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WINTER HABITS OF THE RUFFED GROUSE IN PETERSHAM, MASSACHUSETTS

by

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Introduction

There is no finer game bird than the ruffed grouse, Bonasa umbellus umbellus, and New England has long been famous for its grouse shooting.

The abundance in which this bird has maintained itself in much of New England during the past sixty to seventy years, cyclic though its numbers have been, is undoubtedly far above its populations of preceding generations. When its history is traced back to the advent of the early settlers, it is found to have been relatively scarce in the densely stocked climax forest. Since the pioneer period, a sequence of changes arising from economic conditions, chiefly lumbering and agriculture, has many times greatly altered the animal environment, and with each alteration an adjustment in the abundance and occurrence of animal populations has tended to follow.

Although several studies of the ruffed grouse have been conducted, notably in New York, Wisconsin and Minnesota, very little, except on cyclic studies, has been published pertaining to New England conditions. The present study was carried on during the winter of 1935-36 to determine some of the habits of the ruffed grouse in the locality of Petersham, Massachusetts.

Description of Locality

In order to understand the vast changes that have occurred in the town of Petersham during the two hundred years since it was settled, and the consequent effects on the wildlife population, a brief history and description are necessary.

Physiographically the town is characterized by long, low, widely separated ridges which extend in a north and south direction. The topography, however, is quite irregular due to the modification of the ridges and valleys by minor features such as drainage channels, rocky outcrops, and glacial deposits. Except for sandy outwash plains, the soil of both ridges and valleys is fertile but generally unsuited for present-day agriculture because of an abundance of glacial boulders.

The climax forest typical of the region has been classified as belonging to the transition zone, and contains both the coniferous and deciduous species common to the Northern Hardwood and Central Hardwood regions.

Settlement of the Petersham region began about 1730. Homesteads were first established on the ridges, and the many acres of timberland were gradually cleared and converted into agricultural and pasture lands. By 1830, with fifty-five to sixty per cent of the area cleared and used as farm land, the first change in the use of the region had reached its peak. But this condition was destined to be altered, for the westward surge of population that began about 1850 and the effects of the Civil War a decade later resulted in a period of rapid abandonment of farms. After release

from cultivation the fields reverted to woodland, and, because conditions were favorable to the regeneration of white pine, "old field pine" became the predominant forest type, with hardwoods usually occupying the more moist locations. Because farm abandonment has continued to the present time, but at a much slower rate than when first started, old field pine stands are now represented in ages ranging from the extreme of seventy or eighty years to newly established stands. Most of the older ones have been cut and in their places have followed stands of hardwood species, the most of which are not over forty-five years. The major part of the forest land today is covered by either old field pine or young hardwoods. An occasional patch of culled old growth is sometimes found.

To intensively study winter relations of the ruffed grouse, one of the best grouse covers in the township was chosen. This area (469 acres), located on the gently sloping west side of the ridge extending through the village of Petersham, not only contained a representation of all common types of forest but also offered an opportunity for comparison of the effects that land use might have on the grouse population. Approximately one-half of the tract was situated on the upper slope and, as evidenced by stone walls subdividing this portion into lots, it had been entirely cleared at one time and used either for crop land or grazing. The abandonment of this area had been progressive and consequently a complete range of developmental stages was present from old fields to eighty-year stands of pine. Since abandonment, nothing

had been done to any of the stands. The other half of the tract adjoins the first area on the lower side and extends to a pond border at the base of the ridge. Although this area had been entirely cutover in the past, its rocky nature and general unsuitability for cultivation narrowed its use to pasture and led to earlier abandonment than in the other block. The present status of this area as contrasted with the other is quite different as it has been under management as part of the Harvard Forest for twenty-seven years. Under forest management, it has had numerous silvicultural operations conducted in its stands, namely, logging of old field pine by clear cutting and shelterwood methods, plantings of conifers on cutover land, weedings and thinnings in stands of hardwood and conifers, and gypsy moth control cuttings.

To follow the movements of the grouse in determining their relations to certain locations, a cover type map was made for the entire area. For the Harvard Forest section a suitable map was made from the forest compartment maps, while for the other block a map was constructed by the use of aerial photographs. The shape, size, and position of the stands obtained from the photos were supplemented by field observations to get age class divisions and were then plotted on a skeleton map of roads and stone walls constructed from a staff compass and pacing survey.

Forest Type - Habit Relations

During the winter and early spring field observations were made to determine habits of the birds in relation to forest types. The method used in general field investigation was to cover the

area a number of times under various weather conditions by wandering around and recording all observations. Data were recorded on a form sheet and included the signs observed, the number of birds found, flushing distance, description and map number of the type in which birds or signs were found, activities, and information on weather conditions.

Roosting A summary of observations on the roosting of grouse during the fall and winter showed it to be a habit which was quite dependent on certain types of cover. Before deep snow arrived, the birds selected roosts in dense young coniferous stands, or if such stands were not present, as in large areas of older timber, the shelter of a dense understory hemlock might be chosen. A good roosting habitat, as evidenced by extensive use of nearly all such stands, was a well-stocked area of pine, fifteen to twenty years of age with dense crowns forming a closed canopy. In a stand of this nature the birds usually roosted eight to twelve feet from the ground and at a point within the live crown level. Tree roosts were not found in younger stands where the closed canopy had not yet risen above the ground and were seldom found in older stands where the lower limit of the live crown had risen above twenty feet. Plantations of conifers were used as readily as natural stands. A one-acre plantation of dense fifteen-year-old red pine was used continuously throughout the fall and winter, while another area of mixed red pine and hardwood with less density of stocking was used intermittently.

Climatological data on temperature, humidity, and wind velocity were recorded from November to April in an effort to determine the effects of different cover types in ameliorating

these influences within their bounds. Instrument stations were established in three different types in close proximity to each other and having the same exposure with approximately equal elevations. The types selected were the following: (1) a very dense fifteen-year-old natural stand of white pine with dead length* reaching about six feet above ground; (2) a fully stocked, eighteen-year-old natural stand of hardwoods containing yellow and black birch, red maple, white ash, red oak and aspen; (3) a cutover area on which white pine was logged six years previously and now containing a plantation of six-year-old white pine and a natural growth of hardwood sprouts. The instruments used consisted of hygrothermographs placed at three and one-half feet and anemometers placed at five feet above ground.

In figures 1, 2, and 3 are graphs of the weekly averages of the weather data for the three sites. The differences which these curves show between types are quite marked. This is especially true for wind velocity; and since this is a weekly average, the difference would be even greater at certain times. The latter statement also applies to the temperature curves, for, although the pine, which is always the warmest at night, differs at most only three and one-half degrees in a weekly average, the temperature on certain nights may be as much as seven degrees higher than in hardwoods or open land. Although these results showed dense pine to be the most comfortable roost, its use cannot be altogether ascribed to weather factors since protection from

* Portion of stem along which the branches have been killed.

enemies must also be considered. Nevertheless, weather is undoubtedly an important influence for, whenever a condition was produced which favorably affected some factor such as temperature or wind, advantage is taken of it. Thus roosting in the snow is begun in preference to roosting in conifers as soon as the snow is of a satisfactory depth. Although snow temperatures were not recorded, a plausible explanation for this preference may be taken from the air temperature data which show higher daily temperatures in open or hardwood areas. This may result in the snow of such places having a greater amount of heat during the night than the snow of dense pine stands. Also, the protection from wind afforded by the snow is obviously much greater than that in a dense pine crown. However, the reason should not be ascribed wholly to weather factors, as the ability for a rapid take-off in case of molestation by a predator may influence the choice. When the surface of the snow becomes thickly crusted and impenetrable, conifer crowns are used as roosts, but when another snowstorm covers the crust for several inches, the birds roost in the snow digging down into it as deeply as possible, usually on the south side of some object such as the base of a tree.

Sunning Sunning and resting hold important places in the daily winter life of the grouse. During the morning hours of cold days when the sun produces a rapidly rising temperature soon after a low point around six or eight o'clock, a bird will often move from a roost in the snow to a warm, protected spot such as at the base of a tree. On bright afternoons birds were found to use different types of rests. A number of times they were

flushed in singles or in groups of from two to six from the sunny side of the live crowns of tall pines at heights of from forty to seventy feet from the ground. As the pines offered no food, sunning was considered to be the reason for the presence of the birds. Another well-used spot was in a 1-acre stand of sixty-year-old white pine which was bordered on the east, south, and west sides by a stand of hardwoods. The position of the hardwoods and the open character of the edge of the pine permitted the rays of the sun to strike for a distance of around one hundred feet into the pine stand throughout most of the day. The heating action of the sun's rays around the bases of the trees, causing the snow to melt and warming the bark and bed of needles, and the overhead protection from enemies were well utilized by the grouse. Droppings at the base of nearly every tree showed where birds had rested either on the pine needles or at the base of dead limbs a foot or two above the ground. Many other stands of pine and pine-hardwood, which offered some concealment and yet were open enough for sunning, were used.

Feeding This most important of the fall and winter relations of the ruffed grouse, upon which livelihood depends, is one that is exceedingly dependent upon weather conditions. If the winter is mild and open, birds may continue with certain of their fall feeding habits, but, with a hard winter bringing deep snows, feeding is limited to shrubs and trees. The habits under the latter condition were not studied in detail because of the impossibility of obtaining quantitative food data, but material

was collected during the hunting season between October 20 and November 20. Foods taken during this period were studied by an analysis of thirty-nine crops obtained in Petersham and the surrounding towns. Although the number analyzed was not very large and the period in which they were obtained short, a picture is presented of the importance of certain foods in the fall diet. The results are presented in Table 1. The method used in analysis was to separate the material contained in a crop and measure the volume of each article in cubic centimeters with a glass graduate and then to oven dry the material and weigh to the nearest tenth of a gram. Anything less than one cubic centimeter or one-tenth of a gram was recorded as a trace.

A most interesting crop collected on October 29, 1935, in Royalston, Massachusetts, and submitted to the Biological Survey for analysis contained:

Hickory galls (3100)	90%
Clover, Trifolium sp.,	7%
Sedge, Carex crinita, seeds	3%
Fire cherry, Prunus pennsylvanica, twigs	
Ground hemlock, Taxus canadensis, 4 leaves	Trace
Oak, Quercus sp., 2 buds	Trace
Grape fern, Botrychium obliquum, 1 leaf, 1 sporophyll	Trace
Violet, Viola sp., 10 fr. capsule	Trace
Mountain maple, Acer spicatum	Trace
Leaf beetle, Chrysomelidae, fr. of larva	Trace

Table I

Fall grouse foods as determined by crop analysis.

(Based on 39 crops taken between October 20 and November 20,1935)

	Frequency	Volume (C.C.)	Weight (gr.)	% by Wt.
Apple, Malus sp. (leaves)	17	302	58.9	39.4
" (fruit)	8	217	30.0	20.1
" (buds & twigs)	11	17	1.7	1.1
Grape fern, Botrychium obliquum (fronds)	7	62	9.8	6.6
Sheep sorrel, Rumex acetosella (leaves)	19	46	5.7	3.8
Blueberry, Vaccinium sp. (buds & twigs)	11	38	7.2	4.8
White clover, Trifolium repens (leaves)	9	32	4.6	3.1
Dwarf raspberry, Rubus hispidus (leaves)	11	27	4.1	2.7
Hazel, Corylus rostrata (catkins)	5	23	4.8	3.2
Partridge berry, Mitchella repens (berries)	5	14	1.5	1.0
Miterwort, Mitella diphylla (leaves)	3	13	1.7	1.1
Black cherry, Prunus serotina (leaves)	1	12	2.0	1.3
Fire cherry, Prunus pennsylvanica (leaves)	3	11	2.4	1.6
Grape, Vitis sp. (fruit)	1	11	2.1	1.4
Trembling aspen, Populus tremuloides (leaves)	2	10	1.5	1.0
" (buds)	3	5	1.4	0.9
Shin leaf, Pyrola sp. (leaves)	2	9	1.1	0.7
Red clover, Trifolium pratense (leaves)	4	8	1.5	1.0
Strawberry, Fragaria virginiana (leaves)	7	7	1.0	0.7
Cinquefoil, Potentilla sp. (leaves)	11	5	0.7	0.5
Birch, Betula sp. (catkins)	1	3	1.5	1.0
" (buds)	9	3	1.4	0.9
Staghorn sumac, Rhus nirta (fruit)	1	3	0.3	0.2
Wintergreen, Gaultheria procumbens (fruit)	6	2	0.5	0.3
Chokeberry, Aronia melanocarpa (fruit)	1	2	0.3	0.2
Hawthorn, Crataegus sp. (fruit)	1	1	0.2	0.1
Blueberry, Vaccinium sp. (leaves)	2	1g	tr	tr
Wintergreen, Gaultheria procumbens (leaves)	3	tr	0.1	0.1
Wood fern, Aspidium spinulosum (fronds)	4	1	tr	tr
Aster, Aster sp. (leaves)	1	1	tr	tr
Grass (leaves)	11	tr	tr	tr
Canada mayflower (Maianthemum canadense (fruit)	2	tr	tr	tr
Cherry, Prunus sp. (buds)	1	tr	tr	tr
Fireweed, Epilobium angustifolium (leaves)	1	tr	tr	tr
Moss, Polytrichum sp. (capsule and Leaf)	4	tr	tr	tr
Hazel, Corylus rostrata (buds)	2	tr	tr	tr
Wild raisin, Viburnum cassinoides (fruit)	1	tr	tr	tr
Blackberry, Rubus sp. (leaf)	2	tr	tr	tr
Witch hazel, Hamamelis virginiana (buds)	1	tr	tr	tr
Buttercup, Ranunculus sp. (leaves)	1	tr	tr	tr
Pine needles, Pinus strobus	3	tr	tr	tr
Violet, Viola sp. (seed pod)	2	tr	tr	tr
Grit	5	tr	tr	tr
Unidentified leaves		12	0.7	0.5
Unidentified seeds	1	tr	tr	tr
Unidentified buds and twigs	2	tr	tr	tr

Table I (Cont'd)

	Frequency	Volume (C.C.)	Weight (gr.)	% by Wt.
Snails	2	3	5	0.3
Crickets (Orthoptera: Gryllidae)	1	3	0.4	0.3
Walking stick (Orthoptera: Phasmidae)	1	1	tr	tr
Spider (Arachnida)	1	tr	tr	tr
Treehoppers (Homoptera: Membracidae)	2	tr	tr	tr
Carrion-beetles (Coleoptera: Silphidae)	2	tr	tr	tr
Fly (Unident) (Diptera:)	1	tr	tr	tr
Grasshopper (Orthoptera:)	1	tr	tr	tr
Leaf-beetle (Coleoptera: Chrysomelidae)	1	tr	tr	tr
Unidentified	2	tr	tr	tr
				99.9

To show where the foods were produced this food habits work was supplemented by a quantitative study of the grouse foods present in various types. A sample was obtained by laying out mil-acre quadrats at one-chain intervals on lines run through the types and, to obtain a complete cross-section of the study area, a range of types and ages, representing the most common successional stages in the region, was studied. The data were collected in early spring before growth of annuals had started, and represented available, low-growing materials used by grouse as food during fall before the ground is covered with snow and in spring after the snow leaves, and shrubby material available during winter. The height to which material was collected was limited to three feet which is the approximate height limit to which a bird could feed from the snow. All material known to be used as food by the grouse was picked from the plots, oven-dried, weighed, and computed in grams per acre. The figures are presented in Table 2.

Notes on feeding during the winter were recorded whenever fresh and unmistakable signs were found but were limited entirely to ground observations and were of no quantitative value. The following is a list of the species which were observed to be eaten during the winter and early spring. The figures give the number of times observed.

Chokeberry, Aronia melanocarpa	10
Blueberry, Vaccinium sp.	7
Dwarf raspberry, Rubus hispidus, leaves	7
Wintergreen, Gaultheria procumbens	4
Wood fern, Aspidium spinulosum	3
Sheep laurel, Kalmia angustifolia	3
Yellow birch, Betula lutea	3
Shadbush, Amelanchier sp.	3
Red maple, Acer rubrum, buds	2

Type & Age	Mitch.	Rubus hisp.	Pyrolla	Gaulth-eria	Asp. Spin.	Oxalis aceto.	Coptis trifolia	Prunus sp.	Poten-tilla	Frag-aria	Botrych-ium obl.	Vacc. buds	Coryl buds
		Amount of various food species per											
Old field		8200	1070						20	590	tr		
Pine-20		90									tr		
Pine-40	7075	575	100	7650	1775							200	
Pine-45	625	tr	25	7225	300							375	tr
Pine-50	100	33	1149	20479									
Pine-50(H)	27125	109	200	2554	5690							64	
Pine-60	4220	60	380	4860	4100					tr		40	
Pine-60-70	560			2980	330								
Mx-Sd-2	9650	3750	50	26800								1400	
P-Hd-6	1458	15966	367	19249						25		50	150
P-Hd-10	tr									tr			
P-Hd-13-14	2	68		763								9	
P-Hd-15-20	633	tr		300									
P-Hd-20	tr	20			210		tr			tr			
Hd-30	84												
Hd-40	tr	62	tr	8188			570					12	
Hd-60	750	25		tr	175								
Hd-70					4								
Hd-80-90	90	8	69	1300									
P-Hm-Hd-7	1706					150	75	8					

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er acre - grams

orylus buds	Ostrya buds	Maianth-emum	Viola lvs.	Vacc. lvs.	Cornus lvs.	Polypo-dium	Shield Fern	Y.Birch buds	R.Maple buds	Polysti-chum	Viburnum lvs.	Totals
												9880
												90
												17375
tr	tr											8550
		tr	tr									21761
		tr		9	18	4318	72					40159
								200				13880
												3870
												40250
1500									8			38673
												tr
												842
												933
												230
			12							1912		2177
					tr						12	8844
						25				3950		4925
							8	17		150		179
										1277		2744
												1939

Goldthread, Coptis trifolia	1
Mountain laurel, Kalmia latifolia	1
Rock polypody, Polypodium vulgare	1
Cinquefoil, Potentilla sp.	1
Partridge berry, Mitchella repens	1
Caltha palustris	1
Dogwood, Cornus sp.	1
Cherry, Prunus sp.	1
Poplar, Populus sp.	tr

In addition to these observations a crop was obtained from a grouse which was killed by flying into a window on the evening of January 21. The last meal of this bird had consisted of:

Betula catkins	9 c.c	2.6 gr.
Betula buds	2 "	0.5 "
Vaccinium buds	1 "	0.2 "

At this date the ground had been covered with snow for over a month and feeding must necessarily have been confined to bud and twig material, yet this bird was in very good physical condition and had a good layer of fat on its intestines.

Of singular importance in these fall relations is the apple tree, which is well-known as a source of fall and winter grouse food over a wide range and as shown by Table 1 is especially so in this locality. Apple leaves, fruits or twig materials were found in twenty of the thirty-nine crops analyzed. This high total percentage shows that apple material in general is very well-liked, while the large amount of apple fruit eaten during a year when it was very scarce proves it to be a much sought-after food. In a year of abundant fruit the total percentage of apple materials eaten might be even greater. However, apple trees are usually absent in a well-stocked forest, for, being an intolerant species they are dependent on openings as a site for establishment and

survival. As most old fields contain apple trees either as remnants from old orchards or as younger trees which have seeded in upon abandonment, they are the most important type for fall feeding. The period through which these apple trees in old fields may be expected to survive is dependent upon the density of the more tolerant, faster growing species with which they are in competition. In a dense stand of young pine, twenty to thirty years will be sufficient time for the conifers to overtop and kill even a large tree. However, if the pine comes in as an open stand, it may take forty to fifty years for this same action.

Besides apple, the many other food producing herbs, shrubs, and vines which grow up in old fields in the process of reversion make a very attractive feeding ground. The five species eaten in greatest amounts (Table 1), apple, grape fern, sorrel, blueberry, and hazel, are all practically limited to openings, while many of the other species on the list are abundant in open areas.

An agency which must be recognized as an important substitute for old fields is a certain type of old road. This was shown by the numerous flushes, droppings, and tracks occurring along these throughout the fall and winter. Old woods roads which are used only occasionally for vehicular traffic but which are kept open and free of woody vegetation usually become grassy and support a growth of such important herbaceous foods as clover, strawberry, cinquefoil and sheep sorrel. When these roads are closely bordered by some cover such as young pine containing an intermixture of shrubs including blueberry, chokeberry, hazel and others valuable for their buds and fruits, they are much used as feeding grounds

during the fall and winter. On roads which are more used by automobiles, the feeding of grouse on the kernels of cracked red oak acorns has been observed.

The use of the pine type in feeding is governed by the density of the stand, which in turn is contingent upon the density of origin and the age. Where the pine has originated in a poorly stocked condition, there may be a succession of food plants throughout the entire life of the stand, but, with full stocking, the establishment of an understory of hardwoods, shrubs, and herbaceous vegetation is dependent upon the increase in light and upon other reactions which come with increasing age. Spaeth (1920) set fifty years as the age at which hardwoods such as red oak, white ash, sugar maple, and yellow birch become established under old field pine stands. This is also true of other plants. As shown by Table 2 a dense twenty-year-old stand was barren of vegetation but stands forty years old and older on favorable sites had an abundant growth of shrubby and herbaceous plants. A fifty-year-old stand that was thinned ten years previously had the largest amount of material and the greatest variety of any stand studied.

The value for winter feeding of the one cutover area located on the tract was immaterial. This area (three and one-half acres), from which a seventy-year-old pine stand was logged six years previously, contained a plantation of six-year-old white pine with a mixture of natural hardwood sprouts. The sprouts, mostly oak, had been weeded once to release the planted pine. Shrubby food species, such as blueberry, hazel, and dwarf raspberry, were scattered over the area and grouse inhabited the surrounding types throughout the

winter. These types included young white pine, young red pine, old hardwood, old white pine, and pine-hemlock-hardwood, but the birds were never flushed within the cutting nor were tracks seen within the area except along its boundaries with the surrounding types. The apparent reason for this avoidance was the lack of protective cover for, with two feet of snow on the ground, the tips of the pine and bushy shrubs that jutted above the surface offered slight shelter. The use of the abundant winter food on this area will probably be delayed several more years until the pine reaches the stage where it affords some protection.

Feeding in hardwood stands depends chiefly upon the presence of tree species which are preferred in budding, such as birch and aspen. The feeding is confined almost wholly to the crowns of the trees, for dense young stands of hardwood--and most of them are dense--are as barren of ground vegetation as dense young stands of pine, and older stands of hardwood do not possess the abundant ground cover which is found in old pine stands. For this reason and because of the lack of cover, grouse tracks in the snow were very rare in pure hardwood stands. On several occasions while following the tracks of feeding grouse, birds which had been budding on shrubs and eating dwarf raspberry leaves under pine were found to have flown upon reaching the edge of adjoining hardwoods alighting at the far side or in adjoining pines. The lack of protective cover among the crowns of pure hardwoods is probably the reason why birds were seldom found budding within large areas of pure hardwood but were found more often within mixtures of pine-hardwood and pine-hemlock-hardwood close to the edge of a pine stand.

An interesting happening occurred in a small hardwood stand when some scattered aspens were cut in January as a gypsy moth control measure. Grouse which had been living near immediately took advantage of the easy accessibility of buds and began feeding on the ground among the scattered tops.

Escape In the winter life of the grouse the all-important relation of pine stands to the daily routine is of utmost importance when life itself is endangered. During the brief but exciting moments when a bird is being pursued by some raptor, the value of the dense crowns of conifers as escape coverts cannot be questioned.

On the several occasions when the disturbing of grouse was so immediately followed by the pursuit of a goshawk that it was judged the presence of each was known to the other, the location of the grouse in the pine stands at the time of disturbance was inferred to be for concealment. On one occasion the value of conifers for hiding was demonstrated when two grouse were flushed from a dense pine crown a moment after a goshawk had been disturbed from a pine at a point less than fifty feet away.

Summary of Forest Type - Habit Relations

As stated in the beginning of this section, the study of winter habits resolved itself from merely observations on the relation of habits to forest types into the problem of distribution of population. Initial census work during late fall showed, first, that, principally on the unmanaged block, the greater part of the population was grouped around certain localities and, second, that the unmanaged block held a slightly larger

Table 3

Comparison of per cent of grouse flushed in various types with per cent of total area of the types

TYPE	% Total Area	% of Grouse Flushed
Pine - young	4.7	24.4
- old	28.8	26.4
Hardwood - young	4.1	2.6
- old	16.6	5.2
P - Cd	5.9	11.9
Open - Old field	3.2	8.3
P-Hd - young	6.5	1.6
- old	12.5	5.7
P-Hm-Hd	8.7	7.8
Open - Swamp	1.0	0.5
Cd	2.8	4.1
Hd-Sw	1.4	0.5
Spr. - Plantation	0.8	0.5
Hm-Hd	2.2	-
Open land	0.8	-
Road - Boundary	-	0.5

population than the managed part. These relationships held until May when the study was ended.

The reasons for this distribution are to be found in the presence and distribution of certain cover types. By summarizing the above data on habits, it is shown that some types are of much greater value during the winter than the others. The pine type, of universal importance in all the habits discussed, is the most prominent in this relation, and its value is upheld by a record of the flushes of birds. Table 3 lists the per cent of birds flushed (recorded while censusing and studying movements) within various types, and the per cent of total area contained in each type. (Note- The division of pine and other types into young and old is an arbitrary division placed at about thirty years, which is the age at which the use of a type by grouse begins to change. When the stand is dense the live crown begins to rise to a height above the ground which appears to be unsatisfactory for roosting at about this age.) Approximately one-half of the flushes were in 157 acres of pure pine, about equally divided between young and old stands, while the importance of mixtures of pine with other types also is shown. The meagre 7.8 per cent of flushes in the 97.1 acres of old hardwood is noteworthy, while the high percentage in old fields also is outstanding.

However, it should not be presumed from the above statements that any one type, pine for example, when situated alone is of paramount importance, for when the flushes are plotted on a map the striking effect is not that they are chiefly in pine but that they are grouped about certain localities. This grouping is pre-

Table 4

Comparison of areas of various cover types on the two blocks.

TYPE	Unmanaged Forest Area (Acres)	%	Managed Forest Area (Acres)	%	Total Acres	%
Pine - young	19.7	9.1	2.5	1.0	22.2	4.73
- old	94.1	43.5	40.7	16.1	134.8	28.72
P-Cd - young	10.7	4.9			10.7	2.28
- old	3.8	1.8	12.9	5.1	16.7	3.57
Hardwood - young			19.2	7.6	19.2	4.09
- old	51.0	23.6	26.9	10.6	77.9	16.60
P-Hd - young			30.6	12.1	30.6	6.52
- old	21.9	10.1	36.5	14.4	58.4	12.44
P-Hm-Hd - old	.3	.1	40.5	16.0	40.8	8.69
Hd - SW			7.7	3.0	7.7	1.64
Hm-Hd			10.4	4.1	10.4	2.22
Spr. Plantation			3.7	1.5	3.7	.79
Open Old Field Reverting to Woodl.	14.4	6.6	0.4	0.2	14.8	3.15
Open land			8.2	3.2	8.2	1.75
Cd - young	.8	0.3	2.6	1.0	3.4	.72
- old			9.8	3.9	9.8	2.09
Totals	216.7	100.0	252.6	99.8	469.3	99.99

eminent on the non-managed tract and appears in places where there is a combination of reverting old field, with old and young pine, and pine-cordwood. Associated with such a combination which provides satisfactory winter food, cover and means of escape there is apt to be a large permanent population. The reason for the close association with certain open areas was not determined. Besides the abundant fall and winter food supplied by these and the effect which it has upon maintaining a concentration throughout the winter, the original cause for the grouping may be due to some relation of the nesting or rearing season.

This need for open areas and interspersion of types and the inefficacy of large areas of pure, even-aged stands in having a well-stocked grouse population is emphasized by the absence or scarcity of birds from certain areas of unbroken old timber. Particularly noticeable in this quality are old dense stands of pure hemlock which have a very bare and unattractive forest floor.

The difference in population on the two blocks is closely correlated with the interspersion of types. Because of the differing histories of the two areas, chiefly during the past eighty years, the acreage contained in the various types differs considerably on the two blocks. Table 4 is a percentage tabulation of these areas. The managed area was totally abandoned much earlier than the other and the old fields and pastures of fifty to eighty years ago have grown a crop of timber so there are at present no old fields in the initial stages of reversion except

for a very small plot. Also the roads of the older forest are less favorable as openings due to the greater shading by taller stands. Nevertheless, the cuttings which have been made intermittently for the past twenty-seven years have reduced the even-aged character of the forest and increased the interspersion of types by reproducing to stands of hardwood and pine. The patches of young pine of suitable age are favored as roosts and when bordered by a road, which has increased its herbaceous vegetation since the cutting of the adjacent timber, a combination of especial attractiveness is formed. However, the deficiency of old fields with their accompanying qualities is probably the reason for the lesser total population and accounts for the wider ranging of birds instead of the tendency to remain about a definite locality.

Another area, distinct from the two blocks intensively studied, was censused while hunting during the fall by N. W. Hosley and clearly exemplifies the value of open areas for holding a large population. The area hunted, approximately fifty acres, was a strip of land about a half-mile in length and was made up of a series of edges between old fields, old field pine, young pine plantations and hardwoods. This area had a population of thirty birds at the beginning of the hunting season.

Forest Types

The classification of types used in the study (Table 3) is according to the system employed by the Harvard Forest. This system has as its basis the three main types of cover, pine,

hemlock, and hardwood, and the various other types are made up of combinations of these three. Thus, pure pine is made up of at least eighty per cent pine, while if the percentage is below this it is called P-Hm (pine-hemlock), P-Hd (pine-hardwood), or P-Hm-Hd (pine-hemlock-hardwood), depending upon the associated species. Hardwood stands are not typed separately on a basis of species except that stands of inferior species and form are classified as cordwood instead of hardwood. The better hardwood species are red oak, Quercus borealis, white ash, Fraxinus americana, yellow birch, Betula lutea, paper birch, Betula papyrifera, black birch, Betula lenta, sugar maple, Acer saccharum, and basswood, Tilia americana, while the cordwood species are poplar, Populus tremuloides and P. grandidentata, gray birch, Betula populifolia, and red maple, Acer rubrum.

Census

Censusing on the tract of 469 acres was carried on with two purposes in mind, (1) to determine the applicability and use of various methods for censusing grouse, and (2) to determine the population, movements and changes which might occur during the winter.

With the completion of a type map of the entire area, census work was begun to ascertain the fall population. After a reconnaissance was made to find the approximate number of birds and their whereabouts and to become familiar with the country, a 100% census was made in the first week of December.

100% Census Method In employing the 100% census method, in which the entire area is covered in an attempt to tally every

bird, several practices are possible. Although it is possible for one man alone to cover a sizeable area, it is impracticable because of the time element which demands that a complete census be made as quickly as possible in order that retallies through movement of birds will be prevented. The method is much more satisfactory when two men work together. The use of a good grouse dog not only improves the method from a time standpoint but is a necessity in making reasonably sure that all birds are located. It is possible for an observer to approach very close to well-concealed birds without knowledge of their presence, and, with no means of detecting them, they may be passed unnoticed and left untallied. A dog that gets out of control is, of course, worse than useless because birds are flushed beyond the point where they can be seen or heard.

Of primary importance in applying the method are a map and a good knowledge of the area and, because of the necessity of keeping oriented, the system is dependent upon the presence of internal bounds of either natural or artificial structure. The maze of stone walls and old roads which is a peculiarity common to much of New England, and the smallness of the forest stands, furnish a very well-defined set of subdivisions. Each unit is traversed so that the entire area is covered by man or dog, and when a reasonable flushing distance is allowed, depending upon the type, this may be done with zigzag lines separated by 100 to 300 feet. The rate of censusing by this method varied from 150 to 170 acres per 8-hour man and dog day.

The advantages of the method are:

(1) It gives an accurate total figure and eliminates the uncertainty which is inherent in the partial estimate.

(2) With sparse populations the probable error is much smaller than with a partial estimate.

Strip Method During early spring a test was made to determine the practicability of censusing in the area with the strip method which was developed by R. T. King in Minnesota and is used in a modified form by the Michigan Department of Conservation. As specified in the method (Trippensee and Adams) lines were mechanically located on the area in gridiron arrangement, but because of the shape and size of the tract they were spaced at a distance of one-third mile rather than the customary one-quarter mile. To facilitate the following lines instead of cutting out paths, strips of white cloth were fastened on trees at one hundred foot intervals. The distance of each hundred foot point on the base line was marked on a light tree trunk blaze with an indelible pencil.

The procedure of an observer while making a census is to follow each line and record the flushing distance of each bird and the type from which it flushed. After completion of field work the figures obtained are applied in a proportional formula and the total population computed. The formula which is used in these computations is:

$$\frac{\text{Total area of tract}}{\text{Area covered by strip}} = \frac{\text{Total estimated grouse}}{\text{Grouse seen on strip}}$$

The area covered by the strip equals the distance covered on lines multiplied by twice the average flushing distance.

With the method as originally formulated the proportion stated above is employed, but in the modified method of the Michigan Conservation Department the variation of population between different types is recognized and each type computed separately. The formula then becomes:

$$\frac{\text{Total area of type}}{\text{Area of strip in type}} = \frac{\text{Total grouse in type}}{\text{Grouse on strip in type}}$$

The results obtained by these methods proved to be unsatisfactory for accurate determination of population, for not only did the number of birds flushed vary considerably on four trials within a period of a month, but also the computed population by both formulae yielded figures which varied greatly and were either too high or too low.

The following table gives the results of the four trials conducted at a time when the approximate population was thirty birds.

No. birds flushed	Population computed by Original Formula	Modified Formula
8	37	37
5	18	21
4	21	37
1	5	5
Average	20.2	25.0

The result was attributed to the uneven distribution of the population, for, with the birds grouped at certain points rather than uniformly over the area, an accurate sampling by strips is dependent upon lines passing through some of the points of concentration. Although not tried, a more accurate census might

have been obtained by increasing the number of lines on the area. A disadvantage of the modified method is that it is especially difficult to record and compute the data in this section because of the exceedingly irregular shapes and sizes of the forest types.

The reliability of the census methods used was found to be affected by certain factors:

(1) Wind - Extremely windy days are very poor for censusing as the noise and continuous movement produce a condition in which it is very difficult to hear and see flushing birds. The readiness of the birds to flush may also be influenced.

(2) Time of day - Often in early morning when roosting or especially when sunning in trees or in the snow, birds must be approached very closely before they will flush.

(3) Time of year - Late fall and early spring when the leaves are off the trees seem to be the best periods to census for total populations.

(4) The ability of the observer - One must "know" grouse to accurately census them, for a single note or an almost silent flight may be the only evidence of a bird's presence.

(5) The ability of the dog, if one is used -

Population of the area

The fall census of the 469 acres gave a population of forty birds, or a density of a bird to eleven acres. Since the grouse population cycle was considered to be near the peak, this density was perhaps as high as possible under the existing environmental conditions. The distribution of the forty birds between the two

areas, as stated before, was slightly unequal as fifty-seven per cent of the total number was found on the unmanaged part which contained only forty-six per cent of the area.

The spring census showed that twenty-nine birds had lived through a severe winter, and that eleven had been lost. Six of the eleven were accounted for by discovery of kills. There was no known poaching on the area.

Predation

The known winter mortality on the area, as evidenced by the finding of kills, was due to fox and goshawk predation. Foxes were quite numerous on the area if the number of tracks may be taken as an indication of abundance, but only one goshawk was known to live in the vicinity. Although signs observed at the kills pointed to fox work in three of the six cases, the most dangerous enemy on the area, based on kills per predator, must have been the goshawk which quite evidently killed two of the grouse and was seen pursuing birds several times. A large owl was known to have visited the area occasionally as several pellets and a feather were found but there was no evidence of predation on grouse.

Fox scats were collected on the area throughout the course of the study and were analyzed by Wm. J. Hamilton, Jr.

Sex Ratio

Sex determination of birds killed during the hunting season of October 20 to November 20, 1935, produced a striking result, for of the twenty birds which were sexed sixteen were males and four females, or a sex ratio of 80:20. This unbalanced condition has been noted before and has been interpreted as part of the cyclic phenomenon. Leopold (1933) stated that an unbalanced ratio with males in excess has often been recorded for ruffed grouse when the cycle was at the low point, but the condition in the present case was apparently occurring very near the peak of the cycle.

Summary

1. Observations were made on ruffed grouse, Bonasa umbellus umbellus, between October, 1935, and May, 1936, to study winter relations characteristic of the species in Petersham, Massachusetts. Particular emphasis was placed on the study of the relation of various habits to forest types.

2. Dense young coniferous stands were preferred for roosting during the fall and early winter.

3. Grouse began roosting in the snow whenever it reached an uncrusted depth of five or six inches and continued to do so as long as it was of satisfactory depth and uncrusted.

4. Pine and open pine-hardwood were the main types used for sunning and resting during the winter.

5. Apple leaf, fruit, bud and twig materials were the most important fall grouse foods and made up 59.5% by weight of the total fall food as determined by crop analysis. Bud and twig material, and fruit, when present, were also important in winter.

6. Open areas, such as old fields in the early stages of reversion and old roads, were very important fall and winter feeding grounds.

7. Where apple trees were lacking, the species of greatest importance for winter feeding were black and yellow birch and aspen. They were supplemented by ground feeding on such shrubs as chokeberry and blueberry, which were available above the snow line.

8. Most old field pine stands, forty to fifty years of age or older were found to contain an abundant growth of ground vegetation. The buds and twigs of young hardwoods and shrubs were fed upon in winter, while the smaller plants were used in fall and spring when the snow did not cover them.

Summary (Cont'd)

9. An increase in the understory plants of old field pine stands may be induced by augmenting the natural opening of stands by thinnings.

10. Dense conifers furnished the best coverts for concealment from enemies.

11. For the section of the town studied, the ideal winter grouse habitat possessed an intermixture of types, including dense young pine, old pine, old field in the process of reversion to woodland, and hardwood or pine-hardwood containing birch. Such combinations had larger populations than large solid areas of pure or even-aged stands.

12. Provided the grouse population is not too dense, (there was no difficulty with a bird per eleven acres) areas of 500 acres or less may be censused accurately by one or two observers covering the entire area with the aid of a well-trained bird dog.

13. Computation of the population by use of the strip method did not yield results comparable to those of the 100% method. This was considered to be due to the uneven distribution of the birds.

14. Although the most dangerous predator on the tract, based on kills found and pursuit of the grouse, was a goshawk, the large fox population of the Petersham section probably accounts for a considerable portion of the winter mortality. Whether the birds were healthy and vigorous when killed is, of course, another matter.

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