1954

Food consumption and relative digestibility of various winter diets fed to elk (Cervus canadensis nelsoni) under controlled conditions

Anthony Felix Geis
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THE FOOD CONSUMPTION AND RELATIVE DIGESTIBILITY OF VARIOUS WINTER DIETS FED TO ELK (Cervus canadensis, nelsoni) UNDER CONTROLLED CONDITIONS

by

ANTHONY F. GEIS

B. S., Montana State University, 1950

Presented in partial fulfillment of the requirements for the degree of Master of Science in Wildlife Management

MONTANA STATE UNIVERSITY

1954

Approved by:

[Signature]
Chairman, Board of Examiners

[Signature]
Dean, Graduate School

June 3, 1954
ACKNOWLEDGEMENT

During the course of this study invaluable assistance was received from many persons, only a few of whom may be mentioned here. I am especially indebted to Professor Melvin S. Morris, under whose direction the project was organized and carried out. He gave freely of his time both in the field and in the classroom.

I am sincerely grateful to Dr. John J. Craighead, Leader of the Montana Cooperative Wildlife Research Unit1 for valuable assistance throughout the study and for many helpful suggestions in the preparation of the thesis.

Special thanks are due the State of Montana Fish and Game Department for providing equipment and financial aid during the two years of the study. This project would not have been possible without their aid. In particular, I extend my thanks to Stan Mongrain, Manager of the Blackfoot-Clearwater Game Range during the first year of the study, to Wes Woodgerd, Manager of the Game Range during the second year of the study, to Richard L. Hodder, Range Biologist, and to Robert F. Cooney, Director, Wildlife Restoration Division for many valuable suggestions.

I wish to make grateful acknowledgement to the Montana Cooperative Wildlife Research Unit for providing equipment, transportation, and financial aid. My participation in this study was made possible by a research fellowship granted by that organization.

1. Fish and Wildlife Service, U. S. Department of the Interior, Montana Fish and Game Department, Montana State University, and the Wildlife Management Institute cooperating.
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PROPER MANAGEMENT OF ANY SPECIES INVOLVES MAINTAINING A BALANCE BETWEEN POPULATION NUMBERS AND THE COMPLEX FACTORS MAKING UP THE ENVIRONMENT OF THE ANIMAL. SOME OF THE PRINCIPAL FACTORS IN THE ENVIRONMENT ARE FOOD, COVER, AND WATER. COVER AND WATER ARE USUALLY NOT A LIMITING FACTOR IN THE NORTHERN ROCKY MOUNTAIN REGION; HOWEVER, THE TOTAL FORAGE AND RANGE REQUIREMENT OF WILD REMNANTS IN MONTANA IS VERY GREAT AND IN MANY INSTANCES CAN BE THE LIMITING FACTOR. SUFFICIENT FEED IS AVAILABLE TO THEM IN THE SPRING, SUMMER, AND FALL, BUT IN WINTER, WHEN DEEP SNOWS LIMIT THE AMOUNT OF RANGE AVAILABLE, LARGE NUMBERS OF ANIMALS ARE FREQUENTLY CONCENTRATED IN A RELATIVELY SMALL AREA. WHEN THIS OCCURS OVERUSE OR ELIMINATION OF SOME PLANTS FROM THEIR RANGE, AND SOIL DETERIORATION MAY BE THE RESULT.

TO MAINTAIN A BALANCE BETWEEN POPULATION NUMBERS AND FOOD SUPPLY, IT IS NECESSARY TO KNOW THE AMOUNT OF FORAGE PRODUCED ON A GAME RANGE, THE QUALITY OF THIS FOOD, AND THE FORAGE NEEDS AND PREFERENCES OF THE GAME SPECIES PRESENT. TO DETERMINE THE NEEDS AND PREFERENCES FOR ELK A CONTROLLED FEEDING STUDY WAS UNDERTAKEN.

THE PURPOSE OF THIS STUDY WAS TO OBTAIN INFORMATION ON THE NUTRITIONAL VALUE OF IMPORTANT SELECTED FORAGE SPECIES FOR ELK AS EXPRESSED IN FOOD CONSUMPTION AND ANIMAL CONDITION; AND TO DETERMINE A FORAGE REQUIREMENT VALUE FOR ELK AND CATTLE TO USE IN PRESENT AND FUTURE ELK RANGE SURVEYS.

-1-
Native forage plants found on winter game ranges in western Montana were used as basic elk diets in the study. The diets consisted of cured native bunchgrass, meadow hay, and native browse plants and combination diets were formulated from the three basic diets.
The true value of any food material is best determined by actual feeding experiments under control conditions. Chemical analysis of the food does not account for all of the factors determining the value of a food. Animal husbandry investigators have been fully aware of this fact for many years as evidenced by many experiments with domestic livestock. The determination of a food requirement of different classes of animals by feeding under controlled conditions is a standard method.

Food requirement studies with elk are limited. Blunt (1951) reported the consumption of alfalfa hay by elk calves to be 3.6 pounds per animal per night at the National Elk Refuge, Jackson, Wyoming. "Creeper corrals" were used, allowing free access to the forage by the calves but excluding older animals. He was not certain of the number of calves using the corrals during the night. Murie (1951) reports the average daily ration per head fed to elk in several zoological parks as follows:

National Zoological Park, Washington, D.C. - 10 pounds mixed hay, 4 quarts oats and corn, 1 pint bran.

New York Zoological Park - 7 pounds clover hay, 6 quarts plus, crushed oats, some vegetables (more grain in winter).

Philadelphia Zoological Garden - 10 to 15 pounds mixed hay, 3 quarts cracked corn, crushed oats, bran.

He points out that these results are inapplicable to the wild because they include concentrates that elk do not obtain on the range. Murie (1951) also reports that based on estimates of the total number of elk
fed over a known period of time and the grass tonage of hay supplied to them on the National Elk Refuge, daily hay consumption was seven to ten pounds per animal per day. In the winter of 1938-39, the ration was about eight pounds per animal. Murie (1951) also describes a study made on the National Elk Refuge in the winter of 1940-41, under controlled conditions, to determine the food requirements per day, per individual and per hundredweight, over a period of 43 days. In one pen were placed 29 elk calves and in another pen 25 adults (seven bulls and eighteen cows). The animals were weighed at the beginning of the study on February 5 and again when they were released on March 9. The hay given to them was weighed each day. Four Hereford cattle were also fed from the same hay. The average amounts consumed per day were reported:

- Elk Calves........... 7.8 pounds each or 3.11 pounds per cwt.
- Adult Elk............ 12.5 pounds each or 2.50 pounds per cwt.
- Adult Cattle......... 31.0 pounds each or 3.60 pounds per cwt.
- Elk all ages......... 9.8 pounds each or 2.70 pounds per cwt.

The animals were fed an unrestricted diet but the elk not only lost weight but ate progressively less. The cattle gained weight during the study.

Olsen (1945) reported that one adult elk fed at the Utah State Fish and Game Farm consumed 10 pounds of hay and 5 pounds of grain per day, or an equivalent of 17.5 pounds of hay. He also reported that a group of seven elk, including one calf, two yearlings, two cows and two bulls were fed a ration of eleven pounds of hay per animal per day. Olsen concluded that adult cow elk need sixteen pounds of hay per day.
Hungerford (1952) found that adult elk consumed an average of 10.7 pounds of hay daily, or 2.06 pounds per hundredweight. Calves fed hay consumed 5.83 pounds daily or 2.3 pounds per hundred weight. Adult elk consumed 10.4 pounds of stem cured bunchgrass, or 2.02 pounds per hundredweight. The average daily consumption of one elk fed browse was 8.84 pounds forage per day or 2.07 pounds per hundredweight. The adult elk lost weight throughout the study, but the elk calves gained weight during the study period.

No other reports could be discovered describing actual feeding of elk for the purpose of determining maintenance requirements. Other methods have been employed to arrive at the daily consumption of elk. Murie (1951) reports an examination of 139 elk paunches by Assistant Chief Ranger Maynard Barrows, Yellowstone Park, Wyoming, in 1937. Based on the dried contents, he obtained the following averages:

- Bulls - 13.753 lbs.
- Cows - 9.498 lbs.
- Calves - 7.512 lbs.

From these data it was concluded that for the period represented by the stomach contents, adult elk require about 11.5 pounds and calves about 7.5 pounds, per day. Schwartz and Mitchell (1945) report wet paunch weights of recently killed elk to weigh 60 to 98 pounds. West (1941) refers to a paunch of an adult cow elk as being 87 pounds wet weight. The dried contents were 12.8 pounds or 15 per cent of the wet weight.

Several investigators have conducted studies using both mule deer and white-tailed deer. Smith (1953) reported that two mule deer
consumed an average of 3.49 pounds of air dry herbage per hundredweight of deer during the summer months 1947 and 1948. The study was primarily a forage preference study. In an earlier study, Smith (1950) reported the consumption of browse species to be 2.7 and 2.6 pounds per day for a 107 pound and a 106 pound mule deer. Weight was not maintained in this study. Nichol (1938) found that the average consumption of mixed herd of mule deer and Arizona Whitetail deer to be 2.35 pounds per hundredweight. Doman and Rasmussen (1944) recommended 3.0 pounds of air dry forage per hundredweight and 1.0 pounds per day for the average deer. Morland (1951) found that Black-tailed deer consumed 2.85 pounds of forage per hundredweight and the deer lost an average of 8.6 per cent on the browse diet. Davenport (1939) found the average daily total consumption to be 2.94 pounds per hundredweight for calves, 1.91 pounds per hundredweight for does, and 1.85 pounds per hundredweight of northern white-tailed deer.

Murie (1951) reported that the Hereford cattle used in the 1940-41 study on requirements at the National Elk Refuge consumed 3.6 pounds of forage per hundredweight. From this information he concluded that for purposes of range stocking, three elk, herd run are equivalent to one adult domestic cow. Stoddard and Smith (1943) quote Rasmussen, et. al. (1941) and give direct comparisons between cattle and various wild ruminants. He gave a rating of 1 elk equals 4.07 white tailed deer, 3.09 mule deer and 0.53 cattle, or one cow equals 1.88 elk. Rush (1930) quotes a figure of 1.33 elk per head of cattle. Pickford and Reid (1945) defined one cow as equal to 1.25 elk. Sampson (1952) states
that mature elk consume one-half to three-fourths as much forage as a mature domestic cow.

Body surface, although a direct index to forage requirements, is difficult of determination. Most feeding standards are based on weight. Experience in feed lots with cattle show that weight is a sufficiently reliable index (Stoddard and Smith, 1943). Maintenance of weight is the basic criterion for defining a maintenance ration. Wintering of game animals in colder climates, however, maybe accompanied by a normal loss of weight during this season. Murie (1951) states that elk usually lose weight during the winter. Trippensee (1948) states that loss of weight during the winter is probably characteristic of most deer. Feeney (1946) considered a thirty percent weight loss to be fatal in deer. He considered a twenty percent weight loss of adults and a fifteen percent weight loss of fawns to be "allowable".

A review of the literature regarding the feeding value, chemical composition, and digestibility of range forage shows the winter to be generally most critical. Deer foods produced under conditions which resulted in a minimum protein content during the summer were almost valueless in midwinter. Although deer were eating as much bulk as formerly, it appeared that the protein value was so low that the deer received little nourishment (Einarsen, 1946). Mature grasses are comparatively high in energy but low in most other aspects. Elk can winter much better on dry grass than deer, but it is not known whether
or not dry grass alone is an adequate diet to bring elk through a severe winter (Mitchell, 1951). In years past, vast herds of bison depended on cured grass for winter feed, and at present it is not an uncommon practice for farmers and ranchers to turn their horses out on the open range to shift for themselves during the winter. Cattle and sheep, likewise, must depend on the range grasses, wholly or in part, for their winters supply of food (Christensen and Hopper, 1932). Browse plants are comparatively high in protein and phosphorus but are relatively low in energy supplying constituents. Forbs, et al. (1941) shows that winter deer browse is of low nutritive value.

Chemical analyses alone do not give a complete picture of the nutritive value of vegetation, but they do provide a comparative measure and show what constituents are deficient or present in excess. For the most part, however, it is on these analyses that attempts to evaluate the nutritive quality of feeds are based and with reference to which the digestibility of feeds is determined (Ellis, Matrone, and Maynard, 1946). I quote Maynard and Crampton who pointed out the unsatisfactory nature of the customary crude fiber-nitrogen-free extract method when applied to digestibility trials, and suggested the determination of lignin, cellulose, and other carbohydrates (primarily starches and sugars) instead. This method divides the carbohydrates into indigestible, partially digestible, and easily digestible fractions, respectively. It is superior to the old crude fiber nitrogen-free extract method because it provides fractions of biological significance rather than of arbitrary chemical significance,
Since lignin is apparently not digested (Ellis, et. al., 1946, and McCall, et al. 1943), the lignin values in feeds and feces prove useful in determining the coefficient of digestibility of other feed constituents.

The study reported here was designed to obtain further quantitative information on the winter food requirements of elk, and on the nutritive value and digestibility of native range forage.
METHODS AND PROCEDURE

The feeding pens used in the study were constructed during the Fall of 1951 and expanded in the Fall of 1952. The original physical plant consisted of four rectangular units 16 by 80 feet with wedge shaped passages leading to the weighing lane and two large holding pens. The expansion program included the construction of four additional feeding pens. The physical plant now consists of eight individual feeding pens and two large holding pens.

Each pen was provided with facilities for feeding, watering and provided with shelter for the feed. Each pen was designed so that the animals could be driven to the weighing facilities. A building was provided to store the feed and to house the weighing facilities.

The pens are located on the Blackfoot-Clearwater Game Range about 50 miles up the Blackfoot River from Missoula. The immediate vicinity of the pens is frequented in the winter by wild elk.

Experimental Animals-1953

During the winter of 1952-1953 the experimental animals were trapped on the Blackfoot-Clearwater Game Range. Trapping operations began early in December but were unsuccessful until December 17, 1952, when four elk calves and three cow elk were trapped and held for the study. On December 21, one more elk calf and one cow elk were added to the group being held. Additional cow elk were trapped on December 24, when two more were added, December 27, when three more were added
Plate I - Experimental feeding pens viewed from the southwest.

Composition of the meadow hay used in the feeding study.  
1. Agrostis alba  
2. Phleum pratense  
3. Carex spp  
4. Agropyron repens  
5. Taraxacum officinale and Potentilla sp.  
6. Trifolium hybridum
on January 1 and 2, 1954 when one more was trapped each day and held for the study. When the study began, eleven cow elk and five elk calves were available.

In addition to the elk, four mature range cattle were donated for use during the 1952-1953 study by Stan Mongrain, Manager of the game range.

The cow elk, as they were brought into the feeding pens were given meadow hay, stem cured bunchgrass, and mixed browse. The diet of the animals was gradually adjusted toward the diet to be used in the study, so that when the study the animals were in good flesh and were considered to be in normal early winter condition.

At the beginning of the study, the animals were extremely wild and the slightest activity would disturb them.

**Experimental Animals-1954**

Efforts to obtain a supply of elk for the nutrition study began on November 24, 1953 when it was attempted to drive elk on the National Bison Range with the use of a helicopter. Efforts failed because of inclement flying weather. Several other attempts were also unsuccessful.

The first elk were trapped on the Blackfoot-Clearwater Game Range on December 21, 1953 when two cow elk and two elk calves were held for
the study. One cow elk was caught on January 1, 1954 and three cow elk and two calves on January 4, 1954. On January 10, 1954, four cow elk and one calf were added to the study from a group of elk that had been brought to the Blackfoot-Clearwater Game Range as a part of the Yellowstone Park reduction program. When the study began, ten cow elk and five elk calves were available for use in the study.

The elk were handled in a manner similar to the first year. All of the cow elk were fed all of the food materials to be used in the study and the diet of each was gradually adjusted toward the diet to be used in the study. When the study began, all of the elk were extremely wild.

Five mature range cattle were also used in the study. The cattle were contributed for use in the 1953-54 study by Mr. J. J. Hendricks, Cottonwood Ranch, Woodward, Montana.

Forage Collection

Blackfoot Bunchgrass - Stem cured native bunchgrass was harvested on Blanchard Flat on the Blackfoot-Clearwater Game Range on October 23, 24, and 25, 1952. No rain or snow had fallen on the area during the Fall, and as a consequence, the bunchgrass was somewhat more dusty than normal.

The grass was cut with a power mower (Plate II) equipped with a metal pan attached to the sickle bar. The bunchgrass was hauled to the game range headquarters, baled, and stored under cover. About one ton
Facing 13

Plate II - Collecting bunchgrass on the Sun River Game Range.

Equipment used to harvest bunchgrass, showing collecting pan attached to the sickle bar.
was collected and stored. This bunchgrass was not used in the study, but was harvested and held in reserve in the event that inclement weather should prevent harvesting bunchgrass from the Sun River Game Range, Augusta, Montana. No additional bunchgrass was harvested in 1953.

Although the Blackfoot bunchgrass was not used in the study, the composition of the forage is presented for comparison with the bunchgrass harvested on the Sun River Game Range for use in the study. The Composition (Table I) is based on twenty random plots, five square feet, clipped on Blanchard Flat, and is expressed in per cent of total weight by species.

**TABLE I**

**COMPOSITION OF THE BLACKFOOT BUNCHGRASS IN PER CENT OF TOTAL WEIGHT BY SPECIES**

<table>
<thead>
<tr>
<th>Species</th>
<th>1952-53</th>
<th>1953-54</th>
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<tbody>
<tr>
<td>Festuca scabrella</td>
<td>30.52</td>
<td>31.39</td>
</tr>
<tr>
<td>Agropyron spicatum</td>
<td>30.47</td>
<td>35.34</td>
</tr>
<tr>
<td>Festuca idahoensis</td>
<td>24.39</td>
<td>23.48</td>
</tr>
<tr>
<td>Balsamorhiza sagittata</td>
<td>6.91</td>
<td>4.83</td>
</tr>
<tr>
<td>Koelaria cristata</td>
<td>2.79</td>
<td>2.30</td>
</tr>
<tr>
<td>Miscellaneous weeds</td>
<td>.92</td>
<td>.66</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100.00%</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

**Sun River Bunchgrass** - On November 1, and 2, 1952, stem cured bunchgrass was mowed on the Sun River Game Range near Augusta, Montana. The grass was mowed as close to the ground as possible using the same equipment that had been used to harvest the grass on Blanchard Flat. It was baled and hauled to the Headquarters of the Blackfoot-Clearwater Game Range, near the feeding pens, and stored under cover for future use. The area harvested had been covered by eight inches of snow on October 13
but had melted off by the time the bunchgrass was harvested. It was desirable to get forage similar in nutritive value to forage that the wild elk would be using during the winter. It is doubtful whether enough precipitation had fallen on the forage to cause nutrient loss through leaching equivalent to that which could be expected in forage collected in midwinter. Results of chemical analysis (Appendix, Table X) of a sample of the forage collected during the Fall compared with the results of a sample collected in late February, 1953 indicates that the nutritive quality of the feed was similar. The work of Hart, et al. (1932), McCall (1939), Helmers (1940), Stoddard (1941) and Cook and Harris (1950) all indicate that it would be expected that the more soluble fractions would have been leached out of the forage used in the study by the time it was cut, but this was not the case.

On October 29 and 27, 1953, stem cured bunchgrass was collected on approximately the same area as the previous year on the Sun River Game Range. The method of harvesting and handling was the same as had been used on the Blackfoot-Clearwater Game Range and on the Sun River Game Range the previous year. One and one-half tons of forage was harvested each year for the study.

The composition, based on twenty random samples, five square feet each, clipped in the immediate area, is presented in Table II. Composition is expressed in per cent of total weight by species.
### TABLE II

COMPOSITION OF THE SUN RIVER BUNCHGRASS IN PER CENT OF TOTAL WEIGHT BY SPECIES

<table>
<thead>
<tr>
<th>Species</th>
<th>1952-53</th>
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<tbody>
<tr>
<td>Agropyron spicatum</td>
<td>16.00</td>
<td>18.50</td>
</tr>
<tr>
<td>Festuca scabrella</td>
<td>13.80</td>
<td>26.00</td>
</tr>
<tr>
<td>Festuca ovina</td>
<td>13.80</td>
<td>14.60</td>
</tr>
<tr>
<td>Balsamorhiza sagittata</td>
<td>11.50</td>
<td>15.40</td>
</tr>
<tr>
<td>Lupinus sp.</td>
<td>0.00</td>
<td>4.50</td>
</tr>
<tr>
<td>Koeleria cristata</td>
<td>2.30</td>
<td>0.00</td>
</tr>
<tr>
<td>Muhlenbergia asperifolia</td>
<td>0.00</td>
<td>3.40</td>
</tr>
<tr>
<td>Oxytropis sp.</td>
<td>0.00</td>
<td>1.50</td>
</tr>
<tr>
<td>Phleum pratensis</td>
<td>1.10</td>
<td>0.00</td>
</tr>
<tr>
<td>Miscellaneous weeds</td>
<td>11.50</td>
<td>16.10</td>
</tr>
<tr>
<td>100.00%</td>
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</tbody>
</table>

Chemical analysis (Appendix, Tables X and XI) of samples of bunchgrass collected both years from the Sun River Game Range and from the Blackfoot-Clearwater Game Range show the forage on both of these ranges to be of similar nutritive value. The dominant species, making up the bulk of the food material, was also very similar (Tables I and II). Bunchgrass from either game range could probably have been used in the study with comparable results.

Hay - Irrigated meadow hay was selected from hay harvested on the Blackfoot-Clearwater Game Range. A portion of the meadow was selected that was as free from long awned grasses as possible and without a high percentage of clover and sedges. A meadow hay of medium nutritive quality was desired, near an average for western Montana (Plate 1).
Plate III - Elk calves used in the feeding study showing method of feeding.

One of the cattle used in the study showing general type and conformation of the animals.
Chemical analysis (Appendix, Table X) of a sample of the forage harvested from the meadow the first year showed the forage to be deficient in protein and to have a very wide calcium to phosphorus ratio. The meadow was fertilized in the early spring of 1953 to correct these deficiencies. They hay was harvested in early August each year, baled and stored under cover for use in the study. About two and one-half tons were harvested for the study in 1952 and three tons in 1953.

The composition of the meadow hay was based on twenty random samples, five square feet, in 1952 and from baled samples collected throughout the feeding period in 1953 and 1954 is presented in Table III. Composition is expressed by per cent of total weight by species.

TABLE III

<table>
<thead>
<tr>
<th>Species</th>
<th>1952-1953</th>
<th>1953-1954</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agrostis alba</td>
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<td>46.73</td>
</tr>
<tr>
<td>Phleum pratensis</td>
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<td>37.27</td>
</tr>
<tr>
<td>Carex longistis</td>
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<td></td>
</tr>
<tr>
<td>Carex nebraskensis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carex festivella</td>
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<td></td>
</tr>
<tr>
<td>Eleocharis sp.</td>
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<td>13.10</td>
</tr>
<tr>
<td>Agropyron repens</td>
<td>3.87</td>
<td>1.42</td>
</tr>
<tr>
<td>Taraxacum sp. and potentilla sp.</td>
<td>1.94</td>
<td>.78</td>
</tr>
<tr>
<td>Trifolium hybridum</td>
<td>.87</td>
<td>.70</td>
</tr>
</tbody>
</table>

100.00% 100.00%

Browse - The browse supply was cut at weekly intervals both years throughout the feeding period on the Flathead Indian Reservation lands near Evaro, Montana, utilizing student help. Two species of Salix sp.
and *Amelanchier alnifolia* were the major species available. *Acer glabrum*, *Cornus stolonifera*, and *Ceanothus velutinus* were collected in the Blackfoot River valley within a ten mile radius of the feeding pens. The branches were cut in four foot lengths and tied in bundles with heavy twine. The browse was trucked to the feeding pens and stored until needed. Approximately one and one-half tons of browse were used each week during both years of the feeding study.

**Feeding Methods**

A known weight of hay or grass was fed to the animals each morning in the sheltered feed bunks (Plate IV). The next morning, the remaining unused material was reweighed and the amount consumed was calculated by difference. All of the feed material was weighed with a Hanson dairy scale and weights were recorded to the nearest one-tenth pound. After the amount consumed had been determined, an amount of forage approximately equal to that consumed was added to bring the total weight up to the daily ration. Approximately one-third more feed was presented to each animal than it normally consumed to be sure it would take as much as it desired. Twice, each week, all of the coarse refused material was weighed and discarded and a new daily ration presented to the animal. This was done to give the animals some choice but to prevent the use of only the most palatable species in the hay or grass.

The browse forage was tied into bundles for ease in handling and to keep the elk from scattering the material. Sufficient browse forage was presented to the animal so that approximately fifteen or
Plate IV - Cow elk feeding in the shelter over the feed bunk.

Cow elk feeding on browse under shelter erected to keep snow off the browse.
more pounds of current years growth was available. It was not possible
to present equal amounts of different species to the elk at all times
because of the difficulty of procuring large amounts of some of the
species.

Several methods of presenting the browse to the animals were
tried before a satisfactory method was found. The most satisfactory
method tried was to place the browse bundles behind a rub-rail along
the fence. Shelters were constructed over the browse in the rub-rails
to eliminate snow and rain. The browse bundles were weighed before and
after being browsed by the elk, using the same scale that was used to
weigh the hay and grass.

The amount of forage consumed in a feeding study is usually re-
duced to an air dry basis. This was done when the forage varied in
moisture content or when precipitation fell on the feed during the ex-
periment (Moreland, 1951). The meadow hay and bunchgrass were sheltered
from the time they were cut until used by the elk in the study so that
it was unnecessary to apply a correction factor. The browse forage,
collected fresh each week, was found to vary considerably in moisture
throughout the study period. Samples, seventy-five to one-hundred
grams, were taken twice each week throughout the study period, dried
to air dry moisture content and reweighed. All browse weights were
adjusted to an air dry basis to make the weights of hay, grass, and
browse comparable.

The average moisture content of the browse used in the study is
presented in Table IV.
TABLE IV

AVERAGE MOISTURE CONTENT OF BROWSE FORAGE
USED IN THE STUDY

<table>
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<th>1953-54</th>
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</thead>
<tbody>
<tr>
<td>January</td>
<td>19.49%</td>
<td>24.35%</td>
</tr>
<tr>
<td>February</td>
<td>22.50%</td>
<td>29.29%</td>
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</tbody>
</table>

Weather Data

Weather data were recorded both years throughout the study period. Maximum and minimum temperatures were read at 5 o'clock P.M. daily. Daily average wind velocities were obtained from a three cup anemometer mounted in the center of the feeding pens.

Chemical Analysis

The analyses commonly made on feedstuffs are: moisture, ether extract, crude protein, crude fiber, ash, and nitrogen free extract. These analyses show the relative proportions of the various nutrient constituents present in the food material. Samples were taken daily of all of the diets throughout the period of the study. The chemical analyses were conducted by the Department of Chemistry Research, Montana Agricultural Experiment Station, Bozeman, Montana and was carried out in accordance with A.O.A.C. standards. Results of the chemical analyses of the food material used in the study are shown in the Appendix, Tables X and XI.

Lignin values for both the food and the feces were determined by a method suggested by Ellis, Matrone, and Maynard (1946). Details
of the Lignin determination method are presented in the Appendix. Since lignin is apparently not digested by ruminants, the lignin values of the feeds and feces may be used to determine the relative digestibility of the other constituents in the feed. This method of determining digestibility is referred to as the lignin ratio method. Samples used for lignin determination of the feed was a part of the same material used in the standard analysis. Samples of the feces for lignin determination were collected twice each week throughout the study period both years. The lignin determinations were done in duplicates. In cases of obvious lack of correlation, an error in laboratory procedure was considered to be present and the test was repeated. The relative digestibility of the feed was determined by using the following formula:

$$\text{Percent Digestibility of a Feed} = 100 - \left( \frac{\% \text{Lignin in Feed}}{\% \text{Lignin in Feces}} \times \frac{\% \text{NonLignin in Feces}}{\% \text{Non Lignin in Feed}} \right)$$
Results with Bunchgrass

Animals #3 and #8 were fed together in one of the feeding pens from January 6, 1953 until February 16, when cow #8 was removed from the study. Cow #3 was fed alone in the pen until March 1. Daily consumption and consumption per hundred pounds of body weight was calculated as an average of the two during the time they were being fed together. The initial weight of cow #3 was 148 pounds and of cow #8, 501 pounds. Both were animals trapped on the Blackfoot-Clearwater Game Range.

Two more animals, #2 and #7, were fed a bunchgrass diet from January 11 until March 7, 1954. Cow #2 was given a bunchgrass-conifer diet, but since she showed no preference for any of the coniferous browse presented to her during the period of the study, she was essentially taking a bunchgrass diet. The animals were fed in separate pens throughout the study. Consumption values were computed as an average of the two animals. The initial weight of cow #2 was 510 pounds and of cow #7, 472 pounds, and both were a part of the group brought to the Blackfoot-Clearwater Game Range as a part of the Yellowstone Park reduction program. During the second year of the study, the animals were handled the same during the adjustment period and were fed the same weight of feed as during the previous year.

The average food consumption of the pair of cow elk fed bunchgrass was 10.75 pounds, or 2.30 pounds of feed per hundred weight during the first year of the study. Total average consumption and
Figure I  Food Consumption and Weight Trends of Cow Elk on Native Bunchgrass Diet
and consumption per hundred weight was lower during the second winter of the study, when they were fed in separate pens. The cow elk consumed an average of 7.75 pounds of bunchgrass daily, or 1.58 pounds of food per hundred weight during the second year of the study.

The animals did not maintain their original weight either year when fed the bunchgrass diet. The loss in weight was 6.45 per cent of the study and 1.93 per cent during the second year. Weight trends and average daily consumption are shown in Figure 1. Consumption of bunchgrass per hundred weight compared to other diets is shown in Figure 8.

**Results with Meadow Hay**

Cow elk #2 and #4 were fed together in one of the feeding pens. Cow #5 was fed separately in an adjacent feeding pen. All three elk had been previously trapped on the Blackfoot-Clearwater Game Range and had been given a diet of bunchgrass, meadow hay, and browse, until the study began. The relative proportions of the different food materials had been adjusted gradually toward the meadow hay diet to avoid an abrupt change in diet. The original weight of cow #2 was 429.5 pounds, of cow #4, 538 pounds, and of cow #5, 432 pounds. All three elk were given the meadow hay diet from January 4, until February 1, when cows #2 and #4 were removed from the study (Disease, Injuries, and Mortality, Page 50). Cow #5 continued in the study with a browse-hay diet.

During the second winter of the study, cow #1 trapped on the Blackfoot-Clearwater Game Range was given a meadow-hay diet for 34 days.
from December 28 to February 1. She was removed from the study at that time because she failed to adjust to captivity. Her original weight was 466 pounds.

During both years of the study, the elk were given from 15 to 78 pounds of hay per animal. The coarse refused material was discarded twice each week. None of the cow elk maintained their original body weight during either year of the study. During the first winter of the study the elk ate an average of 7.23 pounds of air dry hay daily, or 2.01 pounds of feed per hundred weight and lost 2.66 per cent of their original body weight. During the second winter of the study, cow #1 ate an average of 9.72 pounds of air dry hay per day, or 2.09 pounds per hundred weight and lost 6.00 per cent of her original body weight. Weight trends and average daily food consumption are shown in Figure 2. Comparative consumption of air dry hay per hundred weight is shown in Figure 8.

Five elk calves, trapped on the Blackfoot-Clearwater Game Range were fed air dry meadow hay in one of the large holding pens during the first year of the study. Five elk calves were also fed hay during the second year of the study. Four of the calves were trapped on the Blackfoot-Clearwater Game Range and one calf was added to the study from the group brought to the Blackfoot-Clearwater Game Range from Yellowstone Park.

The average feed consumption for the calves during the first year of the study was 6.75 pounds of air dry hay, or 2.59 pounds per
Figure 2 - Food Consumption and Weight Trends of Cow Elk on a Meadow Hay Diet
Figure 3 - Food Consumption and Weight Trends of 5 Elk Calves on a Meadow Hay Diet
hundred weight and gained 1.73 per cent of their original body weight. During the second winter the calves consumed 7.32 pounds each daily, or 2.66 pounds per hundred weight and gained 0.18 per cent of their original body weight. The weight trends and daily consumption for both years of the study are shown in Figure 3. Comparative consumption during both years of the study per hundred weight is shown in Figure 8.

Four mature range cattle were fed meadow hay during the first winter of the study and five during the second winter, in a large holding pen adjacent to the elk feeding pens. The average feed consumption during the first winter of the study averaged 17.14 pounds daily, or 2.01 pounds per hundred weight. The five cattle averaged 19.56 pounds of hay each during the period of the study, or 2.36 pounds per hundred weight. During the first year of the study, the cattle lost 3.57 per cent and during the second year of the study they gained 4.15 per cent. During both years of the study the cattle consumed an amount of food commensurate with their age and weight when compared to National Research Council standards. Daily consumption and weight trends of the cattle are shown in Figure 4. Comparative consumption per hundred weight for the cattle for both years of the study is shown in Figure 8.

**Results with Browse**

During the first year of the study Cow #6 was given a mixed deciduous browse diet. After she had been trapped on the Blackfoot-Clearwater Game Range and moved to the feeding pens, she was given hay, bunchgrass, and mixed browse before the study began, a diet similar to the other elk in the study. Her diet was gradually changed toward
Figure 4 - Food Consumption and Weight Trends of Cattle on a Meadow Hay Diet
Figure 5 - Food Consumption and Weight Trends
of Cow Elk on a Browse Diet
browse during the adjustment period. At the beginning of the study she weighed 556 pounds. From January 6 to January 30 she lost 10.88 per cent of her body weight and was removed from the study.

During the second year of the study Cows #3 and #5 were given a mixed deciduous browse diet from January 25 to March 7. Both animals had been trapped on the Blackfoot-Clearwater Game Range and had also been given hay, bunchgrass, and mixed browse during the adjustment period. The animals were fed in separate pens throughout the study period because it was impossible to present enough browse for both of the animals in one pen.

The food consumption during the first year of the study for one elk averaged 8.68 pounds daily, or 1.56 pounds per hundred weight. Cow #6 lost an excessive amount of weight, 10.88 per cent, during the 27 day period she was given mixed browse.

Cows #3 and #5 consumed an average of 9.77 pounds of forage each during the 42 days they were mixed browse, or 2.08 pounds of food per hundred weight. All weights of food eaten have been adjusted for moisture content (Table IV). These animals lost an average of 1.92 per cent of their body weight during the period. Daily food consumption and weight trends are shown in Figure 5. Comparative consumption per hundred weight is shown in Figure 8.

**Results with Hay-Browse**

A combination diet of meadow hay-mixed deciduous browse was added to the study on February 2 during the first year of the study.
Cow #5 which had been given a meadow hay diet during the early period of the first year of the study was changed over to the new diet. During the preceding period this cow had eaten an average of 7.23 pounds daily, or 1.68 pounds per hundred weight and had lost an average of 2.66 per cent. When mixed browse was added to her diet, her daily consumption was raised to 13.14 pounds or 3.18 pounds per hundred weight. Her rate of weight loss was also changed when browse was added to her diet. She had lost 2.66 per cent when fed only hay and 1.54 per cent when browse was added.

A meadow hay-browse diet was also used during the second year of the study. Cow #4 was trapped on the Blackfoot-Clearwater Game Range and Cow #9 was added to the study from the group brought in to the Game Range from Yellowstone Park. Both animals were fed in the same pen from January 10 to March 7. The consumption for both animals the second year was 12.93 pounds daily, or 2.15 pounds per hundred weight. The original weight of Cow #4 was 467 pounds and of Cow #9, 478 pounds. These two cows gained an average of 2.12 per cent of their original body weight during the study period. During the first year of the study, browse made up 39.01 per cent and hay made up 68.91 per cent of the food consumed by the elk. During the second year of the study, browse made up only 9.00 per cent, and hay 91.00 per cent of the food consumed by the elk. The food consumption and weight trends of the animals during both years of the study are shown in Figure 6. Comparative consumption per hundred weight is shown in Figure 8.
Figure 6 - Food Consumption and Weight Trends of Cow Elk on a Hay-Browse Diet
Results with Bunchgrass-Browse

A combination diet of bunchgrass-mixed deciduous browse was fed during both years of the study. This diet combination was formulated to simulate conditions found on several elk winter ranges in the foot-hill regions of western Montana.

Two cow elk, both trapped on the Blackfoot-Clearwater Game Range, were fed the combination diet during the first year of the study. Both cows were fed together from January 6 until February 1, when one cow continued on in the study until March 1. When the study began, Cow #7 weighed 477.5 pounds and Cow #10 weighed 464 pounds. During the period of the study, 11.80 pounds of food were taken by the elk, or 2.49 pounds per hundred weight. These animals lost 0.35 per cent of their original body weight. Bunchgrass made up 62.25 per cent of the food consumed while mixed browse made up 37.75 per cent.

During the second year of the study, two more elk were given the same diet. Cow #6, weighing 513 pounds and trapped on the Blackfoot-Clearwater Game Range was paired with Cow #8, weighing 504 pounds and trapped in Yellowstone Park and moved the study area on the Blackfoot-Clearwater Game Range. Both animals were fed in the same pen together until February 15, when Cow #6 was removed from the study and turned loose. She was removed from the study because she did not adjust to confinement in the feeding pens.

During the period of the study the second year, the elk consumed an average of 9.28 pounds of forage daily, or 1.90 pounds per hundred
Figure 7 - Food Consumption and Weight Trends of Cow Elk on a Bunchgrass-Browse Diet
weight. The animals did not maintain their original body weight during the second year of the study but lost 5.36 per cent. Bunchgrass made up 66.01 per cent of the food taken by the elk while mixed browse made up the remaining 33.09 per cent. The food consumption and weight for this combination diet during both years of the study are shown in Figure 7. Comparative consumption per hundred weight is shown in Figure 8.

**Results with Bunchgrass-Conifer**

During the first year of the study, it was planned to use a combination diet composed of bunchgrass and conifer browse. The cow elk assigned to this diet did not adjust to confinement in the feeding pens and was removed from the study after only a few days. During the short period of time she was given conifer browse and she showed no preference for it.

Cow #2, weighing 510 pounds and brought to the Blackfoot-Clearwater Game Range from Yellowstone Park was given the same combination diet during the second year of the study. The conifer browse consisted of Douglas fir (*Pseudotsuga taxifolia*) and Lodgepole Pine (*Pinus contorta var. Murrayana*) and the supply of this food material was collected locally as it was needed in the study.

During the period of the study, no preference was shown for conifer browse. The food consumed by the elk was essentially a bunchgrass diet and the consumption values are included under that heading.
Figure 8 - Comparison of Consumption per Hundredweight of Cow Elk, Elk Calves and Cattle
Throughout the two winters of the study, weights of the various browse species were recorded by species. To obtain a measure of browse preference, the amount of the food eaten by the elk was compared to the total amount available to them each day. During the first year of the study, Dogwood (*Cornus stolonifera*), and Snowbrush (*Ceanothus velutinus*) rated the highest. The preference values were 16.39 per cent and 16.07 per cent, respectively, although these values are based on only a few days. The elk used 10.94 per cent of the total amount of Willow (*Salix* spp.), 7.50 per cent of the Mountain Maple (*Acer glabrum*) and 6.19 per cent of the Serviceberry (*Amelanchier alnifolia*). Two browse species, Sage Brush (*Artemisia tridentata*) and Russet Buffalo Berry (*Elaeagnus canadensis*), received 0 per cent preference. Browse preference in percent of the total amount available to the elk in 1953 is presented in Table V.

In the second year of the study, Snowbrush again rated the highest with a value of 27.58 per cent. Willow rated second with a value of 14.99 per cent. Dogwood was rated third with a value of 11.94 per cent. The elk used 10.06 per cent of the Mountain maple and 7.55 per cent of the Serviceberry. Again the second year of the study, Snowbrush, Mountain maple, and Dogwood were in short supply and could be used in the study only when available. Browse preference in percent of total amount available to the elk in 1954 is presented in Table VI.
<table>
<thead>
<tr>
<th>Serviceberry</th>
<th>Total Available Pounds</th>
<th>Per cent of Diet</th>
<th>Ave. Available/day Pounds</th>
<th>Total Eaten Pounds</th>
<th>Ave. Eaten/day Pounds</th>
<th>No. of days Available</th>
<th>Per cent Eaten</th>
</tr>
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<tbody>
<tr>
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<td>10.94</td>
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TABLE VI
BROWSE PREFERENCE IN PER CENT OF THE TOTAL AMOUNT AVAILABLE THAT WAS Eaten BY THE ELK - 1954

<table>
<thead>
<tr>
<th>Plant</th>
<th>Total Available Pounds</th>
<th>Per cent of Diet</th>
<th>Ave. Available/day Pounds</th>
<th>Total Eaten Pounds</th>
<th>Ave. Eaten/day Pounds</th>
<th>No. of days Available</th>
<th>Per cent Eaten</th>
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<td>7210.80</td>
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<td>11.94</td>
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<tr>
<td>Species</td>
<td>1953 Ave. Amount eaten per day</td>
<td>1953 Per cent of Species in ave. daily diet</td>
<td>1954 Ave. amount eaten per day by each cow</td>
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<tr>
<td>Russet Buffaloberry</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>15.23 lbs</strong></td>
<td><strong>100.00%</strong></td>
<td><strong>10.82 lbs.</strong></td>
<td><strong>100.00%</strong></td>
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</tbody>
</table>
The average amount of browse by species eaten per day by the cow elk given a browse diet during both of the years of the study is presented in Table VII. The amount of each species eaten by the cow elk was influenced by the amount of each species that was available to feed the elk. It was not possible to give the elk enough of each of the species used in the study to arrive at a true preference rating. The fact that Serviceberry, for instance, made up 34.60 per cent of the amount taken by the elk in 1953 and 36.58 per cent in 1954 is a reflection of the amount available rather than a preference rating. If enough of each browse species had been available so that the elk could have had free choice, the values would represent a more complete picture of the food habits. Willow, which made up 29.35 per cent of the diet in 1953 and 25.59 per cent in 1954, made up 34.72 per cent of the total of the browse available in 1953 and 24.97 per cent of the total available in 1954 (Table V and VI). Serviceberry made up the bulk of the rest of the browse available, 62.70 per cent in 1953 and 70.36 per cent in 1954. If as much willow had been available for use in the study as Serviceberry, the preference ratings may have been changed considerably.

During the adjustment period, before the study began, all of the cow elk were given meadow hay, mature bunchgrass, and mixed browse. During this period none of the cow elk ate any of the browse and very little of the bunchgrass. Bunchgrass was eaten in small amounts when sufficient hay was not available to them.
Relative Digestibility of Forage

The lignin values for both the food and the feces and the calculated per cent digestibility of the food is presented in Table VIII.

<table>
<thead>
<tr>
<th>Diet</th>
<th>Per cent Lignin in food</th>
<th>Per cent Lignin in feces</th>
<th>Calculated Per cent Digestibility of food</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1953</td>
<td>1954</td>
<td>1953</td>
</tr>
<tr>
<td>Hay</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elk calves</td>
<td>7.99</td>
<td>8.11</td>
<td>16.71</td>
</tr>
<tr>
<td>Cow elk</td>
<td>7.99</td>
<td>8.11</td>
<td>17.28</td>
</tr>
<tr>
<td>Cattle</td>
<td>7.99</td>
<td>8.11</td>
<td>18.98</td>
</tr>
<tr>
<td>Bunchgrass</td>
<td>9.31</td>
<td>9.13</td>
<td>16.21</td>
</tr>
<tr>
<td>Browse</td>
<td>18.47</td>
<td>18.89</td>
<td>21.06</td>
</tr>
<tr>
<td>Hay - Browse</td>
<td>11.25</td>
<td>12.64</td>
<td>17.58</td>
</tr>
<tr>
<td>Bunchgrass -</td>
<td>12.77</td>
<td>11.97</td>
<td>22.59</td>
</tr>
</tbody>
</table>

Patton and Gieseker (1942) stated that lignin was not only indigestible, but also that it decreased the digestibility of other constituents by the mechanical effect of an indigestible encrusting material.
There is some indication in the study that lignin content of the diet did affect the digestibility of the nutrients in the food. Table VIII shows when the lignin content is high, the digestibility of the food material is low. The low calculated digestibility of the browse is also reflected in the weight response of the elk (Figure 5). Chemical analyses (Appendix Table X and XI) show that the browse was one of the best diets in the study.

Meadow hay and bunchgrass, which had a lower lignin percentage, also had a higher calculated digestibility. Combination diets varied in lignin percentage depending on how much hay, bunchgrass, or browse the animals ate. The calculated digestibility of these diets varied almost directly with the lignin content.

The percent of lignin in the diets was found to be very similar in both years of the study. The percent of lignin in the feces differed more widely in the two years, indicating a variability in the digestive capacities of the elk. This individual variability is reflected in the calculated percent digestibility of the food (Table VIII).
ADDITIONAL OBSERVATIONS

Temperament

The adult cow elk used in the study were very nervous and excitable during the adjustment period and well into the study period. As the study progressed they became more adapted to the routine activities necessitated by the study and to the presence of familiar humans. Any change in the routine activities or any outside visitors were immediately detected by the elk. During both years of the study, none of the elk would eat during the daylight hours when any humans were present, until well toward the end of the study period, when several of the cow elk were observed coming up to the feed bunks and eating immediately after the daily ration was put before them. Cow #3 became tame enough to take food from any familiar persons hand during the second year of the study but would immediately become disturbed if an unfamiliar person came near the feeding pens. Anger was usually expressed by the cow elk by grinding of the teeth or by striking with the front feet, and occasionally by barking. Disturbance was expressed by pacing back and forth along the fence. The calves milled around when they were disturbed. The elk calves became well adjusted early in the study both years and even if they were disturbed by unfamiliar visitors, would soon become adjusted to the new situation.

All of the animals became excessively disturbed when they were driven from their pens to the scales to be weighed. Food consumption dropped from one day and occasionally for two days following the
Plate V - Cow elk used in the study. Also showing canvas curtains erected at the back end of each pen used by the elk to hide behind when disturbed.
disturbance (Figures 1 through 7). Less and less difficulty was experienced weighing the animals as the study progressed and by the end of the study the elk were disturbed very little by the experience. Usually, after an initial weight loss when the cow elk were first brought to the pens, they gained back the lost weight as they became adjusted to the conditions of the study. If the elk were unable to adjust to confinement, the loss in weight continued.

When cow elk or elk calves were fed together, they ate side by side in the feeding shelter (Plate III).

In general, beginning with the calves, and progressing through the older age groups, the animals became progressively less able to adjust themselves to confinement and to the presence of humans. The calves were always easy to handle and adjusted readily to any new situation. Cow #3, during the second year of the study, had been ear-tagged as a calf two and one-half years before, and still retained the ability to adjust to a new situation, although less so that the calves. Older cow elk, as judged by increasing incisor wear in the lower jaw, remained wild.

During the middle of January of the first year of the study, canvas curtains were hung across the pen, eight feet from the end to break the momentum of the elk, in case they became excessively disturbed and ran down to the end of the pen too fast to stop before running into the fence and injuring themselves (Plate V). The elk soon began using
the canvas to hide behind whenever they became disturbed. The canvas proved to have a quieting influence on the elk. The use of canvas across the pen proved successful during the second year of the study as well.

No difficulty was experienced using mature range cattle in the study. They readily adjusted themselves to the conditions of the study within a very short time.

**Disease, Injuries, Mortality**

During the first year of the study, seven of the cow elk became infected with hoof rot. Excessive wearing of the hooves of the elk and the resulting infection was determined to be the cause of death. All seven of the elk that were infected were removed from the study and were autopsied by personnel from the U. S. Public Health Service, Hamilton, Montana. During the second year of the study when the canvas curtains were employed from the beginning of the study and considerable screening was done to get younger animals for the study, no difficulty was experienced with the hoof rot. Three cow elk were removed from the study the second year however, when it was seen that they remained wild and did not adjust themselves to confinement.

One calf was injured before the study began during the first year when it ran into the fence at the end of the pen. The calf soon recovered however, and was fed throughout the study period. One calf was injured during trapping operations the second year and developed
a limp in the left hind leg. The calf was replaced by another calf before the study began. There was no evidence of necrotic stomatitis in the elk calves.

Water Consumption

Water was made available to the cow elk and the calves by placing a metal container in the pen and filling it by hand through the fence daily. During most of the first winter, and throughout the second winter, fresh snow was available to the elk. During the first winter of the study all of the Blackfoot elk including the calves drank the water, the Yellowstone Park elk preferring to eat snow. The water was not measured quantitatively but the amount used by the cow elk was judged to be about eight quarts for each animal daily, including any evaporation. The calves used about one-half as much as a cow elk, or about four quarts. Some difficulty was experienced from the water freezing before it was used by the elk, but as the study progressed, the elk learned to use the water before it became frozen.

The range cattle used in the study had free access to the water in Johnson's Spring Creek and no quantitative information is available from these animals.

Salt Consumption

Crushed rock salt was available to the elk from the middle of January of the first year of the study and throughout the second year. Very little salt was consumed. Cows #3 and #8, fed a bunchgrass diet, used a small amount over an extended period of time. Little desire for
salt was evident during the second year of the study. The range cattle had free access to block salt and used it freely during both years of the study.

**Concentrates**

During the adjustment period before the study began each year, one-fourth to one-half pound amounts of steer fattener pellets, manufactured by the Montana Flour Mills, Missoula, Montana, were given to each elk. The food was a 15.00 per cent protein concentrate. Both the adult elk and the calves ate the concentrate freely during the first year, but during the second year, the Yellowstone Park elk and the elk calves refused it completely. The Blackfoot elk, used in the study, again used it freely during the second year.

**Influence of Weather**

Neither cold weather nor storms caused any apparent discomfort to the elk or cattle. The cattle commonly bedded down under shelter but the elk were never observed using the shelters because of inclement weather. Temperatures were relatively warm during the first year of the study (Figure 10) and the influence of weather factors on forage consumption and weight trends are difficult to interpret. During the second winter of the study extended periods of cold weather were experienced but showed little effect on the forage consumption of the elk (Table IX). The average intake per cow elk per day steadily increased throughout the study period and cannot be correlated with weather conditions, but rather, may be explained in terms of tempera-
Figure 9 - Daily Maximum and Minimum Temperatures at Study Pans
As the elk became more adjusted to the conditions of the study the forage consumption increased.

**TABLE IX**

RELATION OF TEMPERATURE TO FOOD CONSUMPTION & WEIGHT RESPONSE IN 1954

<table>
<thead>
<tr>
<th>Two-week Period</th>
<th>Ave. daily Temperature</th>
<th>Ave. intake per cow per day</th>
<th>Ave. per cent gain or loss in weight per cow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan. 11 to Jan. 24</td>
<td>8.4°F</td>
<td>9.14 lbs.</td>
<td>-1.72%</td>
</tr>
<tr>
<td>Jan. 25 to Feb. 7</td>
<td>24.5°F</td>
<td>10.02 lbs.</td>
<td>-2.17%</td>
</tr>
<tr>
<td>Feb. 8 to Feb. 21</td>
<td>28.7°F</td>
<td>10.89 lbs.</td>
<td>+1.85%</td>
</tr>
<tr>
<td>Feb. 22 to Mar. 7</td>
<td>24.7°F</td>
<td>10.89 lbs.</td>
<td>-1.28%</td>
</tr>
</tbody>
</table>
SUMMARY

1. A study was conducted during the winters of 1953 and 1954 to obtain a quantitative food requirement for elk to use in present and future elk range surveys. Other major objectives were to rate native forage plants for use in inventory work on elk ranges, and to compare nutritional values of various types of feed available to elk on the winter range.

2. A supply of stem cured bunchgrass was harvested from the Sun River Game Range each fall for use in the Study. Meadow Hay was harvested each year from the Blackfoot-Clearwater Game Range. Native browse species were cut at weekly intervals throughout the study period.

3. Eleven cow elk and five elk calves were trapped on the Blackfoot-Clearwater Game Range in early winter of 1953 for use in the study. Four mature range cattle were also used in the study the first year. Six cow elk and four elk calves were trapped in the early winter of 1954 on the Blackfoot-Clearwater Game Range. Four additional cow elk and one calf were added to the study from a group brought in to the Blackfoot-Clearwater Game Range as a part of the Yellowstone Park reduction program.

4. Diets studied included meadow hay, fed to cow elk, elk calves, and mature range cattle, stem cured bunchgrass, fed to cow elk, and browse, fed to cow elk. Combination diets of meadow hay-browse and bunchgrass-browse were also fed to cow elk. Food material was weighed and recorded to one-tenth pound. Animals on all diets were fed an unrestricted amount of the forage.
5. Standard forage analyses were conducted by the Department of Chemistry Research, Montana Agricultural Experiment Station, Bozeman, Montana, and carried out in accordance with A.O.A.C. standards. Lignin values for both the feed and the feces were determined by the author.

6. Two cow elk, fed stem cured bunchgrass during the first year of the study, consumed an average of 10.75 pounds each or 2.30 pounds of forage per hundredweight. During the second year of the study, two cow elk consumed an average of 7.75 pounds each, or 1.58 pounds per hundredweight.

7. Three cow elk, fed meadow hay during the first year of the study, consumed an average of 7.23 pounds of forage each, or 2.04 pounds per hundredweight. One cow elk consumed an average of 9.72 pounds of air dry forage, or 2.09 pounds per hundredweight. Five elk calves, fed meadow hay, consumed 6.75 pounds of air dry forage each or 2.59 pounds per hundredweight. During the second winter of the study, five elk calves consumed an average of 7.32 pounds of air dry forage each daily, or 2.66 pounds per hundredweight. Four mature range cattle, fed meadow hay, consumed 17.04 pounds of forage daily, or 2.04 pounds per hundredweight. During the second year of the study, five mature cattle averaged 19.56 pounds each, or 2.36 pounds of forage per hundredweight.

8. One cow was fed mixed native browse during the first winter of the study. She consumed 8.68 pounds of forage daily, or 1.56 pounds of forage per hundredweight. Two cow elk, fed the same diet, consumed
an average of 9.77 pounds of forage each, or 2.08 pounds per hundredweight.

9. One cow elk, fed a combination diet of hay-browser consumed 13.4 pounds of forage, or 3.18 pounds per hundredweight. Two cow elk, fed this diet the second year each consumed 12.93 pounds of air dry forage or 2.45 pounds per hundredweight.

10. Two cow elk, fed a bunchgrass-browser diet during the first winter, consumed an average of 11.80 pounds of forage, or 2.49 pounds of forage per hundredweight. Two cow elk, fed the same diet during the second winter of the study consumed 9.28 pounds of air dry forage daily, or 1.90 pounds per hundredweight.

11. One cow elk was given a combination diet of bunchgrass-conifer browse during the second year of the study. She showed no preference for conifer browse. The bunchgrass she consumed was included under that heading.

12. The amount of browse eaten compared to the total amount available was one method used to rate the different species of browse used by elk in the study. Dogwood was given a numerical rating of 16.39 per cent, snowbrush 16.07 per cent, willow 10.94 per cent, mountain maple 7.50 per cent, serviceberry 6.19 per cent, and sagebrush and russet buffalo berry, 0 per cent, during the first winter of the study. During the second year of the study, snowbrush again rated highest with 27.58 per cent, willow 14.99 per cent. Dogwood 11.94 per cent, mountain maple 10.06 per cent and serviceberry 7.55 per cent.
13. Preference rating for each browse species, based on the average amount eaten per day by the elk, during the first winter of the study, was serviceberry 34.60 per cent, willow 29.35 per cent, dogwood 12.47 per cent, snowbrush 12.15 per cent, mountain maple 11.43 per cent, and sagebrush and russet buffaloberry 0 per cent. During the second winter of the study, serviceberry made up 36.58 per cent of the diet, willow 25.59 per cent, snowbrush 15.15 per cent, mountain maple 11.74 per cent, dogwood 10.94 per cent and sagebrush and russet buffaloberry 0 per cent.

14. The relative digestibility of the different diets used in the study was calculated, using the lignin index method. The meadow hay had the highest digestibility, stem cured bunchgrass next and browse very low.
CONCLUSIONS

An adequate daily feed allowance for cow elk appears to be approximately 2.2 pounds of air dry forage per hundred pounds of live weight. A five hundred pound cow elk should then have about eleven pounds of forage per day under winter conditions. The forage requirement per hundred weight for the cattle fed in the study was very similar to that of adult cow elk. The relative requirements of cow elk and cattle are then proportional to their weights. A one-thousand pound cow will require twice the forage that a five hundred pound elk will require. Elk calves have a higher forage requirement per hundred weight and responded well to the conditions of the study.

Mature stem cured bunchgrass has high energy values for elk nutrition during the winter even though chemical analysis of the forage indicates that it is deficient in many essential nutrients. Deficiencies in the food material had little apparent effect on the animals during the period of the study.

Cow elk will readily utilize deciduous browse but may not be capable of digesting this type of food material as easily as meadow hay or bunchgrass. The data secured on the use of browse is not consistent with the general opinion held by many workers in the field. Combination diets containing browse, used in the study, proved to be satisfactory under the conditions of the study.

In general, the cow elk lost weight throughout the study period during two winters, but lost more weight on a browse diet than with
either bunchgrass or meadow hay. Weight losses were not excessive, however, and may be less than the normal loss in weight commonly experienced by wild elk during the winter period.

The absence of necrotic stomatitis in the elk calves suggests that the hay used in the study and the conditions of the feeding were such that necrotic stomatitis need not be the expected consequence of meadow hay fed to elk calves.

Adequate amounts of the various browse species were not available to offer a complete ration of each species to the animal to obtain a true preference rating. However, willow was utilized more readily than serviceberry but serviceberry and mountain maple use indicates these species are very desirable on a winter range. Other browse species were also readily taken when supplies of them were available. Sagebrush, russet buffaloberry and coniferous browse were not utilized by the elk. Heavy use of these species on some elk winter ranges must imply excessive use on other more preferred forage species.
Weigh one gram of air dried material ground to pass a 40 mesh screen into a coarse porosity alundum extraction thimble and extract the sample with an ethanol-benzene mixture (32 parts 95 per cent ethanol to 68 parts by weight of benzene) for 4 hours. Then with the aid of suction wash the sample in the thimble with two small portions of 95 per cent ethanol followed by two small portions of ether. Heat at 45°C in a non-sparking oven to drive off all ether and transfer the sample to a 50 ml. glass-stoppered Erlemeyer flask. Add 40 ml. of 1 per cent pepsin (U. S. P. grade) in 0.1 N HCl and incubate at 40°C. overnight, shaking the flask a few times during the first hour to insure thorough mixing. The next morning transfer the residue to a 250 ml. wide-mouth Erlemeyer flask with the aid of a stream of hot distilled water. Filter1, filtration is carried out with a filter stick usually referred to as an immersion tube with fritted glass disk by most supply houses. The authors use a pyrex, 30 mm. diameter, medium porosity type. A row of 12 filter sticks for simultaneous use is set up using six student model, double burette holders. An 18 cm. length of 10 mm. glass tubing fitted with a 5 cm. side arm near the upper end, projecting at an upward angle, fits into the burette clamp and is connected to the vacuum line at the top by rubber tubing and joined at the bottom with a short section of rubber tubing to the filter stick. The purpose of the side arm is to facilitate the introduction of liquids into the inside of the filter stick for thorough washing off of solids from the fritted disk. Since the authors have found that about one-third of the filter sticks as purchased are unsatisfactory, it is advisable to purchase more than needed and discard those that do not filter well. The filter sticks are coated with pre-asked diatonaceous earth (hyflo Supercel, Johns-Manville, N. W.) by suspending some in water and sucking on a thin layer with vacuum. This usually is sufficient for easy filtration; if not, extra Supercel added to the residue being filtered will often help.
add 20 to 30 ml. of hot water, and again filter. Wash the residue in this manner three times. After the last filtration, force 7 to 8 ml. of 5 per cent (by weight) H$_2$SO$_4$ solution downward through the filter stick with the aid of air pressure, thus washing the residue from the stick into the flask. Wash the stick further with 5 per cent H$_2$SO$_4$ and add a sufficient volume to bring the total to approximately 150 ml. After refluxing$^2$ for one hour, the acid is filtered off. Wash the residue three times with 20 to 30 ml. portions of hot distilled water, twice with 15 to 20 portions of 95 per cent ethanol, and twice with 15 ml. portions of ether. After the final ether washing, leave the vacuum on a few minutes to dry the residue. By tapping and brushing remove the residue from the filter stick leaving it in the same flask. Evaporate residual ether in oven at 45°C. Some immature plant materials dry from ether into disks difficult to break up into a finely divided state. In these cases wash down the filter stick with ether and disperse the residue in the ether before evaporating it on a steam bath. To the residue add 20 ml. of 72 per cent H$_2$SO$_4$ (by weight) at 20°C. for 2 hours with occasional stirring. Then add 125 ml. of water, filter, wash once with a 15 to 20 ml. portion of hot water and again filter. Wash residue from the filter stick as before with a 3 per cent H$_2$SO$_4$ making the volume to 150 ml. and reflux 2 hours. Filter the residue into a Gooch or an alundum crucible and wash the residue with hot distilled water until free of acid. Dry at 105°C to 110°C and determine ligning by loss of weight on ignition at 600°C.

$^2$An ASTM extraction apparatus is used for all refluxing operations.
<table>
<thead>
<tr>
<th>Sample</th>
<th>Moisture</th>
<th>Protein</th>
<th>Ether Extract</th>
<th>Crude Fiber</th>
<th>Nitrogen-free Extract</th>
<th>Ash</th>
<th>Phosphorus</th>
<th>Calcium</th>
<th>Carotene mg/g</th>
<th>Lignin</th>
</tr>
</thead>
<tbody>
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<td>3.7</td>
<td>3.0</td>
<td>36.4</td>
<td>45.7</td>
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<td>.08</td>
<td>.49</td>
<td>3.0</td>
<td>9.1</td>
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### CHEMICAL ANALYSIS OF FORAGE SPECIES AND RATIONS USED IN THE 1953-1954 ELK NUTRITION STUDY

**Determined by the Agricultural Experiment Station, Bozeman, Montana**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Moisture</th>
<th>Protein</th>
<th>Ether Extract</th>
<th>Crude Fiber</th>
<th>Nitrogen-free Extract</th>
<th>Ash</th>
<th>Phosphorus</th>
<th>Calcium</th>
<th>Carotene (mg/g)</th>
<th>Lignin</th>
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</thead>
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<td>Bunchgrass, Blackfoot Fall</td>
<td>4.4</td>
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LITERATURE CITED


