EVALUATING RUFFED GROUSE FOODS FOR HABITAT IMPROVEMENT[1]

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Food habits research is a necessary step in planning habitat improvement programs. Adequate food supplies for the managed species must be provided at the critical season either by a good natural range or by an improved habitat. Wildlife managers have long known that the success of a fall grouse hunt hinges mainly on survival of the young through the summer. For this reason the present study aimed at determining the most important plant foods of ruffed grouse broods and developing a method for evaluating foods for possible use in habitat improvement work.

Ruffed grouse are well known as omnivorous feeders throughout the eastern United States where their food habits have been thoroughly studied. Food habits of grouse in the East have been documented particularly well by Hosley (1938), Edminister (1947), and Bump and associates (1947). Little has been published regarding ruffed grouse foods in the Pacific Northwest, particularly in Idaho. Judd (1905) reported briefly on a single specimen of ruffed grouse collected in British Columbia. Marshall (1946) reported on the foods of the ruffed grouse in the Boise National Forest, Idaho, indicating the crop contents of three specimens and the results of some winter snow trailing studies. With so little information regarding food habits of ruffed grouse in publication, the present study emphasized this information.

It was apparent from an ecological study (Hungerford, 1951a) that the heavy losses to the huntable population occur during the summer brood season. The food habits study has been directed primarily toward obtaining information during the brood period and toward determining the key plants which may be used as food by broods of young grouse in order that this information can be applied to management.

DESCRIPTION OF THE STUDY AREA

The study area comprises a 2,200-acre block of the University of Idaho Experimental Forest in Latah County. This area was heavily logged during the 1920's and early 1930's, and is now typical of much of the cutover white pine forest land of northern Idaho. The second growth timber consists primarily of Douglas fir (*Pseudotsuga taxi-*

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folia) and Ponderosa pine (*Pinus ponderosa*) on the ridges and a mixture of western redcedar (*Thuja plicata*), grand fir (*Abies grandis*), western white pine (*Pinus monticola*) and western larch (*Larix occidentalis*) on the slopes and in the stream courses. The pattern of ruffed grouse cover use as correlated with the micro-climate of this area has been described in an earlier paper (Hungerford, 1951b).

The altitude of this area varies from 3,000 to 3,500 feet. The climate is characterized by long, dry summers. Precipitation comes principally during the winter and spring months with an average annual rainfall of about 22 inches at Moscow, Idaho, 35 miles distant. However, more than 33 inches of rainfall were measured on the study area during the year ending June 30, 1950. It is important that the low precipitation period for the year is during July and August during the time when the broods are being raised. About 0.50 inches or less of rain were recorded for each of these months during the study period.

This area is well covered with herbaceous vegetation as an understory to the second growth timber. This growth contains some large shrubs which occasionally reach tree size, such as: mountain maple (*Acer glabrum*), serviceberry (*Amelanchier florida*), and a number of smaller shrubs such as huckleberry (*Vaccinium*) and snowberry (*Symphoricarpos*). In many parts of the area, particularly in the openings and along the wood roads used as feeding areas by the broods, the ground cover is made up primarily of various grasses, particularly Kentucky blue grass, and Dutch white clover.

PREVIOUS WORK

This study is partly a search for a better method of evaluating food habits of ruffed grouse. In this way it is a criticism of the customary analysis of crops and the expression of data as a percentage by volume or weight without any consideration of the relative amounts of foods available.

Dalke (1934) was one of the first to show the value of the dropping analysis method of food habits study. He found by comparison of several methods of food habits study that parts of nearly all foods taken by pheasants pass through the digestive tract undigested. It was determined that some completely digestible foods were indicated in the droppings by the color and consistency. Since the quantity of the dropping material was almost unlimited, this tended to minimize individual differences in feeding habit and expressed more accurately the general trend of a population of pheasants.

Dalke expressed his results as a percentage or frequency of occurrence of the total number of droppings. He was able to identify only

about 35 species of plants and most of the data were expressed by classes of food. He concluded that the dropping analysis for any period was a better indicator of the availability of the various classes of food than was the crop analysis.

Jensen and Korschgen (1947) reported on a force feeding experiment with bobwhite quail in which the relative merits of the crop, gizzard and dropping analysis were compared. Seven kinds of seeds were used in a diet force-fed to the birds. Comparisons were made on the basis of volume analysis of the droppings and volume and weight analysis of the crops and gizzards. As a result of this experiment, these writers conclude that crop analysis gave the best basis for determining food habits, while dropping analysis was equal in value to gizzard analysis. The "average deviation" of the gizzard analysis by volume was 14.2 per cent and the droppings 12.8 per cent, where the deviation is from the volume of foods in the original diet. This points to a definite limitation of gizzard analysis or dropping analysis where either is used for volume determination. However, it should be pointed out that of the seven items used in the feeding experiments, each showed up to some extent in the droppings analysis. Hence, the droppings would have been perfectly valid in showing the frequency of occurrence of each item. Also, it should be noted that in analyzing the droppings by volume, the largest discrepancy was an item of 41 per cent undetermined. If the average deviation were calculated without this undetermined item, the figure is 6.9 per cent or somewhat more than twice the deviation of 2.7 per cent for the crop analysis. If the 41 per cent undetermined has all been properly identified, the dropping analysis by volume might be fairly close to the crop analysis. The plant micro-techniques as recently described by Dusi (1949) show much promise in reducing the amount of undetermined materials in the dropping analysis.

One of the first attempts to consider the availability of wildlife food along with its utilization was that of Glading, Biswell, and Smith (1937) in a study of the food of the California quail. To show the relative importance of leaf material during a period when it made up practically all of the quail diet, a "desirability co-efficient" was developed which was based on the percentage volume in the total diet, the percentage occurrence in the stomachs of the quail and the percentage of the species in the total plant population. Bellrose and Anderson (1943) also applied a utilization-abundance ratio with duck food plants.

Beck (1952) suggested a "food rank index" which included the volume in per cent, the occurrence in per cent, and the density of the

food items themselves. This particular method was developed for use with evaluating wild turkey foods.

Another attempt at evaluating wildlife foods beyond just the percentage by volume was that of Baumgartner, *et al.* (1952) working with Oklahoma bobwhite food relations. These workers developed a "volume-frequency index" in which the rank of the food by the volume index and the rank of the food by the frequency index was combined.

More recently Beck and Beck (1955) combined the earlier food rank index with a nutritional value in still another method for evaluating foods of wildlife. As these writers point out, the nutritional quality of a food item in terms of the daily nutrient requirements has a great deal to do with its relative importance to wildlife. This present study does not include the nutritional factor; however, plans for future study include this important item.

PROCEDURE

The dropping analysis considered above was chosen to indicate food choice of ruffed grouse on individual range units. Droppings were collected on individual brood range units during the period from June through November. Droppings were collected at bi-monthly intervals or oftener. Collections were made at the clearing, logging road, trail or abandoned railroad grade which was used as an evening feeding area by each brood. Direct observation of broods indicated that the maximum number of droppings left by an average brood of five birds on the evening feeding ground is about 15 droppings during one 24-hour period. This averages some 210 droppings for a two-week period for the average brood of five birds. Considering that about 10 per cent of all available droppings would generally be an adequate sample, 20 droppings from one brood range for one bi-monthly period was set as a minimum. For most ranges 30 to 60 droppings are available for each two-week period.

The dropping analysis method used in the present study is essentially the same as that used by Dalke (*op. cit.*) and Phillipe (1945) working with pheasants and ruffed grouse respectively. Phillipe (1945) was able to collect most of his material for a general study of ruffed grouse winter food habits at the roosting spots. For the purposes of this study, roosting site collections did not prove adequate for there was too heavy ground cover at usual roosting sites. This prevented the location of a sufficient number of samples. As mentioned above, the evening feeding areas provided the best sites for making the dropping collections.

Droppings were collected in small paper sacks, labeled as to areas and date, and stored dry. Droppings were softened by soaking in warm water on paper towels. A collection of droppings from a brood range for a two-week period was placed on the paper towel and labeled as to source and date. After soaking on enamel trays, the droppings were teased apart and left to dry. The parts of each droppings dried and adhered to the towel fibers making a convenient way of storing and handling for microscopic study.

Study with a binocular dissecting microscope and comparison with a collection of grouse food items resulted in a classification of items present in each dropping. The comparison collection for use with dropping analysis consists of parts of grouse food plants mounted on 5- by 8-inch cards. Whole plants or parts of plants were mounted with a series of seeds commonly used. Other cards had buds and parts of buds of each shrub species commonly used. Individual species cards contain parts such as leaves, flowers, fruits, seeds, and buds. These collections were made on each brood range as studies of availability were made.

The availability of the various grouse foods on each brood range was determined by a series of one-tenth meter sample plots. The plot dimension is 0.2 by 0.5 meter giving a total area of 0.1 square meter. Plot frames of heavy steel wire were used in field work. A line of 20 plots, six feet apart, was chosen as the fundamental sampling unit. Lines of plots were run through each brood range after the feeding areas had been determined. On each line of plots, plant species were indicated by plots on a special field form if they were present. No counts were made. Presence by plot was translated to percentage occurrence for the availability figures for each brood range (Table 1). In some cases, shrub species bearing fruits important as food were present on brood ranges but not sampled adequately by the series of plots. On brood ranges where this was the case, a line intercept was

TABLE 1. AVAILABILITY OF RUFFED GROUSE FOODS ON THE EVENING FEEDING AREAS OF SOME SELECTED BROOD RANGES. AVAILABILITY WAS DETERMINED BY A SERIES OF 20 PLOTS, EACH 0.1 SQUARE METER IN AREA, AND EXPRESSED IN TERMS OF PERCENTAGE OCCURRENCE.

Food Species	Percentage Occurrence by Brood Ranges					Mannering Cr. Area
	4-A-3	4-B-1	5-A-1	4-B-2n	4-B-2	
Trifolium repens	100	70	100	85	100	90
Geum macrophyllum	90	55	90	80	90	25
Poa spp.	50	30	50	95	60	10
Plantago major	75	40	55	55	30	15
Taraxacum officinale	45	25	30	50	45	30
Rumex acetosella	25	....	25	10	5	....
Fragaria bracteata	15	10	5	5	5	25
Carex spp.	55	20	20	40	40	....
Festuca idahoensis	55	5	55	5	5	....
Bromus spp.	....	30	....	....	....	55

TABLE 2. AVAILABILITY OF RUFFED GROUSE FOODS ON THE UPLAND FEEDING AREAS OF SOME SELECTED BROOD RANGES. AVAILABILITY WAS DETERMINED—WHERE POSSIBLE—BY TWO SERIES OF 20 PLOTS EACH 0.1 SQUARE METER IN AREA. FOR THE LARGE SHRUBS THE LINE INTERCEPT METHOD WAS USED.

Food Species	Percentage of Occurrence by Brood Ranges						
	33-C-3	4-A-3	4-B-2w	4-B-2e	33-C-1	33-A-1	33-A-2
Linnaea borealis	80	30	30	65	85	75	50
Cornus canadensis	....	20	60	30	....	15	20
Rosa gymnocarpa	25	5	5	5	25	15	10
Calamagrostis rubescens	100	....	....	....	90	30	50
Clintonia uniflora	....	30	40	35	25	10	20
Vaccinium membranaceum	15	....	....	10	65	20	5
Galium spp.	45	15	10	25	20	25	35
Viola spp.	....	25	50	55	5	40	....
Smilacina stellata	....	15	5	....	5	25	35
Lathyrus spp.	55	5	15	5	5	....	20
Geum macrophyllum	15	....	....	....	....	10	....
Prunella vulgaris	....	5	....	....	....	20	....
Chamaphila umbellata	....	10	....	5	10	15	....
Symphoricarpos albus	60	....	....	....	30	5	5
Rubus parviflorus	....	5	5	....	....	....	....
Carex geyeri	....	40	10	15	25	35	....

run through the brood range and the percentage composition of these shrub species was determined (Table 2).

These methods of sampling both ground cover plants and shrub growth give a measure of the occurrence of the vegetative parts of plants. In the actual field sampling technique no records of number of fruits available were kept. This was attempted at the beginning of the study but was found to involve too great an expense of time. However, the data recorded on seasonal development of important ruffed grouse foods (Table 3) were applied to the availability as recorded from the plot studies. This applies to only the fruit- or seed-bearing plants. During the period in which the mature fruits are available, the percentage availability has been increased arbitrarily by 50 per cent.

FOOD INDEX

To correlate results of the dropping analysis and the availability studies within each brood range, a new technique was developed. An index is needed to the value of a particular food item based on both availability and use for a given period. The index is based on the assumption that an item which is eagerly sought out by the grouse but is scarce on the brood range has a higher value than an item which is used just as often but is common on the brood range. Both utilization and availability are expressed as percentage figures. Availability must be expressed in opposition to utilization in order to properly weight the index. The most convenient expression is the "percentage absence" as used by Blackman (1935), which is equal to 100 percent minus the percentage of occurrence. Thus, a percentage occurrence of 10 would be translated into a percentage absence of 90 to give the positive weight to the availability factor. The combined factor is

TABLE 3. SEASONAL DEVELOPMENT OF SOME IMPORTANT RUFFED GROUSE FOODS ON THE FLAT CREEK STUDY AREA, LATAH COUNTY, IDAHO. ONLY FRUIT PRODUCING SPECIES THAT HAVE A FAIRLY DEFINITE PERIOD OF DEVELOPMENT ARE SHOWN. THESE DATA WERE USED TO MODIFY THE SEASONAL AVAILABILITY OF THE PLANTS.

Species	*Flowering Dates*	*Immature Fruits*	*Mature Fruits*
Amelanchier florida	May 20-June 10	June 15-30	Aug. 1-Sept. 15
Arctostaphylos uva-ursi	June 10-30	Aug. 15-30	Sept.-Dec.
Clintonia uniflora	June 15-30	July 15-30	Aug.-Sept.
Cornus canadensis	June 1-July 21	July 10-Aug. 1	Aug.-Oct.
Cornus stolonifera	June 10-30	July 15-Aug. 15	Aug. 15-Oct.
Fragaria bracteata	May 15-June 30	June 15-July 1	June 15-Aug. 1
Geum macrophyllum	June 1-15	June 10-30	July-Sept.
Linnaea borealis	June 20-Aug. 1	July 15-30	Aug.-Sept.
Lonicera utahensis	May 15-June 15	June 18-July 15	July 15-Sept.
Rosa gymnocarpa	June 15-July 15	July 20-Aug. 20	Aug. 20-Nov.
Rubus parviflorus	June 1-20	July 10-20	July 20-Aug. 20
Smilacina racemosa	July 1-31	July 15-20	July 20-Sept.
Streptopus amplexifolius	June 15-July 15	July 15-30	Aug.-Sept.
Symphoricarpos albus	July 1-31	Aug. 10-30	Sept.-Oct.
Vaccinium membranaceum	May 15-June 15	June 20-July 10	July 15-Aug. 30
Viburnum pauciflorum	May 15-July 10	June 5-Aug. 10	Aug. 15-Oct.

called the "food index" and may be expressed by the following formula:

$$\text{Food Index} = \frac{\text{Percentage Utilization} \times (100 - \text{Percentage Availability})}{100}$$

Where Percentage Utilization = the percentage occurrence of the various food items in the grouse droppings, Percentage Availability = the percentage occurrence of the foods in plot studies on the same brood range, and denominator of 100 appears only for reducing the maximum index value to 100.

For example, *Cornus canadensis* is present in the droppings of one brood of grouse from August 1 to 15, at the rate of 20 per cent. On the same area *Cornus canadensis* was found to be distributed on the feeding grounds at the rate of 30 per cent, based on the one-tenth meter study plots. Placing these values in the formula:

$$\text{Food Index} = \frac{20 \times (100 - 30)}{100} = 14.0 \text{ for } \textit{Cornus canadensis}$$

FOOD HABITS RESULTS

Although this paper reports primarily the study of plant foods, those of animal origin are also important. Utilization of insect food by adults begins before the young are hatched. By early July the young grouse are beginning to be more active in feeding and use of insects continues relatively high through November (Table 4). A number of kinds of insects have been determined including species of wasp, cricket, various beetles, grasshoppers, caterpillar, honey bee and three species of ants. Other kinds of animal food identified were spiders and snails. Since most of this material was identified from the

droppings, closer determination was not possible. No reliable method for determining availability of insect food was found. Therefore, no attempt has been made to calculate a food index for insect items to compare with the plant foods.

Analysis of the results for plant foods include records for use by broods on 30 brood ranges over a period of four years. Not all brood ranges were occupied each year, and in some cases broods disappeared

TABLE 4. RELATIVE AMOUNTS OF INSECT FRAGMENTS IN RUFFED GROUSE DROPPINGS BY SEASON. BASED ON THE PERCENTAGE OF OCCURRENCE IN DROPPINGS COLLECTED ON KEY BROOD RANGES ON THE FLAT CREEK STUDY AREA, LATAH COUNTY, IDAHO

	April	July 15-31	Aug. 1-15	Aug. 16-31	Sept. 1-15	Sept. 16-30	Oct. 1-15	Oct. 16-30	Nov. 1-15	Nov. 16-31
No. of Droppings	55	87	203	135	90	12	....	110	81	6
Percentage Occurrence Insects	20	74	70	88	67	100	....	40	53	66

TABLE 5. RELATIVE FOOD INDEX OF SOME IMPORTANT GROUSE FOODS AS DETERMINED BY A CORRELATION OF UTILIZATION AND AVAILABILITY ON GROUSE BROOD RANGE 4-B-2

Kind of Food	Percentage Utilization	Percentage Availability	Food Index
For the Period July 15-31			
Clover leaves	50	25	37.5
Carex seeds	58	20	46.4
Cornus canadensis seeds	13	23	10.0
Cornus stolonifera seeds	5	5	4.7
For the Period August 1-15			
Clover leaves	47	25	35.2
Grass leaves	18	41	10.6
Carex seeds	63	20	50.4
Geum macrophyllum seeds	6	42	3.5
Cornus canadensis seeds	27	23	20.3
Cornus stolonifera seeds	8	5	7.6
Rosa gymnocarpa seeds	4	3	3.9
Arctostaphylos seeds	22	....	....
Symphoricarpos seeds	8	3	7.8
For the Period August 16-31			
Clover leaves	93	25	69.7
Grass leaves	10	41	5.9
Symphoricarpos seeds	14	3	13.6
Cornus canadensis seeds	29	23	22.3
Cornus stolonifera seeds	11	5	10.4
Arctostaphylos seeds	4	....	....
Rosa gymnocarpa seeds	4	3	3.9
Carex seeds	11	20	8.8
For the Period September 1-15			
Clover leaves	75	25	56.2
Grass leaves	16	41	9.4
Geum macrophyllum seeds	17	42	9.9
Cornus stolonifera seeds	33	5	31.3
For the Period October 16-31			
Clover leaves	25	25	18.7
Grass leaves	59	41	34.8
Symphoricarpos seeds	21	5	19.9
Thuja plicata leaves	32	20	25.6
Cornus stolonifera seeds	9	5	8.5

from a brood range for varying periods of time, as for example the period September 16-30 and October 1-15 of Table 5. In this case the hunting season was probably the reason for the shift.

Analysis of the plant foods by the food index where both utilization and availability are considered, shows the relative importance of each food in a new light. Many foods rating high on the basis of crop analysis by volumetric comparison, rate no higher than many others based on the food index when comparisons for the same periods are available. Use of the food index shows one important thing. When foods are analyzed for each separate brood range, a new perspective is given. Items that may show up as most important foods over a general area, show up on only those brood areas where the availability is reasonably high. This points to the fact that certain foods can easily be replaced by others in terms of relative importance through the availability on the range. The importance of foods should perhaps be considered in the light of certain groups of foods which are mutually replaceable by the others in terms of the availability at a particular brood range.

Table 5 indicates the most important foods throughout a typical season for one of the 30 brood ranges studied. This is more or less a typical brood range. It shows rather clearly the importance of *Carex* seeds during the early part of the brood season. *Vaccinium* fruits are another food which is important during a restricted part of the season. It does not appear in important quantities on the brood range illustrated in Table 5 but is shown in Figure 1, indicating its importance on other brood ranges. *Vaccinium* appears to fill the place occupied by blackberry and raspberry in New York (Bump, *et al.*, 1947).

Leaves of Dutch white clover rate high in the utilization picture during most of the summer. Some series of crops from ruffed grouse on this study area taken during September and early October show this clover as the most important food. The food index figures (Table 5) bear this out for many brood ranges. However, on other brood ranges where clover is not so readily available, other leaf material almost completely replaces the clover. Kentucky blue grass, and other ground cover plants of the group listed in Table 1, seem to supply this need as adequately as clover. It seems then that this group of plants should be considered together as mutually replaceable, without any one of them being given a higher value than another, except as to management potential as discussed below.

Bunchberry (*Cornus canadensis*), snowberry (*Symphoricarpos* spp.), red osier dogwood (*Cornus stolonifera*) and bald hipped rose (Rosa gymnocarpa) are replaceable from one brood range to another

in food index value. On some brood ranges other such fruits as serviceberry (*Amelanchier* spp.), mountain ash (*Sorbus sitchensis*), bearberry (*Arctostaphylos uva-ursi*) or honeysuckle (*Lonicera* spp.) replace others of this group in the relative food index value. Here again is a group of plant foods which should be considered as mutually replaceable on any brood range. Their value depends more on the availability than any apparent preference by the grouse themselves. This group of foods is most important in late summer and early fall (Figure 1).

The food index analysis showed that in the fall the leaves of Western redcedar (*Thuja plicata*) become important for a short period. This apparently occurs during the shift from the omnivorous diet of fruits, leaves and insects to the winter diet of buds. While cedar is readily available on the study area, it is not found throughout the range of grouse in Idaho. Its use here points to the possible need of some coniferous leaves during the period of diet change in the fall.

APPLICATIONS IN HABITAT IMPROVEMENT

An earlier ruffed grouse study in northern Idaho (Hungerford, 1951b) showed how dependent the ruffed grouse broods can be upon sufficient food and cover in the ravines and stream courses. The three principle requirements of the broods during the summer are: 1. Suitable night roosting cover, which is usually a heavy thicket of young conifer growth on a slope or small ridge adjacent to the ravine. 2. Suitable cover for resting and loafing during the middle of the day in the bottom of the ravine, and 3. A good source of summer foods.

The methods and results described above for evaluating summer foods were used in designing habitat improvement experiments on the same study area in northern Idaho. As shown in Figure 1, and in the food habits results above, the food index calculations have demonstrated that a series of foods can supply the need for leafy, succulent vegetation for grouse broods. Of this group Kentucky blue grass and Dutch white clover seem to rate as high as any other plants. Leaves of other plants listed in Table 1 are all used interchangeably with the clover and bluegrass. Their relative value seems to hinge mostly on the availability rather than the factor of preference. In choosing plants in this group with the greatest possibility for seedings in habitat improvement work, only two, the bluegrass and clover, have readily available seed and well known cultural practices. On this basis Kentucky blue grass and Dutch white clover were used in experimental plantings on grouse brood ranges. In the seeding experiments two conditions were found to be essential in establishing seed-

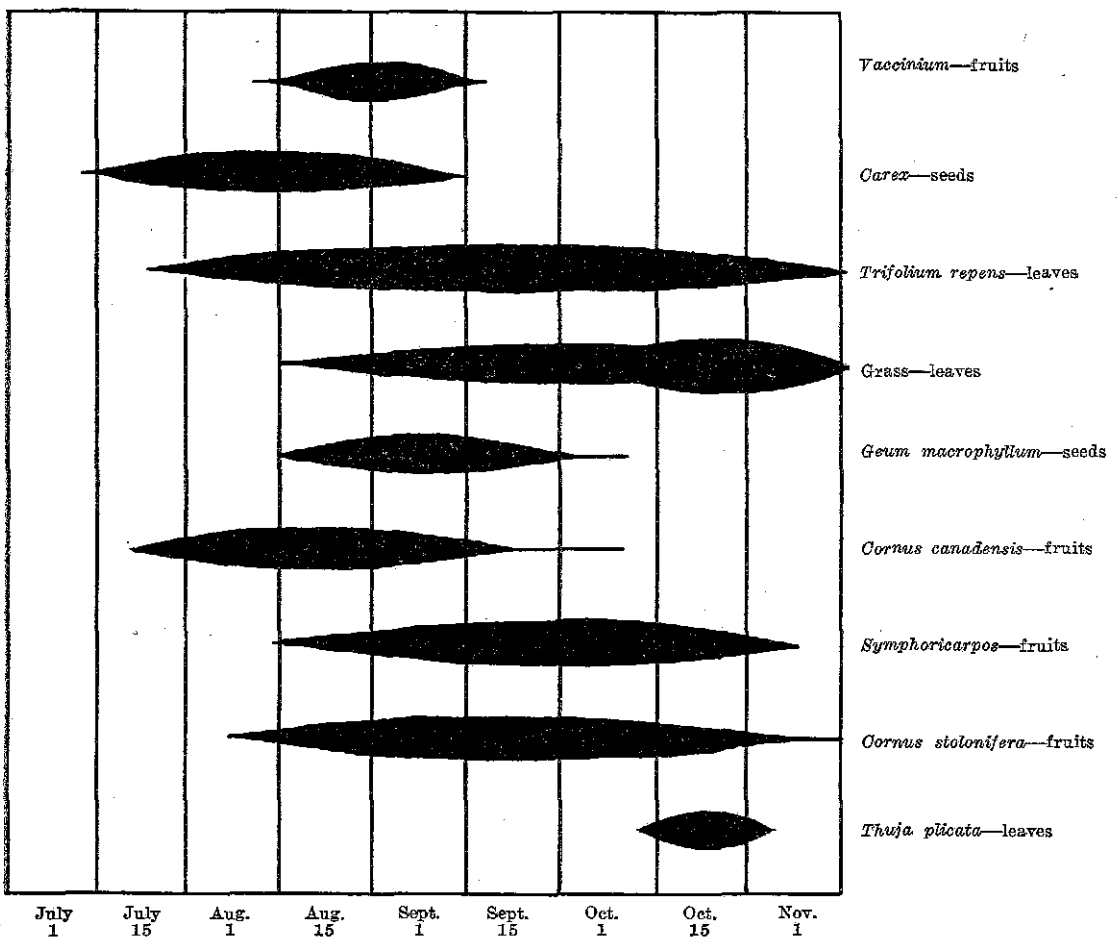

Figure 1. Relative Importance of Plant Food to Ruffed Grouse Broods as Shown by the Food Index.

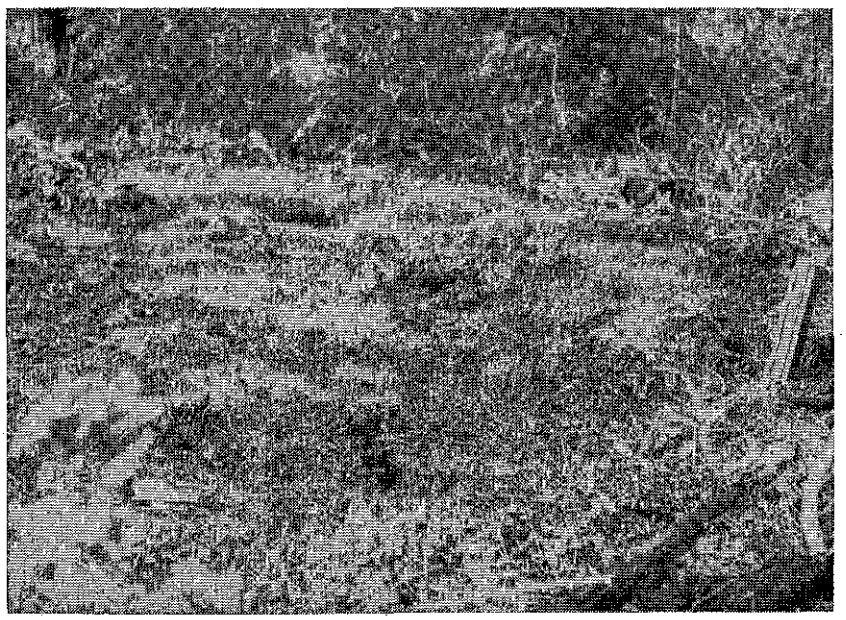

Figure 2. Example of a slash burn spot which has been seeded to a mixture of Kentucky blue grass and Dutch white clover. Seeding was done in April following fall burning. Seeds were broadcast and raked into the ashes.

ings under Idaho conditions: First an adequate seed bed preparation, and second, sufficient sunlight reaching the ground. Seedings were made successfully in the ashes of burned piles of logging slash (Figure 2), in skid trails created by logging operations, and in logging roads following heavy summer and fall traffic. Seedings were made only in those parts of the habitat having potential grouse use, that is, at the bottom of a ravine or watercourse. Good results were obtained seeding on the bare ground in late fall, where seeds were broadcast on top of the snow in early spring and in some cases where seeds were raked into the ground in late spring.

Another kind of food required by grouse broods are those fruits and seeds which make up an increasingly important part of the diet in late summer and early fall. These are the foods of the upland feeding areas as listed in Table 2. Such foods represent a wide variety of fruits, seeds and sometimes leafy material. With a wide range of choice grouse exhibit definite likes and dislikes. A comparison made from one brood range to another on the basis of food index described above indicated that the favored foods varied from one brood range to another, depending a good deal upon availability. When one usually

favored food was absent, another replaced it. With such a wide range of native species available in abundance no attempts were made to plant additional foods of this kind. Rather, an attempt was made to get better production of the existing food plants in key parts of the brood range. Small barbed wire exclosures about one rod on a side proved effective in protecting these key sites. Six exclosures have been built experimentally at a cost of $10 to $15 each (Figure 3). These were spaced at four to five per square mile. Each of these is located at a seep or a spring giving a source of water. They are located in juxtaposition to the resting cover used during midday. A primary purpose is to protect a source of this kind of food from the trampling and grazing of cattle present on the study area. The water source itself does not appear necessary to the grouse broods, but the cover and food protected by the enclosure gets constant use by grouse during the summer.

The most difficult part of such habitat improvement experiments is to evaluate the results, particularly with a variable population exhibited by ruffed grouse. Use by grouse broods is apparent on nearly all the developments described here. The most encouraging result is the use of at least two sites by ruffed grouse broods following the ex-

Figure 3. Barbed wire exclosure around a water seep on a ruffed grouse brood range. Fenced areas of this kind were designed to protect the native food and cover from trampling and overuse by cattle.

perimental habitat improvement, where no grouse broods had been known before.

Marshall (1953) took a long look at the farm game habitat programs in a fifteen state area. I feel that many of the deficiencies and failures in habitat improvement such as he described could be avoided first by better evaluation of food habits information such as the food index which is here proposed, and second, by the testing of habitat improvement measures on a pilot scale before extending them to large programs. It should in the long run point toward more efficient habitat programs. In other words, let's do most of our evaluation before we begin.

SUMMARY

The purpose of this study was to determine the most important foods of ruffed grouse broods and to develop a means for evaluating these foods for possible use in habitat improvement. The dropping analysis method was used and availability was determined by a series of plots on each brood range. An availability-utilization correlation was developed giving a "food index" value.

Insect foods were found to be important throughout the summer, but lacking a reliable method of sampling availability, the food index was not applied. Plant foods were studied on 30 brood ranges over a period of four years. The relative importance of each food must be considered in a new light when availability is included. Since the analysis was done for each two week period on each brood range considerable shift in the importance of individual foods was shown. *Carex* and *Vaccinium* fruits had the highest food index of any plant foods early in the brood season. Dutch white clover, Kentucky blue grass, and a wide range of other plants bearing succulent leaves appeared to have a high value as a group, any one of which could replace the others. These plants were of value throughout the brood season. Another group of plants included the fruit and seed bearing shrubs. These plants again appeared to be mutually replaceable, filling a need during the late summer and early fall.

In applying these results to management, two steps were taken in experimental habitat improvement. First, seedings of Kentucky blue grass and Dutch white clover have been made on evening feeding areas of grouse brood ranges. These two species were used because of easily available seed and known cultural practices, in other words, greater management potential. A second experiment was the construction of small exclosures to protect the other food plants from over-use and trampling by livestock.

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DISCUSSION

DR. PETERLE [Michigan]: What technique did you use in delineating the brood ranges, Dr. Hungerford?

DR. HUNGERFORD: Brood ranges were delineated mostly during the earlier ecological study. We have a constant study of ecological conditions going on. Most of the work is done on the ground. We used a system of red paint blazes and when we found a place, we marked it by a blaze on the tree at the site grouse were using, and after a summer's work, we felt we had them pretty well delineated.

Each brood range, I might add, covered a range of from ten to twenty acres on this site.

DR. BUSS: You mentioned that certain important groups of plants, as well as those not so important, are replaceable on the basis of your research findings, and on the basis of assigned index numbers; and you have also indicated that there

are two important exotic species in the management you propose. These are Dutch white clover and Kentucky bluegrass.

I would ask what are the two native species that took the place of these two imported exotics.

DR. HUNGERFORD: That goes back to the land use history of this area. Logging was done during the 1920's and the 1930's. In those days horses or by skidding logs to the railroad grades that were built on the stream courses. With the horse logging, there came in hay to feed those horses.

The hay consisted of clovers, timothy, and blue grass and a number of other species, and that is the way they got started on the range. They were well adapted to filling in these particular sites, that is, the old skid trails, landings, and the railroad grades themselves.

Those are the areas the grouse are using, and it points out a problem that we will have in the future, because logging is now done by tractors, which, of course, do not eat hay. The seeding will have to be done by some other means.

If it does have high value, as indicated, it seems we have exotics which are taking the place of many of the native foods which were originally, I believe, the dandelion, sheep sorrel, and plantain and other ground cover plants which still exist there.

BEN GLADING [California]: I would like to ask if he used the formula referred to by Leopold in California, as a test of desirability.

DR. HUNGERFORD: We made some comparisons of the formulas you used and also the one Bellrose and Anderson used; and we found that many of these foods rated in a different order. Generally the top ones were in the same ratio; but when we got down to Numbers two, three, four, five and six, and so on, the arrangement generally shifted quite a bit.

I believe the one I use tends to give a little more emphasis, if anything, to availability. We felt justified in that because we took our availability figures from the specific area where the grouse were feeding.

MR. GLADING: It is interesting to note that you are working on this concept of availability versus utilization as a management factor. I think that has been badly overlooked in all wildlife research in the last 16 years. The basic work on availability was done about twenty years ago, but it has not been actually used as a management tool for 15 years.

In the West there has been much said about range of brooding. We are striving to put in plants that we are not completely certain are essential or desirable. We have all the basic data, in all the western states at least, to find out if we are working with the right species, and so far I think we have fallen down quite a bit, not only in grouse, but in a lot of other species.

DR. HUNGERFORD: I might mention that we have been testing this concept with deer, and also in plans for future research, we are trying to determine nutrient values, as well as availability and utilization.

DR. PETERLE: Some time ago there was a publication by Leopold of California suggesting that differences in food habits could be detected through measurement of the caeca. Has anything been done on that for ruffed grouse? The reason I ask this: In the sharp-tail, I did measure the caeca and found differences between the two populations.

DR. HUNGERFORD: We have not done that. I do not know of any application to ruffed grouse.

MR. GLADING: I believe some work has been done. It has some interesting applications where they are primarily concerned with green food.