AN ABSTRACT OF THE THESIS OF

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Title: Leadership Behavior and Foraging Strategies of a Herd of Roosevelt Elk Inhabiting the Oregon Coast Range

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A cow-calf herd of Roosevelt elk (Cervus elaphus roosevelti) resident to Indian Creek Research Center (ICRC), Oregon was observed June-August, 1985 and March-August, 1986. Cows at ICRC reproduced in alternate years; cows with calves led the herd a significantly greater number of times than cows without calves (1985, $P < 0.05$; 1986, $P < 0.01$).

Activity budgets of 9 individual cow elk were significantly different ($X^2 = 97.52$, $df = 24$, $P < 0.001$) with the greatest differences occurring in the feeding and alert categories (61%-86% and 2%-27%, respectively). One individual had an alert frequency more than 3 times the mean cow alert frequency of 8% and could be considered a sentry.

There was a highly significant difference ($P < 0.001$) in the activity budgets of cows and young calves (1-3 months old), cows and older calves (8-11 months old), and cows and yearlings (12-15 months old). During summer, cows spent a greater proportion of time feeding (78%) compared to calves 1-3 months old (66%). Alert frequency for yearlings and cows during summmer equalled 1% and 8%, respectively; young calves spent no time watching for potential danger. Yearlings

fed more frequently (87%) than cows (78%); male yearlings spent 28% more time feeding than females. There was no significant difference between the activity budgets of cows with calves and cows without calves.

The foraging strategies of cows and calves differed throughout the study period. The greatest differences between the diets of cows and calves occurred when the calves were 1-2 months old. Young calves were more selective in their foraging habits and relied primarily on forbs to meet their energy needs. Both cows and calves selected the most nutritious, palatable, forage available each season. As the calves matured, grasses made a larger contribution to their diets. Herd use of the meadow areas was highly correlated to meadow size and percent clover ($r^2 = 0.87$, $F = 23.18$, $P = 0.001$).

Leadership Behavior and Foraging Strategies of a Herd of Roosevelt Elk Inhabiting the Oregon Coast Range

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INTRODUCTION

Individuals within a population are inherently different. When individuals live in groups these differences are first apparent at the class level, i.e. dividing the group into adults and juveniles. Within each class, differences emerge due to variance in sex, physical condition, reproductive status, and experience. This can result in a group of related individuals which vary in their physiological conditions and, consequently, in their energetic requirements. Individuals should adopt behaviors, activity budgets, and foraging strategies appropriate to their particular energy needs.

For example, a herd of Roosevelt elk (Cervus elaphus roosevelti) can be classified as cows, calves, and yearlings (adult males live solitarily throughout most of the year). Calves and yearlings have a large growth requirement, spend little time at alert behavior, and receive nutritional supplementation by nursing. One would expect to find different behaviors and foraging strategies for calves and yearlings compared to cows.

Individual cows may differ due to their reproductive status. Cows which reproduce successfully have large energy requirements due to the metabolic drain of gestation and especially lactation. Cows that do not reproduce in a particular year do not have these added energetic burdens. This results in two cow classes which should vary in their foraging strategies according to their particular physiological needs.

Thus, the goal of this study was to determine whether individuals in a class, and classes within a herd of Roosevelt elk employ different behaviors, activity budgets, and foraging strategies to fulfill their apparent physiological needs.

I. LEADERSHIP BEHAVIOR AND ACTIVITY BUDGETS OF A HERD OF ROOSEVELT ELK INHABITING THE OREGON COAST RANGE

ABSTRACT

A cow-calf herd of Roosevelt elk (Cervus elaphus roosevelti) resident to Indian Creek Research Center (ICRC), Oregon was observed June-August, 1985 and March-August, 1986. Cows at ICRC reproduced in alternate years; cows with calves led the herd a significantly greater number of times than cows without calves (1985, $P < 0.05$; 1986, $P < 0.01$).

Activity budgets of 9 individual cow elk were significantly different ($X^2 = 97.52$, $df = 24$, $P < 0.001$) with the greatest differences occurring in the feeding and alert categories (61%-86% and 2%-27%, respectively). One individual had an alert frequency more than three times the mean cow alert frequency of 8% and could be considered a sentry.

There was a highly significant difference ($P < 0.001$) in the activity budgets of cows and young calves (1-3 months old), cows and older calves (8-11 months old) and cows and yearlings (12-15 months old). During summer, cows spent a greater proportion of time feeding (78%) compared to calves 1-3 months old (66%). Alert frequency for yearlings and cows during summer equalled 1% and 8%, respectively; young calves spent no time watching for potential danger. Yearlings fed more frequently (87%) than cows (78%); male yearlings spent 28% more time feeding than females. There was no significant difference between the activity budgets of cows with calves and cows without calves ($X^2 = 7.13$, $df = 4$, $P = 0.13$).

Ignoring the differences that exist within a population, whether at the individual, sex or age class level can lead to inappropriate assessment and, therefore, management of a species.

INTRODUCTION

Roosevelt elk (Cervus elaphus roosevelti) is a gregarious, nonmigratory, subspecies of North American elk inhabiting the Pacific Northwest. The basic social group is a herd consisting of cows, their calves, and yearlings of both sexes (Franklin et al. 1975, Franklin and Lieb 1979). Males 2-3 years of age leave the herd and live solitarily throughout most of the year. Social organization of the cow-calf herd is hierarchical in nature. The herd is led by a matriarch who is thought to be one of the older cows in the group (Altmann 1952, Franklin and Lieb 1979, Hall 1983).

In Darling's (1937) study of a herd of European red deer (C. e. elaphus) the matriarch was always a successful breeder; if a leader failed to breed, she ceased to lead. Franklin and Lieb (1979) found the matriarch in a herd of Roosevelt elk to be a cow with the most social bonds, and only cows with calves had a strong tendency to lead. Roosevelt cow elk resident to the Oregon coast range reproduce in alternate years (Harper 1971, Trainer 1971). This low reproductive rate was attributed to poor physical condition resulting from low quality forage typical of coast range habitats (Harper 1971, Trainer 1971, Cleary 1976) where extensive rainfall and cloudy periods tend to leach nutrients from the plants resulting in a nutrient deficient forage base (Laycock and Price 1970, Cleary 1976). If a cow's reproductive status has a strong influence on her leadership behavior, the alternate year reproductive pattern found in Oregon Roosevelt cow elk could result in alternating matriarchal positions.

Although the matriarch leads the herd to safety in response to a disturbance, other high ranking cows may share in attentive duties. If an individual spent a greater proportion of time alert than would be predicted based on the size of the group, the individual may be considered a sentry. Altmann (1952), noted several "guard cows" which alerted to perceived disturbances and gave alarm barks when a disturbance was detected. Darling (1937) and Franklin and Lieb (1979) described a "rear guard" cow who stayed behind and brought up the rear of the herd when leaving an area.

Differences in behavior between individuals or classes of individuals within a herd can be expected due to differences in age, sex, physical condition, reproductive status, and experience. The low reproductive rate of Roosevelt elk may result in two cow classes that vary greatly in physical condition. Due to the heavy energy expenditure of calving and early lactation, cows with calves have very high nutritional requirements as opposed to cows without calves (Mitchell 1973, Arman et al. 1974, Clutton-Brock et al. 1982), and a different foraging strategy might, therefore, be expected for each class.

Likewise, the foraging and behavioral strategies of calves and yearlings would be expected to differ from those of adults due to their different nutritional and physiological requirements (Geist 1982). Both calves and yearlings have a considerable growth requirement, spend virtually no time watching for predators, and receive additional nutritional supplements by nursing; clearly different foraging strategies would be employed to meet their respective energetic demands.

Because there are differences in physiological condition and consequently, nutritional requirements between individuals within and between classes within a herd, and these differences should be reflected in their foraging and behavioral strategies, the objectives of this study were: 1) to determine if matriarch Roosevelt elk retain their rank in the herd regardless of their reproductive status; 2) to determine if any individual in an elk cow-calf group is attentive more frequently than would be predicted by its proportional representation in the group (i.e. existence of a sentry); and 3) to determine if different foraging strategies (activity budgets) exist between distinct classes within the herd.

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STUDY AREA

Indian Creek Research Center (ICRC) consists of 416 ha of private property located within the Siuslaw National Forest, Lane County, Oregon. The property is situated along the West Fork of Indian Creek (Township 16S, R10W) and contains both open meadow areas and primarily second growth mixed deciduous-coniferous forest (Fig. I.1).

Topography ranges from slopes of less than 10% along the creek channel associated with lower elevations to 70%-80% at the higher elevations with an average of 20%-30% for the study area. Elevation ranges from 122-229 m. The climate is maritime with a mean annual precipitation of 267cm and mean annual temperature of 11.09°C. Temperatures range from a low of -6.11°C to a high of 32.78°C (U.S. Dept. of Commerce).

The study area is comprised of three distinct habitats: timber, brush, and meadow areas. Timber areas consist primarily of Douglas fir (Pseudotsuga menziesii), red alder (Alnus rubra) with some Western red cedar (Thuja plicata). Brush areas are characterized by dense stands of Himalayan blackberry (Rubus discolor), evergreen blackberry (R. ovatum) and bracken fern (Pteridium aquilinum). The meadow areas contain a variety of grasses and forbs, major species include orchardgrass (Dactylis glomerata), velvetgrass (Holcus mollis), bentgrass (Agrostis alba), white clover (Trifolium repens), yarrow (Achillea millefolium), and English plantain (Plantago lanceolata).

METHODS

Elk were observed at ICRC during the summer of 1985 (June-August) and during spring (March-May) and summer (June-August) 1986. A spotting scope equipped with a 15x-45x zoom lens was used during all observations. To assure equal visual accessibility to every individual in the herd, observations were restricted to the herd's use of open meadow areas. Therefore, direct observations occurred from dawn to ~8:30am and from ~5:30pm to dark. Individuals were recognized on the basis of natural markings, scars, and pelage coloration and assigned an identification number. Herd location, size, and composition was recorded daily.

Behavioral Strategies

Lead cows were identified whenever possible. Leading occurred during normal feeding movement, general movement (movement not involving active feeding), and in response to human disturbance. The number of times a cow led was then compared to the total number of times leading was observed. The reproductive status of each cow was also noted. The Kolmogorov-Smirov Test for discrete data (Steel and Torrie 1980) was used to analyze individual lead cows. The data was then pooled into 2 classes based on reproductive status: lead cows with calves versus lead cows without calves and analyzed via the Binomial Test (Langley 1970). Data for the summer of 1985 and 1986 were analyzed separately.

Activity budgets were recorded and compared between individual cow elk and between distinct classes of individuals. Specific

activities recorded were feeding, alert, moving, standing, bedded, grooming, and playing. Individual cow elk were identified and their activity recorded every 2 minutes for as long as possible during an observation period. Activity budgets were obtained in this way for 19 cow elk during summer 1986; however, only 9 had a sufficient number of observational minutes to be included in the Chi-square analysis.

To examine differences between distinct classes, the herd was classified as cows with calves, cows without calves, calves, and yearlings. Every 2 minutes an individual representing each class was randomly selected and its activity recorded. If no statistically significant difference was found between summer 1985 and summer 1986 class data, it was pooled for analysis. Data for each class were compared by Chi-square analysis. Only those activities which contained a sufficient number of observations (expected values > 5) were included. To avoid differences influenced by seasonal changes in plant phenology, spring and summer data were analyzed separately.

RESULTS

Six hundred and 50 hours of observation were accumulated during the study period. Elk were available for observation on the open meadow areas from 1-3 hours in the early morning and from 1-4 hours in the evening. The elk sought shelter during the heat of the day by entering forested areas associated with higher elevations, and were unobservable during this time.

Herd Composition

Mean herd size ranged from 28 individuals in June 1985, to 42 individuals in July and August; with an overall mean of 36 for the summer of 1985. The herd included 12 calves, 10-12 yearlings, one branched bull (2-3 years of age), and 18-25 cows.

During spring and summer 1986, mean herd size numbered 46 and 49 individuals, respectively. Summer 1986 herd composition included 9 calves, 10-15 yearlings, 2 branched bulls (2-3 years of age), and 20-25 cows. In general, cows made up 50-66% of the herd with the remaining 33-50% divided between calves and yearlings. The herd was not a static unit but rather consisted of an aggregation of small family groups with small numbers of individuals frequently leaving and rejoining the herd.

The Matriarch

During both summers, lead cows with calves led the herd a proportionately greater number of times than lead cows without calves (Figure I.2). During summer 1985, lead cows with calves led

significantly more often (12 times compared to 5, Px = 36%, $P < 0.05$) than those without calves. During the summer of 1986, lead cows with calves led 14 times while lead cows without calves led 4 times, the difference was also significant (Px = 27%, $P < 0.01$).

During the summer of 1985, one cow (#23) who had a calf, spent a significantly greater proportion of time leading (47%) than any other single lead cow ($P < 0.05$) most of which led less than 10% of the time (Table I.1). Cow #23 could, therefore, be considered the matriarch for summer 1985.

During summer 1986, the leading frequency among individual lead cows ranged from 6% to 28% (Table I.2). There was no significant difference among individual lead cows ($P > 0.05$) suggesting there was no apparent matriarch for the summer of 1986.

Activity Budgets - Individual Cow Elk

Considerable individual variation in activity budgets existed among cow elk at ICRC (Table I.3). Feeding, alert, moving, and standing were compared among 9 of the 19 original cows observed. There was a highly significant difference among the cows ($X^2 = 97.52$, df = 24, $P < 0.001$); the greatest differences occurred in frequency of feeding and alert behaviors which ranged from 61%-86% and 2%-27%, respectively (Table I.3).

Cow #73 was by far the most attentive individual in the herd with an alert frequency of 27% compared to a mean alert frequency of 8% for all cows. This particular cow frequently gave alarm barks in response to a perceived disturbance, yet led the herd to safety only once during the summer of 1986 (leading freq. = 6%). Because cow #73

spent a greater proportion of time watching for potential danger than would be expected or predicted, she could be considered a sentry. Conversely, there were individuals who spent far less time being attentive than would be expected (cow #59, Table I.3).

Cows vs. Calves

Amount of time spent feeding, alert, moving, standing, and bedded were significantly different (X^2 = 154.28, df = 4, $P < 0.001$) between cows and calves during the summers of 1985 and 1986 (Fig. I.3). The greatest difference was in feeding frequency; cows spent a greater proportion of time feeding (78%) than calves (66%) (Table I.4). Calves ranged from 1-3 months of age during this time and still derived a large proportion of their nutritional requirements from milk. Calves spent no time watching for potential danger (alert freq. = 0) compared to an overall alert frequency for cows of 8%. Compared to cows, ICRC calves spent twice as much time moving while the herd was actively foraging (15% vs. 7% respectively, Table I.4).

Cows vs. Older Calves

Activity budgets were compared between cows and calves (8-11 months of age) during March, April, and May 1986. Analysis of feeding, alert, and moving activities revealed a highly significant difference between the 2 classes (X^2 = 30.47, df = 2, $P < 0.001$, Fig. I.4). The proportion of time cows and older calves spent feeding was similar 70% and 72%, respectively); however, there was a large difference in alert frequencies between the 2 classes (16% for cows vs. 2% for calves, Table I.4). Both cows and older calves spent a

greater proportion of time moving during spring than during summer. Cows spent 12% of the time moving during spring and 7% during summer. Older calves spent a greater proportion of their time moving than cows, 20% in spring and 15% during summer (Table I.4).

Cows with Calves vs. Cows without Calves

Comparison of the activity budgets of cows with calves and cows without calves during the summer of 1985 and 1986 revealed no significant difference between the 2 classes (X^2 = 7.13, df = 4, P = 0.13, Fig. I.5). No behavioral category differed by more than 3% of the total activity budget.

Yearlings vs. Cows

A significant difference existed in the proportion of time cows and yearlings spent feeding, alert, moving, standing, and bedded during summer 1985 and 1986 (X^2 = 35.32, df = 4, P < 0.001, Fig. I.6). Although considerably smaller both in body and rumen size compared to adult elk, yearlings exhibited a very high feeding frequenty (87%). Yearlings (individuals 12-15 months old) also seemed to lack attentive responsibility; the proportion of time they spent watching for potential danger was only 1% compared to 8% for mature cows (Table I.4). Yearlings continued to receive nutritional supplementation by continuing to nurse.

Male vs. Female Yearlings

There was an apparent difference between activity budgets of male and female yearlings during summer 1986, with males spending a

proportionately greater amount of time feeding than females (85% for males vs. 57% for females, Yates X^2 = 3.60, df = 1, P = 0.058, Fig. I.7). However, the data may be biased due to small sample size.

DISCUSSION

The Matriarch

The tendency for cows with young calves to lead to a much greater extent than cows without calves (Darling 1937, Franklin and Lieb 1979, Fig. I.2.) may be explained through kin selection; anything a cow can do to increase the survival of her calf will also increase her own genetic survival (Hamilton, 1964). Because the majority of Roosevelt cow elk in Oregon do not reach reproductive maturity until 3 years of age, reproduce in alternate years, and produce only a single offspring (Harper 1971, Trainer 1971), their potential lifetime reproductive success is very limited. A cow would, therefore, be expected to invest very heavily early in the lives of her infrequent offspring in order to offset this low reproductive potential. Leading a young calf to safety in potentially dangerous situations is part of that strong parental investment. Likewise, parental investment in the form of protection would be expected to decline with increasing size and age of the offspring (i.e. as the calf becomes less vulnerable to predation).

In this study, there was some indication that the parental investment associated with the reproductive status of a cow elk influenced its leadership behavior. Only those cows with calves showed a strong tendency to lead. Evidence supporting an assumed reproductive rate of approximately 50% was provided by the observed cow/calf ratio.

During both the summer of 1985 and 1986, total numbers of adult cow elk ranged from 20 to 25; while the total number of calves

remained constant at 12 for 1985 and 9 for 1986. Cow #23 was the most active leader during summer 1985 with a leading frequency of 47% during which time she had a calf. During summer 1986, cow #23 led only 11% of the time and nursed a female yearling. Lieb (1973) working at Prairie Creek Redwoods State Park, California found that the most dominant cow in the "Beach" cow group had a calf, was at least 6 years of age and led 52% of the time compared to all other lead cows which led less than 10% of the time, while the most dominant cow of the "Prairie" cow group led 46% of the time.

At ICRC, the matriarchal position appeared to be held by an older cow in the herd who had a calf; however, it was not the sole reponsibility of the matriarch to lead the herd to safety in response to a disturbance. Several adult cows (>3 years of age), particularly those with calves, also actively led although far less frequently. Finally, the matriarchal position of cow #23 was not retained in 1986 and may have changed in accordance with her reproductive status.

Activity Budgets - Individual Cow Elk

Attentive behavior was not shared equally among mature cows in the herd, but varied greatly from individual to individual. Cow #73 was alert far more frequently than would be predicted based upon her proportional representation in the group. Conversely, cow #59 spent very little time participating in attentive behavior. This individual was visibly emaciated; because of her apparent physiological demands, cow #59 would be expected to spend as much time as possible trying to build up her energy reserves. It can also be assumed that a cow in good physical condition would not have such

an urgent nutritional demand and would therefore spend less time feeding and a greater amount of time on other activities.

Many behavioral studies tend to overlook the individual animal and focus on the "average" behavior of the population; this can lead to erroneous assumptions and conclusions (Hirsch 1962). In their study of Soay Sheep (Ovis aries) Grubb and Jewell (1974) found that the average daylight grazing duration for rams was 2.5 hours; but individual rams grazed for as little as 1.83 hours and as much as 3.25 hours. Craighead et al. (1973), studying Rocky Mountain elk (C. e. nelsoni), found large variations in 24 hour activity budgets among the 7 cow elk monitored; yet, these differences were not apparent when the data were combined to represent the activity budget of an "average" cow elk. According to Tryon (1934), the "average individual is, in fact, a man-made fiction, and the behavior of a species can properly be understood only by considering the variations in behavior of all (or a random sample of) the individuals who are classed in it."

Cows vs. Calves

Calves have the time, morphological features, and physiological requirements to be more selective in their foraging habits. Because mature cows take the responsibility of watching for predators, calves are free to spend more time pursuing other activities (Geist 1982). Additionally, nutrition derived from suckling may allow the young animals to spend less time foraging and more time on rest and play activities (Bunnell and Gillingham 1985). While ICRC cows devoted most of their time toward feeding and watching for potential danger,

young calves spent their time feeding (including frequent nursing), moving, standing, and bedded.

Due to their smaller body size, smaller, less-developed rumen, high metabolic rate, and large growth requirement, calves have a physiological requirement to seek and consume high quality, easily digestible forage (Geist 1982); it is logical that young animals search more thoroughly for preferred plant species (as shown by increased movement while feeding). This was the case according to Harper (1962) who found elk calves moved considerably during a given observational bout, selecting 3 to 4 different plant species while cows fed only on a single species during the same interval. At ICRC, when both cows and calves were actively foraging, calves spent a greater proportion of time moving than cows.

Cows vs. Older Calves

The different behavior exhibited by cows and calves during the spring of 1986 can best be explained on the basis of their varying physiological needs. Calves 8-11 months old have a strong growth requirement, nurse less frequently, and increase their consumption of herbaceous material considerably in order to meet their nutritional requirements. This could account for the similar feeding frequencies found between older calves and cows. In addition, by continuing to nurse, calves receive a nutritional supplement that may help them achieve higher growth rates. The low frequency of vigilant activities found in older calves (alert freq. = 2%) allow them to invest in other behaviors such as increased movement (20% for calves

vs. 12% for cows) which may be associated with the ability to select high quality forage.

The variation in herd movement between seasons at ICRC can partially be explained by the changes occurring in plant phenology. Available plant biomass was visibly lower during spring than during summer and the elk may have had to utilize a variety of plant communities in order to fill their rumen. Clutton-Brock et al. (1982) found that when the biomass of a preferred plant community decreased significantly, the herd shifted its use to plant communities supporting a larger standing crop. In addition, the nutritional quality of plants is greater during early stages of growth (during the spring) when plants are less fibrous and easily digestible. Higher forage quality may allow elk to be more selective in spring than in summer when plant biomass is high and quality lower (Nelson and Leege 1982), and this could help explain the increased frequency of movement of both cows and calves during spring.

Cows with Calves vs. Cows without Calves

Because the elk at ICRC reproduce in alternate years, 2 cow classes existed which varied in their energetic requirements. To reproduce successfully, a cow elk must expend a large amount of metabolic energy. Arman et al. (1974) reported that during early lactation red deer hinds required 2.4 to 2.6 times the maintenance diet of hinds without calves. In fact, the metabolic energy associated with early lactation is equal to three times the metabolic energy required for pregnancy alone (Oftedal 1985). The heavy energy expenditure associated with lactation should be reflected in the

individual's foraging strategy; i.e. through increased feeding time or by consumption of better quality forage, if available.

Clutton-Brock et al. (1982) found that during June, July, and August, hinds with calves spent a greater proportion of time feeding (57%) than hinds without calves (51%). At ICRC, differences were not observed between the 2 cow classes. The sampling period in this study encompassed daylight hours only and observations were restricted to the herd's use of open meadow areas. Differences in the activity budgets may have existed at night or while animals were in forested habitats. Additionally, cows without calves did not necessarily represent nonlactating cows. At ICRC, barren cows (cows that did not calve that year) continued to nurse their yearling offspring during the summer, although less frequently and for a shorter time than cows with young calves.

Yearlings vs. Cows

A yearling has a tremendous growth requirement and should spend a large proportion of its time feeding. The feeding frequency of yearlings may be higher than expected when compared to that of adult cows (87% vs. 77%, respectively), however, the yearling data may be positively biased by comparing both male and female yearlings to adult females. Male yearlings at ICRC spent 28% more time feeding than female yearlings perhaps reflecting a larger growth requirement of males.

Male elk reach an overall larger body size and weight than females (318-499kg vs. 265-284kg, respectively, Boyd 1978). In addition, large body size and weight are extremely important factors

affecting the reproductive success of a bull elk (Appleby 1982, Suttie 1982, Clutton-Brock 1985). According to Clutton-Brock (1985), the reproductive success of a male red deer is dependent upon his ability to fight (harem defense); which is directly affected by his size, weight, and growth rate during his first year. Not only was dominance rank an important factor in a male's breeding success (Appleby 1982, Suttie 1982) but it was also maintained throughout the individual's lifetime (Appleby 1982; Clutton-Brock et al. 1982). Thus, early growth and development are extremely important factors to a young male as it ultimately affects the individual's lifetime reproductive success.

Management Implications

The management of any species is based on information representing the "average" individual or the "average" population; however, no such entity exists in nature. Ignoring differences which may exist, whether at the individual, sex, or age class level, may result in the erroneous assessment of a population's requirements or needs which can lead to inappropriate management recommendations. The variance which exists in any population must be considered if management of a particular species is to be at an optimum level.

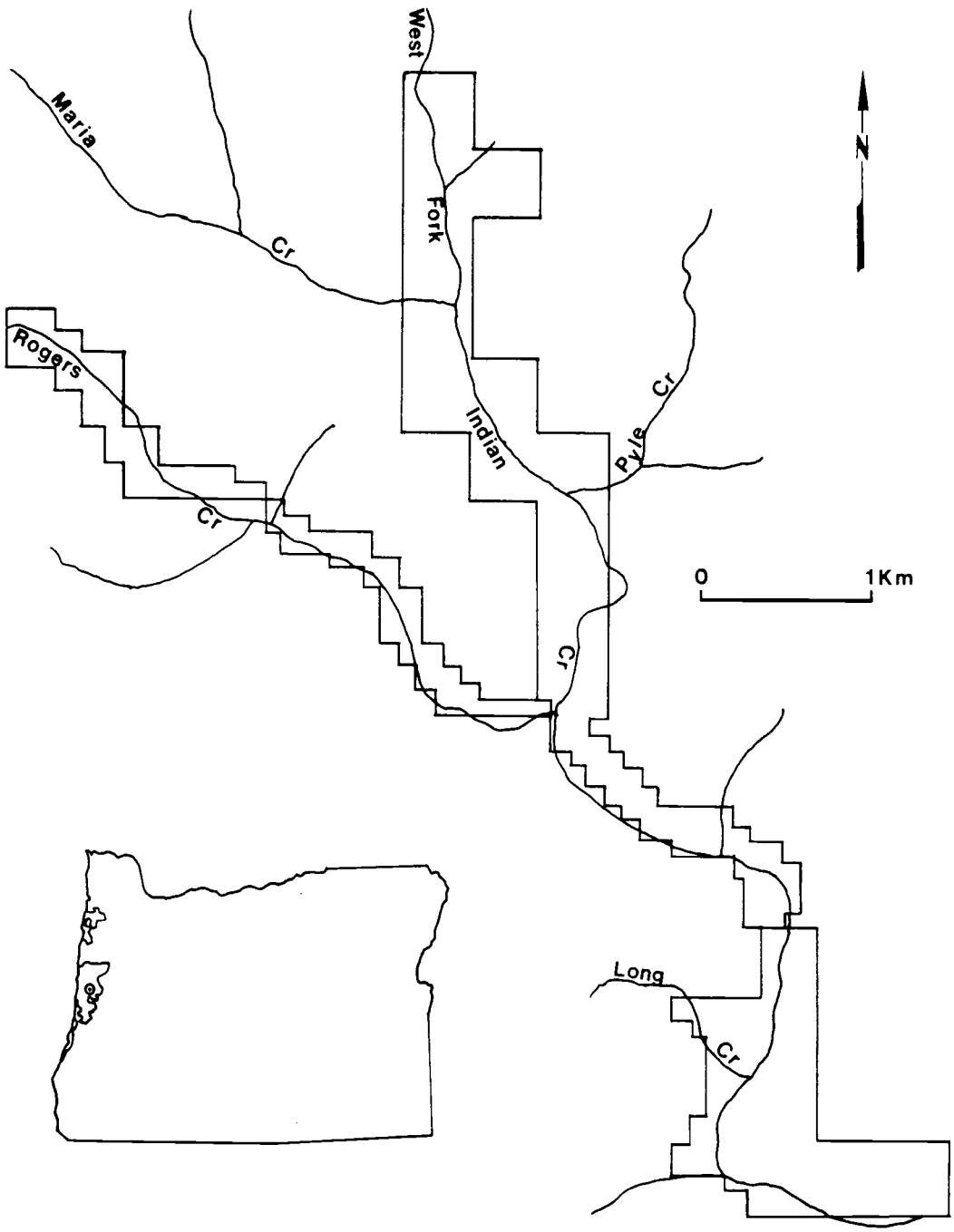

Figure I.1. Map of Indian Creek Research Center (ICRC). Area bounded within the map of Oregon refers to the Siuslaw National Forest. ⊙ refers to ICRC, Township 16S, R10W, Lane County, Oregon.

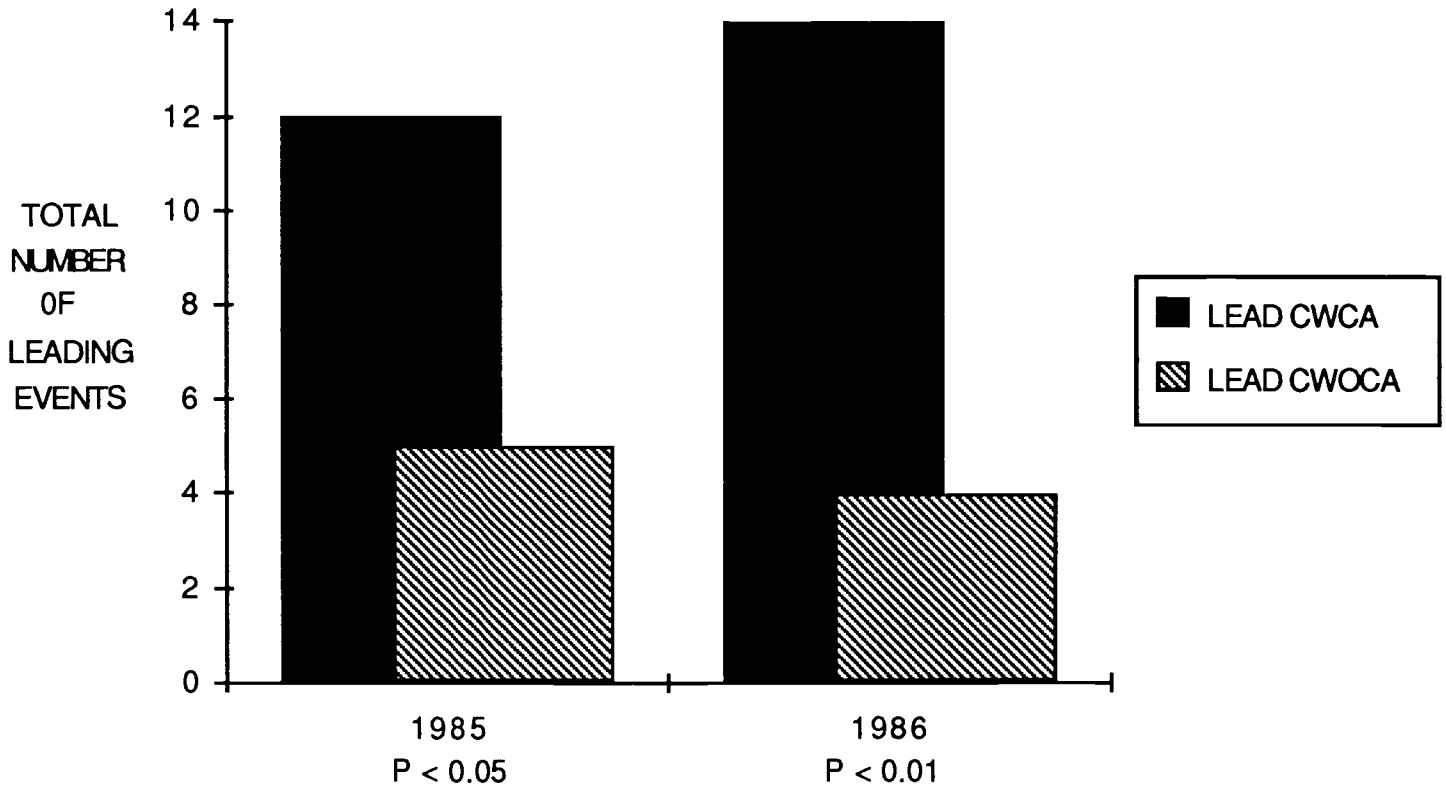

Figure I.2. Influence of reproductive status on leadership behavior in Roosevelt cow elk resident to Indian Creek Research Center, Oregon, summer 1985 and 1986. CWCA = cows with calves; CWOCA = cows without calves

Table I.1. Frequency of observed leadership in individually identifiable cow elk resident to Indian Creek Research Center, Oregon during summer, 1985.

	Single Leader									Two or More Leaders				
	5	*9	*10	14	*16	*23	*28	30	33	A	B	C	D	Total
Feeding Movement	1			1	1	5	1			1	1	1	1	13
General Movement						1		2	1					4
Human Disturbance		1	1			2								4
Total	1	1	1	1	1	8	1	2	1	1	1	1	1	21
Frequency	6%	6%	6%	6%	6%	47%	6%	12%	6%					

* cows with calves

Feeding Movement = movement associated with active feeding
General Movement = movement not associated with active feeding
Human Disturbance = movement in response to human disturbance

A = 6,11,*23,35 B = *1,*21,*23 C = 3,*28,30 D = *23,33

Table I.2. Frequency of observed leadership in individually identifiable cow elk resident to Indian Creek Research Center, Oregon during summer, 1986.

	Single Leader							Two or More Leaders					
	*3	*12	23	*57	59	63	*73	A	B	C	D	E	Total
Feeding Movement	2	2	1	1		1		1	2	1	1	1	13
General Movement	2			3								1	6
Human Disturbance		2	1	1	1		1						6
Total	4	4	2	5	1	1	1	1	2	1	1	2	25
Frequency	22%	22%	11%	28%	6%	6%	6%						

*cows with calves

Feeding Movement = movement associated with active feeding
General Movement = movement not associated with feeding
Human Disturbance = movement in response to human disturbance

A = *3,*57,58 B = *3,*73 C = *12,*68,*69 D = *3,*68 E = *3,9,*57

Table I.3. Activity budgets (% frequency) for 9 individually identifiable cow elk resident to Indian Creek Research Center, Oregon during summer, 1986.

	Activity					
Cow	Feed	Alert	Move	Stand	Bed	Total Minutes
#57	76%	7%	8%	6%	3%	488
#73	61	27	5	5	2	210
#69	82	7	6	4	1	272
#12	82	4	7	4	3	114
#68	82	8	8	1	1	260
#3	76	5	11	7	1	186
#59	86	2	5	4	3	532
#9	73	10	6	9	1	580
#60	73	11	10	4	1	162
Mean*	78	8	7	5	2	

*Mean frequency for all cows, summer 1985 and 1986.

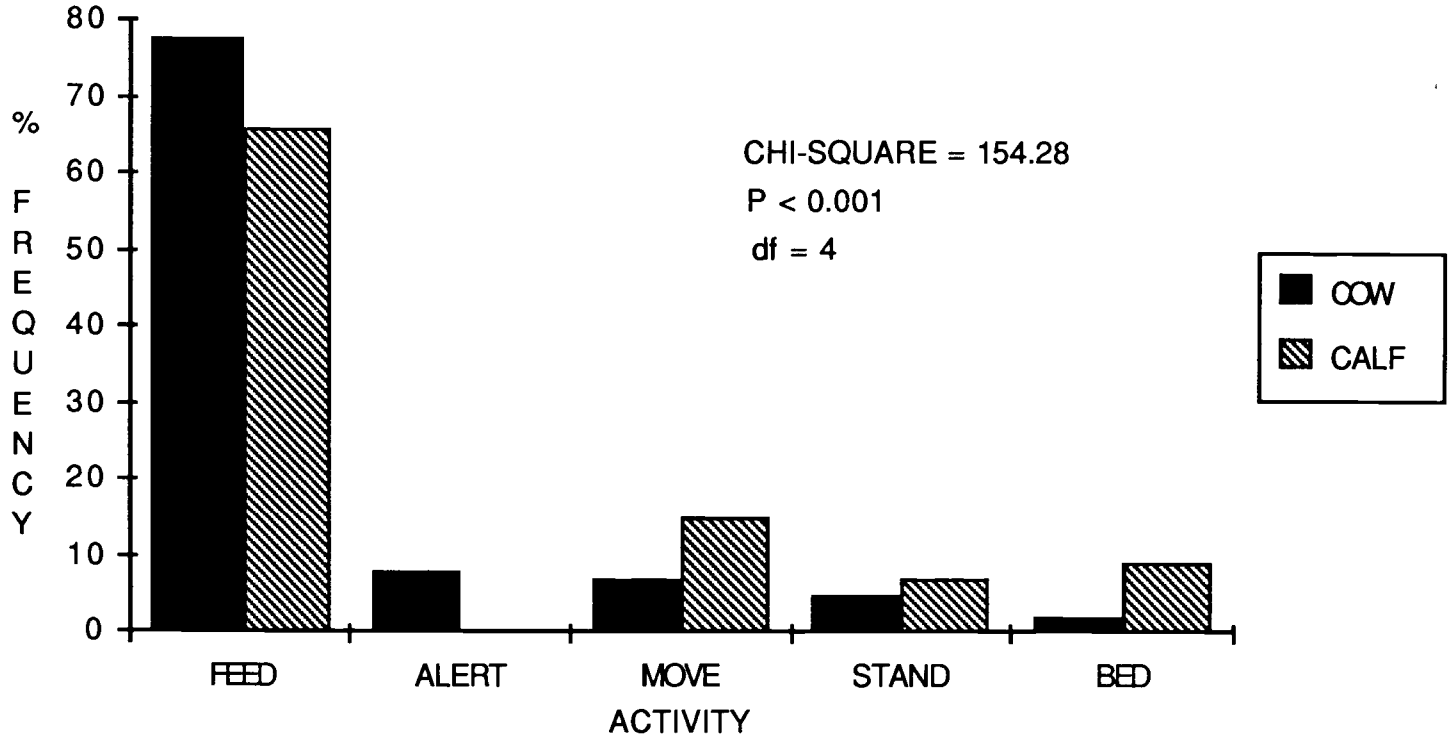

Figure I.3. Activity budgets of Roosevelt elk cows and calves, summer 1985 and 1986, Indian Creek Research Center, Oregon.

Table I.4. Activity budgets (% frequency) of distinct classes of elk during summer 1985, spring 1986, and summer 1986, Indian Creek Research Center, Oregon.

Class	Feed	Alert	Move	Stand	Bed	Groom	Play	Total Mins. Obs.
All Cows[a]	78%	8%	7%	5%	2%	0	0	3484
Calves[b]	66	0	15	7	9	2	1	1416
CWCA[c]	77	9	8	4	2	0	0	1628
CWOCA[d]	79	6	7	5	2	1	0	1856
Yearlings[e]	87	1	9	1	1	1	0	602
Cow-spring[f]	70	16	12	1	0	1	0	494
Calf-spring[g]	72	2	20	3	2	1	0	494

[a] Pooled summer 1985 and 1986 data

[b] Individuals 1-3 months old; summer 1986 data only

[c] Cows with calves; pooled summer 1985 and 1986 data

[d] Cows without calves; pooled summer 1985 and 1986 data

[e] Individuals 12-15 months old; 1986 data only

[f] All cows; spring 1986 data only

[g] Individuals 8-11 months old; spring 1986 data only

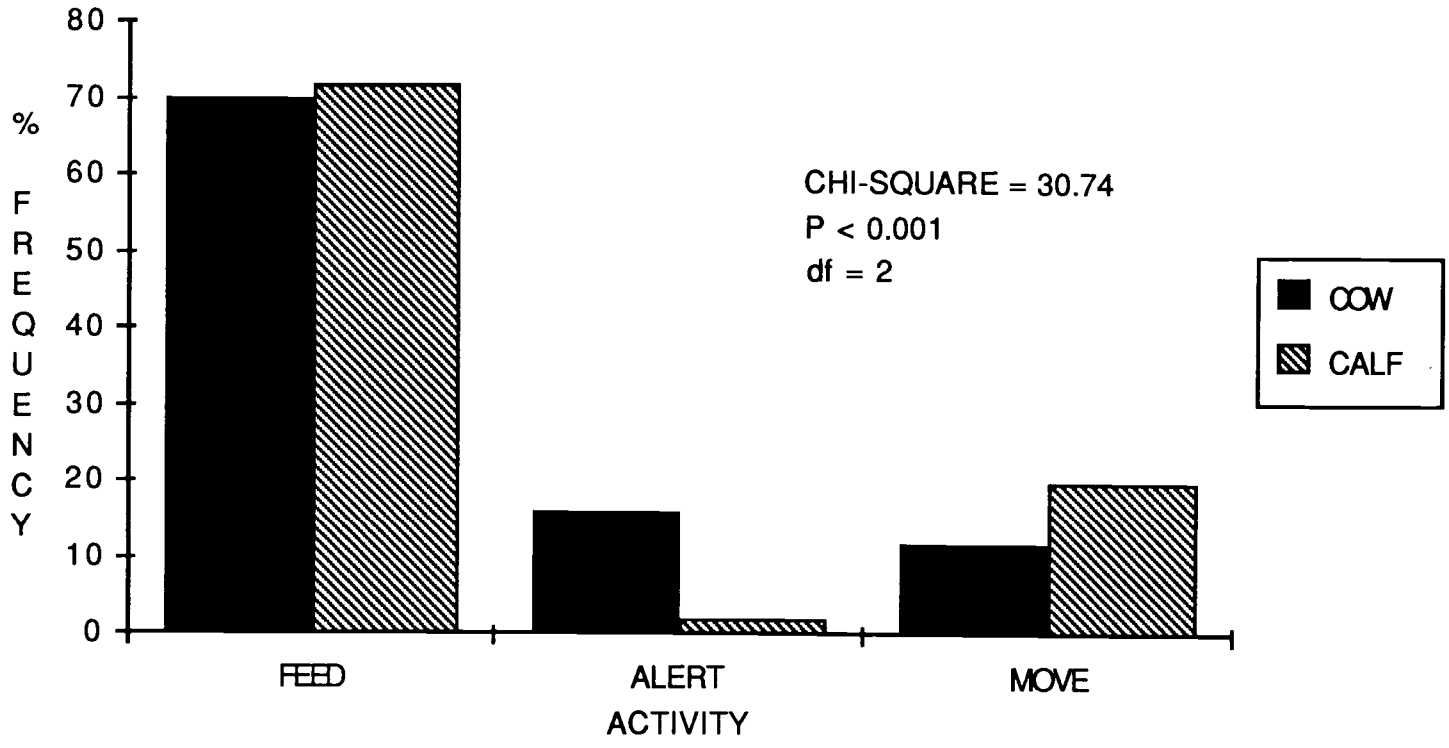

Figure I.4. Activity budgets of Roosevelt elk cows and calves, Indian Creek Research Center, Oregon, spring 1986.

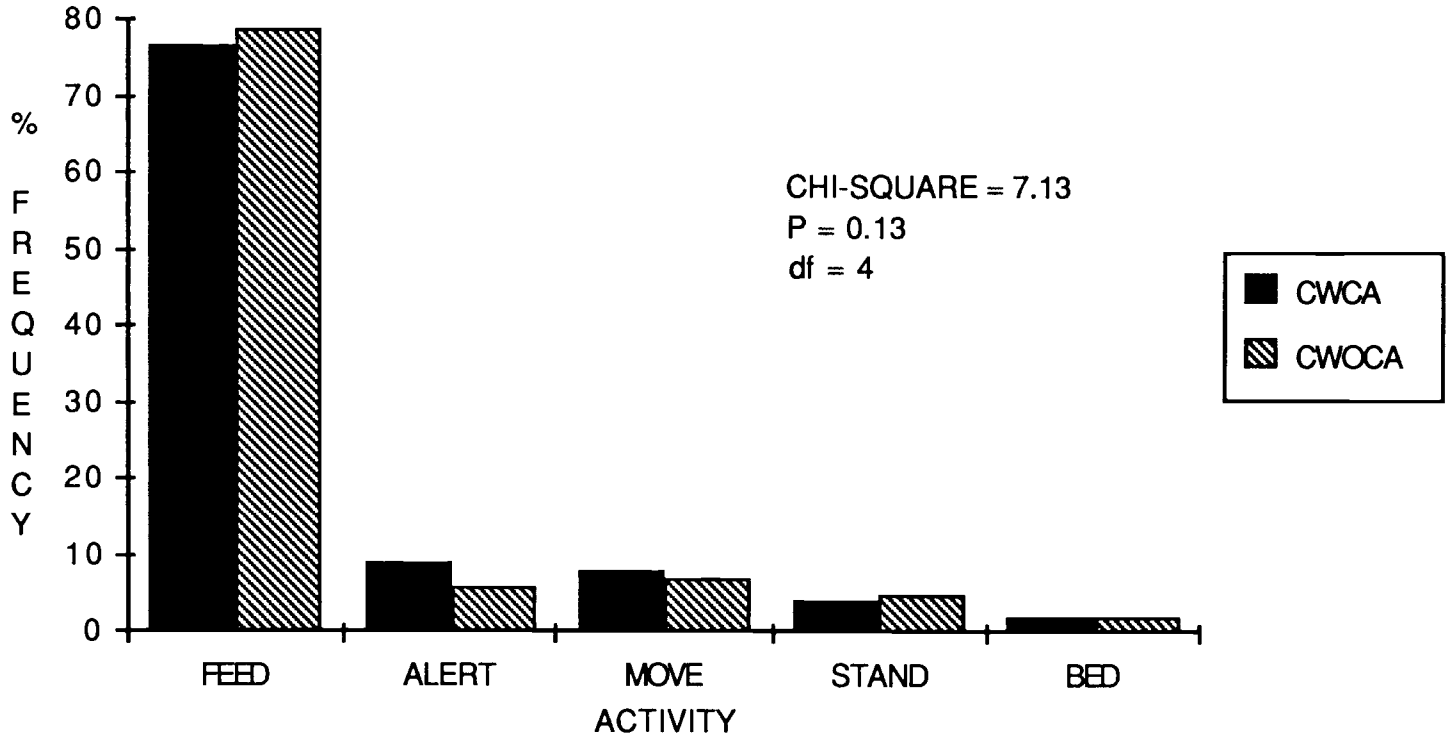

Figure I.5. Activity budgets of Roosevelt elk cows with calves and cows without calves, summer 1985 and 1986, Indian Creek Research Center, Oregon.
CWCA = cows with calves; CWOCA = cows without calves

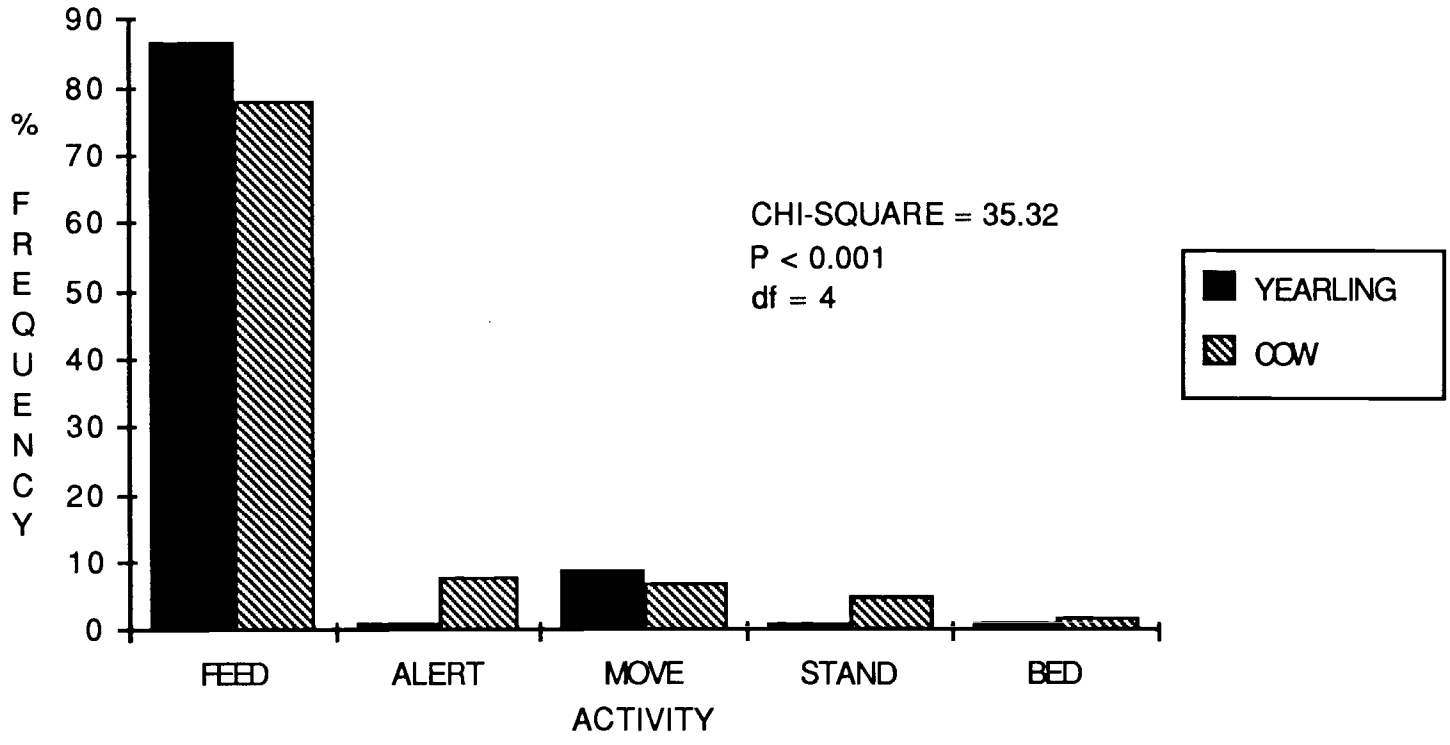

Figure I.6. Activity budgets of Roosevelt elk yearlings and cows, summer 1985 and 1986, Indian Creek Research Center, Oregon.

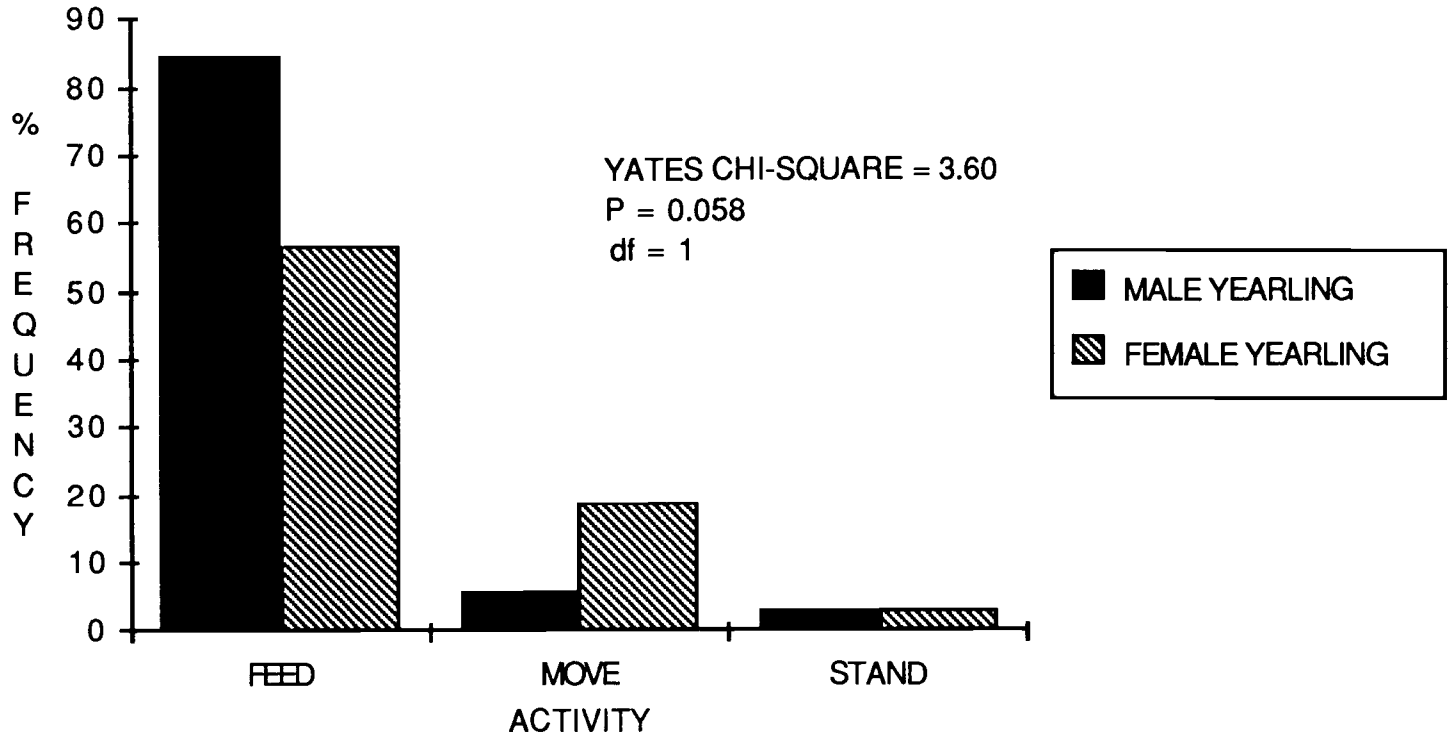

Figure I.7. Activity budgets of Roosevelt elk male and female yearlings resident to Indian Creek Research Center, Oregon, summer 1986.

II. A COMPARISON OF THE FORAGING STRATEGIES OF COW AND CALF ROOSEVELT ELK RESIDENT TO THE OREGON COAST RANGE

ABSTRACT

The diets of Roosevelt elk (Cervus elaphus roosevelti) cows and calves resident to Indian Creek Research Center (ICRC), Oregon were compared during August 1985, March, April, July, and August 1986 by microhistological analysis of the fecal samples. Differences between the diets of cows and calves were greatest when the calves were 1-2 months old. Young calves were more selective in their foraging habits and relied primarily on forbs to meet their energy needs. Four species, Rubus discolor, Anaphalis margaritacea, Plantago lanceolata, and Trifolium repens comprised 87.2% of the total diet of calves during July 1986. Diets of cows during this time had an approximately 50/50 grass to forb ratio, however, cows had a strong preference for Lolium perenne which contributed 30.3% to their July diets. Both cows and calves appeared to select the most nutritious, palatable, forage available each season. As the calves matured, grasses made a larger contribution to their diets.

There was a significant difference in the number of hours the elk spent in each meadow ($X^2 = 160.02$, $n = 9$, $P < 0.001$). Herd use of the meadows was strongly correlated to meadow size and percent clover ($r^2 = 0.87$, $F = 23.18$, $P = 0.001$).

INTRODUCTION

Classes of individuals within a social group should differ in their foraging strategies due to differences in age, sex, experience, physiology, and consequently, energetic needs (Clutton-Brock et al. 1982, Geist 1982). A herd of Roosevelt elk is typically comprised of adult females (cows), their calves, and immature males; males 2-3 years of age leave the herd and use different habitats throughout most of the year (Franklin et al. 1975, Franklin and Lieb 1979). Cow elk and their calves share the same home range during the entire year, yet because the two classes differ substantially they should use the available forage differently.

Cow elk have a much larger body and rumen size than calves. The large rumen volume and associated microflora give the cows the ability to eat a large quantity of relatively poor quality forage (Hanley 1982, Geist 1982). Cow elk are constrained primarily by the quantity of available food. Cows with young calves, however, have additional energetic needs due to the energy expenditure associated with lactation (Arman et al. 1974, Clutton-Brock et al. 1982). Cows may rely on less digestible vegetation due to large rumen volume and longer rumen retention time, however, they must select forage high in protein in order to meet their energy needs (Arman et al. 1974, Clutton-Brock et al. 1982).

Young calves have a small rumen which is not fully developed during the first few months (Short 1964). In addition, young calves have large growth requirements and high metabolic rates which impose strong energetic demands on the animal (Geist 1982). Young calves

must select a high quality diet to meet their energetic needs. A diet of easily digestible forage and a small rumen would result in faster rumen turnover and fermentation rates which would help provide the nutrition needed (Hungate 1959). Calves can be more selective in their foraging habits because they don't devote any time toward alert behavior; cows generally watch for possible danger (Altmann 1952, Geist 1982, Fig. I.3). Furthermore, calves are provided a major nutritional supplement through nursing during this time (Harper et al. 1967, Mitchel 1973, Clutton-Brock et al. 1982).

Because of the obvious physiological and energetic differences between cow and calf elk, the two age classes should adopt foraging habits to meet their respective energetic requirements. Accordingly, the objective of this study was to determine whether Roosevelt elk cows and calves differ in their foraging strategies.

This material is based upon work supported under a National Science Foundation Graduate Fellowship. Additional support was provided by the Oregon Parks Foundation. I am grateful to Jean Anderson and Ugo Pezzi for their hospitality, support, and enthusiasm during my stay at ICRC. I thank Rosemary Stussy for help in the field, Bruce Davitt for the microhistological analysis, and Drs. D. S. deCalesta, S. H. Sharrow, and B. E. Coblentz for reviewing earlier drafts of this manuscript.

STUDY AREA

Indian Creek Research Center (ICRC) consists of 416 ha of private property located within the Siuslaw National Forest, Lane County, Oregon. The property is situated along the West Fork of Indian Creek (Township 16S, R10W) and contains both open meadow areas and primarily second growth mixed deciduous-coniferous forest (Fig. II.1).

Topography ranges from slopes of less than 10% along the creek channel associated with lower elevations to 70%-80% at the higher elevations with an average of 20%-30% for the study area. Elevation ranges from 122-229 m. The climate is maritime with a mean annual precipitation of 267cm and mean annual temperature of 11.09°C. Temperatures range from a low of -6.11°C to a high of 32.78°C (U.S. Dept. of Commerce).

The study area is comprised of three distinct habitats: timber, brush, and meadow areas. Timber areas consist primarily of Douglas fir (Pseudotsuga menziesii), red alder (Alnus rubra) with some Western red cedar (Thuja plicata). Brush areas are characterized by dense stands of Himalayan blackberry (Rubus discolor), evergreen blackberry (R. ovatum) and bracken fern (Pteridium aquilinum). The meadow areas contain a variety of grasses and forbs, major species include orchardgrass (Dactylis glomerata), velvetgrass (Holcus mollis), bentgrass (Agrostis alba), white clover (Trifolium repens), yarrow (Achillea millefolium), and English plantain (Plantago lanceolata).

METHODS

Six cow and 4-6 calf fecal samples were collected bimonthly from open meadow areas at ICRC from June-August, 1985 and March-August, 1986. Fecal samples were placed in 6 oz whirl-pac plastic bags and immediately frozen after collection. Cow and calf fecal samples were distinguished by pellet size, calf pellets were 1/4-1/2 the size of adult pellets. Ten to 15 pellets from each individual cow and calf were combined to form one cow and one calf composite sample for monthly comparisons, diets were then determined by microhistological analysis (Miller 1980) at the Wildlife Habitat Laboratory, Washington State University, Pullman, Washington. Due to the differential digestibility of plant species, correction factors were calculated by reconstructing the originally determined diets and digesting them in vitro with elk inoculum (Miller 1980). Sixty one plants were collected and pressed during June-August, 1986 to serve as a reference collection.

Botanical composition was obtained for each of 10 meadows by point sampling every 10 cm along 3-9 randomly placed 30-meter line transects (Pieper 1978). To minimize error due to phenological changes in plant species, botanical composition was recorded from 19 June 1986 to 11 July 1986. Percent frequency was calculated for each plant species encountered by dividing the number of "hits" for a single species by the total number of "hits" for all plants (Levy and Madden 1933). Relative preference indices (RPI) were computed by comparing plant species in the diet to that in the meadows (i.e.

%Diet / %Available). RPI values greater than 1 indicated preference of a plant species.

The total number of hours the elk spent foraging in each meadow was recorded by direct observation. Meadow size was measured and recorded (Gary Thompson, Forest Industries Consultant) during an inventory of ICRC, summer 1986.

Chi-square analysis and Bonferroni Z statistics (Neu et al. 1974) were used to compare elk use of the meadow areas to availability. Correlation analysis and multiple regression (Hintze 1984) was used to determine which factors (meadow size, %total grasses, %total forbs, or specific plant composition) correlated with actual elk use of the meadows. Combining individual pellet groups to form composite samples for microhistological analysis may have eliminated individual variation in the diets, and the resulting sample size was too small for statistical analysis; therefore, major differences between the diets of cow and calf elk were noted and compared to the chi-square and regression results.

RESULTS

Diets - August 1985

Total graminoid consumption by cows and calves (1-3 months old) at ICRC during August 1985 equalled 39.9% and 46.0%, respectively (Fig. II.2). Cows and calves selected Bromus sitchensis (14.7% and 17.6%, respectively). Although consumption of ryegrass (Lolium perenne) was minimal for cows (2.2%) and calves (6.4%) it remained a preferred plant species (RPI = 1.2 and 3.4, respectively; Table II.1).

Total forb consumption was similar for cows (46.5%) and calves (40.6%; Fig. II.2). Cows and calves showed a strong preference for yarrow (Achillea millefolium) (16.8%, RPI = 2.4 and 17.8%, RPI = 2.5, respectively; Table II.1). Cows selected clover (Trifolium repens) (13.9%); cows and calves showed a preference for sandwort (Arenaria macrophylla) (RPI = 2.8 and 2.9, respectively; Table II.1), although, it was not a major component in their diets. Shrubs comprised 13.6% of the diets of cows and 12.1% of the diets of calves (Fig. II.2).

March 1986

Graminoid consumption by ICRC cows and calves (8-10 months old) during March 1986 was 78.3% and 46.2%, respectively (Fig. II.3). Three species comprised the majority of the total grass consumption of cows: bentgrass (Agrostis alba) (14.2%), Bromus sitchensis (37.8%), and orchardgrass (Dactylis glomerata) (11.1%). Sweet vernalgrass (Anthroxanthum odoratum) (14.6%) and ryegrass (9.5%) were the major graminoid species selected by calves.

Forb consumption was substantially lower in March 1986 than in August 1985. Forbs comprised only 8.5% and 4.3% of the total diets of cows and calves, respectively (Fig. II.3). Salal (Gaultheria shallon) contributed 8.8% to the total diets of cows. Calves consumed 30.6% total shrubs (24.8% salal). Douglas fir (Pseudotsuga menziesii) comprised 17.6% of the total diets of calves, but only 2.4% of the diets of cows.

Cows and calves exhibited a high degree of selectivity in their foraging habits. Four species (bentgrass, Bromus sitchensis, orchardgrass, and salal) made up 71.9% of the total diets of cows while four species (salal, Douglas fir, sweet vernalgrass, and ryegrass) comprised 66.5% of the total diets of calves for March 1986 (Appendix 3).

April 1986

Graminoid and forb consumption was similar for cows and calves (9-11 months old) during April 1986. Total graminoid consumption was 48.1% for cows and 56.0% for calves; total forb consumption equalled 48.8% for cows and 40.8% for calves (Fig. II.4). Major graminoid species in the diets of cows included Carex spp. (14.8%) and ryegrass (11.8%); while calves selected orchardgrass (22.9%). Cows and calves were highly selective for yarrow (18.3% and 18.1%, respectively) and clover (18.9% and 16.2%, respectively; Appendix 4). Total shrub consumption was minimal; 2.0% and 0.3% for cows and calves, respectively (Fig. II.4).

July 1986

During July 1986, diets of cows at ICRC consisted of 53.8% grasses compared to only 3.6% for calves (1-2 months old) (Fig. II.5.). Cows had a strong preference for ryegrass (30.3%, RPI = 15.9; Table II.2). All other graminoid species contributed less than 4.5% to the diets of both cows and calves. Forbs contributed 44.4% to the diets of cows and 72.7% to the diets of calves (Fig II.5). Calves were highly selective in their forb consumption; three species, English plantain (Plantago lanceolata), pearly everlasting (Anaphalis margaritacea), and clover comprised 10.9%, 20.4%, and 35.2% of the diet, respectively (Table II.2). Yarrow was the major forb species consumed by cows (11.3%, RPI = 1.6; Table II.2) while sandwort was preferred by both cows and calves (RPI = 6.2 and 4.5, respectively; Table II.2).

Shrubs were a minor component in the diets of cows (1.8% total) compared to that of calves (23.7%) (Fig. II.5). One species, Himalayan blackberry (Rubus discolor) comprised 20.7% of the total diets of calves.

In general, calves (1-2 months old) at ICRC were extremely selective in their foraging habits. Four species Rubus, Anaphalis, Plantago, and Trifolium comprised 87.2% of their total diet. The diets of cows was approximately 50/50 grass/forb, however, cows had a strong preference for ryegrass which comprised almost 1/3 of their total diet.

August 1986

Cows and calves increased their consumption of graminoids during August 1986 (cows = 66.1% vs. calves = 20.5%; Fig. II.6.). Bentgrass 17.8% and ryegrass 27.4% were the dominant grasses in the diets of cows. Ryegrass was still highly preferred (RPI = 14.4; Table II.3) by cows, but only eaten in proportion to its availability (RPI = 1.1) by calves.

Forb consumption decreased in August 1986 for cows and calves (27.8% and 58.5%, respectively; Fig. II.6.). Cows and calves continued to show a preference for Arenaria (RPI = 2.2 and 9.9, respectively; Table II.3). Calves were highly selective in their forb consumption with Anaphalis, clover, and Arenaria comprising 13.3%, 12.7% and 10.9% of the total diets of calves. Shrubs remained a minor component of the diets of cows (6.1% total; Fig. II.6) while Rubus discolor comprised 15.2% of the total diet of calves.

Two species, bentgrass and ryegrass comprised 45.2% of the August 1986 diets of cows; the remaining 54.8% was more evenly distributed among grasses and forbs (Appendix 6). Four species, Rubus, Anaphalis, Arenaria, and clover comprised 52.1% of the total diets of calves. Overall, diets of cows and calves during August 1986 differed in selection and preference compared to the August 1985 diets.

Meadow Characteristics

There was a highly significant difference between observed and expected elk use of meadows at ICRC during summer, 1986 (X^2 = 160.02,

n = 9, $P < 0.001$; Table II.4). Meadows ranged from 0.51-8.22 ha, and there was a tendency for the elk to use the larger meadows, however, this was not consistent. The correlation between elk use of meadow areas and size (ha) was 0.53 (Table II.5).

When the botanical composition of each meadow was correlated to elk use, clover had the highest correlation ($r = 0.85$; Table II.5). Cat's ear (Hypochaeris radicata) had a correlation coefficient of 0.69 followed by Arenaria ($r = 0.59$). Arenaria was a highly preferred species by cows and calves during summer 1985 and 1986, however cat's ear was either absent or only a trace species in the diets of cows and calves at ICRC during the study period.

Regressing clover with the other positively correlated variables to predict elk use of the meadows available at ICRC resulted in a variety of significant regression equations; the strongest relationship included meadow size and percent clover ($r^2 = 0.87$, $F = 23.18$, $P = 0.001$), indicating that these two variables accounted for 87% of the variation in meadow use by the elk.

DISCUSSION

Diets

The greatest differences between the diets of cows and calves at ICRC occurred at a time when the two elk classes differed the most. In July, when calves were 1-2 months old, the rumen was very small and in a stage of rapid development. In white-tailed deer (Odocoileus virginianus) the stomach of a one month old fawn is capable of digesting 60% vegetable matter and 40% milk (Short 1964). By two months of age, the rumen weight and contents of the entire stomach increase by 400% allowing the animal to increase its use of vegetation to 80% (Short 1964). Consequently, as a young ruminant grows and its rumen matures, the ability to process vegetable matter also increases.

Due to their small body size, less-developed rumen, high metabolic rate, and greater growth requirement, calves should select a high quality diet (i.e. a diet rich in forbs) (Hanley 1982, Geist 1982). Calves require greater selectivity in their feeding habits and, indeed, many factors allow this to be possible. For example, calves receive an additional nutrient supplement through nursing and spend no time in attentive behavior which gives them time to search for preferred plant species (Geist 1982).

Thus, in contrast to the diets of cows, the diets of calves in July should contain a larger proportion of easily digestible, nutritious forbs and a smaller proportion of grasses. This was the case at ICRC where the diets of calves were comprised primarily of forbs (72.7%). Calves were also extremely selective during this

time; only four forage species contributed to 87.2% of their total July diet.

By August 1986, calves increased their consumption of graminoids which may reflect an increased ability to digest grasses, and/or an increase in graminoid availability. In addition, during summer 1986, the diets of calves (1-3 months old) contained a large proportion of Rubus discolor which was either absent or a trace species in the diets of cows. Similarly, Harper et al. (1967) found Rubus spp. to be a major component in the diets of Roosevelt elk in northern California; during July and August elk calves consumed 20% and 30% Rubus spp., respectively compared to 10% and 15%, respectively for cows.

The strong selection by young calves for Rubus discolor may be correlated with the high degree of succulence associated with the leaves. According to Short (1981) broad leaves contain a large amount of digestible material and remain good forage during the photosynthetic stage of the plant. Compared to forbs and grasses, shrubs contain higher levels of phosphorus, carotene, and digestible protein as the plants mature (Cook 1972). In addition, the large surface area of the Rubus leaf compared to the leaves of grasses or forbs may give the young calves an advantage by allowing them to increase their consumption rates, bite size, and energy intake (Wickstrom et al. 1974).

The differences found in the diets of cows and calves between August 1985 and August 1986 were probably due to the different climatic conditions between years and the associated effect on plant phenology. August 1985 was very dry, consequently plants dried

quickly in the open meadows. As a result the elk used the habitat differently between years and that was probably reflected in the animal's diets (Harper et al. 1967, Korfhage et al. 1980, Clutton-Brock et al. 1982).

The March 1986 diets reflected the seasonal changes in plant phenology and the physiological changes in the elk. The proportion of grasses was considerably higher in the diets of cows and calves during March compared to summer and may have reflected the early growth and succulence of the available graminoids. However, because March was the last winter month, many plant species remained unavailable; for example, the green-up of preferred forbs at ICRC had not begun and the absence of many forb species was apparent in the diets of cows and calves.

With the low-biomass of grasses and scarcity of forbs the elk must rely on other plant species to fill their rumen. For example, calves consumed large proportions of salal and Douglas fir, both species considered to be poor quality, and low in digestibility (Schwartz and Mitchell 1945). During winter, forage quality and quantity is greatly limited and elk must resort to evergreen browse to fill their rumen; salal and Douglas fir become major components in the diets of elk resident to the Pacific Northwest during this time (Schwartz and Mitchell 1945, Hines 1970).

During April 1986, many plants were in stages of regrowth and cows and calves adjusted their foraging strategies to utilize them. Calves (9-11 months old) began to consume graminoids, forbs, and shrubs in proportions similar to cows. Although the calves were still smaller than adult elk, the ratio of rumen volume to body

weight may allow the calves to process forage in proportions similar to adults (Short 1964).

Although elk are considered generalists in their feeding habits, they have the ability to select the most succulent and nutritious plants available each season (Korfhage et al. 1980, Mereszczak et al. 1981). This was evident at ICRC, where cows and calves were very selective in their feeding habits during the study period. The four species that made the greatest contribution to the diets of cows at ICRC were (in order of decreasing importance) ryegrass, Bromus sitchensis, yarrow, and white clover. The species that made the greatest contrbution to the diets of calves included white clover, Rubus discolor, yarrow, and Anaphalis margaritacea, indicating that these species were nutritionally important to the animals.

Because ryegrasses range from 65%-80% in dry matter digestibility, they are characterized as high quality forage (Riewe and Mondart 1985). In this study, ryegrass was largely underestimated in the originally determined diets for July and August, 1986 (Appendices 5-6), indicating a high degree of digestibility. Likewise, yarrow was underestimated in the original diets during the months it was a preferred plant species by both elk classes.

Meadow Characteristics

Yarrow and clover were present in large proportions in the diets of both elk classes. Clover is a nutritious, palatable legume; when added to perennial grasses, clover increased the levels of nitrogen and calcium in the grasses (Dobson and Beaty 1980). The yield of the

perennial grass/clover mixtures also increased significantly compared to the yield of grass/nitrogen mixtures (Dobson and Beaty 1977).

Because clover has a high nitrogen content and increases the nutritive value of species associated with it, and because elk prefer diets high in protein, it was expected that ICRC elk would spend more time foraging in meadows which contained the greatest clover content. This was the case: elk use of the meadows was strongly correlated with percent clover available in the meadows ($r = 0.85$). Clutton-Brock et al. (1982) found that red deer females with calves restricted their feeding during the summer to plant communities high in protein content. They hypothesized that this may be due to the higher energetic requirements imposed by lactation, or that the small rumen and strong energy needs of the calves may restrict the females' use of the habitat to those areas supporting large proportions of nutritious forage. Both explanations may account for the variation in habitat use by elk at ICRC. ICRC elk left the forested areas to feed in the open meadows every morning and evening. All meadow areas were equally available to the elk and each meadow varied in size and botanical composition. The elk at ICRC consistently preferred to forage in meadows supporting the largest proportion of clover.

When the diets of cows and calves during summer 1986 were compared to herd use of the meadows, calves showed a strong preference for clover, however, clover was not consumed in large proportions by cows. Therefore, the use of the meadows at ICRC by the elk seemed to reflect the dietary needs and preferences of the calves. Alternatively, the meadows with the greatest clover content

may also contain the most nutritious forage, and the cows may have selected these meadows to fulfill their own energetic requirements.

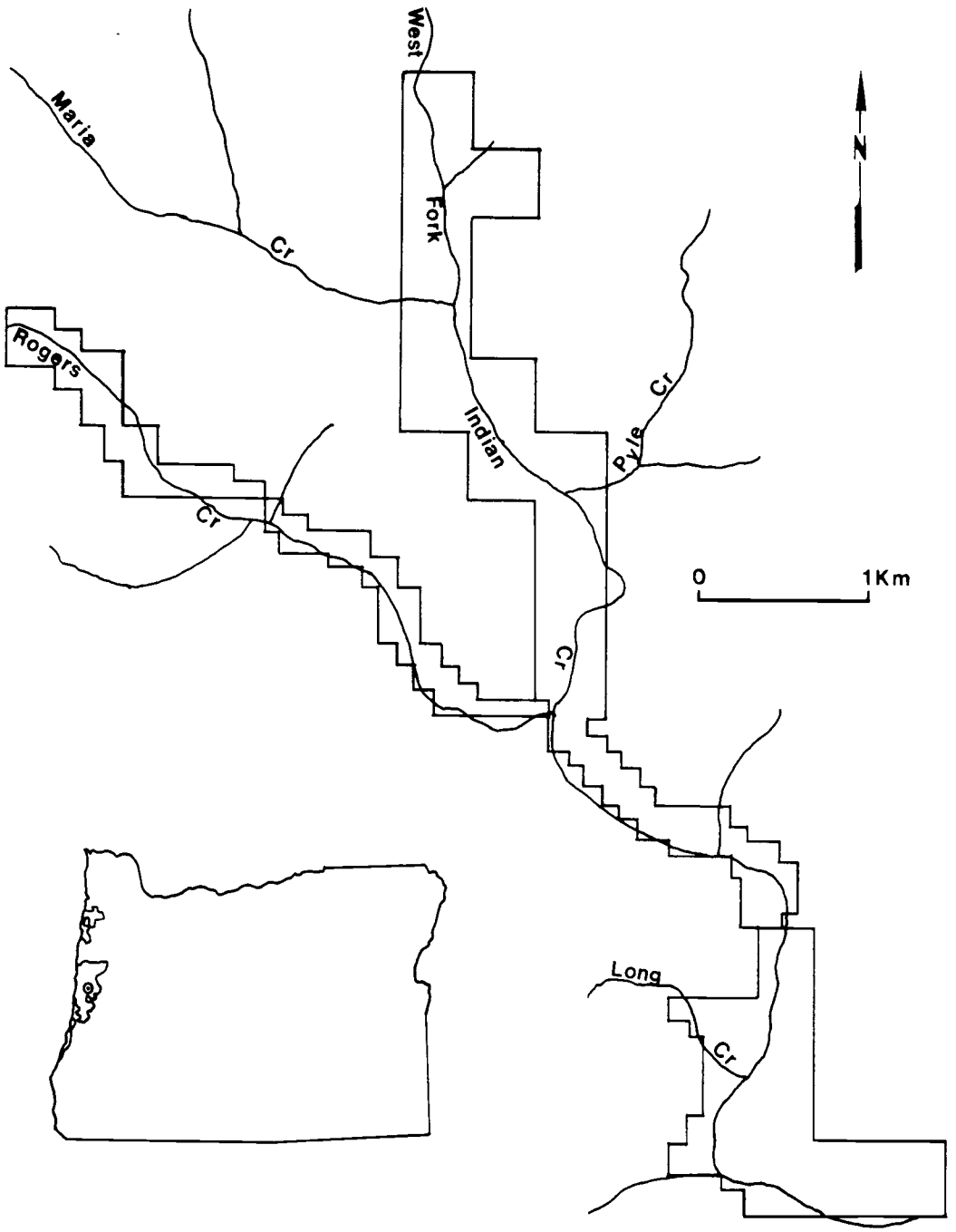

Figure II.1. Map of Indian Creek Research Center (ICRC). Area bounded within the map of Oregon refers to the Siuslaw National Forest. ⊙ refers to ICRC, Township 16S, R10W, Lane County, Oregon.

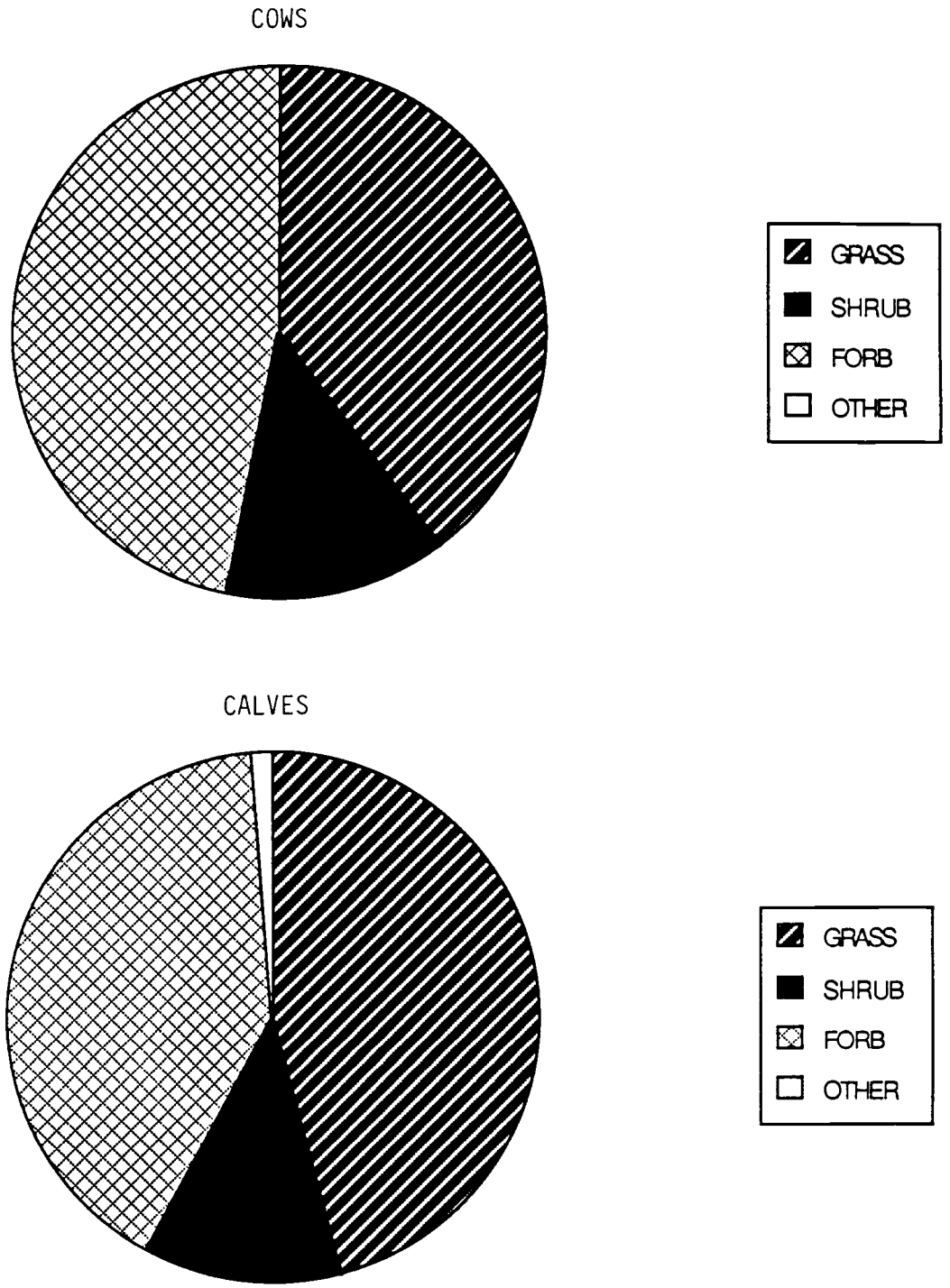

Figure II.2. Proportion of grasses, shrubs, and forbs in the diets of Roosevelt elk cows and calves (1-3 months old), Indian Creek Research Center, Oregon, August 1985.

Table II.1. Major plant species in the diets of Roosevelt elk cows and calves resident to Indian Creek Research Center, Oregon, August 1985, determined by fecal analysis.

August 1985: Forage	Cows			Calves		
Graminoid	%Diet	%Avail	RPI	%Diet	%Avail	RPI
Agrostis alba	4.3	34.5	0.1	8.3	34.5	0.2
*Bromus sitchensis**	14.7	-	-	17.6	-	-
Dactylis glomerata	8.0	13.7	0.6	7.4	13.7	0.5
Holcus mollis	5.8	14.6	0.4	1.5	14.6	0.1
Lolium perenne	2.2	1.9	1.2	6.4	1.9	3.4
Forb						
Achillea millefolium	16.8	7.0	2.4	17.8	7.0	2.5
Arenaria macrophylla	3.1	1.1	2.8	3.2	1.1	2.9
Trifolium repens	13.9	8.3	1.7	3.9	8.3	0.5

RPI = %Diet/%Avail; RPI > 1 = preference

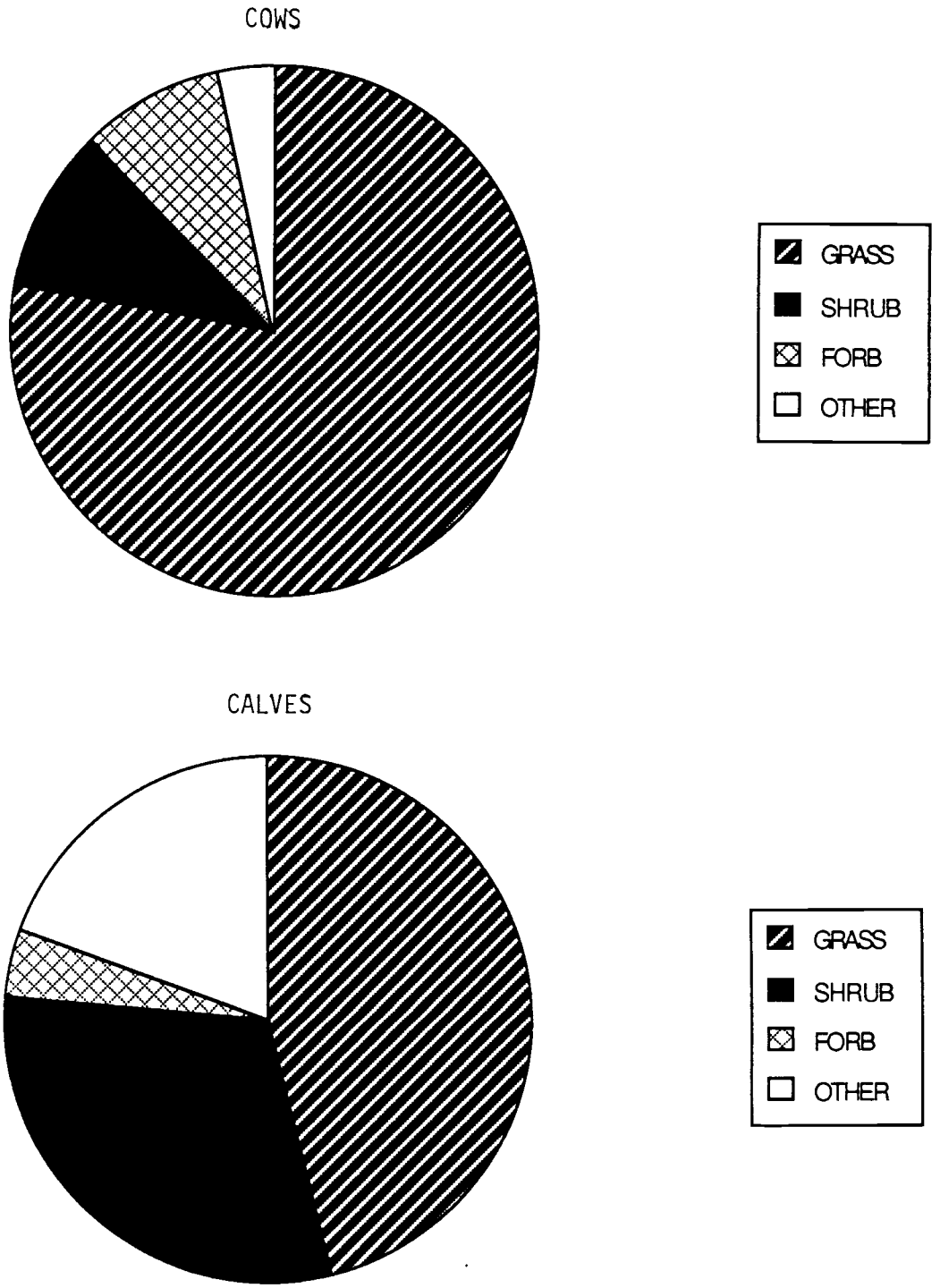

Figure II.3. Proportion of grasses, shrubs, and forbs in the diets of Roosevelt elk cows and calves (8-10 months old), Indian Creek Research Center, Oregon, March 1986.

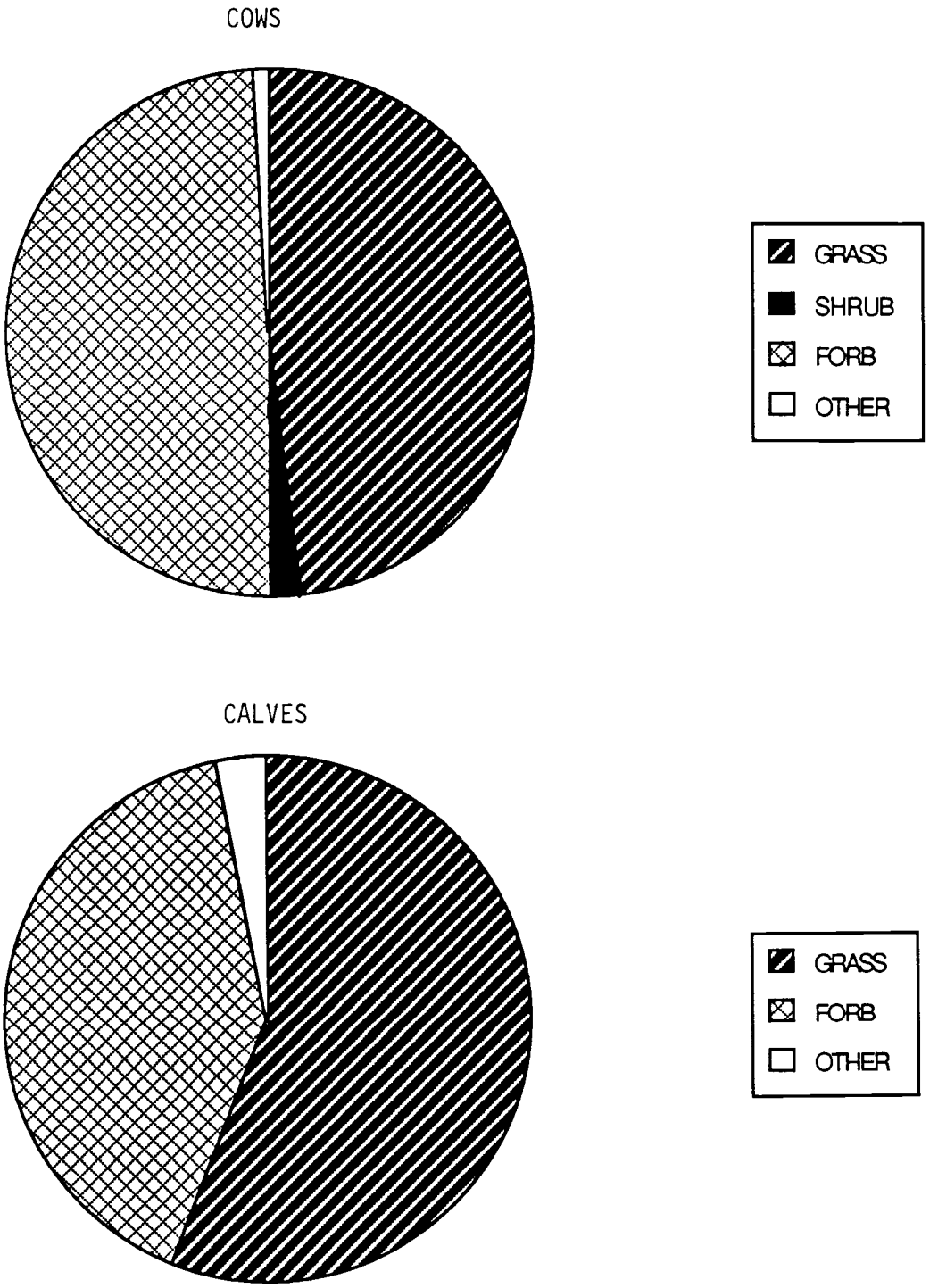

Figure II.4. Proportion of grasses, shrubs, and forbs in the diets of Roosevelt elk cows and calves (9-11 months old), Indian Creek Research Center, Oregon, April 1986.

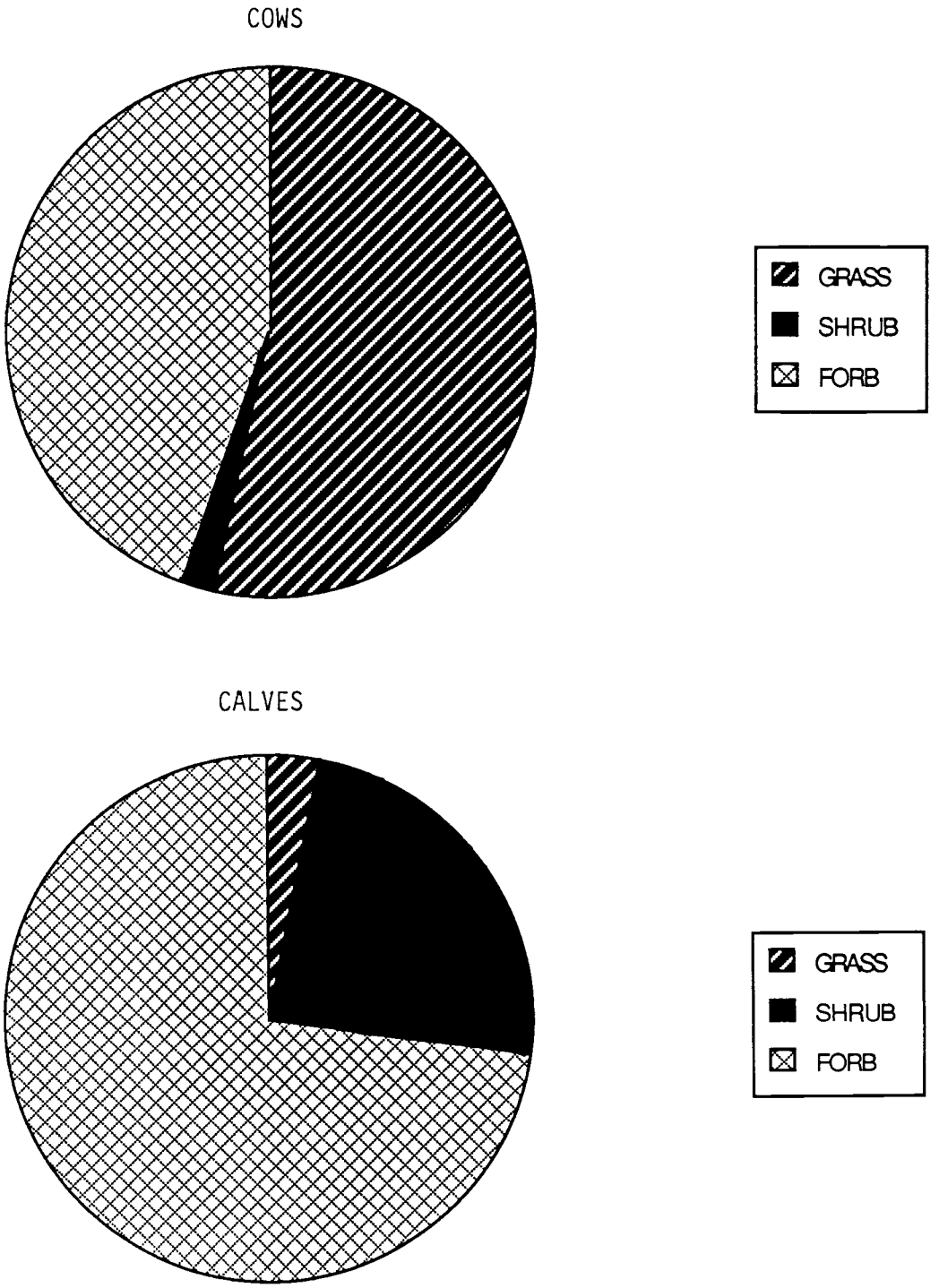

Figure II.5. Proportion of grasses, shrubs, and forbs in the diets of Roosevelt elk cows and calves (1-2 months old), Indian Creek Research Center, Oregon, July 1986.

Table II.2. Major plant species in the diets of Roosevelt elk cows and calves resident to Indian Creek Research Center, Oregon, July 1986, determined by fecal analysis.

July 1986: Forage	Cows			Calves		
Graminoid	%Diet	%Avail	RPI	%Diet	%Avail	RPI
Agrostis alba	4.3	34.5	0.1	0.4	34.5	0.0
Bromus sitchensis	4.3	-	-	1.0	-	-
Holcus mollis	4.4	14.6	0.3	0.0	14.6	0.0
Lolium perenne	30.3	1.9	15.9	1.2	1.9	0.6
Forb						
Achillea millefolium	11.3	7.0	1.6	0.3	7.0	0.0
Anaphalis margaritacea*	4.4	-	-	20.4	-	-
Arenaria macrophylla	6.8	1.1	6.2	5.0	1.1	4.5
Plantago lanceolata	3.5	5.5	0.6	10.9	5.5	2.0
Trifolium repens	6.3	8.3	0.8	35.2	8.3	4.2
Shrub						
Rubus discolor*	0.0	-	-	20.7	-	-

RPI = %Diet/%Avail; RPI > 1 = preference
*Availability unknown.

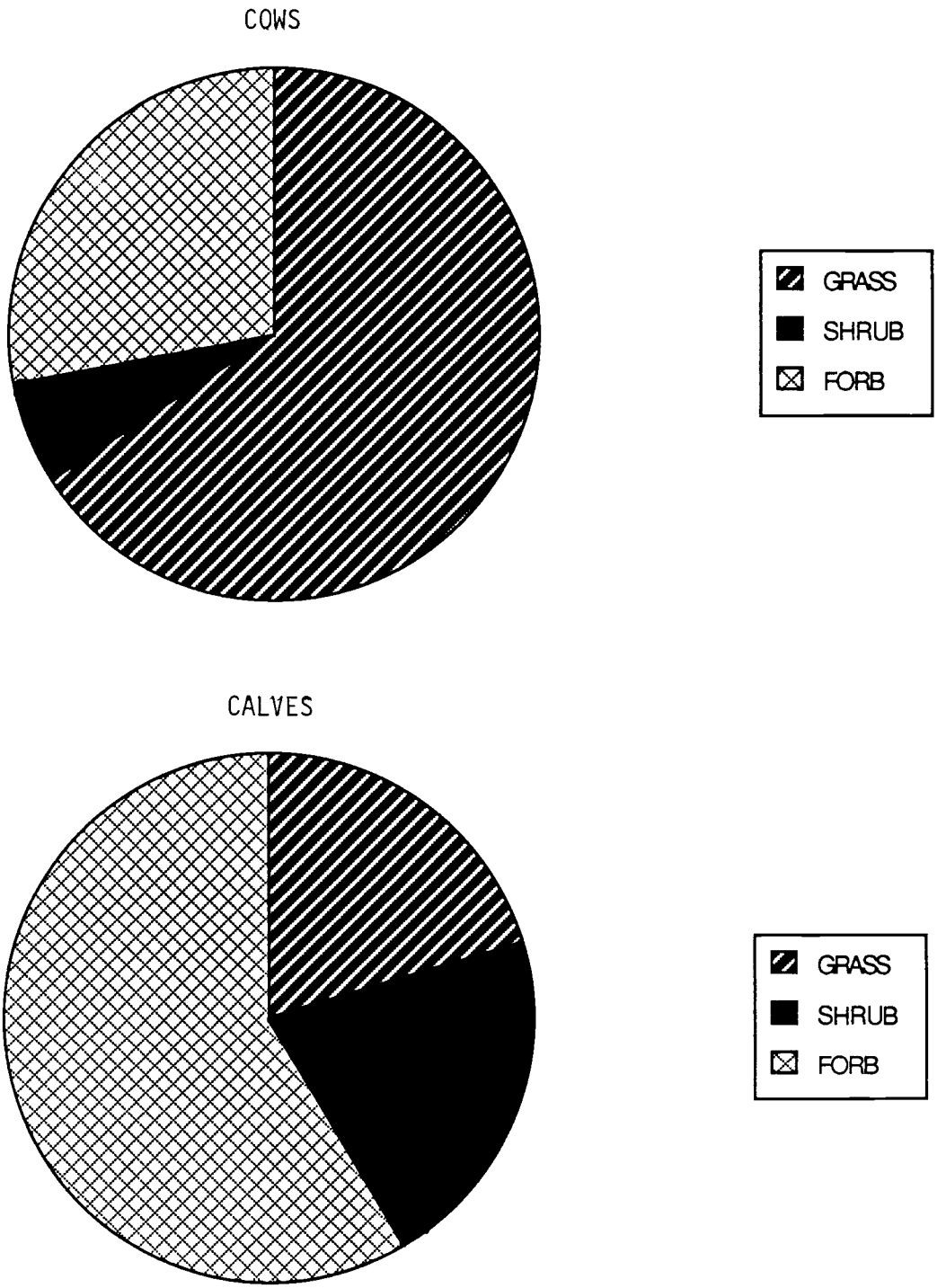

Figure II.6. Proportion of grasses, shrubs, and forbs in the diets of Roosevelt elk cows and calves (1-3 months old) Indian Creek Research Center, Oregon, August 1986.

Table II.3. Major plant species in the diets of Roosevelt elk cows and calves resident to Indian Creek Research Center, Oregon, August 1986, determined by fecal anaylsis.

August 1986: Forage	Cows			Calves		
Graminoid	%Diet	%Avail	RPI	%Diet	%Avail	RPI
Agrostis alba	17.8	34.5	0.5	5.5	34.5	0.2
Anthroxanthum odoratum	4.6	3.2	1.4	2.5	3.2	0.8
Bromus sitchensis*	6.8	-	-	1.0	-	-
Lolium perenne	27.4	1.9	14.4	2.0	1.9	1.1
Forb						
Achillea millefolium	1.6	7.0	0.2	5.5	7.0	0.8
Anaphalis margaritacea*	4.3	-	-	13.3	-	-
Arenaria macrophylla	2.4	1.1	2.2	10.9	1.1	9.9
Trifolium repens	6.2	8.3	0.7	12.7	8.3	1.5
Shrub						
Rubus discolor*	0.4	-	-	15.2	-	-

RPI = %Diet/%Avail; RPI > 1 = preference
*Availability unknown.

Table II.4. Observed and expected herd use of meadow areas, Indian Creek Research Center, Oregon, summer 1986.

Meadow	Size (ha)	pio	Observed Herd Use (hrs)	Expected Herd Use (hrs)	pi	*90% Family Confidence Interval
C	3.60	0.076	2	21	0.007	-0.005 < p1 < 0.025
H	4.66	0.098	6	28	0.021	-0.002 < p2 < 0.042
W	7.90	0.166	66	47	0.234	0.165 < p3 < 0.295
LL-h	0.51	0.010	12	3	0.043	0.010 < p4 < 0.070
L	6.93	0.145	62	41	0.220	0.156 < p5 < 0.284
D	4.09	0.086	45	24	0.160	0.104 < p6 < 0.216
S	6.89	0.145	17	41	0.060	0.024 < p7 < 0.096
R	2.75	0.058	41	16	0.145	0.095 < p8 < 0.205
K	2.07	0.043	3	12	0.011	-0.005 < p9 < 0.025
U	8.22	0.173	28	49	0.099	0.054 < p10< 0.146
Total	47.62		282	282		

pio = Proportion of total hectarage (Neu et al. 1974)
pi = Proportion of observed herd use
*Confidence interval for pi; tests the Ho: pio = pi.

Table II.5. Correlation of herd use to meadow size and botanical composition, Indian Creek Research Center, Oregon, summer 1986.

Variable	r	r2	Prob |r| = 0
Meadow size	0.53	0.28	0.118
Total Forbs	0.48	0.23	0.158
Achillea millefolium	-0.46	0.21	0.178
Agrostis alba	0.11	0.01	0.760
Anthroxanthum odoratum	0.50	0.25	0.139
Arenaria macrophylla	0.59	0.35	0.070
Chrysanthemum leucanthemum	0.35	0.12	0.320
Dactylis glomerata	0.00	0.00	0.997
Holcus mollis	-0.36	0.13	0.309
Hypochaeris perforatum	0.69	0.48	0.027
Plantago lanceolata	0.52	0.27	0.126
Rumex acetosella	-0.19	0.04	0.596
Lolium perenne	-0.19	0.04	0.604
Trifolium repens	0.85	0.72	0.002

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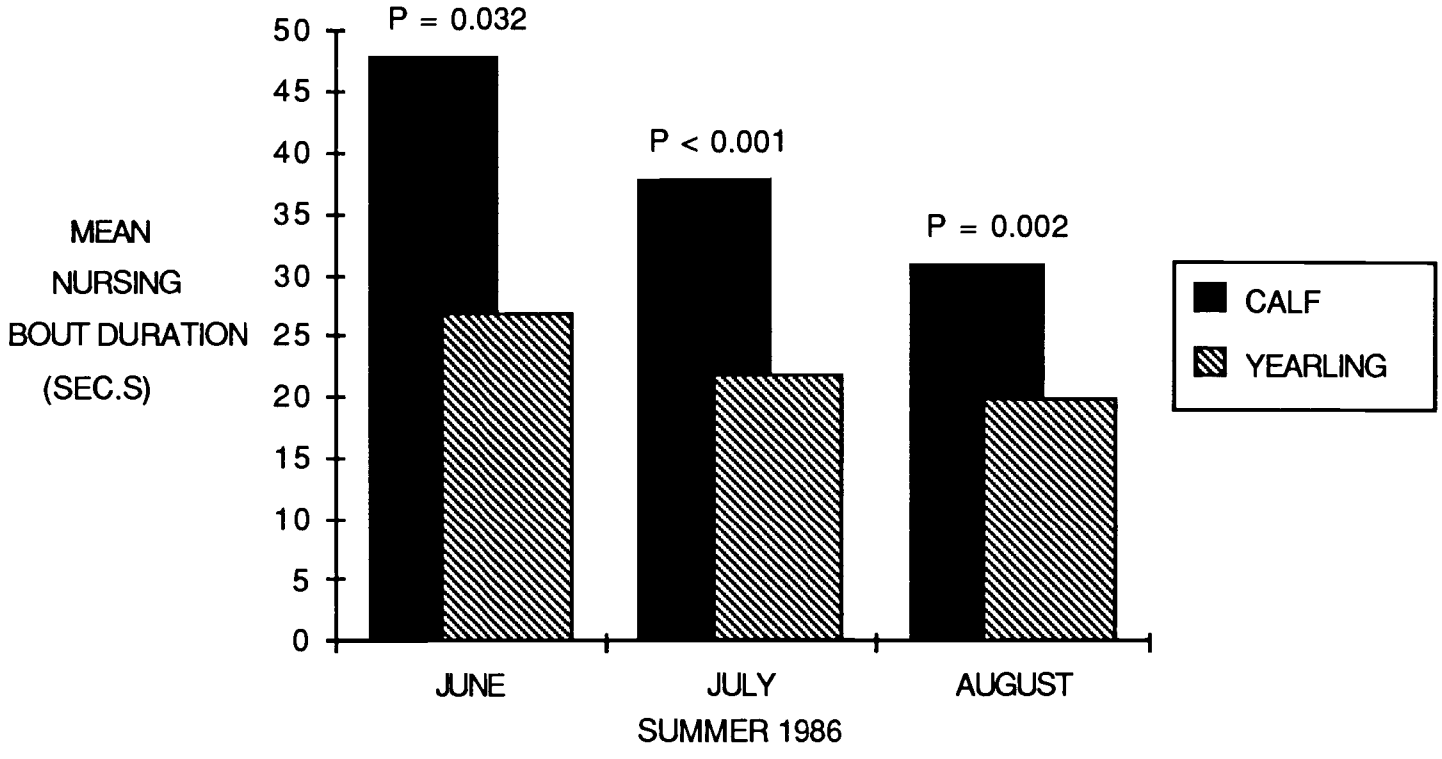
APPENDICES



Appendix 1. Comparison of nursing bout duration between Roosevelt elk calves and yearlings, Indian Creek Research Center, Oregon, summer 1986.

Appendix 2. Original and corrected diets (% frequency) of cow and calf elk resident to Indian Creek Research Center, Oregon, August 1985 determined by microhistological analysis of fecal samples.

PLANT SPECIES	COW/AUG.1985		CALF/AUG.1985	
GRAMINOID	Orig.	Corr.	Orig.	Corr.
Agrostis alba	5.6	4.3	11.0	8.3
Anthroxanthum odoratum	0.0	0.0	0.9	1.2
Bromus sitchensis	13.7	14.7	14.1	17.6
Carex spp.	0.0	0.0	0.5	0.7
Dactylis glomerata	7.7	8.0	7.2	7.4
Holcus mollis	2.6	5.8	1.2	1.5
Lolium perenne	5.9	2.2	7.4	6.4
Phalaris aquatica	7.0	4.9	2.2	2.9
TOTAL	42.5	39.9	44.5	46.0
SHRUBS				
Acer spp.	2.0	1.4	0.7	0.4
Alnus rubra	4.1	3.9	0.0	0.0
Corylus cornuta	0.4	0.3	0.0	0.0
Holodiscus discolor	0.0	0.0	0.3	0.2
Rhamnus purshiana	1.5	1.0	0.4	0.2
Rhododendron macrophyllum	0.2	0.2	3.0	1.7
Rubus discolor	0.9	0.6	12.2	6.7
Rubus spp.	3.1	1.9	0.5	0.2
Sambucus callicarpa	5.5	4.0	2.8	1.6
Vaccinium parvifolium	0.3	0.3	1.8	1.1
TOTAL	18.0	13.6	21.8	12.1
FORBS				
Achillea millefolium	9.5	16.8	5.2	17.8
Anaphalis margaritacea	2.7	2.1	4.5	4.2
Arenaria macrophylla	4.0	3.1	2.5	3.2
Chrysanthemum leucanthemum	0.0	0.0	0.7	0.7
Equisetum arvense	2.3	1.8	2.5	2.6
Fern	1.3	1.0	0.4	0.4
Heracleum lanatum	0.5	0.4	0.0	0.0
Hypochaeris radicata	0.2	0.2	0.0	0.0
Lotus corniculatus	0.9	0.7	0.0	0.0
Oenanthe sarmentosa	0.0	0.0	4.6	4.8
Plantago lanceolata	2.6	2.1	1.8	1.9
Prunella vulgaris	0.9	0.7	0.0	0.0
Rumex acetosella	1.8	1.4	0.4	0.4
Stachys mexicana	2.9	2.3	0.7	0.7
Trifolium spp.	9.9	13.9	5.9	3.9
TOTAL	39.5	46.5	29.2	40.6
Lichens	0.0	0.0	1.1	0.8
Seed/nut	0.0	0.0	3.4	0.5

Appendix 3. Original and corrected diets (% frequency) of cow and calf elk resident to Indian Creek Research Center, Oregon, March 1986 determined by microhistological analysis of fecal samples.

PLANT SPECIES	COW/MAR.1986		CALF/MAR.1986	
GRAMINOID	Orig.	Corr.	Orig.	Corr.
Agrostis alba	9.4	14.2	3.8	3.8
Anthroxanthum odoratum	0.0	0.0	10.5	14.6
Bromus sitchensis	19.8	37.8	4.5	4.2
Carex spp.	1.3	0.1	0.3	0.2
Dactylis glomerata	11.1	11.1	4.6	4.4
Holcus mollis	1.9	2.0	3.0	1.3
Juncus ensifolius	2.7	2.8	6.0	5.7
Lolium perenne	6.0	3.5	6.0	9.5
Phalaris aquatica	6.7	6.7	2.8	2.7
TOTAL	58.9	78.3	41.5	46.2
SHRUBS				
Gaultheria shallon	14.9	8.8	27.5	24.8
Rubus discolor	0.5	0.2	0.8	0.7
Rubus spp.	0.5	0.3	0.8	0.8
Vaccinium parvifolium	0.7	0.4	4.3	4.3
TOTAL	16.6	9.7	33.4	30.6
FORBS				
Achillea millefolium	2.2	1.5	1.0	1.1
Anaphalis margaritacea	1.1	0.8	0.0	0.0
Arenaria macrophylla	0.1	0.1	0.0	0.0
Lotus corniculatus	0.8	0.5	0.0	0.0
Marah oreganus	0.0	0.0	0.3	0.3
Moss	5.1	3.5	3.0	2.2
Plantago lanceolata	0.0	0.0	0.1	0.1
Ranunculus repens	1.1	0.7	0.5	0.5
Rumex acetosella	0.4	0.3	0.0	0.0
Stachys mexicana	0.6	0.4	0.4	0.5
Trifolium spp.	1.0	0.7	0.6	0.7
TOTAL	12.7	8.5	5.9	4.3
Ferns	7.8	1.0	1.0	1.1
Lichens	0.3	0.1	0.2	0.2
Pseudotsuga menziesii	3.9	2.4	18.0	17.6

Appendix 4. Original and corrected diets (% frequency) of cow and calf elk resident to Indian Creek Research Center, Oregon, April 1986 determined by microhistological analysis of fecal samples.

PLANT SPECIES	COW/APR.1986		CALF/APR.1986	
GRAMINOID	Orig.	Corr.	Orig.	Corr.
Agrostis alba	10.2	5.6	6.4	1.8
Anthroxanthum odoratum	0.0	0.0	7.0	9.3
Bromus sitchensis	10.3	9.0	12.5	7.7
Carex spp.	16.7	14.8	12.3	7.1
Dactylis glomerata	6.4	3.9	15.5	22.9
Holcus mollis	0.4	0.3	1.5	1.1
Juncus ensifolius	2.8	1.8	0.6	2.1
Lolium perenne	16.8	11.8	11.1	2.0
Phalaris aquatica	1.2	0.9	2.9	2.0
TOTAL	64.8	48.1	69.8	56.0
SHRUBS				
Gaultheria shallon	0.0	0.0	0.6	0.1
Rhamnus purshiana	0.0	0.0	0.6	0.1
Rubus spp.	1.8	1.9	0.5	0.1
Vaccinium parvifolium	0.2	0.1	0.0	0.0
TOTAL	2.0	2.0	1.7	0.3
FORBS				
Achillea millefolium	6.2	18.3	5.3	18.1
Chrysanthemum leucanthemum	0.0	0.0	0.4	0.3
Moss	0.0	0.0	1.4	1.0
Plantago lanceolata	3.8	4.6	1.3	0.9
Ranunculus repens	1.1	1.3	3.1	2.1
Rumex acetosella	0.0	0.0	0.6	0.4
Stachys mexicana	3.3	4.0	1.7	1.2
Trifolium spp.	11.4	18.9	6.7	16.2
Unknown	8.2	1.7	0.0	0.0
Vicia sativa	0.0	0.0	0.9	0.6
TOTAL	27.2	48.8	21.4	40.8
Ferns	6.0	1.1	6.7	2.6
Lichens	0.0	0.0	0.4	0.3

Appendix 5. Original and corrected diets (% frequency) of cow and calf elk resident to Indian Creek Research Center, Oregon, July 1986 determined by microhistological analysis of fecal samples.

PLANT SPECIES	COW/JULY 1986		CALF/JULY 1986	
GRAMINOID	Orig.	Corr.	Orig.	Corr.
Agrostis alba	9.0	4.3	1.4	0.4
Anthroxanthum odoratum	3.4	2.6	0.0	0.0
Bromus sitchensis	8.5	4.3	3.4	1.0
Carex spp.	0.6	0.3	0.0	0.0
Dactylis glomerata	2.9	2.2	0.5	0.2
Holcus mollis	6.0	4.4	0.0	0.0
Juncus ensifolius	3.3	2.5	0.5	0.2
Lolium perenne	17.6	30.3	3.8	1.2
Phalaris aquatica	3.7	2.9	2.1	0.6
TOTAL	55.3	53.8	11.7	3.6
SHRUBS				
Alnus spp.	0.0	0.0	10.7	2.3
Rubus discolor	0.0	0.0	30.2	20.7
Rubus spp.	1.3	0.9	1.6	0.7
Sambucus spp.	1.3	0.9	0.0	0.0
TOTAL	2.6	1.8	42.5	23.7
FORBS				
Achillea millefolium	4.7	11.3	1.3	0.3
Anaphalis margaritacea	4.2	4.4	10.4	20.4
Arenaria macrophylla	9.9	6.8	2.0	5.0
Chrysanthemum leucanthemum	0.7	0.7	0.0	0.0
Equisetum arvense	1.4	1.5	0.0	0.0
Fern	0.4	0.2	0.0	0.0
Heracleum lanatum	0.1	0.2	0.0	0.0
Marah oreganus	0.1	0.2	0.8	0.5
Oenanthe sarmentosa	0.8	0.9	0.6	0.4
Oxalis oregana	0.9	1.0	0.0	0.0
Plantago lanceolata	6.7	3.5	7.6	10.9
Prunella vulgaris	0.4	0.4	0.0	0.0
Ranunculus repens	3.8	4.0	0.0	0.0
Rumex acetosella	0.7	0.8	0.0	0.0
Stachys mexicana	0.9	1.0	0.0	0.0
Trifolium spp.	5.2	6.3	23.1	35.2
Vicia sativa	1.2	1.2	0.0	0.0
TOTAL	42.1	44.4	45.8	72.7

Appendix 6. Original and corrected diets (% frequency) of cow and calf elk resident to Indian Creek Research Center, Oregon, August 1986 determined by microhistological analysis of fecal samples.

PLANT SPECIES	COW/AUG.1986		CALF/AUG.1986	
GRAMINOID	Orig.	Corr.	Orig.	Corr.
Agrostis alba	16.9	17.8	9.3	5.5
Anthroxanthum odoratum	5.1	4.6	3.2	2.5
Bromus sitchensis	8.3	6.8	8.4	1.0
Dactylis glomerata	4.7	3.3	4.0	3.1
Holcus mollis	0.6	0.5	0.3	0.2
Juncus ensifolius	3.2	2.9	0.9	0.7
Lolium perenne	15.5	27.4	13.9	2.0
Phalaris aquatica	4.5	2.8	5.1	5.5
TOTAL	58.9	66.1	45.1	20.5
SHRUBS				
Acer spp.	0.3	0.2	0.0	0.0
Alnus rubra	2.6	1.3	4.8	2.2
Corylus spp.	0.0	0.0	0.6	0.5
Gaultheria shallon	0.0	0.0	0.8	0.4
Rhamnus purshiana	0.8	0.4	0.0	0.0
Rubus discolor	0.8	0.4	10.6	15.2
Rubus spp.	2.1	1.0	2.2	1.8
Sambucus callicarpa	4.1	2.1	1.1	0.4
Vaccinium parvifolium	1.4	0.7	0.6	0.5
TOTAL	12.1	6.1	20.7	21.0
FORBS				
Achillea millefolium	1.2	1.6	5.1	5.5
Anaphalis margaritacea	3.2	4.3	4.6	13.3
Arenaria macrophylla	5.6	2.4	7.6	10.9
Chrysanthemum leucanthemum	0.0	0.0	0.4	0.7
Equisetum arvense	0.6	0.7	1.0	1.9
Fern	0.0	0.0	1.2	2.0
Heracleum lanatum	0.5	0.5	0.0	0.0
Lotus corniculatus	0.9	1.0	1.1	1.9
Marah oreganus	0.8	0.9	0.0	0.0
Moss	0.3	0.2	0.7	1.1
Oenanthe sarmentosa	0.2	0.2	1.0	1.6
Oxalis oregana	1.5	1.6	0.0	0.0
Plantago lanceolata	2.5	2.8	1.1	2.3
Prunella vulgaris	0.0	0.0	0.3	0.5
Rumex acetosella	2.4	2.7	1.9	3.2
Stachys mexicana	1.2	1.4	0.5	0.9
Trifolium spp.	6.9	6.2	7.7	12.7
Unknown	1.2	1.3	0.0	0.0
TOTAL	29.0	27.8	34.2	58.5

Appendix 7. Botanical composition (% frequency) of the meadows at Indian Creek Research Center, Oregon, summer 1986.

Meadow	BG	OG	VG	RG	SVG	YW	PN	WC	RX	CE	DY	SW
C	2.2	5.9	77.8	1.7	1.0	1.3	2.9	3.4	0.1	2.0	0.1	0.8
H	35.3	18.0	25.0	5.3	0.0	9.3	0.9	0.5	1.7	0.0	0.7	1.0
W	56.5	0.0	6.9	1.4	1.0	3.3	1.0	12.6	1.2	2.0	0.2	2.0
LL-h	40.2	10.1	5.7	18.8	2.0	4.7	2.2	9.0	3.9	0.0	0.1	1.3
L	29.0	7.9	6.8	0.6	6.2	0.7	12.7	15.5	0.6	9.7	6.6	1.5
D	19.6	45.2	4.7	1.2	3.9	3.1	6.1	9.1	1.4	2.2	0.3	0.7
S	54.0	1.8	3.2	0.0	1.1	26.4	1.8	4.7	1.5	1.0	1.6	1.1
R	28.3	31.9	3.0	1.2	4.2	7.3	7.7	10.7	0.9	3.3	0.0	0.9
K	60.1	7.0	0.6	0.0	1.3	19.0	1.6	2.2	2.1	0.3	0.2	0.6
U	49.3	3.3	1.2	0.0	7.9	11.8	6.6	4.5	2.0	4.6	0.2	0.7
Overall	34.5	13.7	14.6	1.9	3.2	7.0	5.5	8.3	1.2	3.5	1.7	1.1

Note: Overall = Botanical composition of all 10 meadows combined.
BG = Bentgrass (Agrostis alba)
OG = Orchardgrass (Dactylis glomerata)
VG = Velvetgrass (Holcus mollis)
RG = Ryegrass (Lolium perenne)
SVG = Sweet Vernalgrass (Anthroxanthum odoratum)
YW = Yarrow (Achillea millefolium)
PN = Plantain (Plantago lanceolata)
WC = White clover (Trifolium repens)
RX = (Rumex acetosella)
CE = Cat's ear (Hypochaeris radicata)
DY = Daisy (Chrysanthemum leucanthemum)
SW = Sandwort (Arenaria macrophylla)