Literature and Status Review of Big Game Species in Hells Canyon

Mountain Goat, Bighorn Sheep, Black Bear, Mountain Lion, Mule Deer, and Elk

John T. Ratti
Matthew B. Lucia

Department of Fish
and Wildlife Resources
University of Idaho

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Mountain Goat, Bighorn Sheep, Black Bear, Mountain Lion, Mule Deer, and Elk

Submitted to:

Frank Edelmann
Idaho Power Company
P.O. Box 70
Boise, Idaho 83707
208-388-2355

Submitted by:

John T. Ratti and Matthew B. Lucia
Department of Fish and Wildlife Resources
University of Idaho
Moscow, Idaho 83844
208-885-7741

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1. INTRODUCTION

In August 1996, John Ratti (see Appendix A) and the University of Idaho contracted with Idaho Power Company to conduct a literature and status review of big game species in Hells Canyon of the Snake River (Idaho Power Company 1995). The primary objective of this work was to locate all literature associated with the Hells Canyon region that provides relevant information on the biology, ecology, and management of 6 big game species: 1) mountain goat (*Oreamnos americanus*), 2) Rocky Mountain bighorn sheep (*Ovis canadensis*), 3) black bear (*Ursus americana*), 4) mountain lion (*Felis concolor*), 5) mule deer (*Odocoileus hemionus*), and 6) Rocky Mountain elk (*Cervus elaphus*).

Deliverables, as described by the Request for Proposals (Idaho Power Company 1995:7) include the literature and status review report, an electronic database of all literature in Pro-Cite® format, photocopies of all documents (especially agency reports), and a list of keywords for use with the Pro-Cite® database.

Note regarding **units of measure:** In the following sections and subsections we review a wide variety of literature with sources that vary from peer reviewed journals, symposia proceedings, books, and agency and committee reports. We recognize that most professional natural-resource publications present units of measure in metric format (e.g., CBE Style Manual Committee 1994, Ratti and Smith 1998). However, for this report we have chosen to present units of measure as they were reported by the authors in the original publication. Although presentation of both English and metric units is inconsistent, we avoid potential errors in the conversion process and other sources of confusion that may result from conversions.

2. STUDY AREA

The study area for this report is that portion of the Snake River between the confluence of the Snake and Salmon rivers (on the north) and the Weiser Bridge (on the south; see Tier 2, Figure 1). Within that section of the Snake River, the study area includes all habitats defined as “rim-to-rim” between the Idaho side canyon (on the east) and the Oregon side canyon (on the west). For this report, reference to Hells Canyon or the Hells Canyon region refers to the Hells Canyon National Recreation Area and areas adjacent to Hells Canyon, Oxbow, and Brownlee reservoirs, within Tier 2 of the study area (Figure 1).

Physiography, vegetation, and other environmental aspects of Hells Canyon have been described in detail by Claire et al. (1971), Asherin and Claar (1976), Draper and Reid (1986), U.S. Forest Service (1981), U.S. Department of Energy (1984a, 1984b, 1985), Reid et al. (1991), and Reid and Gallison (1994). Terrestrial vegetative environments of this region include 1) riparian, 2) river benches, 3) steep rocky slopes, 4) cliffs, and 5) springs and seeps (Draper and Reid 1986:13). For a list of the 100 most-common plants in Hells Canyon see Draper and Reid (1986:Tables 2.2-2.4). The region's physiography includes alpine mountain peaks, forests, meadows, and grasslands; elevations range from 800-9,393 feet (USDA Forest Service 1981). The 31.5-mile section of river between Hells Canyon Dam and Pittsburg Landing is designated "Wild" under the Wild and Scenic Rivers Act. The 36-mile section of river downstream from Pittsburg Landing to river-mile 180.2 is designated "Scenic" (USDA Forest Service 1994b).

3. METHODS

We attempted to locate all literature associated with the biology and ecology of our target species, hydroelectric operations, and the Hells Canyon region. Our search for literature included: 1) computerized literature search services, 2) use of University library special documents (e.g., government reports), 3) personal contact with state and federal biologists with experience or responsibility in or adjacent to Hells Canyon, and 4) review of key publications on our target species and the literature cited. In the subsections below, we list the various resources used during our search.

3.1. Computerized Literature Services

- ABSEARCH Databases (wildlife, ecology, conservation biology, Canadian zoology, and mammalogy)
- AGRICOLA
- Applied Science and Technology Abstracts (SilverPlatter)
- Biological and Agricultural Index
- BIOSIS
- Consultative Group on International Agricultural Research (CIARL)
- Current Contents (CC Search)
- Dissertation Abstracts ON DISC (UMI)
- Economic Literature (EconLit)
- Engineering Index (EI COMPENDEX)
- Essential Ecology, Zoology, and Plant Science Abstracts (NISC DISC)
- Essential Fisheries Abstracts (NISC DISC)

- Forestry Abstracts (TREECD)
- Geology Reference (GeoRef DISC)
- Life Sciences
- Natural Resource Metabase (NISC DISC)
- North American Water and Environment Congress and Destructive Water (ASCE)
- Public Affairs Information System (PAIS International)
- Social Science Abstracts (Silver Platter)
- Water Resources Abstracts (NISC DISC)
- Wildlife Worldwide (NISC DISC)

3.2. University of Idaho Library and Other Sources (via access to CARL)

- U.S. Government Documents Archive
- Special Collections Archive
- Reserve Collections (on CD-ROM)
- Interlibrary Loan Services
- Alfred W. Bowers Laboratory of Anthropology

3.3. Personal Contacts (listed alphabetically)

- John Beecham, Idaho Department of Fish and Game, Boise, ID
- Frances Cassirer, Idaho Department of Fish and Game, Lewiston, ID
- Victor Coggins, Oregon Department of Fish and Wildlife, Enterprise, OR
- Dinah Demers, Washington Department of Fish and Wildlife, Spokane, WA
- Jerome Hansen, Idaho Department of Fish and Game, Boise, ID
- LuVerne Grussing, Bureau of Land Management, Cottonwood, ID
- George Keister, Oregon Department of Fish and Wildlife, Baker City, OR
- Curt Mack, Nez Perce Tribe, Lapwai, ID
- Pat Matthews, Oregon Department of Fish and Wildlife, Enterprise, OR
- Kevin Martin, USDA Forest Service, Enterprise, OR
- Sam McNeill, Idaho Department of Fish and Game, Lewiston, ID
- Steve Nadeau, Idaho Department of Fish and Game, Lewiston, ID
- John O’Neill, Idaho Department of Fish and Game, Brownlee Reservoir, ID
- Lee Sappington, Department of Anthropology, University of ID, Moscow
- Tim Schommer, USDA Forest Service, Baker City, OR
- Roderick Sprague, Department of Anthropology, University of ID, Moscow
- Alan Slickpoo, Sr., Nez Perce Tribe, Lapwai, ID
- Jim Unsworth, Idaho Department of Fish and Game, Nampa, ID
- Walter Van Dyke, Oregon Department of Fish and Wildlife, Ontario, OR
- Bruce Womack, USDA Forest Service, Enterprise, OR

3.4. Review of Key Literature

In addition to review of literature located from the sources listed above, we also examined the Literature Cited sections of major publications for each of our target species. This exercise was basically redundant to our efforts above. However, review of these specialized publications provided a “double check” for important literature that may have been missed by other methods. All of these citations are provided in the Pro-Cite® database with this report and are cited in the sections below, thus, most will not be repeated here. However, examples of “key publications” include monographic or review works such as Chapman and Feldhamer (1982), Seidensticker (1973), Wallmo (1981), and Thomas and Toweill (1982).

3.5. Search Terms

During our search for literature, we used a series of search terms designed to locate literature germane to this report topic. These terms are listed in Appendix B.

4. PRO-CITE® DATABASE AND HARD-COPY FILES OF LITERATURE

Pro-Cite® is a literature management program available in Windows, DOS, and Macintosh formats. This program allows efficient and quick search of the database provided with this report. A brief tutorial for use of the DOS version 2.1 of Pro-Cite® is provided in Appendix C, however, users unfamiliar with the program should also consult the Pro-Cite® manual.

It is important to note that our database does not contain all literature on our target species for North America (i.e., only selected major publications are included in the database, and many of these are cited in the first subsection under “General Species Account and Review”). However, ***all*** literature that we located on our target species specific to Hells Canyon or the Hells Canyon region has been included in the database. Terms that may be useful for searching the database are listed in Appendix D. The hard-copy files are organized by species, and each paper is numbered. A description of the hard-copy file organization is presented in Appendix E. Please review this appendix for more-efficient use of the Pro-Cite® database and the hard-copy file.

5. REVIEW OF SPECIES: MOUNTAIN GOAT
(Oreamnos americanus)

5.1. General Species Account and Review

5.1.1. Evolution

The mountain goat is in the family Bovidae, is a monotypic genus endemic to North America, and is not a true goat (Kurten 1980). The mountain goat's nearest phylogenetic relatives are the chamois (*Rupicapra rupicapra*) of Europe, and the goral (*Naemorhedus* sp.), takin (*Budorcus taxicolor*), and serow (*Capricornus* sp.) of Asia.

5.1.2. Reproductive Ecology

Important studies on mountain goat reproduction include Brandborg (1955), Lentfer (1955), Peck (1972), Chadwick (1974), Bailey (1991), and Festa-Bianchet et al. (1994). The breeding season in most ranges is late fall and is usually restricted to females ≥ 2 years of age. Most births are to a single kid in late May or early June; twins are not uncommon. Mountain goats are polygamous. Mountain goats have low rates of increase, and most populations are stable and normally do not exceed carrying capacity (Hjeljord 1971). Festa-Bianchet et al. (1994) reported nutrient availability as a limiting factor for reproduction of goats in Alberta.

5.1.3. Habitat Requirements and Food Habits

Habitats are usually described as subalpine or alpine zones, and characteristically are rocky cliffs, ledges, and steep talus slopes. Saunders (1955) described 4 basic habitats: grassy slide-rock slopes, ridge tops, alpine meadows, and timber. Use of higher elevations are common in winter, but deep winter snows often force animals to lower elevations and use of forests (Anderson 1940, MacGregor 1977, Arnett and Irwin 1989).

Mountain goats are fond of salt and will often travel substantial distances to visit salt licks (Wigal and Coggins 1982). Saunders (1955) reported grasses, sedges, and rushes as primary summer foods; forbs were reported as most important during summer by Peck (1972). During winter there is a shift toward the use of shrubs and conifers for food. In some regions mosses, lichens, and choke cherry (*Prunus virginiana*) leaves were important (Richardson 1971). Anderson (1940) reported 34 plant species used as summer food, and 16 during winter. Wigal and Coggins (1982:1013-1014) provided comparative tables of winter and summer food habits for 8 studies from 5 states and 2 provinces. Smith (1986) documented over 50 plant species in the diet of Alaskan goats; conifers, mosses, and lichens dominated winter diet. Suitable forage may be a major limiting factor during winter (Wigal and Coggins 1982). Watering areas are a requirement for mountain goats, and water availability may limit summer range (Anderson 1940).

5.1.4. Other Limiting Factors

5.1.4.1. Accidents.

Most accidental mortality is probably associated with snow slides (avalanches) and land slides (Brandborg 1955, Vaughan 1973). Falls have not been widely reported, but are assumed to be the cause of some moralities.

5.1.4.2. Predation.

Mountain lions, and to a lesser degree bobcats (*Felis rufus*), are considered to be the most important predators on mountain goats (Brandborg 1955, Rideout and Hoffmann 1975, Fitzgerald et al. 1994). Anderson (1940) and Brandborg (1955) both reported goat hair in Coyote (*Canis latrans*) scats for Washington and Idaho, respectively. However, consumption of goats by coyotes is assumed to be mostly as carrion. Other minor predators include black bear, grizzly bear (*Ursus arctos*), and golden eagle (*Aquila chrysaetos*). Both Anderson (1940) and Brandborg (1955) have reported observing eagle predation during spring when kids were small. For some populations, predation has been documented as a major source of mortality (Festa-Bianchet et al. 1994).

5.1.4.3. Parasites.

Studies of parasites include works by Kerr and Holmes (1966), Richardson (1971) and Cooley (1977). The most common ectoparasite is ticks (*Dermacentor* and *Otobius* spp.). Many endoparsites have been reported for mountain goats including stomach worms (*Ostertagis*, *Marshallagia*, *Teladorsagia*, and *Tricholstongylus* spp.), thread-necked worm (*Nematodirus* sp.), pin worm (*Skrjabinema* sp.), whipworm (*Trichuris* sp.), lungworm (*Protostrongylus* and *Muellerius* sp.), threadworms (*Strongyloides* sp.), lancet and liver flukes (*Dicrocoelium* and *Fasciola* spp.), and tapeworms (*Thysanosoma*, *Monezia* and T*hysaniezia* spp.). As with most species, mountain goat mortality from parasites is difficult to document and assumed to be rare; however, Boddicker et al. (1971) reported parasite-induced mortality in South Dakota. The effects of parasitic infection may contribute significantly to other forms of mortality.

5.1.4.4. Disease.

Contagious ecthyma (CE) is a viral disease often associated with domestic sheep and goats (Blood 1971, Samuel et al. 1975). This disease is also know as sore mouth, contagious pustular dermatitis, scabby mouth, infectious labial dermatitis, and orf (Wigal and Coggins 1982). The disease is apparently associated with animals that frequent artificial salt areas (i.e., salt blocks). White muscle disease is a paralytic symptom in the hindquarters that is associated with selenium deficiency (Herbert and Cowan 1971). This disease was reported during the stress of capture and often caused death. Thus, it is assumed stress and exhaustion from harassment by hunters or predators may cause many unreported deaths from this disease. Other mountain goat diseases are discussed by Wigal and Coggins (1982).

5.1.4.5. Hunting.

Because mountain goats are found in remote rugged environments, they were not highly prized for meat or trophy prior to the 1960s (Kuck 1986). Hunting has not been a serious limiting factor in most regions for many decades. However, increases of road accesses associated with timber harvest and mining, and the increase in hunter demand, has led to overharvest of many herds (Wigal and Coggins 1982, Kuck 1986). Smith (1986:743) noted that prime-aged goats (2-8 yrs) were “relatively invulnerable to natural mortality factors but suffered considerable hunting mortality.” Herbert and Turnbull (1977) have recommended that hunter harvest not exceed 4% of the total goat population. In Idaho, habitat is patchy and herds are often small and widely separated. This characteristic, and the tendency by hunters to seek accessible animals, has led to overharvest and elimination of some herds (IDFG 1981).

5.2. Historical and Contemporary Species Ecology in Hells Canyon

5.2.1. Distribution

Randolph and Dahlstrom (1977), Reagan and Womack (1981), and Draper and Reid (1986) reported that mountain goats were among food items used by prehistoric people living in Hells Canyon. Randolph and Dahlstrom (1977:1) identify the specific site (Smithsonian site designation 10IH483) and give coordinates for the He Devil quadrangle map 1:62,500.

Current Hells Canyon distributions are restricted primarily to Idaho Department of Fish and Game (IDFG) management units 18 and 22, and populations are in the vicinity of the Seven Devils mountain range adjacent to the Snake River (IDFG 1981, Kuck 1986). These populations are the result of goat transplants in 1962, 1964, and 1989. No goat populations exist in Oregon within the Tier 2 extensive study area (Figure 1).

5.2.2 Abundance

Vogel (1996:Appendix C) summarized Idaho mountain goat census data for unit 18; populations estimates were 71 in 1981, 82 in 1987, 137 in 1993, and 68 in 1996. In 1996, 49 goats were also counted in unit 22 (IDFG 1996:30); this count was higher than the 1995 count.

5.2.3. Movement Patterns

No specific research has been conducted on daily or seasonal movement patterns by goats in Hells Canyon. However, movement between units 18 and 22 has been documented (IDFG 1996). The 1996 decline in unit 18 and the simultaneous increase in unit 22 has led to speculation of movement by goats from unit 18 to 22. At the present time, there are no goats on the Oregon side of Hells Canyon, and the river is suspected as a barrier to movement between Oregon and Idaho (Kevin Martin, U.S. Forest Service, Enterprise, Oregon, personal communication).

5.2.4. Habitat Associations

Hells Canyon mountain goat habitat has been described as “deep, rugged canyons of the Snake and Salmon rivers” (IDFG 1996:19). Unit 18 habitat is described as “drier” than goat habitat in units 10 and 17. No specific quantitative data were located on Hells Canyon goat habitats, either historical or contemporary. Reid (1991) presented a general description of the paleoenvironment of the Snake River basin (also see Reid and Gallison 1994).

5.2.5. Harvest

Mountain goat hunting in Hells Canyon is restricted to Idaho Game unit 18 (for maps of Idaho and Oregon game units, see Appendix E); harvest permits have been issued since 1974 (Kuck 1977, IDFG 1996). During the past 10 years, goat harvest has averaged 4.4 animals per year; the 3-year average (1992, 1993, [1994 no data], and 1995) was 4.0 (IDFG 1994, 1996). Because goats are highly sensitive to exploitation, harvest permits in unit 18 have been conservative (Kuck 1986).

5.3. Cultural Significance in Hells Canyon

5.3.1. Historical

Many anthropological studies have determined the prehistoric existence of mountain goats in the Hells Canyon region, primarily on the Idaho side of the Snake River (Pavesic 1971, Randolf and Dahlstrom 1977, Reagan and Womack 1981, Draper and Reid 1986, Leonhardy and Thompson 1991). However, among big game animals for the region, goats were not a dominant species used by native peoples (possibly due to their inaccessible habitat and difficulty of harvest with primitive weapons). Regardless, mountain goats are among the big game species considered to be of cultural importance to aboriginal peoples of the Nez Perce territory (Walker 1971).

5.3.2. Contemporary

Mountain goats are among a number of wildlife species that remain culturally important to the Nez Perce people. These species are part of native religious ceremonies and medicine dances, and they are also important for young tribal men that seek an individual spiritual quest, or “Wayekin” (Alan Slickpoo, Sr., Tribal Historian, Nez Perce Cultural Resource Program, Lapwai, Idaho, personal communication). Alan Slickpoo did not distinguish among big game species regarding relative importance to religious ceremonies. Protection of important cultural resources is one objective for management for USDA Forest Service lands within Hells Canyon National Recreation Area (USDA Forest Service 1986b).

5.4. Potential Hydroelectric Impacts to Populations and Habitat in Hells Canyon

Foster and Rahs (1983) estimated that 80% of mountain goats elicited a behavioral “stress-response” to hydroelectric exploration activities (primarily aircraft) in British Columbia. Thus, any activity of this nature must be considered with caution. Warnick and Clapp (1978) noted concern for big game animals in Hells Canyon, including mountain goats, that use riparian zones subject to water fluctuations. However, we did not locate any literature that noted riparian areas as important goat habitat. We conclude that existing hydroelectric operations in Hells Canyon will have minimal or no impact on current mountain goats populations.

However, it should be noted that no information is available regarding traditional (i.e., historical) movement patterns by goats in the Hells Canyon region (and little information is available on recent movements). Some concern has been expressed regarding reservoirs restricting movement and migration for sheep and deer (see sections 6.4 and 9.5 below). The potential impact on goat movements is unknown.

5.5. Issues Associated With Population Viability in Hells Canyon

5.5.1. Ecological

Timber harvest, aircraft, and recreation constitute important habitat and disturbance factors for mountain goats. Arnett and Irwin (1989) reported that timber harvest can have serious impacts on critical winter range of goats. Timber harvest creates disturbance, increases snow depth on some important sites, and may eliminate “heavily forested areas on or near precipitous terrain” that may provide critical winter habitat. Chadwick (1974) noted that helicopters were a serious disturbance factor on mountain goats in Montana. Vogel et al. (1996) concluded that increased recreation, timber harvest, and development has increased legal and illegal kill of mountain goats throughout their range, and has likely been a significant factor associated with population declines. Hunting is also discussed above; hunting in Hells Canyon is restricted to 5 permits annually and likely has minimal impact on populations.

5.5.2. Public and Political

Domestic livestock rarely forage in mountain goat habitat; consequently, few publications express concern about competition for range. However, in Idaho competition with domestic sheep and horses has been noted on some meadow habitats used by goats (IDFG 1981:97). Disturbance from recreation, timber harvest, or other development is commonly reported (Chadwick 1974, Smith 1986, Arnett and Irwin 1989, Cote 1996, Vogel et al. 1996). Thus, any of these activities on or near goat habitat may create public and/or political conflict between goat habitat and other resource uses of the region.

5.6. Species Management and Mitigative Options in Hells Canyon

Mountain goat management in Hells Canyon is limited (as of 1997) to periodic population counts and regulation of hunting. Future mitigative options should include protection of forested habitats used by goats (or immediately adjacent to used sites), and prevention of disturbance from recreation and/or aircraft (for specific recommendations to minimize disturbance, see Arnett and Irwing 1989). Foster and Rahs (1983) reported that mountain goats were highly sensitive to disturbance factors in British Columbia. Foster and Rahs (1985) recommended the following mitigative options: 1) range enhancement, 2) enhancement of non-consumptive use, and 3) enhancement of hunter recreation and sustained kill. Impacts from hunting (both animals killed and disturbance) should be monitored closely. Various harvest options are presented and discussed by Bailey (1986). Naylor et al. (1990) concluded that relatively small goat populations (i.e., near Pend Oreille Lake, ID) will likely require "active" management, and they recommend close monitoring of harvest and periodic introductions of new animals to the gene pool.

6. REVIEW OF SPECIES: ROCKY MOUNTAIN BIGHORN SHEEP

(Ovis canadensis)

6.1. General Species Account and Review

6.1.1. Evolution

Bighorn sheep have been residents of North America for over 1.5 million years (Geist 1971, Rutter et al. 1972, Harris and Mundel 1974, Manville 1980). Cowan (1940) concluded that North American sheep evolved from an Asiatic origin and entered the continent via the Bering Sea land bridge in the late Pliocene or early Pleistocene. Fossil records indicated that prehistoric populations extended farther from mountains than current populations, especially along badlands and river formations (Manville 1980). Eight subspecific populations of mountain sheep have been classified (Lawson and Johnson 1982).

6.1.2. Reproductive Ecology

Rutting behavior among males is a well-known aspect of reproduction by bighorn sheep. Females usually mate the first time at 2.5 years; males typically mate the first time at 7-8 years, depending on the age structure of other males (Geist 1971). Several authors have noted that breeding is polygamous (Lawson and Johnson 1982). Blunt et al. (1977) reported that bighorn sheep have a gestation period of 176 days, and average birth weight of lambs was 5.5 kg. Females give birth in steep cliff areas (Geist 1971); usually only single young are born, however, twins have been reported (Eccles and Shackelton 1979). Thompson and Turner (1982) concluded that lambing in northern populations is tied to a brief and predictable spring period of plant growth. Weaning is usually completed in 4-6 months (Giest 1971). Geist and Petocz (1977) speculated that winter separation by males from females and offspring increases survival, and is related to the rams' fitness. Much of the reproductive ecology literature was from desert or Alaskan populations (e.g., Nichols 1978, Chilelli and Krausman 1981, Leslie and Douglas 1979, Douglas 1986).

6.1.3. Habitat Requirements and Food Habits

Mountain sheep habitat has been described as "semiopen, precipitous terrain with rocky slopes, ridges, and cliffs or rugged canyons" (Todd 1972; cited by Lawson and Johnson 1982:1040). Habitat use in Arizona was usually associated with escape terrain and slopes >60%; groups with lambs used lower-elevations but steeper sites (Gionfriddo and Krausman 1986).

Because mountain sheep populations have a wide range of geographic distribution, forage preferences reflected available forage on acceptable topography (Lawson and Johnson 1982). Food habits of bighorn sheep in Colorado were dominated by forbs during summer and graminoids were also used in later seasons (Daily et al. 1984). However, woody plants dominated the diet for other populations in Colorado (Rominger et al. 1988). During winter and spring, Goodson et al. (1991) reported a diet consisting of 85-96% graminoids, 3-8% forbs, and 1-5% browse. Miller and Gaud (1989) recorded that Arizona sheep consumed 121 plant taxa; browse was the dominant food in all seasons, and forbs and grasses varied considerably with season. Grasses and forbs were a dominant food in Idaho (Smith 1951, Morgan 1970). Use of mineral licks by sheep is well known, but the specific nutritional requirement is unclear (Geist 1971, Lawson and Johnson 1982, Holl and Bleich 1987). Shank (1982) concluded that food selection tends to be “population specific.” Thus, sheep food habits are variable among geographic region and among populations within a geographic region.

6.1.4. Other Limiting Factors

6.1.4.1. Accidents.

Accidental mortality for sheep has been reported from drowning, falls, and avalanches (Nichols and Ericson 1969, Mensch 1969, Morgan 1970). Most accidental deaths probably go undetected. Allen (1980:184) noted that the significance of accidental deaths to population dynamic cannot be estimated due to lack of information.

6.1.4.2. Predation.

Predation on bighorn sheep is mostly limited to predation on lambs. Hornocker (1969) observed attempted predation by a bobcat on a bighorn sheep lamb. Hass (1989) estimated the lamb survival was <25%, and that coyotes were the primary predator (most losses were during the first 3 days after birth). For some populations, wolves are a major predator (Geist 1971). Foster and Crisler (1979) documented golden eagle predation on domestic sheep lambs. Lawson and Johnson (1982) noted occasional predation on wild sheep by golden eagles; bears and wolverines will consume sheep as carrion.

6.1.4.3. Parasites.

Parasites have been studied extensively with bighorn sheep, and Lawson and Johnson (1982:1046-1048) provided a good discussion in addition to a tabular review of gastrointestinal nematodes in wild sheep for North America. Although sheep parasites are numerous, lungworms may be the most commonly reported. Blood (1963) documented sheep parasites from a sample of wild sheep in British Columbia, and Festa-Bianchet (1991) documented the prevalence of lungworms (*Protostrongylus* spp.) for an Alberta population. The lifecycle of lungworms and preventive management has been described by Forrester (1991). Stelfox and Mcgillis (1970) estimated the impact of lungworms on weight changes by sheep (1200+ larvae/gm of feces) was associated with a 20% weight loss by ewes. Uhazy et al. (1973) noted that nearly all sheep in western Canada were infected with lungworms, and most animals free of the parasite were lambs. The lungworm-pneumonia complex can be caused by 7 species of nematode.

6.1.4.4. Disease.

Disease has been a major factor in the decline of many wild sheep herds in North America (e.g., Smith 1954, Buechner 1960, Morgan 1970, Trefethen 1975). Lawson and Johnson (1982:1046-1048) present a good review of sheep diseases. Diseases that infect wild sheep include soremouth (ecthyma), bluetongue, encephalitis, lumpy jaw (actinomycosis), lungworm-pneumonia, mange, amyloidosis (metabolic disorder), and white-muscle disease (associated with selenium-deficient soils). The lungworm-pneumonia complex has been considered the most serious of sheep diseases (Buechner 1960, Onderka and Wishart 1984, Risenhoover et al. 1988). Blood (1971) noted that soremouth disease is primarily associated with use of salt blocks and association with domestic sheep; the disease usually "runs a benign course and is followed by spontaneous healing." Disease is a major problem with populations in Idaho and Oregon from contact with domestic sheep (USDA Forest Service 1994c, HCBSRC 1997; also see discussion below).

6.1.4.5. Hunting.

Bighorn sheep were hunted thousands of years ago and were an important resource to Native American people (Grant 1980, Kurten 1980). Hunting is a major form of mortality on bighorn sheep and overharvest has been reported as the cause of major population declines (e.g., Buechner 1960, Hansen 1967, Kurten 1980). Festa-Bianchet (1989) estimated that hunting accounted for 68% of the mortality on males ≥ 5 years old. However, if hunting is properly regulated and populations are monitored annually, hunted populations can be maintained at a relatively high level (Jorgenson 1993). Hunting may also be used as a management tool to maintain populations below levels that increase disease risk (Forrester 1971).

6.2. Historical and Contemporary Species Ecology in Hells Canyon

Just prior to initiation of this project, the Hells Canyon Bighorn Sheep Restoration Committee (HCBSRC) released a literature review and management plan for bighorn sheep (HCBSRC 1997) in conjunction with the "Hells Canyon Initiative" to restore *O. c. canadensis* to the Hells Canyon region. This report is authored by a committee including 10 state and federal biologists with experience and knowledge on bighorn sheep herds in the Hells Canyon region; thus, this report is the definitive reference on sheep for the study area. Frances Cassirer (Idaho Department of Fish and Game) has provided us with a copy of the report, from which we liberally reference and quote information in the following subsections associated with Hells Canyon sheep.

6.2.1. Distribution

Historical populations of bighorn sheep were extinct in the Hells Canyon region by 1945 (Smith 1954, Johnson 1980, Parker 1985, Oregon Department of Fish and Wildlife [hereafter ODFW] 1992). Between 1971 and 1995, 33 sheep transplants to the Hells Canyon and Wallowa Mountains were completed (20 in Oregon, 5 in Idaho, and 8 in Washington). A total of 451 animals were transplanted; 53% were ewes, 22% rams, and 25% lambs (HCBSRC 1997, Errata Table 2). Sheep were transplanted from source populations in Canada, Montana, Wyoming, Idaho, and Colorado (HCBSRC 1997, Errata Table 3).

Distribution of current bighorn sheep populations in the Hells Canyon region has been described in detail by the HCBSRC (1997:2, Table 1, Figure 1) report. Three of the current Hells Canyon herds are in Idaho, 7 are in Oregon, 2 are in Washington, and 2 have interstate home ranges in Oregon and Washington. (**NOTE:** Several of these herds may be outside the boundary of primary concern by Idaho Power Company; please review Figure 1 of the HCBSRC 1997 report.)

6.2.2. Abundance

Hells Canyon has 14 bighorn sheep herds; 10 from reintroductions and 4 from dispersal (from the reintroduced herds). The average herd size is 50 (range = 5-130), and the total Hells Canyon population is 697 (HCBSRC 1997, Table 1). Population estimates are usually determined by counts from ground, helicopter, and fixed-wing aircraft (ODFW no date [7001]). Estimation of sheep abundance in Idaho canyon habitats using sightability models has been reported by Bodie et al. (1995); the model needs further validation and is not recommended for sheep herds that use timbered habitat.

The HCBSRC (1997) estimated average population growth for all 14 of the Hells Canyon sheep herds was 7% ([production + immigration] - mortality). The average lamb:ewe ratio between 1971-1996 has been 41:100; range 14-76:100 (HCBSRC 1997, Table 5). The average ram:ewe ratio was estimated at 52:100 (range = 32-76:100). In the absence of major mortality from disease, the Hells Canyon sheep population may double within 10 years. Additional translocations of sheep would likely increase potential for population expansions beyond current estimates.

6.2.3. Movement Patterns

Seasonal movements by bighorn sheep have been recorded for a number of populations (e.g., Becker 1978, Festa-Bianchet 1986); most recorded movements are among lambing grounds, summer range, and winter range. Movements have also been linked with nutritional requirements and plant phenology (Herbert 1973) and sex and age composition of herds (Leslie and Douglas 1979). Smith (1954) noted the sheep moved 10-20 miles between summer and winter ranges on the Salmon River drainages. Risenhoover et al. (1988) noted that movements among suitable habitats is essential for long-term health of sheep populations.

Trefethen (1975) reported some general information on movements by sheep in the Wallawa Mountains; the Lostine herd was noted to establish distinct winter and summer home ranges. Movements among Hells Canyon sheep herds have been documented, especially during rut (HCBSRC 1997:3); no additional details are provided by the report. We did not locate any literature with quantitative information on movements by Hells Canyon sheep herds. However, the HCBSRC (1997:11) noted that with future reintroductions, “bighorns in the project area will be radio-collared and regularly relocated” and “goals are to quantitatively document post-release movements.”

6.2.4. Habitat Associations

Few studies provided information on sheep habitat use near Hells Canyon. Smith (1954) examined habitat use on the Middle Fork and Main Salmon river drainages of Idaho. Sheep habitats were described as areas with little human disturbance, steep rocky topography, open bunchgrass slopes, and areas with sedges, grasses, rushes, and forbs. Smith (1954) noted that sheep seek cliffs and scattered stands of timber during periods of inclement weather.

Habitat availability for bighorn sheep was estimated for the Hells Canyon region with a Geographic Information System and habitat predictive models (HCBSRC 1997:4). These results indicated that suitable bighorn sheep habitats were steep slopes (31-85°), with high visibility, in proximity to free water (<3.2 km), and with winter range that must be relatively free of snow. Slope was the primary habitat component that limited sheep distribution. The model predicted 541,000 ha (1,337,000 ac) of suitable habitat for the analysis area (HCBSRC 1997, Figure 1). Approximately 68% of all potential habitat was publicly owned, mostly by the USDA Forest Service (HCBSRC 1997, Table 9).

6.2.5. Harvest

Hunting for bighorn sheep in the Hells Canyon region began in 1976; 206 permits have been issued and 184 sheep have been harvested (HCBSRC 1997:26, Table 4). Fourteen permits were issued in 1996. The most heavily hunted herds have been the Imnaha and Lostine herds in Oregon. With the current rate of harvest, populations are predicted to grow approximately 7% annually (HCBSRC 1997:4).

6.3. Cultural Significance in Hells Canyon

6.3.1. Historical

Many historical and archeological reports verify that bighorn sheep occupied the Hells Canyon region (Buechner 1960, Pavesic 1964, Gustafson 1990, Meatte 1990, Reid et al. 1991, Chatters et al. 1995, Hackenberger et al. 1995). Animal remains were estimated to be "at least 5600 years BP" (Pavesic 1964). Butler (1978) noted that hunting of bighorn sheep on the Snake and Salmon river drainages was "of great cultural importance to the aboriginal people." And Grant (1980:8) noted that "the most dramatic evidence of the importance of the bighorn in the lives of the Indian people is represented by the vast number of paintings and petroglyphs of bighorn and the hunting of bighorn" (also noted by Nesbitt 1968). Bighorn sheep were also noted to be an important animal to the Nez Perce Indian society and culture (Spinden 1964, Walker 1971). The finest bows were made from bighorn sheep horns, and horns were an item of trade with other Indian tribes.

6.3.2. Contemporary

Bighorn sheep are among a number of wildlife species that remain culturally important to the Nez Perce people. These species are part of native religious ceremonies and medicine dances, and they are also important for young tribal men that seek an individual spiritual quest, or "Wayekin" (Alan Slickpoo, Sr., Tribal Historian, Nez Perce Cultural Resource Program, Lapwai, Idaho, personal communication). Alan Slickpoo did not distinguish among big game species regarding relative importance to religious ceremonies. Protection of important cultural resources is one objective for management for USDA Forest Service lands within Hells Canyon National Recreation Area (USDA Forest Service 1986b).

6.4. Potential Hydroelectric Impacts to Populations and Habitat in Hells Canyon

As noted below (see section 7.4), riparian habitats are often disturbed by fluctuating water levels associated with hydroelectric operations. No publications were located that suggested riparian habitats were important to bighorn sheep. Current hydroelectric operations and fluctuating river flows should have minimal or no impact on bighorn sheep herds in the Hells Canyon region. However, there is some concern that reservoirs may impede migration and seasonal movements. Sheep have been observed crossing bridges and Hells Canyon Dam, and swimming the river (Frances Cassirer, Idaho Department of Fish and Game, Lewiston, Idaho, personal communication). The overall impact on populations is not known at this time. In some cases, restrictions to movements may help isolate diseased herds. On the other hand, movement restrictions may limit dispersal, which may lead to overpopulation on range with limited forage, which may (in turn) render animals more susceptible to disease.

6.5. Issues Associated With Population Viability in Hells Canyon

6.5.1. Ecological

Two important habitat issues are invasion of exotic weeds and competition from livestock. The yellow star-thistle (*Centaurea solstitialis*) has been rapidly invading grassland/canyon habitats in the Hells Canyon region, and the impact on sheep (and other wildlife) is unknown. When the plant becomes established it dominates ground cover and eliminates most native non-woody vegetation, and it seems biologically reasonable to predict habitat impacts will be negative. Competition for forage between domestic livestock and bighorn sheep has been reported for a number of sheep populations (Smith 1954, Buechner 1960, Stevens 1966, Morgan 1970, Trefethen 1975, Jones 1980, and others), and this issue remains a concern for some Hells Canyon habitats (for description of specific grazing allotments see HCBSRC 1997:6). Use of timber patches within bighorn sheep home ranges has been noted (Smith 1954, MacArthur et al. 1979). Timber harvest on or near forested areas used by Hells Canyon sheep may impact local herds. However, timber harvest generally is viewed as benign or positive (if the altered new habitat produces desired forage) (Frances Cassirer, Idaho Department of Fish and Game, Lewiston, Idaho, personal communication).

The primary ecological concern with livestock in the Hells Canyon region is disease. As noted above, disease has been a major problem with North American wild sheep, and Hells Canyon populations have not been an exception. Seven disease “die-offs” have been documented in the Hells Canyon region; 5 linked to contact with domestic sheep, 1 with a feral goat. Most mortality in these cases has been from lungworm-pneumonia diseases (HCBSRC 1997:3).

6.5.2. Public and Political

As noted for mountain goats, timber harvest, aircraft, and recreation constitute important habitat and disturbance factors for bighorn sheep. The negative impact of human disturbance on wild sheep herds has been well documented (Hicks and Elder 1979, Kurten 1980, Leslie and Douglas 1980, Hansen 1982, Fraley 1986, Etchberger et al. 1989). MacArthur et al. (1982) documented cardiac response by wild sheep to human-disturbance factors. Hikers with dogs caused some of the worst responses, as did cases of people approaching sheep from over a ridge. Aircraft were not a problem if >400 m from the herd; reactions to automobile traffic were minimal. No specific data on human disturbance of sheep in Hells Canyon were located. However, in the absence of specific research, the above information should be assumed applicable to herds in Hells Canyon. Consideration of disturbance should include all seasonal habitat ranges (winter, lambing, summer), watering sites, and migration routes (Becker et al. 1978).

Conflicts associated with use of natural resources will likely dominate biopolitical concerns for many decades to come in this nation and the world. With bighorn sheep in the Hells Canyon region, the primary public and political issue is basically the same as one key ecological issue; livestock. Livestock compete with wild sheep for available forage, and they are a source of disease. Thus, ideal bighorn sheep range would be free of contact with domestic livestock. In recent decades "range wars" associated with conflicts between wildlife managers and environmentalists and ranchers with traditional use of western range lands for livestock have intensified. Similar conflicts may influence population viability of bighorn sheep in Hells Canyon.

A second potential conflict between the public and bighorn sheep is recreational disturbance of sheep herds. One study by Harris et al. (1995) indicated that most hikers in the Sierra Nevada Mountains wanted sheep herds protected and were willing to be regulated to minimize disturbance (e.g., dog control and restricted access to some areas important to sheep). Hicks and Elder (1979) also found that recreational hikers in California seldom overlapped with key sheep habitats and bighorn-human encounters were not adversely affecting bighorn populations. Similar quantitative data on bighorn-human encounters for most Hells Canyon sheep herds are not available. Any restrictions designed to protect sheep from disturbance may result in public or political responses.

6.6. Species Management and Mitigative Options in Hells Canyon

Because bighorn sheep have limited habitat and are vulnerable to overharvest, regulation and monitoring of hunter harvest by state agencies (IDFG 1997a, ODFW no date [7001], and 1997) will always be important management in Hells Canyon. However, Wishart (1978:171) noted that "hunting seasons and closures have done nothing to prevent degradation and reduction of bighorn ranges due to livestock overgrazing and disturbances." Within the Hells Canyon National Recreation Area, the U.S. Forest Service has retired most domestic sheep grazing allotments (or converted them to cattle) to protect sheep. As additional mitigation, other grazing allotments in the Hells Canyon region could be retired (or converted to cattle) via acquisitions or purchase of easements.

During summer months, protection of sites used for obtaining water may be critical for some Hells Canyon herds (Olech 1979), especially those without direct and general access to the Salmon or Snake rivers. Prescribed burning has been recommended to improve and maintain range conditions for bighorn sheep

(Hobbs 1984, Fraley 1986, Wakelyn 1987, Risenhoover 1988, Etchberger et al. 1989). Spowart and Hobbs (1985:944, Table 1) reported comparative forage-class composition for burned and unburned areas in Colorado. Prescribed fire is one habitat management option being considered by the Hells Canyon Initiative (HCBSRC 1997:14). Fertilization and salt blocks have also been recommended to improve range for bighorn sheep (Wishart 1978, Fraley 1986, HCBSRC 1997). However, as noted above, use of salt licks has been linked to some diseases, and salt-block placement for habitat improvement must be conducted with caution (cautionary factors have been noted by the HCBSRC 1997:14). Weed control and restoration of native bunchgrass would also be a beneficial mitigative action for sheep (Frances Cassirer, Idaho Department of Fish and Game, Lewiston, Idaho, personal communication)

Roy and Irby (1994) noted that transplanting sheep into ranges with existing sheep herds may minimize inbreeding depression (also see Risenhoover 1988). In Hells Canyon, reintroductions are planned to “fill unoccupied habitat and augment existing herds” (HCBSRC 1997:8). Reintroductions under the Hells Canyon Initiative will hopefully establish several new herds within 10 years, and reintroductions are planned “as long as suitable vacant habitat or understocked habitat” are available. Potential release sites are listed and evaluated by the HCBSRC report (HCBSRC 1997:36-50, Tables 11-18, Figure 6).

As noted above, disease is a major problem for wild sheep, including the Hells Canyon herds (USDA Forest Service 1994c). Forrester (1971) recommended 4 management actions to lessen sheep disease from contact with livestock: 1) prevent competition with livestock, 2) maintain sheep herds at a density that will not promote disease, 3) prevent feces buildup at key use sites such as salt licks, and 4) control intermediate lungworm hosts at sheep concentration sites via chemical means. Disease treatment, monitoring, and research have been proposed under the Hells Canyon Initiative (HCBSRC 1997:12).

7. REVIEW OF SPECIES: BLACK BEAR

(Ursus americana)

7.1. General Species Account and Review

7.1.1. Evolution

The family Ursidae originated in Europe early in the Miocene and was derived from the Miacidae, a family of small tree-climbing carnivorous mammals (Simpson 1945). The genus *Ursus* arose in the Old World in the early Pliocene, and black bear fossils in North America have been estimated at 2 million years of age (Kurten 1980). Hall (1981) listed 16 subspecies of black bear.

7.1.2. Reproductive Ecology

Beecham and Rohlman (1994) classified black bears as long-lived species, that mature late, with low reproductive rates. The peak in breeding association between male and female black bears occurs in June and July (Knudsen 1961, Jonkel and Cowan 1971, Barber and Lindzey 1986), and usually is limited to several brief periods of only a few hours to a few days. Black bears have delayed implantation and the gestation period is 7-8 months (Wimstat 1963). Altricial cubs are born in winter dens in late January or early February. Most litters are 2 cubs, and reported mean litter size ranges from 1.7-2.6 (Eiler et al. 1989, Beecham and Rohlman 1994). Both the quality of diet and body mass are directly related to reproductive success (Rogers 1976, Beecham and Rohlman 1994, Samson and Huot 1995). Overall cub mortality was reported at 41% by 1 year and 61% by 2.5 years (Elowe and Dodge 1989).

7.1.3. Habitat Requirements and Food Habits

Numerous studies have reported habitat use and selection by black bears (e.g., Erickson et al. 1964, Irwin 1985, Clark et al. 1993). For this report we have restricted most of our habitat review to publications and reports from Idaho (no publications on bear habitat were located for eastern Oregon or Washington).

Idaho black bears are most commonly found in mountainous coniferous forests (Larrison and Johnson 1981, Beecham and Rohlman 1994). Amstrup and Beecham (1976) completed one of the first rigorous studies of black bears in Idaho (adjacent to the Weiser River watershed, east of Council), and subsequent studies were completed on the same area by Unsworth et al.

(1989). Bear habitat use was directly related to food availability (Amstrup and Beecham 1976, Reynolds 1977). During early summer, bears used lower to middle elevations and moved to higher elevations as snow melted and food items became more abundant. Bears frequently were associated with use of grasses and forbs at lower elevations in May and June. During mid-summer, they frequented middle-elevation regions abundant with huckleberries (*Vaccinium globulare*). In August bears moved to higher elevations to feed on wild cherries (*Prunus* spp.) and mountain ash (*Sorbus scopulina*) fruit. Insects are dominant animal food in the black bear diet, and larger animals are consumed rarely (Pelton 1982, Beecham and Rohlman 1994). Unsworth et al. (1989:670, Table 1) conducted seasonal bear studies, and reported habitat use-availability analysis for 14 cover types. These data were obtained from 10 adult radiomarked female black bears, and they concluded that timber, open timber, shrubfields, and riparian areas were all important habitats for bears.

7.1.4. Other Limiting Factors

7.1.4.1. Accidents.

Accidental death is probably rare for black bears, and primarily restricted to vehicle collisions (e.g., Hellgren and Vaughan 1989). Unfortunately, few studies that document road-killed animals are available in the literature (the Case [1978] study from Nebraska excluded the normal range of black bears [Pelton 1982:504, Figure 24.1]).

7.1.4.2. Predation.

Predatory mortality on black bears has been limited in most cases to attacks from other black bears. Jonkel and Cowan (1971) documented predation by large bears on smaller bears, but reported the incidence was low. Predation on denned bears by wolves (*Canus lupus*) and other bears has been documented (Alt and Gruttadauria 1984). Alt and Gruttadauria (1984) reported 1 case of a female black bear and her cub killed in the den by another black bear (assumed to be an adult male). Gill and Beck (1990) noted that most cannibalism is by young bears, and may be a limiting factor on some populations. They concluded that cannibalism may increase with removal of adult males, which opens territories for young males that do not have an established home range.

7.1.4.3. Parasites.

Hamilton (1978) reported 25 genera and 36 species of endoparasite and 8 genera and 12 species of ectoparasites for captive and wild North American black bears. These data have been summarized in tabular form by Pelton (1982:511, Table 24.3). A similar summary of parasites from 148 black bears in Ontario, Canada, is presented by Addison et al. (1978). In their review on parasite of bears, Rogers and Rogers (1976) reported 31 parasites from North American black bears. Worley et al. (1974) documented that *Trichinella spiralis* was moderately prevalent in bears examined in western Montana and Wyoming. Parasites are more prevalent in bear populations from southeastern United States (Pelton 1982). No publications were located that reported parasites being a significant limiting factor to populations of black bears.

7.1.4.4. Disease.

Pelton (1982:511, Table 24.2) lists a number of diseases that have been reported for black bears, but noted that none are considered to be a significant regulatory factor on populations. These fall into 4 categories: 1) neoplastic (tumors), 2) rickettsial (fluke fever), 3) viral (rabies), and 4) bacterial (e.g., caries and periodontal disease). Authors often report disease as a probable mortality factor, but seldom have specific data or reason for concern (e.g., Elowe and Dodge 1989, Gill and Beck 1990). Beecham and Rohlman (1994) reported that the most serious black bear diseases in Idaho were tularemia, brucellosis, and toxoplasmosis.

7.1.4.5. Hunting.

Hunting is a major cause of death in most black bear populations (Barber and Lidzey 1986, Hellgren and Vaughan 1989, Gill and Beck 1990). Black bear hunting in Idaho is an important form of recreation, and bear densities may reach 2 per square mile in high-quality habitats (Beecham 1986). Harvest rates are influenced by vegetative density (visibility), road access, difficulty of terrain, and the number of hunters. Although hunting can cause population fluctuations, declines can be compensated for by more restrictive harvest regulations. Thus, properly managed populations are not endangered by hunting (Beecham and Rohlman 1994). However, Gill and Beck (1990) noted that overharvest is difficult to detect, which encumbers harvest management. Fraser et al. (1982) and Hellgren and Vaughan (1989) documented higher hunting mortality among males, which may be due to 1) greater movement patterns, 2) hunter selection, and 3) later denning.

7.2. Historical and Contemporary Species Ecology in Hells Canyon

7.2.1. Distribution

Black bear are year-long residents of Hells Canyon (Wilson 1975, IDFG 1993). Although black bears have a specific home range (Hamilton 1978), they are relatively nomadic and often move large distances (Rogers 1977). Black bears may be observed in most habitats within Hells Canyon, especially regions with cover provided by timber (John Beecham, IDFG, Boise, Idaho, personal communication).

7.2.2. Abundance

Idaho may support 20,000 to 25,000 black bears within an estimated 30,000 square miles of bear habitat (Beecham and Rohlman 1994). Oregon populations were estimated at 25,000 bears throughout their historical range in the state (ODFW 1993b). Specific density data are not available for the Hells Canyon study area, however, Beecham (1983) reported 1 bear/1.3 km^2 for the study area southeast of Council, Idaho, and these data are probably comparable to timbered portions of Hells Canyon with quality bear habitat (John Beecham, IDFG, Boise, Idaho, personal communication). Beecham (1983) noted that annual variation in reproductive success is the main factor influencing short-term population fluctuations; climate affects availability of nutritious food, and is likely the primary extrinsic factor controlling long-term population levels.

7.2.3. Movement Patterns

Black bears have relatively large home ranges, and movement patterns vary in relationship to animal sex and age, season, bear density, and habitat quality (Pelton 1982). Hygnstrom (1994) reported that adult females have home ranges from 6 to 19 square miles, and that adult male home ranges are often several times larger. For black bears in North Carolina, Hamilton (1978) reported an average home range of 9,107 ha for males, and 777 ha for females. For Idaho, Amstrup and Beecham (1976:345) estimated average home range for adult males at 112 km^2 and 49 km^2 for females. Mean daily movements (linear distance) were 3.0 and 2.1 km for males and females, respectively.

7.2.4. Habitat Associations

General habitat requirements for black bear are reviewed above, including data from the Council, Idaho region. No specific data were located regarding quantification of habitat use in Hells Canyon. However, habitat use in portions of Hells Canyon with forest cover should be similar to that reported for the Council area (John Beecham, IDFG, Boise, Idaho, personal communication).

7.2.5. Harvest

Because no bear studies are being conducted at this time in Hells Canyon, the best *index* of population status is annual harvest estimates. For Oregon (units 58, 59, 62, 64, and 65, which are adjacent to and/or include Hells Canyon) recent harvest totals have been 40, 60, and 100, for 1993, 1994, and 1995, respectively (ODFW 1994, 1995, 1996a). Idaho harvest data are more difficult to decipher, due to the geographic nature of game units and data analysis units (DAU), which do not correspond well with the Hells Canyon region. Four Idaho game-management units (13,18, 22, and 31) are adjacent to Hells Canyon. However, harvest statistics are presented by DAUs, which combine with other game units not adjacent to Hells Canyon (IDFG 1993, 1995a). Thus, Hells Canyon data are included with annual harvest estimates, but it is not possible to assign specific harvest numbers exclusively to that region (John Beecham, IDFG, Boise, Idaho, personal communication). The 3-year average harvest (1992-4) for Idaho DAUs that included Hells Canyon has been: DAU 1E = 36, DAU 1F = 75, and DAU 1H = 37.

7.3. Cultural Significance in Hells Canyon

7.3.1. Historical

Black bear are among faunal remains identified at a number of archeological sites in Hells Canyon (Spinden 1964, Pavesic 1971, Randolf and Dahlstrom 1977, Meatte 1990, Reid et al. 1991, Hackenberger et al. 1995). Spinden (1964) reported that bear claws were worn around the neck by Nez Perce Indians as a “good luck” ornament, and such items served an important role in Nez Perce society and culture.

7.3.2. Contemporary

Black bears are among a number of wildlife species that remain culturally important to the Nez Perce people. These species are part of native religious ceremonies and medicine dances, and they are also important for young tribal men that seek an individual spiritual quest, or "Wayekin" (Alan Slickpoo, Sr., Tribal Historian, Nez Perce Cultural Resource Program, Lapwai, Idaho, personal communication). Alan Slickpoo did not distinguish among big game species regarding relative importance to religious ceremonies. Protection of important cultural resources is one objective for management for U.S. Forest Service lands within Hells Canyon National Recreation Area (USDA Forest Service 1986b).

7.4. Potential Hydroelectric Impacts to Populations and Habitat in Hells Canyon

The primary impact on habitat from hydroelectric operations that may affect black bear populations in Hells Canyon is degradation to riparian habitats (Warnick and Clapp 1978). Quality bear habitats are limited in the Hells Canyon region, and important habitats include timber (for bedding) and riparian (for feeding and travel corridors) (Unsworth et al. 1989:670, Table 1). Riparian habitats are impacted primarily by fluctuating water levels, wind erosion, and erosion from boat wakes; each of these factors may cause habitat loss and/or inhibit reestablishment of riparian vegetation (McKern 1976, U.S. Dept. of Energy 1984b:VIII-46). McKern (1976:48) also noted that entrapment of sediments by Oxbow and Hells Canyon dams prevent "recruitment of materials to form new sand bars and silt deposits which are the basis of riparian growth."

7.5. Issues Associated With Population Viability in Hells Canyon

7.5.1. Ecological

As noted above, both timber and riparian habitats are important habitats for bears (Unsworth et al. 1989:670, Table 1). Timber harvest is of concern due to 1) direct loss of habitat, 2) disturbance from timber harvest operations, and 3) increased access from logging roads (which has a direct impact on legal and illegal harvest, and general disturbance). Recreation (e.g., rafting, jet boating, camping, hiking, and hunting) is a potential disturbance factor to both timber and riparian zones; however, the majority of Hells Canyon recreational disturbance will likely occur in riparian zones.

7.5.2. Public and Political

The most important issue of a public or political nature regarding black bears is related to hunting methods. A relatively well-organized contingent of Idaho citizens recently attempted to force elimination of spring bear hunting (when sows have cubs), hunting bears with dogs, and/or hunting bears over bait. Although bear hunting regulations have not changed, these forms of bear hunting (especially over bait) are particularly unpalatable for many citizens, and the issue will likely remain controversial. A similar controversy has recently occurred in Oregon, especially with regard to use of dogs for bear hunting. Although a proposed elimination of bear hunting with dogs was defeated by public vote, the issue remains contentious (Mark Henjum, ODFW, LaGrande, Oregon, personal communication).

In some areas, especially parks, black bears become a public nuisance at camp grounds (Ayers et al. 1986), where they destroy camping equipment in their search for food. Occasionally black bears attack and injure campers and hikers. We did not locate any literature noting bear problems at campsites within the Hells Canyon National Recreation Area; i.e., beach campsites along the Salmon and Snake rivers are relatively free of garbage. At this time, bear visitation to campsites is not a problem on the Salmon River, however, there have been minor increases in bear visits to campsites along the Snake River in recent years (LuVerne Grussing, Bureau of Land Management, Cottonwood, Idaho, personal communication).

7.6. Species Management and Mitigative Options in Hells Canyon

The IDFG monitors bear populations in the Hell Canyon region for indicators of overharvest or population declines (IDFG 1993). More-restrictive harvest regulations were enacted in 1986; further seasonal restrictions were incorporated into the 1992-2000 Black Bear Management Plan. Black bear may be harvested in game-management units adjacent to Hells Canyon in both Spring and Fall hunting seasons on the Idaho side of the canyon (IDFG 1997b). On the Oregon side, black bears are hunted only during the fall season (ODFW 1997).

Mitigative options in Hells Canyon for black bears include restriction of recreational disturbance at important habitat sites, protection from disturbance or loss of habitat from timber harvest, and reduction of impacts on riparian vegetation. McKern (1976:52) made a number of recommendations for mitigative enhancement of riparian areas; however, most of these apply to reservoirs (vs. the free-flowing river between Hells Canyon Dam and the Salmon River confluence). The Confederated Salish and Kootenai Tribes et al. (1989:61) also noted riparian-habitat damage below Kerr Dam in Montana. The primary mitigative action for these habitat losses was off-site habitat enhancement. Idaho Power Company will initiate in 1998 a 3-year study to determine 1) the impacts of water level on riparian habitat, 2) the effects of flow changes below dams, 3) the effects of operations on the quantity and quality of riparian habitat, 4) the terrestrial species habitat impacts, and 5) potential mitigation options (Idaho Power Company 1997:VIII, 296-297, 314).

8. REVIEW OF SPECIES: MOUNTAIN LION

(*Felis concolor*)

8.1. General Species Account and Review

8.1.1. Evolution

The mountain lion is a member of the Felidae family. Fossil records indicated that mountain lions have existed in its present form since the Pleistocene (Dixon 1982). Thirteen subspecies have been identified for North American populations north of Mexico.

8.1.2. Reproductive Ecology

The mountain lion is essentially a solitary animal (Seidensticker et al. 1973); males and females maintain a brief association only during the female's estrus cycle (23 days). Mountain lions first reproduce at 2.5 years of age. Following a gestation period of 82-98 days, births may occur during any month (Dixon 1982:714, Figure 38.4). The peak period for birth is June-September. Robinette et al. (1961) reported an average prenatal litter size of 3.4 kittens (n = 66), and an average postnatal litter size of 2.9 (n = 258). Den sites have been described as "a shallow nook on the face of a cliff or rock outcrop" (Dixon 1982:714).

8.1.3. Habitat Requirements and Food Habits

Lions use numerous habitats within large home-range areas. Most populations today are restricted to mountainous, semi-arid environments (Whitaker 1996). Seidensticker et al. (1973:715) noted that lion movements often seem "random"; they reported Idaho habitats to include dense Douglas-fir timber, open ponderosa pine, sagebrush-grass openings, and talus slopes. Although a wide range of habitat use was documented, cover was a key component (over 95 percent of lion locations were in timber or rocky, broken areas). Logan and Irwin (1985) described lion habitat in Wyoming as rugged topography with slopes >50%; preferred habitats were mixed conifer and curleaf mountainmahogany (*Cercocarpus ledifolius*), and riparian zones. For northeastern Oregon, lion habitat was described as being closely associated with deer and elk habitat, primarily open mixed conifers (including pine-bunchgrass) and canyon country (ODFW 1993b).

The most common food prey of the mountain lion is deer (Hall and Kelson 1959, Dixon 1982, Whitaker 1996), however, some studies have also documented significant predation on elk (Hornocker 1970). Ackerman et al. (1984) reported that mule deer represented 81% of the biomass consumed in Utah (data from 239 mountain lion scats). Leopold and Krausman (1986) found that seasonally, deer represented 73-85% of mountain lion prey items in Texas; the second most important prey (20-25 %) was collared peccary (*Tayassu tajacu*) during spring and summer (all data from 433 lion scats collected over a 5-year period). Hornocker (1970) reported that 50% of deer and elk killed by mountain lions were in poor condition. However, O'Gara and Harris (1988) found that lions killed prime-aged deer and only 7% were in poor condition. Mountain lions also prey on bighorn sheep, but reports are limited (Hornocker 1970, Krausman et al. 1989). Other lion prey species include porcupine (*Erethizon dorsatum*), lagomorphs, rodents, and vegetation (for tabular reviews with seasonal and geographic comparisons see Spalding and Lesowski 1971:379, Table 2; Dixon 1982:717, Table 38.3; and Leopold and Krausman 1986:293, Table 3). Beier (1995) estimated that mountain lions killed and consumed an average of 48 large mammals and 58 small mammals each year.

Predation by lions on domestic cattle and sheep has been reported in many studies (e.g., Robinette et al. 1959, Spalding and Lesowski 1971, Shaw 1977, and Dixon 1982). Knight (1994) estimated that mountain lions account for 20% of the annual total predation on domestic livestock in western states. However, some studies have also failed to detect predation on domestic animals (e.g., Toweill 1977, Leopold and Krausman 1986). Surplus killing has also been reported for both domestic and wild animals, however, this behavior is considered to be relatively rare (Mills 1922, Dixon 1967, Shaw 1977).

8.1.4. Other Limiting Factors

8.1.4.1. Accidents.

Most accidental deaths are likely from mountain lion collisions with automobiles while crossing major highways (Currier 1976, Dixon 1982). Macgregor (1976) reported cougars drowning in drainage canals in California (which are used as daytime refuge by lions that frequent urban areas to hunt domestic cats and dogs). Gashwiler and Robinette (1957) reported that accidental deaths are often the result of their hunting method, i.e., "rapid charging and springing" on prey, which resulted in accidental collision with hard objects. One such case was documented where a piece of wood penetrated the brain cavity of a lion.

8.1.4.2. Predation.

Only man is a significant predator on mountain lions (see Hunting subsection below). Predators such as wolves, coyotes, and bears (especially grizzly bears), may occasionally kill young, old, or sick lions. However, we did not locate any literature reporting documentation of non-human predation on mountain lions.

8.1.4.3. Parasites.

Known ectoparasites of mountain lions include fleas, ticks, mites, and lice; endoparasites include nematodes, tapeworms, and flukes (for tabular review of species and sources of data see Dixon 1982:721, Tables 38.6 and 38.7). Worley (1974) documented that *Trichinella spiralis* was highly prevalent in mountain lions examined from wilderness areas of Montana and Idaho, and concluded that lions were a primary host for this nematode. No studies were located that considered parasites to be an important limiting factor on lion populations.

8.1.4.4. Disease.

Little information is available on disease in mountain lions, and disease is not considered a limiting factor (Dixon 1982). Russell (1978) reported that feline distemper may be a source of mortality for mountain lions.

8.1.4.5. Hunting.

Hunting by humans has been a major source of mortality on most mountain lion populations (Currier 1976, Dixon 1982). Ashman (1975) estimated that 1 Nevada population was reduced to 50% below normal carrying capacity from hunting. However, other populations have been reported to sustain regulated hunting without serious reductions to populations (Currier et al. 1977). Ross and Jalkotzy (1992) estimated that hunting (legal and illegal) accounted for 3-14% of annual mortality for a lion population in Alberta, Canada, and that populations could quickly rebound from these losses. Lindzey et al. (1992) concluded that mountain lion mortality from hunting was not compensatory with other forms of mortality. Dixon (1982) noted that 12 western states practiced sustained-yield harvesting of mountain lions, i.e., harvesting at a rate that balances with the annual rate of productivity.

However, sustained-yield harvest will vary among populations dependent upon dispersal rates and movement patterns (Seidensticker et al. 1973).

8.2. Historical and Contemporary Species Ecology in Hells Canyon

8.2.1. Distribution

Aside from human disturbance, the lack of necessary stalking cover may limit the distribution of mountain lions (Currier 1976). No data (or studies) were located that provided information on the distribution of mountain lions in Hells Canyon. However, based on many studies that associated the location of lions with deer and elk herds, distributional information on these prey species may provide an indication of use areas by lions (for distribution of Hells Canyon deer and elk, see Phase II report, dated 30 November 1997, submitted to Idaho Power Company). Lions will most likely use habitats with both deer and/or elk, and rugged topography that enhances hunting (stalking) opportunities.

8.2.2. Abundance

Considering the large non-overlapping home ranges of male mountain lions (Seidensticker et al. 1973, see below), population densities will be limited by the number of minimum-sized territories available within suitable habitat. Currier (1983) noted that although numerous estimates of lion abundance have been attempted, accurate estimation is difficult. Ross and Jalkotzy (1992:420, Table 2) estimated mountain lion density in Alberta to vary between 2.7 and 4.7 lions/100 km^2. Currier (1976) estimated lion abundance on a Colorado study area to be 1 lion/30-60 km^2, and densities were reported to vary directly with prey density and stalking cover. In Utah, Lindzey et al. (1994) estimated lion density to be 0.37/100 km^2, and Logan et al. (1986) estimated density at 1 lion/22-29 km^2 in Wyoming. Seidensticker et al. (1973:59) concluded that a "land tenure system maintains the density of breeding adults below a level set by food supply in terms of absolute numbers of mule deer and elk."

No literature or reports were located that estimated current populations of mountain lions in Hells Canyon. Harvest statistics (see below) may provide a crude index to population trends for lions. However, few wildlife-ecology studies have demonstrated a direct relationship between density and populations indices, especially for large mammals (Rotella and Ratti 1986).

8.2.3. Movement Patterns

Annual home range size for male mountain lions ranged from 194 to 575 km^2; home range for females is smaller and ranged between 104 and 203 km^2 (see Dixon 1982:715, Table 38.2, summary data from 4 studies in 3 states). Ashman (1975) documented “drastic” changes in home range due to hunting disturbance. Movement patterns by mountain lions have been studied extensively in the Big Creek drainage of north-central Idaho (Seidensticker et al. 1973:7, Figure 1). Resident male lion home ranges were distinct and overlapped little with other males. However, female home ranges often overlapped with other females and males. Use of areas within home ranges was influenced heavily by deer and elk herds, and topography that provided greater opportunities for prey capture (Seidensticker et al. 1973:58). Average daily movements were 2-5 km, and varied by season and sex (Seidensticker et al. 1973:26, Tables 12 and 13). Beier et al. (1995) monitored daily and seasonal movements of lions in California with radio telemetry. Hunting lions waited an average of 0.7 hours to ambush prey and then moved 1.4 km to a new location (this pattern was repeated 6 times per night when prey was not captured). No data were located on movement patterns of mountain lions in Hells Canyon.

8.2.4. Habitat Associations

General habitat use by mountain lions in Idaho, Oregon, and elsewhere was described in this report above. No detailed studies of lions in Hells Canyon have been conducted, thus, no specific habitat data from the Hells Canyon region are available.

8.2.5. Harvest

Hunting of mountain lions in the Hells Canyon region includes harvest in both Idaho and Oregon (IDFG 1997b, ODFW 1996a). Oregon does not report lion harvest for Hells Canyon units; for eastern Oregon lion harvest averaged 87 for the past 3 years, and 73 for the past 10 years. On the Idaho side, lion harvest associated with Hells Canyon included game-management units 13, 18, 22, 31, and 32. Average annual harvest for those units in the past 3 years (and 10 years) has been: 13=7 (6.8); 18=8.7 (6.2); 22=8.0 (3.5); 31=3.3 (2.8); and 32=0.7 (0.9).

8.3. Cultural Significance in Hells Canyon

8.3.1. Historical

Many anthropological records of mountain lions from the Hells Canyon region have been reported (Randolf and Dahlstrom 1977 [data from Bernard Creek rockshelter], Draper and Reid 1986, and Meatte 1990). Most of these records were from sites used by prehistoric people nearly 7000 years ago, and indicated the cultural importance of mountain lions to native peoples of the Hells Canyon region (Meatte 1990).

8.3.2. Contemporary

Mountain lions are among a number of wildlife species that remain culturally important to the Nez Perce people. These species are part of native religious ceremonies and medicine dances, and they are also important for young tribal men that seek an individual spiritual quest, or “Wayekin” (Alan Slickpoo, Sr., Tribal Historian, Nez Perce Cultural Resource Program, Lapwai, Idaho, personal communication). Alan Slickpoo did not distinguish among big game species regarding relative importance to religious ceremonies. Protection of important cultural resources is one objective for management for U.S. Forest Service lands within Hells Canyon National Recreation Area (USDA Forest Service 1986b).

8.4. Potential Hydroelectric Impacts to Populations and Habitat in Hells Canyon

Impacts to mountain lion populations in Hells Canyon are likely to be from both indirect and direct sources: Indirect sources include 1) disturbance (e.g., recreation, timber harvest, grazing, hunting), and 2) harvest of lions from legal and illegal killing. More direct impacts include 1) changes in abundance or distribution of deer and elk herds, and 2) degradation or loss of riparian habitats. Riparian habitats are used by lions (Logan and Irwin 1985), and these habitats are important to lion prey such as deer (Carson and Peek 1987, Loft et al. 1991). Thus, hydroelectric operations in Hells Canyon that negatively affect riparian vegetation may impact mountain lion populations.

As with other species reviewed in this report, we note that reservoirs may have created barriers for seasonal movements and dispersal (see section 9.5.1). Additional barriers may be created during fall and winter months when river flows are artificially higher than the long-term average. The impacts of such barriers, if they exist, are unknown.

8.5. Issues Associated With Population Viability in Hells Canyon

Because data are lacking on mountain lion biology in Hells Canyon, the following comments on population viability are speculation by the authors, based on lion information from other regions.

8.5.1. Ecological

We speculate that the most important ecological issues in Hells Canyon associated with population viability of mountain lions will be disturbance. As noted above, lions have large home ranges, relatively low populations densities, and have evolved in (and have been largely restricted to) wilderness or semi-wilderness environments. Both outdoor recreation and human populations are increasing in Idaho and Oregon, and these factors, which are directly related to disturbance, will likely have some impact on Hells Canyon mountain lion populations.

Assuming that legal and illegal mountain lion harvest is regulated within historical limits, the other primary ecological concern would be the general health of Hells Canyon deer and elk herds. Mountain lion population viability, like many large predators, is directly tied to prey availability.

8.5.2. Public and Political

The most important public and political issues related to mountain lion populations in Hells Canyon are lion predation on livestock (and occasionally on domestic pets) and lion attacks on humans. As noted above, predation on livestock has varied among studied populations from very significant to nonexistent. Because many areas within and adjacent to Hells Canyon are used for livestock grazing, predation on cattle and sheep will likely remain a public and political concern.

During recent decades we have experienced dramatic increases in unprovoked attacks by mountain lions on humans (Beier 1991), and news reports over the past 5 years in western states suggest the problem may be worsening. We are not aware of any scientific explanation for this trend, however, it seems reasonable to speculate the attacks on humans has increased due to: 1) lions becoming habituated to humans from increased recreational activity and development in their home ranges, and 2) given a behavior habituation response, some lions stressed by inadequate food supplies may be more inclined to consider humans as potential prey. Regardless of the reason or explanation, if attacks on humans continues to increase, public and political pressure to reduce lion populations will increase, and will likely prevail.

8.6. Species Management and Mitigative Options in Hells Canyon

Oregon Department of Fish and Wildlife (1992b) provided an outline of general mountain lion management over the past 150 years, including periods of bounty hunting, government hunter programs, elimination of problem animals, sport hunting, discontinuation of sport hunting, and the introduction of controlled-permit hunting. The primary current management tool for mountain lion populations in most states is to monitor and regulate hunting and attempt sustained-yield harvest (e.g., Cope 1977, Dixon 1982, IDFG 1995b). Lindzey et al. (1992) conducted a rigorous experiment on harvest management of mountain lions in Utah. They concluded that population response to harvest is complex and dependent on the age and sex composition of both resident and transient animals, and that management without current and accurate data on population dynamics will likely be ineffective.

One basic problem with mountain lion management is the conflicting opinions and concerns about what constitutes proper management, i.e., 1) some segments of society want lion populations protected completely (e.g., Sitton and Weaver 1977, Kellert 1979); 2) others prefer to have populations controlled to protect livestock, reduce losses to big game herds, and/or reduce the risk of attacks on humans; 3) and a third segment want lion populations to remain high and open for sport hunting with hounds. With controversial species of this nature, land managers and wildlife agencies have a difficult task with management.

Assuming a management objective of maintaining mountain lion populations at or near carrying capacity, the primary mitigative options would be: 1) protection of forested areas from timber harvest; 2) protection of lion habitat from disturbance related to timber harvest, grazing, development, and recreation; and 3) maintenance of deer and elk populations at or near carrying capacity. Both legal and illegal harvest of lions are important factors, and optimal mitigation and management can only be accomplished with an ongoing program of population monitoring (see Lindzey et al. 1992).

9. REVIEW OF SPECIES: ROCKY MOUNTAIN MULE DEER (*Odocoileus hemionus*)

9.1. General Species Account and Review

9.1.1. Evolution

Mule deer are classified in 1 of 17 genera in the family Cervidae throughout the world. Mule deer evolved as a species during the Miocene in the Old World (Mackie et al. 1982). However, North American populations have evolved significant physiological and behavioral differences from Old World ancestors (Geist 1981). Fossil records are generally poor and the evolution of similar species and subspecies is open to speculation (Wallmo 1981). Cowan (1956) recognized 11 subspecies, but more recent taxonomic reports list only 7 (Wallmo 1981). Mule deer are closely related to white-tailed deer (*O. virginianus*), and interbreeding has been documented.

9.1.2. Reproductive Ecology

Mule deer reach reproductive maturity at 1.5 years, and fawn pregnancies are rare (Mackie et al. 1982). Like most North American Cervids, breeding occurs in fall and early winter. The mating system is polygamous, and males wander extensively seeking females in estrus. Competition among dominant males for females is often intense, and the rutting period is physiologically stressful for mature bucks (Geist 1981). Geist (1981) provided a detailed behavioral description of rutting males.

Robinette et al. (1973) conducted a 10-year study on captive mule deer in Colorado, and documented a mean gestation period of 201 days for 172 animals. Robinette et al. (1955) reported litter size for 492 females as 37% with 1 fetus, 60% with twins, and 1% with triplets. Mackie et al. (1981) noted that 25-30% of fawns suffer mortality by fall, 50% die by winter, and 75% may die by the first spring. Richens (1967) reported 80-85 fawns per 100 females during December and January (two years of data) in Utah, and estimated net productivity at 31%.

Reproductive performance is strongly influenced by dietary nutrition and the condition of the female during pregnancy (Hungerford 1970, Robinette et al. 1973, Mackie et al. 1982). Fawn weight is the biggest predictor of overwinter survival (White et al. 1987). One Colorado study has demonstrated that winter fawn mortality was density dependent and compensatory (Bartmann et al. 1992).

9.1.3. Habitat Requirements and Food Habits

Numerous studies have been conducted on habitat and food habits of mule deer in the United States. Because populations include large geographic areas with diverse environments, these topics are best treated by geographic regions of 1) desert and chaparral, 2) rocky mountain and intermountain, 3) coniferous forest, and 4) plains (Wallmo 1981). Most of the studies cited below are for regions 2 and 3, which correspond to Hells Canyon habitats. A general definition of mule deer habitat is “semiarid, open forest, brush, and shrublands associated with steep, broken, or otherwise rough terrain” (Mackie et al. 1982). Although some studies make specific reference to habitat use or food habits separately, it is often assumed that habitat use reflects foods consumed.

In northeastern Oregon, Bodurtha et al. (1989) described preferred mule deer habitat as near-climax communities with high-vegetative diversity. During winter and spring, deer preferred south and west-facing slopes with bluebunch wheatgrass (*Agropyron spicatum*)-cheatgrass brome (*Bromus tectorum*) plant communities. During summer and fall, deer used north and east-facing slopes with bluebunch wheatgrass-Sandberg bluegrass (*Poa secunda*) plant communities. For a detailed seasonal presentation of plant community use by mule deer in Oregon, see Bodurtha et al. (1989:317, Table 1).

For northcentral Washington, Carson and Peek (1987) found that mule deer preferred conifer and riparian habitats during both winter and summer. Basin big sagebrush (*Artemisia tridentata*) and antelope bitterbrush (*Purshia tridentata*) were preferred plant communities during winter. For detailed season habitat use of both cover types and land forms see Carson and Peek (1987:49, Tables 1 and 2). Mule deer use of seral stage for habitat types in this region was examined by Griffith and Peek (1989).

Keay and Peek (1980) documented winter habitat use by mule deer in eastcentral Idaho, and the relationship to habitats subjected to fire. Mule deer selected sites with relatively little cover, and preferred burned Douglas-fir (*Pseudotsuga menziesii*)/ninebark (*Physocarpus malvaceus*) and ponderosa pine (*Pinus ponderosa*)/bluebunch wheatgrass habitat types. Akenson (1992) noted that mule deer in central Idaho used the same habitats occupied by elk and bighorn sheep, especially spring grasslands. Thomas and Irby (1991) studied winter habitat used in southeastern Idaho. They documented mule deer use of winter wheat and perennial grass/forb mixtures when fields were adjacent to broken terrain and native habitats. Numerous other mule deer habitat studies have been published, and most reflect some differences in habitat selection relative to the geographic region of the study population (e.g., Martinka 1968, Anthony and Smith 1977, Collins and Urness 1983, Ordway and Krausman 1986, Kraft 1989, Wood 1989, Armleder et al. 1994).

Among studies from different populations, foods consumed by mule deer (like habitats used) are extremely varied. Urness (1981), Wallmo and Regelin (1981), and Crouch (1981) provided comparative tabular data on food habits reported for many mule deer populations throughout the United States and Canada. Wallmo and Regelin (1981:391, Table 60) listed the most commonly reported forage species for Rocky Mountain mule deer; this list included 17 browse species, 6 grass and sedge species, and 17 forb species (data from over 69 food-habits studies). The most frequently reported species for each category, respectively, was snowberry (*Symphoricarpos* spp., 69 studies), bluegrass (*Poa* spp., 31 studies), and buckwheat (*Eriogonum* spp., 63 studies). Peek and Krausman (1996:184) also presented a thorough, yet concise review of mule deer forage choice.

"Mule deer are herbivores, possessing a four-chambered ruminating stomach in which vegetation is reduced to usable form by microbial fermentation" (Mackie et al. 1982:865). Lovaas (1958:279, Table 3) analyzed 25 rumen samples from mule deer in Montana and reported results by season. During summer, deer used mostly forbs, and raceme pussytoes (*Antennaria racemosa*) was the most heavily used species. During Fall, both forbs and browse were used commonly (53% vs. 44%, respectively), and Oregon grape (*Mahonia repens*) and aster (*Aster* spp.) were most frequently consumed. Browse constituted the bulk of winter diet (78%), and common juniper (*Juniperus communis*) represented 57% of the browse species consumed. During spring, deer continued to use juniper heavily (30% of volume), but grasses increased dramatically in the diet to 38% (up from 1.3% during winter).

Bartman et al. (1982) studied captive mule deer in both pens and free-ranging pastures in Colorado to document food habits. Over 80% of the diet was shrubs and trees, with forbs and graminoids representing most other food items. The most abundantly consumed forages included antelope bitterbrush, Utah serviceberry (*Amelanchier utahensis*), true mountainmahogany (*Cercocarpus montanus*), and bluegrasses (*Poa* spp.) (Bartman et al. 1982:809, Table 3).

No specific food habits studies were located for mule deer populations in or adjacent to Hells Canyon.

9.1.4. Other Limiting Factors

9.1.4.1. Accidents.

Accidental mule deer mortality has been reported by a number of authors (Caswell 1953, Williams 1964, Richens 1967, Case 1978, Reed 1981:524), and the most common is from automobile collisions. Over 150,000 deer are killed on U.S. highways annually, and for some states automobile deaths represent over 50% of the annual population harvest (Reed 1981). In the west, annual mortality from automobiles ranges from 20,000 in California to 1,600 in Montana. Management techniques to prevent deer/automobile accidents include barrier fencing, roadway warning signs, reflectors to deter deer, highway under- or overpasses, and high-pitched whistle devices placed on automobiles to alert deer near highways.

Many cases of deer mortality from entanglement in fences have been reported, but are not well documented in professional literature. No literature on accidental deaths by mule deer was located for the Hells Canyon region, however, we suspect that deer occasionally drown in the Snake and Salmon rivers while attempting to cross (especially during escape from predators and humans). In addition, drowning from falling through ice on Brownlee Reservoir is suspected, but not documented.

9.1.4.2. Predation.

A detailed treatment of predation on mule deer is presented by Connolly (1981), and much of the text for this subsection was extracted from that book chapter. The most commonly studied predators on Rocky Mountain mule deer are coyotes and mountain lion; other predators include wolves, bears, bobcats, golden eagles, and feral dogs. All of these predators are present in the Hells Canyon region, except wolves.

Early studies on coyote predation were conducted by Murie (1940), Horn (1941), and Leopold et al. (1951). These studies documented that coyotes consumed deer primarily during mid- to late winter, and fawns during spring. Murie concluded that most winter kills reflected the condition of the range and the animal, and that coyotes were simply “the agent rather than the actual cause of deer mortality." Predation on fawns by coyotes likely have a more direct impact on populations, but these studies failed to convincingly show that predator reductions increased fawn survival. Subsequent to these studies, Robinette et al. (1977) also concluded that fawn survival was closely related to habitat quality, and that declining fawn survival could not be reversed by predator control. However, Brown (1961), McMichael (1970) and Austin et al. (1977) noted small to moderate increases in fawn survival and/or deer densities in areas with coyote control. Some studies have noted fairly dramatic impacts on deer populations from coyote predation, but few have demonstrated that coyote populations can be controlled at a level that consistently reduces overall deer mortality, or that the expenses (monetary, political, and social) of control programs are justified. Hamlin et al. (1984) noted that fawn mortality from coyotes was lower when microtene rodent populations were high.

Mountain lion predation on mule deer has been documented by Richens (1967), Hornocker (1970), Nellis (1977), Robinette et al. (1977), Shaw (1977), and others. Both Hornocker and Nellis conducted their studies in Idaho. Richens (1967) estimated that 54% of 89 mule deer killed in Utah were killed by predators, and over half of the predation was from mountain lions. Hornocker (1970) reported that 70% of lion scats contain mule deer or elk. Shaw (1977) documented 62 lion kills, and 60% of these were mule deer (he also reported that 62% of lion scats contained mule deer). Nellis (1977) estimated that hunter harvest was approximately equal to the number of deer killed by lions. Thus, deer populations are extremely important to population viability of mountain lions.

9.1.4.3. Parasites.

Some mule deer populations are heavily infected with parasites, and animal body condition influences parasitic impact. However, the overall influence of parasites on deer populations is not fully understood. Mule deer populations from relatively dry environments suffer fewer parasitic (and disease) problems (Mackie et al. 1982). Mule deer parasites include *Elaeoporosis* (intraarterial nematodes), *Setaria* (abdominal worms), gastrointestinal nematodes, lungworms, foot and leg worms, eye worms, tapeworms, Trematodes (liver flukes), *Sarocycystis* (muscle parasites), *Toxoplasmosis*, Diptera (horseflies), Myiasis (botflies), louse flies, lice, mites, ticks, fleas, and *Anaplasmosis* (rickettsial parasite) (Hibler 1981). A thorough review of the life cycle and biology of various mule deer parasites was presented by Hibler (1981:138).

9.1.4.4. Disease.

The impact of disease on mule deer is a complex issue, and often population responses are in combination with environmental stresses, nutrition, competition, and predation (Hibler 1981). Viral diseases that infect mule deer include bluetongue, epizootic hemorrhagic disease, foot-and-mouth disease, malignant catarrhal fever, and bovine virus diarrhea/mucosal disease complex. Bacterial diseases include pasteurellosis, brucellosis, necrobacillosis, actinomycosis, blackleg and malignant edema, caseous lymphadenitis, and anthrax. As with parasites, the overall impact of disease on most deer populations is poorly understood. Like other wild animals, deer suffering from disease or severe parasitic infections are more susceptible to predation, or often remain in cover where their sickness or deaths are seldom noted. Hibler's (1981:129) review of mule deer diseases is thorough, yet concise.

9.1.4.5. Hunting.

Mule deer are one of the most popular of all hunted species in western United States, and regulation of hunting is a dominate management effort by state fish and game agencies (Mackie et al. 1981). Deer populations and the relationship to hunting has always been controversial. At the turn of the century in the west, populations were low. During mid-century (1940s to 1960s) populations were high and doe harvest was promoted to control herd size. In the late 1960s and 1970s, most populations declined and management agencies received much pressure regarding management strategies (Connolly 1981). During more-recent decades, populations and harvest in western states continued to fluctuate. Flather and Hoekstra (1988) noted increases in the 1980s, but the general trend in the 1990s has been decline (unpublished data, Mule Deer Workshop, 1997, RioRico, Arizona; G. C. White, Colorado State University, Fort Collins, personal communication). For example, harvest in Oregon has fluctuated from 27,000 in 1950, 98,000 in 1961, 24,000 in 1975, and 19,000 in 1995. Data from Idaho show a similar trend. For a 26-year review (1950-1976) of population and harvest estimates for each western state, see Connolly (1981:230, Table 21; 234, Table 24). Connolly (1981:237, also see Table 20) noted that no single factor (including hunting) has been identified that explains population declines.

9.2. Historical and Contemporary Species Ecology in Hells Canyon

9.2.1. Distribution and Abundance

Mule deer are found in most habitats throughout the Hells Canyon region. Distribution may be influenced as much by hunter access and recreational disturbance as habitat quality. On the Oregon side there are 36 search units adjacent to Hells Canyon, and a total of 2,026 deer were counted in these units during spring 1997. No data were collected in 4 of these 36 units and these data should be viewed with caution because of the relatively small search units and the time of year surveys were conducted. The highest counts were from Keating unit 63:01 (341), and Pine Creek units 62:08 (196), 62:05 (129), and 62:07 (123) (unpublished data, George Keister, ODFW, Baker, Oregon; see maps attached to publication 7004).

On the Idaho side, data are available for a limited number of game management units or subunits, and only for certain years. In 1996, 1,477 deer were counted in unit 22, and in most years, approximately 25% of the animals are counted on the Brownlee Wildlife Management Area (WMA). A total of 456 deer were counted on unit 32A (both counts December 1996). In 1995, 392 deer were counted on the Brownlee WMA portion of unit 31 (see unpublished data in publication packet 7008). From available data, it is difficult to reach any conclusion regarding population trends for units in the Hells Canyon region.

These data from Oregon and Idaho are not directly comparable due to different configurations and establishment of management units. In addition, the management units are not a direct reflection of animal distribution or abundance within the Hells Canyon region, because some of the unit boundaries extend beyond Hells Canyon. New survey methods have been implemented during recent years, which is responsible for some changes in numbers by unit (George Keister, ODFW, Baker, Oregon, personal communication). Thus, these data should be viewed with caution.

9.2.2 Movement Patterns

Data on movement patterns for mule deer in Idaho and Oregon have been reported by Zalunardo (1965), O'Neil and Witmer (1991), Brown (1992), and Merrill et al. (1994). Zalunardo (1965) documented that summer range surrounded winter range in south-central Oregon, and was usually within 30 miles of winter range. Movements from winter habitat ranged from 2-46 miles. In southeastern Idaho, Brown (1992) reported that average movements between summer and winter habitats was 19.7 km, and ranged from 7-28 km. Twenty-six percent of 45 marked deer in Idaho were classified as non-migratory.

No specific data or publications were located that reported movement patterns for mule deer in the Hells Canyon region.

9.2.3 Habitat Associations

Mule deer habitat was described above in subsection 9.1.3. No specific data or publications were located that described habitat use by mule deer in the Hells Canyon region.

9.2.4 Harvest

As with the distribution and abundance data, the harvest statistics below (Table 1) include animals within management units that extend beyond the Hells Canyon region. Harvest data for mule deer in Oregon are available for the Pine Creek and Lookout big game units, but not all units within Hells Canyon (unpublished data, Oregon Department of Fish and Game, 1997, 7001). Harvest for these 2 units has averaged 318 animals, and ranged from 142-573. The increased harvest in 1995 and1996 was due to an increase in permits issued to hunters (George Keister, ODFW, Baker, personal communication).

Table 1. Mule deer harvest data (Pine Creek bucks only; Lookout includes does) for 2 Oregon game-management units within the Hells Canyon region.

YEAR	1989	1990	1991	1992	1993	1994	1995	1996	
Unit									8-yr Avg.
Pine Creek	63	112	133	254	112	134	174	256	155
Lookout	79	107	179	195	83	157	190	317	163
Total	142	219	312	449	195	291	364	573	318

Harvest on the Idaho side for game management units 13, 18, 22, and 31 have averaged 1,585 animals over the past 8 years, and ranged from 885-2,658 (Table 2). These data show a general decline in harvest, which is consistent for most western populations (see above). However, changes in hunting regulations and harvest pressure may also influence harvest trends.

Table 2. Mule deer harvest data from Idaho game-management units adjacent to Hells Canyon (Idaho Department of Fish and Game 1997, 7011).

YEAR	1988	1989	1990	1991	1992	1993	1994	1995	
Unit									8-yr. Avg.
13	261	246	172	188	141	236	185	68	187
18	343	402	400	311	200	180	115	34	248
22	1274	750	551	973	829	395	465	548	723
31	780	834	377	520	269	281	123	235	427
Total	2658	2232	1500	1992	1439	1092	888	885	1585

9.3. Cultural Significance in Hells Canyon

9.3.1. Historical

Mule deer were an important resource to native people in Hells Canyon, and are commonly reported among anthropological studies for the region (Randolph 1976, Draper and Reid 1986, Pavesic et al. 1986, Reid et al. 1991). Reid et al. (1991:318) noted that “the artifact and faunal assemblages are heavily oriented toward hunting… with a strong emphasis on deer and to a less extent bighorn sheep.” Spinden (1964) noted that mule deer (and other big game) “served an important role in the Nez Perce society and culture” (similar conclusions reported by Walker 1971).

9.3.2. Contemporary

Mule deer are among a number of wildlife species that remain culturally important to the Nez Perce people. These species are part of native religious ceremonies and medicine dances, and they are also important for young tribal men that seek an individual spiritual quest, or “Wayekin” (Alan Slickpoo, Sr., Tribal Historian, Nez Perce Cultural Resource Program, Lapwai, Idaho, personal communication). Alan Slickpoo did not distinguish among big game species regarding relative importance to religious ceremonies. Protection of important cultural resources is one objective for management for U.S. Forest Service lands within Hells Canyon National Recreation Area (USDA Forest Service 1986b).

9.4. Potential Hydroelectric Impacts to Populations and Habitat in Hells Canyon

Potential impacts on mule deer from hydroelectric development have been reported by Pacific Northwest Power Company (1971), Warnick and Clapp (1978), Bissell and Yde (1985), Fraley (1986), Yde and Olsen (1986), and

O'Neil and Witmer (1991). Concerns include both direct loss of habitat, indirect changes in habitat availability or quality, and interference with migration routes (see below). Asherin and Claar (1976:284) noted changes to riparian vegetation from fluctuating water levels in the free-flowing stretch of the Snake River in Hells Canyon; similar conclusions were reported by Claire et al. (1971) and Rickard et al. (1982) for the Columbia River. Damage to riparian vegetation (i.e., loss or inhibition of re-establishment) occurs from fluctuations on capillary action, erosion from wind/wave action, and boat wakes (McKern 1976). Riparian zones are used by deer throughout the year, but may be especially important as habitat for fawns (Kraft 1986, Ball 1988).

No data were located that specifically addressed changes in riparian vegetation in Hells Canyon and the direct or indirect impacts on mule deer populations.

9.5. Issues Associated With Population Viability in Hells Canyon

9.5.1. Ecological

The U.S. Department of Interior (1964) noted that reservoirs created by water-development project may "block or create hazards to big-game animals during migrations." More detailed concerns have been expressed by the ODFW (26 August 1997 letter from George Keister, ODFW, Baker, Oregon): "as a result of dam construction, there was a direct loss of at least 100 ft of lower elevation habitat and potentially extensive riparian vegetation, particularly above Brownlee Dam." These habitats are critical during harsh winters. In addition "the reservoirs have created a barrier to migration, of deer in particular, and caused mortality due to stranding of deer on the ice." The letter noted that these factors have negatively impacted "deer populations, hunter recreation, and Department revenue."

One additional factor is the artificial maintenance of river flows at relatively high levels throughout the year. Prior to establishment of Hells Canyon Dam, river flows in the canyon most years were likely very low during fall and early winter months (compared to average flows during these periods with current dam operation). These may have been traditional periods when animals had the opportunity to migrate across the Snake River with ease at many different locations.

Development of lands in the Hells Canyon region (primarily recreational cabin sites) may be a potential threat to some portions of the mule deer herd, especially from loss of or displacement from wintering habitat. For example, the Twin Rivers Ranch has recently sold over 30,000 acres northwest of White Bird, Idaho. Nearly all of the land was sold in parcels ranging between 20 and 200 acres, and most buyers were seeking recreational home sites (personal communication with salespersons employed by Twin Rivers Ranch, White Bird, Idaho). Recently, the Bureau of Land Management has purchased an easement to prevent such development from a private ranch on the oxbow portion of the Salmon River. This easement protects 3,700 acres adjacent to the river and was purchased for $3.5 million (LuVerne Grussing, Bureau of Land Management, Cottonwood, Idaho, personal communication). However, many thousands of acres of private remote lands in the Hells Canyon region remain susceptible to the general trend of development for recreational use.

Competition for forage between mule deer and domestic livestock has been a controversial issue for decades (Peek and Krausman 1996). However, the relationship is complex, and the interaction varies considerably among deer populations and local regions of conflict. Peek and Krausman (1996:183) noted that:

> "Domestic livestock grazing may interact with mule deer by altering plant succession to favor or reduce forage and cover. Changes in plant productivity may also affect mule deer. Disturbance of mule deer by livestock and associated human activity may also occur. Mule deer responses may include changes in distribution patterns and habitat use, modification of activity, or alteration in population density."

The relative value of 16 grasses as forage for mule deer and cattle is presented by Peek and Krausman (1996:185, Table 1). We did not locate any information that indicated competition for forage is a significant issue related to viability of mule deer in the Hells Canyon region.

9.5.2. Public and Political

Because big game hunting in the Hells Canyon region is extremely popular (U.S. Department of Interior 1964), the primary public/political issue with mule deer is hunting. As noted above, most populations have declined and the long-term trend in the west continues to decrease. No clear single answer is available to explain population declines (Connolly 1981:237). All natural-resource agencies with land-management responsibility bear some responsibility to wildlife populations, but state Fish and Game agencies receive the most pressure regarding big game populations. On occasion, hunters become well organized and vocal about their interpretations of problems and solutions. Consequently, biologists are often forced to attempt a “quick fix” with management programs dictated by agency administrators and politicians. Because mule deer populations are doing poorly in many western states and because factors causing declines are not understood completely, there is little reason to suspect that the Hells Canyon deer population will be the focus of any major public or political issue. However, Snake River dams may have caused the loss of important riparian habitat and prevention of migration across the river (George Keister, ODFW, Baker, Oregon, personal communication), and these potential problems should be addressed by future research.

An obvious political conflict may potentially become important regarding the relationship between mule deer and mountain lions. Deer are important lion prey, yet many deer hunters want lions controlled to limit the number of deer taken from the population by this predator. On the other hand, many segments of the general public want lion populations to remain relatively high, and may even support limited hunting on deer to protect lion prey. Because modern wildlife management must be responsive to both consumptive and non-consumptive users, this type of conflict is nearly impossible to resolve completely.

As noted above, interactions between mule deer and domestic livestock may result in some conflict over use of some portions of Hells Canyon that function both as grazing lands and wildlife habitat. However, these conflicts and associated problems are relatively minor (i.e., compared to interactive problems with big horn sheep). Such problems vary locally (Peek and Krausman 1996), and no data or information were located that identified specific problems between domestic livestock grazing and mule deer in the Hells Canyon region.

Deer have always been an important species for wildlife viewing and photography. Deer often become fairly tame around campsites and are important to the average recreationist with regard to a quality outdoor experience. Many wildlife enthusiasts are anti-hunting, and it is important to have “no hunting” sanctuaries around public camping areas to minimize potential negative interactions between hunters and those members of the general public that find hunting distasteful.

9.6. Species Management and Mitigative Options in Hells Canyon

No specific literature was located that outlines management of mule deer in Hells Canyon. Deer management in both Idaho and Oregon is largely restricted to annual population surveys, law enforcement of established hunting regulations, and manipulation of harvest levels. Peek and Krausman (1996) outline general methods of managing grazing of domestic livestock to increase compatibility with mule deer. These methods could be applied to the Hells Canyon region if cooperative programs could be developed with local ranchers.

Mitigation for deer populations in regions with hydroelectric dams are referred to in very general terms, e.g., “wildlife habitat enhancement” (Fraley 1986), “intense habitat management, conservation easements” (Yde and Olsen 1986), and “restoring and enhancing riparian and shrub cover, and preventing recreational access into rough terrain if necessary” (Ball 1988).

McKern (1976:52) made a number of recommendations for mitigative enhancement of riparian areas; however, most of these apply to reservoirs (vs. the free-flowing river between Hells Canyon Dam and the Salmon River confluence). The Confederated Salish and Kootenai Tribes et al. (1989:61) also noted riparian-habitat damage below Kerr Dam in Montana. The primary mitigative action for these habitat losses was off-site habitat enhancement. Idaho Power Company will initiate in 1998 a 3-year study to determine 1) the impacts of water level on riparian habitat, 2) the effects of flow changes below dams, 3) the effects of operations on the quantity and quality of riparian habitat, 4) the terrestrial species habitat impacts, and 5) potential mitigation options (Idaho Power Company 1997:VIII, 296-297, 314).

10. REVIEW OF SPECIES: ROCKY MOUNTAIN ELK

(*Cervus elaphus*)

10. 1. General Species Account and Review

10.1.1. Evolution

Rocky Mountain elk are in the order Artiodactyla and family Cervidae, which has 17 genera and 53 species (Bryant and Maser 1982, Peek 1982). Elk, also commonly called wapiti, first appeared in North America after apparent migration across the Bering Sea land bridge during the Illinoian glaciation (Guthrie 1966). For several decades there has been controversy as to whether Eurasion red deer and North American elk are separate species. Bryant and Maser (1982:14) presented a critical review of this controversy and concluded the 2 forms represent a single species. Six subspecies of North American elk have been classified, but 2 are now extinct (Peek 1982:851), and comparative measurements and phenotypic characteristics were presented by Bryant and Maser (1982:26, Table 3; also see Peek 1982:852-853, Tables 43.1 and 43.2). The Rocky Mountain elk (*C. e. canadensis*) are the most widely distributed and abundant of the North American subspecies (Bryant and Maser 1982:25, Figure 16).

10.1.2. Reproductive Ecology

Both Bubenik (1982:166) and Peek (1982:854) presented detailed reviews of elk reproduction. Female elk are reproductively mature as yearlings, but breeding usually occurs the first time when animals are 2 years old. Yearling males may also contribute significantly to breeding (Squibb 1985), but this case is usually restricted to populations with few mature bulls (e.g., heavily hunted populations). Breeding occurs in the fall, and calves are born in spring following 247-262 days of gestation. Pregnancy rates for females usually exceed 90% (Peek 1982:855); most cows have a single calf and twinning is rare in most herds (Kittams 1953, Bubenik 1982:170). McCorquodale et al. (1988) estimated survival of 0.91 calves/female. Thorne et al. (1975) determined that weight loss by females during gestation was directly related to calf weights at birth, which were directly related to calf survival the first 4 weeks.

10.1.3. Habitat Requirements and Food Habits

Elk habitat varies from open plains to forested mountains (Skovlin 1982, Peek 1982), and their distribution extends from northern British Columbia to New Mexico, and from California to North Dakota. Thus, specific habitat use varies considerably among populations, and much of the review below is restricted to literature from Idaho, Oregon, and neighboring regions. Skovlin (1982:376, Table 60) summarized key habitat factors as topographic (elevation, slope, and land features), meteorological (e.g., precipitation, temperature, and wind), food (availability and quality), cover (e.g., type, density, composition, structure, and successional stage), and specialized habitats (e.g., salt, calving, wallows, and trails).

Elk prefer the upper portions of moderate slopes (15-40%) with southern to southwestern exposures - especially during winter and spring (Dalke et al. 1965, Zahn 1974, Leege et al. 1975, Skovlin 1982). Among weather factors, snow depth is the most limiting. In central Idaho, snow depths of 46-61 centimeters caused elk movements to areas with less snow (Leege and Hickey 1977). During summer, however, elk avoid southerly aspects (Simmons 1974, Skovlin 1982:378), and often use cool, damp, dense forests with limited understory (Skovlin 1982:383). Elk will readily use open habitats, but hiding and escape cover is essential for populations subjected to hunting or other forms of disturbance. Ecotones between heavy cover and open areas are preferred habitats. Logging will temporarily displace elk (Edge and Marcum 1985, Edge et al. 1987), but timber harvest often creates ecotones that are preferred.

In the lower Selway River drainage of Idaho, Dalke et al. (1965) reported that during winter elk followed the snow line, but descended to new growth of grasses, sedges, and forbes during spring. After spring, elk moved to higher elevation summer range. During fall, elk gradually moved to lower elevations and laterally along slopes above the river. Irwin and Peek (1983) documented elk habitat use in a cedar-hemlock (*Thuja - Tsuga*) zone of northern Idaho. They summarized spring and summer habitats as grass-shrub (for feeding) and tall seral brushfields or pole timber (for resting). Fall habitat shifted more to timber communities on mesic slopes.

For Oregon and Washington, Thomas et al. (1979:109) concluded that optimal elk habitat consisted of a “ratio of 40% of a land type in cover to 60% in forage areas of proper size and arrangement.” Hiding cover is required for escape from human disturbance and predators; thermal cover is important for energy conservation (especially during winter). They noted that optimal calving habitat contains forage areas, hiding cover, and thermal cover. Hall and Thomas (1979) described many silvicultural options to increase compatibility between timber harvest and habitat requirements of elk.

Elk habitat use is closely associated with food habits, and food habits are "highly variable and depends upon the local availability of forage" (Peek 1982:855). Kufeld (1973) summarized 48 food-habits studies and concluded that grasses, shrubs, and forbs represented the bulk of the elk diet throughout the annual cycle. During winter, grasses and shrubs are the dominant foods and vary considerably with local environments and plant availability. During spring, grasses are more consistently important in the diet. Forbs are consumed in all seasons but become more important during summer, and dominate the diet in some regions. During fall, the diet shifts back toward heavy use of grasses and shrubs. Kufeld (1973) ranked various elk foods, and concluded that the most valuable grasses were *Agropyron spicatum*, *Carex* spp., *Festuca* spp., and *Poa* spp. Highly valuable forbs included *Agoseris glauca*, *Geranium viscossimum*, *Lupinus* spp., and *Aster* spp. Among shrubs, the most-important species were *Amelanchier alnifolia*, *Ceanothus* spp., *Populus tremuloides*, *Prunus virginiana*, *Purshia tridentata*, *Quercus gambellii*, and *Salix* spp.

10.1.4. Other Limiting Factors

10.1.4.1. Accidents.

Taber et al. (1982) concluded that accidental deaths of elk are uncommon, but did report one case of an elk that slipped while feeding on branches in a tree, became entangled in the tree base, and strangled. Accidental deaths by elk in Washington state (1950-1965) included 117 automobile accidents, 12 train accidents, and 11 deaths from fence entanglements (Potter 1982). Huggard (1993) also reported data on elk killed by automobiles and trains in Canada. Asherin and Orme (1978) suggested that elk likely drown while crossing ice on Dworshak Reservoir (which has also been confirmed in recent winters by reports to local newspapers). No other published literature on elk accidents was located, however, most western state fish and game agencies likely have data similar to those reported above for Washington.

10.1.4.2. Predation.

Most documented reports of predation on elk are from winter periods, likely due to the relative ease of obtaining data (i.e., obvious and easily located evidence of predation in snow, especially from aircraft surveys). Primary predators on elk are wolves and mountain lions (Taber et al. 1982:291).

Wolf predation on elk has been well documented in Canada's Rocky Mountain, Riding, and Banff national parks (Cowan 1947, Carbyn 1983, Huggard 1993). Cowan (1947) reported that 80% of the wolf's diet was big game and that elk contributed 47% of the big-game portion. Carbyn (1983) documented that predation by wolves on elk was higher during periods of deep snow. During 1 such period, he reported 1 elk or moose killed every 2.7 days by a pack of 5 wolves. He also documented that predation was highest on young or old age classes of elk. Huggard (1993) also reported that adult elk killed by wolves had lower reserves of marrow fat than calves or adults killed by automobiles or trains.

In Idaho, the primary reports of predation on elk are from mountain lions (Hornocker 1970, Seidensticker et al. 1973). These studies documented that elk were dominant among lion big game kills over a 4-year period, that elk prey were predominantly young or old individuals, and that lions constantly altered their home range in response to the location of elk or deer herds. Toweill and Meslow (1977) also reported elk as prey of mountain lions in Oregon, however, only 2 elk were among prey identified from 25 cougar stomachs.

Some cases of elk being killed by grizzly bear during periods of severe weather have been reported, but most cases of elk consumed by bears were carrion or very sick and weak animals (Cole 1972). Large ungulates have been documented as a dominant portion of winter diet by coyotes, however, most elk were scavenged, and "their occurrence in the winter diet was primarily a function of the number dying within each coyote territory" (Bowen 1981:639).

10.1.4.3. Parasites.

Numerous research efforts have been published on parasites and disease of North American elk. However, the most thorough review of this topic was presented by Kistner et al. (1982). Thus, most of the information on these topics has been extracted from their review. Nearly all elk have parasites, and multiple parasitism (i.e., several different species of parasites) is the general rule. Few parasites cause elk mortality, but severe parasitism may increase the susceptibility of animals to other stress factors such as weather, malnutrition, or predation. Most elk parasites have coevolved with the host, and are of little consequence to management of herds. Some parasites (e.g., gastrointestinal worms) are density dependent and may be problematic during winter.

Elk parasites include mites, ticks, flies, horseflies and botflies, lice, mosquitoes, flukes, tapeworms, protozoa, filarial worms, lungworms, threadworms, and whipworms (for tabular summary of parasite species and specific references see Kistner et al. 1982:197, Table 23). A number of parasites cause concern. Scabies mite often attacks older animals or those in poor nutritional condition; these infected animals are especially unsightly in parks where they may be easily observed by visitors. Large liver flukes are relatively unimportant as a parasite on elk, but they can be a significant problem for domestic livestock. Tapeworms (i.e., *Echinococcus granulosus*) cause few problems for elk, but a major concern is disease potential for man (as the intermediate host). Both meningeal worms (*Pneumostrongylus tenuis*) and arterial worms (*Elaeophora schneideri*) can cause significant problems for elk herds.

10.1.4.4. Disease.

Bacterial diseases that affect elk include Actinomycosis (lumpy jaw), arthritis, brucellosis, clostridia, leptospirosis, necrotic stomatitis (e.g., foot rot), and several bacterial diseases. Of these, “brucellosis in bison and elk of western Wyoming, in and around Yellowstone and Grand Teton Parks, has sparked considerable controversy, because the animals represent a continual source of infection for man and domestic livestock” (Kistner et al. 1982:188).

Neoplastic diseases (tumors) in elk are uncommon and have little negative impact on populations. Rickettsial diseases associated with elk include anaplasmosis and Rocky Mountain spotted fever in man. Anaplasmosis is of particular concern because of the significant economic losses to the cattle industry. The only known “naturally occurring” viral disease in elk is rabies, but reports have been limited. Other significant viral diseases in elk include bluetongue and epizootic hemorrhagic disease. Both of these diseases are transmitted by biting midges (*Culicoides* spp.); outbreaks are limited to summer and autumn, and cattle are the primary reservoir (Kistner et al. 1982).

10.1.4.5. Hunting.

Elk are probably the most popular big game species in the west, and especially in Idaho and Oregon where elk are featured on both official state seals. Hunting exterminated elk from much of the original range that extended coast to coast, but western populations have thrived for decades in rugged habitats and with the aid of modern wildlife management (Potter 1982). However, in more recent decades there has been increased concern for disturbance to elk habitat in combination with heavy hunting pressure. During the 15-year period from 1950-1965, the number of elk hunter visits on national forest lands has increased from 1.5 million to 25 million, and harvest success rates during the same period declined from approximately 23% to 5% (Potter 1982:516, Figure 101). These statistics are partially due to timber harvest. Peek (1982:859) noted that “a major problem associated with logging is access by hunters to areas previously not accessible by vehicle prior to the establishment of road systems.” Unsworth et al. (1993:495) estimated that “86% of all elk deaths [in Idaho] occurred during September and October and were associated with hunting.” Increased hunting pressure and harvest has also resulted in the general decline in the number of “trophy” bulls (e.g., Boyd and Liscomb 1976). Potter (1982:532, Table 80) summarized elk harvest between 1935 and 1979 for 16 states and 4 Canadian Provinces. Recent harvest data for Idaho and Oregon are presented below.

Potter (1982:537) noted that the challenge for management of elk hunting in future decades will be finding a “balance between numbers of hunters, quality experiences, and harvest success” (also see Fried et al 1995). As elk numbers and hunter success decrease, state fish and game agencies are under increasing pressure to respond to sportsmen who criticize management programs, hunting regulations, and call for predator control. On the other hand, many regions must have winter and spring control hunts to limit damage to agricultural crops. Potter (1982) provided a thorough review of elk hunting in North America, including topics on hunter satisfaction, hunter demographics, licensing history, harvest rates, and illegal kills.

10.2. Historical and Contemporary Species Ecology in Hells Canyon

10.2.1. Distribution and Abundance

Elk are commonly reported in the Hells Canyon region (e. g., U.S. Department of Interior 1964, Wilson 1975, Asherin and Clarr 1976, Mckern 1976, U.S. Department of Energy 1984b, Meatte 1990, USDA Forest Service 1994b, and ODFW 1997). No research data were located that documented specific elk distribution within the Hells Canyon region. However, distributions may be partially inferred from fall harvest data and winter/spring survey counts (see below).

Elk survey data for recent years in Oregon are presented below in Table 3. These data reflect relatively stable populations for the survey units that are partially included in the Hells Canyon region.

Table 3. Elk survey counts for Oregon management units that include portions of Hells Canyon (publication 7001).

	Year					
	1992	1993	1994	1995	1996	
UNIT						5-yr Avg.
Chesnimnus - 58	3550	3550	3400	3100	2600	3240
Snake River - 59	4200	4150	4200	4000	3500	4010
Pine Creek - 62	455	321	390	418	267	370
Lookout Mtn - 64	723	803	789	769	651	747
Beulah - 65	2000	2100	2200	2500	2500	2260
TOTAL	10928	10924	10979	10787	9518	10627

For Idaho, counts of elk in unit 22 have varied in recent years from 1,400 to 2,329 (Table 4). In 1993, 1,329 elk were counted in the Hillman Ranch portion of unit 31 (see unpublished data in publication packet 7008). As with the mule deer survey data, elk counts are not consistent among years or survey units, and are not specific to Hells Canyon. Thus, it is difficult to reach firm conclusions regarding the current status of elk in Hells Canyon.

Table 4. Elk count summary for Idaho game management unit 22. Raw count data from helicopter surveys (unpublished data, Idaho Department of Fish and Game, see packet 7008).

	Year			
	1991	1993	1995	1997
SURVEY SEGMENT				
Hells Canyon	444	518	474	661
Kleinschmidt-Wildhorse	132	137	476	385
Wildhorse	329	301	133	262
Andrus WMA	49	407	388	640
Cambridge	396	5	357	103
N. Hornet-West Fork Weiser	240	32	294	278
TOTAL	1590	1400	2122	2329
Bull:Cow:Calf Ratio	14:100:29	15:100:40	9:100:36	8:100:47

Estimates of the total population of elk in the Hells Canyon region (on the Oregon and Idaho sides) are not available. Data from Oregon and Idaho are not directly comparable due to different configurations and establishment of management units. In addition, the management units are not a direct reflection of animal distribution or abundance within the Hells Canyon region, because some of the unit boundaries extend beyond Hells Canyon. In addition, new survey methods have been implemented during recent years, which is responsible for some changes in numbers by unit (George Keister, ODFW, Baker, Oregon, personal communication). Thus, these data should be viewed with caution.

10.2.2. Movement Patterns

As with distribution, no specific data were located that documented movement patterns by elk in the Hells Canyon region. However, it may be assumed that general movements are consistent with seasonal-habitat use described above.

10.2.3. Habitat Associations

No specific data were located on habitat associations for the Hells Canyon region. Seasonal habitat use will likely be similar to that described in the general section on habitat above. Some macro-habitat inferences may be drawn from fall harvest data and winter/spring survey counts.

10.2.4 Harvest

Recent elk harvest data for Idaho game management units that include portions of Hells Canyon are presented in Table 5. Overall harvest has been relatively stable for these units (combined data), but harvest in unit 13 has dramatically declined in recent years.

In Oregon, data are available for elk harvest in the Pine Creek and Lookout units; boundaries of these units partially include Hells Canyon (Table 6).

Table 5. Elk harvest data for Idaho game management units that partially include portions of Hells Canyon region (publication 6001).

YEAR	1989	1990	1991	1992	1993	1994	1995	
Unit								7-yr Avg.
11	81	113	57	75	76	35	55	70
13	109	120	90	115	113	34	42	89
18	88	78	73	63	60	95	69	75
31	178	305	368	199	294	256	235	262
22	485	551	489	632	460	460	507	512
32	344	332	283	588	611	498	370	432
TOTAL	1285	1499	1360	1672	1614	1378	1278	1441

Table 6. Elk harvest data (bulls and cows) for 2 Oregon game-management units within the Hells Canyon region (unpublished data, George Keister, Oregon Department of Fish and Wildlife, Baker, Oregon).

YEAR	1989	1990	1991	1992	1993	1994	1995	1996	
Unit									8-yr Avg.
Pine Creek	284	355	408	436	227	204	211	178	288
Lookout	120	155	142	61	137	141	232	194	148
TOTAL	404	510	550	497	364	345	443	372	436

As noted, these data are only a partial reflection of harvest within Hells Canyon. Thus, conclusions regarding harvest must be made with caution and through consultation with area biologists.

10.3. Cultural Significance in Hells Canyon

10.3.1. Historical

Numerous published records have documented the existence and importance of elk to aboriginal people of the Hells Canyon region, including sites on the upper Snake and Salmon river drainages (Butler 1978), the lower Snake River basin (Reid et al. 1991), the western Snake River basin (Meatte 1990), Hells Canyon Creek (1 mile north of Hells Canyon Dam, Pavesic 1971), Tyron, Knight, and Bernard creeks (Hackenberger et al. 1995, Hackenberger 1993, and Randolph and Dahlstrom 1977, respectively), and Pittsburg Landing (Reid et al. 1991). Elk were relatively infrequent among remains at several sites, and were referred to as a “small proportion of identifiable faunal remains” (Hackenberger et al 1995), or that elk remains were “relatively few” (Reid et al. 1991). Leonhardy and Thompson (1991) reported that from one site in Hells Canyon (Wallowa County, Oregon) “the absence of elk is notable.”

However, Draper and Reid (1986) concluded that among terrestrial mammals, elk were one of the most important large mammals to Native American people. Spinden (1964) reported that, in addition to food, “elk teeth were also used as decorative necklaces” and “elk hides were used to make shields for war.”

10.3.2 Contemporary

Elk are among a number of wildlife species that remain culturally important to the Nez Perce people. These species are part of native religious ceremonies and medicine dances, and they are also important for young tribal men that seek an individual spiritual quest, or “Wayekin” (Alan Slickpoo, Sr., Tribal Historian, Nez Perce Cultural Resource Program, Lapwai, Idaho, personal communication). Alan Slickpoo did not distinguish among big game species regarding relative importance to religious ceremonies. Protection of important cultural resources is one objective for management for U.S. Forest Service lands within Hells Canyon National Recreation Area (USDA Forest Service 1986b).

10.4. Potential Hydroelectric Impacts to Populations and Habitat in Hells Canyon

As noted above, one of the primary potential impacts to wildlife habitat in Hells Canyon from hydroelectric operations is fluctuating water levels, and subsequent impacts on riparian vegetation (McKern 1976, U.S. Department of Energy 1984b:VIII-46). No publications from typical current range of Rocky Mountain elk were located that indicated riparian habitats were important (i.e., their primary habitat use is upper portions of moderate slopes, e.g., Dalke et al. 1965). The only exception was for a small elk herd that colonized the Arid Lands Ecology Reserve in Washington; these animals have been reported to use riparian habitats during the calving period and late summer months (McCorquodale et al. 1986). However, this case, with animals highly protected in a sanctuary zone and using a sagebrush-desert environment, must be considered an anomaly.

Some concerns exist regarding barriers to movements and migration of big game, especially for deer. However, elk were not noted regarding this matter (see letter dated 26 August 1997, George Keister, ODFW, Baker, Oregon).

10.5. Issues Associated With Population Viability in Hells Canyon

10.5.1. Ecological

The primary ecological issues related to elk viability in Hells Canyon are livestock grazing, timber harvest, and recreation. Competition for range between elk and livestock can be an important consideration for elk management, especially if the range is in poor condition (Stevens 1966, Peek 1982). Thus, we have noted that livestock grazing is an issue of significance for several big game species that inhabit Hells Canyon.

As noted above, timber harvest creates direct disturbance to habitat and increases hunter access to remote regions. Some clearcut areas also provide beneficial browse conditions.

The most critical form of recreational disturbance is hunting, and hunting pressure must be carefully regulated to prevent overharvest and severe disturbance to herds (Peek 1982). Hikers and boating traffic on the river are not likely to create a significant disturbance for elk herds at the current levels of activity (see Thomas et al. 1979:109, Figure 58).

10.5.2 Public and Political

Elk are an extremely important species for the hunting public in both Oregon and Idaho. As with mule deer, elk management will generate much concern from sportsmen, and sportsmen's groups are becoming increasingly active in the political arena. For example, recently the Moscow, Idaho, newspaper (*Moscow/Pullman Daily News*) has published a series of articles entitled "Hunting For Answers." The series is authored by a group of local sportsmen who are credited with a combined "200 years of involvement with wildlife issues in the region." Although obvious that these individuals have no credentials in wildlife management, they take dogmatic positions on issues such as predator control, elk hunting regulations, competence of regional biologists, and hiring or dismissal of key individuals employed by the IDFG.

Public pressure for more elk and high-quality hunting experiences will remain in future years. On the other hand, competition for resources (i.e., timber harvest and livestock grazing) will likely continue in some portions of the Hells Canyon region as well. As we move forward in the era of resource-use conflict, maintaining viable populations of elk will always have potential for significant public and political controversy.

10.6 Species Management and Mitigative Options in Hells Canyon

Modern elk management is usually directed at 1) restricted harvest and effective enforcement of hunting regulations, 2) reducing competition for forage with domestic livestock, 3) range enhancement (e.g., burning to encourage resprouting of palatable shrubs), 4) limiting timber harvest and construction of new roads (and closure of previously established logging roads), 5) limiting or regulating disturbance, and 6) and prevention of herd overpopulation and forage deterioration (Lyon 1975, Thomas et al. 1979, Lyon and Ward 1982, Peek 1982, Peek et al. 1982, Gratson et al. 1993).

In the Hells Canyon region, appropriate mitigative actions might include modifications to standard timber-harvest techniques (e.g., selective cutting), reduction of competition for forage with domestic livestock, and range enhancement (in addition to current harvest regulations). Range enhancement may include fertilization, prescribed burning, reseeding, and elimination of non-desirable vegetation with herbicides (Lyon and Ward 1982). All mitigative actions must consider potential impacts (negative and positive) on non-target wildlife species.

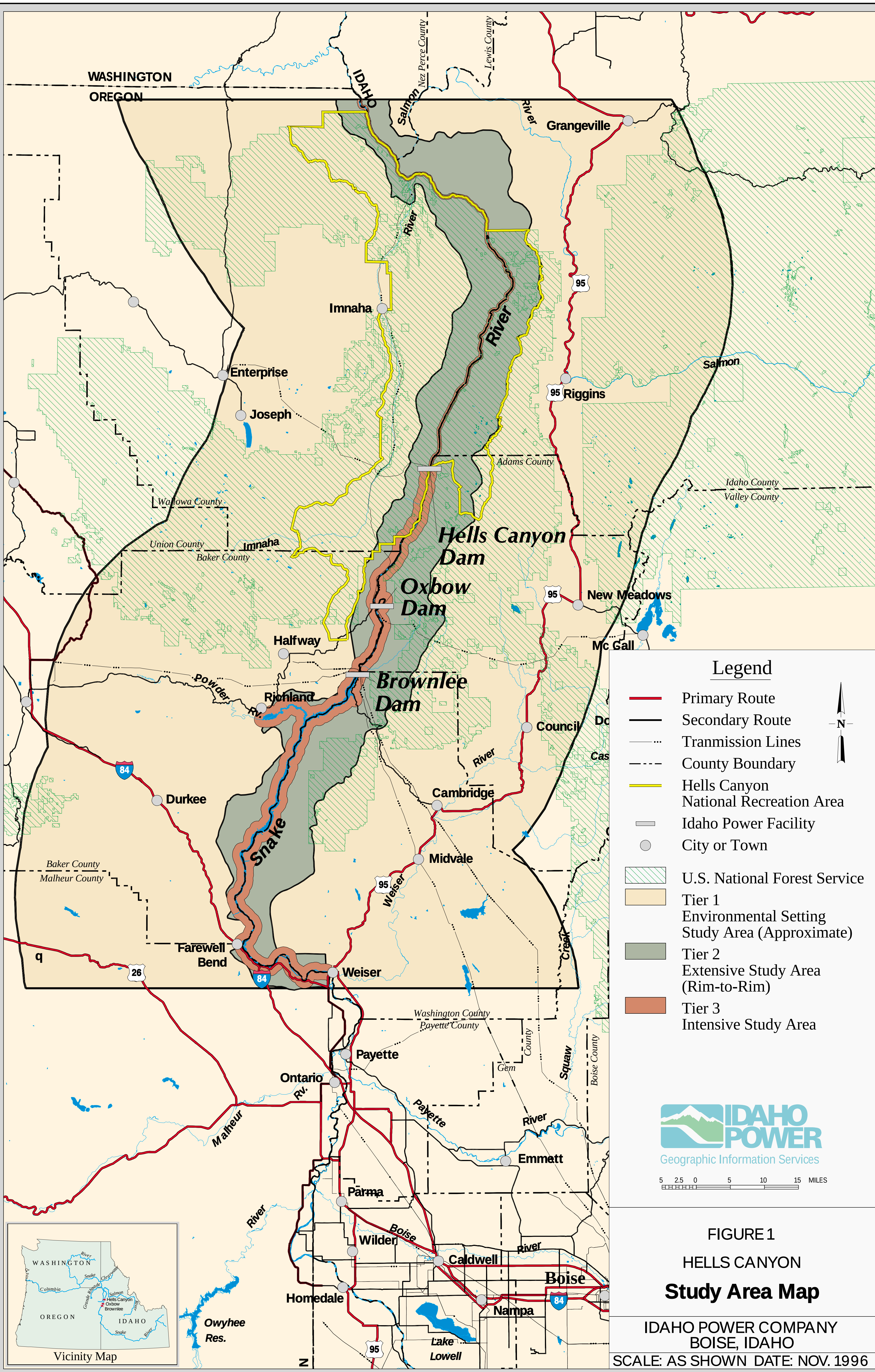

FIGURE 1
HELLS CANYON
Study Area Map

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***Please Note*: Citations not found in this section are listed in Appendix F.**

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Please Note: **Citations not found in this section are listed in Appendix F.**

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APPENDIX A: AUTHOR RESUMES

JOHN T. RATTI
Department of Fish and Wildlife Resources
University of Idaho
Moscow, Idaho 83844-1136
Tel 208-885-7741 FAX 208-885-9080 E-Mail jratti@uidaho.edu

Dr. Ratti completed his Ph.D. in Ecology (1977) and M.S. in Wildlife Biology (1973) at Utah State University, and his B.S. in Business Management (1969) at Indiana State University. His professional employment includes Assistant Professor at South Dakota State University (1977-80) and Washington State University (1980-85), Associate Professor at Colorado State University (1985-86), and Research Professor at the University of Idaho (1986-present).

In addition to teaching numerous wildlife ecology and management courses, Dr. Ratti has been awarded over $2.4 Million for 29 separate research grants and contracts (as of July 1997), and has 65 professional publications (mostly in peer-reviewed journals).

Dr. Ratti has served on numerous national committees for The Wildlife Society, several expert panels for federal agencies, has served as Associate Editor for *The Journal of Wildlife Management*, and as President of the Northwest Section of The Wildlife Society. He also has served as a professional consultant to the U.S. Forest Service, Bureau of Land Management, Idaho Attorney General, Confederated Salish and Kootenai Tribes, Idaho Power Company, and Hecla Mining Company.

MATTHEW B. LUCIA
Department of Fish and Wildlife Resources
University of Idaho
Moscow, Idaho 83844-1136
E-Mail luci0898@novell.uidaho.edu

Matt Lucia completed his B.S. in Environmental Studies (1997) at Utah State University, and he is currently an M.S. candidate in Wildlife Resources at the University of Idaho. He has 4 years of temporary employment experience with the Idaho Department of Fish and Game, Utah Division of Wildlife, Utah State University, and the U.S. Fish and Wildlife Service.

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APPENDIX B: SEARCH TERMS FOR LOCATION OF LITERATURE

1. Search terms used in combination with **common name(s)** and **species names** of each of the six big game species:

activity
hunting
Idaho
Oregon
Washington
hydroelectric
dams
Hells Canyon
Middle Snake River
Brownlee
Oxbow
behavior
breed (ing)
competition
density
diet
disease
dispersal
distribution
disturbance
ecology
evolution
food
forage
gestation
growth
habitat
home range
limiting factors
management
migration
mortality
movements
nutrition
parasites
predation

Search terms, continued:

reproduction
reservoir
Snake River
vegetation
logging
livestock
fire

2. Search term **hydroelectric** used alone and in combination with:

wildlife
mitigation
dams
Hells Canyon
Idaho
Oregon
Development

3. Search term **dams** used alone and in combination with:

wildlife
Idaho
Oregon
environment
development
mitigation
flow fluctuation

4. Search term **Hells Canyon** used alone and in combination with:

dams
wildlife
development
recreation
reservoir
vegetation
climate
mitigation
Environmental Impact Statement

Search terms, continued:

flow fluctuation
forest management
prehistory
archaeology
Nez Perce
ecology
hunting
livestock
native
management

5. Search term **Brownlee** used alone and in combination with:

reservoir
dam
hydroelectric
power plant
wildlife
mitigation
Environmental Impact Statement
flow fluctuation

6. Search term **Oxbow** used alone and in combination with:

reservoir
dam
hydroelectric
power plant
wildlife
mitigation
Environmental Impact Statement
flow fluctuation

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APPENDIX C. Tutorial for use of the Pro-Cite® database.

(Note: This tutorial is designed to provide information on use of the Pro-Cite® database that was submitted to Idaho Power with this report. The following information is for the DOS version 2.1 of Pro-Cite®; Macintosh and Windows versions are also available. We assume the most users of the database will be familiar with Pro-Cite® and will have a manual. However, one hour of practice with this tutorial will introduce you to most of the basic operations needed to use the database. Users of the Mac or Windows versions may also find it helpful to quickly review this tutorial.)

This information sheet is designed to assist learning a few basics about operation of Pro-Cite® (DOS 2.1) and using the Idaho Power Company--Hells Canyon Big Game Database. The database files must be loaded onto your computer hard disk (8 HC files were delivered to Idaho Power Co.), and you must indicate the location of your files before you begin to work with the database (at the main menu select **Customize**, then select **Default Directories.** Be sure your database location is correctly identified on line two of this menu. If necessary, press the <F10> key to save your changes, and exit to the main menu.

At your Pro-Cite® Subdirectory, Start the program by typing **Procite** and press <Enter>. If you are satisfied with the screen colors, go to the next paragraph. If not, set your monitor by pressing "H" (for the Hardware/Software Setup), press "M" and highlight color **or** monochrome with the arrow keys, and press <Enter>. Press "T" to set the text colors, use the space bar to review text colors, and press <Enter> to select a text color. Press "B" and use the same procedure to select a background color. Press <Esc>, and answer "Y" (for yes) to save your changes. (This procedure only needs to be done once.)

At the main menu press "D" to select databases. At the Databases Menu press <Enter> (or "O" to open a database); the third menu screen will list your data files. For this tutorial, open the Hells Canyon (HC-all) database. To see records in your database, press "E" or move the highlight bar with the arrow key down to "Edit, Insert, View" and press <Enter>. Press "J" for Jump, type **Beecham**, and press <Enter>. Now you will see the first Beecham record, and if you press "N" (for Next record) you will move alphabetically down through the database. This is a very quick way to move among records, and is especially helpful if you do not know the exact spelling of an author name and want to search various records with similar spelling (e.g., Andrew or Andrews). However, **it is important to note** that Jump only moves to senior-author names. To exit the Edit Screen press "X" or the <Esc> key.

Next we will **search the database**. From the Main Menu press "S" (for Search Database). At this point get in the habit of pressing "A" to select all records if you want to search the entire database (this is important because Pro-Cite® will hold selected records in memory from a previous search). Press "S" again and you will see the Search Expression Screen. Be sure the Quick Search message at the bottom of the search screen is ON. If not, press <F7> to turn Quick Search ON. Press <F2> for the Fields Menu; those marked "quick" are the only fields used for Quick Search. Press <Enter> to select Author=. On the search screen immediately after Author= type **Smith** and press <Enter>. After the search process (just a few seconds), press the space bar. To see your selected records press <Esc> **twice** for the main menu. Now press "E" (for Edit). With the "T" (next selected record) and "V" (previous selected record) keys you can quickly browse your selected records. Note that if you press "N" (for Next) or "P" (for Previous) you will move to the adjacent record in the database, **which may not be one of your selected records**. If your record exceeds one screen, press <PgDn> to see additional portions of the record. Press <Esc> to return to the main menu.

To preview your selected records on the screen, press "P". At the Print Menu press "O" (for Output options) and move the highlight bar to Screen Preview (if necessary) and press <Enter>. Press "U" to open the Punctuation Files Menu, move to HC_ABS, and press <Enter> (this is one of 2 punctuation files, one for including abstracts and one for excluding abstracts). Then press "P" in the Print Menu to print your selected records. The print screen will take you to the end of your selected records. If you have expanded memory on your computer, you may only need to press the page-up key or use your up-arrow key to scroll through your selected records.

(If you do not have expanded memory, you will see a menu at the bottom of the screen; press "J" (for Jump), type **1**, and press <Enter>. This will take you to page 1. Press "V" (for View), and use your down-arrow key to scroll through the text. At the bottom of the page, press <Enter>, and "N" (for Next Page), and repeat the process described above ("V" for View, etc). Press <Esc> until you return to the Print Menu when you are finished.)

To preview your selected records without the abstracts, press "U" to see the Punctuation Files Menu and move the highlight bar to HC_PUB and press <Enter>. Now press "P" again and you will print your records to the screen with a new punctuation file that does not include the abstracts (this is the punctuation file you would use for a report or publication). Press <Esc> to return to the Print Menu.

If you want **to print your selected records to a printer**, you must first set your printer driver. Press <Esc> to return to the Main Menu. Press "H" (Hardware/Software Setup), and select "P" (for Printer). Using arrow keys highlight Epson (for dot-matrix printers) or one of the HPLJs (for LaserJets) and press <Enter> and press <Esc>. At the save message, type "**Y**" to save your changes. This procedure **only needs to be done once**. One of these 2 drivers works for most printers; to create a customized printer driver contact RIS for technical assistance (619-438-5526). Next, Press "P" for the Print Menu, press "O" (for Output), highlight Printer and press <Enter>. Press "P" again to print to your printer (be sure your printer is turned On).

To search the entire database, including the text of abstracts, requires a slightly different search process. Press <Esc> to return to the main menu. Press "S" for the Search Database Menu. Note the number of your selected records in the upper right-hand corner. Press "A" and that number will change to your entire set of records in the HC-All database. Press "S" for the Search Expression Screen, and <F8> to clear your last search expression (if necessary). This time we will **not** use the <F2> key, but simply type **goat* AND movement*** and be sure the AND is in all caps (the * is a wildcard so you will find goat or goats, etc.). Press <Enter>. Now you will see that the search process is much slower than our first example (this is because the program is searching all text in the database, including the abstracts). This search will take 1-10 minutes, depending on the speed of your personal computer. **Remember, if you want to do a Quick Search**, (the fastest search that does not search the abstract text), be sure the Quick Search is <u>ON</u>, use <F2>, and select only search fields marked "quick". Now you can do an additional search on your selected records. Press space bar, press <F8> to clear the **goat* AND movement*** expression, press <F2>, press "D" (for date) and press <Enter>. Now hit your backspace key to erase the equal sign and type **>1980**. Press <Enter>. This second-level search will reduce your selected records to only those published after 1980. You could have combined these search expressions the first time (**goat* AND movement* AND Date>1980**). Secondary searches are often used to reduce the set of selected records if the first search found many more records than you anticipated or wanted. Now you can press the space bar and press <Esc> twice to return to the main menu where you can Browse or Print your records as described above. Press "Q" for Quit to exit the program. (**Important Note:** It is essential to understand the different search methods; e.g., a quick title search for a given topic word may result in less than half the number of selected records that you will find with a text search ... and you will likely find a different number if you conduct a quick key-word search using the descriptor field. Practice these different search methods after you complete this tutorial.)

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APPENDIX D: SEARCH TERMS FOR USE OF THE Pro-Cite® DATABASE

NOTE: When using the Pro-Cite® database, use of the following search terms may be helpful.

A. Alphabetical order

aboriginal
activity
aesthetic
antelope
archaeology (ical)
<u>bear</u>
behavior
bighorn
bighorn sheep
black bear
breed (ing)
Cervus elaphus
cliffs
climate
competition
<u>cougar</u>
culture
dam (s)
<u>deer</u>
denning
dens
density
description
development
diet (s)
disease
dispersal
distribution
disturbance
ecology
economy (ics)
<u>elk</u>
evolution
flows
fluctuation
food (s)
forage
forest management
forest
gestation
<u>goat (s)</u>
grazing
growth
habitat
HCNRA management
HCNRA
Hells Canyon
hibernate (ing) (tion)
history (ic)
home range
homing
hunting
identification
introduce (d) (tion)
inventory
limiting factors
lion
livestock
logging
managed
management
measurement (s)
migrate (tion)
mortality
mountain (goat) (lion) (sheep)
mt. (goat) (lion) (sheep)

Search terms continued:

mule deer
native (s)
Nez Perce
nutrition (al)
Odocoileus hemionus
Oreamnos americanus
Ovis canadensis
parasite (s)
petroglyph
population
power plant
predation
prehistory (ic)
prey

range
recreation
reproduction
reservoir
riparian
riparian habitat
<u>sheep</u>
Snake River
territory
transplant
Ursus americanus
vegetation
water fluctuation
weight
wildlife

APPENDIX E: HARD-COPY FILE ORGANIZATION

I. ORGANIZATION

A. Each hard-copy is numbered in the upper left-hand corner. This number corresponds to a Pro-Cite® entry number under the "Note" field. The hard-copy file is organized as follows:

1) **Black bear #1000-1999** *Black bear are found along the Snake River in Idaho, Oregon, and Washington. State agencies do not conduct population inventories for black bear. Management is based on hunter harvest statistics.

2) **Bighorn sheep #2000-2999** *Bighorn sheep are found along the Snake River in Idaho, Oregon, and Washington. Bighorn sheep in Hells Canyon are a result of an intensive re-introduction program initiated in 1971.

3) **Mountain lion #3000-3999** *Mountain lions are found along the Snake River in Idaho, Oregon, and Washington. State agencies do not conduct population inventories for Mountain lion. Management is based on hunter harvest statistics.

4) **Mountain goat #4000-4999** *The only Mt. goat populations in Hells Canyon are in game-management units 18 and 22 in Idaho. This population is the result of an introduction initiated in 1962.

5) **Hells Canyon and Hydroelectric Development #5000-5999** *This file contains information on topography, vegetation, National Forest management, Hells Canyon National Recreational Area (HCNRA) management, wildlife, prehistory, archaeology, political issues related to development, and cultural aspects related to Hells Canyon. It also contains information on problems associated with hydroelectric development on projects other than Hells Canyon.

6) **Elk #6000-6999** *Elk are found along the Snake River in Idaho, Oregon, and Washington. State agencies conduct population inventories via ground and aerial surveys. Management is based on population estimates.

7) **Mule deer #7000-7999** *Mule deer are found along the Snake River in Idaho, Oregon, and Washington. State agencies

conduct population inventories via ground and aerial surveys. Management is based on population estimates.

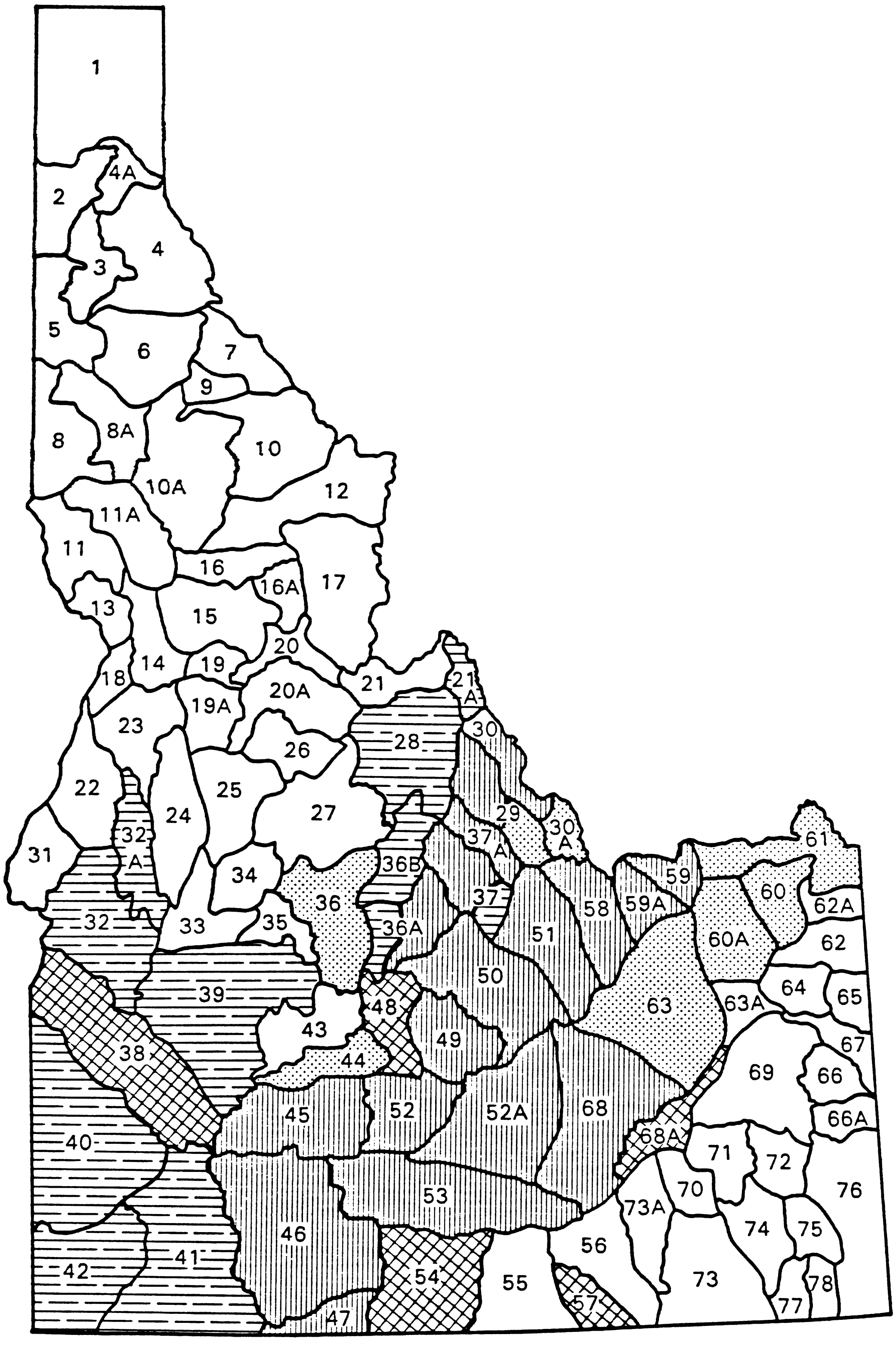
B.

1) Some of Pro-Cite® entries within a particular species will be cross-referenced to other species hard-copy files. 2) When using a search term, **search all fields (i.e., full-text search NOT a quick search).** 3) When searching for a particular file number under the “Note" field, always include the number sign (e.g., #1000, #2000, #3000, #4000, #5000, etc.). 4) For punctuation files, use ANSI Standard, or the HC file delivered with the database. 5) For state PR reports, a single Pro-Cite® entry may include more than one publication. 6) Washington's game-management unit (GMU) # 184-Joseph and 185- Black Butte were combined in 1996 to form GMU 186-Grande Ronde.

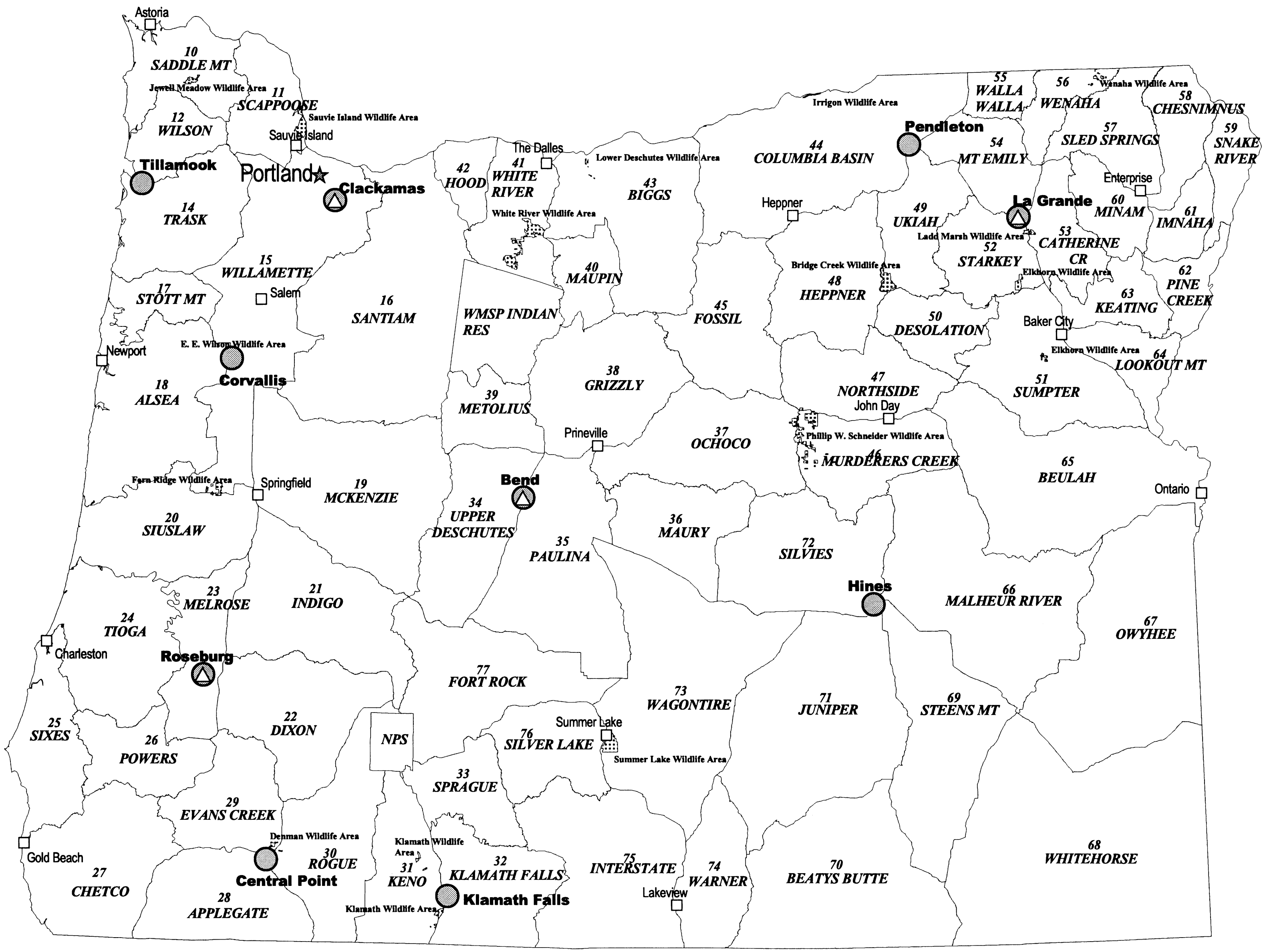
II. GAME MANAGEMENT UNITS (from north to south). See attached maps.

A. Oregon
1) #58, Chesnimnus.
2) #59, Snake River.
3) #62, Pine Cr.
4) #64, Lookout Mt.
5) #65, Beulah.

B. Idaho
1) #11.
2) #13.
3) #18.
4) #22.
5) #31.
6) #32.



Idaho Game Management Units



Oregon Game Management Units

APPENDIX F. LIST OF PUBLICATIONS INCLUDED IN THE HC-ALL Pro-Cite® DATABASE

Note: This list contains many of the publications cited in the report, not included in the Literature Cited section above.

Ackerman, B. B.; F.G. Lindzey, and T. P. Hemker. 1984. Cougar food habits in southern Utah. J. Wildl. Manage. 48: 147-155.

Adams, L. G.; and J.A. Bailey, 1983. Winter forages of mountain goats in central Colorado. J. Wildl. Manage. 47: 1237- 1243.

_____, 1982 Population dynamics of mountain goats in the Sawatch Range, Colorado. J. Wildl. Manage. 46: 1003-1009.

Addison, E. M., M. J. Pybus, and H. J. Rietveld. 1978. Helminth and arthropod parasites of black bear, *Ursus americanus*, in central Ontario. Can. J. Zool. 56: 2122-2126.

Aegerter, S., and P. Messerli. 1983. The impact of hydroelectric power plants on mountainous environment: a technique for assessing environmental impacts. Mountain Res. Dev. 3:157-175

Akenson, H. A. 1992. Spatial relationships and behavior of bighorn sheep sharing a winter range with mule deer and elk in central Idaho

Alderman, J. A., P. R. Krausman, and B. D. Leopold. 1989 Diel activity of female desert bighorn sheep in western Arizona. J. Wildl. Manage. 53: 264-271.

Aldous, C. M. 1945. A winter study of mule deer in Nevada. J. Wildl. Manage. 9: 145-151.

Allen, E. O. 1968. Range use, foods, condition, and productivity of white-tailed deer in Montana. J. Wildl. Manage. 32: 130-141.

Allen, R. W. 1980. Natural mortality and debility. Pp. 172-185 in G. Monson and L. Sumner, eds. The desert bighorn: its life history, ecology, and management. The University of Arizona Press, Tucson, Arizona.

Alt, G. L., and J. J. Beecham. 1984. Reintroduction of orphaned black bear cubs into the wild. Wildl. Soc. Bull. 12: 169-174.

Alt, Gary L.; Gruttadauria, Janice M. Reuse of black bear dens in northeastern Pennsylvania. J. Wildl. Manage.. 1984; 48(1): 236-239.

Amstrup, Steven C.; Beecham, John. Activity patterns of radio-collared black bears in Idaho. J. Wildl. Manage.. 1976; 40(2): 340-348.

Anderson, Allen E.; Frary, Ladd G.; Stewart, Robert H. A comparison of three morphological attributes of mule deer from the Guadalupe and Sacramento mountains, New Mexico. Journal of Mammalogy. 1964; 45(1): 48-53.

Anderson, Allen E.; Medin, Dean E.; Bowden, David C. Mule deer numbers and shrub yield-utilization on winter range. J. Wildl. Manage.. 1972; 36(2): 571-578.

Anderson, Allen E.; Snyder, Walter A.; Brown, George W. Stomach content analyses related to condition in mule deer, Guadalupe Mountains, New Mexico. J. Wildl. Manage.. 1965; 29(2): 352-366.

Anderson, N. A. [Report]. Mountain goat study. State of Washington: State of Washington Dept. of Game; 1940. 21 pages. State of Washington Dept. of Game.

Anderson, Roy C.; Lankester, Murray W.; Strelive, Uta R. Further experimental studies of Pneumostrongylus tenuis in cervids. Can. J. Zool.. 1966; 44(5): 851-861.

Anthony, Robert G.; Smith, Norman S. Ecological relationships between mule deer and white-tailed deer in southeastern Arizona. Ecological Monographs. 1977; 47(3): 255-277.

Armleder, Harold M.; Waterhouse, Michaela J.; Keisker, Dagmar G.; Dawson, Richard J. Winter habitat use by mule deer in the central interior of British Columbia. Can. J. Zool.. 1994; 72(10): 1721-1725.

Arnett, E. B.; Irwin, L. L. (National Council of the Paper Industry for Air and Stream Improvement, Inc. (NCASI) Wildlife Program). [report]. Mountain goat/forest management relationships: a review. [unknown]: NCASI; 1989; Technical bulletin no. 562. 16 pages. NCASI.

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