THE AVAILABLE NUTRIENTS IN SELECTED DEER BROWSE SPECIES GROWING ON DIFFERENT SOILS

by

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF ILLUSTRATIONS

LIST OF TABLES

LIST OF APPENDIX TABLES

LIST OF APPENDIX TABLES (Continued)

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INTRODUCTION

General field observations have shown differences in deer preference for the same browse species in different sections of Virginia. This demonstrated variation in preference and the many implications which it suggests are of interest and importance to those concerned with the management of deer. For this reason this reconnaissance investigation was started during September, 1954, and continued through October, 1955, with the following objectives: (1) to determine the differences, if any, in available nutrients of selected deer browse species which are growing on different soils, (2) to investigate the variations in available soil nutrients as they may relate to the chemical composition of selected deer browse species, and (3) to determine the variations in available plant nutrients in the selected browse species during different seasons of the year.

Facts relating to the above objectives would be useful, it was thought, in the intelligent appraisal and management of deer habitat, especially in western Virginia. The deer herd in western Virginia is increasing rapidly, and consequently, both foresters and game managers are concerned with the problem of preventing excessive demands upon the plants utilized by deer. It is realized that over-utilization would cause damage to both the forest and the deer herd. Knowledge of the extent to which available deer nutrients are affected by available soil nutrients is of notable importance in appraising the range carrying capacity and in indicating the number of deer that may be safely carried on a given segment of the range.

This investigation is one phase of the Virginia Agricultural Experiment Station's long-range project entitled "Ecology and Economics of Native Plants in Virginia". The results of this phase will be used in the over-all project in interpreting the ecology of the mountainous regions of Virginia, particularly with respect to the manner in which deer influence forest ecology.

REVIEW OF LITERATURE

The majority of the reported investigations attempting to correlate soil and plant nutrients to animal nutrition have dealt with the influence of soil type on the nutritional quality and mineral content of food for domestic stock or with food stuffs other than those normally utilized by deer. Fonder (1921) studied the influence of soil type on the calcium and magnesium content, and other physiological characters, of the alfalfa plant. Daniel and Harper (1934) showed the relation between total calcium and phosphorous in mature prairie grass and available plant food in the soil. Some of the relationships of soils to plant and animal nutrition with regard to the major elements was demonstrated by Brown (1938), Beeson and La Clerc (1937), and Beeson (1941). Aston (1928) correlated a malnutrition disease in sheep to lime-deficient areas. Price, Linkous, and Hill (1946) found that the same grasses and legumes contained differences in mineral composition on different soils.

Food preference and/or palatability have received the attention of several investigators; as yet, no investigation has shown conclusively to what extent preference is governed by the factors of palatability, availability, plant location, leaf size, leaf color, and related factors. Gostler, Moxon, and McKean (1951) ran a proximate analysis (moisture, protein, ether extract, ash, crude fiber, and nitrogen-free extract) plus carotene, phosphorous, calcium, iron, and manganese content on eleven plants which had been rated as being either palatable or non-palatable to deer in the Black Hills of South Dakota. In this investigation, palatability was based on whether or not the plant was observed being eaten or by its presence and quantity in stomach analyses. However, the chemical analyses of the browse species did not substantiate their field observation and stomach analyses division of plant species into palatable and non-palatable groups.

Other works which mention food preference of deer as well as, in some instances, seasonal availability, are: Davenport (1937) who worked in Michigan; Maynard et al. (1935) who worked in New York; Bramble and Goddard (1953) and Hellmers (1940) who worked in Pennsylvania; Chapman (1938) who did his work in Ohio; Dalke (1941) who lists the use and availability of more common winter deer browse plants in the Missouri Ozarks; and Harris (1954) who reported on the fluctuations in forage utilization by cattle on ponderosa pine (Pinus ponderosa) range in eastern Oregon.

With regard to the daily food requirements of deer, Davenport's work (1939) in Michigan indicated that from 3.48 to 7.45 pounds of food of six natural diets (the food poundage depending upon which of the six diets was being used) per day per hundredweight of deer were needed to maintain the deer in good health and strength for a period of 90 days, the estimated yarding season in Michigan. Nichol (1936) found that 2.2 pounds of a basal ration consisting of half roughage (alfalfa hay) and half concentrate (equal parts of whole oats, whole shelled corn, and rolled barley) per day per hundredweight was necessary for deer maintenance and growth. In a later work, Nichol (1938) found that the coefficient 2.35 multiplied by the hundredweight of deer gives, in pounds, the amount of air-dry forage removed daily by deer from the range in Arizona; this work also includes palatability tests on 168 different native plants.

Growth studies by French et al. (1955, Bull. 600P:6) "...indicated a daily requirement of about 2 pounds (3,600 Calories) of good quality, air-dry feed for a deer weighing 50 to 60 pounds, 3 to 4 pounds (6,300 Calories) for a 100-pound deer, and 5 to 6 pounds (9,900 Calories) for a 150-pound deer. The latter is the equivalent of at least 10 to 12 pounds of good deer browse of usual moisture content. The protein requirement for optimal growth was found to be 13 to 16 per cent of the ration." In another work by the same authors (1955, Bull. 600:4), it was stated that the presence of spikes and the antlerless condition in adult male deer "...is a direct sign of malnutrition..." except where complicated by a genetic factor.

It has been shown by Smith and Albrecht (1941) that fecundity is very closely related to the nutrition of an animal, particularly in regard to available proteins and mineral contents of feeds as controlled by soil fertility. Dunkeson (1955), who investigated birth records in yearling deer, although he does not postulate reasons for births in yearlings, indicates that good range conditions might help provide factors leading to such births.

Mitchell and Hosley (1936) presented data supporting the theories that leaf size, leaf color, and reducing sugar content of the leaves formed the criteria on the basis of which deer selected one type of browse in preference to another. However, they found no significant differences or trends which were consistent in the frequency or intensity of browsing related to the above criteria.

DeWitt and Derby (1955), in their work on changes in nutritive values of browse plants following forest fires, showed that while total solids, ash, ether extract, crude fiber, and nitrogen-free extract contents of red maple (Acer rubrum) and flowering dogwood (Cornus florida) were not affected by fire, the protein content of the foliage was significantly higher in the season following a low-intensity fire. Einarsen (1946) in his work with the black-tailed deer in northwestern and central costal Oregon reported that good areas are those upon which high protein browse grows and persists well into winter. He concludes (p. 312) that "...protein analysis has been found to be a valuable aid as a wildlife technique on this western range since it determines specifically the food values or lack thereof on occupied habitat."

Forbes and Bechdel (1931) report that laurel (Kalmia latifolia) and rhododendron (Rhododendron maximum) are poisonous to deer, but that the deer do not eat of their own choice enough of either to exceed their toxic tolerance. Their work showed that when deer were restricted to a diet of either laurel or rhododendron alone, young deer would not eat enough of either plant to maintain live weight; when restricted to laurel or rhododendron and grain for seven weeks, they remained contented and in good health.

Very little information is available on digestibility trials and digestion coefficients for the browse species used in this investigation. Forbes *et al.* (1941), using deer and rabbits as experimental animals determined the coefficients of digestion on three naturally occuring deer foods and several domesticated animals' rations. They found that deer were more efficient than rabbits in digesting woody fibers of dogwood (*Cornus paniculata*) and willow (*Salix humilis*) and were able to digest nutrients of concentrated feeds equally as well as rabbits. The massive compilations of coefficients of digestion of woody species by Russell (1947) and Schneider (1947) would certainly be helpful in selecting study species in the future. Perhaps such information can be obtained in a manner suggested by Chariet-Lery, Francois, and Leroy (1952), who show that coefficients of digestion may possibly be determined by analysis and calculation without experimental feeding.

The paucity of literature on any one aspect of this investigation reaches its zenith in works concerning quantitative and qualitative requirements of essential nutrients, minerals, and vitamins for deer; using the great abundance of such information available for domestic stock as a criterion, there is a great need for this type of research with wild game.

A second aspect not adequately covered by the deponents concerns whether or not any given foodstuff, of which the coefficients of digestion and total digestible nutrients (T. D. N.) are known, has the same values when it is eaten alone and when it is eaten with other foods. If the coefficients of digestion and T. D. N. of red maple, for example, were known for deer, they would have to have been determined experimentally which involves feeding deer this species only. Would these values be valid for use in rating red maple as a browse species since deer seldom, if ever, feed exclusively on one species? The apparently random manner by which deer feed first here and then there on over 600 known species (Atwood, 1941) makes this an important question.

Works which list preferred foods for various regions, nutritive values of foods, methods of studying browse preference, and similar topics are given in the "Literature Cited" and "Selected References" sections.

METHODS AND PROCEDURES

SELECTION OF STUDY AREAS

The following criteria were used to select study areas: (1) the areas had to be of different soil origin, (2) the areas had to be relatively close to one another and to Blacksburg, Virginia, thereby making it possible to reach the areas, collect the samples, and return to Blacksburg early enough to place the samples in dryers of the V. P. I. Agronomy Department, (3) the same browse species had to be present on all the areas in sufficient quantity to permit clipping of current year's growth throughout a 13 month period, and (4) the areas had to afford year-round accessibility.

SELECTION OF BROWSE SPECIES

Three browse species were found growing on four areas of different geological origin in sufficient numbers to permit the annual growth being clipped throughout the year. It was not at all simple to find such conditions, and they were found only after much field investigation in the company of qualified geologists and botanists.

When areas satisfying the soil requirements were found, a preliminary investigation of the vegetation was made by observing, while walking through the areas, the frequency of occurrence of the species present and at a height available to deer. Of the 21 woody species found, only sassafras (*Sassafras albidum*), red maple, flowering dogwood, and black locust (*Robinia pseudoacacia*) were found in sufficient quantity on all areas to warrant their selection as study species. Obtaining even this small number of selected species was done by eliminating as study areas sites on Chemung, Price, and Juniata formations.

Flowering dogwood, black locust, red maple, and sassafras are considered to be important deer browse species and as such were considered suitable for use in this study. In addition, buffalo nut (*Pyrularia pubera*), which has been shown by general field observations to be a highly preferred browse plant, where present, and rhododendron, which is heavily utilized during the winter, where present, were collected and analyzed. This latter analysis was made with the hope of determining the reasons for their heavy use by deer, especially since rhododendron is reported to have toxic qualities (Forbes and Bechdel, 1931).

TECHNIQUES OF SAMPLING AND COLLECTING

Soil

Soil samples collected in a random manner on each area were obtained with the aid of a soil auger. A minimum of 15 auger borings per study area comprised a sample.

Vegetation

Quadrats used in this study were two meters by eight meters in size. The first quadrat on each area was located randomly; thereafter, the quadrats were spaced at 50 feet intervals in the direction of the longer axis of the first quadrat.

Vegetation within the quadrats was divided into that which was growing at a height of six feet or above and that growing below six feet. Tables 1 - 5 give the results of the quadrats. Plants listed under "A" reached six feet or more above the ground; those under "B" were below six feet. In some cases, browse was available to deer on plants reaching six feet or more above ground because of their growth habits. In these tables, density is calculated by the formula: Density = Total B/number of quadrats.

Scientific names of plants listed in Tables 1 - 5 are given in Appendix Table 1.

Collecting Procedure Prior to December, 1954: Collection of plant analyses data was started with the first twig samples which were collected in September, 1954. With two exceptions, the following browse species were collected from seven study areas: flowering dogwood, black locust, red maple, and sassafras. The exceptions were dogwood on the Millboro shale study area and red maple on the Rome study area where there were not enough of these plants to permit regular collections. In addition to the above four species, however, rhododendron was collected on the Brallier and Clinch formations, and buffalo nut was collected on the Brallier formation study area.

Clipped twig samples were collected at two-month intervals. The current growth portion of twigs were cut from the plants selected. Growth habit of the plants varied from shrubby plants to tall trees with low-hanging limbs. Approximately 50 grams of dried, ground material were desired for analysis. Since preliminary work showed

Table 1. Quadrat counts of woody plants on Martinsburg shale formation *

Species	Area 1		Area 2		Area 3		Area 4		Total		A & B	% B	B	
	A	B	A	B	A	B	A	B	A	B	Total		Fre-quency	Density
Azalea		23		7		22		22		74	74	20.2	100	18.5
Blueberry		3		1		28		76		108	108	29.5	100	27.0
Chestnut			1	1	2		6		9	1	10	0.3	25	0.3
Dogwood, Flowering		1		5		7				13	13	3.5	75	3.3
Greenbrier				2		4				6	6	1.6	50	1.5
Gum, Black	1	1	1			1	2	22	4	24	28	6.5	75	6.0
Hickory					1		2		3		3	0.0	0	0.0
Laurel, Mountain		3								3	3	0.8	25	0.8
Locust, Black		1		2						3	3	0.8	50	0.8
Maple, Red		12		14		12				38	38	10.4	75	9.5
Oaks (red group)		15		18		17				50	50	13.6	75	12.5
Oaks (white group)						1				1	1	0.3	25	0.3
Pine, White		1						1		2	2	0.5	50	0.5
Sassafras		7		2		9		21		39	39	10.6	100	9.8
Sourwood	2	1	1	1		2		1	3	5	8	1.4	100	1.3
TOTALS	3	68	2	53	4	103	10	143	19	367	386	100.0		

* Scientific names of plants listed in Tables 1 - 5 are given in Appendix Table 1.

Table 2. Quadrat counts of woody plants on Clinton formation

Species	Area 1 A	Area 1 B	Area 2 A	Area 2 B	Area 3 A	Area 3 B	Area 4 A	Area 4 B	Area 5 A	Area 5 B	Total A	Total B	A & B Total	% B	B Fre-quency	B Density
Azalea		21		8		42		34		16		121	121	28.7	100	24.2
Blueberry				6		18		37		8		69	69	16.4	80	13.8
Cherry						1						1	1	0.2	20	0.2
Chestnut		1		4		1						6	6	1.4	60	1.2
Cucumber Tree						1		1		1		3	3	0.7	60	0.6
Dogwood, Flowering				1	2	4				1	2	6	6	1.4	20	1.2
Greenbrier		1							3	8	3	9	12	2.2	40	1.8
Gum, Black			1	1		1					1	2	3	0.5	40	0.4
Hickory	2			4	4	2		5			6	11	17	2.6	60	2.2
Locust, Black				4		1						5	5	1.2	40	1.0
Maple, Red				1	2	4				1	2	6	8	1.4	60	1.2
Oaks (red group)				2								2	2	0.5	20	0.4
Oaks (white group)		1		5	1	3					1	9	10	2.2	60	1.8
Sassafras		70		44		19	4	8	2	23	6	164	170	39.0	100	32.8
Shadbush										6		6	6	1.4	20	1.2
Virginia Creeper			1							1	1	1	2	0.2	20	0.2
TOTALS	2	94	2	83	9	97	4	85	5	65	22	421	443	100.0		

Table 3. Quadrat counts of woody plants on Huntersville chert formation

Species	Area 1 A	Area 1 B	Area 2 A	Area 2 B	Area 3 A	Area 3 B	Area 4 A	Area 4 B	Area 5 A	Area 5 B	Total A	Total B	A & B Total	% B	B Fre-quency	B Density
Azalea		29		59		102		10		24		224	224	40.4	100	44.8
Birch		3		2		9		1		10		25	25	4.5	100	5.0
Blueberry		45		8		4				3		60	60	10.8	80	12.0
Chestnut		5		4				2				11	11	2.0	60	2.2
Dogwood, Flowering	2	4									2	4	6	0.7	20	0.8
Fetter-bush				2		8		5		3		18	18	3.2	80	3.6
Hazelnut		20										20	20	3.6	20	4.0
Hickory	1	6		1							1	7	8	1.3	40	1.4
Locust, Black		4		1				2		1		8	8	1.4	80	1.6
Maple, Red		11		6		3				44		64	64	11.5	80	12.8
Oaks (red group)	3	1		8		8		15	2	12	5	44	49	8.0	100	8.8
Oaks (white group)				1	1	25		12		5	1	43	44	7.8	80	8.6
Pine, White		1				2		1		1		5	5	0.9	80	1.0
Sassafras		8		4		2		1		4		19	19	3.4	100	3.8
Viburnum, Maple-leaved				3								3	3	0.5	20	0.6
TOTALS	6	141		102	1	166		50	2	107	9	555	564	100.0		

Table 4. Quadrat count of woody plants on Brallier formation

Species	Area 1		Area 2		Area 3		Area 4		Total		A & B	% B	B	
	A	B	A	B	A	B	A	B	A	B	Total		Frequency	Density
Arrowwood				11						11	11	8.6	25	2.8
Blueberry				16		3		12		31	31	24.2	50	7.8
Buffalo Nut				2		5				7	7	5.5	50	1.8
Dogwood, Flowering		1			1	1			1	2	3	1.6	50	0.5
Grape	1			1			1		2	1	3	0.8	25	0.3
Greenbrier		1								1	1	0.8	25	0.3
Gum, Black								1		1	1	0.8	25	0.3
Hazelnut		3								3	3	2.3	25	0.8
Hickory	1		1	3					2	3	5	3.1	25	1.0
Laurel, Mountain		13		8		11		12		44	44	34.3	100	11.0
Maple, Red	12					1		2	12	3	15	2.3	50	0.8
Oaks (red group)	6	2	16	2	3	4	5		30	8	38	6.3	75	2.0
Oaks (white group)					3	2		3	3	5	8	3.9	50	1.3
Pine, Virginia					1				1			0.0	0	0.0
Pine, White		1			1				1	1	2	1.6	50	0.3
Sassafras					1	1		1	1	2	3	1.6	25	0.5
Witch-hazel				3						3	3	2.3	25	0.8
TOTALS	20	21	17	46	10	28	6	31	53	126	179	100.0		

Table 5. Quadrat analysis of woody plants on a second area of Brallier formation from which the buffalo nut was collected. This area is located in Poverty Valley, Montgomery County, Virginia

Species	Totals of 5 Quadrats	Density	Frequency	Approximate % of Total Plant Numbers
Ash	1	0.2	20	0.01
Azalea	57	11.4	100	9.00
Blueberry	286	57.2	100	49.02
Buffalo Nut	69	13.8	100	11.85
Cherry	2	0.4	20	0.05
Chestnut	31	6.0	100	0.50
Chinquapin	1	0.2	20	0.01
Dogwood, Flowering	2	0.4	20	0.05
Greenbrier	7	1.4	20	0.10
Gum, Black	10	2.0	60	0.17
Hickory	8	1.6	60	0.10
Laurel, Mountain	32	6.4	100	5.50
Locust, Black	1	0.2	20	0.01
Maple, Red	11	2.0	80	0.17
Oaks (red group)	13	2.6	100	0.20
Oaks (white group)	32	6.0	100	5.50
Sassafras	17	3.0	80	0.18
Willow, Prairie	1	0.2	20	0.01
TOTALS	582	100.0		100.00

that the browse species contained 50% - 60% water, it was decided to collect 105 grams of fresh browse to ensure obtaining the required amount of dried material. Only the annual growth of the twigs was collected to form the samples. The sample for each species on each soil was composed of 35 grams of current growth only, collected from each of three trees of the same species; the collection was done in this manner to minimize the effect of variations that might occur between individuals of the same species.

Twigs were cut with pruning shears, and leaves, but not buds nor fruit, were stripped from the twigs. The twigs were then cut into one-quarter to one-half inch lengths to facilitate grinding. The leaves were removed because they are not available to deer year-round, and it was desired to minimize seasonal variations; buds and fruit were not removed because they would normally constitute a part of the browse during dormant months.

All browse samples were placed in labeled bags and brought back to Blacksburg the same day they were collected. Upon arrival from the field, they were placed in a V. P. I. Agronomy Department silage dryer operating at 80° C. where they were dried for 24 hours to stop enzymatic action and mold development or action. The dried twigs were then ground in a Wiley mill which powdered and mixed the material efficiently. Powdered samples were further mixed by rolling each on paper to ensure that any one gram or more portion could be considered representative of the entire sample. The powdered sample was stored in labeled, sealed, glass jars.

Changes in Collecting Procedure Made in December, 1954: After two sampling periods (i.e., in November, 1954) using the sampling method described above, it was found that sampling error and the interaction between soil and species could not be determined statistically. Consequently, instead of grouping the 35 grams from the three trees of the same species to constitute a sample, each 35 grams were held and analyzed as a separate sample.

Since this revised method of collecting would have tripled the analytical procedures and because of the limitations of time, equipment and facilities, the project was revised so that three species of plants growing on four study areas were sampled instead of four species on seven areas. In addition to the three species (flowering dogwood, black locust, and red maple on Martinsburg shale, Brallier, Clinton, and Huntersville chert formations), rhododendron and buffalo nut on Brallier were sampled.

It was not possible to return to the same individual buffalo nut plants throughout the investigation because the plants originally used were reduced in size or removed from the original area by brush removal under a power line. Furthermore, the growth habits of this species made the use of the same plant for all collections impracticable. In addition to this deviation from the planned standard, another departure was made in February, 1955, and October and December, 1954. At those times, it was necessary to collect some of the sample of flowering dogwood on the Huntersville chert study area from trees other than those that had been marked for use because the amount of annual growth that would be produced was overestimated.

The revised project began in December, 1954. Collections and analyses were made at two-month intervals until October, 1955. This report includes only data from the September and November, 1954, collections which are applicable to the revised project.

METHODS OF ANALYSIS

Soils

Soil samples were analysed by (1) flame spectrophotometer methods of Peech et al. (1947) and Rich (1952), (2) LaMotte Soil Testing Outfit manufactured by the LaMotte Chemical Products Company, Baltimore, Maryland, and (3) rapid soil testing procedures as described by Rich (1955).

Twig Collections

Twig samples were analysed by methods approved by the Association of Official Agricultural Chemists (1950) for moisture content, ether extract (crude fat), nitrogen (protein), and ash (mineral matter). Crude fiber content was determined by the method described by Whitehouse, Zarrow, and Shay (1945). The nitrogen-free extract, representing digestible carbohydrate, was obtained by difference based on dry weight. The above analyses constitute a proximate analysis.

Minor elements determinations on one-third of the October, 1955, samples of red maple, black locust, and flowering dogwood, which were collected after leaf fall had occurred, were made by methods approved by the Association of Official Agricultural Chemists (1950).

DESCRIPTION OF STUDY AREAS

The four study areas, each about one acre in size, which were used throughout the project were located on soils which arose from the following geological formations: Brallier, Clinton, Huntersville chert, and Martinsburg shale. The last three areas are on Draper Mountain, Pulaski County, Virginia; the Brallier formation is along Craig Creek in Montgomery County, Virginia. Soil types for the areas were: Jefferson sandy loam on Martinsburg shale; Muskingum soils on Clinton, Brallier, and Huntersville chert formations.

Locations of the study areas are shown in Figures 1 and 2.

The elevations of the study areas above mean sea level were: Brallier, 2000 feet; Clinton, 2500 feet; Huntersville chert (hereafter referred to as "chert"), 2300 feet; and Martinsburg shale (hereafter referred to as "shale"), 2100 feet.

Rainfall data collected at Blacksburg, the nearest place to the study areas from which such information is available, is presented in Table 6.

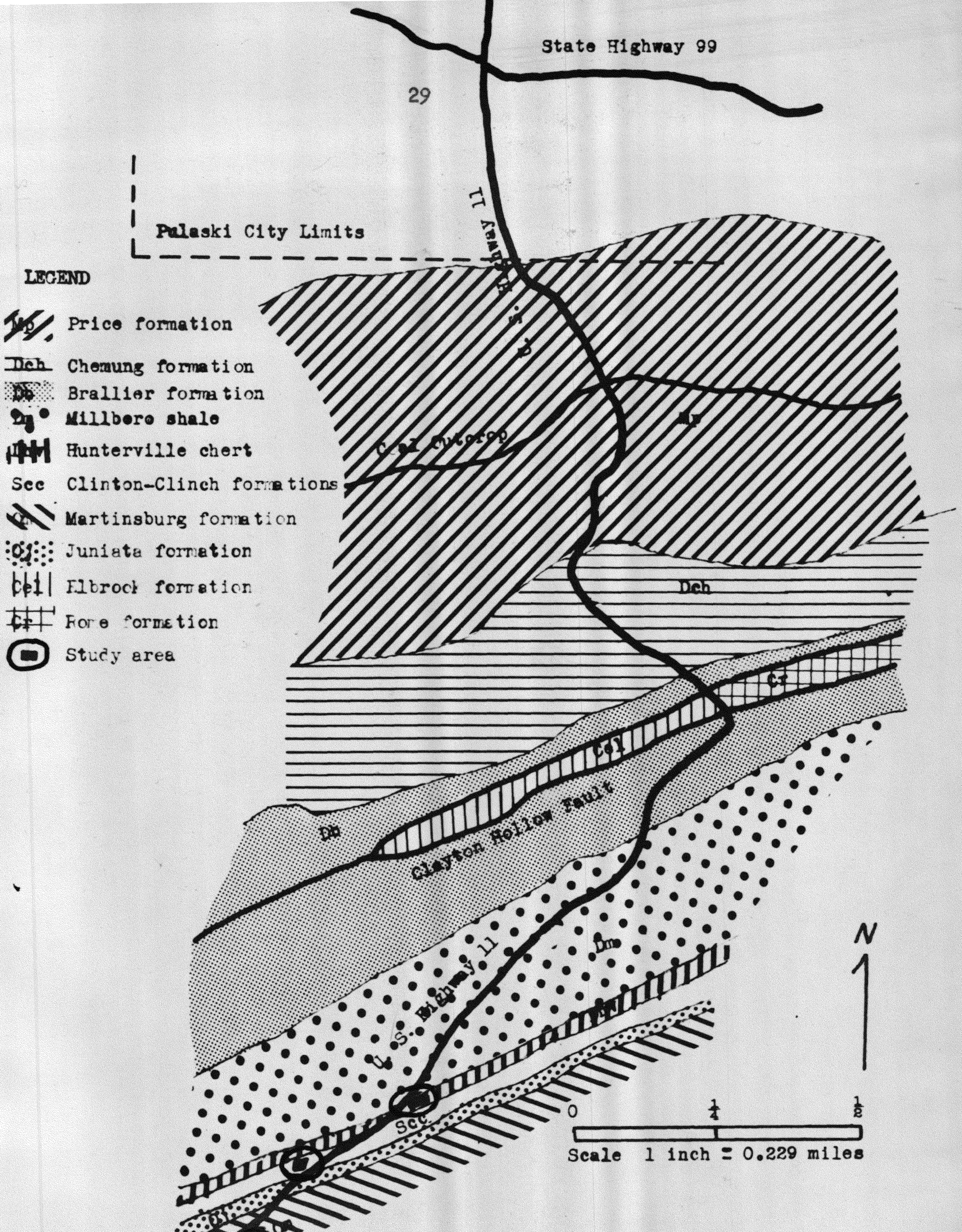

Figure 1. Geologic map of Draper Mountain showing location of study areas (after Cooper, 1939).

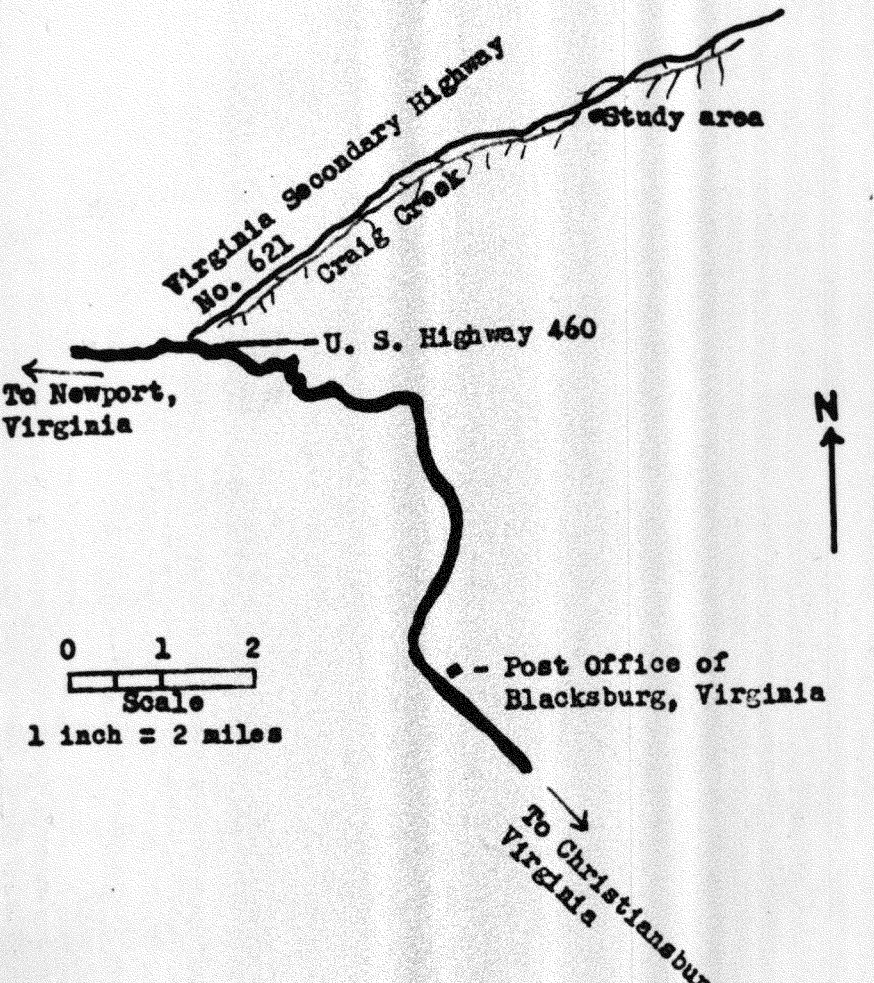

Figure 2. Location of Brallier formation study area along Craig Creek in Montgomery County, Virginia

Table 6. Total precipitation and temperature data collected at Blacksburg, Virginia

Month		Total Precipitation in Inches	Temperature in Degrees Fahr. Highest	Average	Lowest
September	1954	1.52	95	67.1	38
October	"	4.22	88	56.3	23
November	"	2.62	68	39.6	19
December	"	3.61	63	32.1	10
January	1955	1.51	61	30.7	6
February	"	4.57	63	34.6	0
March	"	8.08	73	44.2	12
April	"	2.48	82	55.2	27
May	"	1.66	87	63.3	37
June	"	3.87	87	62.5	40
July	"	2.14	91	74.7	59
August	"	3.46	92	73.4	54
September	"	0.45	88	65.6	45
October	"	1.56	81	54.8	29

Tables 1 - 4 show the counts of woody plants on the quadrats established on the four study areas which were used throughout this investigation for plant and soil collections. Table 5 gives the result of quadrat counts on an area from which buffalo nut was collected when this species was drastically reduced on the original study area by brushing under a power line; the area supporting the vegetation described and counted in Table 5 was also on Brallier formation as was the original area on which buffalo nut was found.

Neither deer nor domestic livestock were present on any of the study areas.

RESULTS

SOILS

Tables 7 - 9 show the analytical data for the soils of the study areas. These data show that the soil associated with the shale area had the highest values in pH, calcium, phosphorous, per cent base saturation, and total exchangeable cations, and it had the lowest values in organic matter. The values for pH of the other three study areas generally were lower and at approximately the same level. The Brallier study area soil was lowest in phosphorous and second highest in both total exchangeable cations and organic matter. The Clinton study area soil was second highest in values for pH, phosphorous, and per cent base saturation while being highest in organic matter and manganese. The chert study area soil was the next lowest in values for phosphorous, and lowest in values for pH, calcium, total exchangeable cations, and per cent base saturation.

SEASONAL VARIATIONS OF NUTRIENTS IN PLANTS

Figures 3 - 14 show the seasonal variations in the nutritive values in plants for the four study areas. These values are expressed on an oven-dry basis. A detailed commentary on each figure would be too complex and involved for the reader to follow conveniently, and for that reason Tables 12 - 14 summarize the information from these graphs. Table 12 gives the consistencies and trends in nutritional qualities of the selected species arranged by species. Table 13 shows

Table 7. Mean analytical results of soil analyses by flame spectrophotometer

Geological Formation	pH	Phos-phorous ppm.	Organic Matter %	Exchangeable Cations (m.e./100 gms. soil) Ca	Mg	K	Mn (ppm.)	H	Total*	Base Satura-tion ** %
Brallier	4.72	3.99	2.09	0.42	0.18	0.14	2.15	10.03	10.77	6.87
Clinton	4.87	5.83	2.49	0.42	0.18	0.10	5.76	7.50	8.20	8.54
Chert	4.48	5.37	1.69	0.07	0.10	0.08	4.19	7.36	7.61	3.29
Shale	6.91	6.75	0.79	0.50	2.84	0.12	1.00	3.08	12.54	75.44

* Summation of exchangeable cations; i.e., Ca plus Mg plus K plus H.
** (Ca plus Mg plus K) divided by H.

Table 8. Results of soil analyses using a LaMotte Soil Testing Outfit. Symbols: VVL - very, very low; VL - very low; L - low; ML - medium low

Analysis	Brallier	Clinton	Chert	Shale
pH	4.6	4.9	4.4	6.9
Nitrate (ppm.)	4	3	2	4
Phosphate (lbs./acre)	25-L	10-VL	25-L	50-ML
Potash (lbs./acre)	105	105	100	110
Calcium (ppm.)	Less than 100	Less than 100	Less than 100	750
Ammonia Nitrogen	VVL	VL	VVL	VVL
Manganese	VL	VL	VL	VL
Magnesium	VVL	VL	VL	VL
Ferric Iron	Small amount	Small amount	Small amount	Small amount
Chlorides (ppm.)	100	Less than 25	Less than 25	Less than 25
Sulfates (ppm.)	Less than 50	Less than 50	Less than 50	Less than 50
Aluminum	VL	VL	VL	VL

Table 9. Results of soils analyses using the rapid method of Rich (1955). Organic matter is given in per cent. All other figures except pH are in pounds per acre. L stands for low; M, medium

Geological Formation	pH	Calcium	Magnesium	Organic Matter	Phosphoric Acid	Potash
Brallier	4.6	280-L	48-M	2.6	25-L	111-M
Clinton	4.3	10-L	4-L	3.5	35-M	63-L
Chert	4.8	30-L	20-L	2.5	19-L	52-L
Shale	4.9	20-L	12-L	2.2	29-M	63-L

the same information arranged by the separate sections of a proximate analysis; Table 14, by geological formations.

Figures 3 - 14 were not designed as a means of obtaining the exact results of any given analysis for any species on any study area; they were designed to show the seasonal trends and variations in the various nutrient values by species and soils. The analytical results are given in detail in Appendix Tables 2 - 25.

Rhododendron and Buffalo Nut

Rhododendron and buffalo nut were found on only one of the study areas; therefore, they were not shown in Figs. 3 - 14 nor were they mentioned in Tables 12 - 14 which summarize these data. Data from their analyses are also in Appendix Table 2 - 25.

Generally, both rhododendron and buffalo nut follow the seasonal trends described in Table 13, especially with regard to moisture, protein, and ether extract. Both species are slightly more erratic in trends in ash content than the other three species; in crude fiber content, both species exhibited a decrease from September through June and an increase from June through October. In nitrogen-free extract, rhododendron showed an increase from September through August followed by a decrease between August and October whereas buffalonut showed a decrease from September through February and an increase from February through October.

Rhododendron had the highest moisture content of the five species studied; buffalo nut generally had very high moisture content. In protein rhododendron ranged from low to average (in comparison to

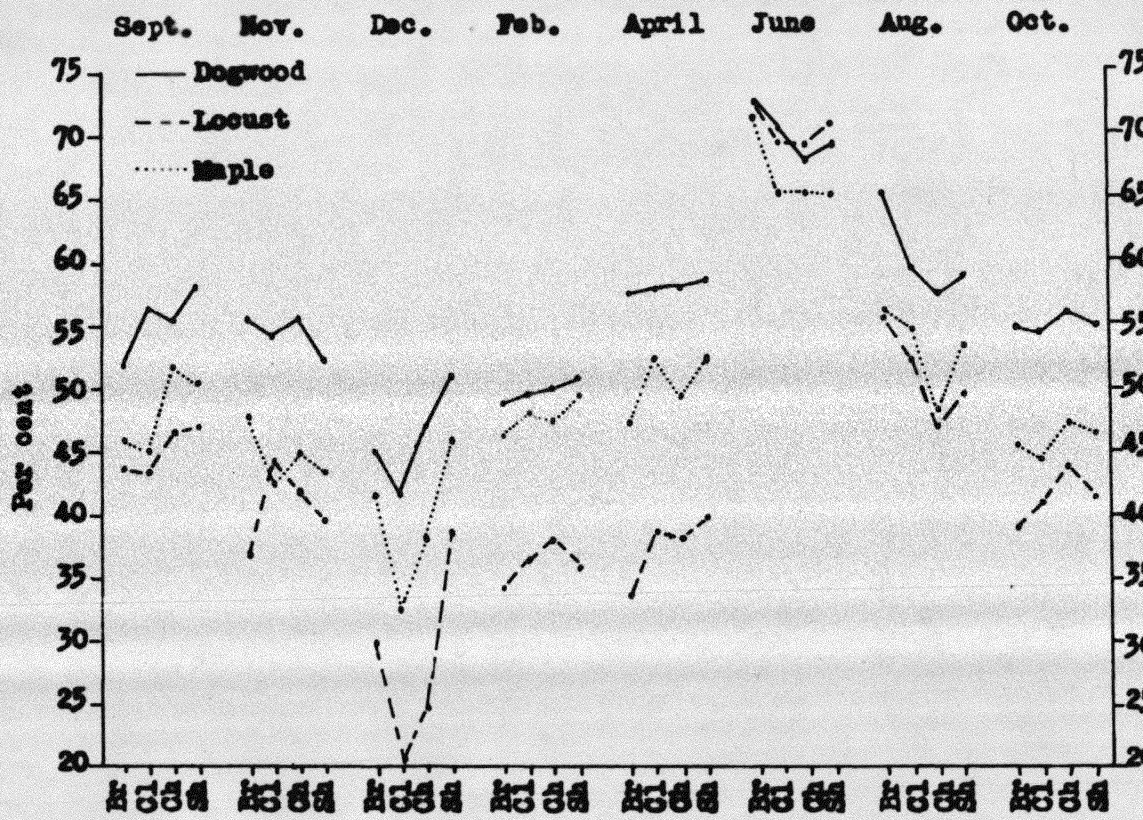

Figure 3. Seasonal variations in mean moisture content of three browse species on four geological formations. Symbols: Br - Brallier; Cl - Clinton; Ch - Chert; Sh - Shale.

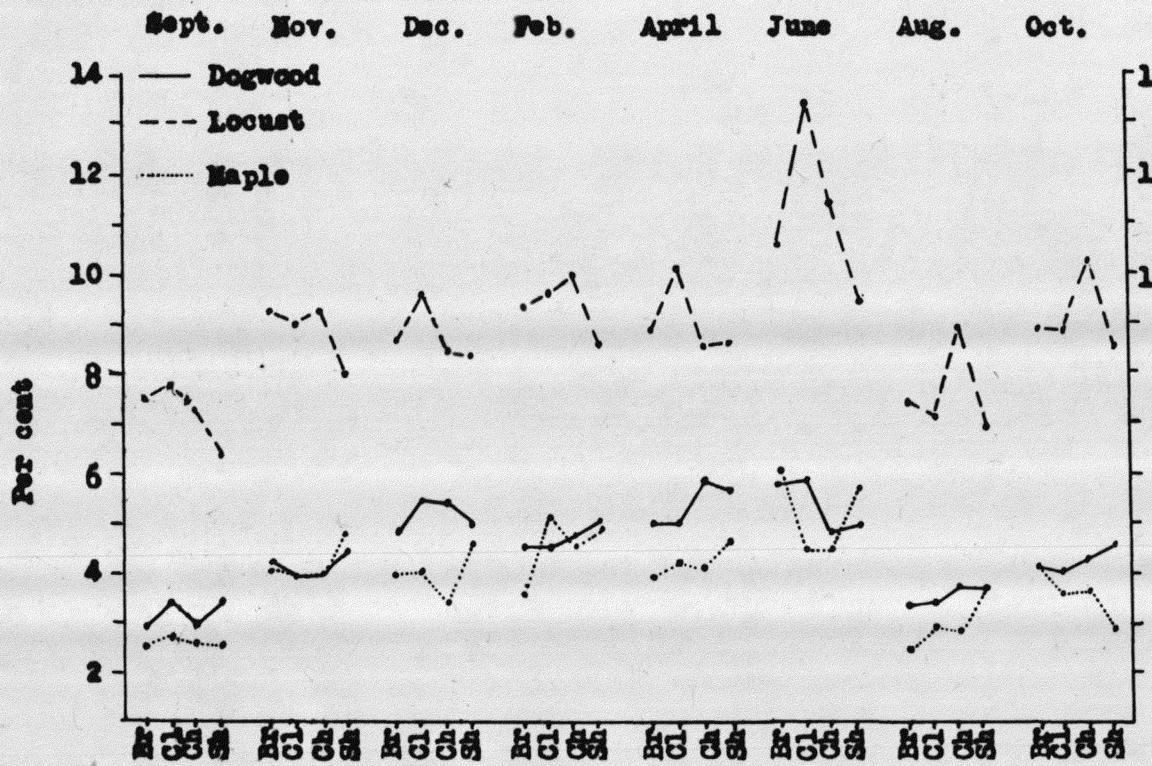

Figure 4. Seasonal variations in mean protein content of three browse species on four geological formations. Symbols: Br - Brallier; Cl - Clinton; Ch - Chert; Sh - Shale.

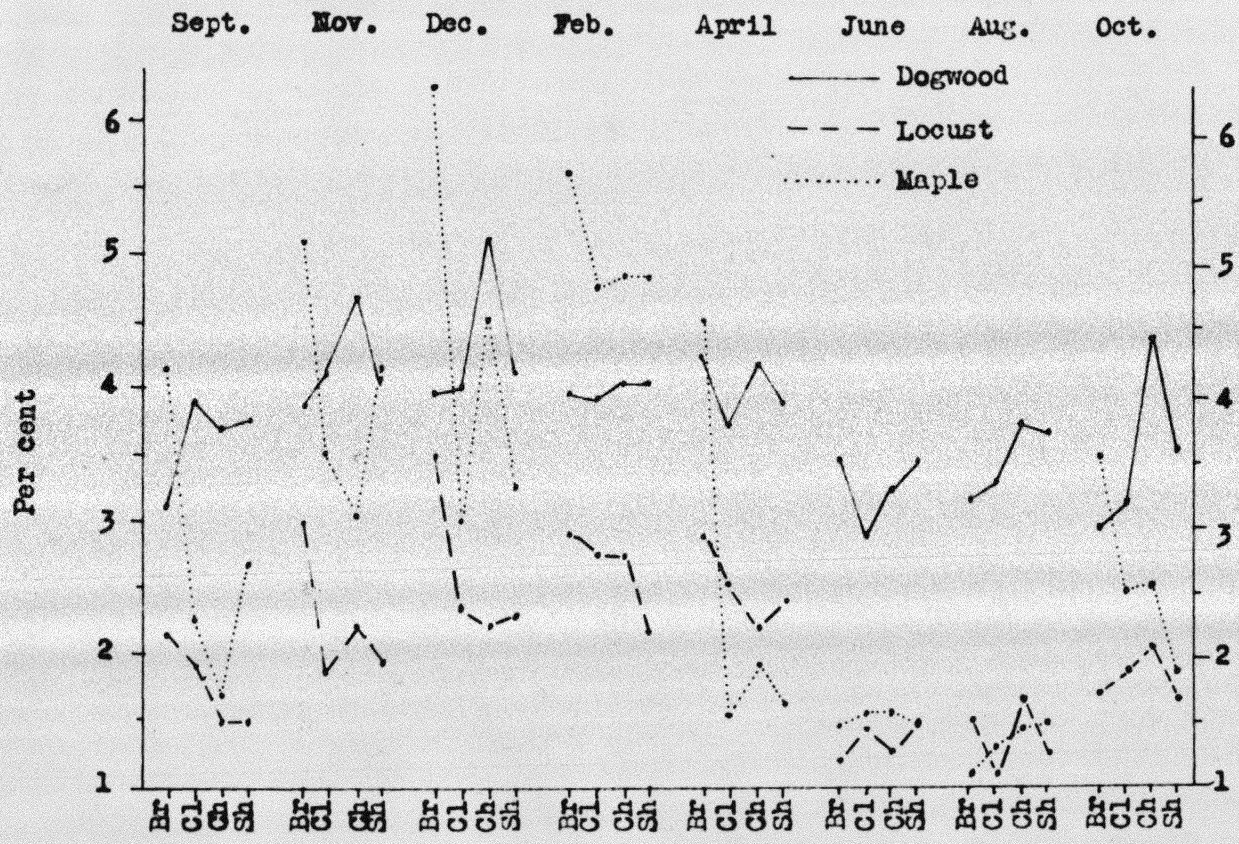

Figure 5. Seasonal variations in mean ether extract of three browse species on four geological formations. Symbols: Br - Brallier; Cl - Clinton; Ch - Chert; Sh - Shale.

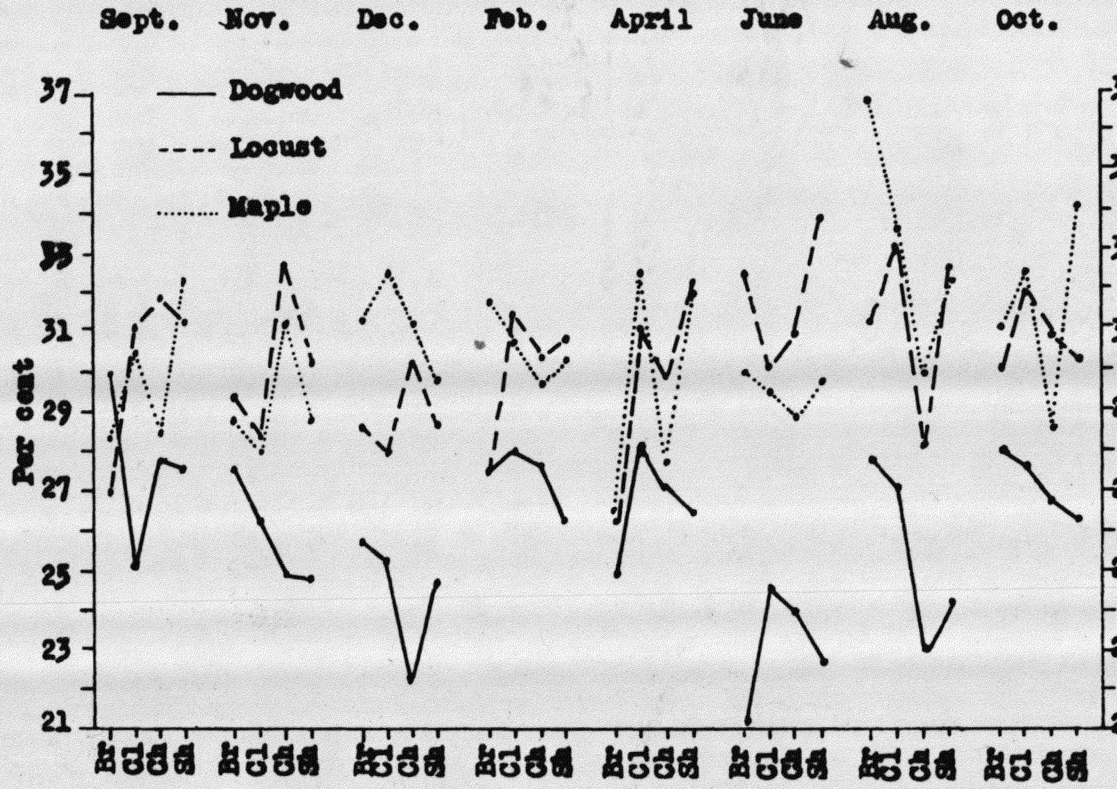

Figure 6. Seasonal variations in mean crude fiber content of three browse species on four geological formations. Symbols: Br - Brallier; Cl - Clinton; Ch - Chert; Sh - Shale.

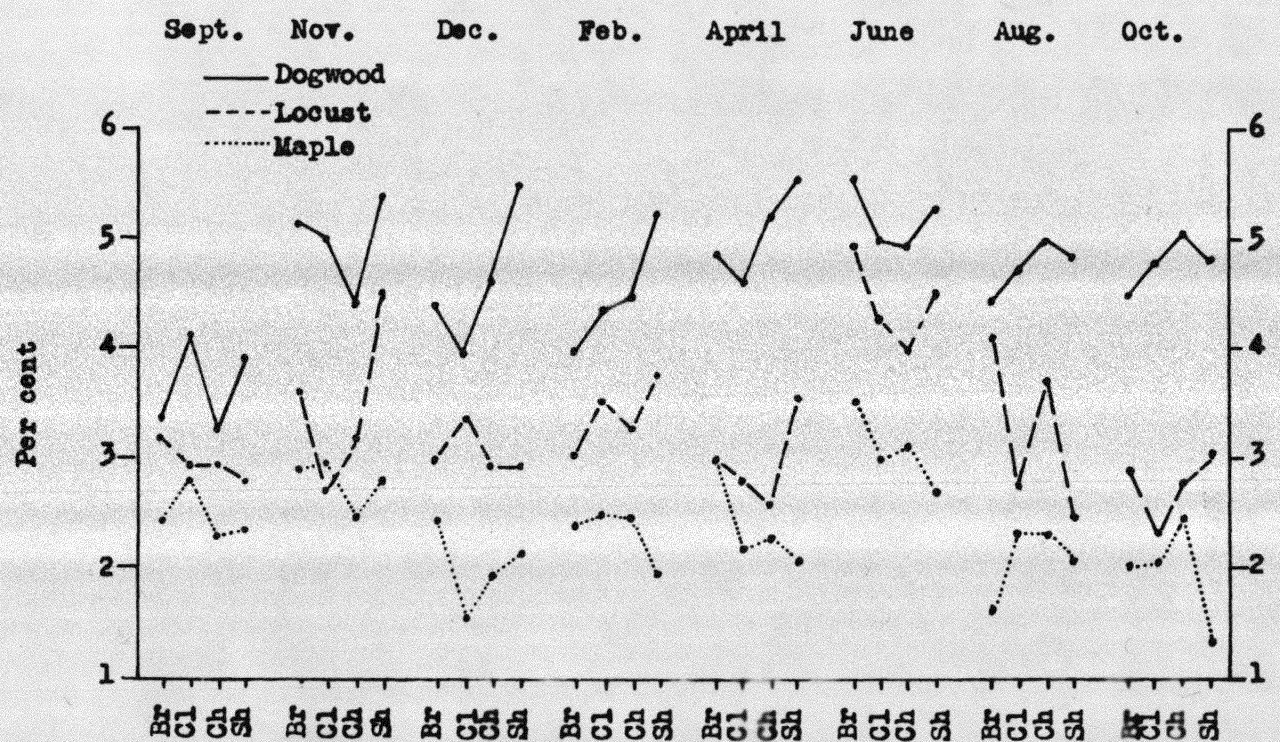

Figure 7. Seasonal variations in mean ash content of three browse species on four geological formations. Symbols: Br - Brallier; Cl - Clinton; Ch - Chert; Sh - Shale.

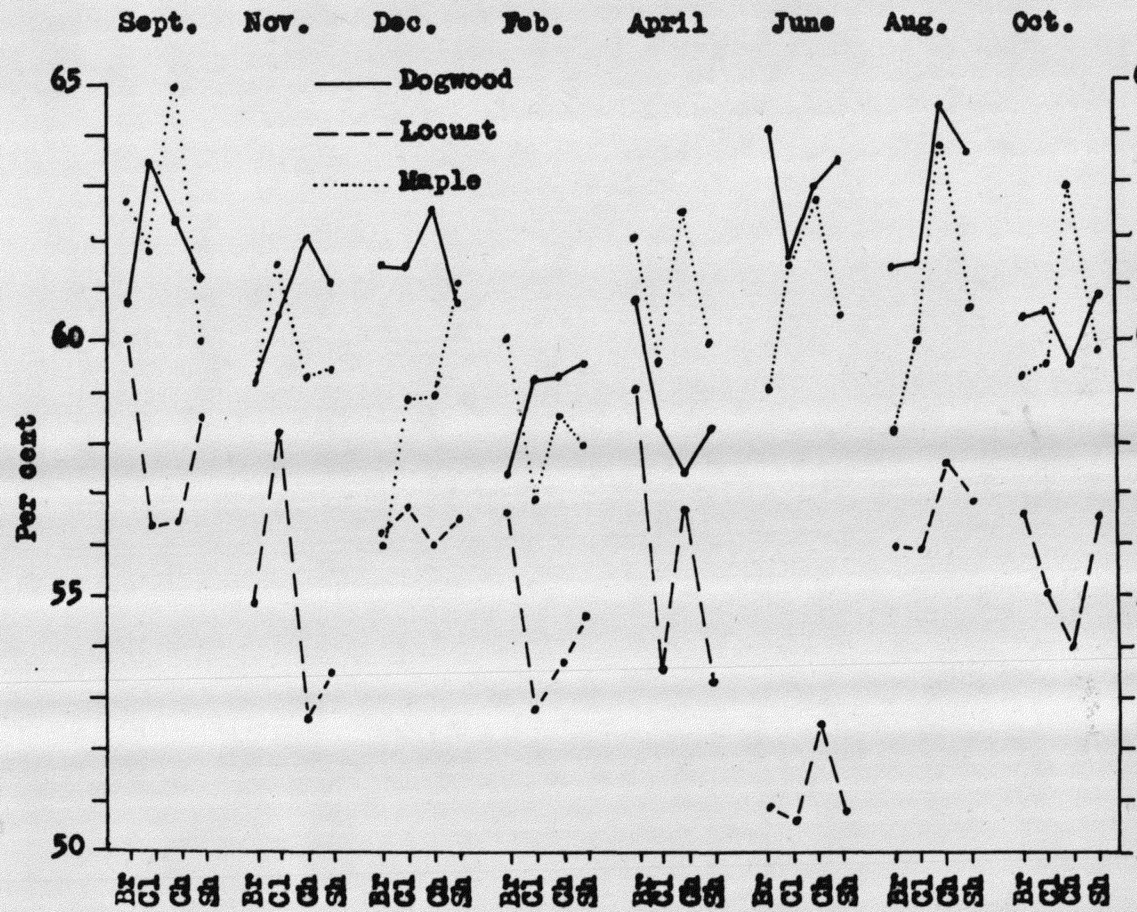

Figure 8. Seasonal variations in mean nitrogen-free extract of three browse species on four geological formations. Symbols: Br - Brallier; Cl - Clinton; Ch - Chert; Sh - Shale.

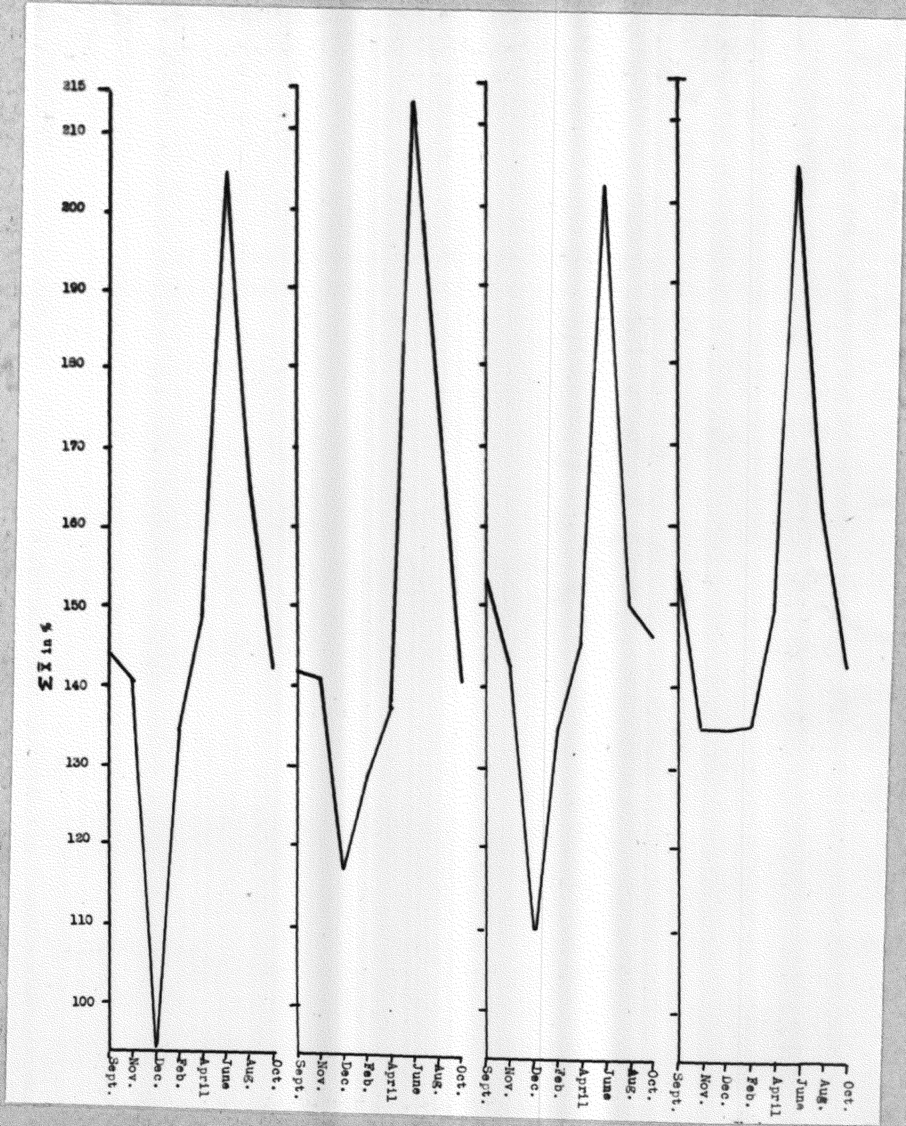

Figure 9. Seasonal variations in total moisture content of all selected browse species which grew on every study area. The geological formations, from left to right, are Clinton, Brallier, chert, and shale. The high moisture content for December on shale is attributed to ice being on the samples collected.

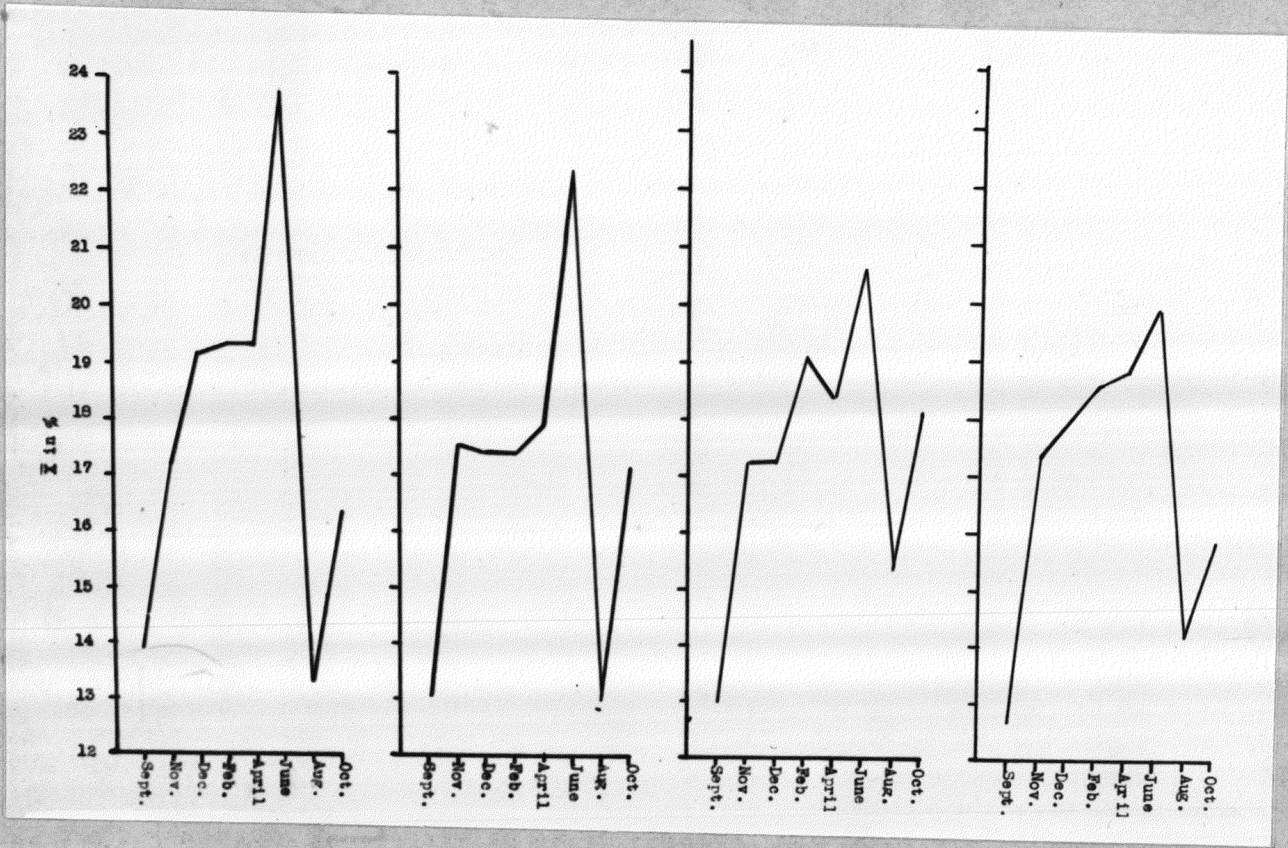

Figure 10. Seasonal variations in total protein content of all selected browse species which grew on every study area. The geological formations, from left to right, are Clinton, Brallier, chert, and shale.

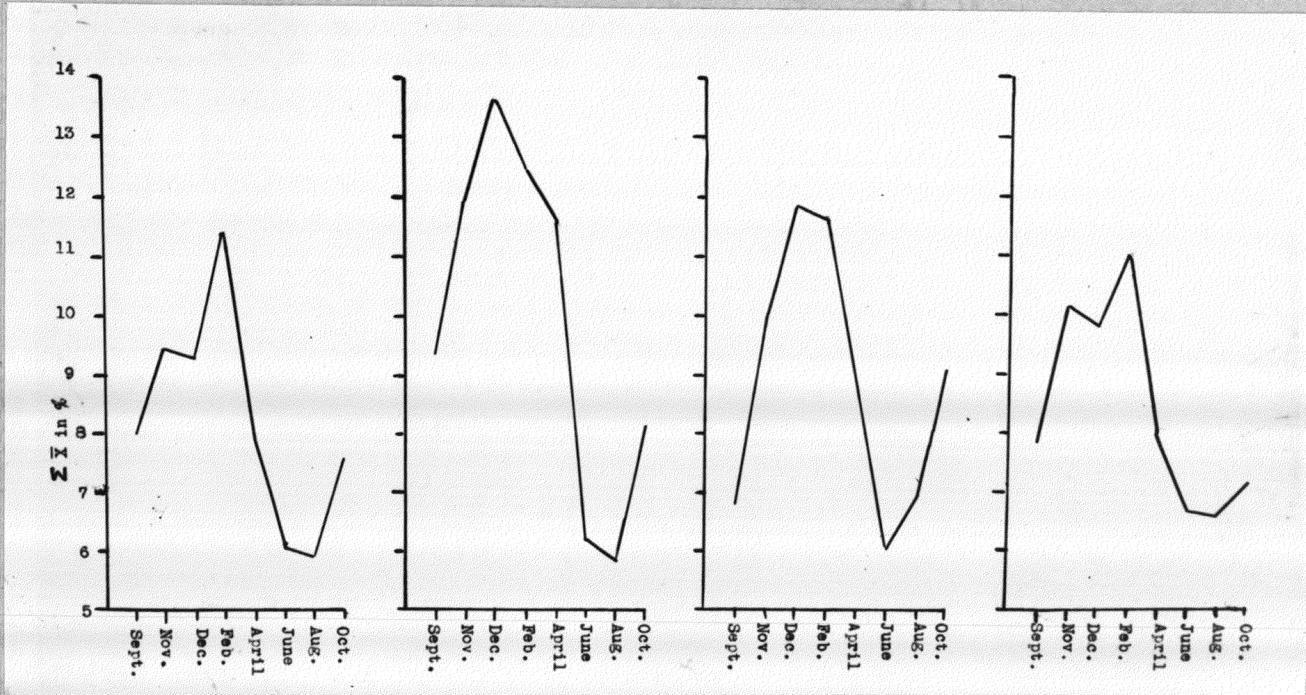

Figure 11. Seasonal variations in the total ether extract of all selected browse species which grew on every study area. The geological formations, from left to right, are Clinton, Brallier, chert, and shale.

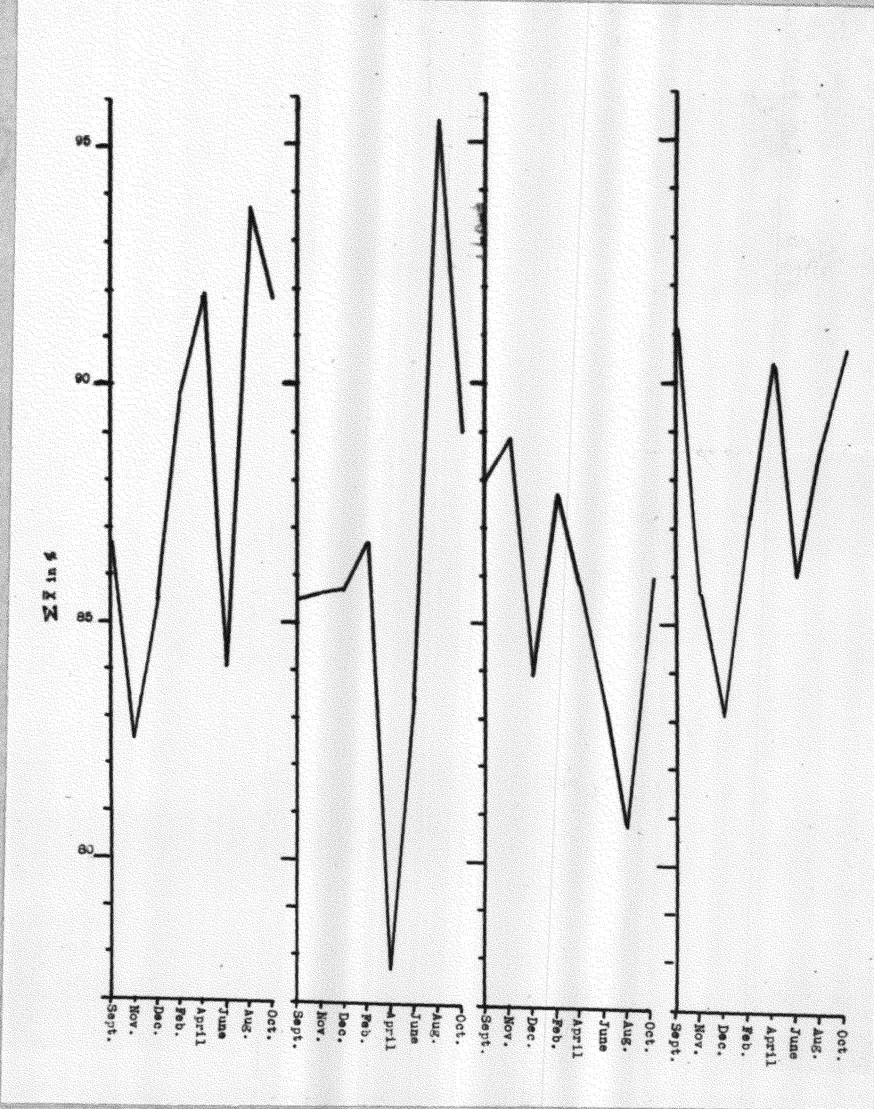

Figure 12. Seasonal variations in the total crude fiber content of all selected browse species which grew on every study area. The geological formations, from left to right, are Clinton, Brallier, chert, and shale.

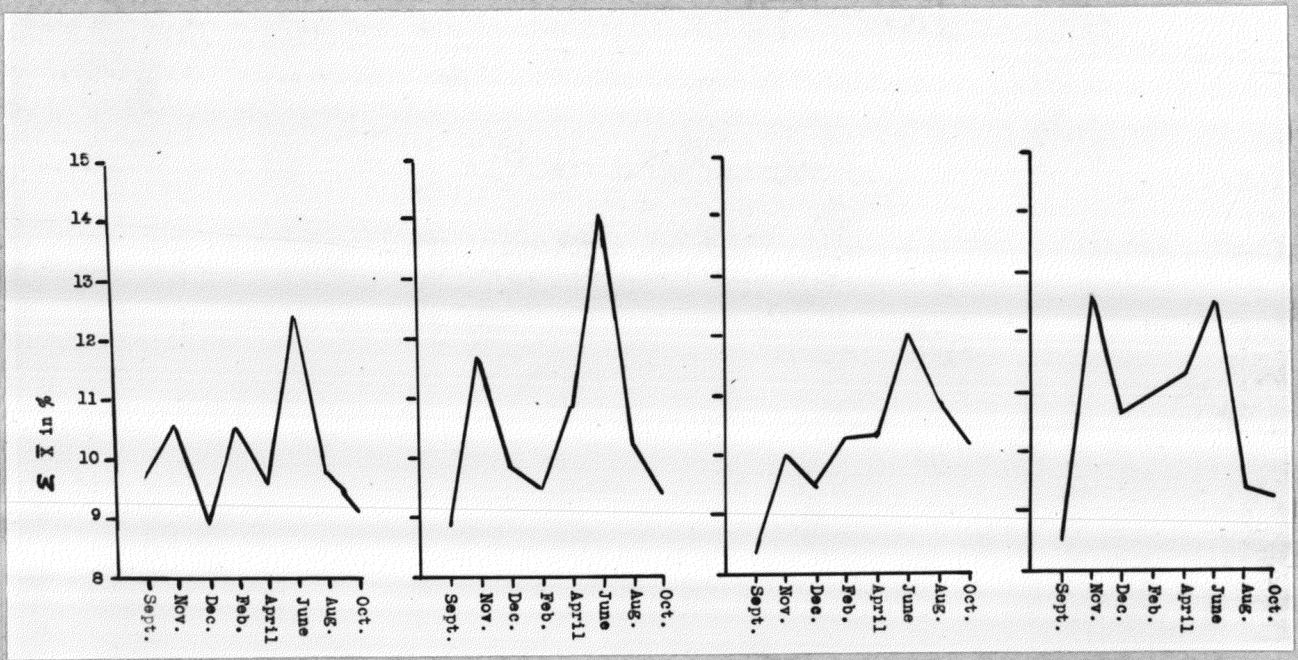

Figure 13. Seasonal variations in the total ash content of all selected browse species which grew on every study area. The soil formations, from left to right, are Clinton, Brallier, chert, and shale.

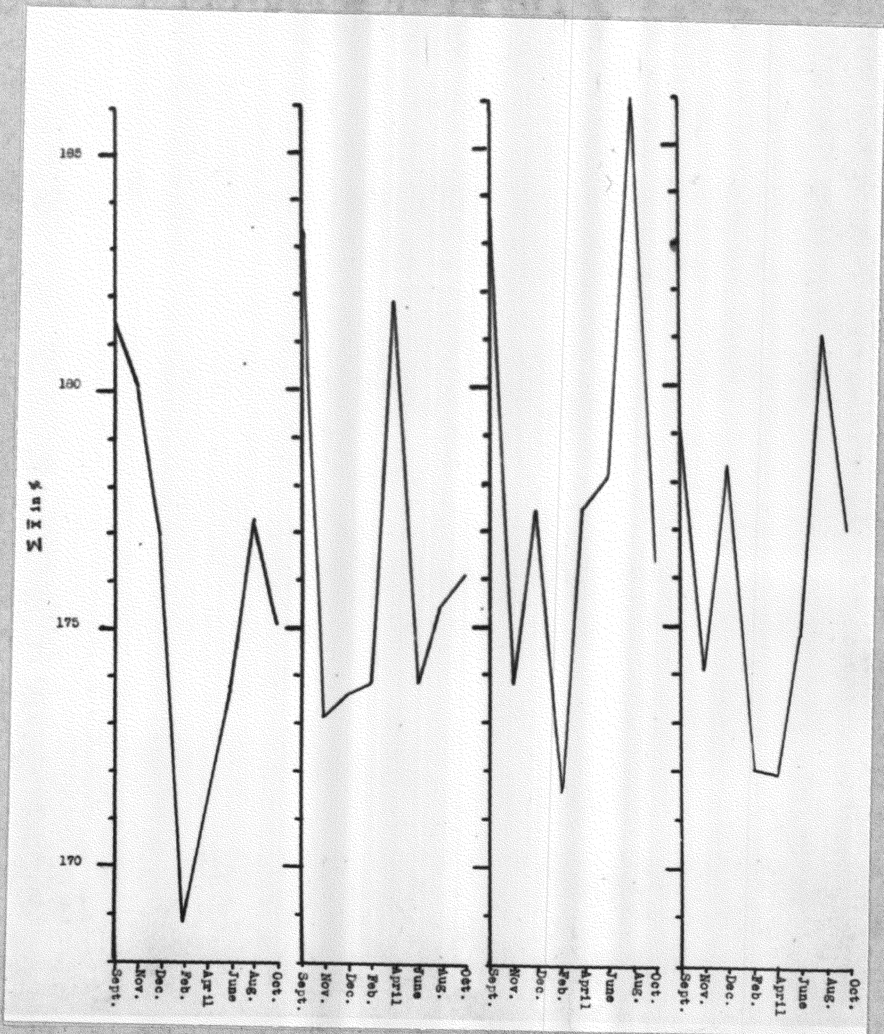

Figure 14. Seasonal variations in the nitrogen-free extract of all selected browse species which grew on every study area. The geological formations, from left to right, are Clinton, Brallier, chert, and shale.

the three species found on all soils) whereas buffalo nut was very high in protein, second only to locust.

Both rhododendron and buffalo nut were about average in ether extract content in comparison with the other species.

The ash content of rhododendron ranged from average to slightly above average whereas that of buffalo nut was generally the highest.

Crude fiber content of rhododendron ranged from average to low; for buffalo nut, about average.

The nitrogen-free extract for rhododendron was generally very high and for buffalo nut very low.

ANALYSIS OF VARIANCE

The analysis of variance using the F test was run on the samples collected from December, 1954, through October, 1955. This statistical test is designed to show the extent of variation of data around a mean where there is more than one variable and whether or not this variation is significant at a given probability level. The analysis of variance also shows whether or not there is interaction between the species and soils studied. If there is interaction, it means that the species studied do not vary in proportion to the variation for a given nutrient value on soils of different fertility. Figure 15 shows an example of an analysis of variance.

The results of the analyses of variance are given in Table 10. The most striking feature of these data is that they show that the different species have different nutritive values when growing on the

DECEMBER PROTEIN

	Brallier	Clinton	Hunters-ville Chert	Martins-burg Shale	Total
Dogwood	4.8	5.8	4.6	5.4	
Dogwood'	4.5	5.1	5.8	4.6	
Dogwood"	5.0	5.6	5.8	4.8	
T	14.3	16.5	16.2	14.8	61.8
Locust	9.0	9.8	8.8	8.3	
Locust'	9.1	10.0	7.4	8.1	
Locust"	7.9	9.0	8.1	8.7	
T	26.0	28.8	25.3	25.1	105.2
Maple	4.0	4.0	3.9	4.2	
Maple'	4.1	4.0	3.3	5.3	
Maple"	3.9	4.1	3.1	4.4	
T	12.0	12.1	10.3	13.9	48.3
Total	52.3	57.4	51.8	53.8	215.3

Source	d.f.	SS	M.S.	F
soils	3	2.14	.71	2.84
species	2	147.32	73.66	294.64 [+10 +5]
Interaction	6	4.09	.68	2.72 [+10]
Sample error	24	6.03	.25	

Interpretation

1. There is interaction between soil and species.
2. Soils have no effect on any one species.
3. The three species differ in protein content on any given soil.

$$\text{correction factor} = \frac{(\text{sum of observations})^2}{\text{no. of observations}} = \frac{(215.3)^2}{36} = 1{,}287.61$$

$$\text{Sum of squares between species} = \frac{\Sigma(\text{row totals})^2}{\text{no. of obser.}} - c$$

$$= \frac{(61.8)^2 + \dots + (48.3)^2}{12} - 1{,}287.61 = 147.32$$

$$\text{Sum of squares between soils} = \frac{\Sigma(\text{column totals})^2}{\text{no. of observations}} - c$$

$$= \frac{(52.3)^2 + \dots + (53.8)^2}{9} - 1{,}287.61 = 2.14$$

$$\text{Experimental total} = \frac{\Sigma(T)^2}{\text{no. of obs.}} - c = \frac{(14.3)^2 + \dots + (13.9)^2}{3} - 1{,}287.61 = 153.55$$

Interaction = experimental total − soils − species = 153.55 − 2.14 − 147.32 = 4.09

Sample total $= \Sigma(\text{each observation})^2 - c$ = 1447.19 − 1,287.61 = 159.58

Sample error = sample total − experimental total = 159.58 − 153.55 = 6.03

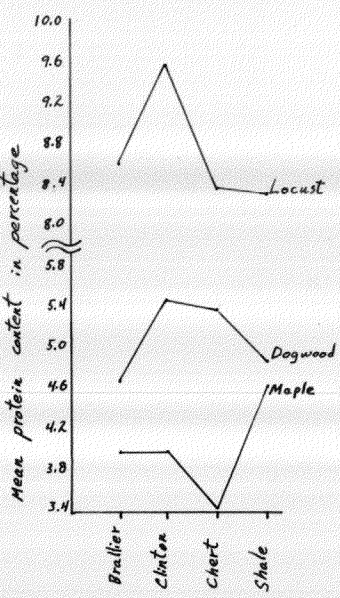

Figure 15. Example of analysis of variance test. Symbols: c - correction factor; d. f. - degrees of freedom; S. S. - sum of squares; M. S. - mean square; F = M. S./sample error.

Table 10. Summary of analyses of variance tests at the 5% probability level on samples of flowering dogwood, black locust, and red maple collected from December, 1954, through October, 1955

	Month	Moisture	Protein	Ether Extract	Crude Fiber	Ash	N-free Extract
There is interaction between species and soil.	Dec.	No	Yes*	Yes	No	Yes*	No
	Feb.	Yes*	Yes*	No	No	No	No
	April	No	Yes*	Yes*	No	Yes*	No
	June	No	Yes*	Yes	Yes*	No	Yes
	Aug.	No	No	No	Yes*	No	Yes*
	Oct.	No	Yes*	Yes*	No	Yes	Yes*
Different soils have a distinct influence on the nutritive value of the same species.	Dec.	Yes*	Yes	Yes*	No	Yes	No
	Feb.	Yes*	Yes*	No	No	No	No
	April	Yes*	No	Yes*	Yes*	Yes*	Yes*
	June	Yes*	Yes*	No	No	Yes*	No
	Aug.	Yes*	Yes*	Yes	Yes*	No	Yes*
	Oct.	Yes	Yes*	Yes	No	No	No
The different species have different nutritive values when growing on the same soil.	Dec.	Yes*	Yes*	Yes*	Yes*	Yes*	Yes*
	Feb.	"	"	"	"	"	"
	April	"	"	"	"	"	"
	June	"	"	"	"	"	"
	Aug.	"	"	"	"	"	"
	Oct.	"	"	"	"	"	"

* Also true at the 1% probability level.

same soil. They also show that during April and August the different soils have their greatest influence on the nutritive values of the plants. Moisture content is greatly affected by the soil, and protein content is only slightly less affected.

Except for the months of February and August, at least three of the six nutritive qualities of the plants were affected by the interaction between the plant and the soil.

MINOR ELEMENTS

The amount of phosphorous, calcium, cobalt, and manganese in one sample of flowering dogwood, black locust, and red maple for each study area were determined from samples collected in October, 1955, i.e., after leaf fall. The results of these determinations are presented in Table 11 and show that (1) locust had the highest phosphorous and cobalt content, (2) dogwood had the highest calcium content, and (3) maple had the highest manganese content. On three of the four study areas, the manganese content of maple exceeded the toxic level for bovines. On the chert study area, the cobalt content of dogwood and maple were deficient by bovine standards.

Table 11. Results of minor element analyses

Geological Formation	Species	Phosphorous %	Calcium %	Cobalt ppm.	Manganese ppm.
Brallier	Dogwood	.067	1.68	.13	10.0
"	Locust	.080	1.01	.15	7.5
"	Maple	.067	0.83	.21	165.0 *
Clinton	Dogwood	.098	1.81	.12	7.5
"	Locust	.092	0.70	.13	25.0
"	Maple	.086	0.76	.12	120.0
Chert	Dogwood	.077	1.30	.06 **	12.6
"	Locust	.116	0.77	.22	30.0
"	Maple	.076	0.85	.06 **	500.0 *
Shale	Dogwood	.074	1.45	.10	7.5
"	Locust	.094	1.22	.23	20.0
"	Maple	.059	0.45	.10	360.0 *

* Above 150 ppm. is considered toxic for bovines.
** Below 0.07 ppm. is considered deficient for bovines.

SUMMARY

1. The purposes of this investigation which was conducted from September, 1954, through October, 1955, were (1) to determine the differences in available nutrients in selected deer browse species growing on different soils, (2) to investigate the variations in available soil nutrients as they may relate to chemical composition of selected deer browse species, and (3) to determine the variations in available nutrients in the selected browse species during different seasons of the year.
2. The current years growth of twigs from flowering dogwood, black locust, and red maple were collected at two-month intervals on study areas whose soil had arisen from either Brallier, Clinton, chert, or shale geological formations. A proximate analysis was run on each browse collection. In addition to the above three species, rhododendron and buffalo nut were collected from the Brallier study area and analyzed. One-third of the samples of flowering dogwood, black locust, and red maple that were collected after leaf fall in October, 1955, were analyzed for calcium, phosphorous, cobalt, and manganese.
3. Soil samples were collected on each area and analyzed by a flame spectrophotometer, LaMotte Soil Testing Outfit, and a rapid method. The soil which arose from the Brallier study area was lowest in value for phosphorous and second highest in values for total exchangeable cations and organic matter. The Clinton study area

values were second highest in pH, phosphorous, and base saturation, and was highest in organic matter and manganese content. The chert area values were the next lowest for phosphorous and lowest for pH, calcium, total exchangeable cations, and base saturation. The shale study area soil gave the highest values for pH, calcium, phosphorous, base saturation, and total exchangeable cations although it was lowest in organic matter.

4. Of the three browse species collected from all the study areas, flowering dogwood was generally high in moisture content, ether extract, ash, and nitrogen-free extract while being average in protein and low in crude fiber. Black locust was high in protein and crude fiber and low in moisture, ether extract, and nitrogen-free extract. Maple was generally high in ether extract, crude fiber, and nitrogen-free extract and low in protein and ash.

5. Rhododendron and buffalo nut were collected from the Brallier study area only. In comparison with the other three species on that area, rhododendron was very high in moisture and nitrogen-free extract; average to low in protein, ether extract, and crude fiber; average to high in ash. Buffalo nut was very high in moisture, protein, and ash; average in ether extract and crude fiber; and low in nitrogen-free extract.

6. Several seasonal trends in nutrient values for the three species collected on all areas can be seen. Protein content rose generally during the dormant months. Moisture content decreased from June through December and was followed by a rise that lasted

Table 12. Consistencies and trends in nutritional qualities of flowering dogwood, black locust, and red maple arranged by species (from Figs. 3 - 8)

	DOGWOOD
Moisture:	Highest of the three species; generally highest on shale during dormant months. No one soil is consistently low.
Protein:	Second highest of the three species; generally highest on shale; low generally on chert or Clinton.
Ether Extract:	Usually high; highest on chert; usually lowest on Brallier.
Crude Fiber:	Lowest of the three species; highest on Brallier from August through October; low generally on chert and shale.
Ash:	Highest of the three species; generally high on shale and chert; generally low on Brallier.
N-free Extract:	Generally high; no one soil is consistently high or low in nitrogren-free extract for dogwood.
	LOCUST
Moisture:	Lowest of the three species; generally low on Brallier. No one soil gives consistently high or low values for locust.
Protein:	Highest of the three species; generally high on Clinton; low on shale.
Ether Extract:	Lowest of the three species; generally high on Brallier; low on shale.
Crude Fiber:	Generally high; no other trend noticeable.
Ash:	Second highest of the three species; no other trend noticeable.
N-free Extract:	Lowest of the three species; no other trend noticeable.
	MAPLE
Moisture:	Middle of the three species; lowest moisture on Clinton except for February, April, and August. No other trend noticeable.
Protein:	Lowest of the three species; usually high on shale and low on Brallier.
Ether Extract:	Usually high; highest on Brallier except for June and August. No other trend noticeable.
Crude Fiber:	Generally high; generally low on chert. No high trend noticeable.
Ash:	Lowest of the three species. No other trend noticeable.
N-free Extract:	Generally high; highest on chert; generally low on Brallier.

Table 13. Seasonal consistencies and trends in nutritional qualities of flowering dogwood, black locust, and red maple arranged by components of proximate analysis (from Figs. 3 - 14)

MOISTURE:	Highest in flowering dogwood; lowest in red maple. Decreasing from June through December; rising from December through June.
PROTEIN:	Highest in black locust; lowest in red maple. Rising from fall through early summer; drops between June and August.
ETHER EXTRACT:	Generally highest in flowering dogwood; lowest in black locust. Rises from September through April; decreases from April through August.
CRUDE FIBER:	Generally high in black locust and red maple; lowest in flowering dogwood. Fairly stable in maple and locust; very erratic in dogwood.
ASH:	Highest in flowering dogwood; lowest in red maple. Erratic from September through April; decreases from April through October.
N-FREE EXTRACT:	Highest in flowering dogwood; lowest in black locust. Decreases generally from September through February; erratic from February through October.

Table 14. Trends and consistencies in nutritional qualities of flowering dogwood, black locust, and red maple arranged by geological formations (from Figs. 3 - 14)

	BRALLIER
Moisture:	Low for black locust. Rising from December through June; decreasing from June through December.
Protein:	Low for red maple. Rising from August through November and from April through June; fairly stable from November through April; decreasing between June and August.
Ether Extract:	High for black locust and red maple; low for flowering dogwood. Rising from August through December; decreasing from December through August. Higher than other soils during dormant months.
Crude Fiber:	High for flowering dogwood during autumn; lowest of the four formations for summation of means for April and June.
Ash:	Low for flowering dogwood. Highest of the four formations for summation of means for April and June.
N-free Extract:	No trends noticeable; erratic.
	CLINTON
Moisture:	Low moisture for red maple except for February, April, and August. Increasing from December through June; decreasing from June through December.
Protein:	Generally high for flowering dogwood and black locust. Rising from August through June; decreases between June and August. Highest of the four formations for summation of means from September through June.
Ether Extract:	Increasing from August through February; decreasing from February through August.
C. Fiber:	Erratic; generally high. No other trends noticeable.
Ash:	Erratic. No trends noticeable.
N-free Extract:	Decreasing from August through February. Increasing from February to August.
	CHERT
Moisture:	Decreasing from June to Dec.; increasing from Dec. to June.
Protein:	Generally low for flowering dogwood. Decreasing from Aug. through December; increasing from December through August.
Ether Extract:	Highest for flowering dogwood. Increasing from June through November; decreasing from November through June.
C. Fiber:	Low for dogwood and maple. Seasonal trend erratic.
Ash:	Generally high for flowering dogwood. Generally low for summation of means from September through June.
N-free Extract:	Highest for red maple. Seasonal trend erratic.

(Continued)

Table 14. Trends and consistencies in nutritional qualities of flowering dogwood, black locust, and red maple arranged by geological formations (from Figs. 3 - 14) (continued)

	SHALE
Moisture:	Generally highest for flowering dogwood. Decreasing from June through December; increasing from December through June.
Protein:	High for flowering dogwood and red maple; low for black locust. Increasing from August through June; decreases between June and August.
Ether Extract:	Low for black locust. Increases sporadically from August through February; decreases from February through August.
C. Fiber:	Low for flowering dogwood. Seasonal trend erratic.
Ash:	High for flowering dogwood. Increases from September through November and from December through June; decreased from November through December and from June through October.
N-free Extract:	Neither generally high nor low for any species. Seasonal trend erratic.

until June. There was a rise in ether extract from September through April whereas the level of ash content was erratic during this period. Crude fiber was fairly stable in red maple and black locust although erratic in flowering dogwood. There was a decrease in the nitrogen-free extract during the winter.

7. Trends and consistencies in the nutritive values of the three species collected on all study areas, based on the study area on which they occur, are presented in Table 14. Such trends are generally in the order of being high or low for one or two individual species rather than for all the species, or else they are considerably erratic.

8. The analyses of variance show that the different species have different nutritive values when growing on the same soil. During April and August, the different soils have their greatest effect on the nutritive values of plants; moisture content is greatly affected by the soil, and protein content is only slightly less affected. Except for the months of February and August, at least three of the six nutritive qualities of the plants were affected by the interaction between the plant and the soil.

9. The analyses for minor elements reveal that black locust had the highest phosphorous and cobalt content; flowering dogwood had the highest calcium content; red maple had the highest manganese content. On three of the four study areas, the manganese content of red maple exceeded the toxic level for bovines. On the chert area, dogwood and red maple were deficient, by bovine standards, in cobalt.

DISCUSSION

Four reasons make it infeasible to rate one soil over another for providing browse of higher nutritional quality. First, in the detection of seasonal trends in nutrient values for individual species, considerable difficulty was encountered because of the sporadic rises and falls in values for one species over or below those of another. Secondly, the variations between collections for the species seldom agree with one another in either degree or direction of fluctuation. Thirdly, the interaction between soil and species affected at least half of the six nutritive qualities investigated. Lastly, there is a dearth of information regarding the coefficients of digestion and total digestible nutrients in the plants studied; this reason also explains why it is impracticable to rate one of the browse species studied over another.

Even with the seasonal interaction between plants and soils affecting at least half of the six nutritive qualities investigated, it is possible to state in some instances which species does best on a given soil for a given nutritive quality; e.g., flowering dogwood had its highest ether extract values on chert, or protein in locust was generally high on Clinton.

This writer does not consider it proper or logical to state that because a certain species was consistently high in one particular nutrient value, such as protein, that species provides the best browse. Under such a scheme, using high protein content as a basis for rating plants, in this investigation black locust and buffalo nut would be rated as the first and second best browse species, respectively. But black locust also had the undesirable qualities of being lowest of the species analyzed in crude fat (ether extract) and digestible carbohydrate (nitrogen-free extract) and was high in crude fiber. Likewise, buffalo nut had the undesirable quality of being low in digestible carbohydrate and was of average crude fiber content. Consequently, this investigator feels that it is better to wait until all the nutrient qualities can be used to rate deer browse in a manner similar to the digestibility ratios of feeds of domestic stock.

It is interesting to compare the seasonal trends mentioned in this work with those of Hellmers (1940) and Swank (1956). Hellmers (l.c.) ran proximate analyses at monthly intervals from November, 1937, to April, 1938 on several natural winter deer foods in Pennsylvania. Swank (l.c.) made determinations for moisture and protein, among other things, from clippings of several western species collected in April and July, 1954, and January and March, 1955. Data herein show that protein rose generally during the dormant months; Hellmers' (l.c.) group of plants declined in protein content during the dormant period, and Swank's (l.c.) samples showed a decrease in protein content between April and July but were fairly stable in this respect from July to March.

With regard to moisture content, data herein show a decrease from June through December followed by a rise that lasted until June; Hellmers (1940) found irregular fluctuations; Swank (1956) found the moisture content was highest in April from which time it declined to January.

It is difficult to make accurate comparisons on the ether extracts because of the volatile oils, resins, gums, and pigments (especially anthocyanins in red maple) found in the different species. However, as stated in Table 13, there was a rise in ether extract from September through April whereas in Hellmers' work (l.c.), the crude fat content was erratic.

Ash content in this investigation was erratic from September through April; in Hellmers' report (l.c.), fairly stable.

The crude fiber content, which has been shown to vary indirectly with the digestibility and nutritional value of feeds (Maynard, 1951; 255) rose during the winter for Hellmers (l.c.) but was fairly stable in red maple and black locust while erratic in flowering dogwood in this investigation.

In the nitrogen-free extract, which represents the digestible carbohydrates, this work agrees with that of Hellmers (l.c.); in both there was a decrease in the winter.

The writer has no explanation to offer for the differences found in comparing the three works. The possible importance of protein in winter foods of deer as shown by Einarsen (1946) would make it worth while to determine why protein levels rose during the winter in this work but declined in the works of Hellmers (1940) and Swank (1956).

Figure 10 shows a trend that may deserve further consideration. The soils are arranged from left to right in order of base saturation with low base saturation shown on the left. Generally, as the base saturation increases, protein content decreases; however, the decrease in protein is not proportional to the increase in base saturation. Whether or not this trend may be of significance in determining overall browse quality of a species, rather than protein content only, has yet to be determined.

On three of the four study areas, the manganese content of maple greatly exceeded the toxic level for bovines. Until it is known that these high levels are caused by maple having an affinity for attracting manganese or the ability to store this element, or both, and until the manganese requirements and toxic level are known for deer, no conclusion can be reached concerning this finding.

The deficiency, by bovine standards, in cobalt content of flowering dogwood and red maple on the chert area is very slight; the deficiency level of this mineral for deer would have to be determined before any significance could be attributed to this finding.

It is generally accepted that nutritional differences exist between browse consisting of young plants and browse obtained from low-hanging limbs of older plants of the same species. Both types of browse were used in this investigation, and any differences between such samples could be attributed just as readily to intraspecific differences as to age differences.

In order to minimize intraspecific differences in the nutritive values of the plants at different times of the year, the same individual plants, insofar as possible, were used throughout this study. However, when it was necessary to collect from additional plants, on one area, there was no greater variation, seasonal or intraspecific, among these new specimens than among those clipped throughout the investigation. Whether or not physiological changes within the plant which may be stimulated by clipping are of greater significance than natural intraspecific differences is not known.

CONCLUSIONS AND RECOMMENDATIONS

Present knowledge is insufficient to allow the use of proximate analyses as a basis for rating different plant species with regard to which provides the most nutritious browse for deer. Further investigations into (1) the quantitative and qualitative nutritional needs of deer, (2) the coefficients of digestion of deer browse, time-consuming and laborious as that would be, and (3) the possibility of using analyses and calculation as a basis for rating feeds without experimental feedings are needed; such works could very well minimize if not eliminate difficulties concerned in rating browse species in nutritional quality.

The geological formations used in this investigation for study areas gave origin to soils very similar to one another. In some instances, it was possible to state which species did best on a given soil for a given nutritive quality, but it was not possible to detect clear trends and consistencies in the nutritive values of the species collected on the study areas. If there were a chemical or analytical method for rating browse, as discussed in the above paragraph, it might be possible to rate soils also, even if they were as similar as those used in this study.

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APPENDIX

NOTE: Data records of chemical analyses of browse collections are expressed in percentages on an oven-dry basis.

Appendix Table 1. Catalog of plant species mentioned in tables of this report; nomenclature is from Fernald (1950)

Common Name	Scientific Name
Arrow-wood	*Viburnum* spp.
Ash	*Fraxinus americana*
Azalea	*Rhododendron nudiflorum*; *R. calendulareum*
Birch	*Betula* spp.
Blueberry	*Vaccinium* spp.
Buffalo Nut	*Pyrularia pubera*
Cherry, Wild	*Prunus serotina*
Chestnut	*Castanea dentata*
Chinquapin	*Castanea pumila*
Cucumber Tree	*Magnolia acuminata*
Dogwood, Flowering	*Cornus florida*
Fetter-bush	*Leucothoe racemosa*
Greenbrier	*Smilax* spp.
Gum, Black	*Nyssa sylvatica*
Hazelnut	*Corylus americana*
Hickory	*Carya* spp.
Laurel, Mountain	*Kalmia latifolia*
Locust, Black	*Robinia pseudoacacia*
Maple, Red	*Acer rubrum*
Oaks (red group)	*Quercus* spp. (Subgen. Erythrobalanus)
Oaks (white group)	*Quercus* spp. (Subgen. Lepidobalanus)
Pine, Virginia	*Pinus virginiana*
Pine, White	*Pinus strobus*
Rhododendron	*Rhododendron maximum*
Sassafras	*Sassafras albidum*
Shadbush	*Amelanchier* spp.
Sourwood	*Oxydendron arboreum*
Viburnum, Maple-leaved	*Viburnum acerifolium*
Virginia Creeper	*Parthenocissus quinquefolia*
Willow, Prairie	*Salix humilis*
Witch-hazel	*Hamamelis virginiana*

Appendix Table 2. Moisture content data records for flowering dogwood

Month	Sample No.	Brallier	Clinton	Chert	Shale
Sept.	1	52.4	56.7	55.8	58.1
Nov.	1	55.9	54.4	55.8	52.1
Dec.	1	42.1	43.2	40.7	53.5 *
	2	47.2	41.9	48.1	50.8 *
	3	46.3	38.6	53.3	48.8 *
	Mean	45.20	41.23	47.37	51.03 *
Feb.	1	48.7	50.0	50.0	50.7
	2	47.1	50.0	50.8	50.0
	3	50.0	50.0	50.0	50.7
	Mean	48.60	50.00	50.27	50.47
April	1	56.6	56.3	57.0	57.8
	2	58.9	57.5	58.1	59.0
	3	57.0	60.0	58.9	58.8
	Mean	57.50	57.93	58.00	58.53
June	1	71.6	70.3	68.3	69.4
	2	71.3	69.5	67.6	68.1
	3	69.8	71.4	68.6	69.0
	Mean	70.90	70.40	68.17	68.83
Aug.	1	64.3	60.0	58.6	61.1
	2	67.1	58.9	55.2	60.3
	3	63.2	59.7	56.9	57.9
	Mean	64.84	59.54	56.97	59.76
Oct.	1	53.1	52.9	55.7	56.1
	2	56.0	54.9	55.4	53.1
	3	54.1	54.1	56.0	54.8
	Mean	54.40	53.97	55.70	54.67

* Much higher moisture content on shale in December was due, in part, to ice on browse samples.

Appendix Table 3. Moisture content data records for black locust

Month	Sample No.	Brallier	Clinton	Chert	Shale
Sept.	1	43.8	43.1	46.8	47.1
Nov.	1	37.0	44.4	42.1	39.7
Dec.	1	30.6	19.4	23.1	44.7 *
	2	33.3	23.5	25.7	41.8 *
	3	27.9	19.4	25.0	28.3 *
	Mean	30.60	20.77	24.60	38.26 *
Feb.	1	33.0	36.8	37.2	34.3
	2	33.8	36.8	37.8	35.6
	3	35.2	36.1	38.7	36.4
	Mean	34.00	36.57	37.90	35.43
April	1	34.0	37.0	40.0	38.5
	2	31.1	40.0	37.5	38.8
	3	36.2	38.5	36.9	40.8
	Mean	33.77	38.50	38.13	39.37
June	1	74.7	68.3	67.6	69.5
	2	71.4	68.9	70.8	73.5
	3	66.7	71.1	68.5	68.1
	Mean	70.93	69.43	68.97	70.37
Aug.	1	62.7	56.4	45.0	45.8
	2	57.3	52.2	47.5	47.8
	3	50.00	47.2	45.8	54.3
	Mean	56.65	51.96	46.07	49.29
Oct.	1	39.7	39.5	42.9	42.3
	2	39.6	43.8	43.8	41.8
	3	40.3	45.2	44.6	40.0
	Mean	39.87	42.83	43.77	41.37

* Much higher moisture content on shale in December was due, in part, to ice on browse samples.

Appendix Table 4. Moisture content data records for red maple

Month	Sample No.	Brallier	Clinton	Chert	Shale
Sept.	1	46.0	45.1	51.9	50.5
Nov.	1	48.2	42.3	45.5	43.2
Dec.	1	40.7		36.1	47.1 *
	2	43.2	39.3	36.1	45.5 *
	3	40.8	25.8	42.9	45.5 *
	Mean	41.57	32.55	38.37	46.03 *
Feb.	1	46.6	47.8	47.1	47.1
	2	45.9	48.1	47.1	51.4
	3	45.8	48.9	46.3	50.0
	Mean	46.10	48.27	46.83	49.50
April	1	45.9	54.3	48.7	55.0
	2	47.2	52.4	50.0	53.7
	3	48.6	51.1	50.0	47.2
	Mean	47.23	52.60	49.57	51.97
June	1	72.8	66.3	64.5	66.7
	2	69.5	65.1	68.1	63.8
	3	72.8	64.3	62.5	65.5
	Mean	71.70	65.23	65.03	65.33
Aug.	1	58.9	54.4	48.2	49.3
	2	56.4	53.68	47.17	53.9
	3	55.8	54.6	47.5	55.3
	Mean	57.05	54.24	47.62	52.80
Oct.	1	45.5	43.6	46.5	47.2
	2	47.6	46.3	47.1	46.3
	3	46.6	45.9	47.2	45.6
	Mean	46.57	45.27	46.93	46.37

* Much higher moisture content on shale in December was due, in part, to ice on browse samples.

Appendix Table 5. Moisture content data records for rhododendron and buffalo nut

Month	Sample No.	Rhododendron	Buffalo Nut
Sept.	1	58.7	59.1
Nov.	1	57.3	59.0
Dec.	1	40.1	44.4
	2	46.2	50.0
	3	40.0	
	Mean	42.1	47.2
Feb.	1	54.8	54.5
	2	56.5	55.6
	3	54.5	54.4
	Mean	55.27	54.83
April	1	53.5	62.5
	2	53.1	62.5
	3	54.5	63.6
	Mean	53.70	62.87
June	1	77.2	77.7
	2	84.9	76.3
	3	83.7	75.6
	Mean	81.93	76.53
Aug.	1	66.3	64.8
	2	67.0	66.2
	3	66.7	68.2
	Mean	66.67	66.41
Oct.	1	61.1	55.7
	2	59.6	57.1
	3	59.3	54.6
	Mean	60.00	55.80

Appendix Table 6. Protein data records for flowering dogwood

Month	Sample No.	Brallier	Clinton	Chert	Shale
Sept.	1	2.9	3.4	3.0	3.5
Nov.	1	4.2	4.1	4.0	4.6
Dec.	1	4.8	5.8	4.6	5.4
	2	4.5	5.1	5.8	4.6
	3	5.0	5.6	5.8	4.8
	Mean	4.77	5.50	5.40	4.93
Feb.	1	4.5	4.3	4.8	4.9
	2	4.9	5.3	4.8	5.3
	3	4.5	4.2	4.5	4.9
	Mean	4.63	4.60	4.70	5.03
April	1	5.3	4.3	5.5	5.8
	2	4.7	5.1	6.0	5.4
	3	5.3	5.9	6.0	5.7
	Mean	5.10	5.10	5.83	5.63
June	1	5.6	5.6	4.8	5.1
	2	5.5	6.0	4.9	4.8
	3	6.1	6.0	4.6	5.0
	Mean	5.73	5.87	4.77	4.97
Aug.	1	3.0	3.4	3.3	3.6
	2	3.1	3.4	3.8	3.3
	3	3.7	3.3	3.9	4.0
	Mean	3.27	3.37	3.67	3.63
Oct.	1	3.7	3.5	4.3	4.8
	2	4.3	4.1	4.1	4.3
	3	4.4	4.4	4.4	4.4
	Mean	4.13	4.00	4.27	4.50

Appendix Table 7. Protein data records for black locust

Month	Sample No.	Brallier	Clinton	Chert	Shale
Sept.	1	7.6	7.7	7.3	6.4
Nov.	1	9.2	9.1	9.3	8.0
Dec.	1	9.0	9.9	8.8	8.3
	2	9.1	10.0	7.4	8.1
	3	7.9	8.9	9.1	8.7
	Mean	8.67	9.60	8.43	8.37
Feb.	1	9.1	9.6	9.9	9.4
	2	9.3	9.3	10.1	8.0
	3	9.3	9.8	9.7	8.3
	Mean	9.23	9.56	9.90	8.57
April	1	9.1	9.4	9.1	7.5
	2	8.9	10.1	8.2	9.1
	3	8.8	10.6	8.3	9.3
	Mean	8.93	10.03	8.53	8.63
June	1	10.7	13.1	11.8	9.4
	2	11.8	13.8	11.0	9.5
	3	9.3	13.4	11.4	9.3
	Mean	10.60	13.43	11.40	9.40
Aug.	1	7.6	7.8	8.9	6.2
	2	7.5	7.4	9.0	7.5
	3	7.1	6.1	8.8	7.0
	Mean	7.40	7.10	8.90	6.90
Oct.	1	9.0	8.6	10.4	8.6
	2	9.0	9.0	10.5	8.4
	3	8.6	8.9	10.1	8.4
	Mean	8.87	8.83	10.33	8.47

Appendix Table 8. Protein data records for red maple

Month	Sample No.	Brallier	Clinton	Chert	Shale
Sept.	1	2.6	2.8	2.7	2.7
Nov.	1	4.1	4.1	4.0	4.8
Dec.	1	4.0		3.9	4.2
	2	4.1	4.0	3.3	5.3
	3	3.9	4.1	3.1	4.4
	Mean	4.00	4.05	3.43	4.63
Feb.	1	3.8	5.5	4.6	4.8
	2	3.2	5.4	4.5	5.2
	3	3.7	4.5	4.3	4.9
	Mean	3.57	5.13	4.47	4.97
April	1	4.0	3.9	4.4	4.6
	2	3.6	4.1	3.9	4.4
	3	3.9	4.4	3.9	4.8
	Mean	3.83	4.13	4.07	4.60
June	1	5.8	5.1	3.9	4.8
	2	5.3	4.0	5.3	6.0
	3	7.0	4.1	4.1	5.8
	Mean	6.03	4.40	4.43	5.53
Aug.	1	2.4	2.9	3.1	3.3
	2	2.2	2.6	2.6	3.8
	3	2.5	3.0	2.6	3.9
	Mean	2.37	2.83	2.77	3.67
Oct.	1	3.8	3.3	2.9	2.7
	2	4.3	3.4	4.0	2.8
	3	4.4	3.8	3.8	3.1
	Mean	4.17	3.50	3.57	2.87

Appendix Table 9. Protein data records for rhododendron and buffalo nut

Month	Sample No.	Rhododendron	Buffalo Nut
Sept.	1	3.1	8.6
Nov.	1	4.0	8.7
	1	4.0	8.8
Dec.	2	3.8	9.6
	3	3.9	
	Mean	3.90	9.20
	1	4.8	15.6
Feb.	2	4.8	13.8
	3	4.7	12.2
	Mean	4.77	13.87
	1	4.6	12.6
April	2	4.1	12.7
	3	4.6	12.8
	Mean	4.43	12.70
	1	5.3	14.5
June	2	4.9	10.6
	3	5.5	12.3
	Mean	5.23	12.47
	1	3.8	8.3
Aug.	2	3.9	7.9
	3	3.8	8.3
	Mean	3.83	8.17
	1	3.6	7.7
Oct.	2	3.4	8.7
	3	3.7	7.3
	Mean	3.57	7.90

Appendix Table 10. Ether extract data records for flowering dogwood

Month	Sample No.	Brallier	Clinton	Chert	Shale
Sept.	1	3.1	3.9	3.7	3.8
Nov.	1	3.9	4.1	4.7	4.1
	1	4.0	4.0	4.7	4.4
Dec.	2	4.2	4.1	5.3	4.0
	3	3.7	3.9	5.3	4.0
	Mean	3.97	4.00	5.10	4.13
	1	3.9	3.8	4.0	3.7
Feb.	2	3.8	4.2	4.1	4.3
	3	4.2	3.7	4.0	4.2
	Mean	3.97	3.90	4.03	4.07
	1	4.4	3.5	4.0	3.9
April	2	4.0	3.8	4.2	4.0
	3	4.2	4.0	4.4	4.0
	Mean	4.20	3.77	4.20	3.97
	1	3.3	2.4	3.1	3.4
June	2	3.5	3.1	3.5	3.5
	3	3.6	3.3	3.3	3.7
	Mean	3.47	2.93	3.30	3.53
	1	2.9	3.4	3.7	4.0
Aug.	2	3.0	3.7	3.5	3.4
	3	3.7	3.0	4.2	3.7
	Mean	3.20	3.37	3.80	3.70
	1	2.6	2.4	4.5	3.7
Oct.	2	2.9	3.5	4.5	3.2
	3	3.5	3.7	4.4	3.9
	Mean	3.00	3.20	4.43	3.60

Appendix Table 11. Ether extract data records for black locust

Month	Sample No.	Brallier	Clinton	Chert	Shale
Sept.	1	2.2	1.9	1.5	1.5
Nov.	1	3.0	1.9	2.2	2.0
Dec.	1	3.7	2.5	2.7	2.3
	2	3.7	2.5	1.6	2.1
	3	3.0	2.1	2.3	2.5
	Mean	3.47	2.37	2.20	2.30
Feb.	1	3.1	2.7	2.6	2.4
	2	2.9	2.9	3.0	2.0
	3	2.7	2.6	2.7	2.1
	Mean	2.90	2.73	2.77	2.17
April	1	2.8	2.5	1.9	2.0
	2	2.8	2.4	2.4	2.7
	3	3.0	2.7	2.3	2.5
	Mean	2.87	2.53	2.20	2.40
June	1	1.3	1.5	1.3	1.5
	2	1.1	1.6	1.3	1.6
	3	1.3	1.4	1.4	1.6
	Mean	1.23	1.50	1.33	1.57
Aug.	1	1.6	1.4	1.8	1.2
	2	1.4	1.1	1.6	1.4
	3	1.5	1.0	1.7	1.3
	Mean	1.50	1.17	1.70	1.30
Oct.	1	1.8	1.9	2.2	1.5
	2	1.7	2.1	2.3	1.8
	3	1.7	1.7	1.8	1.7
	Mean	1.73	1.90	2.10	1.67

Appendix Table 12. Ether extract data records for red maple

Month	Sample No.	Brallier	Clinton	Chert	Shale
Sept.	1	4.2	2.2	1.7	2.7
Nov.	1	5.1	3.5	3.1	4.2
	1	6.0		4.2	3.4
Dec.	2	6.1	2.9	5.0	3.5
	3	6.6	3.1	4.4	3.2
	Mean	6.23	3.00	4.53	3.37
	1	6.2	4.5	4.9	4.2
Feb.	2	5.1	5.2	5.4	4.6
	3	5.6	4.7	4.2	5.7
	Mean	5.63	4.80	4.83	4.83
	1	4.2	1.6	2.1	1.5
April	2	4.7	1.5	2.0	1.8
	3	4.7	1.6	1.7	1.6
	Mean	4.53	1.57	1.93	1.63
	1	1.4	1.5	1.5	1.5
June	2	1.7	1.4	1.6	1.6
	3	1.5	1.9	1.7	1.6
	Mean	1.53	1.60	1.60	1.57
	1	1.2	1.1	1.5	1.2
Aug.	2	1.2	1.6	1.6	1.6
	3	0.9	1.4	1.3	1.8
	Mean	1.10	1.37	1.47	1.53
	1	2.3	2.5	2.5	1.6
Oct.	2	3.8	2.6	2.7	1.9
	3	4.6	2.4	2.5	2.2
	Mean	3.57	2.50	2.57	1.90

Appendix Table 13. Ether extract data records for rhododendron and buffalo nut

Month	Sample No.	Rhododendron	Buffalo Nut
Sept.	1	2.2	2.9
Nov.	1	3.6	3.4
Dec.	1	4.1	3.4
	2	4.2	3.8
	3	4.1	
	Mean	4.13	3.60
Feb.	1	3.6	4.8
	2	3.8	4.1
	3	3.6	3.3
	Mean	3.67	4.07
April	1	3.3	3.7
	2	2.9	3.6
	3	3.2	3.3
	Mean	3.13	3.53
June	1	3.7	2.8
	2	3.6	2.6
	3	4.0	2.8
	Mean	3.77	2.73
Aug.	1	3.0	1.9
	2	3.5	1.8
	3	3.0	1.6
	Mean	3.17	1.77
Oct.	1	2.8	2.5
	2	2.1	2.3
	3	2.5	2.5
	Mean	2.47	2.43

Appendix Table 14. Ash data records for flowering dogwood

Month	Sample No.	Brallier	Clinton	Chert	Shale
Sept.	1	3.3	4.1	3.3	3.9
Nov.	1	5.2	5.0	4.4	5.3
Dec.	1	3.5	4.3	5.2	5.7
	2	4.5	3.8	4.3	5.4
	3	5.0	3.7	4.4	5.5
	Mean	4.33	3.93	4.63	5.53
Feb.	1	3.9	4.6	4.8	4.8
	2	4.1	4.7	4.5	4.7
	3	3.9	3.8	4.1	6.1
	Mean	3.97	4.37	4.47	5.20
April	1	5.2	4.1	4.9	5.3
	2	4.5	4.5	5.4	5.8
	3	4.9	5.3	5.4	5.7
	Mean	4.87	4.63	5.23	5.60
June	1	5.7	4.7	4.7	5.5
	2	5.8	5.0	5.1	4.8
	3	5.3	5.5	5.0	5.5
	Mean	5.60	5.07	4.93	5.27
Aug.	1	4.3	5.0	4.6	4.8
	2	4.6	4.5	5.2	4.2
	3	4.5	4.7	5.4	5.5
	Mean	4.47	4.73	5.07	4.83
Oct.	1	4.1	3.8	5.1	4.9
	2	4.9	5.0	4.9	4.3
	3	4.5	5.5	5.3	5.3
	Mean	4.50	4.77	5.10	4.83

Appendix Table 15. Ash data records for black locust

Month	Sample No.	Brallier	Clinton	Chert	Shale
Sept.	1	3.2	2.9	2.9	2.3
Nov.	1	3.6	2.7	3.2	4.5
	1	3.2	3.4	3.0	2.8
Dec.	2	3.4	3.9	3.4	2.1
	3	2.5	2.7	2.5	4.0
	Mean	3.03	3.33	2.97	2.97
	1	3.3	3.6	2.8	2.6
Feb.	2	3.1	3.2	4.1	3.7
	3	2.9	3.9	3.1	5.2
	Mean	3.10	3.56	3.33	3.83
	1	2.8	2.8	2.5	3.1
April	2	2.9	2.8	2.5	4.2
	3	3.4	2.8	2.8	3.6
	Mean	3.03	2.80	2.60	3.63
	1	5.2	4.2	3.5	4.5
June	2	4.9	4.4	4.4	4.7
	3	4.8	4.3	4.1	4.4
	Mean	4.97	4.30	4.00	4.53
	1	4.5	3.2	3.7	2.2
Aug.	2	3.7	2.8	3.6	2.1
	3	4.2	2.3	3.8	3.3
	Mean	4.13	2.77	3.70	2.53
	1	3.1	2.3	2.5	3.3
Oct.	2	2.8	2.2	2.8	3.6
	3	2.7	2.4	3.0	2.4
	Mean	2.87	2.30	2.77	2.10

Appendix Table 16. Ash data records for red maple

Month	Sample No.	Brallier	Clinton	Chert	Shale
Sept.	1	2.4	2.7	2.3	2.3
Nov.	1	2.9	3.0	2.5	2.8
Dec.	1	2.4		2.0	2.5
	2	2.5	1.7	1.9	2.0
	3	2.5	1.5	1.8	2.0
	Mean	2.47	1.60	1.80	2.17
Feb.	1	2.5	2.9	2.3	2.0
	2	2.2	3.1	3.0	2.0
	3	2.6	1.9	2.3	1.9
	Mean	2.43	2.63	2.53	1.97
April	1	2.9	2.1	2.8	2.4
	2	3.1	2.3	2.5	1.9
	3	3.0	2.2	2.5	2.0
	Mean	3.00	2.20	2.60	2.10
June	1	3.5	2.8	3.0	2.5
	2	3.9	3.4	3.4	2.7
	3	3.4	3.0	3.0	2.9
	Mean	3.60	3.07	3.13	2.70
Aug.	1	1.6	2.0	2.4	1.9
	2	1.7	2.5	2.4	1.8
	3	1.6	2.4	1.7	2.6
	Mean	2.63	2.30	2.17	2.10
Oct.	1	2.2	2.2	2.1	1.1
	2	1.9	2.0	2.6	1.3
	3	2.1	2.1	2.6	1.6
	Mean	2.07	2.10	2.43	1.33

Appendix Table 17. Ash data records for rhododendron and buffalo nut

Month	Sample No.	Rhododendron	Buffalo Nut
Sept.	1	3.1	5.7
Nov.	1	4.6	5.5
Dec.	1	4.5	5.0
	2	4.1	5.8
	3	3.9	
	Mean	4.17	5.40
Feb.	1	3.7	3.2
	2	3.7	4.5
	3	3.6	3.8
	Mean	3.67	3.83
April	1	4.1	4.5
	2	3.9	4.3
	3	4.1	4.6
	Mean	4.03	4.47
June	1	4.3	6.2
	2	4.5	6.2
	3	5.7	6.9
	Mean	4.83	6.43
Aug.	1	4.9	5.8
	2	4.9	5.6
	3	5.8	5.9
	Mean	5.20	5.77
Oct.	1	4.6	3.9
	2	4.1	5.7
	3	4.8	3.6
	Mean	4.50	4.40

Appendix Table 18. Crude fiber data records for flowering dogwood

Month	Sample No.	Brallier	Clinton	Chert	Shale
Sept.	1	30.0	25.1	27.7	27.6
Nov.	1	27.6	26.3	24.9	24.9
Dec.	1	25.7	25.7	19.5	23.8
	2	25.7	23.0	24.8	25.3
	3	24.2	26.7	22.5	24.9
	Mean	25.87	25.13	22.27	24.67
Feb.	1	27.9	27.8	27.1	29.9
	2	27.9	25.3	26.8	24.9
	3	26.6	30.7	28.7	24.1
	Mean	27.47	27.93	27.53	26.30
April	1	24.5	29.6	25.8	26.5
	2	25.6	29.2	24.5	25.7
	3	24.8	25.6	31.1	27.4
	Mean	24.97	28.13	27.13	26.53
June	1	21.5	25.4	24.8	23.0
	2	20.8	25.9	22.4	23.4
	3	21.1	22.4	24.9	21.7
	Mean	21.13	24.57	24.03	22.70
Aug.	1	29.3	27.2	25.6	23.8
	2	28.2	25.6	20.9	26.4
	3	25.6	28.5	22.3	22.3
	Mean	27.70	27.10	22.93	24.17
Oct.	1	30.5	30.3	26.7	27.3
	2	28.2	26.6	27.0	27.2
	3	25.3	25.7	26.5	24.3
	Mean	28.00	27.53	26.73	26.27

Appendix Table 19. Crude fiber data records for black locust

Month	Sample No.	Brallier	Clinton	Chert	Shale
Sept.	1	27.0	31.1	31.9	31.3
Nov.	1	29.3	28.2	32.8	32.0
Dec.	1	28.4	28.3	27.5	31.6
	2	27.8	27.5	34.9	29.5
	3	29.6	28.1	28.7	28.4
	Mean	28.60	27.97	30.37	29.83
Feb.	1	27.1	31.7	30.8	28.1
	2	27.3	30.8	29.3	33.0
	3	28.0	31.4	30.5	31.3
	Mean	27.47	31.30	30.20	30.80
April	1	26.3	31.8	30.2	34.0
	2	26.5	30.9	30.8	30.4
	3	25.8	30.7	28.8	31.7
	Mean	26.20	31.13	29.93	32.03
June	1	33.3	31.0	31.0	34.4
	2	33.0	29.6	30.2	33.4
	3	30.9	29.7	31.3	33.3
	Mean	32.40	30.10	30.83	33.7
Aug.	1	29.6	33.4	27.2	31.9
	2	33.0	33.0	27.9	31.2
	3	30.6	33.0	29.1	34.3
	Mean	31.07	33.13	28.07	32.47
Oct.	1	29.6	32.7	31.0	30.7
	2	30.3	31.6	30.4	29.4
	3	30.1	31.4	31.1	30.7
	Mean	30.00	31.90	30.83	30.27

Appendix Table 20. Crude fiber data record for red maple

Month	Sample No.	Brallier	Clinton	Chert	Shale
Sept.	1	28.1	30.5	28.4	32.4
Nov.	1	28.8	28.1	31.2	28.8
	1	28.6		29.0	31.5
Dec.	2	33.1	30.8	30.8	23.0
	3	32.2	34.2	33.9	31.5
	Mean	31.30	32.50	31.23	28.67
	1	28.3	29.3	29.6	30.4
Feb.	2	34.5	27.2	28.2	29.6
	3	32.5	35.3	31.2	30.5
	Mean	31.77	30.60	29.67	30.17
	1	27.5	32.9	30.8	32.9
April	2	26.6	32.7	24.7	31.5
	3	25.6	32.3	30.7	31.2
	Mean	26.57	32.63	28.73	31.87
	1	29.3	30.0	31.7	31.3
June	2	31.5	30.0	27.1	28.3
	3	29.0	28.4	27.5	29.6
	Mean	29.93	29.47	28.77	29.73
	1	37.3	34.8	27.9	33.6
Aug.	2	36.8	32.4	28.9	32.3
	3	36.0	33.2	32.5	30.4
	Mean	36.70	33.47	29.77	32.10
	1	32.7	30.8	31.1	37.9
Oct.	2	31.1	33.8	27.8	31.5
	3	29.2	32.7	26.7	33.1
	Mean	31.00	32.43	28.53	34.17

Appendix Table 21. Crude fiber data records for rhododendron and buffalo nut

Month	Sample No.	Rhododendron	Buffalo Nut
Sept.	1	28.8	28.4
Nov.	1	24.5	28.3
Dec.	1	22.8	26.2
	2	23.8	25.3
	3	21.2	
	Mean	22.60	25.75
Feb.	1	20.6	23.5
	2	19.2	26.0
	3	20.0	27.8
	Mean	19.93	25.77
April	1	19.1	26.1
	2	19.1	27.2
	3	18.6	27.2
	Mean	18.93	26.83
June	1	14.3	26.9
	2	18.2	24.8
	3	18.2	23.1
	Mean	16.90	24.93
Aug.	1	25.0	31.9
	2	24.1	29.3
	3	23.5	29.6
	Mean	24.20	30.27
Oct.	1	26.0	28.0
	2	25.6	25.9
	3	24.6	28.2
	Mean	25.40	27.37

Appendix Table 22. Nitrogen-free extract data records for flowering dogwood

Month	Sample No.	Brallier	Clinton	Chert	Shale
Sept.	1	60.7	63.5	62.3	61.2
Nov.	1	59.2	60.6	61.5	61.2
	1	62.0	60.2	66.0	60.7
Dec.	2	61.1	64.0	59.8	60.7
	3	62.1	60.1	62.0	60.8
	Mean	61.40	61.43	62.60	60.73
	1	59.8	59.5	59.3	56.7
Feb.	2	59.3	60.5	59.8	60.8
	3	60.8	57.6	58.7	60.7
	Mean	59.97	59.20	59.27	59.40
	1	60.6	58.5	59.8	58.5
April	2	61.2	57.4	49.9	59.1
	3	60.8	59.2	53.1	57.2
	Mean	60.87	58.37	57.60	58.27
	1	63.9	61.9	62.6	63.0
June	2	64.4	60.0	64.1	63.5
	3	63.9	62.8	62.2	64.1
	Mean	64.07	61.57	62.97	63.53
	1	60.5	61.0	62.8	63.8
Aug.	2	61.1	62.8	66.6	62.7
	3	62.5	60.5	64.2	64.5
	Mean	61.37	61.43	64.53	63.67
	1	59.1	60.0	59.4	59.3
Oct.	2	59.7	60.8	59.5	61.0
	3	62.3	60.7	59.4	62.1
	Mean	60.37	60.50	59.43	60.80

Appendix Table 23. Nitrogen-free extract data records for black locust

Month	Sample No.	Brallier	Clinton	Chert	Shale
Sept.	1	60.0	56.3	56.4	58.5
Nov.	1	54.9	58.2	53.6	53.6
Dec.	1	55.7	56.0	58.0	55.0
	2	56.0	56.1	52.7	58.2
	3	57.0	58.1	57.4	56.4
	Mean	56.23	56.73	56.03	56.53
Feb.	1	57.4	52.4	53.9	57.5
	2	57.4	53.8	53.5	53.3
	3	57.1	52.3	54.0	53.1
	Mean	57.30	52.83	53.80	54.63
April	1	59.0	53.5	56.3	53.4
	2	58.9	53.8	56.1	53.6
	3	59.0	53.2	57.8	52.9
	Mean	58.97	53.50	56.73	53.30
June	1	49.5	50.2	52.4	50.2
	2	49.2	50.6	53.1	50.8
	3	53.7	51.2	51.8	51.4
	Mean	50.80	50.67	52.43	50.80
Aug.	1	56.7	54.2	58.4	58.5
	2	54.4	55.7	57.9	57.8
	3	56.6	57.6	56.6	54.1
	Mean	55.90	55.83	57.63	56.80
Oct.	1	56.5	54.5	53.9	55.9
	2	56.2	55.1	54.0	56.8
	3	56.9	55.6	54.0	56.8
	Mean	56.53	55.07	53.97	56.50

Appendix Table 24. Nitrogen-free extract data records for red maple

Month	Sample No.	Brallier	Clinton	Chert	Shale
Sept.	1	62.7	61.7	64.9	59.9
Nov.	1	59.2	61.4	59.3	59.5
	1	59.0		60.9	58.4
Dec.	2	54.2	60.6	59.0	66.2
	3	54.8	57.1	56.8	58.9
	Mean	56.00	58.85	58.90	61.17
	1	59.2	57.8	58.6	58.6
Feb.	2	55.0	59.1	58.9	58.6
	3	55.6	53.6	58.0	57.0
	Mean	56.60	56.83	58.50	58.07
	1	61.4	59.5	59.9	58.6
April	2	62.0	59.4	66.9	60.4
	3	62.8	59.5	61.2	60.4
	Mean	62.07	59.47	62.67	59.80
	1	60.0	60.6	59.9	59.9
June	2	57.6	61.2	64.7	61.4
	3	59.1	62.6	63.7	60.1
	Mean	58.90	61.47	62.77	60.47
	1	57.5	59.2	65.0	60.0
Aug.	2	58.1	60.9	64.5	60.5
	3	59.0	60.0	61.9	61.3
	Mean	58.20	60.03	63.80	60.60
	1	59.0	61.2	61.4	56.7
Oct.	2	58.9	58.2	62.9	62.5
	3	59.7	59.0	64.4	60.0
	Mean	59.20	59.47	62.90	59.73

Appendix Table 25. Nitrogen-free extract data records for rhododendron and buffalo nut

Month	Sample No.	Rhododendron	Buffalo Nut
Sept.	1	62.8	54.4
Nov.	1	63.2	54.1
Dec.	1	64.6	56.6
	2	64.1	55.5
	3	66.9	
	Mean	65.20	56.05
Feb.	1	67.3	51.6
	2	68.5	51.6
	3	68.1	52.9
	Mean	67.97	52.03
April	1	68.9	53.5
	2	70.0	52.6
	3	69.5	52.6
	Mean	69.47	52.90
June	1	72.4	49.6
	2	68.8	55.8
	3	66.6	54.9
	Mean	69.27	53.43
Aug.	1	63.3	52.1
	2	63.6	55.4
	3	62.3	54.6
	Mean	63.07	54.03
Oct.	1	63.0	57.9
	2	64.8	57.4
	3	64.4	58.4
	Mean	64.07	57.90

ABSTRACT

of

THE AVAILABLE NUTRIENTS IN SELECTED DEER BROWSE

SPECIES GROWING ON DIFFERENT SOILS

by

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DOCTOR OF PHILOSOPHY

in

Biology

The purposes of this investigation which was conducted from September, 1954, through October, 1955, were (1) to determine the differences in available nutrients in selected deer browse species growing on different soils, (2) to investigate the variations in available soil nutrients as they may relate to chemical composition of selected deer browse species, and (3) to determine the variations in available nutrients in the selected browse species during different seasons of the year.

The current years growth of twigs from flowering dogwood (*Cornus florida*), black locust (*Robinia pseudoacacia*), and red maple (*Acer rubrum*) were collected at two-month intervals on study areas whose soils had arisen from either Brallier, Clinton, Huntersville chert, or Martinsburg shale geological formations. A proximate analysis was run on each browse collection. In addition to the above three species, rhododendron (*Rhododendron maximum*) and buffalo nut (*Pyrularia pubera*) were collected from the Brallier study area and analyzed. One-third of the samples of dogwood, locust, and maple that were collected after leaf fall in October, 1955, were analyzed for calcium, phosphorous, cobalt, and manganese.

Soil samples were collected on each area and analyzed by a flame spectrophotometer, LaMotte Soil Testing Outfit, and a rapid method. The soil which arose from the Brallier study area was lowest in value for phosphorous and second highest in values for total exchangeable cations and organic matter. The Clinton study area values were second highest in pH, phosphorous, and base saturation, and was highest in organic matter and manganese content. The chert area values were the next lowest for phosphorous and lowest for pH, calcium, total exchangeable cations, and base saturation. The shale study area soil gave the highest values for pH, calcium, phosphorous, base saturation, and total exchangeable cations although it was lowest in organic matter.

Of the three browse species collected from all the study areas, dogwood was generally high in moisture content, ether extract, ash, and nitrogen-free extract while being average in protein and low in crude fiber. Locust was high in protein and crude fiber and low in moisture, ether extract, and nitrogen-free extract. Maple was generally high in ether extract, crude fiber, and nitrogen-free extract and low in protein and ash.

Rhododendron and buffalo nut were collected from the Brallier study area only. In comparison with the other three species on that area, rhododendron was very high in moisture and nitrogen-free extract; average to low in protein, ether extract, and crude fiber; average to high in ash. Buffalo nut was very high in moisture, protein, and ash; average in ether extract and crude fiber; and low in nitrogen-free extract.

Seasonal trends in nutrient values for the three browse species collected on all areas were observed. Protein content rose generally during the dormant months. Moisture content decreased from June through December and was followed by a rise that lasted until June. There was a rise in ether extract from September through June whereas the level of ash content was erratic during this period. Crude fiber was fairly stable in red maple and black locust although erratic in dogwood. There was a decrease in the nitrogen-free extract during the winter.

Trends and consistencies in the nutritive values of the three species collected on all study areas, based on the study area on which they occur, are generally in the order of being high or low for one or two individual species rather than for all the species, or else they are considerably erratic.

The different species have different nutritive values when growing on the same soil. During April and August, the different soils have their greatest effect on the nutritive values of plants; moisture content is greatly affected by the soil, and protein content is only slightly less affected. Except for the months of February and August, at least three of the six nutritive qualities of the plants were affected by the interaction between the plant and the soil.

Analyses for minor elements reveal that black locust had the highest phosphorous and cobalt content; dogwood had the highest calcium content; red maple had the highest manganese content. On three of the four study areas, the manganese content of red maple exceeded the toxic level for bovines. On the chert area, dogwood and red maple were deficient, by bovine standards, in cobalt.