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Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RL01830

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Executive Summary

Wildlife biologists documented an isolated elk population in 1972 on the U.S. Department of Energy's (DOE) Hanford Site. Since then the herd has grown, exceeding 800 animals in 1999. Limited harvests on adjacent private lands have occurred since 1986. The large herd size coupled with limited annual harvest have increased concerns about private land crop damages, vehicle collisions, degradation of the native environment, and the herd's use of radiologically controlled areas on the Hanford Site. As a result, in 1999, a decision was made by the Washington Department of Fish and Wildlife (WDFW) (animal management), the U.S. Fish and Wildlife Service (USFWS) (land management), and DOE (landowner) to conduct a large-scale animal roundup to remove elk from the DOE-owned lands and relocate them to distant areas within Washington State. The interagency roundup and relocation occurred in spring 2000.

This report presents the current status of the herd size and composition, annual removal estimates, and some limited seasonal area-use patterns by several radio-collared elk subsequent to the large-scale elk roundup.

The elk herd maintained an approximate 25% annual increase until 2000. A large harvest offsite in 1999 coupled with the large-scale roundup in spring 2000 reduced herd size to the current estimate of 660 animals. As of August 2000, the herd consisted of 287 (43%) males, 282 (42%) females, and 91 (13%) calves. There has been a notable cycling of calf recruitment rates throughout the 1990s and in 2000.

Elk home-range estimates revealed a substantial decrease in summer home ranges in 2000, presumably, in part, as a result of the summer 2000 Hanford Site wildfire. Movement analysis also determined that, as population size increased, so has the frequency and extent of the animals' offsite movements, particularly on private lands adjacent to the Hanford Site in both spring and summer seasons. The frequency and duration of movements by male elk onto the central portions of the Hanford Site has increased substantially as the population increased.

Acknowledgments

The authors wish to thank T. M. Poston for peer-reviewing this report, G. P. O'Connor for her editorial finesse, and L. M. Andor for text processing assistance. Outstanding aerial-support services were provided by Hawkins and Powers Inc. and Bergstrom Aircraft We would like to thank the Hanford Aviation Safety Committee for their attention to details and Nori Nichols-Schreck for providing the contractual arrangements. John and Racheal Cook deserve special thanks for conducting body condition measurements from dawn until dusk during the capture events. L. E. Bowman provided excellent photographic coverage of elk-related efforts throughout the year. The photographs included in this report are his.

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1.0 Introduction

An isolated Rocky Mountain elk population was documented in 1972 on the U.S. Department of Energy's (DOE) Hanford Site (Figure 1), an arid shrub-steppe environment in eastern Washington (Rickard et al. 1977). Since then, the herd has grown, exceeding 800 animals in 1999. Limited harvests on adjacent private lands have occurred since 1986. The large herd size coupled with limited annual harvest have increased concerns about private land crop damages, vehicle collisions, degradation of the native environment, and the herd's use of the Hanford radiologically controlled areas. As a result, in 1999, a decision was made by the Washington Department of Fish and Wildlife (WDFW) (animal management), the U.S. Fish and Wildlife Service (USFWS) (land management), and DOE (landowner) to conduct an animal roundup to remove elk from the DOE-owned lands and relocate them to distant areas within Washington State. The interagency roundup and relocation occurred in spring 2000.

Pacific Northwest National Laboratory (PNNL) monitors biological resources on the Hanford Site for DOE as part of the Ecosystem Monitoring Project. Project biologists have documented substantial growth of the Rattlesnake Hills elk herd over the past decade, as well as the herd's increased use of adjacent private properties, extensive movements to the Hanford 200 Areas vicinity across Highway 240, and use of the BC Cribs radiation control zone (Eberhardt et al. 1996). In addition, photographs of elk trails and limited ground-based measurements collected in 1998 indicate significant impacts to the natural resources on the Fitzner/Eberhardt Arid Lands Ecology (ALE) Reserve.

The work is intended to facilitate and continue monitoring several population, habitat and facility/area use characteristics of the herd. This report presents the status of the herd size and composition, annual removal estimates, and some limited seasonal area-use patterns by several radio-collared elk subsequent to the large-scale elk roundup.

1.1 Study Area

We studied elk on or near an approximate 500 km^2 portion of the Hanford Site, a former nuclear materials production site (Figure 1). In general, the area is characterized by shrub-steppe vegetation dominated by big sagebrush (*Artemisia tridentata*) and Sandberg's bluegrass (*Poa sandbergii*) (Daubenmire 1970; Downs et al. 1993), with approximately 16 cm of annual precipitation (Hoitink and Burk 1994). The climate consists of hot dry summers and relatively cool winters when the bulk of annual precipitation occurs. This area borders private agricultural drylands, orchards, and vineyards to the south and west.

A vehicle collision occurred on June 27, 2000, on Highway 24, resulting in one of the largest unplanned wild range fires recorded for the area. Over a 4-day period, the fire consumed virtually all vegetative cover on the ALE Reserve and a large portion of Hanford's central plateau.

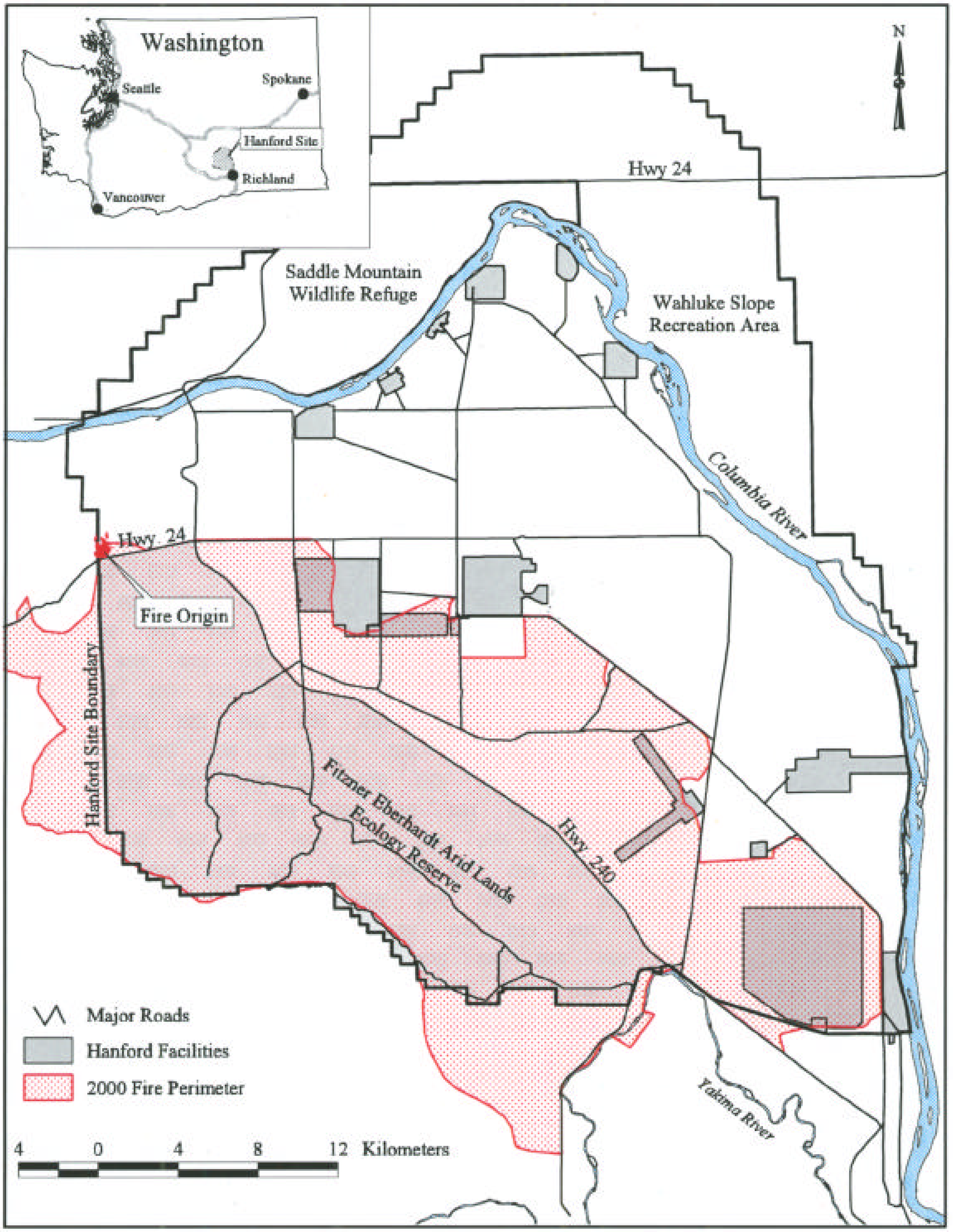

Figure 1. Study Area Illustrating Unplanned Wildfire June 27, 2000

2.0 Methods

This section briefly discusses our methods for conducting a herd census; capturing, sampling, and handling the animals; and tracking animal movements and patterns.

2.1 Population Characteristics

Since 1995, we have conducted an annual census of the Rattlesnake Hills elk population by maximum aerial composition counts during the winter (post-hunting) period when the elk herds gather in the lower elevation areas. Calving rates also have been estimated by ground and/or aerial flights during the summer (post-calving) period since 1995. Before 1995, summer aerial counts resulted in complete enumeration of the elk population, and thus, offered accurate calf recruitment rates. These methods are discussed in detail in Eberhardt et al. (1996).

Since 1995, we have conducted at least 10 ground-based surveys annually during the post-calving period (July-August). We conducted both aerial surveys and ground surveys during the post-calving 2000 season for comparison. For both ground and aerial observations, the total number of elk associated with each tagged animal was recorded and classified as adult bull, spike, cow, or calf. Calving rate estimates were determined by weighted-means analysis of the post-calving data. Variability was represented by standard errors for each year. Annual harvest numbers have been estimated by calling adjacent land-owners each year at the end of the hunting season, having hunters call in information about harvested radio-equipped animals, and contacting WDFW field personnel. The harvest composition was recorded as adult bull, cow, calf, spike, or unknown. The composition of animals removed during the elk roundup conducted in March 2000 was determined by ground crews and included in the herd size calculation. Mortalities of elk by vehicle collisions (road-killed animals) has been recorded by sex, age, and location as courtesy notifications from the Washington Department of Transportation. The non-parametric Multi-Response Permutation Procedure (MRPP) was used to detect significant differences between selected data sets (Meilke 1991). Standard errors were computed for virtually all data sets.

2.2 Animal Capture, Sampling, and Handling

On March 26, 2000, we captured 24 elk, including 20 cows and 4 mature bulls from the ALE Reserve to examine them for physiological condition, age, and pregnancy. We affixed radio-collars for subsequent population census, habitat and facility use monitoring, and to assess animal-specific calving rates. Four of the 20 female elk were previously radio-collared in 1993.

We captured elk by helicopter immobilization technique using a rifle-fired dart containing a 0.5-mg carfentanil citrate and 3.0 mg xylazine Hcl mixture (Wildlife Pharmaceuticals, Fort Collins, Colorado). While under sedation, the animals were assessed for their absolute body condition using two techniques: 1) Body Condition Score (involving palpation of fat and muscle reserves), and 2) ultrasonography (Cook 2000), which measures fat layer and muscle layer depth. Body temperature was measured on all elk captured, and pregnancy was determined using ultrasound and rectal palpation for all females captured.

We did not collect body condition indices on one animal because her body temperature was life threatening after immobilization. For this cow, pregnancy was determined from blood samples drawn and assayed for pregnancy specific protein-B (Sasser 1986).

We removed a canine tooth from each animal for age determination by cementum annuli analysis at (Matson's Laboratory, Milltown, Montana; Erickson and Seliger 1969). Each animal was fitted with a radio-collar for subsequent tracking (Advanced Telemetry Systems, Isanti, Minnesota). Radio-collared elk were labeled with one of 23 unique color-coded symbols for positive identification in the field. Approximately 2 g of ear tissue and 15 c.c. blood were also collected from each animal as requested by Yakama Nation biologists. We reversed the effect of the immobilizing drug using 325 mg of naltrexone Hcl (Wildlife Pharmaceuticals, Fort Collins, Colorado). One animal was found dead 2 weeks after the capture event. The animal was a 14-year-old female, and the mortality was assumed to be capture-related.

2.3 Animal Movements

Radio-equipped animals were located almost weekly using a Trimble Global Positioning System (GPS) from fixed-wing aircraft beginning March 29, 2000. Accuracy of the location monitoring is expected to be between 0 and 100 m from GPS sources and 0 to 300 m from observer sources. In addition, ground-based tracking was conducted from June 5 through August 29. Ground-based locations were determined using a 1-km x 1-km grid map covering the animals' areas of use. To examine movement patterns and calculate home range and area-use estimates, animal location points were entered into an Arcview Geographic Information System (GIS) version 3.2 (Environmental Systems Research Institute, Redlands, California). Animal movements were entered into Arcview extension 3.2 (U.S. Geological Survey-Biological Resource Division).

From 1990 through 1999, locations of several radio-equipped animals (23 females and 4 males) were documented during aerial flights conducted annually during the post-calving (July-August) and post-hunting (December-February) period. The animal location database also includes locations of radio-equipped animals monitored throughout the 1980s.

Since intensive animal movement monitoring began in March 2000, 23 adult (19 F: 4 M) radio-collared elk were relocated 689 times by ground and aerial tracking (between February 2000-September 2000). There were 164 (27%) ground observations and 436 (73%) aerial observations. The spring season was defined as all observations taken before July 1, 2000. The summer season was defined as all observations taken between July 1-August 31, 2000. All elk were relocated at least once weekly for both seasons. Thirty-four percent of all location were obtained from 0500 to 0900, 25% from 0900 to 1300, 18% from 1300 to 1700, and 23% from 1700 to 2100. Care was taken not to disturb collared elk while radio-tracking. Aerial locations were taken by GPS in the UTM coordinate system. Each radio-collared elk location was recorded a maximum of once daily and a minimum of once weekly.

3.0 Results and Discussion

3.1 Population Characteristics

Figure 2 illustrates the Rattlesnake Hills post-calving season elk population size estimate. The herd growth maintained an approximate 25% annual increase until 2000, when nearly 100 elk were removed from the herd during a liberal hunting season, and an additional 191 cows and calves were removed during the interagency (WDFW, USFWS, DOE) roundup in March 2000. Both increased hunting success and the capture/relocation effort, coupled with reduced calving rates in recent years have contributed to the recent elk population reduction (Figure 2). The composition of the elk herd also has changed as a result of the immediate removal of more than 200 females. Of the estimated 660 animals in the herd as of August 2000, 287 (43%) were males, 282 (42%) were females, and approximately 91 (13%) were calves. Calf numbers are estimated based on the post-calving 2000 calf:cow ratios.

Although some illegal harvests of the herd have occurred, annual state-administered elk hunts were initiated in 1985. Annual harvests (Table 1) on adjacent private lands has varied from 4 to 15%, and in recent years, has generally been small. The bulk of harvest each year has occurred in the first few days of the season as the elk recognize ALE as a refuge from hunting pressures. Elk hunting seasons established

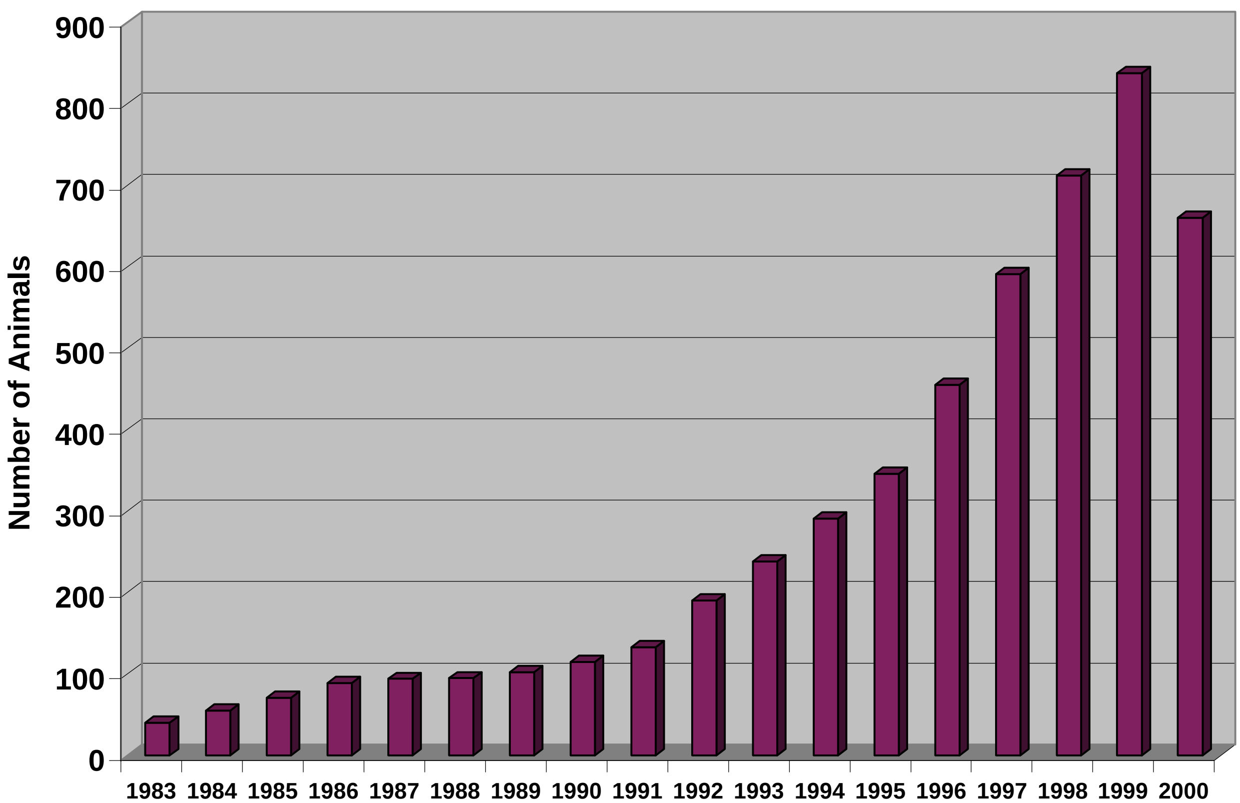

Figure 2. Rattlesnake Hills Elk Population Estimate, Post-Calving Period (July-August)

Table 1. Annual Harvest Estimates of Elk on Private Lands Adjacent to the Hanford Site

Year	Adult Male	Spike	Cow	Male Calf	Female Calf	Unknown	Totals	Herd Size	% Harvest	% Males	% Females	% Unknown
1985	2	0	1	0	0	0	3	71	4	3	1	0
1986	10	0	2	0	0	1	13	89	15	11	2	1
1987	5	1	7	1	0	0	14	94	15	6	7	0
1988	3	1	7	1	1	0	13	95	14	4	7	0
1989	6	2	3	0	0	0	11	102	11	8	3	0
1990	1	2	0	0	0	0	3	115	3	3	0	0
1991	13	1	0	0	0	0	14	133	11	11	0	0
1992	8	0	0	0	0	0	8	190	4	4	0	0
1993	8	1	4	0	1	0	14	238	6	4	2	0
1994	13	5	15	0	0	0	33	291	11	6	5	0
1995	17	0	3	0	0	0	20	346	6	5	1	0
1996	17	0	2	0	0	0	19	455	4	4	0	0
1997	16	1	3	0	0	0	20	591	3	3	1	0
1998	14	0	14	0	0	0	28	712	4	2	2	0
1999	14	1	36	2	3	38	94	838	11	2	4	5

by the WDFW over the last decade have offered either-sex elk tags for this unit. However, because of hunter choice, the majority of harvests have been males. Early season deer hunting has occurred immediately prior to the elk hunting seasons and may have indirectly reduced the availability of elk to hunters. Although we have no data to document changes in land use patterns by elk from year to year, it is reasonable to believe that annual precipitation has also played a role in the use of agricultural property by elk (i.e., high precipitation years reduce the need for elk to forage on agricultural crops), thus affecting the number of animals occupying private land and available for harvest.

In 1999, the hunting seasons were changed to an antlerless-only hunt, followed by an either-sex hunt, followed by another antlerless-only hunt. Several anterless animals were taken during the first hunt, and fewer animals were harvested during the either-sex hunt and the late-season antlerless-only hunt. However, in 1999, for the first time since 1988 (herd size was less than 100 individuals), the majority of animals harvested were females.

Another notable change has been fluctuating calf recruitment rates (Figure 3). From 1983 to 1987, the high productivity (79 calves/100 adult cow) was followed by a 5-year drop to as low as 33 calves/100 adult cows in 1991. Since then, calf recruitment increased over a 5-year cycle, reaching a high of 71 calves/100 adult cows in 1997 followed by a 3-year drop to the current 40 calves/100 adult cows. Although variability (error bars on graph) associated with a particular year overlaps with the error of the

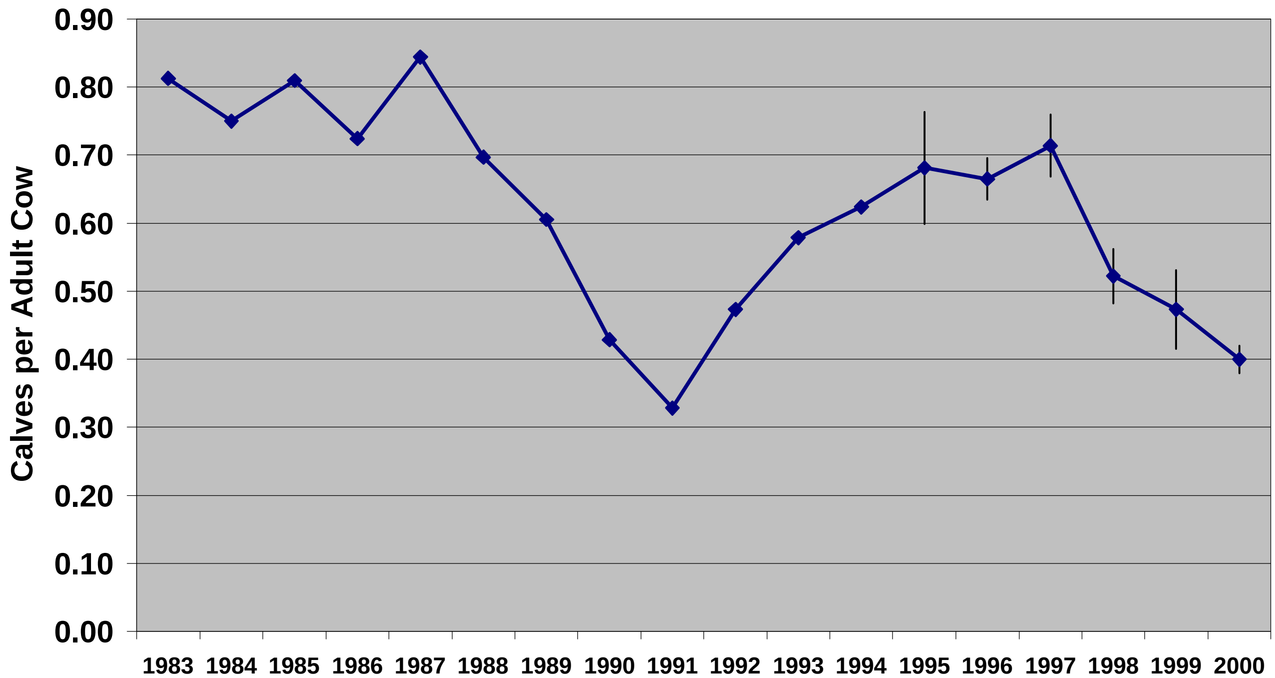

Figure 3. Calf Recruitment Estimates for the Rattlesnake Hills Elk Population (error bars represent ± 1 SE)

preceding or subsequent year, there has been a significant reduction ($\alpha < 0.01$) in calving rates when comparing the calf-per-cow ratios from 1995-1997 to those observed from 1998-2000.

Beginning in 1995, ground-based surveys have been used to estimate calf recruitment because locating all animals within the herd during the summer (when calves are distinguishable from cows) was no longer possible with the increased herd size. We compared accuracy of aerial calf/cow observations to ground-based observations during the 2000 post-calving period (Table 2). Figure 4 shows a calf and cow during this period. We found no statistically significant ($\alpha > 0.4$) difference in these two estimating techniques. This finding is consistent with results reported by Bender and Meyers[a].

The cyclic patterns of the calf recruitment may be a consequence of reduced calf survival in the first weeks of life and/or changes in predation rates. Although predator-related mortalities have not been directly observed on ALE, mountain lion have been documented on the Hanford Site since 1992, and coyotes were observed chasing elk groups during the summer calving period in 1999.

All 20 (including 2 yearlings) female elk checked in the spring of 2000 by palpation, ultrasound, or through hormone assay were pregnant. This finding was consistent with pregnancy rates checked in 20 female elk in 1993 (Eberhardt et al. 1996).

(a) Bender, L. C., and W. L. Myers. 2000. *Comparison of Helicopter and Ground Surveys for Elk and Mule Deer Composition*. (In Review).

Table 2. Comparison of Calf-to-Cow Ratios from Aerial Surveys Versus Ground Surveys, 2000

Aerial Surveys			Ground Surveys		
Date	Calf/Cow	n	Date	Calf/Cow	n
7/5	0.28	104	7/7	0.13	44
7/13	0.37	147	7/11	0.23	58
7/18	0.30	228	7/12	0.42	27
7/25	0.30	122	7/14	0.14	42
8/3	0.37	74	7/18	0.30	117
8/10	0.35	128	7/20	0.09	59
8/16	0.26	73	7/21	0.18	112
8/22	0.49	224	7/24	0.31	88
			7/25	0.29	63
			7/27	0.41	38
			7/28	0.34	134
			8/1	0.35	70
			8/2	0.34	99
			8/3	0.28	261
			8/4	0.47	103
			8/7	0.35	307
			8/15	0.48	90
			8/16	0.36	135
			8/21	0.33	179
			8/22	0.31	154
Total Obs	1100		Total Obs	2180	
Weighted Mean	0.36		Weighted Mean	0.32	
Standard Error	0.03		Standard Error	0.02	

An unplanned wildfire took place in the middle of the calving season (June 2000). Some effect from fire on the 2000 calf recruitment is likely. After the fire, field observers noted a few animals (including one calf) with severe burns, but no animal carcasses were found. It is possible that human-related disturbances (i.e., increased use of calving grounds by people, roundup-related activities, and/or the animals being chased by private helicopters) during pre-parturition periods have influenced the annual recruitment rates, but no data have been collected from this region to assess the potential effect (Phillips and Alldredge 2000).

To date, two studies have inversely related cow age to calf recruitment rates in other areas (Stussy 1993; Clutton-Brock 1982). Assessing body condition as an index for fecundity is based on the hypothesis that the individual animal represents the single best collation of habitat (nutritional) conditions. Thus, body condition increases as habitat (nutritional) quality increases. Percent fat and gross energy/kg are, in turn, the best predictors of individual and population productivity.

(©L. E. Bowman)

Figure 4. Calf and Cow Observed During the 2000 Post-Calving Period

Work on penned elk has demonstrated exactly how much energy is required to calve and successfully raise a calf. Differences between lactating and non-lactating cows demonstrates the energy loss associated with calving in any particular habitat, and whether conditions can be sufficiently recovered to permit normal calf-rearing the following year (Cook 2000).

The cooperative work with WDFW biologists will be incorporated into a database on elk condition in various habitats and across all ranges of elk productivity. This research and database are fundamental to determining what is responsible for herd productivity throughout the Northwest. Rattlesnake Hills elk appear to be on the upper range of the scale on body condition and productivity.

In spring 2000, we examined animal condition by measuring body condition scores (involving palpation of fat and muscle reserves) and percent body fat (gross energy/kg) using utlrasonography (Cook 2000). Our results indicated that animal age was inversely correlated with body condition (Figure 5), suggesting older cows may not be able to sustain the energetic demands needed to recruit calves through the summer, especially in a semi-arid climate. The linear regression (predicted) was significant; however, a polynonimal correlation appears to better correspond with the dramatic drop in percent body fat for animals older than 10 years. To apply this concept to a population-level effect, accurate age-class distributions are needed to correlate age-structure shifts with the observed calf recruitment fluctuations.

Figure 6 illustrates age-distribution data from 18 animals randomly captured in 1993 to 16 animals randomly captured in 2000. Although calf recruitment estimates for 1995 were higher (58 calves/ 100 adult cows) than in 2000 (40 calves/100 adult cows), these limited age data sets indicate relatively more young animals were present in the herd during 2000. These differences could be an artifact of low sample sizes. Continued monitoring will help shed light on this variable.

A few radio-equipped animals were harvested on adjacent private lands between September 1, 2000, and September 10, 2000. One 17-year-old animal was found to be lactating, one of two 8-year-old animals was lactating, and one 3-year-old animal was lactating. Continued monitoring of body condition as related to calf recruitment may shed light on the cyclic patterns of calf recruitment in the Rattlesnake Hills elk herd and other elk populations throughout the Northwest. Energetic deficiencies may only been seen every second or third year. We plan to recapture as many of the radio-equipped females as possible

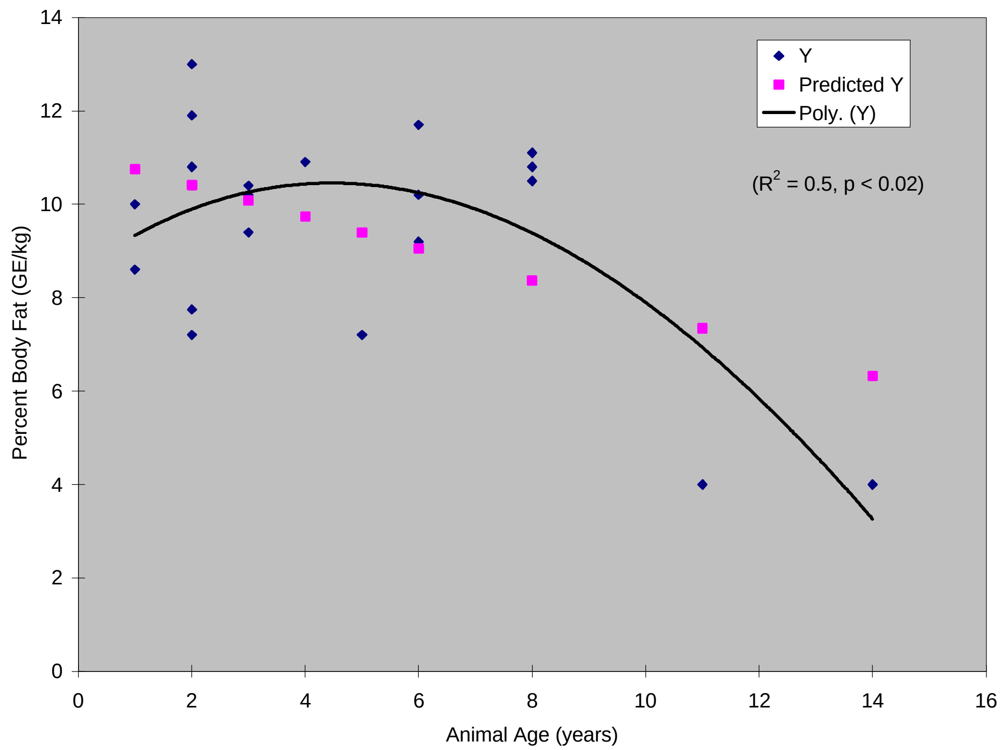

Figure 5. Regression of Animal Age Versus Percent Body Fat (GE/kg) Index of Rattlesnake Hills Elk

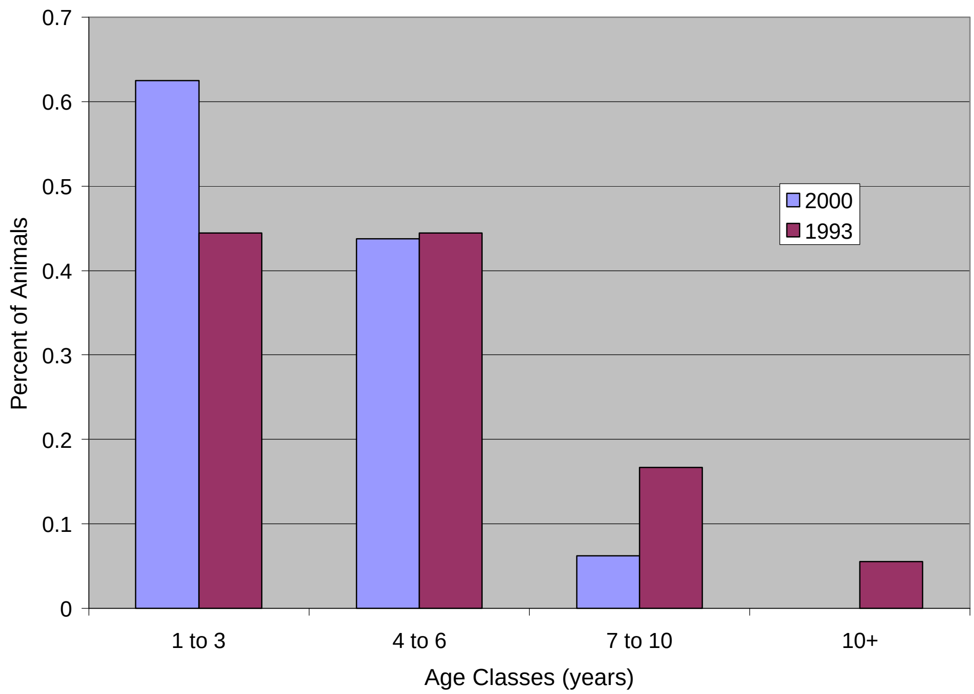

Figure 6. Comparison of Age Structure within Rattlesnake Hills Elk, 1993 and 2000

in late fall 2000 to measure total body condition and determine the calving status for each elk (as related to age and nutrition). These data will help examine whether old-age cows exhibited lowered calf recruitment rates and determine the energetic demands used to rear calves during summer 2000 in the Rattlesnake Hills.

3.2 Animal Movements

Published literature regarding elk movement and use of natural habitats is extensive (Craighead et al. 1973; Strohmeyer and Peek 1996; Clutton-Brock 1982; Stussy 1993; Cole et al. 1997; Unsworth et al. 1998); however, only a few apply to elk living in arid or semi-arid habitats (McCorquodale et al. 1986; McCorquodale 1987; McCorquodale et al. 1989; Strohmeyer and Peek 1996). The bulk of published literature regarding elk movements within a non-montane environment comes from data collected on the Rattlesnake Hills elk population; however, herd characteristics and the environment have changed dramatically since the 1980s, and shifts in animal use areas warrants reinvestigation (Van Dyke et al. 1998).

This section presents data accumulated since the McCorquodale et al. (1989) report and examines implications of the results. This baseline information is essential for both land managers and land-owners to assess contaminant uptake potential, vehicle collision hazards, deterioration of natural habitats, strategic harvest planning, and minimize crop damages and landowner complaints.

Movements of elk within the Rattlesnake Hills herd have been extensively studied, particularly during 1983 and 1984 (McCorquodale et al. 1986; McCorquodale 1987; McCorquodale et al. 1989). In the early 1980s, the Rattlesnake Hills elk population consisted of one major social group. At the time, herd size was less than 100 individuals and only included 40-60 animals during the time animal movements were intensively monitored (see Figure 2). Review of these previously documented movement patterns indicates elk ranges generally conformed to the shape of the ALE Reserve (Figure 1), and animals were never located on other parts of the Hanford Site. A small degree of movement onto private rangeland was documented to the west of ALE, particularly by male elk. During the 1980s, only one of seven radio-equipped female elk spent considerable time off the ALE during June and July, but returned to ALE by August.

Figure 7 illustrates animal locations grouped by decade (1980s and 1990s) and for the year 2000 during the post-calving period (July-August). A total of 463 locations were collected for the post-calving period throughout the 1980s, 82 locations throughout the 1990s, and 689 locations during 2000 (Table 3). Since the 1980s, the major change spatially depicted here in the 1990s and 2000 was increased use of the private and WDFW agricultural and rangelands along the southern boundary of the Hanford Site. Data from two bulls also suggests increased use of the central Hanford areas. Over 30% of all locations determined in the 1990s and 2000 were off of the Hanford Site. This compares to only 5% of all locations documented in the 1980s. The percent of locations found offsite during the 1990s compares to that percent determined for 2000; however, the bulk of locations onsite in 2000 were also very near the Hanford Site border. Locations in 2000 near the border reflect fire-related effects on elk movements. Elk were found onsite during daytime periods, presumably to minimize human encounters and because of the availability of open water there (Figure 8).

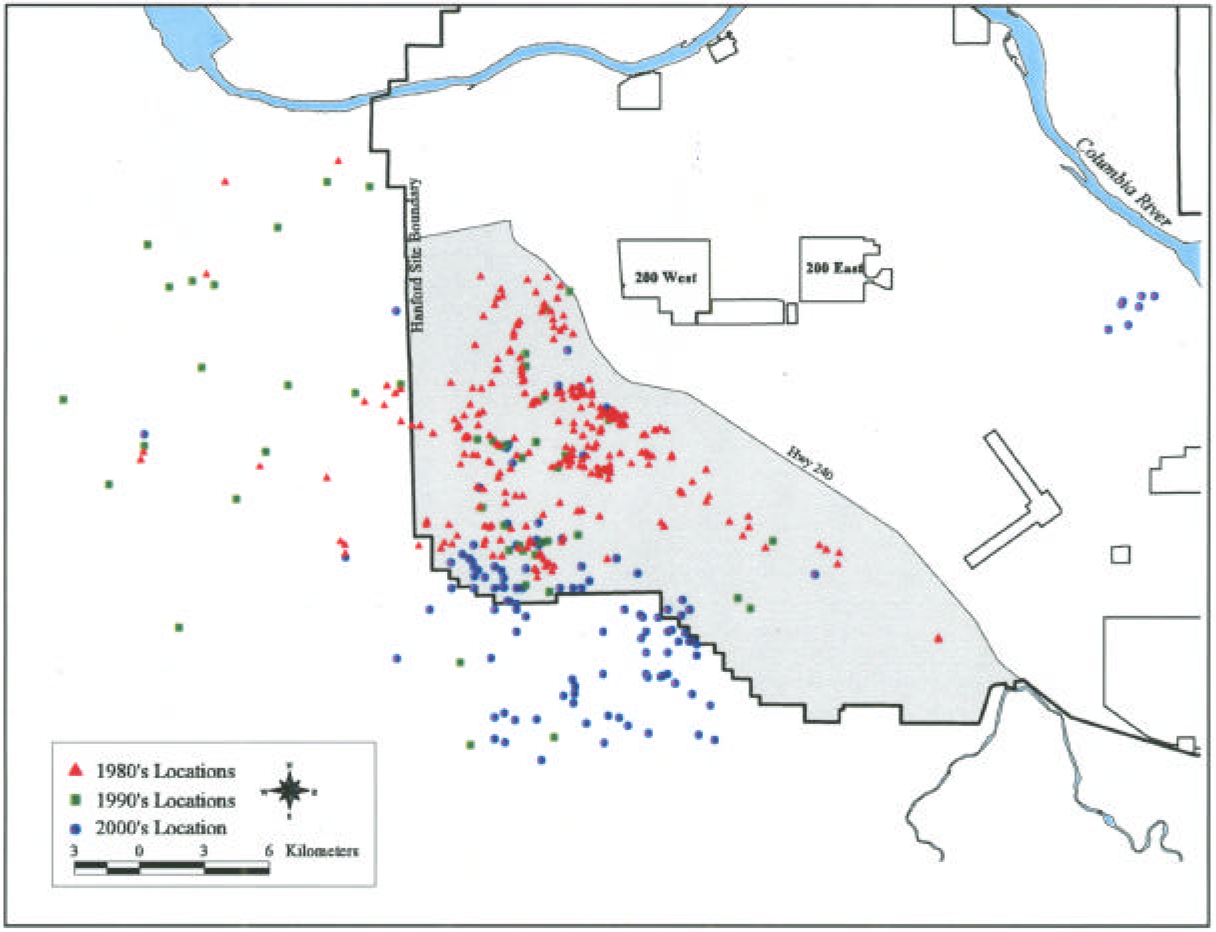

Figure 7. Locations of Radio-Equipped Elk During the Post-Calving Period (July-August) for the 1980s, 1990s, and 2000

Table 3. Summary of Animal Locations Offsite Versus Onsite for 1980s, 1990s, and 2000

Year Classes[(a)]	Percent Offsite	Percent Onsite	# Animals[(b)]	# of Locations
1980s	5	95	M6, F27	463
1990s	33	67	M4, F23	82
2000	34	66	M4, F19	689

(a) Data summarized for July-August period.
(b) Number of radio-equipped animals (male, female).

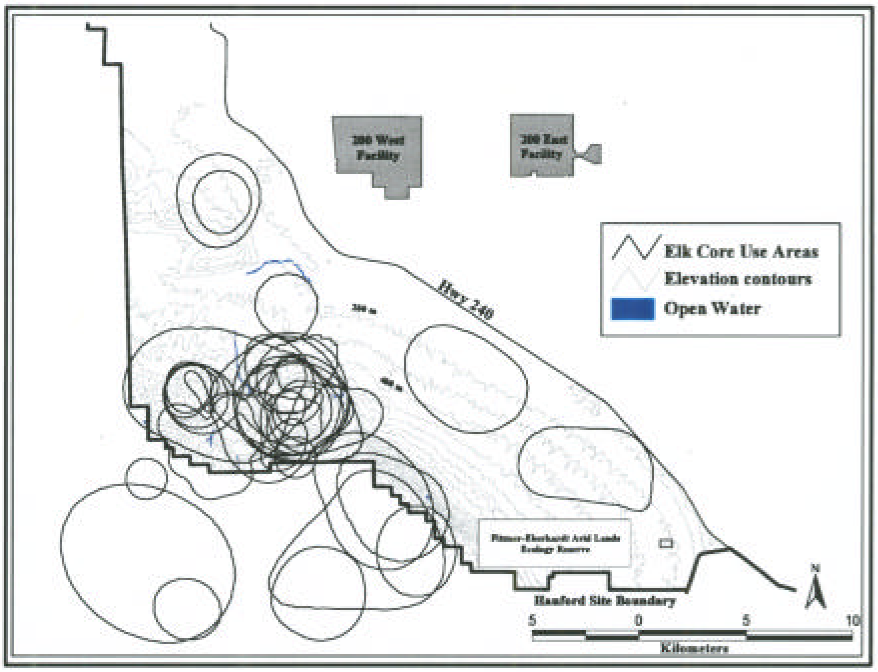

Figure 8. Core Use Areas for 19 Radio-Equipped Elk, Spring (March-June) 2000

Minimum convex polygon home ranges were calculated for all radio-equipped animals monitored since March 2000 for comparison to previously published studies. In this study, average home ranges were larger for males than females for both spring (March-June) and summer (July-August) periods (Table 4). Both sexes decreased home range sizes from spring to summer. These results are consistent with McCorquodale et al. (1989) except that male elk were found to have increased their home ranges during summer 1983 and 1984 when compared to their spring ranges. The previous study documented slightly larger spring home ranges for seven female elk (125.3 km^2), and drastically larger home ranges during the summer (95.2 km^2). Two to three male elk monitored in the 1983-1984 period exhibited home ranges half as large as the current study (60.7 km^2) during the spring and nearly four times (117.7 km^2) the size estimates documented during summer 2000. The previous study included June relocations in the summer period but does not account for the drastic change in home range size observed in 2000.

Figures 8-11 depict spatial use patterns by radio-equipped elk monitored in 2000 using the Kernal core-area use model (Worton 1989). This area-use estimating technique assesses spatial use on a probability grid based on the distribution of animal locations as opposed to MCP, which simply depicts the minimum polygon that can be drawn around the outer-most locations. The Kernal core use-area technique best depicts spatial changes in the animal use areas by season. The frequency of offsite movements and area-use illustrated demonstrate the elk herd's high fidelity to the ALE Reserve and is consistent with previous studies (McCorquodale et al. 1989). However, use of offsite habitats and central Hanford Site in both spring and summer seasons has increased dramatically since the 1980s and suggests a density-dependent phenomenon (Van Dyke et al. 1998).

Table 4. Mean ±1 SE Minimum Convex Polygon Home Range Estimates for Radio-Equipped Elk, Spring and Summer Seasons

	Females			1983 - 1984(c)	Males			1983 - 1984(c)
	MCP(a) ± 1 S.E.	n(b)	# of Locations		MCP(a) ± 1 S.E.	n(b)	# of Locations	
Spring (March-June 2000)	75.8 ± 11	19	246	125.3	153.3 ± 29	4	268	60.7
Summer (July-August 2000)	19.6 ± 3	19	41	95.2	35.3 ± 22	4	36	117.7

(a) Minimum Convex Polygon (MCP) home range size estimates in km^2, 2000.
(b) Number of radio-equipped animals monitored.
(c) MCP home-range estimates (km^2) from McCorquodale et al. (1989).

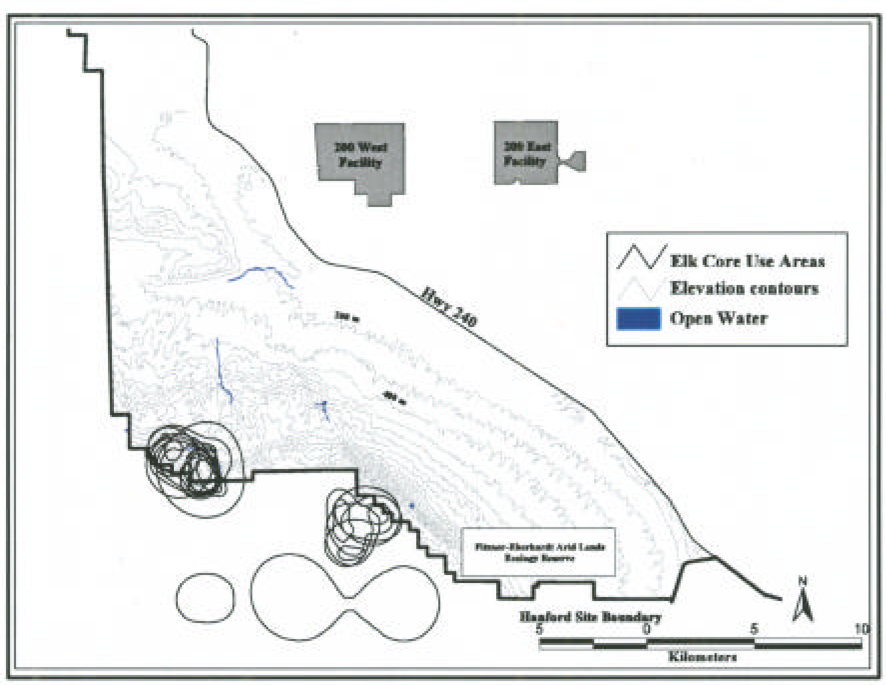

Figure 9. Core Use Areas for 19 Radio-Equipped Female Elk, Summer (July-August) 2000

Before the wildfire, 5 of 19 radio-equipped female elk spent virtually all their time on private and WDWF lands south of the Hanford Site border. Two of 4 radio-equipped males spent the bulk of their time on central Hanford in areas generally absent of human activity.

The dramatic reduction of home range sizes of female elk during the 2000 summer period as compared to sizes in the 1980s is, we believe, partly due to the June 2000 wildfire and loss of forage on ALE. Field crews noted a rapid change in daily animal movement patterns after the fire. The animals routinely

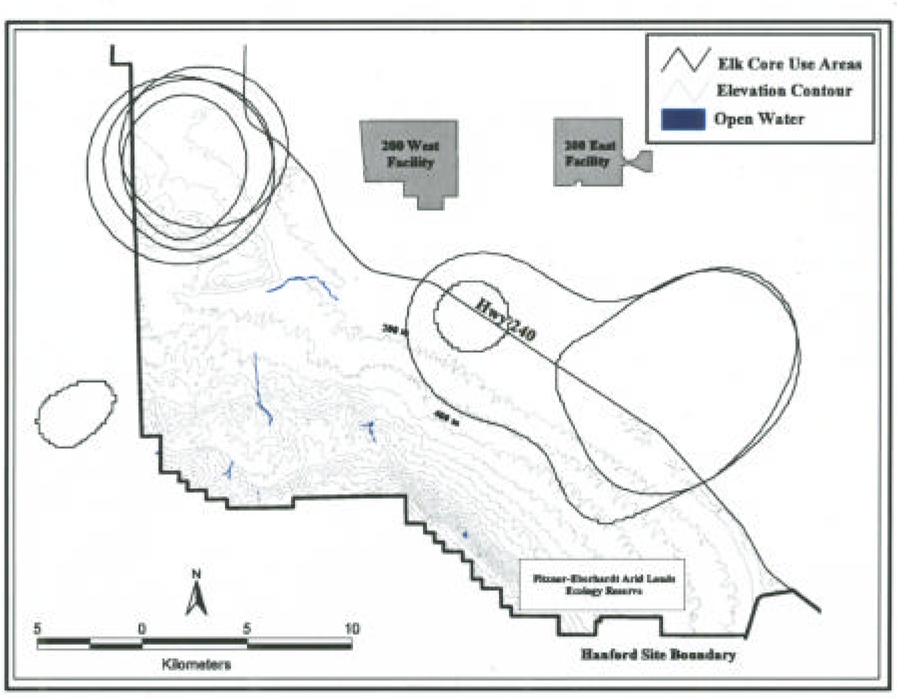

Figure 10. Core Use Areas for Four Radio-Equipped Male Elk, Spring (March-June) 2000

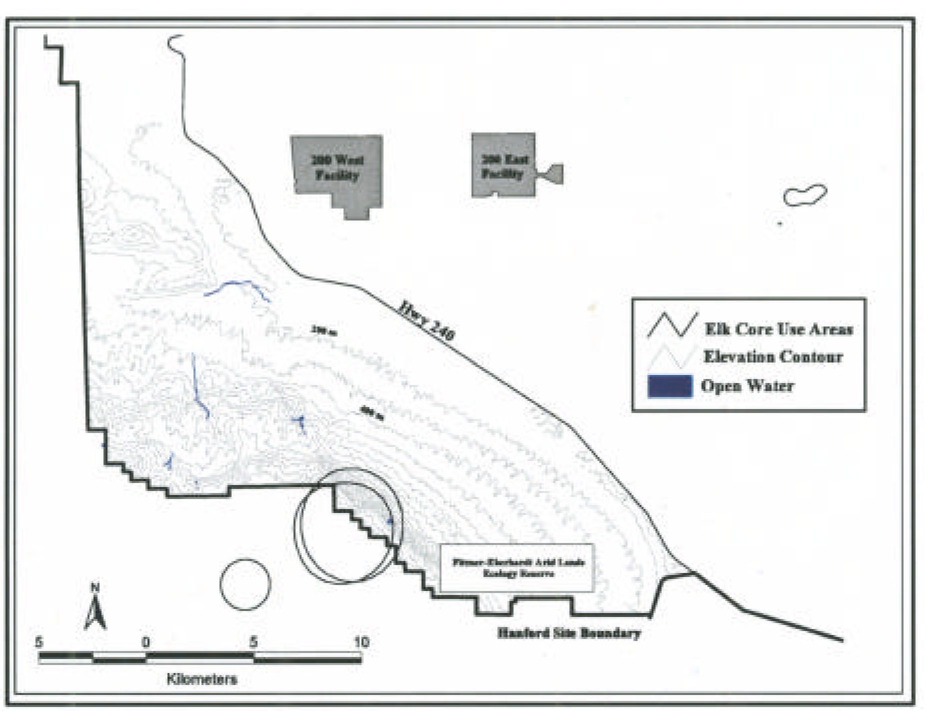

Figure 11. Core Use Areas for Four Radio-Equipped Male Elk, Summer (July-August) 2000

moved from ALE to the dry-land wheat fields at dusk to forage (Figure 12). By daylight, the animals would be back on ALE, presumably to avoid human contact in the agricultural areas and to attain access to open water sources (Figure 8).

The effects of the unplanned wildfire on animal movements is difficult to assess because animal movements have not been intensively monitored during the summer period since the 1980s. Monitoring animal movements in subsequent summers will provide valuable comparisons. Annual precipitation (i.e., extending succulent forage season on ALE) also may play a role in the distribution of animals, as well as their proximity to open water (McCorquodale and Eberhardt 1990). Ground crews noted an immediate increase in herd sizes found on private lands after the fire.

In fall 1999, for the first time since the elk were documented on ALE in 1972, two land damage claims were filed by private wheat farmers on the southern portions of Rattlesnake Ridge (R. Schaffer, WDFW personal communication 2000). In 2000, four extensive land damage claims were filed in the same region. Although the wildfire played a major role in the distribution of elk and subsequent crop damage during summer 2000, the increasing herd size also was a primary factor. The changes in extent of offsite movements and frequency of offsite use throughout the 1990s (in the absence of a large-scale wildfire), and spring 2000 core-use patterns documented for two male elk and five female elk supports this contention.

The movements and land uses documented on central Hanford are not common for most animals or social groups in the Rattlesnake Hills elk herd. A single female elk was observed on central Hanford in 1997. Since then, only male elk have been located on central Hanford or associated with the radio-equipped bulls that have been using the central Hanford regions. Road-kill data gathered along Highway 240 supports these observations. Since 1998, seven road-killed animals have been documented along Highway 240 (that portion separating ALE from the central Hanford) and all were males (6 adults and 1 spike). A maximum single count of 42 bull elk were documented in December 1999 on central Hanford. U.S. Fish and Wildlife officials also have observed two bulls northward across the Columbia River on the Saddle Mountain Wildlife Refuge since 1998 (see Figure 1). Core-use estimates for 2 male elk during spring 2000 include an area on central Hanford known to contain trace levels of surface contamination of radionuclides.

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Figure 12. Elk Moving From Private Lands onto the Fitzner/Eberhardt Arid Lands Ecology Reserve After the Wildfire

4.0 Conclusions

Population characteristics of the Rattlesnake Hills elk herd indicate reduced herd growth rates from the 1980s compared to the 1990s (McCorquodale 1988; Eberhardt 1996). However, the population continued to grow approximately 25% annually through the 1990s, reaching a high of 838 animals in summer 1999. Calf recruitment rates appear to be cyclic and are likely related to reduced calf survival during the first weeks of life; however, late-term abortions may also have occurred. The cause(s) could be predator-related and/or a function of shifts in nutritional condition (age-class distributions, assuming older-age cows are less likely to recruit calves, major climate shifts) or changes in the human-related disturbances during gestation, and/or calf rearing periods.

In fall 1999 and spring 2000, the population was reduced from 838 individuals to 660 individuals. The primary controlling factors were modified hunting seasons on private and state lands and the large-scale roundup conducted in spring 2000. Continued removal of animals (particularly females) within the population will be pivotal to maintain the population at a level that minimizes land damage complaints, animal-vehicle collisions, use of central Hanford areas, and deterioration of natural resources.

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