MONTANA STATE UNIVERSITY

The chemical composition and utilization of greasewood and other browse species as related to some aspects of cattle nutrition on winter ranges in southeastern Montana

by Donald A Jameson

A THESIS Submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of Master of Science in Range Management
Montana State University

Abstract:
A study was designed to explore the possibilities of a. correlation between blood level nutrients of cattle on winter ranges in southeastern Montana and the utilization and chemical composition of some of the major browse species of the area. The study was conducted near Miles City, Montana, and continued for two winter grazing seasons.

Previous work had indicated that browse plants were potentially valuable forage species, but little work had been done on their utilization in the Northern Great Plains.

Utilization was estimated by tagging twig's and measuring the length of these twigs at twenty-eight day intervals. The four browse species selected for the study were shadscale, big sagebrush, winterfat,, and greasewood.

After one season studies were discontinued on shadscale, winterfat, and big sagebrush, and a more intensive study of greasewood was initiated. Sampling was done on pastures under heavy, moderate, and light rates of stocking.

Browse and blood samples for chemical analyses were collected at about the same time that utilization was measured. Blood samples were analyzed for phosphorus, carotene, and vitamin A, and browse samples were analyzed for protein, phosphorus, and carotene.

Phosphorus levels in blood were lower than recommended all during the winter months, but vitamin A levels were adequate.

Utilization of greasewood, on the study plots, at a distance of about 600 yards from water was slightly over 50% under heavy stocking, and about 17% under light stocking. Utilization of greasewood under moderate stocking was about the same as under light stocking the first year, but was about 33% during the second year. About 10% use was made of greasewood in all pastures at a distance of about 1200 yards from water. Winterfat was used at least as much as greasewood. Most of the greasewood and winterfat use occurred during one sampling period in the early part of the season.

Utilization of shadscale was uneven and seems to be related to the amount of fruits left on the stems. Shadscale use may have some relationship to blood phosphorus levels.

Utilization of big sagebrush during one season's grazing was negligible.

Greasewood had an average crude protein content of 8.7%, winterfat and shadscale were about 1% lower, and big sagebrush more than 2% lower.

Phosphorus content of the species studied was too low for adequate nutrition of cattle.

Carotene in all species increased sharply during January of each year, and then dropped to the lowest point of the year just before growth began in the spring. Carotene content was adequate for proper cattle nutrition for most of the winter season.

During the second year, in addition to the analyses of protein, phosphorus, and carotene, greasewood was analyzed for moisture, ether extract, ash, crude fiber, calcium, magnesium, potassium, sodium, lignin, and chlorine. A high sodium content of the samples may have been partly responsible for the rather low salt consumption by the experimental cattle.

THE CHEMICAL COMPOSITION AND UTILIZATION OF GREASEWOOD AND OTHER BROWSE SPECIES AS RELATED TO SOME ASPECTS OF CATTLE NUTRITION ON WINTER RANGES IN SOUTHEASTERN MONTANA

by

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ABSTRACT

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Utilization was estimated by tagging twigs and measuring the length of these twigs at twenty-eight day intervals. The four browse species selected for the study were shadscale, big sagebrush, winterfat, and greasewood. After one season studies were discontinued on shadscale, winterfat, and big sagebrush, and a more intensive study of greasewood was initiated. Sampling was done on pastures under heavy, moderate, and light rates of stocking.

Browse and blood samples for chemical analyses were collected at about the same time that utilization was measured. Blood samples were analyzed for phosphorus, carotene, and vitamin A, and browse samples were analyzed for protein, phosphorus, and carotene.

Phosphorus levels in blood were lower than recommended all during the winter months, but vitamin A levels were adequate.

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THE CHEMICAL COMPOSITION AND UTILIZATION OF GREASEWOOD AND OTHER BROWSE SPECIES AS RELATED TO SOME ASPECTS OF CATTLE NUTRITION ON WINTER RANGES IN SOUTHEASTERN MONTANA

INTRODUCTION

Objectives: This project was established as a part of a larger, year-long range nutrition study. It was designed as a preliminary survey to explore the possibility of a correlation between blood level nutrients of cattle on winter ranges in southeastern Montana and the utilization and chemical composition of some of the major browse species of the area. This sub-project was intended to provide some basis for more intensive research in the future. The ultimate purpose of the project was to help complete the yearlong picture of cattle nutrition as related to range forage. This information may be useful in planning ranches so more adequate winter forage can be obtained, and in determining the supplements needed on winter ranges.

In the words of Hurtt (1950):

> "Range use practices have developed with little or no knowledge of nutritional deficiencies, seasonal variation in nutrients, or of mineral, vitamin, and other obscure characteristics of range plants. Wasteful, inefficient management cannot be corrected until these characteristics are more fully known and used as a basis for supplemental feeding, seasonal grazing, and other range practices."

Although there has been much speculation of the value of browse as a winter feed for cattle in the Northern Great Plains region, there has been very little done in the way of a careful study of the problem.

The study area: This study was conducted at the Lone Pine winter pastures and adjacent areas of the U. S. Range Livestock Experiment Station at Miles City, Montana. Average annual precipitation is 13.2 inches. More than seventy percent of the precipitation comes during the six months period

starting April 1 (U. S. D. A., 1950). During normal winters the snowfall is slight and that which falls remains on the ground for only a short time.

The area is considered to be within the mixed prairie association of the grassland formation. On level and gently rolling portions the vegetation is typical of the grassland type commonly found in the mixed prairie, the dominant species being western wheatgrass (Agropyron smithii), needle-and-thread (Stipa comata), and blue grama (Bouteloua gracilis). On the rough, broken uplands, shadscale (Atriplex confertifolia), greasewood (Sarcobatus vermiculatus), big sagebrush (Artemisia tridentata), winterfat (Eurotia lanata), and silver sagebrush (Artemisia cana) are also important species. In addition to the species listed here there are many others which are present but which are less conspicuous. Figure 1 shows a general view of the area.

Other studies on the area: In 1932 the U. S. Forest Service began a study to determine the effect of light, moderate, and heavy grazing on Hereford breeding cows and range vegetation. The study was conducted on a portion of the U. S. Range Livestock Experiment Station (U. S. D. A., 1950).

Surface acre allowances per cow on a yearlong basis for the three rates of stocking were 38.8 for light, 30.5 for moderate, and 23.1 for heavy. Summer and winter grazing units were established and adjusted to the above rates of stocking. Each of the units was divided into six smaller pastures, two for each rate of grazing. The size of the pastures were varied and each pasture was stocked with ten animal units. The winter pastures were established in rough, broken country to provide protection from storms. The

Figure 1. A general view of the study area, pasture Q in the foreground. The larger browse plants can be seen protruding through the snow.

winter pastures were given the collective name of "Lone Pine", and were used from mid-November until mid-May (U. S. D. A., 1950).

The six pastures at both the winter and summer areas were arranged in a more or less circular pattern and watered by a central well. The winter pastures were designated by the letters Q through V. Pastures Q, R, and S (Figure 2) were used for this study. Pasture Q was heavily grazed, R lightly grazed, and S moderately grazed. The other pastures, T, U, and V were grazed in a similar manner. Weights of the breeding cows on these pastures were taken at twenty-eight day intervals (U. S. D. A., 1950).

In 1947 the Montana State Agricultural Experiment Station began a project on these same pastures to determine the nutritive value of Montana range plants and their influence on cattle nutrition. This project included sampling and chemical analyses of important range grasses and sampling and chemical analyses of the cattle blood. The project indicated within three years that the range grasses being sampled were deficient in some nutrients, especially phosphorus, during the fall and winter months, while at the same time the blood level counterparts of these same nutrients were not dangerously low, and in some cases even increased for a short time. This information indicated that the cattle were receiving nutrients from sources other than the grasses being sampled. The study reported here was launched to determine whether or not the source of some of the nutrients might be the shrubby plants which are abundant on the Lone Pine winter pastures.

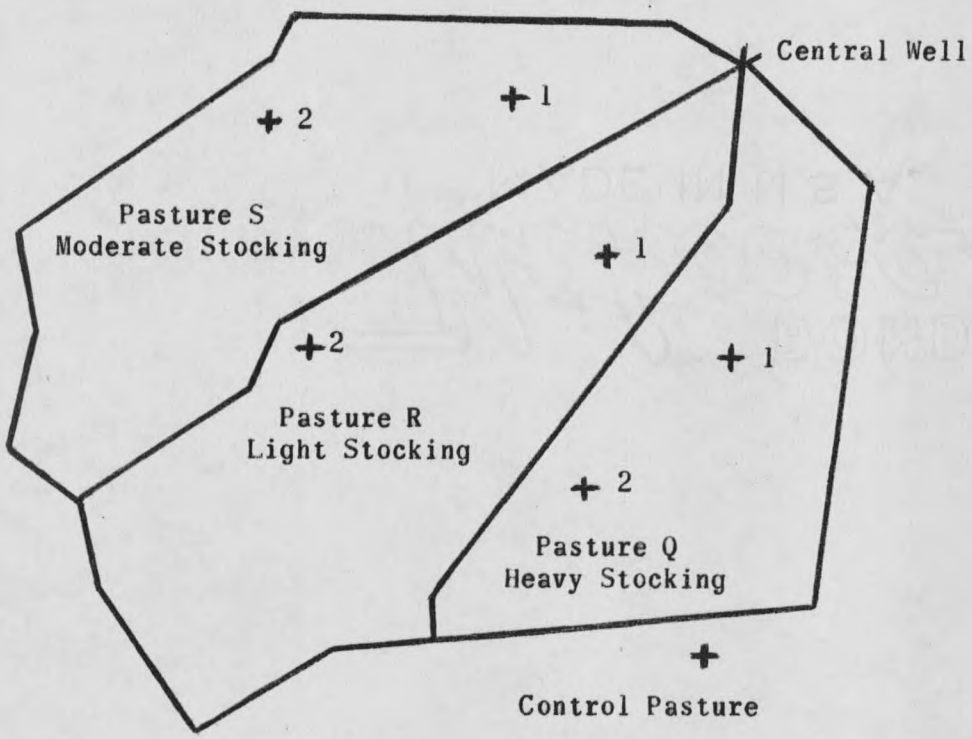

Figure 2. A map of the three Lone Pine winter pastures used in the study. Numbers 1 and 2 refer to the location of plots within the pastures.

REVIEW OF LITERATURE

Results of previous utilization studies: Clarke and Tisdale (1945) stated that:

> "Many of the broad-leaved herbs and shrubs are higher in nutritive value when in the cured stage than are the grasses. In addition such species as pasture sage (Artemisia frigida) and sagebrush (Artemisia cana) which are relatively unpalatable in the summer are utilized to a considerable extent in the winter.....Winterfat (Eurotia lanata), salt sage (Atriplex gardneri), willows (Salix spp.), pasture sage, and some sagebrush are highly desirable on a winter range."

This reference also gives relative palatibility of some browse species as follows: eaten readily - winterfat and salt sage; eaten slightly - pasture sage and sagebrush; eaten rarely or not at all - broom weed (Gutierrezia sarothrae). No other results of studies on the use of browse on cattle ranges of the Northern Great Plains area have come to the attention of the author. Observations of the use of browse species in this area have been made, but these observations have not been qualified by experimental evidence.

Nutritive value of browse species: Averages of chemical analyses of shadscale, big sagebrush, winterfat, and greasewood which have been published are shown in Table I.

Methods of sampling browse utilization: Five criteria were chosen for the selection of a method of sampling utilization of the four major browse species to be measured. The criteria of selection of the method were: 1) it should be applicable to the measurement of utilization of browse species; 2) it should provide an actual, quantitative measure of utilization of the browse species; 3) it would provide this measure of utilization at intervals

Table I. Average winter protein and phosphorus content of shadscale, big sagebrush, winterfat, and greasewood.[1/]

Species	Percent crude protein	Percent phosphorus
Shadscale (*Atriplex confertifolia*)	7.64	.080
Big sagebrush (*Artemisia tridentata*)	10.57	.300
Winterfat (*Eurotia lanata*)	9.46	.107
Greasewood (*Sarcobatus vermiculatus*)	----	.19[2/]

1/ The above figures are averages of analyses published by the following: Bidwell and Wooton (1925), Clarke and Tisdale (1945), Cook and Harris (1950), Esplin, *et al* (1937), Idaho Experiment Station (1937), McCreary (1927 and 1939), and Wasser (1945).

2/ One analysis.

to allow analysis of correlation of utilization of the browse species with blood level nutrients; 4) it should not require removal of a large amount of material from the pastures studied, since these pastures were a part of a rate of stocking study; and 5) it should allow sampling time to be held to a minimum.

Cassady (1941) developed a method of sampling utilization by clipping. Under this method, a given number of plant units of each of the species to be sampled were clipped by hand immediately before grazing by sheep and again immediately after grazing, the time between the two samplings being held to a minimum to reduce the influence of growth on the samples. The difference in the weight of each sample was taken as the amount of each species which was consumed by the grazing sheep.

Cook, Harris, and Stoddart (1948) later modified Cassady's method by adding to the sampling procedure the chemical analysis of both the before and after samples, the difference in the amounts of nutrients present in the two samples being taken as the amount of nutrients consumed by the sheep. This modification proved to give a more accurate measure of nutritive intake than determining the nutrient content of the forage by one sample, since the parts of the plants consumed by the sheep were more nutritious than the average nutrient content of the entire plant. The before and after method of Cook, Harris, and Stoddart has been used on both winter and summer ranges with apparent success (Cook, Cook, and Harris, 1948; Green, et al, 1951). Everson (1951) determined that using the before and after clipping method of determining utilization of individual species would require a minimum of 336

man hours work to reduce sampling error to 5%.

Many methods of estimating utilization have been developed by various workers. At least two of these methods have been developed especially for estimating utilization of browse species. Forsling and Storm (1929) estimated browse utilization and checked the estimates against actual measurements of ungrazed twigs. Hormay (1943) estimated utilization and measured actual diameters of browse plants to arrive at an estimate of utilization weighted by plant diameters.

Pickford and Reid (1948) divided the range into two areas, comparing clippings from ungrazed areas with clippings from grazed areas to determine utilization of the forage. Klingman and co-workers (1943) and others have protected small areas with cages, clipping both protected and unprotected areas after grazing to determine utilization.

Nelson (1930) determined utilization by placing a numbered tag on each of one to three large representative stems, and taking the measurements of all new growth on the larger tagged stems. Measurements could be repeated at intervals without damage to the plants. This method was used on long-time studies of utilization of browse plants, and included a non-grazed control plot to determine the change in length of twigs due to growth. The method was modified by Julander (1937). In the modified method each of four twigs on a plot were marked with numbered aluminum tags. The current growth on each twig was measured before use of the area by deer as winter range, and the same twigs were remeasured immediately after the deer departed for the summer range. The difference between the combined total lengths before and

after browsing represented the linear amount consumed. This modification needed no control plots if only one type of animal was grazing, since it was used in the winter months when no growth was taking place. In addition, if there obviously had been no utilization on a given plant during the winter, no new measurements needed to be taken, since the new measurements would have been the same as the measurements taken the previous autumn. This latter method has been used by Aldous (1945) and others with slight modifications.

McKinney (1951) studied the possibilities of determining species consumed by examination of the silica patterns in the feces of animals, and comparing those patterns with similar structures found in the plants. He concluded that there was some possibility of a qualitative determination of the species, but that there was little possibility of obtaining any quantitative measure of the various species consumed.

Methods of sampling for chemical analysis of browse nutrients: The chief criterion chosen for the selection of a method of collecting material for chemical analysis of nutrients was that of preservation of nutrients until the samples could be analyzed in the laboratory. This preservation was especially important in the case of carotene, because carotene does deteriorate very rapidly following clipping. A very satisfactory method of handling vegetation samples has been developed by Dr. Leon Johnson of the Montana Agricultural Experiment Station Chemistry Research Department.

EXPERIMENTAL PROCEDURE

The project was conducted on a winter cattle range in southeastern Montana during the 1950-1951 and the 1951-1952 winter grazing seasons. The study pastures were those of the U. S. Range Livestock Experiment Station as described earlier in this paper. Three of the six pastures (Q, R, and S; see figure 2) were used in the study. In addition an adjacent pasture, ungrazed during the winter, was used as a control.

Within each of the four pastures, sampling areas were located. Each of these areas were as nearly alike as possible with regard to site potential and grazing use.

The soil type of the sampling areas was kept relatively similar by locating all areas within two similar soil types which made up a major portion of the study area. These soil types are described as having a surface soil of brown to light brown friable clay loam underlain by a brown silty clay (Gieseker, 1948).

Each sampling area was located within a similar vegetative type. Three types were used, these three types making up 55% of the area of the study pastures. Vegetational composition of these types is shown in Table II.

Slope of each sampling area was less than 5%. Exposure was variable, but it is not believed that this variance greatly influenced plant growth or grazing action. Each sampling area, except for the control area, was at least 550 yards but not more than 720 yards from water, with a second area established between 1100 and 1240 yards from water during the second year.

Topography in each pasture was rough and broken with an interspersion of

Table II. Vegetational composition of the major types in the area embracing pastures Q, R, and S, according to reconnaissance survey. Types 1 and 2 were dominated by blue grama and western wheatgrass, type 3 was dominated by western wheatgrass, blue grama, and greasewood.[1]

Plants	Percent of total vegetation		
	Type 1	Type 2	Type 3
All forbs	15	5	10
All grasses	55	75	65
All shrubs	30	20	25
Shrubs by species:			
Greasewood (*Sarcobatus vermiculatus*)	15	6	8
Big sagebrush (*Artemisia tridentata*)	10	8	7
Winterfat (*Eurotia lanata*)	2	2	2
Fringed sagewort (*Artemisia frigida*)	Tr.	Tr.	2
Broom snakeweed (*Gutierrezia sarothrae*)	1	0	2
Shadscale (*Atriplex confertifolia*)	2	4	4
Soapweed (*Yucca glauca*)	0	0	Tr.
Rabbitbrush (*Chrysothamnus* spp.)	0	0	Tr.

[1] U. S. D. A., 1940

fairly level benches.

Vegetation sampling procedure: At each study area, including the pasture used as a control, shadscale (Atriplex confertifolia), big sagebrush (Artemisia tridentata), winterfat (Eurotia lanata), and greasewood (Sarcobatus vermiculatus) were measured for utilization during the first season. These species were selected as being the most abundant (Table III) and as being of possible forage value. Greasewood alone was studied during the second season. Two replications for each species were established, the boundaries of each replication being defined as a measured plot, or, where applicable, as a natural grouping of plants. The location of these replications were selected according to the previously discussed factors of soil type, vegetational type, slope, exposure, and distance from water, and were not selected at random. Each replication contained at least twenty plants of the species to be sampled in that replication.

After the first season, studies were discontinued on big sagebrush because of the very slight amount of use of this species by livestock. Studies were also discontinued on winterfat and shadscale because present methods did not seem to adequately measure the utilization of these species.

Utilization sampling procedure: Two methods of estimating utilization were used the first year, these being derivations of those described by Aldous (1945) and by Cook, Harris, and Stoddart (1948).

In applying the first named method five plants were selected at random within each replication during the first season, and ten plants were selected at random during the second year. The basic measurement unit of each

Table III. Relative amounts of browse species on the pastures studied. The figures were computed by multiplying density times percent composition times surface acres of each type.[1]

Species	Amount
Greasewood (Sarcobatus vermiculatus)	9.90
Big sagebrush (Artemisia tridentata)	9.68
Shadscale (Atriplex confertifolia)	4.82
Winterfat (Eurotia lanata)	1.82
Silver sagebrush (Artemisia cana)	1.35
Broom snakeweed (Gutierrezia sarothrae)	1.19
Rose (Rosa spp.)	0.48
Fringed sagewort (Artemisia frigida)	0.45
Snowberry (Symphoricarpos spp.)	0.32
Gardner saltbush (Atriplex gardneri)	0.27
Cudweed sagewort (Artemisia gnaphaloides)	0.16
Rabbitbrush (Chrysothamnus spp.)	Trace
Soapweed (Yucca glauca)	Trace
Others	0.09

[1] U. S. D. A., 1940

plant was called an observation. In the case of winterfat, an observation included the entire plant. In the cases of shadscale, big sagebrush, and greasewood, an observation was a group of at least five twigs on a major branch which was arbitrarily selected. Each twig on each observation was measured at the beginning of the grazing season and the length recorded. All the observations were marked for future reference. At twenty-eight day intervals these observations were remeasured to determine their utilization.

In applying the last named method (Cook, Harris, and Stoddart) five plants were selected at random in each replication except no plants were selected for winterfat because, due to its growth habit, the entire plant would have had to be taken for one observation of this species. At the beginning of the grazing season at least eight twigs from one major branch were clipped from each plant. These twigs were then air dried and weighed individually.

On February 22, 1951, the clipping procedure was repeated on the same plants as were sampled before. Because an inadequate sample had been clipped previously, the number of twigs clipped per plant was increased to ten or more, usually to about fifteen. These twigs were also dried and weighed individually, the difference between the two clippings giving the utilization on the sample plants.

The plan was to repeat the clippings on March 22, 1951, but since some growth had started on this date, this plan was abandoned. Because a very large amount of material would have been removed from pastures which are also used for grazing intensity studies, this method could not be used to

determine a month-by-month utilization measure, and so was not continued during the second year.

Collection of material for chemical analyses: From the plants chosen for the twig length method of measuring utilization, a twelve gram composite sample for each study area, except the control, was clipped at each twenty-eight day interval. In the case of winterfat, as the entire plant was measured for utilization, nearby plants were used for collection of the samples for chemical analyses. These samples were immediately packed in dry ice for preservation and shipped to the Chemistry Research Department of the Montana Agricultural Experiment Station for the determination of protein, phosphorus, and carotene of each sample. During the second season, sample size was increased to sixty grams of greasewood, and in addition to the individual analyses of protein, phosphorus, and carotene, a composite analysis was made to determine the amount of moisture, protein, ether extract, ash, crude fiber, phosphorus, calcium, carotene, magnesium, potassium, sodium, lignin, and chlorine. Through some mishap, no individual analyses were made at two dates for protein and phosphorus.

Grazing preference determination: At each sampling date that the cattle were actively grazing (ie., the dates when the cattle were not on feed) the cattle of pasture S (the pasture of moderate use) were observed in order to determine grazing preference. After a period of observation of about one-half hour, a sample was collected to represent the material being grazed, both as to the kind of plants grazed and the amount of each taken. These samples were usually collected twice during the day, but during severe

weather, when the cattle spent much of their time in sheltered locations, only one sample was collected each day. The samples were then packed in dry ice and shipped to Chemistry Research for analyses.

Sampling for blood nutrients: At each twenty-eight day interval the cattle from these study pastures were brought to the central corrals for weighing. At the same time, about 40 cc of blood were collected from the jugular vein of five animals from each pasture. The same five animals were bled each month. These samples were packed in wet ice and sawdust and shipped to the Veterinary Research Laboratory of the Montana Agricultural Experiment Station for analyses of phosphorus, carotene, vitamin A, magnesium, and calcium.

Methods of chemical analyses of browse nutrients: Association of Official Agricultural Chemists methods (1950) were used for determination of carotene, moisture, protein, ether extract, crude fiber, and ash. Protein determination was with mecuric oxide as a catalyst.

Phosphorus determination was by the method described by Allen (1940) and modified by Johnson and Giovanini (1949).

Magnesium determination was by the method described by Young and Gill (1951).

Lignin determination was by the methods described by Peterson, Walden, and Hixon (1932); Ritter, Seborg, and Mitchell (1932); and Shervard and Harris (1932).

Calcium, sodium, and potassium determinations were by a flame photometer method developed by Baker (1951).

Methods of chemical analyses of blood nutrients: Phosphorus determination

was done by a slightly modified version of the method published by Fiske and Subbarow (1925).

Carotene and vitamin A analyses were by the method described by Boyer, Phillips, and Smith (1944).

RESULTS AND DISCUSSION

Blood Nutrient Analyses

Phosphorus: Blood phosphorus levels (Tables IV and V) were in all cases below those observed by Thomas (1951) and most other workers, and were even as low as the deficient levels produced by Lewis (1951). In both years there was a highly significant variation between pastures (Appendix Tables I and II). Cows under heavy and light stocking had higher phosphorus than cows under moderate stocking. These differences may be influenced by vegetation of the pastures, as discussed later.

The variation of blood phosphorus levels between dates was highly significant for both seasons (Appendix Tables I and II). Each year as the winter grazing season began, phosphorus levels began to drop off, and in 1950-1951, continued to drop off until mid-season, and then began to slowly increase. In 1951-1952 the phosphorus levels rose in December and then began to drop and continued to drop until spring. Normally, the phosphorus levels were higher during the time hay was fed than during the immediately preceeding period. Analyses of the hay showed it to be higher in phosphorus than either the range grasses or browse. The phosphorus increase may be partly due to an increase in the total feed intake with the beginning of feeding, as well as an increase in the percentage of phosphorus in the feed. At no time were any of the usual external symptoms of a phosphorus deficiency observed.

Carotene: During the first season the blood carotene level (Table IV) on November 30 averaged 80 micrograms per 100 milliliters, and by February 22

Table IV. Phosphorus, carotene, and vitamin A blood levels in cattle on pastures Q (heavily stocked), R (lightly stocked), and S (moderately stocked) during the winter of 1950-1951.

Sampling Date	Pasture	Phosphorus mg/100 ml	Carotene mcg/100 ml	Vitamin A mcg/100 ml
11-30	Q	3.3	81	39
	R	3.2	63	39
	S	2.7	96	40
	Date mean	3.0	80	39
12-28	Q	3.3	57	34
	R	2.8	48	36
	S	2.3	46	33
	Date mean	2.8	50	34
1-24	Q	2.1	45	28
	R	2.2	42	33
	S	1.9	47	33
	Date mean	2.1	44	31
2-22	Q	3.0	44	23
	R	2.8	38	23
	S	2.2	40	27
	Date mean	2.7	41	25
3-22	Q	3.6	33	27
	R	3.0	29	24
	S	2.3	36	29
	Date mean	3.0	32	27
Season-long pasture means:				
	Q	3.0	52	30
	R	2.8	44	31
	S	2.3	53	32
Least significant differences between means:				
Pasture means:	5%	.24	8.0	2.9
	1%	.32	10.7	3.8
Date means:	5%	.32	8.4	3.7
	1%	.42	11.2	5.0