



The forage intake of supplemented cows grazing winter foothill rangelands of Montana
by Mark Estes Turner

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in
Range Science

Montana State University

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Abstract:

This study was initiated to estimate the forage consumption, calf performance and rebreeding success of cows grazing the grass-dominated winter foothill ranges of Montana. During the winters of 1981-82 and 1982-83» 60 two- and three-year-old hereford/angus cows were divided into four groups. One group of six animals served as the non-supplemented controls. The remaining 54 animals were divided into three groups of 18, each receiving a daily supplement of either 0.9 kg of 15 percent barley-based protein, 0.9 kg of 30 percent soybean meal-based protein or 1.8 kg of 15 percent barley-based protein. Six animals were randomly selected from the group receiving 0.9 kg of 30 percent protein daily for collection of total fecal output in addition to six unsupplemented heifers. Through the use of chromic oxide (premixed into all supplements) to provide an estimate of fecal production and esophageal fistulated heifers to estimate forage digestibility, forage intake was estimated for all animals. Though total intake differed between supplement treatments, forage consumption (exclusive of supplements) was equal between treatments and did not significantly differ ($P < .01$) from consumption of unsupplemented animals. No differences in animal response were recorded in measuring calving interval (return to estrus) or body condition of the cows when comparing the supplemental treatments. Post-partum, no significant differences ($P < .05$) in calf performance were recorded among any of the four treatments. Both ADG (average daily gain) and adjusted 205-day weights were, included in the data collected.

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This paper has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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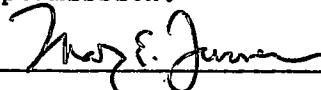
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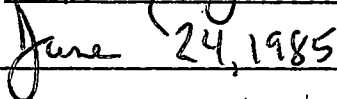
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ABSTRACT

This study was initiated to estimate the forage consumption, calf performance and rebreeding success of cows grazing the grass-dominated winter foothill ranges of Montana. During the winters of 1981-82 and 1982-83, 60 two- and three-year-old hereford/angus cows were divided into four groups. One group of six animals served as the non-supplemented controls. The remaining 54 animals were divided into three groups of 18, each receiving a daily supplement of either 0.9 kg of 15 percent barley-based protein, 0.9 kg of 30 percent soybean meal-based protein or 1.8 kg of 15 percent barley-based protein. Six animals were randomly selected from the group receiving 0.9 kg of 30 percent protein daily for collection of total fecal output in addition to six unsupplemented heifers. Through the use of chromic oxide (premixed into all supplements) to provide an estimate of fecal production and esophageal fistulated heifers to estimate forage digestibility, forage intake was estimated for all animals. Though total intake differed between supplement treatments, forage consumption (exclusive of supplements) was equal between treatments and did not significantly differ ($P < .01$) from consumption of unsupplemented animals. No differences in animal response were recorded in measuring calving interval (return to estrus) or body condition of the cows when comparing the supplemental treatments. Post-partum, no significant differences ($P < .05$) in calf performance were recorded among any of the four treatments. Both ADG (average daily gain) and adjusted 205-day weights were included in the data collected.

CHAPTER 1

INTRODUCTION

The efficiency of western range livestock production is closely related to the ability of range forage to meet minimum nutritional requirements. On Montana's winter rangelands, beef cattle can be faced with nutritional deficiencies in both protein and energy. The importance of adequate nutrition is fairly well understood by livestock producers on the Northern Great Plains. An important part of this maintenance usually includes some type of supplemental concentrate through the winter period. Production factors, influenced by submaintenance nutritional levels, include milk production of the dam and rebreeding success or return to estrus. With rapidly increasing costs and weak livestock markets, basic maintenance costs including adequate nutrition are becoming increasingly important in today's beef industry.

Native forages through the winter months are frequently of poor nutritional quality with inadequate levels of protein and/or energy. Diets high in grass or grass-like plants are often protein deficient through the winter period while providing higher levels of metabolic energy. Pastures with large amounts of browse species present may provide adequate protein levels but be deficient in meeting energy needs. A combination of these two forage classes may provide an adequate level of nutrition without providing any form of supplement.

Forage intake of beef cattle on winter range is often limited by the lower digestibilities of the diet. Bulk fill remains the primary regulatory factor influencing forage intake. The role of a protein and/or energy source, either from a specific forage class or an outside supplement, can not only increase intake and rate of passage but may also provide better utilization of the existing forage. It is generally recognized that range cattle respond to increased levels of protein but do not perform as well when fed increased amounts of energy. Research, testing the influence of supplementation on animal performance, has generated results that are both highly variable and dependent upon specific study conditions. Data suggests that under certain conditions energy and protein appear to be inter-related and the availability of one may influence the utilization of another. Few studies have successfully separated the impact of one from the other. Besides this relationship, numerous site specific factors can influence animal production on winter rangeland. The availability of forage, environmental stress, and specific forages available, besides the physiological state of the animal, all serve to complicate the dynamic balance of nutritional needs and the ability of a given range to meet that requirement.

The emphasis of this study was to both test animal response to differing levels of supplementation, to quantify the animal's needs and to describe the response to the winter range forage base. The specific objectives of the study were: 1) estimate the forage consumption during winter of pregnant two- and three-year-old cows grazing foothill rangeland, 2) examine the impact of protein and energy supplementation

upon the daily forage intake of two- and three-year-old cows, and 3) examine the influence of pre-calving supplementation upon animal performance and rebreeding success.

This research was funded jointly by the Montana Agricultural Experiment Station and Montana State University. The late Dr. O. O. Thomas provided baseline information in the form of animal production data in his work with winter supplemental feeding.

CHAPTER 2

LITERATURE REVIEW

The Forage Resource

Throughout most of the western United States, range animals graze a portion of the year on native rangeland. The available native forages generally provide an adequate level of nutritional stability (Bellido, 1981). However, supplemental feed is often provided during winter months to compensate for lowered nutritional quality, particularly protein, of mature grass species.

Cook et al. (1968) found nutritional levels during winter months to be insufficient to meet the demands of either the mature cow in late gestation or the heifer approaching parturition. Kartchner and Campbell (1979) also found range forage to often be of low to medium digestibility and protein content through much of the year.

Cook et al. (1950) found grasses to be lower than browse species in crude protein and phosphorus, but do not contain higher levels of metabolizable energy. Diets consisting of browse would be deficient in energy but would maintain adequate levels of crude protein, phosphorus and carotene to meet maintenance requirements of cows and ewes (Cook, et al., 1950). Diets composed of grasses only would contain adequate levels of metabolizable energy, yet be deficient in crude protein, phosphorus and carotene. These researchers stated that only through the presence of a mixture of forage classes would one hope to reduce the

need for additional supplementation. In later work, Cook and Harris (1968) found the average total crude protein content of browse species was 9.1 percent while the average for grasses was 3.8 percent through the winter period. These researchers went on to state that the use of a winter supplement may certainly be advisable to off-set nutritional deficiencies on some rangelands. Two studies (Rosiere et al., 1975; Herbel et al., 1966) have found that cattle tend to graze various proportions of forbs, shrubs and grasses during winter months if the variety in forage classes are available.

Van Soest (1965) stated that chemical composition of the diet was influenced by season as well as the kind of plant consumed. Digestion co-efficients decreased gradually from April through September and dropped sharply in December with forage intake levels following a similar pattern.

In examining range condition and its influence on forage quality, Cook et al. (1950) concluded that improvement in range condition will not always result in higher average nutrients in the diet. In later work this same researcher (Cook, 1964) concluded that when comparing good and poor condition ranges, the variability in nutritional content depended upon forage species composition. Additionally, Cook et al. (1964) found protein percentages to be higher on ranges in poor condition as compared to ranges in good condition. This was attributed to the higher portion of browse species in the diet associated with the poor range condition. These researchers also found that range condition had no influence on animal intake. Cook et al. (1964) concluded that plant phenology and the advancement in maturity appeared to influence

the nutritive content of plants to a greater degree than any other factors.

Forage Intake

The factors controlling forage intake by ruminants are highly complex and the interactions amongst the recognized mechanisms make specific factors even more difficult to separate.

In reviewing literature on the forage intake of grazing ruminants, two main areas have received considerable study in the past. These areas are physical factors and physiological mechanisms of intake control (Jones, 1972).

Balch and Campling (1962) and Grovum (1969) concluded that with diets consisting entirely or mainly of roughages, physical distension of the reticulo-rumen is an important factor, though probably not the only one regulating voluntary intake for ruminants. Milchunas et al. (1978) stated that voluntary intake is a function of the turnover time associated with a specific forage and the quantity of dry matter fill possible within the ruminant tract. Bines (1971) proposed that the regulation of intake, from a physical aspect (gut fill), probably involves stretch receptors in the rumen or abdomen, but the exact nature and location was not known. Grovum (1969) found that by inserting water-filled balloons into the rumen, physical distension played a conclusive role in voluntary intake of low-quality forages. A similar physical limitation to forage intake was reported by Conrad et al. (1964) and Campling et al. (1966). They found that cows reduced forage intake as much as 15 percent in the third trimester of gestation. Both researchers stated that this could be due to either the reduction in

rumen capacity caused by the developing fetus or hormonal changes related to pregnancy.

Montgomery and Baumgardt (1965) found intake to increase as the nutritive value of the forage increased, with distension of the rumen acting as the triggering mechanism for satiety. They also stated that most all-roughage rations would probably fall in this category where consumption is directly proportional to nutritive value.

In examining the influence of forage particle size on intake, Mejiš (1981) cited the work of several researchers (Campling, 1970; Rohr, 1977) who supported the concept that rate of passage, and thus intake, was a function of particle size and the limitations imposed specifically by the small size of the reticulo-omasal orifice.

The influence of digestibility on forage intake has been shown to be substantial. Balch and Campling (1962) and Grovum (1969) correlated the rate of passage for various forages with the digestibility of the roughage. Crampton (1952) concluded that voluntary intake of forage was limited by the rate of cellulose and hemicellulose digestion, which was dependent upon lignification in forages of advancing maturity.

Cell wall constituents and lignin have been regarded as inhibitors of forage breakdown (Van Soest, 1965) and, therefore, rate of passage. High cell-wall and or lignin proportions, with other factors constant, indicate a lower digestibility (Van Soest, 1965). With a increase in cell-wall constituents and a decrease in digestibility in the diet, forage nutritive values can be expected to decline with advancing plant maturity (Corbet et al., 1963).

Milchunas et al. (1978) summarized the effect of digestibility on intake, stating that because of the often low-quality, fibrous nature of the ruminant diet, bulk limitations of the digestive system may be reached before an animal's energy requirements are met. Conrad et al. (1964) proposed that voluntary intake would increase with increasing digestibility to a ratio where the supplied nutritive energy was equal to the animal's capacity to utilize it. Above this point (the animal's capacity to metabolize energy) dry matter intake would decrease as bulk-limiting factors no longer regulated consumption.

Jones (1972), in a review of literature, stated physical factors as the primary regulators of intake when digestibilities were less than 66 percent and by physiological mechanisms when digestibility exceeded these levels.

Ellis (1978) listed three factors responsible for intake of less-digestible forages associated with winter rangeland: 1) volume of the reticulo-rumen, 2) volume occupied by forage material and 3) rates of processes which determine turnover of the volume (rate of passage or digestibility).

Montgomery and Baumgardt (1965) stated that chemostatic or physiological mechanisms were operational for the regulation of forage intake in diets with a high nutritive value. When this nutritive plane was increased either by grinding or pelleting, or by the addition of concentrates to the diet, these researchers found overall dry matter intake decreased.

Mejis (1981) broke these physiological control mechanisms into three groups: chemostatic, thermostatic and lipostatic. In considering

chemostatic forage intake mechanisms, volatile fatty acids (the main products of energy digestion for ruminants) have been identified as possible intake control factors in ruminants (Bines, 1971; Baile and Forbes, 1974). In a review of existing literature, Jones (1972) found Propionic acid depressed intake more so than any of the other amino acids. Baile and Forbes (1974) and Anil and Forbes (1977) found the addition of the VFA (volatile fatty acid) more effective in reducing intake when administered intra-ruminal than the same amount administered intravenously. These researchers went on to state that the VFA receptor sites are probably found on the lumen side of the rumen wall.

Several researchers (Balch and Campling, 1962; Montgomery and Baumgardt, 1965) have suggested there may be some form of thermostatic control mechanism responsible for feed intake in ruminants. This research was based on the theory that the hypothalamus may respond to heat produced during nutrient metabolism. Other research designed to test this theory found no response in hypothalamic temperatures associated with hunger or satiety (Baile, 1974). Results of various studies, however, have indicated that the thermostatic regulation of feed intake is responsive to environmental temperature changes (Jones, 1972; Baile and Forbes, 1974). Bines (1971) found that food intake decreased in a warm environment while intake increased in a cold environment. Malechek and Smith (1976) found that under cold stress, cows altered behavior patterns resulting in reduced forage intake and overall energy expenditures. Average daily temperature was generally the most important factor in accounting for animal grazing behavior (Malechek and Smith, 1976). In the same study, daily wind speed and]

daily barometric pressure change accounted for only 3 percent of the variation in energy expenditures for activities.

The fact that environmental influences can greatly affect forage intake by grazing animals is well documented (Jones, 1972; Malechek and Smith, 1976); Van Dyne et al., 1980). Van Dyne et al. (1980) found intake rates in dairy cows to increase as much as 3 kg/day as the daily minimum ambient air temperature decreased from 4° to 1°C.

Christopherson (1976) reported that temperature appears to have an effect on the extent of digestion of energy and protein for ruminants. The researcher also found differences in responses between calves and steers compared to cows which he attributed to differences in maturity and body size. Calves and steers showed reductions in digestibility ranging from 3.5 to 8 percent during exposure to a winter climate in Alberta. In later work, Christopherson et al. (1979) found significant increases in metabolic rate of hereford cows with prolonged exposure to winter temperatures. The researcher also stated that an undefined relationship between temperature and wind speed identifies a critical level where both heart rate and metabolic rate were significantly increased. Webster et al. (1975) also stated that the influence of wind has considerable affect on maintenance requirements and heat production in cold environments.

In considering lipostatic forage intake regularity mechanisms (Journet and Remond, 1976), the feedback for energy balance appears to be governed by the release of free fatty acids in the blood. Additionally, dairy cows, post-calving, were found to have a high level of plasma-free fatty acids corresponding to a low intake, and that

intake increased until plasma-free fatty acids had decreased. Another possible lipostatic mechanism mentioned by Baile and Forbes (1974) was that plasma concentrations of several hormones can affect intake levels. This literature concluded that hormones only play a role in feed intake when concentrations were administered at rates normally not occurring in the ruminant. No clear evidence has yet verified any lipostatic intake mechanism (Mejis, 1981).

The influence of utilization on grazing can be highly variable. Cook et al. (1950) found that forage remaining after grazing on native rangelands was lower in nutrient content than originally and that continued use caused greater reductions in nutrient value. In later work, Cook et al. (1952) showed that increased intensity of grazing reduced daily forage intake and digestibility of the nutrients. The same author (Cook, 1968b) went on to state that as grazing intensity increases, animals show either preference change among plants, or increase the utilization of preferred plants.

Under specific conditions, Havstad et al. (1983) found that for free-ranging heifers grazing a diminishing supply of crested wheatgrass, the quantity of forage available to the animal had no effect on the voluntary intake. The author attributed the differences in results between studies to: 1) the forage quality remained constant as the wheatgrass pasture was mature throughout the study, 2) the study was conducted under bulk-limiting conditions and 3) the grazing animal apparently increased grazing time under conditions of limited forage to maintain voluntary intake (Havstad et al., 1983).

Milchunas et al. (1978) also indicated that under bulk-limiting conditions, forage availability did not affect voluntary intake.) The quantity of forage available could obviously play a role in forage intake, but the actual level where intake is limited by availability is dependent on forage quality and quantity.

Supplementation

The influence of both protein and energy supplementation upon forage intake is well documented and has produced results which vary from study to study. Numerous researchers (Campling et al., 1966; Montgomery et al., 1965; Conrad et al., 1964; Rittenhouse et al., 1970) found larger amount of concentrates to cause depressions in forage intake, while smaller portions invariably increased intake. Blaxter et al. (1962) and Campling et al. (1966) determined that when restricted amounts of concentrates are given to ruminants, the rate of decline in intake was greatest with the more digestible forages. Other researchers (Kartchner, 1981; Bellows and Thomas, 1976) found that supplements routinely fed to mature range cows are questionable because of depressed forage intake.

Cook et al. (1968a) found that on some well-managed range with a variety of vegetative species, supplementation was not a cost effective proposition. The objective was to maximize the use of range and to supplement only at a level to prevent production losses (Cook et al., 1968a). These researchers went on to state that supplements should be fed at an amount that will ensure sufficient and uniform forage intake. Rosiere et al. (1975) explained that winter protein supplementation was probably unnecessary on ranges in New Mexico with a variety of forage

classes present and where gestation or growth was not a factor. However, this research also stated that protein levels in fall and winter diets were well below recommended levels for bred cows or growing calves and supplementation of protein was recommended. Wallace et al. (1972) and Kartchner (1981) stated that forage quality and nutritive value should be the key factors establishing the need for a supplemental feed program.

Rosiere et al. (1975) reported that the variability in research data reflects the need to qualify the factors affecting livestock production as influenced by supplemental feeding. The factors influencing the need for supplementation were dynamic considerations and no fixed seasonal trend could be established.

The influence of a concentrate on forage digestibility has received considerable attention. Elliot (1967) stated that a deficiency of protein in the diet impaired forage digestibility and that only slight improvement occurred with increasing amounts of concentrate. At low levels of protein input, there was very little change in feed intake, corresponding with changes in digestibility. Cook et al. (1968) also concluded that supplements such as corn or barley resulted in a decrease in digestibility of forages on Utah's desert winter range. Rittenhouse et al. (1970) separated the effects of protein supplementation from energy. These researchers concluded that crude protein had only a small influence on dry matter digestibility. It was acknowledged that a high energy supplement would also depress forage digestibility. However, Rittenhouse et al. (1970) stated that when cattle received a supplement while utilizing a low quality forage base, the magnitude of depression

of both digestibility and intake was less, than for higher quality forages. Clanton (1981) found that neither intake nor digestibility was significantly different when comparing both supplemented and non-supplemented control cows on winter range. Supplemental crude protein did have a greater influence on forage dry matter digestibility than on intake, while supplemental energy had no influence on the digestibility of the forage base (Clanton, 1981).

Energy levels in the diet have been shown to have considerable influence on forage intake in ruminants. Baile and Forbes (1974) stated that the overall effects of varying the energy requirements of the ruminant by changing its output of heat, deposition of body fat, yield of milk or available energy in the diet, indicates ruminants tend to maintain a constant energy balance by changing feed intake in proportion to the altered circumstances. Conrad et al. (1964) also cited metabolic energy as having a regulatory influence on feed intake of highly digestible diets. Montgomery and Baumgardt (1965) reported that in diets with a high nutritive value, overall dry matter intake decreased while energy intake remained constant.

When Blaxter and Wilson (1962) added high levels of digestible energy to a low quality hay, voluntary intake of hay declined, while low levels of energy in the diet stimulated intake, again suggesting a control mechanism. These same authors (Blaxter and Wilson, 1962) also stated that an energy-protein interaction might exist because added levels of energy were not iso-nitrogenous.

Osuji (1974) stated that free-ranging cattle expend as much as 25 to 100 percent more energy than confined counterparts. It was suggested

that the increased energy expenditure at pasture would be directly related to costs associated with grazing and harvesting forage, which depends on availability of pasture and environmental stresses (Osuji, 1974). Osuji (1974) went on to state that the work of digestion or the handling of the bulky forage material could be another major component of the increased energy costs. Havstad and Malechek (1981) found free-roaming heifers to utilize as much as 45 percent more energy than their housed counterparts. Fifty percent of this additional energy requirement was attributed to grazing while 20 percent was attributed to travel.

NRC (National Research Council) estimates of daily metabolic energy (ME) needs for maintenance and milk production vary from 15.9 to 27.5 Mcal depending on the cow's weight and quantity of milk production (NRC, 1976). Immature cows would also require additional energy for meeting growth needs. With a 50 percent increase in energy requirements for the free-roaming cow, and using established NRC ME requirements for a range cow, daily energy demand may be as high as 24 to 41 Mcal.

Havstad et al. (1983) estimated a two-year-old heifer with a daily growth rate of .33 kg per day would require approximately 3,450 kg of metabolic energy for total growth requirements. A heifer would have to consume an additional 1.6 kg of forage per day to meet this metabolic need. Malechek et al. (1976) also found that calculated net energy costs for activities through the winter period considerably overestimated NRC requirement recommendations.

In examining the influence of protein on forage intake, several researchers (Bines, 1971; Campling, Freer and Black, 1962; Egan, 1965)

have found the rate of digestion by rumen microorganisms to be closely related to the chemical composition of the specific feed. When feeding poor quality roughage, the addition of a nitrogen source to the rumen increased microbial activity and voluntary intake. Blaxter and Wilson (1962) and Church (1972) also found small amounts of concentrates increased the voluntary intake of hay. They both attributed this to the protein contained in the concentrate.

Blaxter and Wilson (1962) stated that maximum intake occurred only when the crude protein content of the total ration was above 8.5 percent. Egan (1965) found that intake of low quality roughages would increase generally until crude protein reaches 6 to 8 percent of the dry matter. The fact that protein in the diet, below approximately 10 percent crude protein, affects voluntary intake of forage by ruminants is well established (Campling et al., 1962).

Numerous studies have increased the rate of digestion of forages through the addition of dilute solutions of urea as a supplement (Campling et al., 1962; Moir et al., 1962; Zinn et al., 1981). Urea was determined to increase cellulolytic activity, reduce retention times of forages and increase voluntary intake.

In reviewing the research with supplemental concentrates, Rittenhouse (1969) summarized the effect of concentrates on voluntary intake, stating that most cases in the literature do not establish the influence of the supplemented protein from the supplemented energy on the intake or utilization of the roughage.

Elliot (1967) reported one of the few studies where the influence of supplemental protein and energy on forage intake is considered

separately. In this work, at high levels of protein intake, increasing amount of concentrates produced small reductions in forage intake. At the lowest level of protein intake, increasing the amounts of concentrates reduced hay intake. Rittenhouse (1969) in a review of this work (Elliott, 1967) stated that these conclusions must be criticized in that the supplemented protein and energy cannot be evaluated independently and that this occurrence was probably the result of the supplemented protein.

Animal Productivity

The effect of supplementation upon animal productivity is well documented. Numerous researchers have found supplemental feeds for the foraging ruminant can increase calf weights at birth and weaning (Bellido et al., 1981; Cook and Harris, 1968). Bellido et al. (1981) found calving interval to be affected by supplementation when ignoring other variables including age of the dam and yearly climatic conditions. This researcher concluded that supplemented cows had a shorter calving interval than did non-supplemented cows.

The influence of winter management on calving interval has been addressed by various researchers (Joubert, 1954; Wiltbank et al., 1962; Corah et al., 1975; Bellido et al., 1981; Clanton, 1981). Joubert (1954) found the main value of supplemental feeding to be the decrease in the length of interval from calving to first estrus. Wiltbank et al. (1962) also found a larger proportion of cows failed to show estrus when wintered on a lower nutritional plane. This same researcher concluded that a low level of energy prior to calving exerted an effect on the

length of the interval, from calving to first estrus, which was not easily overcome even though the cows received a high level of energy after calving.

The effect of body condition, or the amount of stored fat on an animal when entering the winter period, has been well documented (Church, 1972; Corah et al., 1975; Whitman, 1975). Church (1972) stated that the amount of energy supplement that will be needed during the winter period was closely related to the condition of the cows as they enter the season. Cows that are in good condition coming off of summer pasture can often lose 25 to 50 kg during the winter without having an adverse effect on reproductive performance (Church, 1972).

Cows which are in poor body condition are generally recognized as being slower to return to estrus. Whitman (1975), studying the influence of body condition on reproductive performance, found that the likelihood of estrus 60 days post-partum was 91 percent for cows in good condition at calving compared to only 61 and 46 percent for cows in moderate and thin condition, respectively. The researcher concluded that when a cow is losing weight after calving, the chance of normal cycling 70 to 90 days post-partum was directly related to the amount of stored energy reserves.

Wiltbank et al. (1962) in examining the effects of energy supplementation and body condition on conception rates concluded that when cows were wintered on a lower plane of energy, both the conception rate and the interval to return to estrus were adversely affected by the inadequate diet. The overall condition of a cow becomes an important factor in herd or lifetime calving percentages by decreasing conception

rates and increasing the interval between calving and the return to estrus (Marsh et al., 1959; Wiltbank et al., 1962). In work done by Wiltbank et al. (1962), it was concluded that perhaps body condition and available energy were important factors affecting ovarian activity in beef cattle. Varner, et al., (1977) stated that the management of heifers after weaning is critical in influencing age at puberty and conception rates. The importance of managing and breeding heifers so that they will calve early in the season was emphasized in research by Lesmeister, Burfening and Blackwell (1973) who felt that this period was critical in maintaining early calving throughout their productive lives. The researchers stated that meeting the nutritional requirements of these growing animals should be of priority concern to maximize production potential.

Several investigators have found calves from supplemented cows to be both heavier at weaning and have a higher average daily gain (Corah et al., 1975; Bellido et al., 1981). Bellido et al. (1981) recorded as much as a 14 kg difference in weaning weights (220 days) which they interpreted as reflecting increased milk production by the supplemented cows. Over a five-year study the researchers (Bellido et al., 1981) found a large variation in calf performance which they attribute to yearly environment considerations. Corah et al. (1975) found dams receiving restricted amounts of energy produced calves 12 kg lighter at weaning than calves from dams receiving adequate energy. The researcher also stated that this could be attributed to lower daily milk production by the dam.

Furr et al. (1964) found no significant differences in birth weights between cows receiving a high level of supplement as to those receiving a low level. Continuing the supplement on through weaning, however, did produce significant differences in calf weights. Bellido et al. (1981) also stated that supplementing through the post-calving period has a positive effect on milk production and subsequent calf weights at weaning. The researchers summarized after a four-year study that the influence of year was a significant factor in all portions of the study.

Selection of Study Techniques

Cordova et al. (1978) reviewing forage intake data stated that no method has been developed by which the absolute intake level of grazing livestock could be quantified. In recognition of this statement, the following techniques for estimating forage intake have been developed.

Indirect techniques fall into two categories: ratio and index. Both of these utilize the following formula in estimating intake.

$$\begin{array}{l} \text{ORGANIC} \\ \text{MATTER} \\ \text{INTAKE} \end{array} = \frac{\text{TOTAL FECAL ORGANIC MATTER OUTPUT}}{1 - \text{DIETARY ORGANIC MATTER DIGESTIBILITY}}$$

Ratio techniques involve the calculation of both digestibility and fecal output. By quantifying the level of an indigestible indicator in the feces and comparing it to that which was fed, an estimate of fecal output can be obtained. Common internal markers are lignin, nitrogen and silica. Common external indicators include chromic oxide, iron oxide, monastral blue (Harris, 1968), stains and dyes, plastic or rubber beads and rare earth substances (Van Soest, 1965).

A fecal "grab" sample is taken for laboratory determination of the amount of indicator per gram of feces. Fecal dry matter output is calculated from these grab samples using the following calculation:

$$\begin{array}{l} \text{DRY} \\ \text{MATTER} \\ \text{FECAL} \\ \text{OUTPUT} \end{array} = \frac{\text{AMOUNT EXTERNAL INDICATOR FED (g/DAY)}}{\text{EXTERNAL INDICATOR IN FECES GRAB SAMPLE (g/g DRY MATTER)}}$$

Numerous researchers (Harris, 1968; Kimura et al., 1957) have stated that chromic oxide appears to be the best external indicator when using grab samples to estimate fecal output. Under ideal conditions, chromic oxide administered to an animal is well mixed in the digestive system and is uniformly excreted. The primary difficulty outlined by Raleigh et al. (1980) is to get uniform excretion of the fecal material under grazing situations. Diurnal variation, or the irregular excretion rate over a 24-hour period, remains one of the main concerns with the utilization of chromic oxide. Under free-ranging conditions, total recovery of chromic oxide has been inconsistent from study to study. Rittenhouse (1969) reported only 75 percent of the Cr_2O_3 was recovered in the feces through four separate test periods. The bias was attributed to incomplete collection of feces in the bags. Raleigh et al. (1980) summarized that recovery estimates are wide ranging when comparing a given measured fecal output to an estimated quantity. Over- and under-estimates ranged from - 30 to +87 percent when predicting fecal output. Over-estimates are recognized as being the result of interference of silica in the feces during analysis. Fecal ash included in the standards can help overcome this problem (Raleigh et al., 1980) and was utilized in this data analysis. Basic recommendations to

minimize recovery error (Raleigh et al., 1980) include using the technique for only a comparative basis, not an absolute basis, and maintaining similar conditions when comparing the estimated value to the known. Total fecal collections are often made concurrently with grab estimates as a check for predicting fecal output (Rittenhouse et al., 1970; Kartchner, 1981; Hale et al., 1962).

The only direct method for measuring fecal production involves the use of fecal collection bags. This technique is well documented throughout the literature (Rittenhouse et al., 1970; Harris et al., 1952; Cook, 1968a; Kartchner, 1981) as an absolute method of determining fecal production and subsequent forage intake.

Index procedures of estimating forage intake relate the level of intake or digestibility to some component in the feces through a regression equation. The equation is developed under controlled circumstances and later utilized under field conditions to predict intake or digestibility. The most common fecal component for studies utilizing index procedures has been nitrogen (N). The basis for this method relies on the principle that fecal nitrogen is primarily of body origin and that metabolic fecal nitrogen is excreted in proportion to the quantity of dry matter consumed or digested (Cordova et al., 1978). In a review of the literature, Cordova et al. (1978) stated that errors associated with regression equations and the index procedure indicate that application of this technique is limited to cases where large differences in intake or digestibility exist.

Van Dyne (1965) stated that there is little variation between dietary chemical composition from day to day within short periods under

range conditions and that the digestibility of intake is relatively uniform. Variations in excretion rates and fecal composition become essential in assessing estimates of intake under range conditions (Cordova, 1978).

Cordova (1978) citing work by Scales (1972) concluded that a minimum of six steers was required to estimate fecal excretion within 15 percent of the mean and that six collection days were needed to provide minimal variation in total fecal collection.

In a review of forage intake literature, Cordova et al. (1978) reported that most estimates of intake for sheep and cattle, grazing western United States ranges, lie between 1 and 2.8 percent of body weight per day. These figures are expressed on an organic matter basis because of the high ash content associated with the forage. In a summary of forage intake values, Van Dyne et al. (1980) found intake estimates to range from a low of 0.96 for cattle grazing Nevada's winter deserts to a high of 3.2 for calves grazing summer pastures in Great Britain. Cordova et al. (1978) stated that intake estimates for grazing livestock appear to vary more with techniques used and researchers involved than with forages and environmental conditions tested.

In reviewing forage digestibility, Scales et al. (1974) examined various indirect techniques involved with digestibility trials including in vitro, in vivo and fecal index. The foundations for both the marker-ratio and fecal index techniques were reviewed in the section on estimating forage intake, where the same principles apply.

Estimates of digestibility are also obtained by microbial digestion techniques utilizing in vivo nylon bag procedures or the in vitro

artificial rumen technique. In vivo measures digestibility by the insertion of nylon bags into the rumen. Scales et al. (1974) cited this technique as an invalid estimator of in vivo digestibility. In the in vitro digestions, small forage samples are placed in glass tubes and conditions associated with the rumen are replicated, simulating digestion. In a comparison of in vitro techniques, Scales et al. (1974) stated that the two-stage modified Tilly and Terry (1963) system was the most accurate of the in vitro techniques compared.

Cook (1964) stated that collecting samples of forage representative of the animal's diet is a complex problem as animals select plants and plant parts from a variety of species. Although several methods have been used to collect forage samples, Van Dyne and Torrell (1964) cited the use of esophageal fistulas as the best estimate available of grazing animal's intake.

CHAPTER 3

DESCRIPTION OF THE STUDY SITE

The study pastures were located on the Red Bluff Range Research Ranch operated by the Department of Animal and Range Sciences, Montana State University. The ranch is located 56 km (35 miles) west of Bozeman, Montana on the northwest slope of the Madison Range. Elevations within the pastures range from 1,400' to 1,900 meters (4,600' to 6,200 feet). The annual precipitation averages from 350 to 406 mm (14 to 16 inches) (USDA-SCS, 1976). Pasture I was 256 ha (634 acres) in size while Pasture II was 319 ha (787 acres). The legal description of the sites include sections 8, 9, 16, 17 and 18, T. 3S., R.1E.

In 1980, the Soil Conservation Service classified Pasture I as a silty range site in high good condition with grasses and grass-like plants comprising 75 percent of the vegetation, with forbs and woody species making up the remaining 25 percent. Bluebunch wheatgrass (Agropyron spicatum [Pursh] Scribn and Smith) and Idaho fescue (Festuca idahoensis Elmer) accounted for 70 percent of the principal plant community.

Pasture II was also classified as a silty site with grasses composing 65 percent of the vegetation. Forbs and woody species made up the other 35 percent. Major grass species found on the site included

bluebunch wheatgrass, Idaho fescue, prairie junegrass (Koeleria pyramidata [Lam.] Beauv.) and needleandthread (Stipa comata Trin. and Rupr.).

Payne (1973) in reviewing major range sites of the western portion of Montana categorized the area as foothill grassland with the principal forage species being bluebunch wheatgrass. The carrying capacity was estimated at three acres per AUM (animal unit month). Payne (1973) summarized by saying that this is one of the most common forage types in the western part of the state.

Mueggler and Stewart (1980) classified the key vegetative species of this foothill habitat type as Idaho fescue and bluebunch wheatgrass. These two species together usually comprise between 30 and 65 percent of the total air-dry production (Mueggler and Stewart, 1980). The authors stated that proper use of this habitat type should be keyed primarily to the grazing sensitivity of Agropyron spicatum.

Other major forage species listed by the authors (Mueggler and Stewart, 1980, Payne, 1973) include: threadleaf sedge (Carex filifolia Nutt.), green needlegrass (Stipa viridula Trin.), mountain brome (Bromus marginatus Piper [Hitchc.]), Kentucky bluegrass (Poa pratensis L.), western yarrow (Achillea millefolium L.) and fringed sagewort (Artemisia frigida Willd.). Shallow, rocky ridges are also a part of both pastures with ponderosa pine (Pinus ponderosa Dougl.), limber pine (Pinus flexilis James), and Rocky Mountain juniper (Juniperus scopulorum Sarg.) being the most abundant trees. A complete listing of plant species

found at the Red Bluff Research location has been developed by P. Platenberg (unpublished data) and is presented in Appendix A.

Soil descriptions are presented in Appendix B.

CHAPTER 4

METHODOLOGY

Experimental Design

The experimental unit consisted of 60 two- and three-year-old hereford angus cross cows and heifers. Twelve of these cows were fitted with fecal collection bags and feces-urine separators as utilized by Kartchner et al. (1979). During the 96-hour feces collection period, the 12 bagged cows were gathered once daily at 24-hour intervals. The collection bags were removed, weighed, emptied into containers, cleaned and reweighed for the next collection. The contents of each container was then thoroughly mixed, sampled and labeled. These samples were then froze to be analyzed at a later date for dry matter, organic matter and chromic oxide content.

Six of the bagged total fecal collection animals were used as an unsupplemented control. The remaining 54 animals were divided into three groups of 18, each group receiving a supplement individually fed. This feed program was a part of the late Dr. O. O. Thomas's work where cows were individually fed a protein or energy supplemental ration three times weekly and animal production responses were monitored. These supplemental trials lasted from November to calving in April for both winter periods (1981/82, 1982/83). Specifications for the rations are included in Table 1. From post-calving to breeding, all three supplemental groups received the 1.8 kg per day, 15 percent protein

supplement. Chromic oxide was mixed into each individual ration to ensure a daily intake of 5 grams of Cr_2O_3 . The feed was processed into 1/4 inch pellets. Samples of the supplemental rations were collected periodically for Cr_2O_3 analysis.

Table 1. Ration Specifications kg/1000 kg

	1.8 kg 15% Protein	.9 kg 15% Protein	.9 kg 30% Protein
Barley	603.0	568.5	242.0
Wheat Millrun	300.0	300.0	300.0
Urea	10.0	10.0	25.0
SBM	--	--	340.0
Monosodium Phosphate	--	19.0	10.0
Ruminant Trace Mineral	1.2	2.5	2.5
Salt, Plain	4.9	4.9	4.9
Premix (Cr_2O_3 , corn)	15.0	30.0	30.0
Molasses, Cane	65.0	65.0	65.0
Vitamin A	22,000 I.U./kg for all rations		
Vitamin D	11,000 I.U./kg for all rations		
<u>Approximate Composition</u>			
Protein, %	15.0	15.0	30.0
Phosphorus, %	0.5	1.0	1.0
kg Fed/Day	1.8	0.9	0.9

Fecal Output

Total fecal collections and the chromic oxide dilution technique (Bolin et al., 1952) were used to estimate fecal output. Four 96-hour total fecal collections were implemented over the 10-week sampling period each winter. The collections were started in late December and continued through the first week of March for both the winters of 1981-82 and 1982-83.

Grab samples were taken from the 54 animals receiving the supplemental ration with the indicator every Wednesday throughout the winter period. Within the 54, six of the animals were also fitted with total fecal collection bags allowing an evaluation of chromic oxide as an estimator of fecal output. Those six total feces collection animals received the 30 percent protein supplement. Grab samples were also taken during each day of a total fecal collection period. All grab samples were promptly labeled and frozen. At a later date, all samples were thawed, dried in a forced air dryer at 40°C, ground through a 1 mm screen, then analyzed for chromic oxide content using a colorimetric procedure outlined by Bolin et al. (1952). The percent of chromic oxide in a fecal grab sample was then used to obtain an estimate of daily fecal dry matter production for each cow using the equation outlined in the literature review. These grab sample estimates were then converted to an organic matter basis for comparison with fecal output estimates from total fecal collections.

Digestibility

Dietary digestibility was determined on extrusa samples collected from esophageal fistulated cows and heifers. Esophageal collections

were made three to four times per month. In vitro organic matter disappearance was estimated using Barnes modification of the Tilley and Terry (1962) technique (Harris, 1970).

Prior to collection, fistulated cows were penned overnight. In obtaining extrusa samples, the canula device was removed and extrusa collection bags were attached to the animal. The animals were then released and grazed unattended for 1/2 hour before being herded back to the corral. Extrusa collection bags were removed and the canulas reinstalled. The forage collection was removed from the collection bag, placed in a plastic bag and froze. At a later date, the samples were thawed and dried at 40°C in a forced air dryer. The sample was then ground through a 1 mm screen for use in the in vitro digestibility analysis. The rumen fluid used in the in vitro procedure was taken from a mature, stall-fed cow that had received a good quality grass hay and had free access to water and a trace mineral salt block.

Animal Performance

All cows involved with the study were synchronized and artificially bred using angus bulls. Cows were given equal opportunity for natural breeding after the insemination period. Calving dates were uniformly distributed between the treatments. Animals were weighted before, during and after the supplemental period for both the winter of 1981/82 and 12982/83. The cows and heifers were weighted following a 16-hour shrink. Body weight changes were not adjusted for conception date and represent the supplemental feeding period only (December 15-March 15).

A simple condition scoring system was used to review the influence of the treatments on animal condition (LaMontagne, 1981). Cows were scored three times; before, during and after the supplemental period. A condition score ranging from 1 to 10 was determined for each cow with an average score ascertained by three scorers. Table 2 outlines the specific palpable and visual factors influencing the scoring system.

Table 2. Palpable and Visual Body Conditions

	<u>Score</u>		
	<u>1-3</u>	<u>4-6</u>	<u>7-10</u>
<u>Palpable</u>			
Shoulder			
Ribs	Sharp	Rounded	Smooth
Spinus Processes			
<u>Visual</u>			
Brisket			
Tailhead	No Fat	Moderate Fat	Large Fat Deposits
Twist			

Calf performance data yielded birth dates and weight, average daily gain and adjusted 205-day weights.

The Forage Resource

Forage availability, as related to the degree of utilization, was considered in grazed and ungrazed pastures for the 1982-83 winter only. Two sites, including a shallow upland and an overflow site, were selected as representative grazing areas within the pasture. A transect

running in a line for each of these sites measured key indicator species for these pastures. The total stubble height of both Agropyron spicatum and Stipa comata were measured in both grazed and ungrazed pastures. Fifty different plants were measured for stubble height along a transect for each site.

Statistical Analysis

One factor analysis of variance with randomized complete block design was used to compare all intake estimates between supplemental treatments and fecal output estimating techniques. Animal performance data was examined only with a t-test. The alpha level used for determining significance was 0.05.

CHAPTER 5

RESULTS AND DISCUSSION

Fecal Output and Chromic Oxide Recovery

Direct measures of fecal output, such as total feces collection are laborious, time consuming and may alter animal activity and grazing. However, total fecal collection remains a standard by which investigators measure the success of indirect estimates.

Comparisons of measured fecal output with chromic oxide-derived estimates yielded results as presented in Table 3. During the 1981/82 winter, data indicated that the estimate of fecal output based on one grab sample taken four successive days per week over-estimated fecal output by 10 percent. In the 1982/83 season, the single grab sample over-estimated fecal output by 30 percent while the grab sample taken over four successive days underestimated fecal output by five percent. These estimates fall within values reported by Raleigh et al. (1980).

Total recovery of chromic oxide taken from grab samples over a four-day trial remained fairly constant through both winter periods. The figures, as shown in Table 4 are comparative to other research data as summarized by Raleigh et al. (1980). Chromic oxide recovery should remain fairly constant if there is a uniform forage base and other variables remain unchanged.

Table 3. Cr₂O₃ as an Indicator of Fecal Output

Ration	81/82 Fecal Output (% of BW, OMB)	82/83 Fecal Output (% of BW, OMB)
0.9 kg/day 30% protein Cr ₂ O ₃ based, 1 sample/week	0.95 ^a	0.95 ^a
0.9 kg/day 30% protein Cr ₂ O ₃ based, 4 samples/week	0.75 ^b	0.69 ^b
0.9 kg/day 30% protein Total Collection Measurement	0.68 ^b	0.73 ^b

^{a, b}Means in the same column followed by a different superscript are different (P<.05)

Digestibility

Digestibility figures, utilizing in vitro artificial rumen procedures, are comparable with other research results from the Northern Great Plains. Kartchner (1981) estimated late fall digestibilities at 40 percent from data collected at the Fort Koegh station in Miles City.

Mean forage digestibility estimates for this project are displayed in Table 5. As detailed in the methodology, these values are averages for each year using samples collected through the winter period. Although these digestibility estimates are low, Adams (1984) has reported winter forage digestibility figures of a comparative level in research conducted at the Fort Koegh Research Station, Miles City, Montana.

The influence of the three different supplements on forage digestibility was not measured in the research project. The low

digestibilities of the over-winter averages may have minimized reductions in forage intake caused by the depression of digestibility due to supplementation as Rittenhouse et al (1970) cited.

Table 4. Estimated Chromic Oxide Recovery from Four Successive Fecal Grab Samples.

(expressed in %)		
	<u>Date</u>	<u>Chromic Oxide Recovery (%)</u>
1981/82	1/12/82	101
	2/2/82	110
	2/23/82	93
1982/83	1/11/83	113
	2/1/83	120
	2/22/83	104

Table 5. Forage Digestibility.

<u>Year</u>	<u>Dietary IVOMD</u>
1981/82	32%
1982/83	27%

Forage Intake

Intake figures estimated across both years are comparable to other research results. Cordova et al. (1978) concluded that cattle grazing western United States ranges usually consume quantities of forage dry matter ranging from 1 to 3 percent of body weight (BW). Smith et al. (1968) utilized the chromic oxide techniques with fecal grab samples to

estimate forage intake at .96 percent of body weight for cows on winter range in Nevada. Rittenhouse et al. (1970) estimating intake with total feces collection, found cattle on Nebraska winter range consumed 1.0 percent of their BW daily. These estimates compare favorably with data collected through both winter periods of this project.

In comparing treatments shown in Table 6, supplemental effects on intake varied through both the winter collection periods. In the winter of 81/82, there was no significant difference ($P < .05$) between the control group and the supplemental group receiving the .9 kg/day 30 percent protein ration. The .9 kg/day 15 percent protein ration had a depressant effect on forage intake through the winter period. Weston (1967) also found that intake and digestibility were influenced by additions of a concentrate. Below a specific supplemental level, forage intake remained the same or was depressed. Topps (1972) working in Africa with cattle on low protein forage also found a depression in cellulose digestibility and subsequent intake associated with small additions of carbohydrates. Elliott (1967) provided a possible explanation stating that the patterns of intake may be explained on the basis of reduced digestibility of the fiber as a consequence of reduced pH in the reticulo-rumen. Merrill et al. (1984) working with steers supplemented with equal amounts of either corn or soybean hulls supported this idea. All steers in the study were on tame pasture and gained the same regardless of which supplement they received. Corn was fed to half the steers. This high carbohydrate source would lower rumen pH making the ingested forage base less digestible. The soybean hulls, low in carbohydrates and high in fiber, would not affect rumen pH

substantially enough to reduce digestibility. Both of these rations produced similar results as far as average daily gain.

Table 6. Adjusted Total Intake^a

Supplemental Ration	81/82 Total Intake (% of BW, OMB)	82/83 Total Intake (% of BW, OMB)
0.9 kg/day 15% protein	0.8 ^b	1.0 ^b
0.9 kg/day 30% protein	1.0 ^c	1.0 ^b
Control	1.0 ^c	1.0 ^b
1.8 kg/day 15% protein	1.4 ^d	1.3 ^c

^aThese adjustments are based on the known overestimate of fecal output from Cr₂O₃ content of grab samples taken once weekly.

^{b,c,d}Means in the same column followed by a different superscript are different (P<.05).

There was no significant differences (P<.05) between the control group and either of the two .9 kg/day rations for the 1982/83 winter season. The failure of increased levels of supplemented crude protein to stimulate intake may have been the result of a slower rate of passage. Rittenhouse (1969) suggests that the lignification of cell-wall constituents, typical of the winter forage base, can both delay particle breakdown and offset any stimulatory effect of an improved nitrogen status. At a higher level of supplementation, more efficient utilization of the diet resulted in increased forage intake levels through both the winter periods. In data collected for both the winters of 1981/82 and 1982/83, the 1.8 kg/day 15 percent protein ration increased total intake. Numerous researchers have identified nitrogen as the first limiting nutrient of growing cattle under range conditions

(Van Dyne et al., 1980; Elliot, 1967; Balch and Campling, 1962). It is assumed to stimulate intake and utilization of low quality forages associated with winter range conditions.

Clanton (1981), during the winter of 1964/65, recorded an interaction between the protein level and energy level of supplemented calves on winter range. With a high energy concentrate, gains decreased; however, when the high energy supplement was matched with a high protein supplement, gain was at its highest. Clanton (1981) suggested that the high level of supplemental energy could have influenced the amount of energy available from the forage by altering either its digestibility and/or intake.

The results of this project, shown in Table 6, show a similar interaction as in both years the 1.8 kg/day 15 percent protein ration, both high in energy and protein, stimulated forage intake. There was little difference between the high protein or high energy supplement and the unsupplemented control group through both years of the project.

Body Weight Response

The effect of various supplements on weight response for cows on winter forage has been well documented. Research, testing animal production as influenced by level of supplementation, has yielded variable results dependent on specific conditions of the individual study. Generally, the control groups or the non-supplemented cattle lost both body condition and weight. Jordan et al. (1967) found that unsupplemented pregnant cows lost as much as .5 kg/day through the winter period.

Clanton (1981), after five years of study, found various differences in how supplements affect weight gain of cattle through the winter period. In one example, the cows that received the high protein supplement gained weight at a more uniform rate than did the non-supplemented group. In another year when the hay to be fed contained 8.4 percent protein, the unsupplemented cows gained as well as the supplemented. Clanton (1981) concluded that although the non-supplemented cows often gained slower through the winter period, their gain through the summer compensated enough to maintain an equal weight with the supplemented group.

The data presented in Table 7 suggests that the various supplemental levels did play a role in influencing average weights for the cows. Unsupplemented control cows lost an average of 32 kg, which would put daily weight loss at .4 kg/day during the winter study of 1981/82 (approximately 85 days). Other body weight responses through the two winters are shown in the table provided. Generally, increasing the amount of supplement, with the ration high in both protein and energy (1.8 kg/day 15% C.P.) had the greatest influence on weight response through both winters. Body weight changes were not adjusted for conception date and represent the supplemental feeding period only (December 15-March 15).

Calving Interval/Body Condition

The calving interval or return to estrus for the 1982/83 winter's work is shown in Table 8. There were no significant differences ($P < .05$) between the various supplemental treatments. Corah et al. (1975),

feeding energy supplements to first calf heifers, also found supplemental levels to have no significant influence on the interval to first estrus. The researcher concluded that these results may be explained by the fact that the heifers were in excellent body condition at the start of the supplemental period.

Table 7. Livestock Responses to the Pre-Calving Supplemental Rations

Ration	1981/82	1982/83
	Average Body Wt. Change (kg)	Average Body Wt. Change (kg)
0.9 kg/day 15% protein	-50.6 ^a	+4.5 ^a
0.9 kg/day 30% protein	-33.0 ^b	+11.5 ^b
1.8 kg/day 15% protein	-8.8 ^c	+15.9 ^b
Control (unsupplemental)	-32.3 ^d	+ 5.9 ^c

a,b,c,d Means in the same column followed by a different superscript are different (P<.05).

Table 8. Body Condition Scoring and Calving Interval (1982/83 only).

Ration	Body Condition Score		Calving Interval (days)
	Initial	Change	
0.9 kg/day 15% protein	4.9 ^a	+0.1 ^{a,b}	383 ^a
0.9 kg/day 30% protein	5.1 ^a	-0.1 ^{b,c}	380 ^a
1.8 kg/day 15% protein	4.8 ^a	+0.6 ^a	368 ^a
Unsupplemented Control	5.2 ^a	-0.7 ^c	398 ^a

a,b,c,d Means in the same column followed by a different superscript are different (P<.05).

For the 1982/83 winter season, no significant differences ($P < .05$) were found in body condition scores at the beginning of the winter feed period. Ten weeks later, there were significant changes in body condition between the treatments. The superscripts in Table 8 display similarities and differences in body condition as influenced by the supplemental variables.

No specific production variables with the potential to influence either calving interval or body condition were monitored outside of the 12 week supplemental period. Backgrounding of the herd remained constant throughout the study with no difference between treatment groups.

Calf Performance

To measure response of the supplements fed during the winter of 1982/83, both average daily gain and adjusted 205-day weights were recorded. No differences in calf performance was found between any of the four treatments including the unsupplemented control group. All groups received an identical ration post-partum.

These results compare favorably with other research depending on the specific study conditions (Table 9).

Specific variables influencing calf performance were not measured as a portion of this project. This data is included to highlight the influence of supplemental feed. Several factors that have obvious influence on calf performance, but were not monitored include: specific sire traits, adjusted calving date, percentage of the herd cycling post-

calving, and herd health management. Backgrounding of the herd remained constant throughout the study with no difference between treatment groups.

Table 9. Calf Performance 1982/83.

<u>Cow Supplemental Treatment</u>		
<u>Pre-calving/Post-Calving</u>	<u>ADG (kg)</u>	<u>Adjusted 205-Day Weights (kg)</u>
0.9 kg/day 15% protein/ 1.8 kg/day 15% protein	0.91 ^a	220.2 ^a
0.9 kg/day 30% protein/ 1.8 kg/day 15% protein	0.90 ^a	219.5 ^a
1.8 kg/day 15% protein/ 1.8 kg/day 15% protein	0.89 ^a	216.0 ^a
Unsupplemented/ 1.8 kg/day 15% protein	0.89 ^a	215.8 ^a

^aMeans in the same column followed by the same superscript are not significantly different ($P > .05$).

Utilization

In this study, utilization measurements were conducted through the 1982/83 winter only. Measurements for two pastures of both grazed and ungrazed indicator plants are included for the two main sites within each pasture. A simple instrument developed by the U.S. Forest Service for measuring the utilization of several specific grasses was used. According to the pocket gauge, utilization measurements in pasture I amounted to an average of 33 percent between the two major sites in the pasture (Table 10). In pasture II, overall use, again between two sites, averaged 12 percent utilization. It is unlikely that utilization had any influence upon either intake or digestibility within this study.

Table 10. Utilization Measures of Key Indicator Plants for 1982/83 Winter.

	<u>Grazed Height (cm)</u>	<u>% Utilization</u>
<u>Pasture I</u>		
1/6/83	13	26
1/19/83	9.5	40.5
<u>Pasture II</u>		
2/25/83	20.5	12.5

Climatic Conditions

Temperature averages between the two years for the Norris/Madison climatological station varied 6°C with the 1981/82 winter averaging -4°C and the 1982/83 winter averaging 2°C (Table 11). These averages were determined using only the four months involved in the winter collection period. Although data on average wind speed for the project sites was not recorded, it was thought to have considerable impact on animal activity and metabolic rate.

The only major differences in factors which would influence forage intake between years of the study was the climate factor. It could be assumed that forage intake and animal weight response differences to supplemental rations between years were caused by yearly temperature differences. Colder temperatures during the first year of the study could account for significant differences in forage intake and subsequent weight changes through the study period. Intake and weight response differences for the second year of the study possibly reflect

the milder average temperature for this season. Animal weights respond quite closely with reductions in intake for both years.

Table 11. Climatological Data.

	Average Temperatures ($^{\circ}\text{C}$)	
	<u>1981</u>	<u>1982</u>
December	-2	-1
January	-7	2
February	-6	3
March	0	4
	$\bar{X} = -4^{\circ}\text{C}$	$\bar{X} = 2^{\circ}\text{C}$

Climatological Data

Norris/Madison Station
 U.S. Weather Bureau
 Montana (Vol 84-86)

CHAPTER 6

CONCLUSIONS

Intake rates for cows and heifers on winter range was 1 percent of body weight for unsupplemented animals. For the typical 400 kg (880 lbs) cow, this equates to a daily intake of 5.2 kg (11 lbs) of dry matter per day. These intake estimates correspond with other intake data generated on winter rangelands.

In comparing the influence of the supplemental treatments on intake, results of this study indicate that the isonitrogenous supplements (.9 kg/day 30% crude protein and 1.8 kg/day 15% crude protein) produced more favorable animal responses than did the isocaloric supplements (.9 kg/day 15% C.P. and .9 kg/day 30% C.P.). These conclusions parallel those of Cook and Harris (1968) who determined that the digestibility and subsequent intake were directly related to the level of supplemented protein. The 1.8 kg/day 15 percent supplement also provided an additional amount of metabolic energy. The role of this additional energy had a positive effect on forage intake. In the 1981/82 year, the low level of energy supplement (.9 kg/day 15% C.P.) without the additional protein had a negative effect on forage intake. This response is similar to those recorded by Merrill and Klopfenstein (1984) where low amounts of supplemented energy had a negative effect on animal performance. This reduction in intake is likely the result of an altered microbial habitat due to changes in rumen pH. The end result being less efficient utilization of the forage

base. Total intake figures varied only slightly between the control group and the treatments for the animals across both years.

Livestock response to the supplements was most significantly displayed in weight change for both of the years. There were significant changes in body condition through the 1982/83 season. I suspect that if body condition measurements would have been a part of the 1981/82 data collection, differences between the treatments would have been more dramatic as temperatures were lower.

A balance between protein and energy provided the most favorable intake response for these two collection years. Clanton (1981) also found a combination of protein and energy to produce the highest average daily gain. This researcher also recorded variable responses between years suggesting an interaction between supplemented protein and energy dependent upon yearly climatic variables.

The effect of environment was a significant factor influencing animal performance between years for this study. Both of these winters had fairly mild temperatures. This variability is characteristic of winters on the Northern Great Plains and can substantially influence the foraging animal's maintenance needs. Other variables that are seasonal included the amount of snow and the condition of the range or the available forage. These factors, however, had no measured effect for either of the years on animal production response.

In summary, it appears that the need for supplemental feed is highly variable, dependent upon the specific conditions involved. These variables include the quality and amount of available forage, the physical condition of the animal and yearly climatic variables. Results

from this project indicate that precalving supplementation did not stimulate increased forage consumption, but maintained or improved body condition through the supply of additional nutrients. However, supplying additional nutrients through pre-calving did not enhance subsequent calf performance over non-supplemented animals when a high nutritional plane was supplied during the post-calving pre-breeding period.

Supplementation is often times a cost effective practice for livestock producers. However, there are variables that can reduce or increase the need for supplemental feeds on winter range. In some instances unsupplemented animals may remain as productive as their supplemented counterparts. If several forage classes are present, the range itself may meet specific energy and protein requirements. If the livestock are physically mature, requirements for maintenance and production are easier to meet. When temperatures remain mild, animal maintenance requirements are often obtainable on native range without the need for any form of supplementation. The fact that supplements play a vital role in livestock production when temperatures drop is well documented. The impact of a lower average temperature during the first year of this study was dramatically displayed by changes in body condition and weight response regardless of the type of supplement fed.

Stockmen need to recognize the importance of body condition and that often times this accumulated fat going into the winter period has the ability to carry livestock through without supplementation. The management of younger, growing heifers needs to be oriented towards insuring growth and maintenance requirements are met prior to the winter

period. It is well understood that sub-standard nutritional levels for this group of maturing animals will affect the breeding success and production potential throughout their productive life. Individual management of growing heifers should be stressed for livestock producers with optimum production goals.

The relationship between supplemental energy and protein is not well-defined. Partially because it is difficult to separate the affects of one from the other. With a multitude of supplemental options available to livestock producers, it should be stated that neither of the two, protein or energy, should be ignored. Research data suggest that the influence of one may impact the utilization of the other. Without knowing the specific amounts of protein and energy a given winter range can provide, stockmen are well-advised to supplement based on physiological need and environmental stress.

Although no absolute factors have been identified in determining supplemental need, managers should key winter feed rations to the needs of the animal and specific yearly climatic variables. Research needs to continue to assess the mechanisms influencing animal performance on winter rangelands.

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APPENDICES

APPENDIX A

RED BLUFF RANCH PLANT SPECIES (THIRD DRAFT)
Compiled by Pat Plantenberg

RED BLUFF RANCH PLANT SPECIES* (THIRD DRAFT)
Compiled by Pat Plantenberg

<u>Acer glabrum</u>	Rocky Mountain maple
<u>Achillea millefolium</u> (<u>A. lanulasa</u>)	western yarrow
<u>Actaea rubra</u>	chinaberry
<u>Agastache</u> spp.	giant-hyssop
<u>Agoseris glauca</u>	pale agoseris
<u>Agoseris</u> spp.	
<u>Agropyron caninum</u> (<u>A. trachycaulum</u> and <u>A. subsecundum</u>)	slender wheatgrass crested wheatgrass
<u>A. cristatum</u>	western wheatgrass
<u>A. smithii</u>	bluebunch wheatgrass
<u>A. spicatum</u> (<u>A. inerme</u>)	ticklegass
<u>Agrostis scabra</u>	nodding onion
<u>Allium cernuum</u>	prairie onion
<u>A. testile</u>	pale alyssum
<u>Alyssum alyssoides</u>	desert alyssum
<u>A. desertorum</u>	
<u>Amelanchier alnifolia</u> var. <u>alnifolia</u>	serviceberry
<u>Anaphalis margaritacea</u>	pearly everlasting
<u>Androsace occidentalis</u>	western rockjasmine
<u>A. septentrionalis</u>	northern androsace
<u>Antennaria microphylla</u> (<u>A. rosea</u>)	rose pussytoes
<u>Antennaria</u> spp.	pussytoes
<u>Apocynum</u> spp.	dogbane
<u>Arabis holboellii</u>	holbell rockcress
<u>Arctium minus</u>	burdock
<u>Arenaria congesta</u>	ballhead sandwort
<u>Arenaria lateriflora</u>	bluntleaf sandwort
<u>Aristida longiseta</u>	red threeawn
<u>Arnica cordifolia</u>	heartleaf arnica
<u>A. sororia</u>	twin arnica
<u>Artemisia campestris</u> (<u>A. canadensis</u>)	field sagewort
<u>A. cana</u>	silver sagebrush
<u>Artemisia dracunculus</u>	green sagewort
<u>A. frigida</u>	fringed sagewort
<u>A. ludoviciana</u>	cudweed sagewort
<u>A. tridentata</u> var.	big sagebrush
<u>A.</u> spp.	sagewort
<u>Asperugo procumbens</u>	mildvetch
<u>Aster falcatus</u>	aster
<u>A.</u> spp.	white prairie aster

*Nomenclature after Hitchcock, C. L. & A. Cronquist. 1974. Flora of the Pacific Northwest, University of Washington Press, Seattle, WA, 730 pp.

<u>Astragalus</u> spp.	madwort
<u>A. adsurgens</u> (<u>A. stridatus</u>)	standing milvetch
<u>A. agrestis</u> (<u>A. dasyglottis</u>)	field milkvetch
<u>A. chinensis</u>	China milvetch
<u>A. crassicaarpus</u>	groundplum milkvetch
<u>Astragalus drummondii</u>	drummond milvetch
<u>A. gilviflorus</u>	threeleaved milvetch
<u>A. kentrophyta</u> (<u>A. tegetarius</u>)	thistle milkvetch
<u>A. purshii</u>	pursh loco
<u>A. missouriensis</u>	Missouri milkvetch
<u>Balsamorhiza sagittata</u>	arrowleaf balsamroot
<u>Berberis repens</u> (<u>Mahonia repens</u>)	Oregon grape
<u>Besseya wyomingensis</u> (<u>B. cinerea</u>)	Wyoming kittentail
<u>Betula occidentalis</u>	waterbirch
<u>Bouteloua gracilis</u>	blue grama
<u>Bromus carinatus</u> (<u>B. marginatus</u>)	mountain brome
<u>B. inermis</u>	smooth brome
<u>B. japonicus</u>	Japanese brome
<u>B. tectorum</u>	cheatgrass
<u>Clamagrostis montanensis</u>	plains reedgrass
<u>Calamovilfa longifolia</u>	priarie sandreed
<u>Caltha leptosepala</u>	marsh marigold
<u>Camelina microcarpa</u>	littlepod flaseflax
<u>Campanula rotundifolia</u>	roundleaf harebell
<u>Capsella bursa-pastoris</u>	shepherds purse
<u>Cardaria draba</u>	whitetop
<u>Carex</u> spp.	sedge
<u>C. filifolia</u>	threadleaf sedge
<u>C. lanuginosa</u>	wooly sedge
<u>C. nebraskensis</u>	Nebraska sedge
<u>C. rossii</u>	ross sedge
<u>C. stenophylla</u> (<u>C. eleocharis</u>)	needleleaf sedge
<u>C. sprengeellii</u>	sprengell sedge
<u>C. vallicola</u>	valley sedge
<u>Castilleja pallescens</u>	palish paintbrush
<u>Castilleja sessiliflora</u>	downy Indian paintbrush
<u>C. spp.</u>	paintbursh
<u>Centaurea maculosa</u>	spotted knapweed
<u>Cerastium arvense</u>	field chickweed
<u>C. spp.</u>	chickweed
<u>Cercocarpus montanus</u>	birchleaf mountain mahogany
<u>Chaenactis douglasii</u>	dusty maiden
<u>Chenopodium album</u>	lambs quarters
<u>C. leptophyllum</u>	slimleaf goosefoot
<u>Chrysopsis villosa</u>	
(<u>Heterotheca villosa</u>)	hairy goldenaster
<u>Chrysothamnus nauseosus</u>	rubber rabbitbrush
<u>C. viscidiflorus</u>	green rabbitbrush
<u>Cirsium</u> spp.	thistle
<u>C. arvense</u>	Canada thistle
<u>C. undulatum</u>	wavyleaf thistle
<u>Claytonia lanceolata</u>	lanceleaf spring beauty

<u>Clematis columbiana</u>	rock clematis
<u>C. ligusticifolia</u>	white clematis
<u>Collinsia parviflora</u>	blue-eyed Mary
<u>Collomia linearis</u>	slenderleaf collomia
<u>Comandra umbellata</u> (<u>C. pallida</u>)	bastard toadflax
<u>Conimitella williamsii</u>	conimitella
<u>Conium maculatum</u>	poison hemlock
<u>Cornus stolonifera</u>	redosier dogwood
<u>Crataegus</u> spp.	hawthorn
<u>Crepis acuminata</u>	tapertip hawk's beard
<u>C. occidentalis</u>	hawk's beard
<u>Cryptantha ambigua</u>	obscure cryptantha
<u>Cryptantha celosioides</u> (<u>C. bradburiana</u>)	miner's candle
<u>C. torreyana</u>	Torrey's cryptantha
<u>Cynoglossum officinale</u>	houndstongue
<u>Dactylis glomerata</u>	orchardgrass
<u>Danthonia unispicata</u>	onespike danthonia
<u>Delphinium bicolor</u>	low larkspur
<u>D. occidentale</u>	tall larkspur
<u>Deschampsia</u> spp.	hairgrass
<u>Descurainia pinnata</u>	pinnate tansymustard
<u>D. sophia</u>	flixweed
<u>Disporum</u> spp.	fairy bell
<u>Dodecatheon conjugens</u>	slimpod shooting star
<u>Douglasia montana</u>	Rocky Mountain douglasia
<u>Draba nemorosa</u>	woods draba
<u>D. oligosperma</u>	few seeded draba
<u>D. reptans</u>	carolina draba
<u>Eleocharis palustris</u>	common spikrush
<u>Elymus glaucus</u>	blue wildrye
<u>E. canadensis</u>	Canada wildrye
<u>E. cinereus</u>	basin wildrye
<u>E. junceus</u>	Russian wildrye
<u>Equisetum arvense</u>	common horsetail
<u>E. spp.</u>	horsetail
<u>Erigeron caespitosus</u>	grey daisy
<u>E. compositus</u>	cutleaved daisy
<u>E. ochroleucus</u>	buff fleabane
<u>E. pumilus</u>	low fleabane
<u>Eriogonum flavum</u>	yellow buckwheat
<u>Eriogonum pauciflorum</u> (<u>E. multiceps</u>)	few-flowered buckwheat
<u>E. spp.</u>	buckwheat
<u>Erysimum asperum</u>	western wall flower
<u>Erythronium gandiflorum</u>	glacier lily
<u>Euphorbia esula</u>	leafy spurge
<u>E. glyptosperma</u>	ridgeseed spurge
<u>Eurotia lanata</u> (<u>Ceratoides lanata</u>)	winterfat
<u>Festuca idahoensis</u>	Idaho fescue
<u>F. octoflora</u> (<u>Vulpia octoflora</u>)	sixweeks fescue
<u>F. viridula</u>	green fescue
<u>Fragaria vesca</u>	woodland strawberry
<u>F. virginiana</u>	Virginia strawberry

<u>Fritillaria pudica</u>	yellowbell
<u>Gaillardia aristata</u>	blanketflower
<u>Galium</u> spp.	bedstraw
<u>G. boreale</u>	northern bedstraw
<u>Gaura coccinea</u>	scarlet gaura
<u>Geranium richardsonii</u>	Richardson geranium
<u>Geranium viscosissimum</u>	sticky geranium
<u>Geum triflorum</u>	prairie smoke
<u>Gilia</u> spp. (<u>Ipomopsis</u> spp.)	gilia
<u>Glyceria grandis</u>	American mannagrass
<u>Glycyrrhiza lepidota</u>	American licorice
<u>Grindelia squarrosa</u>	curlycup gumweed
<u>Gutierrezia sarothrae</u> (<u>Xanthocephalum sarothrae</u>)	broom snakeweed
<u>Gypsophila paniculata</u>	baby's breath
<u>Haplopappus acaulis</u>	stemless goldenweed
<u>Helianthus nuttallii</u>	nuttalls sunflower
<u>Hedeoma drummondii</u>	flase pennyroyal
<u>Hesperochloa kingii</u>	spike-fescue
<u>Heracleum lanatum</u>	cow-parsnip
<u>Heuchera</u> spp.	alumroot
<u>Hordeum jubatum</u>	foxtail barley
<u>Hydrophyllum capitatum</u>	ballhead waterleaf
<u>Hymenopappus filifolius</u>	fineleaf hymenopappus
<u>Hymenopappus</u> spp.	hymenopappus
<u>Iris missouriensis</u>	Rocky Mountain iris
<u>Juncus balticus</u>	baltic rush
<u>Juncus</u> spp.	rush
<u>Juniperus communis</u>	common juniper
<u>Juniperus scopulorum</u>	Rocky Mountain juniper
<u>Koeleria cristata</u>	prairie junegrass
<u>Lactuca pulchella</u>	blue lettuce
<u>L. serriola</u> (<u>L. scariola</u>)	prickly lettuce
<u>Lappula echinata</u>	bristly stickseed
<u>L. redowskii</u>	western stickseed
<u>Lepidium campestre</u>	field pepperweed
<u>Lepidium densiflorum</u>	prairie pepperweed
<u>L. perfoliatum</u>	clasping pepperweed
<u>Lesquerella alpina</u>	alpine bladderpod
<u>Lewisia rediviva</u>	bitterroot
<u>Liatris punctata</u>	dotted gayfeather
<u>Linum perenne</u> (<u>L. lewisii</u>)	blue flax
<u>Lithospermum incisum</u>	narrowleaf gromwell
<u>L. ruderale</u>	stoneseed
<u>Lomatium</u> spp.	biscuit-root
<u>L. triternatum</u> (<u>L. simplex</u>)	nineleaf lomatium
<u>Lupinus lepidus</u>	pacific lupine
<u>L. sericeus</u>	sticky lupine
<u>Lychnis drummondii</u>	drummond campion
<u>Lygodesmia juncea</u>	skeletonweed
<u>Machaeranthera canescens</u> (<u>Aster canescens</u>)	hoary aster

<u>M. grindelioides</u>	
(<u>Haplopappus nuttallii</u>)	nuttalls goldenweed
<u>Matricaria matricarioides</u>	pineappleweed
<u>Melilotus alba</u>	white sweetclover
<u>Melilotus officinalis</u>	yellow sweetclover
<u>Mentha arvensis</u>	field mint
<u>Mertensia oblongifolia</u>	oblongleaf bluebell
<u>Mertensia</u> spp.	bluebell
<u>Microseris cuspidata</u>	toothed microseris
<u>Microsteris gracilis</u>	pink microsteris
<u>Mimulus</u> spp.	monkey-flower
<u>Monarda fistulosa</u>	horsemint
<u>Montia perfoliata</u>	miner's lettuce
<u>Musineon divaricatum</u>	wild parsley
<u>Myosotis alpestris</u> (<u>M. sylvatica</u>)	forget-me-not
<u>Nepeta cataria</u>	catnip
<u>Oenothera biennis</u>	common evening primrose
<u>O. nuttallii</u>	nuttall evening primrose
<u>Opuntia polyacantha</u>	pricklypear cactus
<u>Oryzopsis hymenoides</u>	Indian ricegrass
<u>Orobanche</u> spp.	broomrape
<u>Orthocarpus luteus</u>	owl-clover
<u>Osmorhiza chilensis</u>	mountain sweetroot
<u>Oxytropis besseyi</u>	bessey pointvetch
<u>O. lagopus</u>	rabbitfoot crazyweed
<u>O. sericea</u>	white pointloco
<u>Pedicularis cystopteridifolia</u>	fernleaf lousewort
<u>Penstemon</u> spp.	penstemon
<u>P. eriantherus</u>	fuzzytongue penstemon
<u>P. nitidus</u>	waxleaf penstemon
<u>Perideridia gairdneri</u>	yampah
<u>Phacelia hastata</u>	silverleaf phacelia
<u>P. linearis</u>	threadleaf phacelia
<u>Phalaris arundinacea</u>	reed canarygrass
<u>Philadelphus lewisii</u>	syringa
<u>Phleum pratense</u>	timothy
<u>Phlox diffusa</u>	spreading phlox
<u>P. caespitosa</u>	tufted phlox
<u>P. albomarginata</u>	whitemargined phlox
<u>P. hoodii</u>	hood phlox
<u>P. longifolia</u>	longleaf phlox
<u>Physocarpus malvaceus</u>	ninebark
<u>Pinus flexilis</u>	limber pine
<u>Plantago patagonica</u> (<u>P. purshii</u> ,	
& var. <u>spinulosa</u>)	woolly plantain
<u>Poa</u> spp.	bluegrass
<u>P. scabrella</u> (<u>P. canbyi</u>)	pine bluegrass
<u>P. compressa</u>	Canada bluegrass
<u>P. cusickii</u>	cusick bluegrass
<u>P. pratensis</u>	Kentucky bluegrass
<u>P. sandbergii</u> (<u>P. secunda</u>)	sandberg bluegrass
<u>Polygonum aviculare</u>	prostrate knotweed

<u>Polygonum</u> spp.	knotweed
<u>P. douglasii</u>	douglas knotweed
<u>Populus</u> spp.	cottonwood
<u>P. tremuloides</u>	quaking aspen
<u>Potentilla diversifolia</u>	diverse leaved cinquefoil
<u>P. glandulosa</u>	gland cinquefoil
<u>P. gracilis</u>	northwest cinquefoil
<u>P. hippiana</u>	woolly cinquefoil
<u>P. ovina</u>	sheep cinquefoil
<u>P. pensylvanica</u>	prairie cinquefoil
<u>Prunus virginiana</u>	chokecherry
<u>Pseudotsuga menziesii</u>	douglas fir
<u>Purshia tridentata</u>	bitter-brush
<u>Ranunculus</u> spp.	buttercup.
<u>R. glaberrimus</u>	sagebrush buttercup
<u>Ratibida columnifera</u>	prairie coneflower
<u>Rhus radicans</u>	poison ivy
<u>R. trilobata</u>	skunkbrush sumac
<u>Ribes</u> spp.	currant
<u>R. cereum</u> var. <u>inebrians</u>	squaw currant
<u>R. setosum</u>	Missouri gooseberry
<u>Rorippa nasturtium-aquaticum</u>	water cress
<u>Rosa arkansana</u>	prairie rose
<u>R. woodsii</u>	Wood's rose
<u>Rosa</u> spp.	rose
<u>Rubus parviflorus</u>	thimbleberry
<u>Rudbeckia</u> spp.	coneflower
<u>Rumex acetosella</u>	sheep sorrel
<u>R. crispus</u>	curly dock
<u>Salsola kali</u> (<u>S. iberica</u>)	Russian thistle
<u>Salix</u> spp. 1	willow
<u>Salix</u> spp. 2	willow
<u>Salix</u> spp. 3	willow
<u>Sanicula marilandica</u>	black snakeroot
<u>Sedum stenopetalum</u>	wormleaf stonecrop
<u>Selaginella densa</u>	dense clubmoss
<u>Senecio canus</u>	wooly groundsel
<u>S. integerrimus</u>	lambstongue groundsel
<u>Silene repens</u>	creeping silene
<u>Sisymbrium altissimum</u>	tumble mustard
<u>Smilacina racemosa</u>	false solomon's seal
<u>Smilacina stellata</u>	lily of the valley
<u>Solidago</u> spp.	goldenrod
<u>Solidago missouriensis</u>	Missouri goldenrod
<u>Sphaeralcea coccinea</u>	scarlet globemallow
<u>Sporobolus cryptandrus</u>	sand dropseed
<u>Stellaria media</u>	chickweed
<u>Stipa columbiana</u>	Columbia needlegrass
<u>S. comata</u>	needle-and-thread
<u>S. viridula</u>	green needlegrass
<u>S. williamsii</u>	William's needlegrass
<u>Swainsona salsula</u>	swainsona

<u>Symphoricarpos albus</u>	common snowberry
<u>Taraxacum officinale</u>	common dandelion
<u>Tetradymia canescens</u>	gray horse brush
<u>Thalictrum spp.</u>	meadowrue
<u>Thermopsis montana</u>	mountain thermopsis
<u>Thlaspi arvense</u>	fanweed
<u>Townsendia hookeri</u>	hooker townsendia
<u>T. parryi</u>	parry townsendia
<u>Tragopogon dubius</u>	salsify
<u>Trifolium repens</u>	white clover
<u>Triglochin maritimum</u>	seaside arrow-grass
<u>Urtica dioica</u>	stinging nettle
<u>Valeriana spp.</u>	valerian
<u>Verbascum thapsus</u>	flannel mullein
<u>Verbascum thapsus</u>	flannel mullein
<u>Veronica spp.</u>	speedwell
<u>Vicia americana</u>	American vetch
<u>Viola canadensis</u>	Canada violet
<u>V. nephrophylla</u>	northern bog violet
<u>V. adunca</u>	hook violet
<u>V. nuttallii</u>	nuttall violet
<u>Zigadenus venenosus (Z. intermedius)</u>	meadow death-camas

APPENDIX B

SOIL DESCRIPTIONS

SOIL DESCRIPTIONS

The major soil type in both pastures is the Orofino-Pino complex as recognized in the Madison County soil survey of 1980. The unit is 50 percent Orofina gravelly loam and 30 percent Poin very flgy sandy loam. Th Orofina soils are on hillsides and footsples while the shallow Poin soils are on hilltops and ridges. Rocky outcrops are also present on ridgetops and limit the total forage production of the unit.

Two other minor soil types included in these pastures are the Varney clay loam and the Varney cobbly clay loam. They are deep, well draned soils found primarily on terraces, fans, footslopes and drainage ways.

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