Demography, Range, Habitat, Condition and Parasites of the Roosevelt Elk (*Cervus elaphus roosevelti*) of Sinkyone Wilderness State Park, Mendocino County, California

by

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Introduction

In March of 1982, a group of 17 Roosevelt elk (*Cervus elaphus roosevelti*) were translocated from Gold Bluffs Beach, Humboldt County, California to the King Range National Conservation Area, Humboldt County, CA. After release, the elk separated into herds and dispersed along the coast as far South as Ten Mile River (about 13km north of Fort Bragg) (McCoy 1986). After McCoy (1986) conducted a study that traced the newly released herds' movements, habitat use and activity patterns, no further studies were done on the herd.

The goal of this study was to acquire new information and update old information on the ecology of this elk herd of the Sinkyone Wilderness State Park, Mendocino County, CA (hereon referred to as "the Park") including the following analyses: 1) herd counts, demography and reproductive success, 2) range of the main elk herd (females, calves, and juvenile males), as well as range of the adult males extending out of the Park to the North and South, 3) physical condition of the herd, 4) helminth and protozoan prevalence, 5) habitat use, and 6) range condition. These data as well as a more detailed behavioral study will also be used in part as a Master's Thesis in Wildlife at Humboldt State University, Arcata, CA, and will be completed in May of 2001.

Methods

Demography and Reproductive Success. Herd counts were documented three times throughout the season to account for changes due to deaths and births. The first count was done about two weeks before the calving season began, and did not include adult males (bulls) since they were not present with the main herd (females, or cows, juvenile

males, and calves). The second count was compiled about three months into the calving season, during the rutting season (rut), and included estimates of adult bull numbers. The third count was done after the rut and did not include adult bulls, as they were not present in the main herd's range. This final count accounted for deaths of both adults and calves throughout the summer. Demography was described through differentiation of adult and yearling females based on size, and adult and juvenile males (males with only one tine per antler, excluding brow tines). Ratios of adult bulls to adult cows were directly observed, and compared to published ratios. Reproductive success was directly calculated based on the number of calves of the season and counts of reproductive females.

Range. Range of the main herd was determined by following the herd's movements North, South, and East through the Park. The farthest points in these directions the herd was observed to travel represent the boundaries of their range. The Western boundary was the Pacific Ocean.

The complete range of the adult males was estimated two ways. The first method was line transects. This type of method was used to successfully locate and count elk by Weckerly (1996). Starting at the Southern end of the Park, East-West transects spanning the entire width of the Park were walked. Transects were approximately 1.5 km apart, and were located using topographic maps and a compass. Elk or elk sign (tracks, droppings, or antler rubbings) were searched for and if found, indicated on topographic maps.

Range was also assessed through the use of information cards. This technique was used to determine whether the herd's range extended outside the Park. Cards were distributed in areas about 3 miles North of the Park, and 30, 17, 14 miles South of the Park, as well as at the Southern tip of the Park. Cards requested estimates of elk age, sex, location seen, date seen and time of day seen. Additionally, the lessee for the adjacent land South of the Park (Wilderness Unlimited) was contacted for information of elk presence on this land. Surveys requesting the same information as the cards were sent to those Wilderness Unlimited members known to use this land.

Habitat Use. 28 different sites the main herd used throughout the season were analyzed for vegetative characteristics. Each was characterized based on the composition of vegetation (genus and if possible, species) and percentage cover of each vegetation type over the site. Descriptive statistics were used to typify vegetative composition of average sites. Since three obvious classes of habitat were used (coastal meadows, riparian, and forest), each type was averaged individually.

Herd Health. 30 individuals (7 males, 23 females) were assessed for general physical condition through the use of photographs. Assessments were made based on the techniques of Riney (1960, Table 1).

Table 1. Descriptions of physical condition categories for Roosevelt Elk based on Riney (1960).

Category	**Description**
Good	Ribs and backbone not visible, no indentation under the hips, rear slope to tail rounded.
Fair	Ribs and backbone not visible, indentation under the hips moderate, rear slope to tail moderately concave.
Poor	Ribs and backbone visible, indentation under the hips severe, rear slope to tail severely concave.

Range Condition. Condition of the range was assessed indirectly through the use of animal condition as indicators of habitat condition. Nutrient quality of the most abundant forage on the range was also determined through previously published data. Reproductive success was also used as an indicator of forage and range quality, and a subjective determination of overall range condition was made using these three factors.

Parasites. Fecal samples of 20 individuals (3 males, 13 females, and 4 calves) were collected and analyzed to determine prevalence of helminth and protozoan parasites in the elk herd. Direct fecal smear, flotation, sedimentation and living larvae techniques were used for each sample (Sloss and Kemp 1978). Eggs and oocysts of parasites were identified at least to family, most to genus, and prevalence over the herd and genera counts per individual were estimated.

Results

Demography and Reproductive Success. The second count was the highest and included the main herd, adult bulls and new calves (Table 2). Since bulls were only present in the main herd's range during the rut and did not normally congregate in groups, published adult bull to adult cow ratios were used to confirm the count of adult bulls in the herd (Table 2). The adult bull: adult cow ratio in this study was 0.28:1 (using the second count including directly observed bulls), which fell among three other published ratios: 0.38:1 found by Weckerly (1996) in Roosevelt Elk in Prairie Creek Redwoods State Park, CA, 0.19:1 found by Schoen (1977) in Rocky Mountain Elk in western Washington, and 0.26:1 found by Schwartz and Mitchell (1945) in Roosevelt Elk on the Olympic

Peninsula of Washington. One death was directly observed in mid-summer and was probably a yearling female. Predation by mountain lions (*Felis concolor*) was both observed by park personnel, and injuries believed to have been caused by mountain lions were photographed (Appendix B).

Table 2. Direct counts, estimates (in Italics) of adult bull numbers, and demography of Roosevelt Elk in Sinkyone Wilderness State Park, Mendocino County, CA, in the summer of 2000.

	Pre-calving season	**Post-calving/rutting season**	**Post-rutting season**
Cows	48	45	43
Adult	38	36	34
Yearling	10	9	9
Bull	*12*	12	*12*
Adult	*10*	10	*10*
Yearling	*2*	2	*2*
Calves	0	8	8
Totals	60	65	63

Reproductive success was based on the high count of 38 reproductive females, and was 21%.

Range. Range of the main herd extends out of the Park's boundaries only in the Northern region (Figure 1). The Southern-most and Eastern-most point in the range is approximately 1.5 km East of Bear Harbor Campground (Figure 2).

Adult male elk were directly observed in two areas Northeast of the Park (Figure 3). Data obtained through information cards (4 responses) indicated that adult male elk were commonly travelling North of the Park. Responses from Whale Gulch residents (Appendix A) pointed out elk presence in residential areas of Whale Gulch, Humboldt County, CA, as well as in Wailaki Campground in the King Range National Conservation Area (Figure 3).

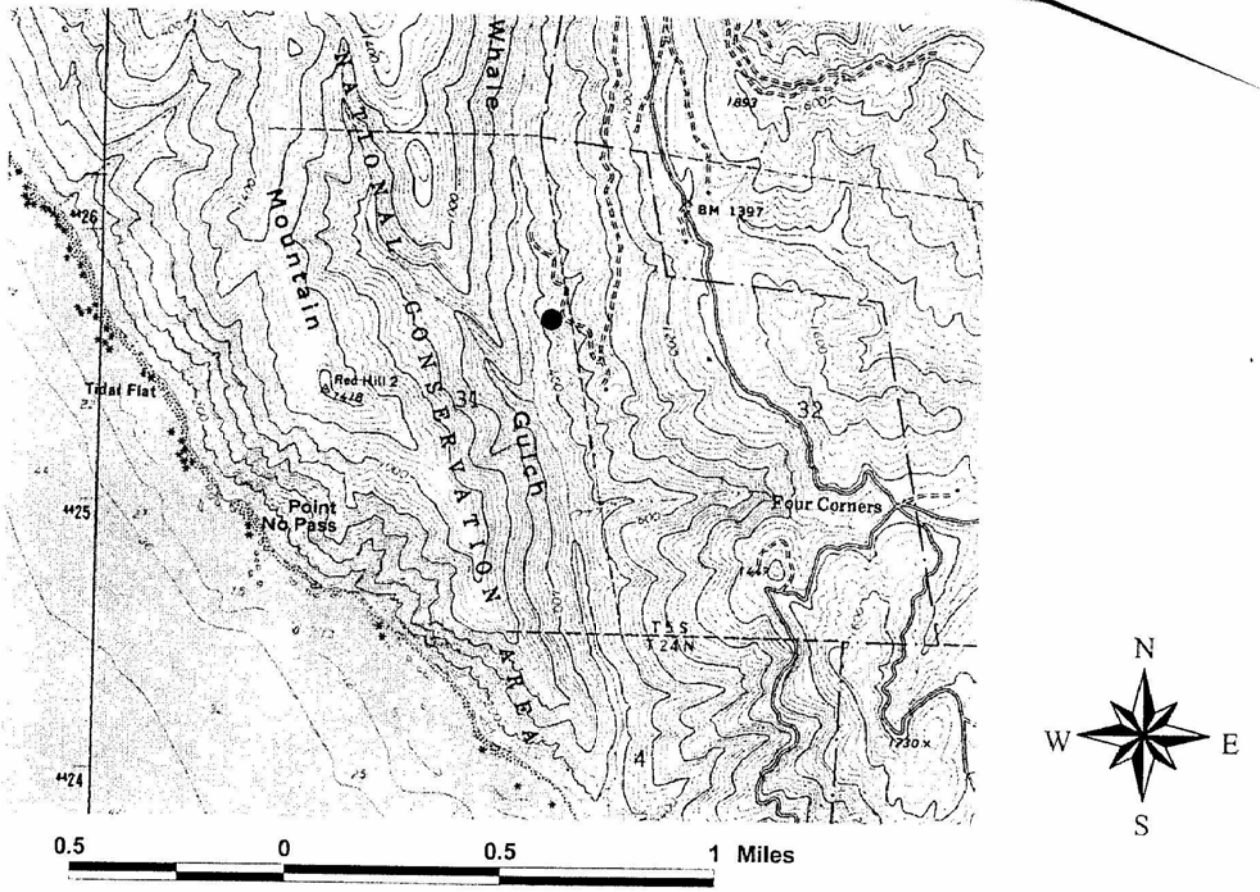

Figure 1. Northern extent of the range of the Roosevelt Elk main herd (females and juvenile males) in Sinkyone Wilderness State Park, Mendocino County, CA, in the summer of 2000. Dot represents the Northern-most elk siting.

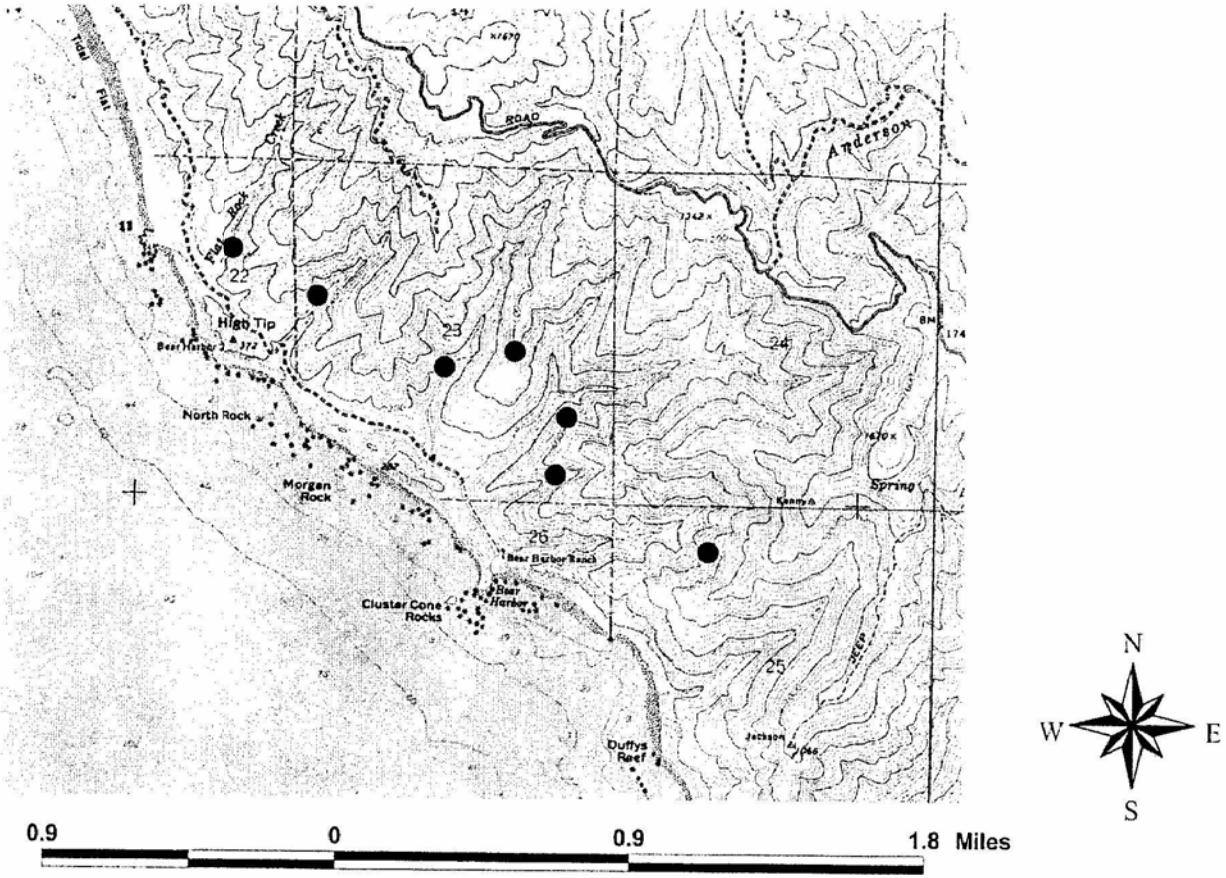

Figure 2. Southern extent of the range of the Roosevelt Elk main herd (females and juvenile males) in Sinkyone Wilderness State Park, Mendocino County, CA, in the summer of 2000. Dots represent sitings along the Eastern edge of the range, and the Southern-most dot represents the Southern boundary of the range of the main herd.

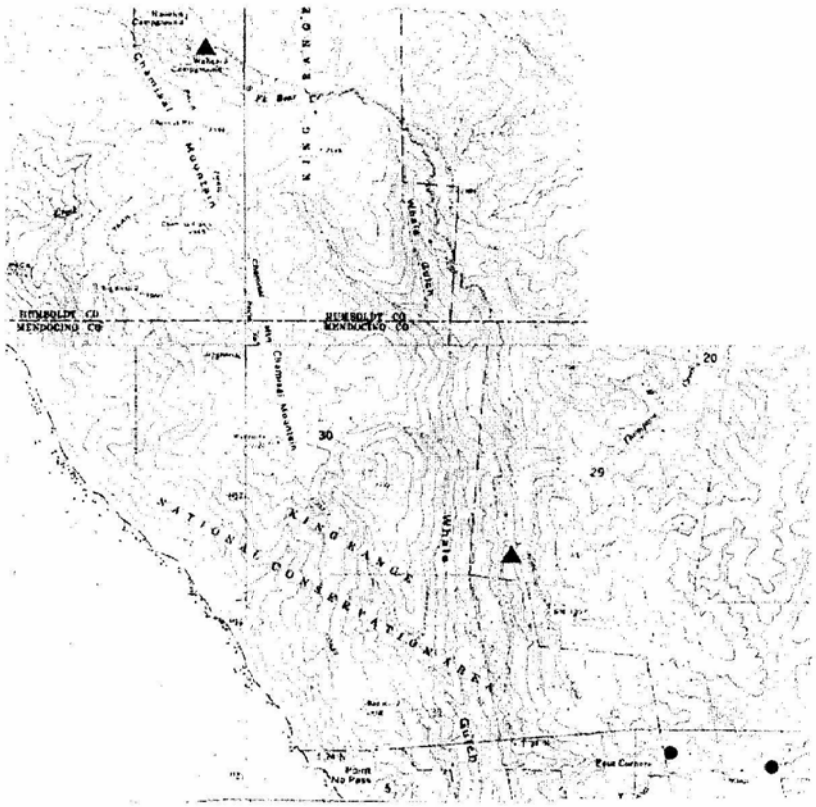

Figure 3. The Northern extent of the range of Roosevelt Elk adult bulls in Sinkyone Wilderness State Park, Mendocino County, CA, in the summer of 2000. Dots represent elk sitings, and triangles represent observations of elk by Whale Gulch Residents.

Through the transect method, elk droppings were found along the Lost Coast Trail at the Southern end of the Park, the Southern-most being found approximately 3 km North of the trailhead at Usal Beach (Figure 4). Information cards also generated information on elk presence within and just outside the Southern tip of the Park (10 responses) (Figure 4).

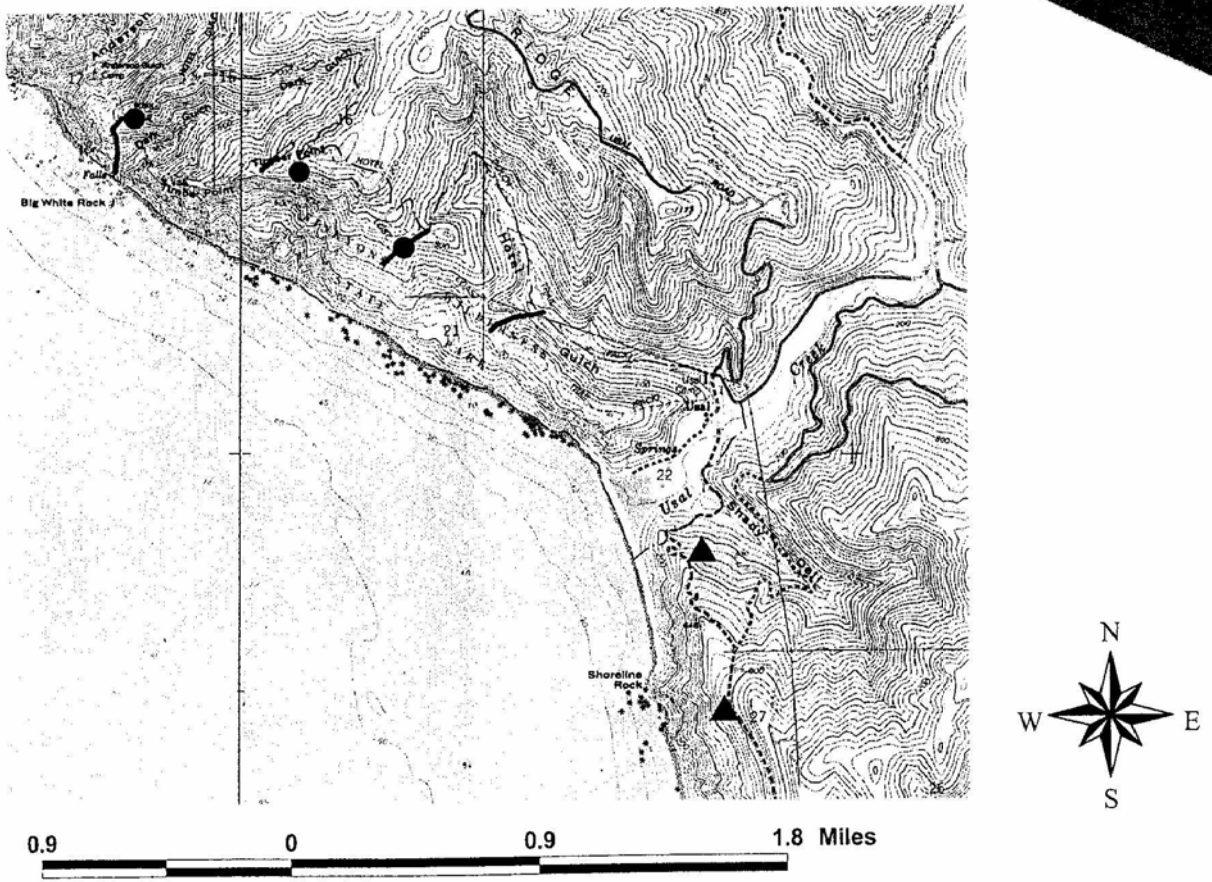

Figure 4. Southern extent of the range of the Roosevelt Elk adult bulls in Sinkyone Wilderness State Park, Mendocino County, CA, in the summer of 2000. Dots represent elk sign found by walking transects (shown as thick lines). Triangles represent observations of adult bull elk by recreational users of the area.

Habitat Use. The main herd was regularly observed to use three different habitat types throughout their range: coastal meadow, riparian, and coastal forest (Tables 3, 4, and 5).

Table 3. Vegetative composition of coastal meadow habitats used by Roosevelt Elk in Sinkyone Wilderness State Park, Mendocino County, CA, in the summer of 2000. Percentages are averaged over 14 sites; percentages do not sum to 100% because species with negligible percentages (<1%) at each site were not specified.

Plant Species	**Percentage (%)**
Grasses and Grass-like Plants	
Avena sativa	11.86
Bromus rigidus	10.71
Holcus lanatus	9.79
Lolium perenne	9.00
Juncus effusus	6.79
Cynosurus echinatus	5.29
Danthonia pilosa	3.57
Festuca spp.	2.86
Melica aristata	2.79
Juncus spp.	2.50
Avena barbata	0.71
Bromus spp.	0.07
Poa annua	0.07
Grasses Subtotal	**66.01**
Forbs and Ferns	
Cirsium spp.	3.07
Senecio jacobaea	1.57
Lupinus spp.	1.29
Plantago spp.	1.07
Lamiaceae	0.71
Ranunculus spp.	0.71
Polystichum munitum	0.71
Equisetum hyemale	0.36
Erigeron spp.	0.36
Hercaleum lanatum	0.36
Asteraceae	0.14
Cirsium vulgare	0.07
Forbs and Ferns Subtotal	**10.42**
Shrubs	
Rhamnus californica	2.14
Baccharis pilularis	8.64
Rubus ursinus	0.50
Shrub Subtotal	**11.28**
Trees (within forage height)	
Alnus rubra	3.93
Pseudotsuga menziesii (shrub-size)	2.14
Malus spp.	0.36
Trees Subtotal	**6.43**

Table 4. Vegetative composition of riparian habitats used by Roosevelt Elk in Sinkyone Wilderness State Park, Mendocino County, CA, in the summer of 2000. Percentages are averaged over 11 sites; percentages do not sum to 100% because species with negligible percentages (<1%) at each site were not specified.

Plant Species	**Percentage (%)**
Grasses and Grass-like Plants	
Cynosurus echinatus	8.55
Holcus lanatus	5.36
Elymus spp.	0.91
Lolium perenne	0.64
Avena sativa	0.45
Juncus effusus	0.45
Juncus spp.	0.45
Danthonia pilosa	0.27
Bromus rigidus	0.18
Triticum aestivum	0.18
Avena barbata	0.09
Grasses Subtotal	**17.53**
Forbs and Ferns	
Cirsium spp.	8.09
Urtica dioeca	7.45
Polystichum munitum	4.09
Ranunculus spp.	3.64
Brassica spp.	2.73
Hercaleum lanatum	2.27
Lamiaceae	2.27
Liliaceae	0.91
Equisetum hyemale	0.82
Vitis californica	0.36
Athyrium filix-femina	0.18
Cirsium vulgare	0.18
Lupinus spp.	0.18
Oxalis oregana	0.09
Forb and Ferns Subtotal	**33.26**
Shrubs	
Rubus ursinus	27.27
Baccharis pilularis	3.36
Sambucus racemosa	1.55
Ribes spp.	1.09
Rhamnus californica	0.91
Shrub Subtotal	**34.18**
Trees (within forage height)	
Alnus rubra	8.64
Trees Subtotal	**8.64**

Table 5. Vegetative composition of forest habitats used by Roosevelt Elk in Sinkyone Wilderness State Park, Mendocino County, CA, in the summer of 2000. Percentages are averaged over 3 sites; percentages do not sum to 100% because species with negligible percentages (<1%) at each site were not specified.

Plant Species	**Percentage (%)**
Grasses and Grass-like Plants	
Holcus lanatus	0.67
Grasses Subtotal	**0.67**
Forbs and Ferns	
Polystichum munitum	40.00
Vinca major	3.33
Hercaleum lanatum	2.33
Vitis californica	1.67
Ribes spp.	1.00
Urtica dioeca	0.67
Forbs and Ferns Subtotal	**49.00**
Shrubs	
Rubus ursinus	10.00
Sambucus racemosa	6.67
Rhamnus californica	1.67
Shrubs Subtotal	**18.34**
Trees (within forage height)	
Alnus rubra	11.67
Acer spp.	1.67
Umbellularia californica	0.67
Trees Subtotal	**14.01**

Herd Health. Out of 30 animals evaluated, only 9 were classified in "good" condition, 14 were classified in "medium" condition, and 7 were classified in "poor" condition (Table 6).

Table 6. Category percentages of physical condition of a sample of 30 Roosevelt Elk in Sinkyone Wilderness State Park, Mendocino County, CA, in the summer of 2000. Methods were based on Riney (1960). Sample sizes are in parentheses.

	Percent Females (23)	**Percent Males (7)**	**Percent Total (30)**
Good	17.4 (4)	71.4 (5)	30.0 (9)
Medium	52.2 (12)	28.6 (2)	46.7 (14)
Poor	30.4 (7)	0.0	23.3 (7)

Range Condition. Assessment of range condition was based on overall herd physical condition, published forage values for different forage types represented in the main

herd's range, as well as incidental indications of range condition. Details and explanations are included in the Discussion section.

Parasites. Eight different types of endoparasites were found through fecal analysis of 20 animals. All worm eggs found were of Nematodes, and one oocyst of the sporozoan genus *Eimeria* was found. Because eggs of the family Trichostrongylidae are extremely difficult to differentiate, genera were not specified. However, it was possible to determine that certain Trichostrongylid eggs were different from each other, so that a total of three different genera in the family Trichostrongylidae were reasoned to be present. Prevalence of each parasite was calculated by number of infected elk/ number sampled, and number of parasite genera per elk was calculated by number of elk with 0, 1, 2, 3, or 4 genera/ number sampled (Tables 7 and 8).

Table 7. Parasite genera and prevalence in herd estimated from fecal analysis of 20 Roosevelt Elk in Sinkyone Wilderness State Park, Mendocino County, CA, in the summer of 2000.

Parasite Genus	**Number of Elk Infected**	**Prevalence**
Trichuris sp.	11	0.55
Capillaria sp.	2	0.1
Trichostrongylidae #1	1	0.05
Trichostrongylidae #2	12	0.6
Trichostrongylidae #3	1	0.05
Marshallagia sp.	1	0.05
Nematodirus sp.	1	0.05
Eimeria sp.	1	0.05

Table 8. Percentage of Roosevelt Elk Herd exhibiting infection with different numbers of parasite genera in Sinkyone Wilderness State Park, Mendocino County, CA, in the summer of 2000.

Number of Different Genera	**Number of Elk**	**Percentage of herd**
0	4	0.2
1	7	0.35
2	5	0.25
3	3	0.15
4	1	0.05

Discussion

Many of the results of this study were similar to those found in other documented elk herds. The direct observation of this herd's demography can easily be substantiated through several published ratios with similar results. As stated, the adult bull: adult cow ratio in this study was 0.28:1. Weckerly's (1996) study of Roosevelt Elk found a higher ratio of 0.38:1 and Schwartz and Mitchell's (1945) study of Roosevelt Elk found a ratio similar to this study at 0.26:1. Skewed sex ratios are common in elk due to higher mortality rates in males for reasons such as greater annual food requirements, use of stored energy during the rut, and accelerated tooth wear compared to females (Flook 1970). It must be added, however, that the current bull elk count in the Park was a minimum count. It is possible that there were more adult bulls in the area, but as subdominants, they avoided the main herd during the rut. As of September 2000, there was a minimum of 65 elk in the Park's herd.

Range of male elk, range condition, herd condition, and parasites found in the herd must also be addressed with management implications and recommendations for further study. It was clear that male elk were leaving the Park at both the Northern and Southern boundaries, and were frequenting residential areas North of the Park (Appendix A). This occurrence obviously has management implications in that elk were using private property. Since most data obtained in the analysis of range outside the Southern boundary of the Park is indirect (responses by third parties), a more accurate and reliable method should be used to determine the exact extent to which male elk travel out of the Park. Suggestions for further study are included in the Recommendations section.

The analysis of herd condition based on a sample of 30 animals suggests a sub-optimal overall condition of the herd. No sampled males were in poor condition while over 30% of the females were in poor condition (Table 6). This indicated that the habitat the main herd used was probably in poor to moderate condition. Additionally, a reproductive success of 21% was much lower than many published values for elk. Schoen (1977) calculated a reproductive success of 66% in Rocky Mountain elk, and Schwartz and Mitchell (1945) found a value of 63% in Roosevelt elk. This was another indicator that main herd's range may be in poor condition, as Trainer (1971) showed that poor nutrition was the fundamental cause of low reproductive rates in Roosevelt elk.

There are several possible explanations for poor animal and range condition. The nutritional quality of available forage in the Park may be insufficient to keep the herd in good condition. However, many of the forage types in the main herd's range are of high value (Table 9), and grasses (totaling 32.7% of the habitat of the main herd, Tables 3, 4, and 5) provide the bulk of the diet of Northern California Roosevelt elk (Jenkins and Starkey 1991). It is unlikely that the cause for poor to moderate range condition is available plant species, rather some other attribute of the available forage. A plant's new growth provides more nutritious forage (digestible protein) than older plant biomass (Langvatn and Hanley 1993), and it's possible that the range is not providing enough new plant biomass with the higher nutrient content. Another possible explanation for poor animal and range condition is reduced soil nutrient levels. Two indicators in elk of poor soil nutrients are broken antlers in bulls, and chewing on bones (McCullough 1969), both of which were observed in this herd (Appendix C). These phenomena may indicate a lack of calcium and/or phosphorous in the soil. A further possibility for poor condition is

that the range's carrying capacity for elk has been reached, and there are too many elk for the range in its present condition. Suggested research and management for these possibilities are in the Recommendations section.

Table 9. Forage values of various plant species, together representing 41.2% of the habitat the Roosevelt elk main herd uses in Sinkyone Wilderness State Park, Mendocino County, CA, in the summer of 2000; (++)= highly valuable, (+) = valuable, (-) = limited value, from Nelson and Leege (1982).

Plant Species	**Value**	**Plant Species**	**Value**
Danthonia spp.	++	*Cirsium* spp.	+
Hercaleum lanatum	+	*Holcus lanatus*	-
Plantago spp.	+	*Alnus rubra*	+
Polystichum munitum	+	*Pseudotsuga menziesii*	+
Ranunculus spp.	-	*Rubus* spp.	+
Bromus spp.	+	*Sambucus racemosa*	++

Though several genera of helminths and one protozoan were found, few, if any, were cause for alarm. Nematodes, though present in approximately 80% of this herd, are probably not a significant cause of mortality (Taber 1976). *Eimeria* spp. has never been shown to cause disease in wild elk, but always poses as a potential pathogen (Kistner et al. 1982), and in more recent experiments, elk calves showed no sign of disease when infected with two species of *Eimeria* (Foreyt and Lagerquist 1994). However, parasitism by various helminths limited antler growth and body size in male white-tailed deer, *Odocoileus virginianus* (Trematoda, *Fascioloides magna,* Mulvey and Aho 1993), and curbed maternal investment in bighorn sheep, *Ovis canadensis* (Nematoda, *Protostrongylus* spp., Festa-Bianchet 1988). Effects such as these may influence population growth or herd condition over the long-term.

Recommendations

Several recommendations can be made for research and management of the Roosevelt elk herd in the Park. Studies of demography, habitat use, and range should be more frequent and span the entire year to capture seasonal variations in these parameters. In future studies, individuals should be permanently marked in order to reliably calculate an accurate estimate of numbers and demography using mark-recapture methods.

The use of radio or GPS telemetry will certainly yield a more precise description of the range used by adult bulls throughout the year. This technique would also yield valuable information on habitat use and preference of both adult bulls and the main herd, and the types of habitat in which they spend most of their time.

Since a possible explanation for poor range condition is low levels of soil nutrients, soils should be tested to check for unfavorable levels of calcium, phosphorous and other important minerals. Further studies should include an analysis of forage abundance in relation to herd size to assess whether elk carrying capacity has been reached in this area. Calorimetry of the available forage should be conducted to find more precise nutrient values. Habitat management regimes are able to help to improve nutrient quality of elk habitat. Prescribed burns of forage areas, especially in the coastal meadows of the Park, can reduce biomass of less valuable types of forage such as shrubs, and encourage growth of the more nutritious young plants (Leege and Hickey 1971; Biswell 1969).

Additional parasitology analyses should be done to check for prevalence and intensity of infection by ectoparasites, as well as bacteria and viruses. Examinations for helminths other than the abomasal and intestinal worms found in this study should be

conducted in order to assess risks of other diseases. Although no toxic plant species, such as *Senecio jacobaea,* were observed to be ingested, rumen analyses should be done to verify this and more accurately characterize food habits (Appendix D shows list of observed forage types).

As this study was the first of its kind on this particular herd of elk, much more detailed and conclusive analyses should be completed to better understand the ecology of these elk, as well as to implement the best possible management plans for this herd. Future research and suggested management practices recommended in this study should aid in accomplishing this goal and improving the health, viability, and stability of this elk herd over the long term.

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Appendix A

From:
Yerba Santa <yerba@humboldt.net> Save Address - Block Sender
To:
elk <g_wengert@hotmail.com> Save Address
Subject:
sightings
Date:
Sun, 24 Sep 2000 09:12:20 -0700

im losing track i see the friggin elk so much:
19 september 6 point male - on my property in whale gulch
20 september 6 point male - " " "
21 september 6 point male - " " "
yerba santa
i am really annoyed bothered perstered perturbed and distressed by the
presense of these animals .... i was here first!!!!!!
i wish they never reintroduced them!
please register my complaints loud and clear with whoever will listen.
i would like to relocate them out of this area.
permanently
(if i had a stun gun i would use it and drive them to your neighborhood)

yerba santa

Appendix A (continued)

From:
Yerba Santa <yerba@humboldt.net> Save Address - Block Sender
To:
g_wengert@hotmail.com Save Address
Subject:
elk sitings
Date:
Tue, 19 Sep 2000 23:52:04 -0700

hello
i saw your sign at the whitethorn post office
elk sited on 12 september, 2000 in whale gulch - about 1 1/2 miles down the yellow dirt road, off the county road, at the property below mine. male 6 points on rack.
elk sited on 13 september, 2000 in whale gulch - about 1 mile down the yellow dirt road, off the county road, on my property. male 6 points on rack.
these animals are a real threat to us here....they are destructive to our trees, gardens, and threaten small children, let alone intimidate adults.
i am constantly chasing them away from my property which they seem to use as a thoroughfare. often there are several at once (3 or more) and several years ago they destroyed electrical lines, fences, and fruit trees. if i can do anything to eliminate them from the area i would like to know what process to follow.
thanx
yerba santa

Appendix A (continued)

From:
"keith rashall" <kfab@humboldt.net> Save Address - Block Sender
To:
<g_wengert@hotmail.com> Save Address
Subject:
elk study
Date:
Wed, 23 Aug 2000 08:21:41 -0700

Hello, my name is Keith Rashall. I saw your notice at the whitethorn post office. Who are you and who is the study for. Does the study have a specific purpose other than determining the
size and health of the herd?

I'm curious, because I've been here for thirty years, and witnessed the importation of the herd and it's growth. I personally have seen the elk almost everywhere in the area, including half
way to whitethorn from four corners. I've seen them on many side roads in whale gulch and off the road too. (bachelor males)
There is alot of info you can get from the locals. Perhaps I can help you find it by passing the word along.
Keith Rashall kfab@humboldt.net

Appendix B

Appendix B. Female Roosevelt Elk with injuries probably incurred by a mountain lion (*Felis concolor*) in Sinkyone Wilderness State Park, Mendocino County, CA, in the summer of 2000.

Appendix C

Appendix C. Female Roosevelt Elk chewing on a bone of a black-tailed deer (*Odocoileus hemionus*) in Sinkyone Wilderness State Park, Mendocino County, CA, in the summer of 2000.

Appendix D

List of Observed Elk Forage Species

Hercaleum lanatum
Alnus rubra
Avena sativa
Holcus lanatus
Pseudotsuga menziesii
Equisetum hyemale
Lolium perenne
Trifolium sp.
Lupinus sp.
Rubus sp.
Vitis californica
Aira caryopyllea
Bromus rigidus
Malus spp.
Baccharis pilularis
Ribes spp.
Polystichum munitum
Phalaris spp.
Cynosurus echinatus
Rhamnus californica
Sambucus racemosa
Cirsium spp.
Erigeron spp.
Vinca major