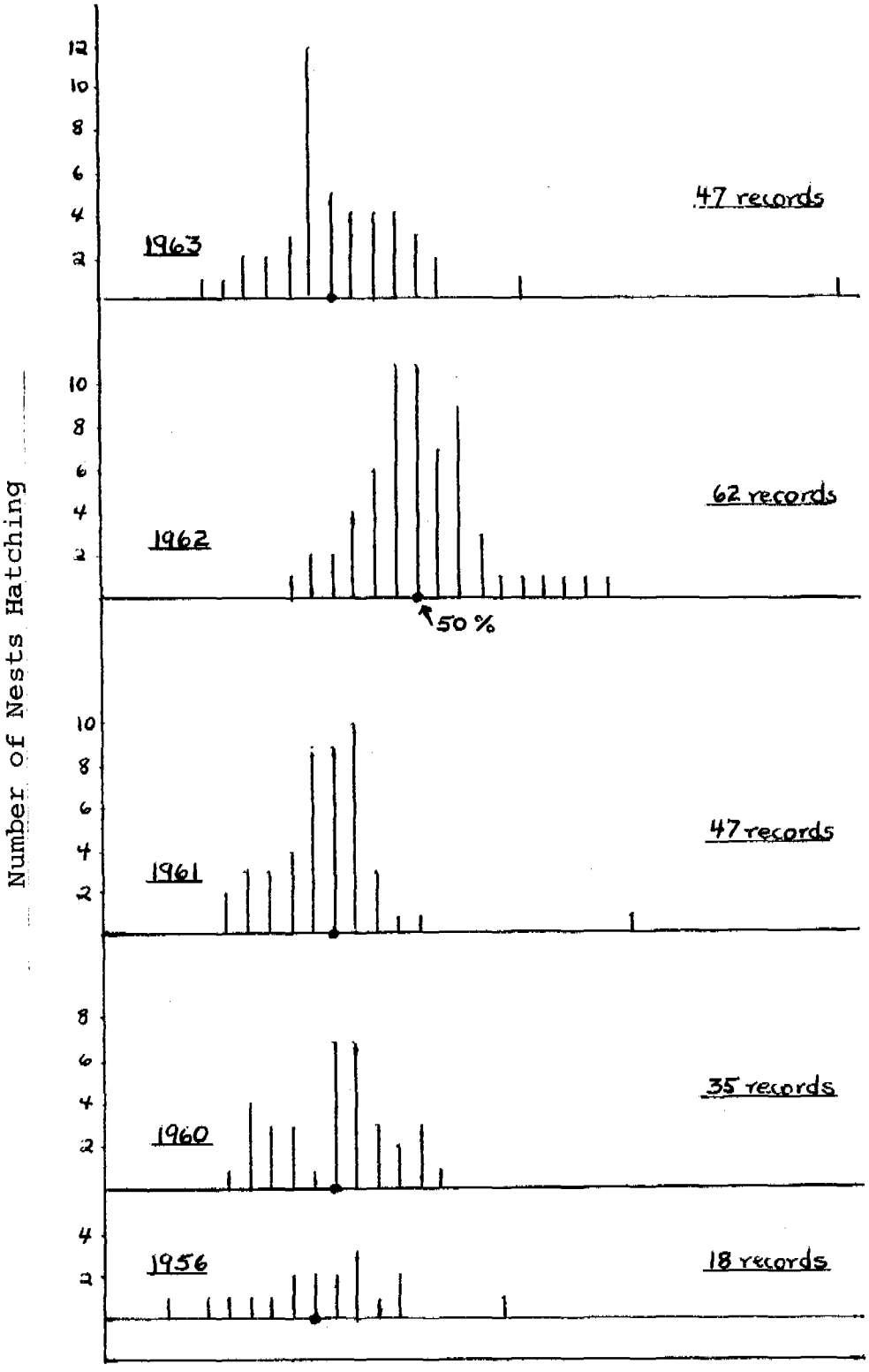
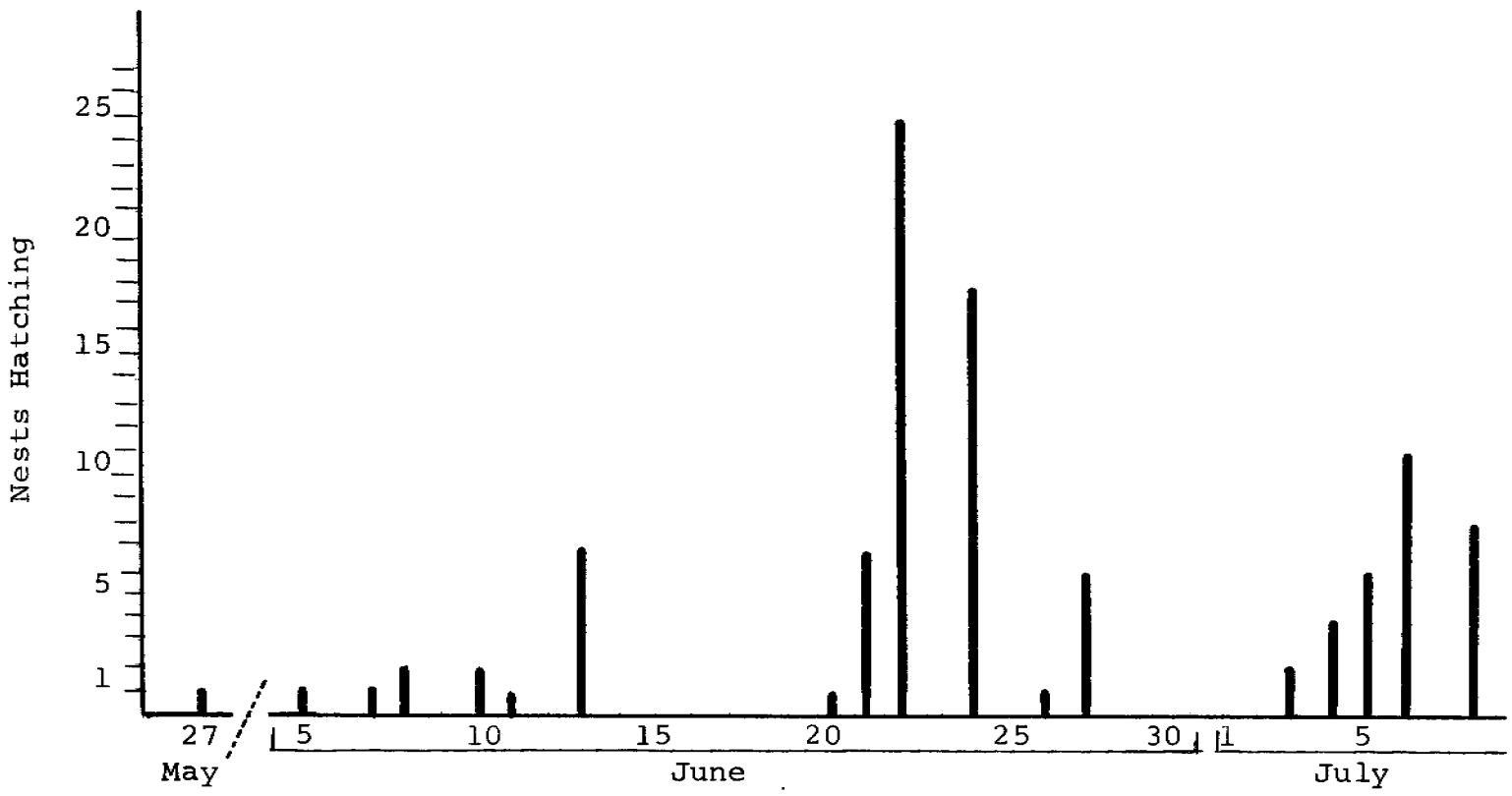


Figure 12. Hatching dates of rock ptarmigan at Eagle Creek, 1953 (Roberts, 1963).



rock ptarmigan at Eagle Creek in 5 other years, and of the concentration of hatching dates in the period June 14-26 each year despite considerable differences in pehnology, I do not know how to interpret Robert's data. His age determinations were only approximate, and inaccuracies in this technique may have affected the hatching curve as presented.

Family groups; behavior and movements: Male rock ptarmigan rarely stay with the hen and chicks in midsummer. Hens brood the chicks at the nest for several hours after hatching, the time being longer in rainy and cold weather than on fine days. Few hens stay at the nest longer than 12 hours after hatching. The chicks are brooded (covered) by the hen at intervals for one to three days after hatching; brooding at night may occur even after this.

Hens keep the chicks close by calling, and probably by virtue of the innate following reaction of chicks to a larger, moving object. Other calls cause the chicks to scatter, to remain motionless, and to feed on specific items which the hen "shows" them. Female rock ptarmigan react immediately to the peeping of a chick, either when a chick is held in the hand, or when a whistled imitation of the chick's call is given after the brood flushes. I often locate hens at distances up to 100 yards by whistling in that manner; females with chicks answer with a low, crooning sound that carries a considerable distance. Some hens react to this whistle while incubating eggs. Fewer hens reveal their presence by crooning when they are leading young, flightless chicks than when the broods are older. Females probably use the call more often under normal, undisturbed conditions in the period when chicks are relatively independent, than before that time.

The movements of family groups are variable. In 1960, one brood was found about 4,200 feet from where it was first located only five days before. In contrast, another brood was found only 50 feet from the original place of observation, ten days earlier. Net movements over longer periods of time also were variable. Two broods were found twice, at intervals of 28 days each; one family had gone 50 feet, the other 7,800 feet.

In general, rock ptarmigan females at Eagle Creek led their chicks in a seemingly erratic pattern within an area of about one half square mile. Neither the nest site nor the

the male's former territory appeared to attract the broods. However, it is likely that hens stayed in terrain familiar to them as long as suitable food and cover existed. An over-all shift of broods to altitudes somewhat higher than most nests and territories was noticeable, particularly in late July. Family groups tended to concentrate on gentle, moist slopes at the heads of valleys, often where sedges, grasses, forbs, and low shrubs dominated the vegetation. Specific parts of the study area attracted broods every year; these localities have not been studied carefully to determine how they differ from areas used less frequently.

Banding and recapture studies have proven the exchange of chicks between broods. Two cases are illustrative: On June 20, 1963 a female brooding five very young chicks was caught, banded, and marked. On July 13 this hen (B2) was found with six or seven chicks. Two were caught and banded, and one other was found with a band. The latter chick had been banded July 12 as part of another brood (B25), also led by a marked hen. On July 20, another banded chick from brood B25 was found with brood B2, which now numbered four chicks. Only three chicks accompanied this female on July 30. One of these was the chick from brood B25 found with B2 on July 20. In another instance, a marked hen with a brood (B29) was found on July 25, 1963. One of six chicks accompanying the hen had been banded with brood B40 on July 13.

I do not know how often such exchanges occur, or what consequence this behavior pattern may have.

Feather development in chicks: A considerable amount of data has been gathered at Eagle Creek on the development of juvenile plumage. I had hoped to use these data to establish criteria for age determination of chicks. However, the exchange of chicks between broods makes the value of information collected in the past very questionable. All chicks, whether banded or not, that were with a hen were formerly considered to be of the same age, and measurements were tallied accordingly. Now it seems that the members of a brood are not necessarily siblings, and therefore not necessarily of the same age.

A general summary of plumage development (emphasizing wing development) follows. This should be considered as a

preliminary description of the timing of feather development in chicks.

At hatching:	Downy except for sheathed primaries 2-3 mm in some specimens.
1 day:	Primaries 8-12 mm, fully sheathed.
2 days:	Primary sheaths to 16 mm. Vane visible on longest primaries of a few specimens.
3 days:	Vane showing on 3-4 primaries.
4-5 days:	Sheaths of secondaries and primary coverts appear; alula present in many specimens.
7 days:	Feathers growing on humeral tract; juvenile tail appears.
8-9 days:	Tail, alula, humeral tract always present; tail 5-17 mm, alula 19-24 mm, longest primary 37-45 mm.
10-11 days:	Chicks fly weakly. Flank feathers, feathers of cervical area visible.
14-15 days:	A few chicks drop the innermost primary (P1); longest primary 55-60 mm, tail 25-28 mm, alula 30-32 mm.
15-16 days:	About half of the chicks have dropped P1.

From 15 days onward, the shedding of juvenile primaries P1-8 and the appearance of P9 and P10 are age criteria:

P1 - 15-21 days	P6 - 30-35 days
P2 - 18-21 days	P7 - 38-42 days
P3 - 21-24 days	P8 - 50-60 days
P4 - 23-26 days	P9 - (white) appears at 18-22 days
P5 - 25-32 days	P10- (white) appears at 19-24 days

Primary replacement and development of brood patches among adults: Ptarmigan have two main "tasks" to accomplish in summer: to reproduce and to replace their plumage. Both activities require energy. Among male rock ptarmigan, molting occurs after the main expenditure of energy for reproduction. Among females the change to brown body plumage occurs during the height of courtship and egg-laying, and the brood patch develops during incubation and is covered with new feathers during the first part of the brood-rearing period. I have collected information on two aspects of summer plumage change: replacement of wing primaries and the waxing and waning of brood patches of females.

Male rock ptarmigan (Table 2) vary in the time at which they begin to drop and replace primaries. Early molters begin in the first five days of June, whereas late molters have a complete set of last-year's flight quills up to June 20. For this reason, samples from the male population show great variability in molt progression in the period June 6 to 20. Thereafter, the data suggest that late molters progress faster (or early molters slow down, or both), bringing all cocks into closer synchrony. The rate of molt seemed to decrease after the first week in July; from June 5 to July 5 males dropped the first six or seven primaries, but from July 5 to August 5 most males lost only two additional primaries. As males become very hard to trap in August, I have no information on the final stages of molt among males.

Table 2. Schedule of wing primary molt of 111 male rock ptarmigan Eagle Creek, 1961-63. Numerals indicate number of males examined.

Period	No Molt	Primary Molted Most Recently									
		P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
May 27-31	19										
June 1- 5	(no data)										
6-10	1		1	1							
11-15	3	2		4	2		1				
16-20	1	2	5	5	7	4					
21-25					3	4	1				
26-30						7	2				
July 1- 5						1	6	5			
6-10								3			
11-15								6			
16-20								2	2		
21-25									2		
26-30									1		1
July 31-											
Aug. 4									2		
Aug. 5- 9										5	

Table 3. Schedule of wing primary molt of 230 females rock ptarmigan, Eagle Creek, 1961-63.

(Part I)

180 Females With Nests or Broods

Period*	No Molt	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
June 16-20	7										
21-25	8	1		1							
26-30	15	14	15	6	3	1					
July 1- 5		4	16	13	10	2					
6-10			1	1	2	8					
11-15				1		6	7	1			
16-20				1**		5	9	3			
21-25							5	1	1		
26-30							1	3	1		
July 31-											
Aug. 4								2	1		
Aug. 5-10								2	1		

* 41 were examined May 27 to June 15; only one had begun the molt. This hen, which had dropped the first four primaries on June 15, was seen June 27 with a flock of adults, without a brood.

** The nest of this hen hatched July 13, 15 days after the last previous known hatching date in 1963. The delated nesting, or renesting, probably accounts for the retarded molt of the bird.

Table 3. (Continued)

(Part II)

50 Females Without Nests or Broods

Period	No Molt	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
June 16-20	7***	1		1	3	2					
21-25					2	6					
26-30					1	3		1			
July 1- 5				1		1	4	1			
6-10						1		1			
11-15								3			
16-20							1	2			
21-25									2		
26-30								1	1		
July 31-											
Aug. 4											
Aug. 5-10										2	2

*** Some hens in this group might have been off nests temporarily when captured, and thus should be in the first category. Others might have lost nests very recently.

The timing of the wing molt of hens is affected greatly by the fate of their nesting attempt (Table 3). Hens that lose nests during incubation begin to drop wing quills during the second and third weeks of June. Other females that incubate successfully do not begin the molt until the last days of June or the first few days of July. As hatching occurred in 1962 and 1963 in this same period (Figure 11), it seems likely that molt of primaries in this group of hens commences when the chicks hatch, or shortly after. The rate of molt may be faster in its initial stages among successful nesters than among unsuccessful hens. The two groups are in similar stages of wing plumage development by early August.

The development of the brood patch was observed qualitatively in 1961, 1962, and 1963, and some general descriptions can be given. The brood (or incubation) patch begins to appear in some females in the last half of May. Occasionally, a female was found during the last days of May that had a fully developed patch. At the other extreme, a minority of hens barely began to show naked areas on the abdomen and lower breast at that time. New white feathers, still largely sheathed, show up on brood patches of unsuccessful nesters in mid-June. Other hens, whose nests are not disturbed, do not begin to grow new feathers on the brood patch until late in June, usually after the chicks have hatched. The timing of plumage renewal on the brood patch in relation to hatching is not clear; there is considerable variation from one hen to another.

Habits of males in summer: Cocks become less and less aggressive in advertizing and defending territories after the first week in June, when hens are on nests nearly all day. When the annual complete molt begins, males show themselves less in open places on their territories. Some males remain on territories all summer; these usually are cocks whose territories contain thickets of tall willow or alder, in which the birds spend most of their time. Most males move from their courting grounds to streamside willow thickets or to high, rocky ridges. At Eagle Creek the area of such habitats is small relative to places used for territories, leading to the concentration of males in well defined areas. The biggest flocks are found on high ridges; groups of 40-50 adults, mostly males, have been recorded there late in June and throughout July. Most groups, especially those along streams, contain 10

or fewer individuals. Hens that have lost nests or broods usually join the flocks in both habitats. The proportion of hens in summer flocks of adults is a rough indication of the proportion of unsuccessful nesting attempts, which can vary markedly from year to year.

Occasionally (perhaps once in 20 observations) a male rock ptarmigan will be found with a brood in June or July. I have never seen a male of this species display or otherwise attempt to defend a brood against my intrusion. Almost without exception, cocks have flown off before the chicks or hen flushed, and no male ever returned when the chicks peeped excitedly.

Autumn flock formation: There is no simple way of identifying a specific period in which flocks form. Although rock ptarmigan are scattered in pairs over the breeding grounds in late May and early June, and are typically found in aggregations in late September, the change from one condition to the other is gradual. Males join into small groups in June and July, and these groups are swelled with the addition of unsuccessful nesting females. Hens are with their broods throughout July and August; beginning early in August, aggregations of several broods are common. These combined broods attract lone cocks or small groups of cocks and unproductive hens, and mixed flocks of varying origins are then scattered across the breeding areas. For reasons not understood, these small groups join, often forming large flocks of 50 to 300 although smaller groups and even single birds still occur. Single hens and their chicks comprised almost 60 per cent of 114 observations at Eagle Creek from August 1 to 20, 1960 to 1963, but only 6 per cent of 69 observations from August 21 to September 30. Conversely, flocks of mixed sex and age groups made up 8 per cent of the early observations and over 70 per cent of the later ones.

The entire subject of autumn behavior in ptarmigan needs much more study. Not only is flock formation an important activity of this season, but so are three associated phenomena: autumnal territoriality, sexual segregation, and migration. Jenkins and Watson (1963) have made a strong case for the importance of autumn territoriality among red grouse (a subspecies of willow ptarmigan found in Scotland). Red grouse seem to parcel out the available ground in autumn, with dominant cocks normally filling all of the good habitat. Surplus birds move away,

either finding empty and suitable territories, or being forced into less favorable places. Thus, the autumn territory serves as part of the mechanism by which the number of red grouse is brought into balance with the supporting capacity of the environment. A similar situation could prevail among North American ptarmigan, but we do not have the necessary information to substantiate such behavior.

Male and female rock ptarmigan often separate into different flocks, areas, or habitats in winter (Weeden, 1964). The sorting seems to occur in October, and precedes (or coincides with) the movement of most females out of alpine breeding habitats. Much more study is needed if this important behavior pattern is to be understood.

Fall movements are another poorly known aspect of the life history of rock ptarmigan. Only casual observations of unmarked birds are available to give clues as to the timing, extent, and routes of migrations or movements of ptarmigan. We do know that movements vary in their characteristics from one region of Alaska to another. Populations on the Aleutian Islands may be very sedentary; at least, there is little genetic interchange among the races described there. In interior Alaska, on the other hand, segments of most populations (especially females) habitually travel perhaps 10-50 miles from breeding to wintering areas.

Willow Ptarmigan

Although willow ptarmigan have been more popular subjects of study over their world-wide range than rock ptarmigan, relatively little research has been done in Alaska. For example, there is nothing in Alaska to match the work of Jenkins and Watson on the red grouse, or to equal the studies of Peters and Bergerud on Newfoundland willow ptarmigan. Some preliminary work was done by DeLeonardis and Roberts in central Alaska, and by Weeden in Chilkat Pass in British Columbia close to the Alaska border. The only detailed study at present in Alaska is focused on the migrations and energy relationships of willow ptarmigan in the region around Anaktuvuk Pass, Brooks Range. The staff of the Laboratory of Zoophysiology, University of Alaska, is doing this work.

Data obtained at Chilkat Pass and in central Alaska on the sequence and timing of major parts of the life cycle of willow ptarmigan are summarized graphically (Figure 13). Explanatory and supplementary comments follow.

Winter: In at least two areas of Alaska (central Brooks Range and the area encompassing the midsection of Alaska Range and interior highlands) male and female willow ptarmigan often spend the winter in different places (Irving, ms. 1964; Weeden, 1964). Most wintering ptarmigan at Umiat and Anaktuvuk Pass are males; hens are common only in October, November, and April. Many of the willow ptarmigan in timbered areas south of Anaktuvuk Pass, however, are females. Alpine-fringe areas in the Alaska Range and Tanana Hills are inhabited largely by males in winter (November to March), whereas most willow ptarmigan in the Tanana Valley in that period are females.

Male willow ptarmigan in interior Alaska often live in winter in timberline areas used also then by male rock ptarmigan or very close to habitats used by the latter species. Mixed flocks of these species are not rare. At times white-tailed ptarmigan are also found in these flocks. The interactions of the various ptarmigan in these mixed flocks, or in areas where the species occupy closely intertwined habitats, would be a fascinating subject for study.

Shrubby habitats with few trees are preferred by willow ptarmigan in winter. Below timberline such habitats are found in burned areas, along rivers, and in areas disturbed by agriculture or other human activities. Dense stands of timber are rarely used. Flocks of thousands of willow ptarmigan sometimes occur in dense willow thickets along rivers near the northern or western limit of trees in Alaska (for example the Noatak and Kobuk Rivers).

The main movement to breeding areas begins in mid- to late March in central Alaska, and continues through April. Further north, migrating flocks seem to reach peak abundance in February and again in April (Irving, 1964, ms.). Many breeding grounds north of the Brooks Range are not occupied until late in May.

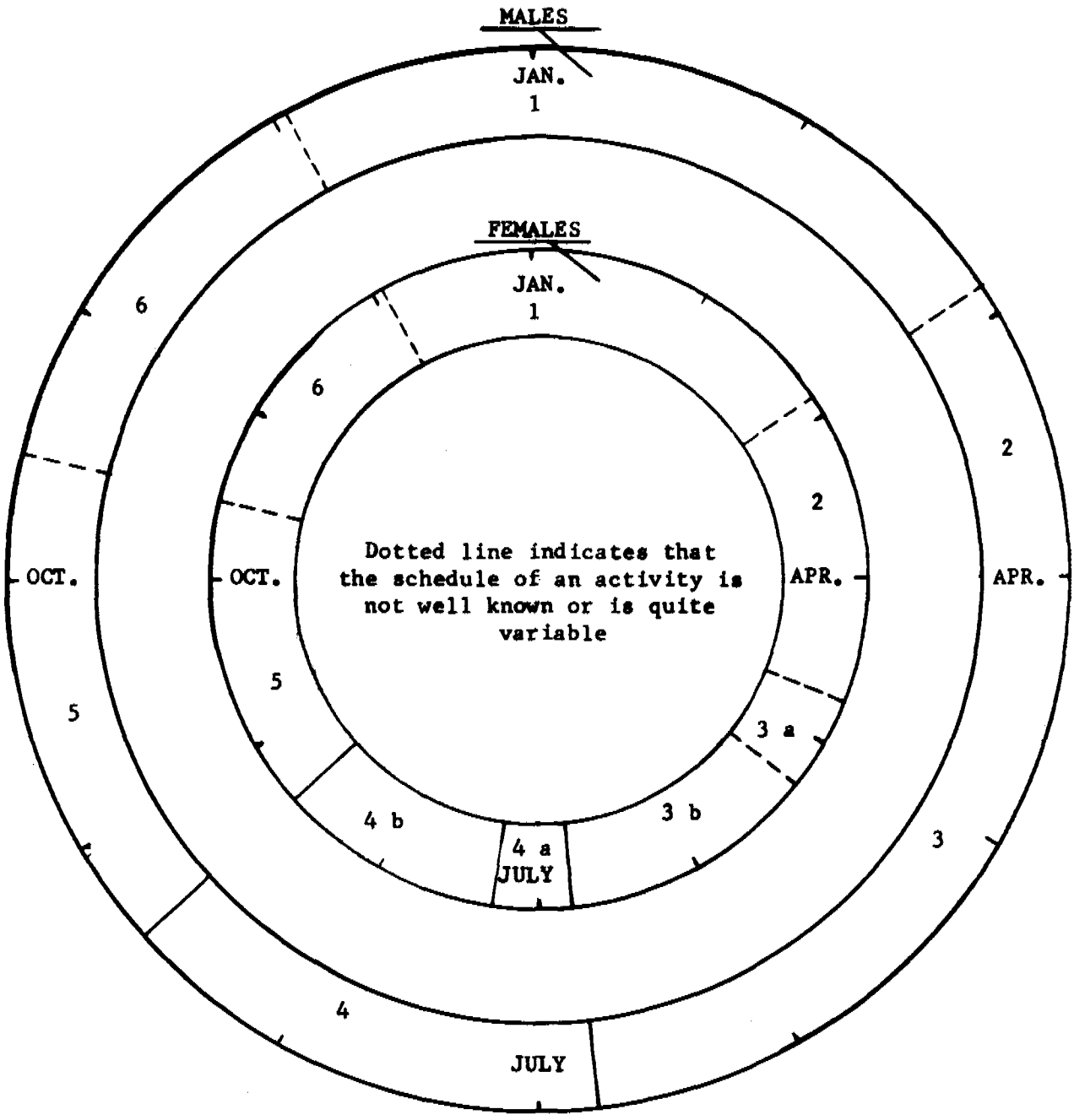


Figure 13. Outline of annual activities of willow ptarmigan in Alaska.

Figure 13. Explanation

1. Birds in flocks, with some tendency toward sex segregation; birds nomadic.

2. Spring period of greatest movement from wintering to breeding places.

3. Males territorial. Flocks still present early in May, although courtship activities begin a month previously.

3a. Hens taking active part in courtship and pair formation.

3b. Hens nesting.

4. Males with broods. Some cocks leave family at onset of molt early in July.

4a. Peak of hatch.

4b. Brood-rearing period.

5. Flock formation. Cocks' display and call; may be territorial.

6. Autumn period of greatest movement to wintering areas.

Breeding season: The behavior patterns of breeding willow ptarmigan basically are very similar to those of rock ptarmigan. Willow ptarmigan select different habitats for territories, as already described, and their gargling courtship calls differ markedly from the rolling "snores" of rock ptarmigan. Male willow ptarmigan stay close to the nesting hen, and are very active in caring for the young. This, of course, is in contrast to the behavior of male rock ptarmigan. However, the general courtship patterns, territory defense, incubation period, etc., are not very different from those of rock ptarmigan.

An interesting divergence of molt patterns is evident between the two species. Female rock ptarmigan begin the change to summer plumage early in May, and are almost completely brown by the first of June. Cocks of this species retain their winter plumage until early June, after the period of courtship is over. Among willow ptarmigan, however, males and females begin to molt late in April (in interior Alaska). The molt, which begins on the head and neck in both sexes, seems to progress faster initially among males. Be early May the cocks have a complete cape of chestnut-red feathers from crown to upper breast. Then their molt is almost arrested for a time during the height of courtship. The female continues to shed white feathers, and is quite brown by the latter part of May. Males get brown feathers slowly during late May, and do not have a complete set of summer feathers until late in June. The essential difference between the two species, therefore, is that the courtship plumage of male rock ptarmigan is pure white (except for the eyestripe and black tail), whereas that of the male willow ptarmigan is a striking contrast of rich brownish-red and white. Possibly these differences are useful in inter-specific recognition among males.

Although my studies of rock ptarmigan have uncovered no instances in which a pair mated in two consecutive summers, two such cases have occurred during my work on willow ptarmigan even though fewer data are available for study. A male and its mate were caught and banded in June and July of 1957 on the study area at Chilkat Pass, and the same two adults were defending a brood 100 yards west of the point of banding in June 1958. At Eagle Creek, a pair observed closely and banded in June, 1962 were found again in the same locality in 1963 with a brood of chicks. One case is known in which a male had different mates in consecutive summers, and one case in which a male mated with one female one year and two females the following year.

Scattered information on hatching dates of willow ptarmigan occurs throughout ornithological literature on Alaska, but the records are too widely dispersed in space and time to be of much value. Data from Chilkat Pass in 1957 (Figure 14) indicate hatching dates from June 21 to July 26 (47 records), with a peak from June 27 to July 3. Visits to the Pass each year early in June have confirmed the impression that this area, with deeper snows and a more coastal spring climate, is phenoligically less advanced than alpine areas in interior Alaska on the same date. Hatching dates of ptarmigan seem to reflect this difference.

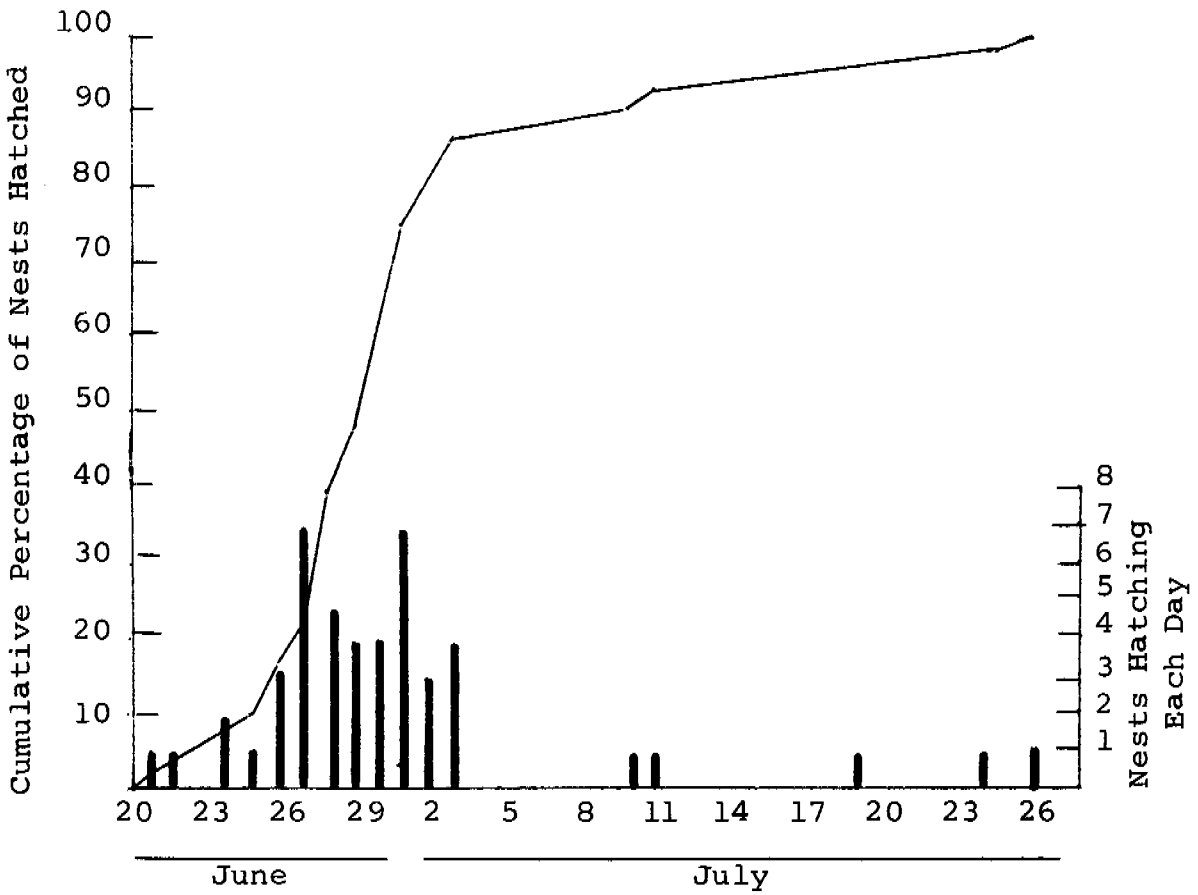
At Chilkat Pass, families of willow ptarmigan began to break up early in August of 1957. Lone chicks, small groups of chicks (sometimes accompanied by one adult), and lone adults were seen much more often than whole families. There seemed to be a movement out of the study area at the same time. I have had no opportunity to observe this late-summer dispersion more fully. The formation of autumnal flocks of willow ptarmigan has not been studied in Alaska.

Food Habits

Wildlife biologists use the term "food habits" in the limited sense of lists of food species found in parts of the digestive tract or in feces. These data give information on the kinds of food consumed by an animal over an extremely short part of its life, and on the relative amounts of the food items. Studies of grouse and ptarmigan rarely have dealt with samples big enough to encompass even the grossest variations due to year, season, age, or sex. Only a few studies (none in Alaska) have related crop or gizzard contents with food availability in quantitative terms. The caloric values and nutritive contributions of food items are almost completely unknown, and seasonal, annual, or local variations in the quality of foods--known to be of great importance to the nutrition of deer, for example--have not been investigated. Finally, we have only a superficial knowledge of the way upland game birds look for, select, and pick up food items, their daily feeding patterns, and other behavioral adjustments to food recources.

Date on food of Alaskan ptarmigan and grouse consist

Figure 14. Hatching dates of willow ptarmigan at Chilkat Pass, 1957; cumulative percentage and number of nests per day.



solely of crop analyses. Crops of rock and willow ptarmigan now available justify a survey of items commonly found in crops of those species throughout the year in central Alaska. The size of collections of crops for all other species is inadequate for a year-round survey, although there are fair numbers of fall crops from interior Alaska populations of spruce grouse.

Rock Ptarmigan

Crops from 482 rock ptarmigan were examined by Harvey Roberts, Salvatore DeLeonardis, or personnel of the Alaska Department of Fish and Game (Table 4). All crops are from birds collected in eastcentral Alaska (Tanana Hills) or in the Alaska Range. Very few specimens were taken in May and June, but nearly all other months are well represented. Most collections were made in 1951, 1952, and from 1959 to 1963, inclusive. Only adult birds, and chicks taken after July 31, are included in the total. Crops with less than 0.5 cc of at least one food item were discarded. Volumes were determined by displacement of water; the volume was recorded to the nearest 0.5 cc. Items with less than 0.3 cc volume were recorded as traces.

On the basis of a preliminary tabulation of food items, I established arbitrary "seasons" as follows: Fall, September 20 to October 10 (21 days); winter, October 11 to May 9 (211 days); spring, May 10 to June 5 (27 days); summer, June 6 to September 19 (106 days). These periods seem to reflect most clearly the seasonal differences in foods eaten by rock ptarmigan.

Winter: Dwarf birch is far more abundant than any other item in crops of rock ptarmigan in winter. Buds, catkins, and (less often) twigs of this shrub are taken. Willows of various species are the only other items appearing consistently in the winter diet of rock ptarmigan. Food present on or within a few inches of the ground (such as dried crowberries, blueberries, and leaves of mountain avens) is used very sparingly.

Spring: This three or four-week period is one of dietary transition, in which much more of the food is picked up on or close to the ground than in winter, and in which the first new

Table 4. Common foods* in crops of 482 rock ptarmigan from interior Alaska.

Item	(Per cent of total volume for each season) Spring** (12 crops)	Summer (249 crops)	Fall (102 crops)	Winter (119 crops)
Dwarf birch buds, catkins	11	12	45	79
Blueberries	13	23	25	2
Crowberries	11	11	7	2
Mountain avens leaves	13	10	2	1
Willow buds, twigs	2	4	5	13
Cranberries	25	2	4	
Sedge seed heads		4	9	
Horsetail tips	18			
Caterpillars		12		
Alpine vetch leaves		8		
Anemone leaves		4		
Smartweed seeds		3		
Lupine leaves	2			
Snails	2			
Unidentified leaves	2	2		
Unidentified flowers	2			
Chickweed leaves		1		
Alder catkins				1

* Only items contributing at least one per cent of the total volume in one season.

** See text for calendar dates of seasons.

growth of plants (horsetail and green leaves of vascular plants, as well as occasional flowers) appears in the diet. Animal foods also begin to show up at this time. Diversity is characteristic of the diet, in contrast to winter conditions.

Very few crops have been collected in this period, and further collections undoubtedly will change the proportions of various items on the spring list, as well as add to the list.

Summer: The summer diet of rock ptarmigan is a diverse array of new plant growth. In a sense, however, it is peculiar that more plant species are not found in significant amounts in the birds' diet at this season. The number of species taken certainly is small relative to the number present in good ptarmigan habitat. However, most crops included in the summer list were taken in August and early September: One would expect that further collecting in June and July would show more diversity and shift the relative abundance of many items. It may be useful, when more birds are collected in early summer, to subdivide the summer period into two segments. Leaves and flowers probably would dominate the earlier period whereas the late-summer period would be characterized by the presence of large amounts of berries and seeds.

The effect of yearly variations in diet in a single part of the year is evident when the occurence of caterpillars is plotted by years. Caterpillars were very rare in crops of rock ptarmigan taken at Eagle Summit in late summer in 1959 to 1963, making up less than one per cent of the diet. In 1952, however, many rock ptarmigan were collected in this area in the last week of August; almost all contained from 10 to 60 large caterpillars. The size of this collection was sufficient to give caterpillars a high percentage of the total volume of foods for the summer period.

Fall: The fall period is one during which the number of food items taken decreases rapidly, dur to the disappearance of insects and green plants and to the increasing snow cover. Blueberries and sedge heads reached their highest relative volumes in this period, and dwarf birch increased drastically in its occurence. Foods taken from the ground generally diminished in percentage of total volume, as in the case of crowberries and leaves of mountain avens.

Willow Ptarmigan

Except in winter (using the same arbitrary seasons as described for rock ptarmigan), data on foods of willow ptarmigan are scarcer than for rock ptarmigan. Only 104 crops are available from central Alaska for the period from May 10 to October 10, and 264 for the whole year. Crop analyses were done by DeLeonardis, Roberts, and the Alaska Department of Fish and Game. Results are given in Table 5 for 264 crops from interior Alaska.

Winter: Willow ptarmigan, like rock ptarmigan, subsist almost wholly on buds and twigs of willow and birch shrubs. The proportion of each species group, however, is exactly reversed in willow ptarmigan. As mentioned earlier, the two ptarmigan often live in close contact in winter. The wide divergence in relative amounts of willow and birch eaten in this season might be a means of preventing too much competition for the food resource.

Spring: The foods consumed by willow ptarmigan in spring are generally like those chosen by rock ptarmigan. The former species appears to eat fewer berries. However, the sample of crops form the spring period is too small for reliable comparisons.

Summer: Willow ptarmigan represented in this collection appeared to rely heavily on blueberries, green leaves of blueberry and willow, and the tips of horsetail (found in abundance in willow thickets by streams). The fact that nearly as many food items (11) were present in measurable volume in 46 summer crops of willow ptarmigan as in 249 crops of rock ptarmigan (13 items) suggests that the former may have a more diverse diet than the latter in summer.

Fall: The same trends were noticeable in the diet of willow ptarmigan in late September as among rock ptarmigan. Buds and twigs became much more common in crops than they were in summer, whereas leaves diminished in importance. Blueberries were the second ranking food by volume in fall crops,

Table 5. Common foods* in crops of 264 willow ptarmigan from interior Alaska.

Item	(Per cent of total volume for each season) Spring (14 crops)	Summer (46 crops)	Fall (44 crops)	Winter (160 crops)
Willow buds, twigs	41	5	36	79
Blueberries		28	31	
Willow leaves	26	23		
Horsetail tips	19	12	7	
Dwarf birch buds, catkins		3	4	12
Cranberries		6	4	2
Crowberries		4	7	
Blueberry leaves		10		
Sedge seed heads		1	7	
Mountain avens leaves	4		1	
Fly larvae	4			
High-bush cranberries				2
Birch leaves	2			
Dwarf dogwood leaves		2		
Flowers (unidentified)		2		
Aspen buds, twigs				2
Bearberries	1			
Caterpillars	1			

* Only items contributing at lease one per cent of the total volume in one season.

as they were among rock ptarmigan.

Crops from the Alaska Peninsula: I obtained 31 crops of willow ptarmigan from Cold Bay, at the south end of the Alaska Peninsula, through the courtesy of the Alaska Cooperative Wildlife Research Unit. The ptarmigan had been collected from September, 1950, to February, 1951, by personnel of the Aleutian Islands National Wildlife Refuge. Analysis of the crop contents (Table 6) brought out a marked difference in diet between birds of the Cold Bay area and those of interior Alaska. Cold Bay birds obviously were able to feed on the ground throughout the winter--a fact confirmed by Robert Jones, Refuge Manager at Cold Bay, in a letter to me dated March 25, 1964. Willow buds and twigs still were the heaviest single item, comprising over 40 per cent of the total weight of the crop contents. (Weights were used rather than volumes because the material had been stored dry in a warm room for about 13 years, making it difficult to measure volumes in water.)

Spruce Grouse

Enough crops from fall-shot spruce grouse have been collected by the Department of Fish and Game to allow a preliminary listing of foods taken in abundance by these grouse in central Alaska. Table 7 summarizes the food items found in 90 crops from birds taken in August, September, and October. The late-summer diet of berries and leaves, typical of spruce grouse in this sample in August and most of September, changed within a few weeks to a diet dominated by spruce needles. The change to a winter diet probably was not complete for most birds in early October. Only five of the 90 crops in this series were taken after October 16.

The Department of Fish and Game is continuing to collect crops of spruce grouse from specimens taken throughout the year. A much more complete survey of foods of spruce grouse at all seasons should be possible in a few years.

Numbers of Upland Game Birds

Classical zoology was concerned mostly with individual

Table 6. Contents of 31 crops of willow ptarmigan from Cold Bay, Alaska Peninsula, in the winter of 1950-51.

Item	(Air dry weight in grams) September (6 crops)	October (8 crops)	November (6 crops)	December (6 crops)	February (4 crops)	Total	Per Cent Total Weight
Willow buds, twigs	0.3	11.3	13.0	23.8	1.8	50.2	41
Crowberry leaves	0.3	12.1	0.2	9.1	13.0	34.7	28
Salmonberry buds			0.1	1.5	21.4	23.0	19
Crowberries and Cranberries (combined)	1.7	8.3				10.0	8
Willow leaves	0.8	1.4				2.2	2
Bearberry leaves		0.1			1.0	1.1	1
Horsetail tips	0.7					0.7	1
Salmonberry leaves			0.5			0.5	--
Birch buds				0.3		0.3	--
Violet capsules	0.1	0.2				0.3	--
						123.0	100

Table 7. Common foods in crops of 90 spruce grouse from central Alaska in August, September, and October.

Item	August (11 crops)	September (57 crops)	October (22 crops)
Cranberries	67*	47	24
White spruce needles		7	46
Horsetail stems	8	5	10
Blueberry leaves	12	12	
Blueberries	3	10	6
Bearberries		5	4
Labrador tea capsules	5	1	
Crowberries	3	2	
Unidentified fungus			5
Birch seeds		3	
High-bush cranberries		3	
Black spruce needles		2	1
Dwarf dogwood fruits	1		1
Alder leaves	1		

* Percentage of total volume for individual months.

animals. Species were described from single specimens chosen because they were "typical" or because they were the only ones available. Anatomy, physiology, and life history were studied as attributes of individuals. The study of single animals still is an important part of zoology. In recent decades, however, students have begun to observe the behavior or performance of aggregates of animals. Instead of noting the size and fate of one clutch of robin eggs, for example, investigators began calculating rates of reproduction of many robins living in a particular area. Similarly, death rates can be calculated for a group, but not for an individual; many other phenomena, such as migrations, can be understood fully only as group patterns.

The word "population" often is used in studies of groups of animals, and it is given many meanings. First, it can mean the total number of individuals of a particular species (or distinct part of the species, such as males, albinos, yearling, etc.) on a specified area at a given time. Second, geneticists use the word to describe a group of interbreeding or potentially interbreeding members of a species that are isolated by barriers of topography, distance, climate, etc. from other similar groups. A genetic population is a discreet, functional unit of a species. Most field biologists, in contrast, apply the term "population" to any aggregation of individuals of a species found on a particular area. This "population" is usually a fraction of a genetic population, and is distinct chiefly because an arbitrary boundary has been drawn around it on a map. It is not an entity, ecologically or genetically.

In this report three types of numerical or "population" phenomena will be discussed: (1) gross numerical changes of upland game birds in Alaska; (2) changes in numbers on small areas studied more intensively; (3) numerical characteristics of rock ptarmigan groups summering at Eagle Creek, with emphasis on reproduction and death rates.

Statewide Changes in Numbers

Salvatore DeLeonardis, Alaska Cooperative Wildlife Research Unit, mailed questionnaires to about 100 selected residents of Alaska, asking them to comment on the abundance of grouse and ptarmigan each year from 1903 to 1951. DeLeonardis (1952) concluded that "...the ptarmigan population in Alaska is subject to a well defined periodic fluctuation in numbers. Peak

populations occur quite regularly at about 10 years intervals. According to the reports, the peak population years in Alaska have been 1903-05, 1913-15, 1926, 1938, and 1946."

I do not think the data support such a conclusion. In the first place, very few assessments were available for tabulation for each year (although each respondent gave information about a number of years). Only 45 comments applied to the 23-year period 1902-24 inclusive, or only two per year. Considering the fuzziness of human memories concerning natural phenomena occurring one-quarter to one-half century previously, I would be reluctant to draw conclusions about ptarmigan numbers from these data. After 1924, from 7 to 39 responses were obtained for each year, with more for the latter part of the period than for the earlier part. DeLeonardis did not indicate how peak years were selected. If peak years are defined as those years in which replies of "abundant" were are least twice as numerous as replies of "scarce" (the only choices given), then "peaks" occurred from 1925 to 1951 in 1925, 1926, and 1929. I am not sure how one can conclude that there was a peak in 1946 when more people thought ptarmigan were scarce (18) than thought they were abundant (13). One feature of the replies was that the evaluation "scarce" was made by a majority of respondents every year from 1939 to 1951. As old residents were relied on for most data, it is possible that the respondents were simply losing touch with the actual numbers of game.

Dr. John L. Buckley (1954) made a more comprehensive compilation of data on grouse and ptarmigan numbers. He used the questionnaire analyzed by DeLeonardis and added information from game harvest records of the United States Fish and Wildlife Service and Alaska Game Commission, from personal interviews, and from published records.

Information in Buckley's reports is skeletal for the period 1850 to 1924. From 1850 to 1897, only 13 references to ptarmigan numbers were found; there were even fewer records of grouse abundance. Considering ptarmigan alone, an average of two references were discovered for each year from 1898 to 1924, except for the years 1916 to 1919 when no information was available. In my opinion, the only conclusion supported by information pertaining to the years 1850 to 1924 is that ptarmigan and grouse numbers fluctuated, and that occasionally two or three parts of

Alaska would impress contemporary travelers as having similar levels of game bird abundance. It would be a mistake to try to force a periodic ("cyclic") pattern on these data. The reports are far too scarce and subjective.

Harvest data for 1925 to 1952 appear more reliable. Grouse harvests were much higher from 1932 to 1935 than from 1925 to 1931 or from 1936 to 1941. Another period of good hunting may have occurred in the years 1942, 1943, and 1944, although the data are not complete. After 1944 the kill decreased irregularly until 1950. From 1951 to 1953 an upward trend was noticeable. The pattern was similar for ptarmigan, except that a high kill occurred also in 1925, followed by a sharp decline in 1926. The peak from 1942 to 1944 was of greater amplitude than for grouse. Although the harvest data were gathered until 1960, they have not been compiled and analyzed.

Buckley concluded that upland game birds tended to be most abundant near the middle of each decade since 1900. Synchronization of peaks among the various species was not precise. Buckley also suggested that peak populations and die-offs occur first in northern and western Alaska, one or two years before the peaks occur in central and eastern Alaska. However, Roberts (1963) studied these data, and said that "Although the irregular historical records give no assurance that ptarmigan populations undergo definite and periodic cyclic changes, there is sufficient evidence to conclude that appreciable fluctuations take place... As far as ptarmigan, either specifically or collectively, are concerned, there appears to be no regular line of progression or geographical contouring in the occurrence of peaks across the state."

Current studies: At present the only practical way to keep a finger on the pulse of game bird populations across the State is through a mailed questionnaire. Because replies to questionnaires are only personal opinions, the only hope of getting useful information is to obtain many such subjective evaluations yearly. The survey conducted by the Department of Fish and Game since 1960 has yielded from 106 to 226 usable replies annually.

On the questionnaire form (Appendix III) two basic questions were asked: 1) In the current year, were grouse (ptarmigan) at

high, moderate, or low levels of abundance? (2) Were grouse (ptarmigan) more abundant, less abundant, or at the same levels as in the previous year? Respondents could reply in a "general" column if they did not differentiate between species of grouse or ptarmigan. To make it easier to compare results from year to year, an index value was calculated as follows:

1. Each answer of "high" (question 1) or "more" (question 2) was given a value of 9.

2. Each "moderate" or "same" response was given a value of 5.

3. Each "low" or "fewer" response was given a value of 1.

4. The total value of all replies for a species or group was divided by the number of replies, giving an average value or index. An index of 5.00 meant that the bird was thought to be at moderate levels; higher indices meant higher judgements of population levels.

A general summary of index values for the State as a whole is in Table 8. The results suggest generally lower numbers of grouse (relative to their own usual levels of abundance) than ptarmigan. In the interior, ruffed and sharp-tailed grouse were relatively scarcer than spruce grouse--and possibly scarcer in an absolute sense as well, judging from the fact that fewer people commented on these species than on spruce grouse. Grouse populations seemed to rise slowly from 1959 to 1961, then drop sharply in 1962. The decline apparently continued in 1963. Ptarmigan rose rather steadily from 1959 to 1962, and were nearly as abundant in 1963 as in 1962. According to the judgment of the cooperators of this project, ptarmigan have not attained unusually high levels of abundance in the years from 1959 to 1963. Of course, the index value measures the unanimity of opinions about the fact that a high population existed, not the amplitude of the peak. Unless ptarmigan were abundant throughout the State simultaneously, the pooling of responses would mask regional differences.

To test for regional differences, I divided the State into arbitrary north-south and east-west divisions. (Appendix III). As such a high proportion of replies for grouse came

Table 8. Index values of replies to questionnaire on abundance of upland game birds, 1960-63; Statewide tabulation. (See pp.67 for explanation of values) Number of replies in parentheses.

Species Group	Abundance in Current Year 1960 (106)	1961 (190)	1962 (226)	1963 (214)	Av. All Years	Comparison With Past Year 1960	1961	1962	1963
Grouse (general)	3.2	3.7	3.3	3.0	3.3	5.0	5.3	4.3	3.8
Ruffed	3.5	3.6	1.5	2.2	2.7	5.2	5.0	2.8	3.2
Spruce	3.9	4.6	3.9	3.1	3.9	5.6	6.1	4.9	3.8
Sharp-tailed	2.3	2.8	2.3	2.5	2.5	4.6	4.8	3.2	3.2
Blue	3.9	4.2	2.1	3.7	3.5	4.2	5.0	3.8	4.6
All Grouse Replies	3.5	4.0	3.1	2.9	3.4	5.2	5.5	4.2	3.7
Ptarmigan (general)	3.4	4.2	4.9	5.0	4.4	5.4	6.3	5.7	5.0
Rock	4.0	4.3	5.2	4.4	4.5	4.8	5.8	6.1	4.7
Willow	4.2	4.9	5.1	5.0	4.8	6.3	6.5	6.1	5.5
White-tailed	2.7	4.7	3.0	3.2	3.4	4.2	6.4	4.1	4.4
All Ptarmigan Replies	3.9	4.5	5.0	4.7	4.5	5.6	6.2	6.0	5.1

from Anchorage and Fairbanks and their surrounding forests, and as the two cities lie in roughly the same north-south plane, testing for differences between eastern and western parts of the State seemed fruitless. Three north-south divisions were set up for analysis of grouse data, one being primarily north of the Alaska Range, one south of the Alaska Range, and one including the southeastern Panhandle section. The various grouse and not distributed equally through all regions. The northern region contains all species except blue grouse, but spruce grouse are more widespread than the other species. The same grouse are found south of the Alaska Range, but spruce grouse far outnumber ruffed and sharp-tailed grouse, which have a restricted range in the region. In southeastern Alaska only blue grouse are common. For these reasons, the only feasible comparisons are of replies relating to spruce grouse populations in Region I (north) and Region II (central), and of replies in the "Grouse, General" column in those regions. The comparisons are made in Table 9. The trends in estimates of relative numbers by the cooperators were very similar in all cases. Both spruce grouse and grouse in general were thought to have reached a peak in both regions in 1961, followed by two years of decline. The amplitude of the change was greater in the northern region than in the area south of the Alaska Range.

Although Alaska was divided into 5 regions for testing differences in ptarmigan populations related to latitude, 2 of the regions (Aleutian Islands and southeastern Alaska, Regions V and IV) are poorly represented in our data. North-south comparisons were limited to Region I (north), Region II (central), and Region III (south). Data for rock and willow ptarmigan are in Table 10.

In the area north of the Arctic Circle, willow ptarmigan apparently were at moderately high numerical levels in 1960, reached a peak in 1961, and dropped in 1962 and 1963. No information on rock ptarmigan in this area is available. Populations of rock ptarmigan were thought to be highest in 1962 in both central and southern regions. Highest ratings for willow ptarmigan in central Alaska were given in 1961 and 1962, whereas in Region III (south) the highest ratings were given in the two years 1962 and 1963. There is a temptation to interpret the information for willow ptarmigan to show a progression of peak years from north to south. However, the time period is much too short to allow such a hypothesis to be made.

Table 9. Index values for current population levels of spruce grouse and grouse (general) in northern (Region I) and central (Region II) Alaska.*

	Spruce Grouse		Grouse (General)	
Year	Region I	Region II	Region I	Region II
1960	2.9 (21)**	4.5 (31)	3.6 (14)	3.6 (14)
1961	4.8 (40)	4.7 (69)	3.8 (23)	4.1 (32)
1962	3.9 (47)	4.2 (79)	2.9 (30)	3.7 (51)
1963	2.4 (32)	3.5 (66)	2.2 (23)	3.3 (51)

* See Appendix III for map of regions. See text for explanation of index values.

** Number of replies.

Table 10. Index values for rock and willow ptarmigan population assessments in three regions of Alaska. Part I, north-south comparisons.*

	Rock Ptarmigan			Willow Ptarmigan		
Year	Region I-	Region II-	Region III-	Region I-	Region II-	Region III
1960	---	4.6 (10)	3.7 (12)	6.0 (8)	4.7 (15)	3.3 (21)
1961	8.0 (4)	3.6 (14)	4.3 (42)	7.4 (10)	5.2 (20)	4.7 (72)
1962	---	5.2 (19)	5.3 (58)	5.4 (10)	5.1 (28)	5.3 (92)
1963	---	4.5 (15)	4.5 (53)	4.6 (9)	4.7 (26)	5.3 (85)

* See text for explanation of index values. See Appendix III for map of regions.

An analysis of data for three east-west regions (Table 11) showed that rock ptarmigan apparently were at their highest numerical levels (for the period from 1960 to 1963) in 1962 in all parts of Alaska. Willow ptarmigan may also have been most abundant in 1962 in the eastern part of Alaska. No clear peaks are discernible in data for central Alaska, and two years of relatively high ratings (1961, 1963) are found in information for western Alaska.

Counts on Small Areas

If there is a rhythmic pattern to fluctuations of numbers of upland game birds, the pattern should be exhibited by birds on small areas. This should be true whether the pattern is forced on a species by rhythmic environmental (extrinsic) factors or whether the rhythm is inherent (intrinsic) in the biology of the species. For that reason, it is useful to have counts over a long period on specific areas to use as checks on data from large areas. Counts on small areas usually are more accurate than information gathered on regional or statewide areas. Furthermore, by combining yearly censuses on small areas with detailed studies of mortality, natality, and other facets of population phenomena on the same areas, one can hope to discover the immediate causes for the changes observed in total numbers.

Only three yearly censuses of upland game birds are being made on small areas of Alaska at present. These are: (1) spring roadside counts of sharp-tailed grouse in eastcentral Alaska, begun in 1961; (2) counts of breeding male willow ptarmigan at Chilkat Pass, begun in 1957; (3) counts of territorial male rock ptarmigan at Eagle Creek, begun in 1960. All counts are being made by the Department of Fish and Game. The Department also plans to begin annual censuses of spruce grouse in central Alaska in 1964 or 1965.

Counts of sharp-tailed grouse: Courting sharp-tailed grouse often are seen along particular stretches of road in the vicinity of Tok, eastcentral Alaska, in the spring. Since 1961 the Department has conducted counts of adult sharp-tailed grouse in this area, partly to determine the practicality of the counting technique and partly to watch the annual change in numbers. The counts are standardized as to time of day, number and exact location of counting stations, and interval between

Table 11. Index values for rock and willow ptarmigan population assessments in three regions of Alaska. Part II, east-west comparisons.*

	Rock Ptarmigan			Willow Ptarmigan		
Year	Region A	Region B	Region C	Region A	Region B	Region C
1960	5.0 (3)	4.1 (13)	3.2 (11)	3.6 (11)	4.0 (23)	4.6 (11)
1961	5.0 (11)	4.1 (32)	4.5 (17)	5.8 (24)	5.1 (55)	4.3 (23)
1962	6.2 (10)	5.1 (54)	5.0 (15)	5.3 (26)	5.3 (79)	5.0 (26)
1963	4.7 (12)	4.8 (43)	4.5 (26)	6.3 (30)	5.1 (61)	4.2 (33)

* See text for explanation of index values. See Appendix III for map of regions.

censuses. Briefly, the observer stops every one-half mile (starting at a fixed point) and watches and listens for grouse for three minutes. Counts are made in a four-hour period before and just after sunrise. (Details are given in completion reports for 1961, 1962, and 1963 for Federal Aid in Wildlife Restoration Investigations Project I-1.) Results of the counts are given in Table 12. The average number of grouse counted per mile on days of maximum counts was 0.66 in 1961, 0.62 in 1962, 1.24 in 1963, and 0.10 in 1964. In the first two years the counts were spaced widely to find when the maximum number of grouse might be expected along the roads. The second of three counts made each year up to 1963 yielded the most birds, and both were in the period from May 5 to May 8. In 1963, therefore, the three counts were concentrated closer to this period when high counts would be expected. This could account for the apparent increase in density in 1963. However, more than twice as many grouse were seen in a single census (May 4 and 5) in 1963 as in any census in 1961 or 1962, suggesting that there were more grouse present in 1963 than previously. Very low counts in 1964 probably resulted from record low temperatures and persistent snow cover throughout the first half of May.

Counts of willow ptarmigan in Chilkat Pass: Male willow ptarmigan have been counted each spring since 1957 (except for 1959) on a 3/4-square-mile area in Chilkat Pass, extreme northwestern British Columbia. The counts are as follows:

1957 - 39	1961 - 141
1958 - 38	1962 - 150
1960 - 75	1963 - 104
	1964 - 41

In 1963 a portion of the area was counted one afternoon and the following morning as a check on the accuracy of the technique; counts of 13 and 9 males were obtained.

Counts of rock ptarmigan at Eagle Creek: Although the first census of the Eagle Creek study area was made in 1956, when 32 male rock ptarmigan were found, consecutive annual

Table 12. Counts of sharp-tailed grouse in spring on census routes near Tok, Alaska, 1961-64.

Period	Tok East	Tok South	Routes Taylor 46-56	Taylor 16-20	Total
1961					
April 30, May 1	8	6	0	0	14
May 7, 8	7	0	7	2	16
May 13, 14	3	1	5	0	9
1962					
April 21, 22	0	0	0	3	3
May 5, 6	5	1	8	0	14
May 23, 24	0	0	3	0	3
1963					
April 28, 29	1	1	9	3	14
May 4, 5	4	9	9	14	36
May 11, 12	2	6	1	1	10
1964					
May 2, 3	1	0	(not run)	0	1
May 9, 10	0	1	0	0	1
May 17, 18	1	1	0	1	3

counts did not begin until 1960. Counts of the males of the 15-square-mile area since 1960 revealed the following numbers: 1960, 88 males; 1961, 134; 1962, 170; 1963, 140, 1964, 109. The census on this area is more accurate than the one at Chilkat Pass because the birds are more easily seen at Eagle Creek due to the general shortness of vegetation, and the densities are lower, decreasing the confusion of counts.

Chilkat Pass supports a higher population of ptarmigan per unit area than Eagle Creek, if one considers only the lower ground in the pass in which the study area is located. Numerical changes in ptarmigan abundance have followed the same trends in both areas: highest densities were recorded in 1962, lowest in 1960.

Recruitment and Losses of Rock Ptarmigan at Eagle Creek

Losses to local animal populations occur through death or permanent outward movement of residents. Additions are made through births and inward movements of individuals from other areas. At Eagle Creek I obtain data on births and summer mortality by direct observation, but get information on winter death rates, emigration, and immigration only by inference and indirect calculations. Rock ptarmigan that live on the study area in May, June, July, and August cannot be followed through the rest of the year. Many locally-reared ptarmigan leave the study area in September and October; their wintering grounds are unknown. Some return in March and April, along with birds raised elsewhere that will breed at Eagle Creek.

Inferred mortality and emigration: If it can be assumed that the Eagle Creek study area is neither more nor less attractive to potential breeding pairs of ptarmigan in spring than adjacent areas of similar habitat, there would be a net balance in numbers of emigrating and immigrating ptarmigan. That is, if 25 adult cocks that previously bred elsewhere moved to the study area in a given year, then presumably a similar number of former residents moved off the area. If that is true, the total survival of adult males over a winter is equivalent to the population on the area the following spring, even though different individuals are involved.

Survival rates from fall to spring should be equal to the number of adults present in the spring divided by the number present in the fall. The number of adults is calculated by applying the yearling:adult ratio (age determined by primary color) among trapped birds to the whole population. Death rates derived in this way are given in Table 13. Death rates for chicks were lowest in 1960-61 and quite uniform in the next two years. Mortality of adults was lowest in 1960-61 and highest in 1962-63.

The rates of return of banded ptarmigan to the study area are presented in Table 14. A greater proportion of banded hens than of cocks or chicks returned each year to the study area, but the proportion of returning birds of all sex and age groups declined each year.

The mortality rates of adult rock ptarmigan at Eagle Creek, as calculated, show some relation to over-all population changes. Low death rates between 1960 and 1961 were associated with a doubling of the breeding population. The number of birds breeding rose again from 1961 to 1962, but at a lower rate. The mortality rates among adults during this period were higher than in 1960. Highest losses of cocks and hens occurred from 1962 to 1963, and a drop in breeding pairs was noted in the spring of 1963. Early losses of chicks, as determined from changes in average brood size throughout the summer, were higher in 1960 than in the other years, when losses from hatching to late July were from 10 to 17 per cent (Table 15). The small number of broods counted late in July, 1960, may account for the high apparent loss that year.

Reproduction: The success of reproduction was gauged at Eagle Creek by the number of chicks hatching, which, in turn, is influenced by clutch size, by the number of eggs hatching in successful nests, and by the number of successful nests. Data on these factors are in Table 16. Clutch size decreased slowly, the lowest average clutch size (in 1963) being 80 per cent of the biggest average clutch (in 1960). The hatchability of eggs not destroyed by predators varied from 91 to 98%, with best and worst performances being in 1960 and 1962, respectively. Nesting success (percentage of nests in which eggs hatched) changed markedly. Two years of relatively good success (83 and 85 per cent in 1960 and 1961 were followed by two years of poor success (55 and 56 per cent in 1962 and 1963). Weasels accounted for

Table 13. Estimated mortality for rock ptarmigan of Eagle Creek, Alaska, 1960-63.

Period	Adult Mortality (Per Cent) ♂	♀	Period	First-Year Mortality (Per Cent)
August 1, 1960 to May 31, 1961	41	38	August 1, 1960 to May 31, 1961	60 - 64
August 1, 1961 to May 31, 1962	54	68	August 1, 1961 to May 31, 1962	72 - 73
August 1, 1962 to May 31, 1963	69	74	August 1, 1962 to May 31, 1963	75 - 77

Table 14. Return of banded rock ptarmigan to the Eagle Creek study area, 1961-63.

Age, Sex, and Year Banded	Percentage Present of Original Number Banded*		
	One Year After Banding	Two Years After Banding	Three Years After Banding
Adult males			
banded in 1960	21	0	0
1961	11	9	
1962	3		
Adult females			
banded in 1960	63	15	6
1961	38	5	
1962	19		
Immatures			
banded in 1960	24	4	2
1961	11	1	
1962	6		

* All banded birds captured up to July 21 (females) or August 1 (males), plus the number estimated in the uncaptured population segment, assuming equal proportions of banded birds in captured and uncaptured segments.

Table 15. Losses of chicks from hatching to late July, Eagle Creek, 1960-63.

Year	Av. No. Eggs All Clutches	Av. Eggs Hatching	Chicks Per Brood in Late July	Loss After Hatching (Per Cent)
1960	8.2	8.0	5.3 (10 broods)	34
1961	7.3	6.8	6.1 (38)	10
1962	7.0	6.4	5.5 (50)	14
1963	6.4	5.8	4.8 (75)	17

Table 16. Reproductive success of rock ptarmigan at Eagle Creek 1960-63.

Year	Nests Used in Computation	Successful Nests	Eggs Hatching in Successful Nests
1960	12	10 (83 per cent)	80 (98 per cent)
1961	20	17 (85)	116 (94)
1962	20	11 (55)	70 (91)
1963	34	18 (56)	105 (94)

almost all losses of nests in the latter years. I assume that the sharp increase in predation was due to an increase in number of weasels on the study area, possibly related to a rise in small mammal abundance noticed in 1962 and 1963.

To summarize the work done at Eagle Creek, it appears that most mortality occurs between September and May, at a time when many summer residents of the study area are wintering elsewhere. Adult mortality varied more than losses of immature birds; losses of adults increased from 1960-61 to 1962-63. Reproductive success was variable, with differences in clutch size and predation on nests being more noticeable than changes in hatchability of eggs. Whether observed population changes were the result of mortality or reproduction factors just mentioned, is not known. The entire picture of population change on the study area is clouded by the fact that emigration and immigration, probably involving a large part of the breeding population, cannot be assessed accurately at this time.

Patterns of Utilization

No adequate survey has been made of the statewide utilization of upland game birds by people for food or recreation. The whole problem is extremely complex; some of the major difficulties encountered would be (1) settlement-to-settlement variation in utilization patterns which would make it necessary to sample a high proportion of the settlements; (2) year-to-year fluctuations in the abundance and distribution of the birds, limiting applicability of one year's data to that year alone; (3) progressive and rapid social changes in settlements (cities as well as villages) resulting in different attitudes toward game birds; (4) distrust of motives of the survey by large groups of people in parts of Alaska; (5) difficulty of separating recreational and subsistence uses. Furthermore, the data obtained may not repay the effort involved, at least from the standpoint of a resource manager. There would be no way to relate the harvest to the resource in quantitative terms.

Despite these difficulties, two agencies have attempted surveys of game bird utilization by particular segments of the public. The Alaska Game Commission and the United States Fish and Wildlife Service requested hunting license applicants

to list the game species taken during the previous year on their new license form. Buckley (1954) listed the numbers of grouse and ptarmigan so recorded in 25 of the years between 1925-26 and 1952-53. The total reported harvest showed a definite increase over the quarter-century as a whole, related to a very great increase in the number of licensed hunters. The increase in harvest was irregular, due partly to fluctuations in the availability of grouse and ptarmigan. The highest harvest of game birds reported by hunters was in the early years of World War II, when only one-third as many hunters were present as in the early 1950's. More ptarmigan were reported than grouse in 19 years out of the 25. In three years more grouse were reported, and in three years the total take was similar for the two species groups.

The method of using reports by license applicants to determine harvests probably results in a sample weighted heavily toward sport hunters. Many people who live "off the land" do not buy hunting licenses (they did not need to before Alaska became a state) and many who do are not likely to report their annual kill very accurately. The United States Fish and Wildlife Service made a survey of 61 villages in rural Alaska in the years 1955, 1956, and 1957, attempting to discover the size of game harvests by native Alaskans in these areas. Personal interviews were employed as the primary means of getting information. People interviewed, mostly heads of households, were asked to estimate total harvests by species during the preceding year The results suggested a much higher yearly harvest of ptarmigan (52,672) than of grouse (3,952) in the areas surveyed. The eastern interior region and southeastern Alaska were not surveyed as thoroughly as the western half of the State, a fact which may have contributed to the relatively small number of grouse reported. The period covered by the survey certainly influenced the harvests recorded. From reports in the files of the Fish and Wildlife Service it is fairly clear that game birds were quite scarce in the period 1955 to 1957. The reported kill might have been much higher if the survey had been conducted three years earlier.

Only one village of about 40 surveyed reported egg collecting as a method of harvesting ptarmigan. Although this may be due to inaccurate reporting by people interviewed, it probably indicates that most subsistence hunting for game birds is done in the fall, winter, and spring. Summer is a busy season for

most rural Alaskans, because employment opportunities are greatest then. This factor, coupled with the annual late-spring disintegration of flocks of ptarmigan, logically would shift the main bird-hunting effort to the winter months.

Some personal impressions of game bird hunting patterns in Alaska might be worth mentioning, although all require quantitive verification:

1. Seasonal patterns

   a) Few grouse or ptarmigan are taken in June, July, or early August anywhere in Alaska.

   b) Most grouse are harvested in late August, September, and October, except for blue grouse which are hunted most heavily in the spring. The secretive habits of blue, ruffed, and spruce grouse in winter cause a drastic decline in hunting pressure at that time.

   c) Ptarmigan harvests have two peaks, one in September and October, another in March and April. Cold weather and short daylight hours are basically responsible for the mid-winter slump.

2. Geographic patterns

   a) Ptarmigan comprise the majority of upland game birds killed in the western half of Alaska (roughly west of 152°W). Most of the ptarmigan taken in this part of Alaska are harvested primarily for their food value.

   b) The eastern half of Alaska contains most of the larger towns and cities. Although subsistence hunting still is very important to rural residents in this area, recreation-seekers harvest the greater share of upland game birds.

   c) The total game bird resource in southeastern

Alaska is not as varied, abundant, or accessible as elsewhere in the State, and ptarmigan and grouse are relatively less important than in the interior, arctic, or west coastal areas.

3. Local patterns

   a) Harvests of grouse and ptarmigan occasionally are concentrated in very small areas where birds are abundant or where they are more accessible. Anaktuvuk Pass, Paxson-Summit Lake, and the Little Susitna River Valley are examples.

   b) Both grouse and ptarmigan often are taken incidentally to other food-gathering or recreational activities. Concentrations of big game hunters, therefore, usually increase the local harvest of upland game birds.

   c) A high proportion of grouse (and, to a lesser extent ptarmigan) are taken on or within a few yards of roads. Laziness of hunters and the concentration of grouse along roadsides early in the fall account for this characteristic of the harvest.

HUMAN ENDEAVOR AND UPLAND GAME BIRDS: PRESENT AND FUTURE

The welfare of grouse and ptarmigan has been affected by Alaskans in their role as predators, an initiators and sweeping environmental changes, and as agents of relocation of various bird species. As predators, people are unique in that they are conscious of the need to perpetuate the quarry as a useful resource; this knowledge had led to the formulation of rules by which we regulate our actions as hunters. It also has led to occasional attempts to introduce game birds into areas where they do not live naturally. These purposeful attempts to control the numbers and distribution of upland game birds, however, have been overshadowed by changes we have made while building a civilization--changes brought about primarily through fire, logging, livestock grazing, and environmental pollution.

Hunting

Regulations

The Alaska Game Law, passed by Congress in 1902, incorporated the first regulations concerning the harvest of ptarmigan and grouse. The law went into effect October 1, 1903. Alaska has had a continuous series of game regulations ever since, although different agencies have promulgated them. Alaska game laws have never fully recognized that seven species of upland game birds are native to the State. All ptarmigan are simply "ptarmigan" in the regulations, and the four kinds of grouse are pooled.

In 1903-04 hunters were allowed to take 10 each of grouse and ptarmigan daily between September 1 and December 15. No season limit or possession limit was imposed, and none have since been incorporated into Alaskan game regulations concerning upland game birds. From 1904-08 the bag limits remained the same, but the season was lengthened by 1 1/2 months, ending on January 31. Greater liberalizations followed; from 1908-25 hunters could take 25 ptarmigan per day from September 1 to March 1 and in the years from 1925-40 the season was almost exactly the same, except that the closing date was February 28. Bag limits on grouse were 15 per day throughout this latter period. Seasons and limits were cut back in 1940-45. Hunting was allowed from August 20 to January 31, with a limit of 10 grouse and 10 ptarmigan per day (except for a limit of 15 ptarmigan in 1940-41).

After the 1944-45 hunting season, upland game bird regulations were made more complex by the division of the State into Fur Districts (until 1955) or Game Management Units (1955 to present). The seasons and limits for the years from 1945-64 are summarized in Table 17. Bag limits on ptarmigan have remained at 20 per day since 1955-56 in all areas, but seasons have been manipulated to coincide with opening dates of hunting seasons on regionally important big game species such as deer, sheep, and caribou. Bag limits on grouse have been reduced since 1961-62 in southeastern Alaska, but were raised from 10 to 15 per day in other sections of the State. One noteworthy trend is the present experimental late spring season on grouse in southeastern Alaska. Blue grouse are almost impossible to

Table 17. Hunting seasons and daily bag limits relating to grouse and ptarmigan in Alaska, 1945-46 to 1963-64.

Hunting Year	Open Season: Grouse	Open Season: Ptarmigan	Daily Bag Limit: Grouse	Daily Bag Limit: Ptarmigan
1945-46	Fur Districts 1, 3; Sept. 1 to Jan. 31 Fur Districts 4, 5; Sept. 15 to Feb. 28 Fur Districts 2, 6-8 Aug. 20 to Jan. 31	Same as for grouse, all Fur Districts	10	10
1946-47	Fur Districts 1-5; Sept. 1 to Feb. 28 Fur Districts 6-8; Aug. 20 to Jan. 31	Same as for grouse, all Fur Districts	10	10
1947-48 and 1948-49	Aug. 20 to Feb. 28	Aug. 20 to Feb. 28	10	10
1949-50 1950-51 and 1951-52	Sept. 1 to Feb. 28	Sept. 1 to Feb. 28	10	10
1952-53	Aug. 20 to Feb. 28	Aug. 20 to Feb. 28	10	10
1953-54	South of Alaska Range; Aug. 20 to Jan. 31 North of Alaska Range; Aug. 20 to April 15	Same as for grouse, north and south of Alaska Range	10	10

Table 17. (Continued)

Hunting Year	Open Season: Grouse	Open Season: Ptarmigan	Daily Bag Limit: Grouse	Daily Bag Limit: Ptarmigan
1954-55	Same	Same	10	15
1955-56	Same	Same	10	20
1956-57	Units 1-17; Aug. 20 to Dec. 31	Aug. 20 to April 15 all Units	10	20
1958-59, and 1959-60	Units 18-26; Aug. 20 to April 15			
1960-61	Units 1-5; Aug. 20 to Dec. 31	Aug. 20 to April 15 all Units	10	20
	Units 6-26; Aug. 20 to March 15		15	--
1961-62	Units 1-5; Aug. 20 to April 15	Aug. 20 to April 15 all Units	5	20
	Units 6, 7, 9-26; Aug. 20 to March 15		15	--
	Unit 8; closed			
1962-63	Units 1-5; Aug. 20 to April 30	Units 1-4; Aug. 1 to April 15	5	20
	Unit 6; Aug. 1 to March 15	Units 5-26; Aug. 10 to April 15	15	20
	Units 7, 9-26; Aug. 10 to March 15		15	--
	Unit 8; closed			

Table 17. (Continued)

Hunting Year	Open Season: Grouse	Open Season: Ptarmigan	Daily Bag Limit: Grouse	Daily Bag Limit: Ptarmigan
1963-64	Units 1-5; Aug. 1 to April 30	Units 1-4; Aug. 1 to April 30	5	20
	Unit 6; Aug. 1 to March 15	Units 5-26; Aug. 10 to April 15	15	20
	Units 7, 9-26; Aug. 10 to March 15		15	--
	Unit 8; closed			

find in winter, but can be located when the hooting males are sought persistently in spring. Hooting generally begins late in March or early in April. In 1961-62 the closing date in the region was extended two weeks to April 15, and another 15 days extension was made in 1962-63. In 1964-65, it will be possible to hunt blue grouse until May 15--the first May season on grouse or ptarmigan in Alaskan history.

Management Problems

Relatively few problems have arisen so far in the regulation of upland game bird hunting in Alaska but three seem to merit discussion in this report. These are the evaluation of hunting pressure, access, and roadside hunting.

Assessing hunting pressure: Although we often forget it, the hunter is the easiest segment of the public for wildlife management agencies to deal with (in contrast to loggers, miners, municipalities, etc.). Agencies responsible for the welfare of the prey control the actions of the human predator, through game regulations. The biggest difficulty is to recognize when and to what degree hunters are limiting the numbers of game. Studies of natural mortality can yield information on the seasonal pattern of mortality, total annual rates of death by year-class and sex, and other related matters. However, this sort of investigation will not tell the game manager how many grouse in a particular area can be shot annually, because the extent to which hunting losses actually add to total annual mortality remain unknown. One fruitful approach might be to carry out controlled shooting experiments, in which predetermined proportions of game birds are removed from specific areas in autumn to stimulate hunting pressure. Annual censuses should show the effect of the shooting. Although the conduct and interpretation of such experiments would not be easy, it should be possible to achieve rules-of-thumb relating to hunting pressure that can be applied in normal hunting situations.

Access: Many game bird populations in Alaska are out of reach of sportsmen. By itself, this fact does not mean that an access "problem" exists. Accessibility becomes a real problem when hunters with reasonable amounts of time, money, and

equipment cannot reach areas where a species is present in harvestable numbers or where the species can be sought without undue interference from other hunters. Under these criteria, I doubt that problems of access are very widespread in Alaska today as far as upland game birds are concerned. These problems will become more frequent in the future. Solutions will include multipurpose recreational access developments by the Department of Fish and Game, Department of Natural Resources, United States Forest Service, Bureau of Land Management or other agencies. Improvements in the road system within Alaska also can be expected to open new areas to hunters and other recreation seekers.

Roads and grouse: Alaskan grouse, particularly spruce and ruffed grouse, go to roadsides in the fall to get grit. Grouse are more vulnerable to hunting during the few weeks of the year when they visit roadsides than at any other time, and hunters have been quick to take advantage of the habit. "Road-hunting" for grouse early on frosty, sunny mornings in September is a tradition among many Alaskans. We do not know whether such localized, persistent hunting influences grouse populations, but it is possible. The Department of Fish and Game is beginning an investigation of the autumn movements of spruce grouse in relation to roads, and soon should be obtaining information on how far grouse travel to obtain grit along roads--a key question in interpreting the effects of roadside shooting.

Filling Empty Niches

Even in Alaska, where the native game bird resource is varied, widespread, and largely untapped by hunters, there are people who want the cards of Nature reshuffled. The only birds foreign to Alaska that have been released in the State are pheasants (various species) and chukar partridges. Elkins and Nelson (1954) list 19 introductions of pheasants in Alaska prior to 1954. All occurred in the years 1934 to 1952, and most were made in southeastern Alaska. The most persistent colonies of pheasants were in the Matanuska Valley, where pheasants were still seen in the mid-50's after a release in 1938, and at Sitka, where the last pheasant was seen in 1953, 19 years after the original release. Seventeen adult chukar partridges were released in 1938 in the Matanuska Valley, and

were reported as late as 1943. Elkins and Nelson doubt that the birds ever reproduced.

Although Kodiak Island has good populations of rock and willow ptarmigan, no grouse are native to the area. Most of the Island is treeless, but parts of Kodiak Island and adjacent islands to the north have stands of Sitka spruce. Local residents have asked for transplants of grouse to Kodiak and Afognak Islands; two species (spruce and blue grouse) have been released at various times on the island group. The Bureau of Sport Fisheries and Wildlife cooperated with the Kodiak Outdoorsmen's Club in a project involving spruce grouse. In 1957, 21 spruce grouse were released near Kodiak, and in 1959, 11 more were released. It seems very doubtful that any spruce grouse are present in the island group now, and as there have been no authentic sightings reported since 1960. Two adult female blue grouse and six chicks, caught near Petersburg in 1962, were released on Chiniak Peninsula, Kodiak Island, by the Department of Fish and Game in July of that year. One more blue grouse was released in the same area in the summer of 1963; in 1964 15 adult hens and six chicks were released on Spruce Cape, north of Kodiak. It is likely that further releases of this species will be made by the Department.

The introduction of non-native grouse and the establishment of new populations of native species, can be accomplished only when a realistic policy has been formed, firmly stated, and consistently applied. The Alaska Game Law allows control of private imports or intra-state transplants of live game birds, and Section 16.25-010 of Alaska Statutes directs the Department of Fish and Game to undertake some 32 specified transplanting programs (three of which concern grouse or pheasants). Neither these nor other game regulations provide guidelines for determining general transplant policies.

The United States Fish and Wildlife Service in Alaska had a rather liberal policy stated as a series of "priorities" (Elkins and Nelson, 1954). First priority was given to the restocking of native species on ranges formerly occupied. Second priority went to extensions of ranges of native species across natural barriers. Other activities, in order to decreasing priority, were (1) movement of species already introduced in Alaska to new ranges; (2) introduction of North American animals not found in Alaska; (3) introduction of exotics where conflict

with native species would not develop. In essence, this policy permitted almost any transplant, but implied varying degrees of reluctance to carry out the aspects mentioned. The Alaska Department of Fish and Game stated a similar policy in its 1960-62 Progress Report (pages 31,32).

A guideline for assessing proposed transplants perhaps should contain at least four basic elements. First, the proposed transplant should serve a useful purpose. Second, the benefits must at least be equal to the cost, and should not accrue only to a handful of individuals. Third, there must be an empty niche (a habitat not used by a native species, or in which the indigenous species no longer occur) in the area of the proposed transplant, and the bird stocked must be capable of occupying this niche. (The mere scarcity of local game birds is not an indication that there is room for more; the basic productivity of the land may be low, at least for grouse-like birds.) Finally, it should be a policy to undertake trial runs on small, isolated parts of the general area to be stocked, before the main transplanting program. In the case of game birds, if the habitat is suitable, the fact will be obvious after only three or four years, as the reproductive potential of the birds is quite high. Knowledge gained in pre-transplant experiments would be well worth the wait.

Destroying and Creating

One of man's unique characteristics is his ability to change the face of the earth and the functioning of living communities, sometimes without even being present himself. Today there is no part of the earth, however tiny or isolated, that is free from the results of human endeavor. Fire, logging, agriculture, and environmental pollution are among the most important factors related to human activities that are affecting game birds in Alaska.

Fire

Wildfire has been part of the Alaskan scene for thousands of years. Both aboriginal man and modern civilizations have set fires by accident and design, adding to the number of

fires started by lightning (Lutz, 1959). Because the forest of interior Alaska are so susceptible to fire, it is likely that most areas have experienced repeated fires in the last few hundred years. In a situation of this sort, we expect--and find--that grouse and ptarmigan have adjusted to an environment of which fire is a part. As a group these birds have been able to survive in a remarkably wide range of post-fire conditions, from new burns with practically no regrowth of vegetation to areas undisturbed by fire for a century or more. As individual species, however, their fortunes are very much affected by the recency and intensity of fires.

The effects of fires on plant and animal communities are bewildering in their variety. In most cases, however, vegetation coming in after a fire contains species different from those in the plant community occupying the site before the fire, or the same species in different proportions; the new stand is essentially even-aged; and new vegetation types usually are short-lived, being replaced by more stable, self-perpetuating vegetation (Lutz, 1956).

In interior Alaska, sharp-tailed grouse are likely to be the first species of upland game birds to occupy a recent burn. This species does well where grasses form an important part of the ground cover, and where there are wide gaps between the crowns of adjacent shrubs or saplings; such conditions are present more often a few years after a fire than when vegetation has been undisturbed for long periods. It seems likely that the high populations of sharp-tailed grouse near Fairbanks in the early 1930's (Cade and Buckley, 1953) resulted from widespread, fire-induced changes in local vegetation that occurred during the first quarter of the 20th century. In this same area, sharp-tails have been scarce for two or three decades; so much of the local terrain is now covered with closed forests of spruce, birch, and aspen that I believe that sharp-tailed grouse will continue to be scarce as long as the forest remains.

The sharp-tailed grouse, therefore, is a pioneering species on burned ground, but is an ephemeral one unless an "open" vegetation type persists. When the new forest closes in, either spruce grouse or ruffed grouse may find conditions to their liking. Ruffed grouse appear earlier in the succession than spruce grouse, in most cases, because the former species is closely associated with stands of deciduous woody plants (willows, alder,

aspen, poplar) which tend to invade burns before coniferous tree species. On burns that revert directly to conifer growth, or after deciduous trees have been crowded out by competition from spruces, spruce grouse are likely to occur.

Although fires have occurred in the treeless breeding habitats of ptarmigan, I have seen no description of the effect of these fires on vegetation. I assume that tundra fires are temporarily detrimental to all herbivores of the Arctic, including ptarmigan. Regrowth of vegetation after fire might take longer in tundra than in forest types. Many ptarmigan move into northern forest habitats in October, living below timberline for the next six months or so. While there, ptarmigan are attracted to areas with a light to moderate cover or shrubs and with few trees. Fires play an important role in creating large areas of such habitat in the forest areas, in contrast to their almost wholly detrimental effects on the tundra. Whether fire-created habitats are necessary to wintering ptarmigan is not known; similar habitats of different origin might be common enough to support the number of ptarmigan moving out of alpine or arctic areas in late autumn.

We should seek all possible information about the interrelationships of fires, fire control, and wildlife abundance. The question is a very complex one that could be studied most fruitfully by a team of biologists including botanists and soils specialists. Observations would have to be continued for a long time if the entire gamut of soil, vegetational, and faunal changes were to be observed on one area from burning to mature forest; this approach, while scientifically preferable, might be impractical. The team might be forced to infer the sequence of changes after fire by studying a number of carefully selected areas burned at intervals in the past. Whatever the approach, it is important to get a fact-finding program under way soon.

Logging

The effects of logging on vegetation are broadly similar to those of fire: the forest canopy is opened up or removed completely, much of the original ground vegetation is changed during logging or subsequently so that different plants are present, and the relatively stable forest stand is replaced by

succession of short-lived vegetation types. Extensive logging is occurring in southeastern Alaska, where blue grouse are the only common grouse. Clear-cutting (the type of logging practiced in Alaska) in similar forests of coastal British Columbia has created large areas utilized heavily by blue grouse during the breeding season (Bendall, 1955; Fowle, 1960). On Vancouver Island, logging was followed by burning. High populations of blue grouse occurred on the burns while plant cover was sparse, but diminished and disappeared when the growth of young conifers became dense and tall.

The relationship of logging to blue grouse in Alaska certainly merits study. There is a chance that blue grouse hunting will be improved greatly by the cutting of timber, if the grouse use the cut-over lands during a season when they can be hunted. One way to find out would be record the abundance of blue grouse, by season, or an area of timber just before cutting. Similar observations would be made in the years following cutting. Studies of a series of areas logged at different times in the past might provide short cuts to the same information, although the data would have more loopholes than records from one area. Cooperation with the Forest Service would be essential to a project of this sort.

Agriculture and Pastoralism

The acreage of cropland in Alaska is very small. According to Johnson and Jorgenson (1963), only 17,085 acres of croplands were harvested in 1958, with an additional 4,430 acres cleared but idle. Although the amount of cropland is higher now, the total acreage still is not significant in terms of over-all land dedication in Alaska. Most croplands are ecological blanks as far as grouse are concerned. A prominent exception is land devoted to small grains. In other states, grainfields are integral parts of the home range of many important upland game birds, including pheasants, partridges, and quails. One grouse found in Alaska, the sharp-tailed grouse, has learned to take advantage of the food supply provided by uncut grain in croplands of interior Alaska. A few specimens I have examined have contained barley grains in the digestive tract. Considering the limitations of agriculture in Alaska, it is not likely that croplands will be important to native grouse for many years.

The use of land for livestock is fairly widespread in Alaska. Reindeer are the most abundant grazers, and the potential grazing range for reindeer is estimated at 50 million acres (Johnson and Jorgenson, 1963). The total land estimated to be suited to grazing by horses, cattle, or sheep is about 10 million acres. In theory, at least, one would expect competition to develop between hoofed and winged herbivores if the food supply (or a vital part of it) became short. We do not know whether competition of this sort has ever developed or is likely to develop between upland game birds (especially ptarmigan) and livestock (particularly grazers of the tundra, reindeer and sheep).

Environmental Pollutants

Radiation from particles ionized during nuclear explosions is increasing in Alaska as elsewhere. Radiation can affect living organisms, primarily through genetic mutation. The extra burden of radiation carried by all life as a result of human inventiveness will have its effect; whether we can detect and measure the results depends partly on the development of sensitive techniques and partly on the duration of the search for radiation effects.

People recently began dumping chemicals into the environment to reduce damage or nuisance caused by plant or animal pests. In comparison with other states, Alaska has experienced relatively little of this activity. Local mosquite control programs have been conducted for a number of years near military bases. Utility and highway rights-of-way are being sprayed with herbicides periodically. The United States Forest Service is contemplating increased use of DDT against forest insect pests in southeastern Alaska. We do not know how wildlife will react to the presence of these and other chemicals.

SUMMARY

1. Alaska is the home of four kinds of grouse (ruffed, spruce, blue, and sharp-tailed grouse) and three kinds of ptarmigan (willow, rock, and white-tailed ptarmigan). One or more of these species occupies almost every part of the State, and the group as a whole is an important recreational and nutritional asset to Alaskans.

2. Blue grouse range throughout the coniferous coastal forests of southeastern Alaska from treeline to the beaches. Spruce grouse also prefer conifer forests, but are primarily birds of interior Alaska. Ruffed grouse and sharp-tailed grouse live where interior forests have been disturbed by fire, river action, or human endeavor. Sharp-tailed grouse prefer open, grassy communities with thinly scattered trees and shrubs; ruffed grouse are associated with aspen, birch, and mixed coniferous-deciduous woods. The ptarmigan live above timberline in summer but range downward into shrubby openings of the boreal forest in winter.

3. No formal investigations have been made of the lives of grouse in Alaska, or of the life history of white-tailed ptarmigan. Several past research projects, plus two detailed studies now in progress, have set forth the main events in the lives of rock and willow ptarmigan, the foods they eat, and a few aspects of population dynamics (birth rates, death rates, homing, short term changes in breeding densities, and migration patterns). Human curiosity is far from satisfied, however; many more aspects of the lives of game birds and their interactions with animals and plants need study, some being of vital importance to resource managers.

4. One line of inquiry is especially fascinating and pertinent to management problems: the study of the marked changes in numbers so characteristic of northern grouse and ptarmigan. Although some workers have described these population changes as rhythmic, with peaks occurring nine or ten years apart, there does not seem to be enough information available to be at all sure. Similarly, it is not known whether different species wax and wane in numbers in synchrony on one area, or whether birds in different places peak and crash simultaneously. Studies begun in the late 1950's and

in 1960 should give some answers to these questions both for Alaska as a whole and for a few selected populations on small areas, if they are continued long enough. On one study area, spring breeding densities of rock ptarmigan rose from about 2 pairs per square mile in 1956 to 10 pairs per square mile in 1962. In 1963 there was a drop to about 9 pairs per square mile. The death rate of chicks rose from about 60 to 65 per cent in 1960-61 to about 75 per cent in 1962-63. Losses of adults also increased. Clutch size, hatchability, and nest losses all showed some annual variation.

5. Upland game birds are used for food or sport throughout Alaska, but we have no evidence that hunting has diminished stocks. With the exception of sporadic attempts to introduce game birds to new areas--particularly pheasants in southeastern Alaska and the Matanuska Valley and spruce and blue grouse to Kodiak Island--management has consisted solely of regulation of the harvest. In comparison with other states, Alaska's seasons and bag limits on grouse and ptarmigan are liberal. In relation to the maximum harvest sustainable by the birds, regulations probably have been conservative.

6. Humans are affecting and will continue to affect the welfare of upland game birds through changes made in the birds' habitats. In interior Alaska, fire is the most potent force, causing widespread and significant changes in the whole flora and fauna. Logging is more important than fire in southeastern Alaska. Although only a small percentage of the land is logged annually, the areas involved are disproportionately important due to their accessibility. Agriculture, pastoralism, river development projects (dams), and urbanization also destroy or create new habitats for grouse and ptarmigan. With the exception of grazing by reindeer in western Alaska, these human activities thus far have involved only a tiny fraction of the land area of Alaska. Environmental pollutants (radioactive isotopes, pesticides) are potentially of great importance to all wildlife, although no urgent problems have arisen to date regarding Alaskan game birds.

7. Management problems of current concern, or with which we will be concerned soon, include the formulation of a workable policy regarding transplants and introductions, finding ways to evaluate the effect of hunting on local game bird populations, providing better access to untouched populations of

game, assessing the impact of roadside shooting on grouse numbers, and investigating the relationships of game species to logging and fire.

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Appendix I. Helminth parasites found in Alaskan ptarmigan (Babero, 1953).

Parasite	Rock Pt. (45)	Willow Pt. (191)	White-tail Pt. (56)	Total No. Infected	Per Cent Infected
Nematodes:					
Ascaris compar	5	11	10	26	8.9
Trichostrongylus tenuis	1	5	0	6	2.1
Capillaria sp.	1	0	0	1	0.3
Trichostrongyle	1	0	0	1	0.3
Trematodes:					
Leucochloridium variae	1	4	3	8	2.7
Brachylaima fuscata	11	16	6	33	11.3
Cestodes:					
Raillietina urogalli	2	4	3	9	3.1
Davainea proglottina	8	3	5	16	5.5
Haploparaxis galli	6	2	0	8	2.7
Rhabdometra nullicollis	1	0	0	1	0.3

Appendix II. Names of plants mentioned in the text.

Horsetail	*Equisetum* spp.
Larch	*Larix laricina*
Lodgepole pine	*Pinus contorta*
Black spruce	*Picea mariana*
White spruce	*Picea glauca*
Sitka spruce	*Picea sitchensis*
Western hemlock	*Tsuga heterophylla*
Mountain hemlock	*Tsuga mertensiana*
Western red cedar	*Thuja plicata*
Yellow cedar	*Chamaecyparis nootkatensis*
Aspen	*Populus tremuloides*
Balsam poplar	*Populus tacamahaca*
Willow	*Salix* spp.
White birch	*Betula papyrifera*
Dwarf birch	*Betula glandulosa*, *B. nana*
Alder	*Alnus crispa*, *A. sinuata*, *A. tenuifolia*, *A. rubra*
Sedge	*Carex* spp., *Juncus* spp.
Smartweed	*Polygonum viviparum*, *P. bistorta*
Chickweed	*Stellaria* spp.
Anemone	*Anemone* spp.

Appendix II. (Continued)

Marsh marigold	*Caltha biflora*
Goldthread	*Coptis asplenifolia*, *C. trifoliata*
Monkshood	*Aconitum delphinifolium*
Black currant	*Ribes bracteosum*
Mountain avens	*Dryas octopetala*
Cloudberry	*Rubus chamaemorus*
Salmonberry	*Rubus spectabilis*
Trailing bramble	*Rubus pedatus*
Nagoonberry	*Rubus stellatus*
Burnet	*Sanguisorba menziesii*
Rose	*Rosa acicularis*
Partridgefoot	*Luetkea pectinata*
Lupine	*Lupinus* spp.
Alpine vetch	*Oxytropis* spp.
Crowberry	*Empetrum nigrum*
Violet	*Viola* spp.
Soapberry	*Shepherdia canadensis*
Devil's club	*Oplopanax horridus*
Dwarf dogwood	*Cornus canadensis*
Wintergreen	*Pyrola* spp.
Labrador tea	*Ledum decumbens*, *L. groenlandicum*

Appendix II. (Continued)

Buckbush	*Menziesia ferruginae*
Mountain azalea	*Loiseleuria procumbens*
Swamp laurel	*Kalmia polifolia*
Mountain heather	*Phyllodoce glanduliflora*, *P. empetriformis*
Bog rosemary	*Andromeda polifolia*
Bell heather	*Cassiope mertensiana*
Bearberry	*Arctostaphylos uva-ursi*
Alpine bearberry	*Arctostaphylos alpina*
Blueberry	*Vaccinium uliginosum*
Blue huckleberry	*Vaccinium ovalifolium*
Red huckleberry	*Vaccinium parvifolium*
Mountain cranberry	*Vaccinium vitis-idaea*
Bog cranberry	*Oxycoccus microcarpus*
Deer heart	*Fauria crista-galli*
Lousewort	*Pedicularis* spp.
Twinflower	*Linnaea borealis*
Highbush cranberry	*Viburnum edule*

Appendix III. Form used in upland game bird population survey by the Alaska Department of Fish and Game.

ALASKA DEPARTMENT OF FISH AND GAME

Statewide Estimate Of Game Bird Numbers

NAME

ADDRESS

KIND OF BIRD	I HIGH	I MOD.	I LOW	II MORE	II SAME	II FEWER
Grouse (General)						
Ruffed (Willow)						
Spruce						
Sharp-tailed						
Blue (Hooter)						
Ptarmigan (General)						
Rock						
Willow						
White-tailed						

INSTRUCTIONS

For each kind of bird, or for grouse or ptarmigan in general, check whether the population is high, moderate or low (I), and whether there were more, the same number, or fewer than last year (II). Use additional cards (Available at address reverse side) for reports on widely separated areas. On map on reverse side, shade in the block or blocks that correspond to the area you are reporting on this card.

WE ARE GRATEFUL FOR YOUR COOPERATION.

How was information obtained? Check one or more:

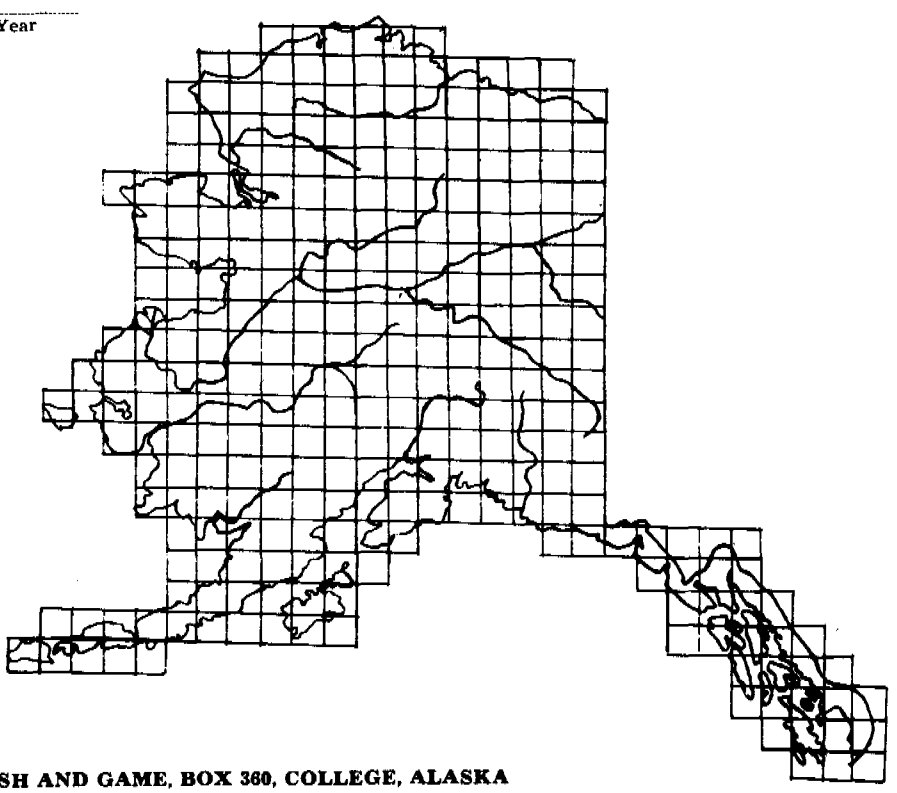
Birds, seen, hunting season ☐

Birds seen, not in hunting season ☐

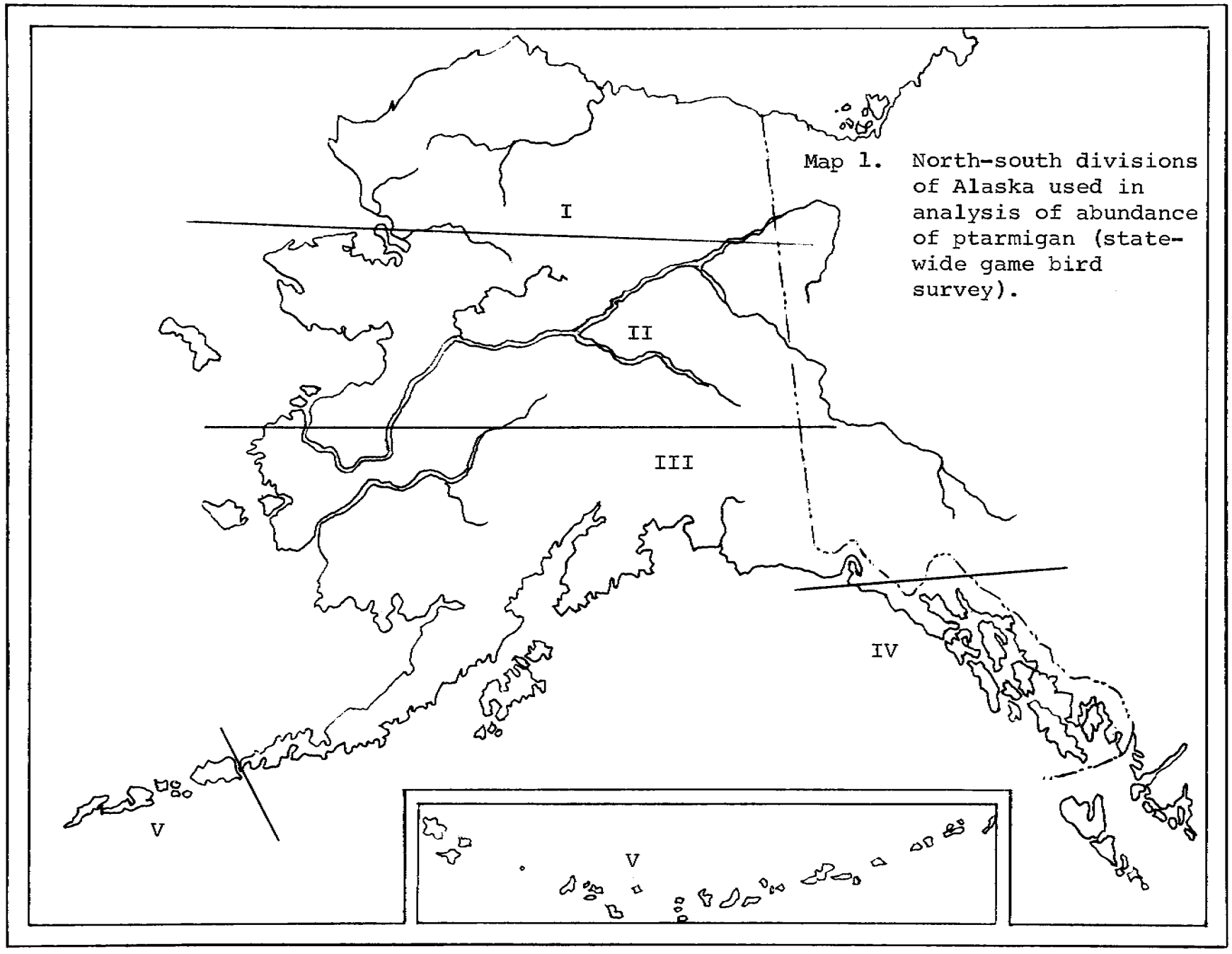
Talks with others ☐

UNISORT ANALYSIS CARD FORM Y9 BURROUGHS CORPORATION - TODD COMPANY DIV. - L HADLEY PRINTED IN U.S.A.

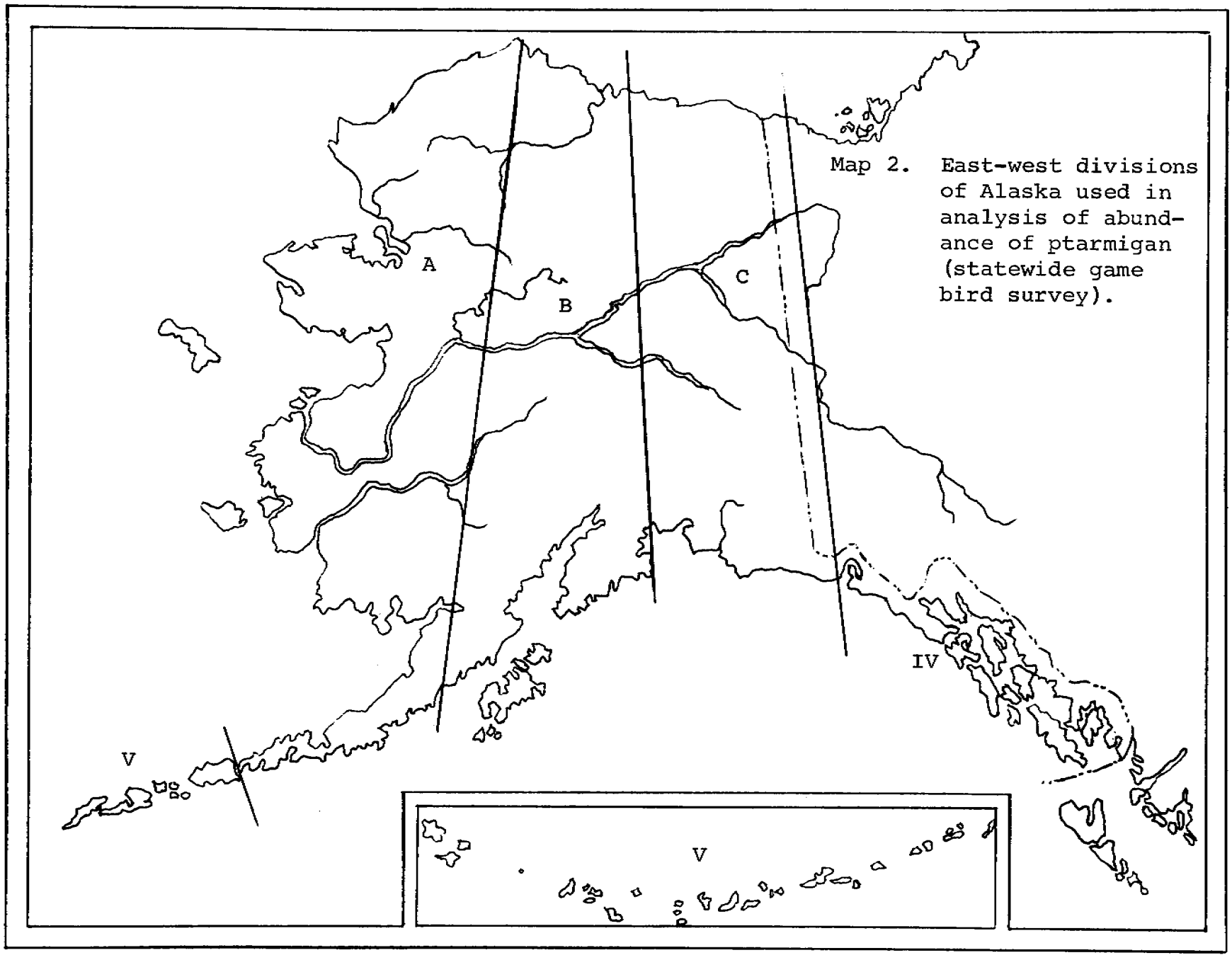
DATE..... Day Month Year



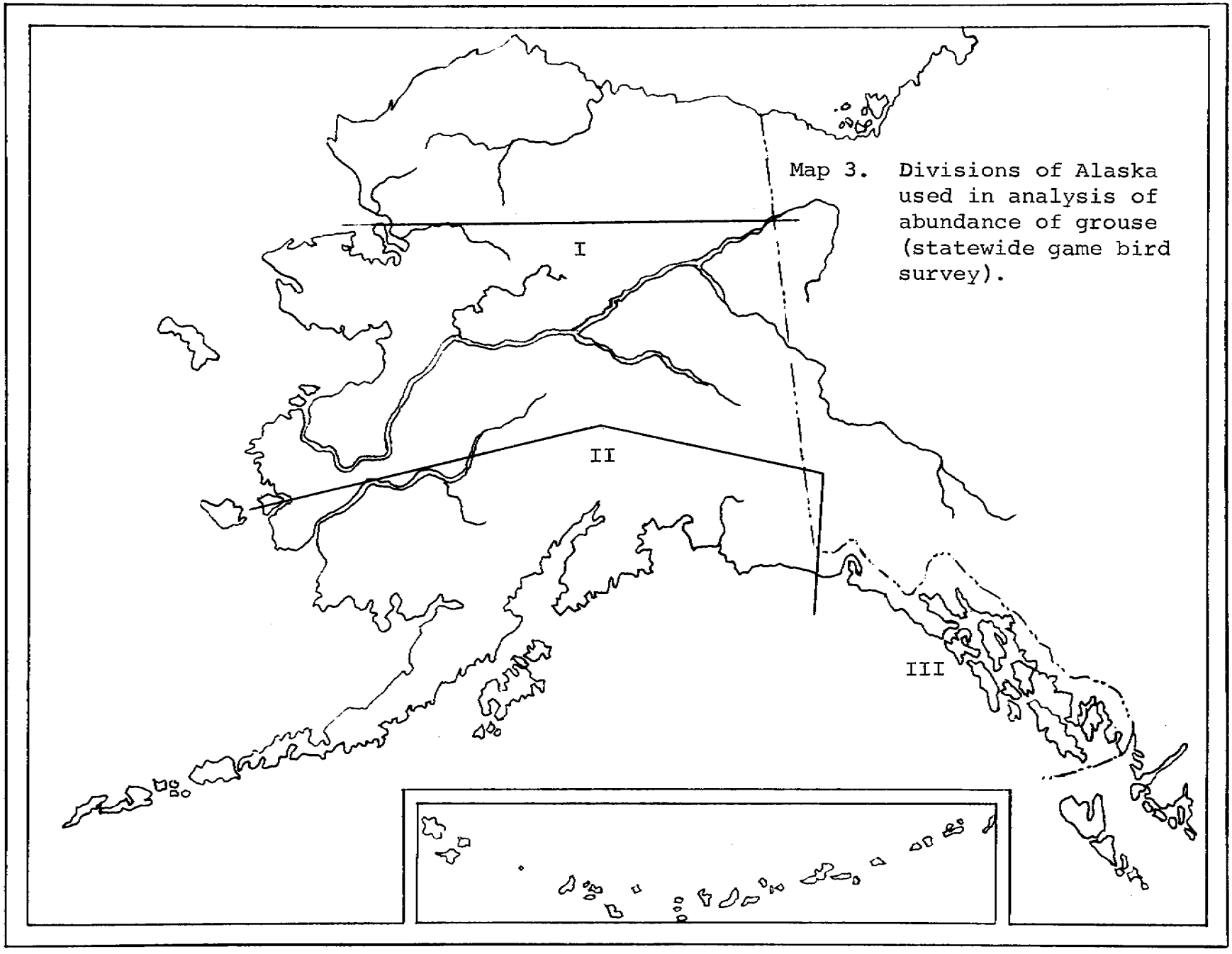
RETURN BY JAN. 15 TO:
ALASKA DEPARTMENT OF FISH AND GAME, BOX 360, COLLEGE, ALASKA



Map 1. North-south divisions of Alaska used in analysis of abundance of ptarmigan (statewide game bird survey).



Map 2. East-west divisions of Alaska used in analysis of abundance of ptarmigan (statewide game bird survey).



Map 3. Divisions of Alaska used in analysis of abundance of grouse (statewide game bird survey).