IDAHO POWER
An IDACORP Company

A Habitat Survey for the Idaho Ground Squirrel

Natalie J. S. Turley
Wildlife Technician

Anthonie M. A. Holthuijzen
Wildlife Ecologist

Brett Dumas
Landscape Ecologist

Kelly D. Wilde
Wildlife Biologist

Technical Report
Appendix E.3.2-26

Hells Canyon Complex
FERC No. 1971

June 2001
Revised July 2003

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

The Idaho ground squirrel has the most restricted geographical range of any *Spermophilus* taxa and one of the smallest ranges among North American mainland mammals. On April 5, 2000, the U.S. Fish and Wildlife Service listed the northern Idaho ground squirrel (*Spermophilus brunneus bruneus*) as threatened and cited habitat loss due to forest encroachment into suitable meadow habitat as the primary threat to the species. The southern Idaho ground squirrel (*S. brunneus endemicus*) was petitioned for listing as endangered on January 26, 2001, because of dramatic declines in numbers thought to be due to conversion of big sagebrush–bunchgrass–forb associations to exotic annual-dominated grasslands.

The general objectives of this study were to 1) determine the presence and location of northern and southern Idaho ground squirrel populations along the Rim-to-Rim Reach of the Hells Canyon Complex (HCC) by employing ground surveys in habitat considered suitable to both Idaho ground squirrels; and 2) identify the presence and location of southern Idaho ground squirrel populations along transmission line rights-of-way (ROW), roads, and tower sites associated with the HCC and within potential Idaho ground squirrel habitat by conducting aerial and ground surveys.

The study area was delineated based on the intersection of three areas: the HCC Rim-to-Rim Reach, the transmission lines associated with the HCC, and the known range of the northern and southern Idaho ground squirrels. Study area evaluation indicated that the southern Idaho ground squirrel could potentially occur along the upper Brownlee Reservoir portion of the Rim-to-Rim Reach and along ROW of Lines 904 and 911, as well as the Paddock Tap Line. The range of the northern Idaho ground squirrel intersects the HCC Rim-to-Rim Reach east of Oxbow and Hells Canyon reservoirs. Potential habitat of the Idaho ground squirrel was identified by expert opinion and by ground and aerial surveys. Based on this information, potential sites for Idaho ground squirrels were first identified and then systematically surveyed on foot.

We surveyed two areas, Barber Flats (elevation 4,400 ft) and Indian Creek (3,800 ft), for northern Idaho ground squirrels. These sites contained habitats and soils similar to sites having existing populations and also had possible habitat corridors linking the sites to historic sites. At least 1 active northern Idaho ground squirrel burrow was found, and a whistle was heard at Barber Flat during surveys conducted in 1998. This site was located on a ridge above Barber Flat and was dominated by bunchgrasses including bluebunch wheatgrass (*Pseudoroegneria* [*Poa*] *spicata*). The nearest historic site to Barber Flat is about 2.4 mi (3.8 km) away at Paradise Flat. However, no active population is currently found there. The nearest active site is at Rocky Comfort Flat approximately 4.7 mi (7.6 km) distant. Thus, the Barber Flat population is isolated, and dispersal is unlikely. At Indian Creek we did not detect ground squirrel signs.

The upper end of Brownlee Reservoir and an area upstream of Brownlee Reservoir to Weiser, Idaho, were identified as potential habitat for the southern Idaho ground squirrel. Ground surveys focused on areas with deep soils, low relief, limited rock, and possible habitat corridor links to known populations to the east of the project area. We found southern Idaho ground squirrel burrows and briefly observed squirrels at the Cobb Rapids and Corral sites. Near Cobb Rapids

along the Snake River, these sites are approximately 3 mi apart. Three historic southern Idaho ground squirrel sites are located in the vicinity of Cobb Rapids. The proximity of several ground squirrel populations is promising for dispersal among sites. Both sites were dominated by gray rabbitbrush (*Chrysothamnus nauseosus*), big sagebrush (*Artemisia tridentata*), and bulbous bluegrass (*Poa bulbosa*).

We conducted an aerial survey to evaluate potential southern Idaho ground squirrel habitat along Lines 904 and 911 and the Paddock Tap Line. Key habitat features along these lines that indicated potential ground squirrel habitat included deep soils, a minor rocky substrate component, available shrub cover, gentle relief, and presence of both ground squirrel and badger (*Taxidea taxus*) burrows. Areas were rated as having high, medium, or low potential for supporting ground squirrels based on the above key habitat features. We then conducted ground surveys at sites on public land identified as having potential for supporting ground squirrels. Four southern Idaho ground squirrel populations were found along transmission lines: 3 along the Paddock Tap Line and 1 along Line 904. The habitat along transmission lines in this area is variable depending on aspect. South-facing slopes are dominated by annual grasses and forbs, primarily cheatgrass (*Bromus tectorum*) and medusahead (*Taeniatherum caput-medusae*). Cheatgrass is an acceptable food plant to ground squirrels but provides little cover, while medusahead is not consumed by the ground squirrels. The presence of medusahead is a good predictor that Idaho ground squirrels are likely absent. The more northerly exposed hillsides have much higher plant diversity and good vegetative cover composed of perennial bunchgrasses—such as bluebunch wheatgrass, Sandberg bluegrass (*Poa secunda*), and Idaho fescue (*Festuca idahoensis*)—and shrubs—such as gray rabbitbrush and big sagebrush. The 2 Idaho ground squirrel populations found on the south end of the Paddock Tap Line are primarily on north- and west-facing hillsides. The third population along this line was found just to the north at a site that includes the valley bottom and some south-facing aspects. This more northerly population appeared to have a lower density of ground squirrels. Along Line 904 the squirrel population was found in habitat rated as high quality. Here, the vegetation was classified as *Shrub Savanna* dominated by big sagebrush. Medusahead was present in the surrounding landscape but was not found near the burrows.

1. INTRODUCTION

The Idaho ground squirrel has the most restricted geographical range of any *Spermophilus* taxa and one of the smallest ranges among North American mainland mammals (Gill and Yensen 1992). The Idaho ground squirrel complex consists of two well-defined allopatric taxons that are currently classified as subspecies: the northern Idaho ground squirrel (*Spermophilus brunneus brunneus*) and the southern Idaho ground squirrel (*S. brunneus endemicus*) (Yensen 1991). Subsequent work has indicated that the two subspecies can be elevated to species level based on differences in pelage coloration, length, and texture; cranial and external morphometrics; bacula; allelic frequencies; DNA sequences; timing of the life history cycle; and behavior (Gill and Yensen 1992; Gavin et al. 1999).

Northern Idaho Ground Squirrel—The northern Idaho ground squirrel is endemic to west-central Idaho. In 1998, 36 historic and currently active sites were known in Adams and Valley counties (Federal Register, April 5, 2000 vol. 65, no. 66: 17779-17786). The geographic range is primarily between the Cuddy and Seven Devils mountains, east to New Meadows in Adams County, and south through Long Valley to Round Valley in Valley County (Figure 1). The range of the species appears to be about 300,000 ha, but the area occupied by the species is less than 500 ha (E. Yensen, Albertson College, *pers. comm.*).

Population numbers of the northern Idaho ground squirrel have steeply declined from approximately 5,000 individuals in 1985 (Yensen 1985) to 1,000 to 1,200 in 1993, 600 to 800 in 1994 (Yensen and Sherman 1997), to probably less than 350 in 2000 (Haak 2000). Populations occur at elevations ranging from 1,155 to 1,580 m in xeric montane meadows often surrounded by coniferous forests of ponderosa pine (*Pinus ponderosa*) and Douglas-fir (*Pseudotsuga menziesii*) (Yensen and Sherman 1997). These sites have a mix of deeper soils used for excavating burrows, often with a component of big sagebrush (*Artemisia tridentata*), and shallower rocky soils with low productivity, not used by Columbian ground squirrels (Dyni and Yensen 1996). The northern Idaho ground squirrel generally is out-competed by the Columbian ground squirrel (*Spermophilus columbianus*); consequently, the former species tends to occur in areas with lower site productivity than those occupied by the latter species. In the absence of Columbian ground squirrels, northern Idaho ground squirrels can inhabit lush meadows. The northern Idaho ground squirrel emerges in late March or early April and ceases above-ground activity in late July or early August.

The U.S. Fish and Wildlife Service (USFWS) listed the northern Idaho ground squirrel as threatened on April 5, 2000 (Federal Register, April 5, 2000 vol. 65, no. 66:17779-17786). The USFWS identified habitat loss due to forest encroachment into meadow habitat as the primary threat to the northern Idaho ground squirrel. Other threats to the species include competition from the larger Columbian ground squirrel, land-use changes, recreational shooting, poisoning, and natural events.

Southern Idaho Ground Squirrel—The southern Idaho ground squirrel occurs in Gem, Payette, and Washington counties in west-central Idaho (Figure 1). Yensen (1991) listed 24 localities, but subsequent fieldwork increased this number to nearly 200 as of 1999. However, many of these

sites are not currently occupied (Appendix 1). The species was originally widespread over the entire area and not restricted to discrete sites (Yensen 1991). Populations occur between 670 to 975 m in elevation on rolling hills composed of lacustrine and fluvial sediments (Yensen and Sherman 1997). Much of the vegetation within the southern Idaho ground squirrel's range has been converted from native sagebrush and bunchgrasses to exotic cheatgrass (*Bromus tectorum*) and medusahead (*Taeniatherum caput-medusae*), and this conversion is the most probable reason for the decrease in southern Idaho ground squirrel populations (Appendix 1). The presence of southern Idaho ground squirrels is weakly associated with deep soils, remnant big sagebrush in areas converted to exotic annuals, badger tunnels, and fence lines next to alfalfa (Appendix 1). The southern Idaho ground squirrel emerges in late January or early February and ceases above-ground activity in late June or early July.

The USFWS and the Idaho Department of Fish and Game (IDFG) have listed the southern Idaho ground squirrel as a species of concern. Furthermore, the USFWS has proposed to consider the southern Idaho ground squirrel a candidate species and on January 26, 2001, received a petition for listing the species as endangered.

Objectives—The general objectives of this study were to 1) determine the presence and location of northern and southern Idaho ground squirrel populations along the Rim-to-Rim Reach of the Hells Canyon Complex (HCC) by employing ground surveys in habitat considered suitable to northern and southern Idaho ground squirrels; and 2) identify the presence and location of the southern Idaho ground squirrel populations along transmission line rights-of-way (ROW), roads, and tower sites associated with the HCC within potential Idaho ground squirrel habitat by conducting aerial and ground surveys.

This study is descriptive and will assist Idaho Power Company (IPC) in meeting the Federal Energy Regulatory Commission's (FERC) requirement to describe wildlife resources of the Hells Canyon Project and its vicinity. The northern and southern Idaho ground squirrels are considered important under FERC regulations for their ecological and sensitive status qualities. This study was proposed in IPC's Formal Consultation Package for the relicensing of the Hells Canyon Project (IPC 1997). Updated study plans were made available in February 2000 (IPC 2000).

2. STUDY AREA

2.1. Location

Hells Canyon Complex Rim-to-Rim Reach—The Snake River, a major tributary to the Columbia River, is the focal point of Hells Canyon. Its generally northward flow forms part of the boundary between Idaho and Oregon. The HCC is located on the Snake River in the southern portion of Hells Canyon and includes three reservoirs—Brownlee, Oxbow, and Hells Canyon. The reach below Hells Canyon Dam is unimpounded, although the three-dam complex controls flows.

Federal agencies, including the Bureau of Land Management (BLM) and U.S. Forest Service (USFS), are responsible for managing the majority of public land in Hells Canyon. These areas fall within the jurisdictional boundaries of the Wallowa-Whitman National Forest, Oregon; Payette National Forest, Idaho; Nez Perce National Forest, Idaho; Four Rivers Field Office (FO) of the Lower Snake River District, BLM-Idaho; Cottonwood FO of the Upper Columbia-Salmon Clearwater District, BLM-Idaho; and Baker FO and Malheur FO of the Vale District, BLM-Oregon. Other agencies with natural resource jurisdiction in the greater project area include the U.S. Department of Interior (USDI) National Marine Fisheries Service, USDI Bureau of Indian Affairs, USFWS, and state agencies from Idaho and Oregon.

Transmission Lines—IPC operates and maintains ROW on about 702 mi (1,130 km) of transmission lines and service roads associated with the HCC (Table 1). These rights-of-way extend from southeastern Idaho west across the Snake River Plain and northwest to Enterprise, Oregon. The transmission-line rights-of-way considered for this study were limited to public lands under the jurisdiction of state or federal authorities. About 357 mi (575 km) of the transmission lines occur on public lands in Idaho and Oregon.

Nearly 50% of the 702 mi (1,130 km) of transmission lines included in the study area occur on private lands and are thus outside the scope of this study. The other 50% occur on public lands under the jurisdiction of either state or federal governments. Five percent of the study area is on State of Idaho land, while less than 1% is on State of Oregon land. Of the area on federal land, 37% is under the jurisdiction of the BLM, and 8% is under the jurisdiction of the USFS. Fewer than 1% of the transmission lines cross USDI Bureau of Reclamation jurisdictional land.

The study area was delineated based on the intersection of three areas: the Rim-to-Rim Reach of the HCC, the transmission lines associated with the HCC, and the known ranges of the northern and southern Idaho ground squirrels (Figure 1). The distributional ranges for the two ground squirrels were mapped by connecting the outermost known historical and existing localities (Haak 1999, 2000; Yensen and Haak 2000) to form polygons. This resulting map suggested that northern Idaho ground squirrel habitat could be present along the rim above Oxbow and Hells Canyon reservoirs (Figure 1). Southern Idaho ground squirrel habitat could be present between the upper reach of Brownlee Reservoir and Weiser (Figure 1). Three transmission lines were shown to pass through habitat likely occupied by the southern Idaho ground squirrel: Lines 904 and 911 and the Paddock Tap, a line running between the Paddock substation and the town of Ontario (Figure 1).

2.2. Physiography

Hells Canyon Complex Rim-to-Rim Reach—Hells Canyon is the deepest and one of the most rugged river gorges in the continental United States. It ranges between 2,000 and 3,000 ft deep from Weiser to Oxbow Dam. Below Oxbow Dam, the river enters a narrow, steep-sided chasm measuring up to 5,500 ft deep. The elevation of the Snake River near Weiser is about 2,090 ft msl, descending to about 910 ft msl at the confluence of the Salmon River approximately 59 mi below Hells Canyon Dam. Throughout the canyon, topography is generally steep and broken, with slopes often dominated by rock outcrops and talus slopes. At the deepest points of the canyon, the walls rise almost vertically. Canyon walls are deeply dissected by

numerous side canyons with tributaries to the Snake River. The Seven Devils Mountains to the east and the Wallowa Mountains to the west form the upper reaches of the canyon. These mountains form a series of jagged peaks reaching almost 10,000 ft and having subalpine and alpine conditions to the west (USDA 1990).

Transmission Lines—The Paddock Tap Line and Lines 904 and 911 pass through more gentle, sloping terrain; river valleys; and the northern part of the Snake River Plain.

2.3. Land Features and Geology

Hells Canyon Complex Rim-to-Rim Reach—Hells Canyon consists of a series of folded and faulted metamorphosed sediments and volcanics overlain unconformably by nearly horizontal flows of Columbia River basalt. This basalt group covered much of eastern Washington, northern Oregon, and adjacent parts of Idaho (Bush and Seward 1992). The older rocks in the series are Permian to Jurassic in age and represent at least two episodes of island arc volcanism and adjacent marine sedimentation similar to that found today in the Aleutian Islands west of Alaska. These rock units represent old island arc chains that were sequentially "welded" to the west coast of North America during the late Paleozoic and early- to mid-Mesozoic eras by subduction of a tectonic plate beneath the North American continental tectonic plate (Asherin and Claar 1976; USDA 1994).

In more recent geologic time, Hells Canyon was formed through erosion by the Snake River of the Blue Mountains in Oregon and Seven Devils Mountains in Idaho (DOE 1985). The Snake River has existed since the Pliocene and probably cut to its present level during the Pleistocene. During the Pleistocene, glacial meltwater provided abundant runoff for down-cutting, while regional uplifting created weak points in the 2,000- to 3,000-foot-thick basalt plateau that overlaid the Blue and Seven Devils mountains. Resulting erosion formed the currently observed drainage pattern that established the Snake River (DOE 1985). Northeast-trending, high-angle fault patterns characterize the extensive Snake River fault system running throughout the study area (Fitzgerald 1982).

Besides basalt, other rock types are also present within the study area. Extensive limestone outcrops are found in some tributary drainage areas, and local granitic outcrops also occur.

Transmission Lines—Extending southeast from Hells Canyon to about Weiser, the transmission-line corridor passes through a mixture of Columbia Plateau basalts and sediments from ancient lakes that were impounded behind the lava flows. Further to the southeast, the geology of the corridor begins grading into the geology of the western Snake River Plain, a basin and range fault block that trends northwest from Twin Falls and that is distinct from the Snake River Plain. The western Snake River Plain fault block filled with white rhyolite ash, black basalt lava flows, and an assortment of valley-fill sediments as it dropped between faults.

2.4. Soils

The soils throughout Hells Canyon are derived primarily from Columbia River basalt, covered in most areas with a thin mantle of residual soils from weathered native rock. Isolated areas contain deposits of windblown silt. Unconsolidated materials include river sands and gravel deposited during the Bonneville floods 15,000 years ago, ash-loess from the Mount Mazama eruption 6,900 years ago, and colluvium and talus deposited more recently. The amount of soil cover declines northward through Hells Canyon. Near Hells Canyon Dam (river mile [RM] 247), most rock faces are nearly vertical with little soil cover (USDA 1994).

Most soil complexes are well drained and vary from very shallow to moderately deep. Loams are the dominant textural class and vary from very stony to silty, often with a clay subsoil component (NRCS 1995).

2.5. Climate

The study area is characterized by cool to cold, moist winters and hot, dry summers. The rain shadow effect of the Cascade Mountain Range blocks Pacific moisture and causes the semiarid climate of the region. The varied topography and geographic position of the study area further create variable climatic conditions. Typically, over 80% of the yearly precipitation comes between October and May (WRCC 1998).

Average annual precipitation is lowest at the southern end of the study area (Weiser, 286 mm), increases northward (Richland, 298 mm), and peaks around Brownlee Dam (445 mm) (Figure 2). The average annual precipitation ranges from about 380 to 500 mm (15 to 20 inches) depending on elevation. Nearly 45% of the average annual precipitation at Brownlee Dam (445 mm [17.8 inches]) falls from November through January; this percentage strongly contrasts with the 9% average recorded for July through September. Thus, most precipitation occurs in spring and winter (Tisdale et al. 1969; Tisdale 1986; Johnson and Simon 1987), and little or no precipitation falls during the hottest months of summer. Average annual evapotranspiration is estimated to be about 1300 mm (52 inches).

Mean annual temperatures are similar among the three weather stations (Figure 2). Generally, the climate tends to become drier and warmer downstream of Brownlee Dam. Climatological information from Brownlee Dam (RM 284.6) is probably characteristic of the central section of the study area. The canyon bottom area is dry with seasonal temperatures ranging from lows of about –5 ºC in January to highs of about 35 ºC in July (Figure 2). Temperatures below freezing are normally experienced from mid-November through mid-April. As a rule, winters in the canyons are mild, while summers on the canyon floor may be hot. Mean temperatures above 2,000 m (6,562 ft msl) range from –9 ºC in January to 13 ºC in July. By contrast, mean temperatures below 1,000 m (3,281 ft msl) range from 0 ºC in January to between 28 ºC and 33 ºC in July (Johnson and Simon 1987).

2.6. Vegetation

Hells Canyon Complex Rim-to-Rim Reach—Two main vegetation types can be identified in the study area: herbaceous- and shrub-dominated.

Herbaceous-Dominated Vegetation Types—The dry climate and typically stony, shallow soils of the canyon have favored development of grassland steppe communities at the lower and middle elevations (Tisdale 1979, 1986). Commonly occurring grass species in the study area include bunchgrasses such as bluebunch wheatgrass (*Pseudoroegneria* [*Poa*] *spicata*), Sandberg bluegrass (*Poa secunda*), and Idaho fescue (*Festuca idahoensis*) (Garrison et al. 1977; BPA 1984, Tisdale 1986; Franklin and Dyrness 1988). Sand dropseed (*Sporobolus cryptandrus*) and red threeawn (*Aristida longiseta*) are also common and, at times, dominant (BPA 1984; Tisdale 1986).

Habitat types in which bluebunch wheatgrass is dominant occur throughout the Rim-to-Rim Reach and occupy over half of its grassland area (Tisdale 1986). Bluebunch wheatgrass flourishes on deep, loamy soils but adapts to coarser and shallower soils as well. Generally, it is associated with Idaho fescue on deeper soils and with Sandberg bluegrass on shallower soils.

In upland habitats, the most common upland weed is cheatgrass (Holmstead 2001). This species can significantly alter native rangeland vegetation composition through competitive exclusion of native species reproduction and the facilitation of wildfires. Other widespread introduced upland species include medusahead (listed noxious in Oregon) and bulbous bluegrass (*Poa bulbosa*) (Holmstead 2001). These annual graminoids have probably been introduced and spread in the canyon by a number of vectors (e.g., livestock grazing, mining, homesteading, recreation). Medusahead is a serious threat to upland assemblages in the canyon. Not only can it can take over sites previously dominated by weeds such as cheatgrass, but it is also capable of establishing and maintaining itself in diverse communities of native perennial plants (Miller 1996).

Shrub-Dominated Vegetation Types—Shrub species comprise a large segment of the canyon's overall vegetation composition. Shrub-steppe vegetation types occur at mid-elevations in the Rim-to-Rim Reach, especially in the southern region. For example, big sagebrush is a dominant species in the southern sector of the study area, particularly in the area around Brownlee Reservoir (BPA 1984, Holmstead 2001). Commonly occurring shrubs include big sagebrush, antelope bitterbrush (*Purshia tridentata*), netleaf hackberry (*Celtis reticulata*), serviceberry (*Amelanchier alnifolia*), and bitter cherry (*Prunus emarginata*) (BPA 1984; Tisdale 1986). Other species of sagebrush are also present, including low sagebrush (*Artemisia arbuscula*), stiff sagebrush (*Artemisia rigida*), and silver sagebrush (*Artemisia cana*) (Tisdale and Hironaka 1981; Franklin and Dyrness 1988). For the most part, sagebrush stands are limited to the area around Brownlee Reservoir. In these stands, the herbaceous layer is dominated by Sandberg bluegrass and cheatgrass, with a variety of forbs also occurring.

Transmission Lines—Shrub-steppe and herbaceous grassland vegetation types dominate the transmission-line corridor, with each type accounting for about 40% of the area, or totaling 80%. Prominent herbaceous species include bluebunch wheatgrass, Idaho fescue, and cheatgrass. Shrub species common to the area include antelope bitterbrush and various types of sagebrush

(*Artemisia* spp.) and rabbitbrush (*Chrysothamnus* spp.). Coniferous forest, composed of ponderosa pine, Douglas-fir, and grand fir (*Abies grandis*), is primarily limited to the Wallowa Mountains in Oregon, encompassing about 5% of the study area. Agricultural land, occurring on about 10% of the study area, is concentrated along the eastern part of the Snake River Plain. About 1% of the area supports riparian or wetland vegetation types.

2.7. Land Use

The study area and vicinity are still dominated by the land-use patterns established at the turn of the previous century: irrigated and nonirrigated agriculture, livestock grazing, mining, large areas of open space, scattered rural development, and rapidly growing recreational activities. The bottomlands adjacent to the reservoirs are generally used for grazing, with some farming and recreation. Since construction of the HCC, most anthropogenic influences have occurred above Hells Canyon Dam. This portion of the study area is more easily accessible for livestock operations, recreation, and other human activities (e.g., farming and residential pursuits) than is the reach below Hells Canyon Dam (Blair et al. 2001). Well before the 1950s, significant disturbances occurred upstream of the Hells Canyon Dam area (Blair et al. 2001). In the upstream watershed, mining, logging, and especially livestock grazing were pronounced. The relatively moderate hill slopes from the headwaters of Brownlee Reservoir downstream to about Brownlee Dam are more accessible to livestock grazing today and in the past than are the steeper, rocky slopes more characteristic of Oxbow and Hells Canyon reservoirs.

3. PLANT OPERATIONS

Hells Canyon, on the Oregon–Idaho border, is the deepest canyon in North America and home to IPC's largest hydroelectric generating complex, the HCC. The HCC includes the Brownlee, Oxbow, and Hells Canyon dams, reservoirs, and power plants. Operations of the three projects of the complex are closely coordinated to generate electricity and to serve many other public purposes.

IPC operates the complex to comply with the FERC license, as well as to accommodate other concerns, such as recreational use, environmental conditions and voluntary arrangements. Among these arrangements are the 1980 Hells Canyon Settlement Agreement, the *Fall Chinook Recovery Plan* adopted in 1991, and, between 1995 and 2001, the cooperative arrangement that IPC had with federal interests in implementing portions of the Federal Columbia River Power System (FCRPS) biological opinion flow augmentation, which is intended to avoid jeopardy of the FCRPS operations below the HCC.

Brownlee Reservoir is the only one of the three HCC facilities—and IPC's only project—with significant storage. It has 101 vertical feet of active storage capacity, which equals approximately 1 million acre-feet of water. On the other hand, Oxbow and Hells Canyon reservoirs have significantly smaller active storage capacities—approximately 0.5 and 1.0% of Brownlee Reservoir's volume, respectively.

Brownlee Dam's hydraulic capacity is also the largest of the three projects. Its powerhouse capacity is approximately 35,000 cubic feet per second (cfs), while the Oxbow and Hells Canyon powerhouses have hydraulic capacities of 28,000 and 30,500 cfs, respectively.

Target elevations for Brownlee Reservoir define the flow through the HCC. However, when flows exceed powerhouse capacity for any of the projects, water is released over the spillways at those projects. When flows through the HCC are below hydraulic capacity, all three projects operate closely together to re-regulate flows through the Oxbow and Hells Canyon projects so that they remain within the 1-foot per hour ramp rate requirement (measured at Johnson Bar below Hells Canyon Dam) and meet daily peak load demands.

In addition to maintaining the ramp rate, IPC maintains minimum flow rates in the Snake River downstream of Hells Canyon Dam. These minimum flow rates are for navigation purposes and IPC's compliance with article 43 of the existing license. Neither the Brownlee Project nor the Oxbow Project has a minimum flow requirement below its powerhouse. However, because of the Oxbow Project's unique configuration, a flow of 100 cfs is maintained through the bypassed reach of the Snake River below the dam (a segment called the Oxbow Bypass).

4. METHODS

4.1. Site Selection

4.1.1. Hells Canyon Complex Rim-to-Rim Reach

Northern Idaho Ground Squirrel—Dr. Eric Yensen, Albertson College of Idaho, provided information on the habitat requirements of the northern Idaho ground squirrel. We intended to use any existing spatial information (e.g., about soils, vegetation cover types, elevation, and aspect) provided to us to develop a potential distribution map of this Idaho ground squirrel for Adams and Valley counties. With the resulting map, we would develop a survey design to search for Idaho ground squirrels at potentially suitable sites. However, the parameters used to delineate potential ground squirrel habitat were too broad, and consequently, the potential distribution map was not sufficiently detailed to be useful for planning purposes. In the absence of a suitable map of potential distribution, we conducted field surveys at sites that were considered suitable based on Dr. Yensen's oral description of Idaho ground squirrel habitat. We used three criteria to select survey sites. First, the potential sites had to fit the description of habitat provided by Dr. Yensen. Second, the sites had to be near either currently existing or historic Idaho ground squirrel sites. Third, only sites within the study area, delineated by intersecting the HCC Rim-to-Rim Reach and the distributional range of the northern Idaho ground squirrel, were considered. Based on these descriptions, we selected two sites: Indian Creek (3,800 ft) and Barber Flats (4,400 ft) (Figure 3). Besides having habitats and soils similar to known sites used by squirrel populations, these sites are near existing colonies (Cuprum and Rocky Comfort Flat, respectively). Barber Flat is owned by IPC and surrounded by USFS (Payette National Forest) and privately owned

lands (OX Ranch); the area also has possible habitat corridors linking the sites to historic populations.

Southern Idaho Ground Squirrel—The upper end of Brownlee Reservoir and upstream of Brownlee Reservoir to Weiser were identified as areas having potential habitat for the southern Idaho ground squirrel (Figure 1). We identified areas with deep soils, low relief, limited rock amount, and possible habitat corridors to known southern Idaho ground squirrel populations east of the HCC (e.g., Henley Basin, Weiser area, and Midvale area). We then conducted ground surveys for southern Idaho ground squirrels in these identified areas.

4.1.2. Transmission Lines

IPC consulted with Dr. Yensen to develop an appropriate survey methodology for the southern Idaho ground squirrel along transmission line corridors, roads, and tower sites associated with the HCC (Appendix 1). Most of the known southern Idaho ground squirrel populations occur in a roughly triangular area between Emmett, Payette, and Henley Basin, which is northwest of Weiser (Figure 1). Southwest of Line 904, this portion of the range runs from Midvale Hill in a southeastern direction to the southern base of Squaw Butte north of Emmett. The transmission corridor that runs from Paddock Junction to Ontario, Oregon, is the only line that crosses this area. However, there are also 4 southern Idaho ground squirrel records northeast of this area. Reconnaissance surveys indicated that suitable habitat for the southern Idaho ground squirrel exists in this region that is crossed by two transmission lines (Lines 904 and 911). This area had not been searched intensively for southern Idaho ground squirrels, but some isolated populations were expected (Appendix 1). Therefore, ROW, service roads, and transmission line tower sites associated with the Paddock Tap Line and Lines 904 and 911, located on public lands, were evaluated.

In February 2000, Dr. Yensen accompanied IPC personnel on an aerial survey to evaluate potential southern Idaho ground squirrel habitat along the identified transmission lines. Key habitat features searched for included deep soils, minor component rocky substrate, shrub cover, gentle relief, and presence of both ground squirrel and badger burrows. Badgers are the principal predator of the Idaho ground squirrel, and concentration of badger burrows indicates ground squirrel presence. We delineated areas as having high, medium, or low suitability for ground squirrels.

4.2. Survey Protocol

4.2.1. Hells Canyon Complex Rim-to-Rim Reach

Identification of Idaho Ground Squirrel Populations—Dr. Yensen trained IPC observers to determine ground squirrel presence based on signs such as burrows, feces, and alarm calls. Many signs of Idaho ground squirrels are relatively inconspicuous. The species does not make obvious mounds; instead, soil is scattered as it is brought to the surface (Yensen and Sherman 1997). Burrow openings are generally small and inconspicuous early in the season but later enlarged. Burrow openings average 6.3 cm wide and 5.4 cm tall (Yensen 1991). Idaho ground squirrel

droppings, however, are distinctive and can be identified reliably by trained observers. Also, the squirrel's alarm calls are distinctive and have been described as high-pitched ventriloquial whistles (Yensen and Sherman 1997). We considered a combination of these signs indicative of the squirrel's presence at a surveyed site.

The Columbian ground squirrel is the only species that could be confused with the southern Idaho ground squirrel. Columbian ground squirrels are generally larger, have a rusty reddish throat, and have a longer, frosted tail than the southern Idaho ground squirrel's short stiff tail (Appendix 1).

At high population densities, the Idaho ground squirrel is readily observed, but detecting it may be difficult when population density is low. On foot, we systematically searched areas containing suitable habitat, looking for burrows or other signs of ground squirrel activity.

Timing of Surveys—From April through early July 1998, we surveyed on foot 2 areas identified as having high potential for presence of northern Idaho ground squirrels: Indian Creek on April 7 and Barber Flat from June 29 to July 1 (Figure 3). The same year, we conducted surveys for the southern Idaho ground squirrel on the upper end of Brownlee Reservoir near Cobb Rapids (April 16 and June 2–4) and Trail Creek (April 14). We also surveyed 1 area away from the reservoir; namely, Henley Basin (April 14) (Figure 4).

All areas surveyed were delineated on topographic maps and digitized using ARC-VIEW©, a Geographical Information System (GIS).

4.2.2. Transmission Lines

We followed aerial surveys with ground surveys on public land in areas identified as having potential for occupation by southern Idaho ground squirrels. Ground squirrel signs used to identify areas occupied included active and inactive burrows, scat, and calls. IPC personnel accompanied by Dr. Yensen visited several known population sites to become familiar with the species and observe signs of their presence.

Our field surveys were initiated in early April and continued into late July 2000. Surveys were conducted on all service roads and transmission line tower sites located on public land. The area surveyed consisted of a 50-m-wide corridor centered on the roads and towers. We surveyed a total of 16.5 linear miles of service roads and 38 tower sites. Searches for ground squirrels consisted of hiking the corridor in a systematic search pattern while listening for calls and watching for activity and signs that would indicate their presence, such as burrows, runways, and scat under bunchgrasses and shrubs. Areas on public land with a high potential for ground squirrel presence were searched more intensely and frequently than areas with a medium or low rating.

5. RESULTS

5.1. Hells Canyon Complex Rim-to-Rim Reach

Northern Idaho Ground Squirrel—At Barber Flat during surveys conducted in 1998, we found 1 active burrow system, and we heard a whistle (Figure 3). These burrows have not been confirmed, but signs were consistent with northern Idaho ground squirrel burrow characteristics. This site was located on a ridge above Barber Flat and was dominated by bunchgrasses, including bluebunch wheatgrass. At the area surveyed near Indian Creek, we detected no signs of the northern Idaho ground squirrel.

Southern Idaho Ground Squirrel—We observed southern Idaho ground squirrel burrows and squirrels at the Cobb Rapids and Corral localities. These sites are approximately 3 mi apart and near Cobb Rapids (Figure 4). Dr. Yensen visited these sites in March 2000 and verified that burrows were those of the southern Idaho ground squirrel. The Cobb Rapids site has flat topography; the dominant shrub is rabbitbrush, with a limited cover of big sagebrush. The dominant grass was bulbous bluegrass, and the dominant forb was redstem stork's bill (*Erodium cicutarium*). The site was lightly grazed. Many of the burrows were found in the cutbanks above and below an abandoned roadbed passing through the site. Pocket gophers were present in the area, and badger digs were common. About 20 to 30 burrow systems were observed, most of which did not appear to be active. Scat and a couple of aboveground tunnels indicated that voles were using some of the burrows. Many of the burrows had vegetation growing in their entrances or had begun to fill in with soil. At the Corral site, the dominant shrub was big sagebrush, with a minor rabbitbrush component. The understory was dominated by cheatgrass and bulbous bluegrass, with a minor component of Sandberg bluegrass and bluebunch wheatgrass. Forbs included redstem stork's bill and longleaf phlox (*Phlox longifolia*). This site was on a moderately steep slope, but most burrows were located near the road at the base of the slope. Ten to 15 burrows were found, but many appeared inactive.

5.2. Transmission Lines

Aerial Surveys—Results of the aerial survey indicated that 9.8 mi (15.8 km) of the Paddock Tap ROW provide high-quality potential habitat for southern Idaho ground squirrels (Table 2). However, much of this habitat is on private land, but we restricted our ground surveys to the public lands, which contained 2.4 mi (3.9 km, as measured by linear miles associated with the transmission line) of high-potential habitat, 2.8 mi (4.5 km) of medium-potential habitat, and 3.4 mi (5.5 km) of low or poor habitat for ground squirrels (Table 2). The highest-quality habitat is found on the southern end of the Paddock Tap Line near Payette (Figure 5).

Lines 904 and 911 had very little high-quality habitat for Idaho ground squirrels (0.5 mi [0.8 km] and 0.4 mi [0.6 km], respectively, on public land) (Table 2). The ROW of Line 904 was considered mostly low-quality habitat (13.1 mi [21.1 km]), with some medium-quality habitat (4.5 mi [7.2 km]). Most of Line 911 was of medium-quality habitat (10.1 mi [16.2 km]) and low-quality habitat (8.6 mi [13.8 km]).

Ground Surveys—Four southern Idaho ground squirrel populations were found along the surveyed transmission lines: 3 along the Paddock Tap Line and 1 along Line 904 (Figure 5). The 3 populations along the Paddock Tap Line occur in high-quality habitat at the southwest end of the line in the vicinity of the Payette landfill and the Clay Peak motorcycle park. The 2 most southerly of these 3 populations are primarily on north- and west-facing hillsides. The third population occurs just to the north, and its site includes the valley bottom and some south-facing aspects. This more northerly population appeared to have a lower density of ground squirrels. These 3 populations occur on approximately 115 ha. We estimated the first site, at the south end of the Paddock Tap, to cover 8.9 ha. The second site, located just to the north, covers 51.8 ha. The third and most northerly site was estimated at 5.4 ha. However, this latter site was mapped with much less precision than the first two, and its area may have been overestimated.

The population along Line 904 was found near Bissel Creek in high-quality habitat (Figure 5). The cover type at this site was classified as *Shrub Savanna* dominated by big sagebrush. Medusahead was present in the surrounding landscape but was not found near the burrows. We estimated this site at 1 ha.

6. DISCUSSION

6.1. Hells Canyon Complex Rim-to-Rim Reach

Northern Idaho Ground Squirrel—The northern Idaho ground squirrel is primarily threatened by habitat loss due to forest encroachment into formerly suitable meadow habitats. This encroachment fragments habitat, limiting dispersal corridors and restricting the species to small, isolated habitat areas (Federal Register, April 5, 2000 vol. 65, no.66:17779-17786). The northern Idaho ground squirrel burrows that we found near Barber Flat are of a previously unknown population. The nearest historic site to Barber Flat is about 2.4 mi (3.8 km) away at Paradise Flat. However, no active population is currently found there. The nearest active site is at Rocky Comfort Flat, approximately 4.7 mi (7.6 km) distant. Researchers have reported dispersal distances of greater than 1 km for various ground squirrels of both sexes (Olson 2001). However, 8 years of mark-recapture studies on the northern Idaho ground squirrel indicate that individuals typically disperse 20 to 200 m, and no movements greater than 1 km from natal burrows have been recorded (Gavin et al. 1999). Thus, the Barber Flat population appears isolated, and dispersal to known existing or historic sites is unlikely.

Other factors threatening the northern Idaho ground squirrel include competitive exclusion from the Columbian ground squirrel, land-use changes, recreational shooting, poisoning, and naturally occurring events (Federal Register, April 5, 2000 vol. 65, no.66:17779-17786). Northern Idaho ground squirrels found at Barber Flat are not located near improved roads; therefore, risks from recreational shooting appear minimal. Poisoning and land-use changes are also not a current threat to ground squirrels at Barber Flat. Unfortunately, a very small population was found in 1998 (i.e., 1 active burrow), and the population may be at high risk of extinction.

In 1997, a northern Idaho ground squirrel joint research project was initiated between Payette National Forest, the USFWS, the IDFG, Albertson College of Idaho, Cornell University, and the OX Ranch. In 1999, the Western Federal Lands Highway Division of the Federal Highway Administration became involved because of proposed improvement and paving of approximately 18 mi (29 km) of the Council–Cuprum Road, which crosses known ground squirrel habitat. Population monitoring was conducted at 8 sites in 1999 and 6 sites in 2000. As at Barber Flat, low population numbers were generally found at all surveyed sites. In 2000, the total northern Idaho ground squirrel population was estimated at less than 350 individuals (Haak 2000). Habitat improvements initiated by the joint project in the late 1990s include thinning and burning of potential Idaho ground squirrel habitat. Other modifications include construction of rock jacks (a cylinder of heavy wire mesh filled with stacks of native rock) and brush piles; these may provide cover and shelter for ground squirrels to improve their dispersal success (Haak 2000). Supplemental feeding has been suggested as a short-term intervention until long-term habitat restoration can be accomplished (Runge et al. 2001).

Southern Idaho Ground Squirrel—The southern Idaho ground squirrel was petitioned for listing as endangered because of dramatic declines in numbers that may be related to conversion of big sagebrush–bunchgrass–forb associations to exotic annual-dominated grasslands. Two common exotic species, cheatgrass and medusahead, have highly variable annual productivity but do not provide a stable food source for ground squirrels (Yensen et al. 1992); squirrels do not consume medusahead. Along Brownlee Reservoir, cheatgrass is the most common grass species, occurring throughout the reach (Holmstead 2001). Medusahead is also common along the Brownlee Reach. Introduced from Eurasia, medusahead is an aggressive winter annual grass, predominant on millions of acres of semiarid rangeland in the Pacific Northwest (Whitson et al. 1992), and a poor-quality food source for wildlife species (Savage et al. 1969). It is also extremely competitive, even crowding out such undesirable species as cheatgrass.

Both newly discovered sites—Cobb Rapids and Corral—occupied by the southern Idaho ground squirrel were dominated by bulbous bluegrass. Studies of the northern Idaho ground squirrel indicate that grasses (primarily bulbous bluegrass, needlegrass [*Stipa*] seeds, and meadow brome [*Bromus commutatus*]), dicot seeds, roots, and bulbs compose much of the species' diet (Dyni and Yensen 1996). The bulblets of bulbous bluegrass are also likely an important food source for the southern Idaho ground squirrel.

Yensen (Appendix 1) suggested that the distribution of the southern Idaho ground squirrel is weakly associated with remnant big sagebrush in areas converted to exotic annuals and with badger digs, deep soils, and fencelines next to alfalfa fields. This characterization was consistent with ground squirrel populations found near Cobb Rapids.

Three historic southern Idaho ground squirrel sites are located in the vicinity of Cobb Rapids. All 3 sites were discovered in 1980. In 2000, two of these sites had confirmed ground squirrel presence while the remaining site was unconfirmed. One of the confirmed sites was approximately 0.5 mi (0.8 km) upstream of the newly discovered Corral site and the other about 0.75 mi (1.2 km) upstream of the newly discovered Cobb Rapids site. The unconfirmed site was approximately 0.5 mi upstream of the Cobb Rapids site. The relatively close proximity of several populations is promising for ground squirrel dispersal among sites and the longtime persistence of this meta-population. However, abundant badger digs in the area suggests that badgers are

likely putting pressure on these populations. Badgers prey on nursing young and also dig out many burrows just after seasonal immergence of the squirrels (Yensen and Sherman 1997). One badger working a small population could potentially extirpate it from a site (Haak 2000). Other factors potentially threatening southern Idaho ground squirrel populations are probably similar to threats identified for the northern Idaho ground squirrel, such as land-use changes, recreational shooting, poisoning, and naturally occurring events. The Cobb Rapids and Corral colonies are adjacent to a road; therefore, recreational shooting might occur. However, given current low population levels, shooting is probably only a minor problem for these colonies because squirrels are unlikely to be detected by passersby.

6.2. Transmission Lines

The 3 southern Idaho ground squirrel populations recorded along the Paddock Tap Line are near each other and other known populations. The 1 population located along Line 904 is approximately 1.5 mi (2.5 km) from a known population and may be part of a larger, continuous population in this area.

The habitat along transmission lines is quite variable, depending on aspect. Annual grasses and forbs, primarily cheatgrass and medusahead, dominate the south-facing slopes. Cheatgrass is an acceptable food plant but provides little cover; medusahead is not consumed by the ground squirrels and is an indication of poor habitat potential for the Idaho ground squirrel. Hillsides with a northerly aspect generally have good vegetative cover composed of perennial bunchgrasses—such as bluebunch wheatgrass, Sandberg bluegrass, and Idaho fescue—and shrubs—such as gray rabbitbrush and big sagebrush. Two southern Idaho ground squirrel populations found on the south end of the Paddock Tap Line are present on primarily north- and west-facing hillsides. The third population was found just to the north at a site including a valley bottom and hills with south-facing aspects. This more northerly population appeared to have a lower population density.

As of 1999, nearly 200 southern Idaho ground squirrel sites had been identified; however, many of these sites are not currently occupied (Appendix 1). Ground squirrel surveys on BLM land in 2000 indicated that 1) low populations existed at all sites and 2) the ratio of occupied habitat to area searched was low (Yensen and Haak 2000). Poor range condition was recorded at most sites. Declines in numbers of southern Idaho ground squirrels are thought to be related to conversion of big sagebrush–bunchgrass–forb associations to exotic annual-dominated grasslands. More specifically, Prescott and Yensen (1999) suggest that a negative relationship exists between medusahead and ground squirrel densities.

7. SUMMARY AND CONCLUSIONS

The general objectives of this study were to 1) determine the presence and location of northern and southern Idaho ground squirrel populations along the Rim-to-Rim Reach of the HCC by employing ground surveys in habitat considered suitable to northern and southern Idaho ground squirrels; and 2) identify the presence and location of southern Idaho ground squirrel populations

along transmission line ROW, roads, and tower sites associated with the HCC in potential Idaho ground squirrel habitat by conducting aerial and ground surveys.

The study area was delineated from the intersection of three areas: the known range of the northern and southern Idaho ground squirrels, the Rim-to-Rim Reach of the HCC, and the transmission lines associated with the HCC. Study area evaluation indicated that the southern Idaho ground squirrel could potentially occur along the upper Brownlee portion of the Rim-to-Rim Reach and along the ROW of Lines 904 and 911 and the Paddock Tap Line. The range of the northern Idaho ground squirrel intersects the Rim-to-Rim Reach east of Oxbow and Hells Canyon reservoirs. Potential habitat of the Idaho ground squirrel was identified by expert opinion and by ground and aerial surveys. From the survey findings, we identified potential sites for Idaho ground squirrels and systematically surveyed those areas on foot.

We surveyed for the northern Idaho ground squirrel at two areas: Indian Creek (elevation 3,800 ft) and Barber Flats (4,400 ft). These sites contained habitats and soils similar to sites having existing squirrel populations and also had possible habitat corridors linking to historic populations. During surveys conducted in 1998, at least 1 active northern Idaho ground squirrel burrow was found at Barber Flat. This site was on a ridge above Barber Flat and was dominated by bunchgrasses, including bluebunch wheatgrass. In the area surveyed near Indian Creek, no ground squirrel signs were found.

We surveyed for southern Idaho ground squirrels at the upper end of Brownlee Reservoir and upstream of Brownlee Reservoir to Weiser. Ground surveys focused on areas with deep soils, low relief, limited rock, and possible habitat corridor links to known populations to the east of the project area. We observed southern Idaho ground squirrel burrows and had brief sightings of squirrels at two sites, Cobb Rapids and Corral, which are approximately 3 mi apart near Cobb Rapids along the Snake River. Three historic southern Idaho ground squirrel sites are located in the vicinity of Cobb Rapids. The proximity of several populations is promising for dispersal among sites. Both sites were dominated by rabbitbrush, big sagebrush, and bulbous bluegrass.

We conducted an aerial survey to evaluate potential southern Idaho ground squirrel habitat along transmission lines in the study area. Areas were rated on key habitat features as having high-, medium-, or low-potential for supporting the ground squirrels. The aerial survey was followed by ground surveys at sites identified as having potential for ground squirrel occupation. Four southern Idaho ground squirrel populations were found along transmission lines: 3 along the Paddock Tap Line and 1 along Line 904. The habitat along transmission lines in this area is quite variable, depending on aspect. On south-facing slopes, annual grasses and forbs, primarily cheatgrass and medusahead, dominate. Cheatgrass is an acceptable food plant to Idaho ground squirrels but provides little cover; medusahead is not consumed by the ground squirrels and is an indicator of the absence of the Idaho ground squirrel. The more northerly exposed hillsides have good vegetative cover of perennial bunchgrasses—such as bluebunch wheatgrass, Sandberg bluegrass, and Idaho fescue—and shrubs—such as gray rabbitbrush and big sagebrush. The two ground squirrel populations found on the south end of the Paddock Tap Line are primarily on north- and west-facing hillsides. The third population, found just to the north, occupies a valley bottom and a hill with south-facing aspects. This more northerly population appeared to have a lower population density. The squirrel population along Line 904 was found in a *Shrub Savanna* cover type dominated by big sagebrush. Medusahead was present in the surrounding landscape

but was not found near the burrows. Declines in numbers of southern Idaho ground squirrels may be due to conversion of big sagebrush–bunchgrass–forb associations to exotic annual-dominated grasslands. Prescott and Yensen (1999) suggested that a negative relationship exists between medusahead presence and Idaho ground squirrel densities.

8. ACKNOWLEDGMENTS

Thanks go to Aaron Utz and Pat Aldrich for conducting ground squirrel surveys. Thanks also go to Sam Adams and Sonny Cabbage for GIS support. Pam Peterson edited the draft manuscript. Corporate Publishing, IPC, formatted the manuscript.

9. LITERATURE CITED

Asherin, D. A., and J. J. Claar. 1976. Inventory of riparian habitats and associated wildlife along the Columbia and Snake Rivers. Volume IIIA. College of Forestry, Wildlife and Range Sciences, University of Idaho, Moscow, ID, USA. 556 p.

Blair, C., J. Braatne, R. Simons, S. Rood, and B. Wilson. 2001. Effects of constructing and operating the Hells Canyon Complex on wildlife habitat. Technical Report E.3.2-44 *in* License application for the Hells Canyon Complex. Idaho Power Company, Boise, ID, USA.

Bonneville Power Administration. 1984. Hells Canyon environmental investigation. Prepared by CH2M-Hill, Boise, ID, USA.

Bush, J. H., and W. P. Seward. 1992. Geologic field guide to the Columbia River Basalt, northern Idaho and southeastern Washington. Information Circular 49. Idaho Geological Survey, University of Idaho, Moscow, ID. 35 p.

Department of Energy [DOE]. 1985. Hells Canyon environmental investigation. Final report. U.S. Department of Energy, Bonneville Power Administration, Office of Power and Resource Management. DOE/BP-11548-1.

Dyni, E. J., and E. Yensen. 1996. Dietary similarity in sympatric Idaho and Columbian ground squirrels (*Spermophilus brunneus* and *S. columbianus*). Northwest Science 70:99-108.

Federal Energy Regulatory Commission [FERC]. 1990. Hydroelectric project relicensing handbook. Federal Energy Regulatory Commission, Office of Hydropower Licensing, Washington, DC, USA.

Fitzgerald, J. F. 1982. Geology and basalt stratigraphy of the Weiser embayment, west-central Idaho. Pages 103-128 *in* B. Bonnichsen and R. M. Breckienridge, editors. Cenozoic geology of Idaho. Idaho Bureau of Mines and Geology Bulletin 26. Moscow, ID, USA.

Franklin, J. F., and C. T. Dyrness. 1988. Natural vegetation of Oregon and Washington. Oregon State University Press, Corvallis, OR, USA.

Garrison, G. A., A. J. Bjugstad, D. A. Duncan, M. E. Lewis, and D. R. Smith. 1977. Vegetation and environmental features of forest and range ecosystems. U.S. Department of Agriculture, Forest Service, Agriculture Handbook No. 475. Washington, DC, USA. 68 p.

Gavin, T. A., P. W. Sherman, E. Yensen, and B. May. 1999. Population genetic structure of the northern Idaho ground squirrel (*Spermophilus brunneus brunneus*). Journal of Mammalogy 80:156-168.

Gill, A. E., and E. Yensen. 1992. Biochemical differentiation in the Idaho ground squirrel, *Spermophilus brunneus*. Great Basin Naturalist 52:155-159.

Haak, B. 1999. Northern Idaho ground squirrel population monitoring and habitat mitigation, 1999 Annual Report. Idaho Department of Fish and Game, Nampa, ID, USA 28 p.

Haak, B. 2000. Northern Idaho ground squirrel population monitoring and habitat mitigation, 2000 annual report. Idaho Department of Fish and Game, Nampa, ID, USA. 19 p.

Holmstead, G. 2001. Vegetation of the Snake River corridor in Hells Canyon—Weiser, Idaho to the Salmon River. Technical Report E.3.3-1 *in* License application for the Hells Canyon Complex. Idaho Power Company, Boise, ID, USA.

Idaho Power Company [IPC]. 1997. Formal consultation package for relicensing Hells Canyon Project FERC No. 1971. Idaho Power Company, Boise, ID, USA.

Idaho Power Company [IPC]. 2000. Detailed final study plans Terrestrial Section, Phase II, for relicensing the Hells Canyon Complex (FERC No. 1971). Idaho Power Company, Boise, ID, USA.

Johnson, C. G., and S. A. Simon. 1987. Plant associations of the Wallowa−Snake province, Wallowa-Whitman National Forest. U.S. Department of Agriculture, Forest Service PNR. R-6 ECOL-TP-225A-86. 272 p.

Miller, H. C. 1996. Demography of medusahead on two soil types: potential for invasion into intact native communities. M.S. Thesis. Department of Rangeland Resources. Oregon State University, Corvallis, OR.

Miller, T. B. 1976. Ecology of riparian communities dominated by white alder in western Idaho. Thesis, University of Idaho, Moscow, ID, USA.

Natural Resources Conservation Service [NRCS]. 1995. Draft soil survey for Adams and Washington counties, Idaho. Weiser, ID, USA.

Olson, G. S. 2001. Dispersal patterns of ground squirrels and their implications for management. Proceedings of the 43rd Idaho Academy of Science Meeting, March 29-31, 2001.

Prescott, D. J., and E. Yensen. 1999. Habitat variables correlated with presence of southern Idaho ground squirrels, *Spermophilus brunneus endemicus*. Unpublished report to Idaho Department of Fish and Game, Nongame Program, Boise, ID, USA.

Runge, M. C., T. A. Gavin, and P. W. Sherman. 2001. A stochastic population model for the northern Idaho ground squirrel (*Spermophilus brunneus brunneus*). Proceedings of the 43rd Idaho Academy of Science Meeting, March 29-31, 2001.

Savage, D. E., J. A. Young, and R. A. Evans. 1969. Utilization of medusahead and downy brome caryopses by chukar partridges. Journal of Wildlife Management 33:975-978.

Tisdale, E. W. 1979. A preliminary classification of Snake River canyon grasslands in Idaho. Forestry, Wildlife and Range Experiment Station, University of Idaho, Moscow, ID, USA. 8 p.

Tisdale, E. W. 1986. Canyon grasslands and associated shrublands of west central Idaho and adjacent areas. Forestry, Wildlife and Range Experiment Station Bulletin No. 40. University of Idaho, Moscow, ID, USA. 42 p.

Tisdale, E. W., and M. Hironaka. 1981. The sagebrush–grass region: a review of the ecological literature. Forestry, Wildlife and Range Experiment Station, University of Idaho, Moscow, ID, USA. 31 p.

Tisdale, E. W., M. Hironaka, and M. A. Fosberg. 1969. The sagebrush region in Idaho: a problem in range resource management. University of Idaho Agriculture Experiment Station Bulletin 512. Moscow, ID, USA. 12 p.

U.S. Department of Agriculture [USDA]. 1990. Final environmental impact statement, land and resource management plan. U.S. Forest Service, Pacific Northwest Region, Wallowa-Whitman National Forest, Baker, OR, USA.

U.S. Department of Agriculture [USDA]. 1994. Final environmental impact statement: Wild and Scenic Snake River recreation management plan. U.S. Forest Service, Hells Canyon National Recreation Area, Pacific Northwest Region, Wallowa-Whitman National Forest, Baker, OR, USA.

Western Regional Climate Center [WRCC]. 1998. Climatological data summaries Web page. Located at: <http://www.wrcc.dri.edu/index.html>. Accessed on June 29, 1999.

Whitson, T. D., L. C. Burrill, S. A. Dewey, D. W. Cudney, B. E. Nelson, R. D. Lee, and R. Parker. 1992. Weeds of the West. Pioneer of Jackson Hole Printer, Jackson, WY. 630 p.

Yensen, E. 1985. Taxonomy, distribution, and population status of the Idaho ground squirrel, *Spermophilus brunneus*. Final Report, Nongame Species Program, Idaho Department of Fish and Game, Boise, ID, USA.

Yensen, E. 1991. Taxonomy and distribution of the Idaho ground squirrel, *Spermophilus brunneus*. Journal of Mammalogy 72:583-600.

Yensen, E., and B. Haak. 2000. Population survey of the southern Idaho ground squirrel. Unpublished report. U.S. Fish and Wildlife Service, Boise, ID, USA. 16 p.

Yensen, E. and P. W. Sherman. 1997. *Spermophilus brunneus*. Mammalian Species 560:1-5.

Yensen, E., D. L. Quinney, K. Johnson, K. Timmerman, and K. Steenhof. 1992. Fire, vegetation changes, and population fluctuations of Townsend's ground squirrels. American Midland Naturalist 128:299-312.

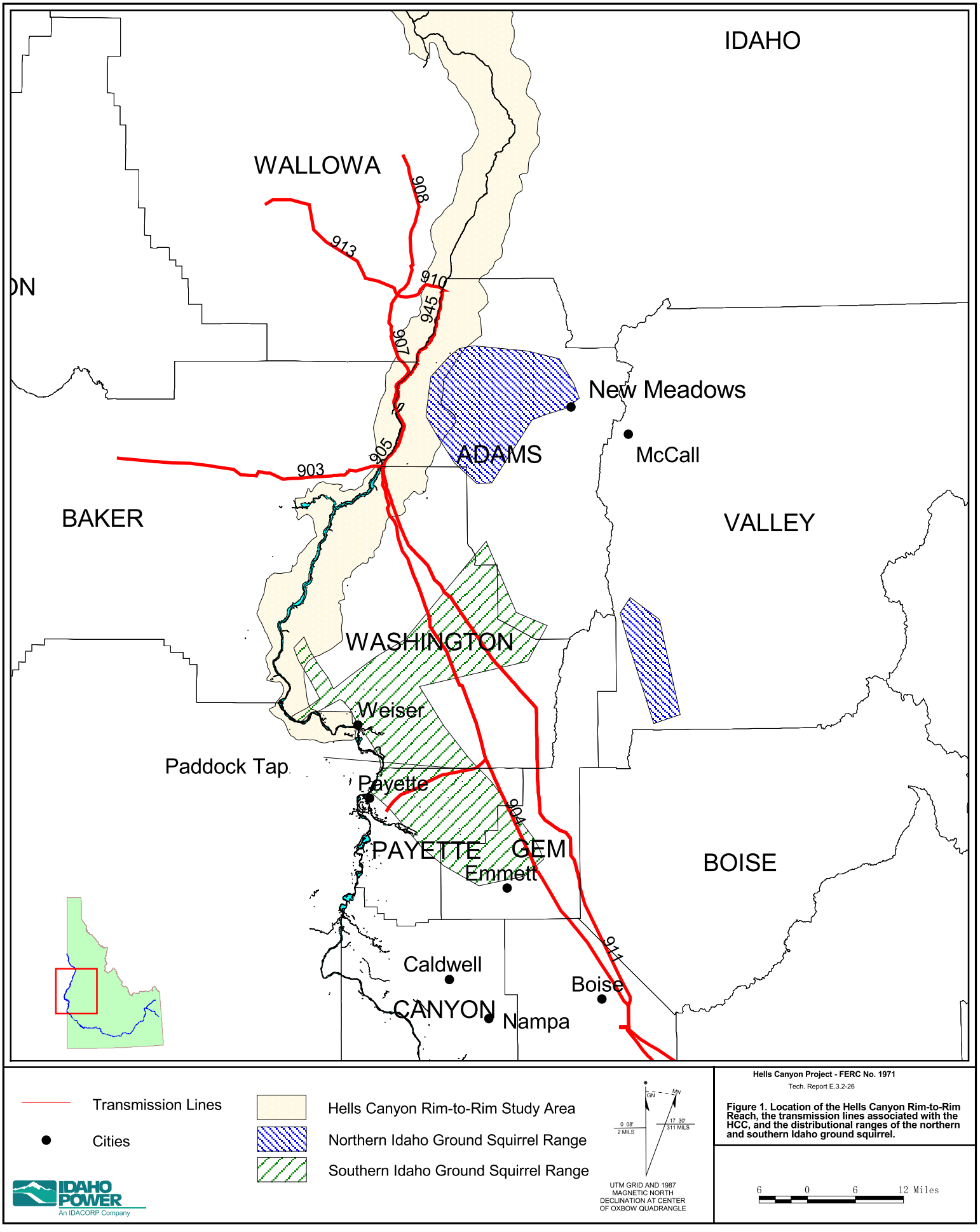
This page left blank intentionally.

Table 1. Transmission lines associated with the Hells Canyon Hydroelectric Complex.

Line	Line Name	Location	(KV)	(MI)	Structure Type
903	Brownlee to Quartz Jct.	Brownlee Dam to Quartz Junction (Baker)	230	46	H-Frame Wood
904	Brownlee to Boise Bench #1 and #2	Brownlee Dam to Boise Bench Substation	230	100	Steel Lattice
904	Paddock Tap	Paddock to Ontario Substation	230	23	Steel Lattice
905	Brownlee to Oxbow	Brownlee Dam to Oxbow Dam	230	11	Steel Lattice
906	Boise Bench to Midpoint #2	Boise Bench to Midpoint Substation	230	105	H-Frame Wood
907	Oxbow to Lolo and Brownlee	Oxbow Dam to Pallette Junction	230	21	Steel Lattice
908	Oxbow to Lolo	Pallette Junction to Imnaha	230	24	H-Frame Wood
909	Oxbow to Lolo	Imnaha to Divide on Snake River	230	21	H-Frame Wood
910	Brownlee to Hells Canyon and Hells Canyon to Hurricane	Hells Canyon Dam to Pallette Junction	230		Steel Lattice
911	Brownlee to Boise Bench #3 and #4	Brownlee Dam to Boise Bench Substation	230	102	Steel Lattice
912	Boise Bench to Midpoint #3	Boise Bench Substation	230	106	H-Frame to Midpoint #3
913	Hells Canyon to Hurricane	Pallette Jct. to Enterprise, OR	230	29	H-Frame Wood
923	Borah to Brady #2	Borah to Brady	230		H-Frame Wood
945	Pine Creek to Hells Canyon	Pine Creek-Oxbow Tap-Ballard Park-Lime Point Creek-Big Bar-Eagle Bar-Hells Canyon Big Bar Tap	69	22	Single Pole Wood
951	Midpoint to Borah #2	Midpoint Tap to Adelaide Tap to Borah	345	78	H-Frame Wood
952	Adelaide Tap	Midpoint Tap to Borah #1	345		H-Frame Wood

Table 2. Miles of high-, medium-, and low-quality habitat (acres) for the southern Idaho ground squirrel on public and private lands, identified by aerial surveys along the Paddock Tap Line and Lines 904 and 911.

Line	Habitat Quality	Public Land	Private Land	Total
Paddock Tap	High	2.4	7.5	9.8
	Medium	2.8	1.0	3.7
	Low	3.4	1.4	4.8
Line 904	High	0.4	0.3	0.7
	Medium	4.5	6.8	11.3
	Low	13.1	6.9	20.0
Line 911	High	0.5	0	0.5
	Medium	10.1	8.8	18.9
	Low	8.6	6.2	14.8



Hells Canyon Project - FERC No. 1971

Tech. Report E.3.2-26

Figure 1. Location of the Hells Canyon Rim-to-Rim Reach, the transmission lines associated with the HCC, and the distributional ranges of the northern and southern Idaho ground squirrel.

This page left blank intentionally.

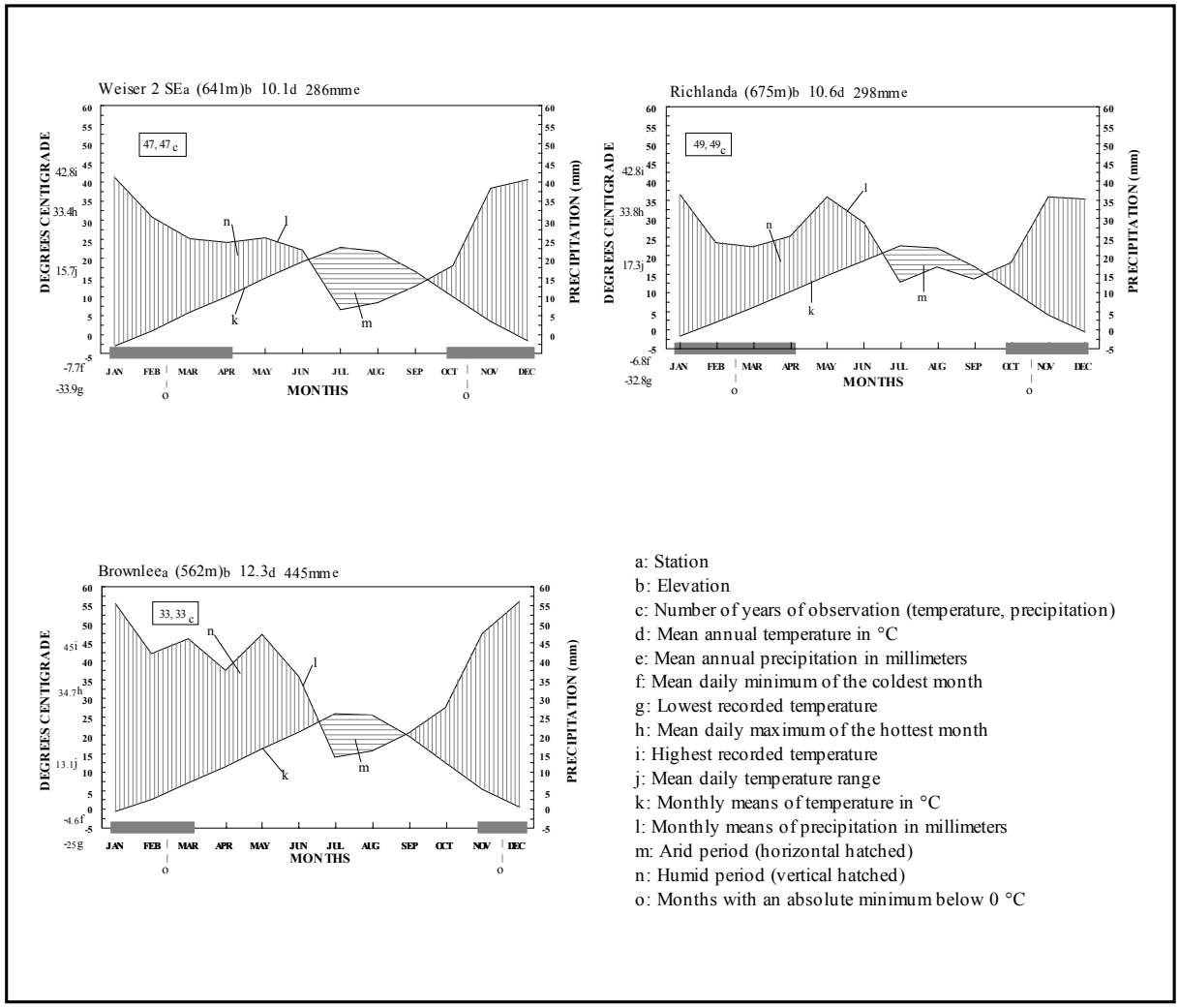
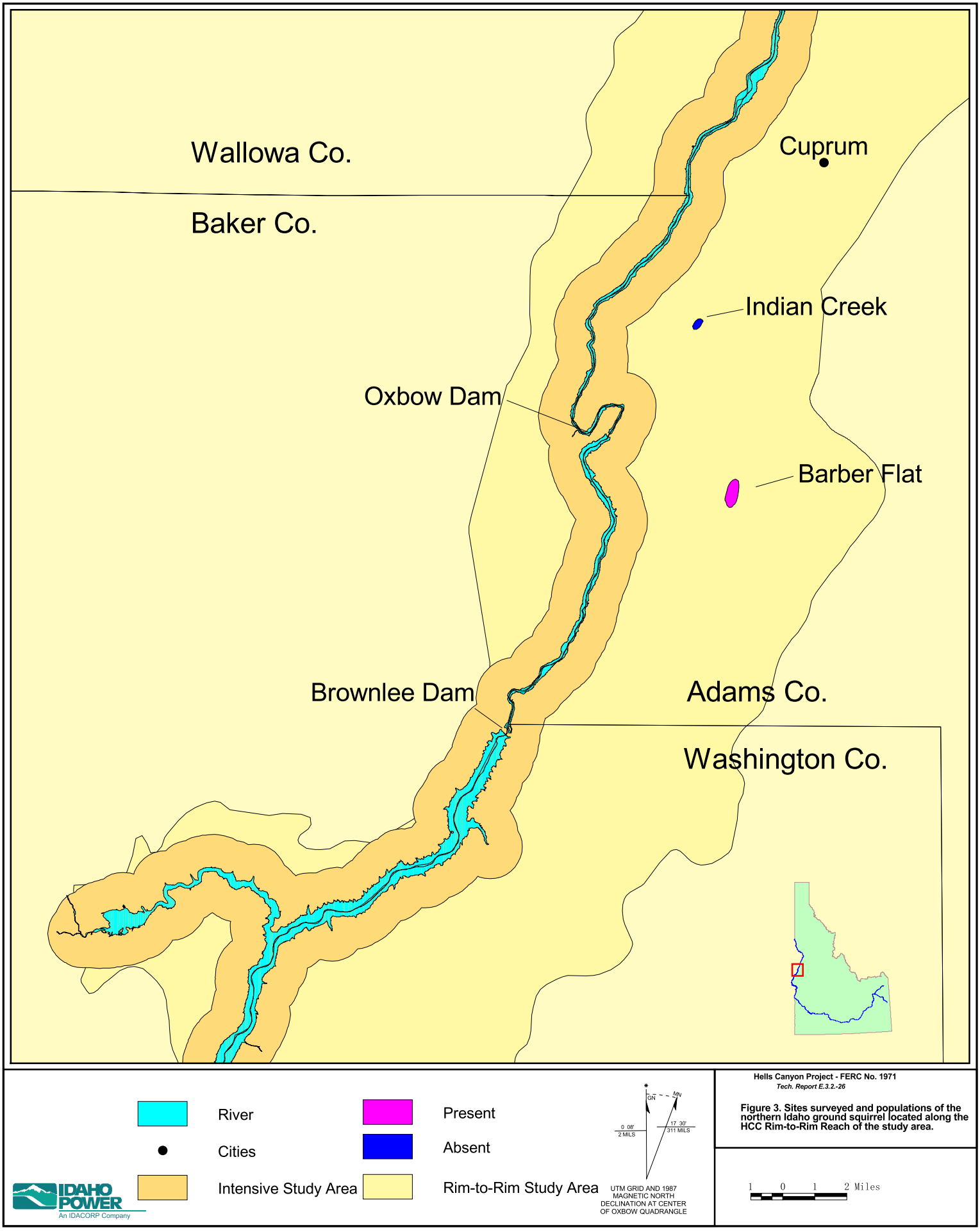


Figure 2. Köppen climate diagrams for the Weiser, Richland, and Brownlee weather stations, Hells Canyon Study Area, Idaho—Oregon border.

This page left blank intentionally.

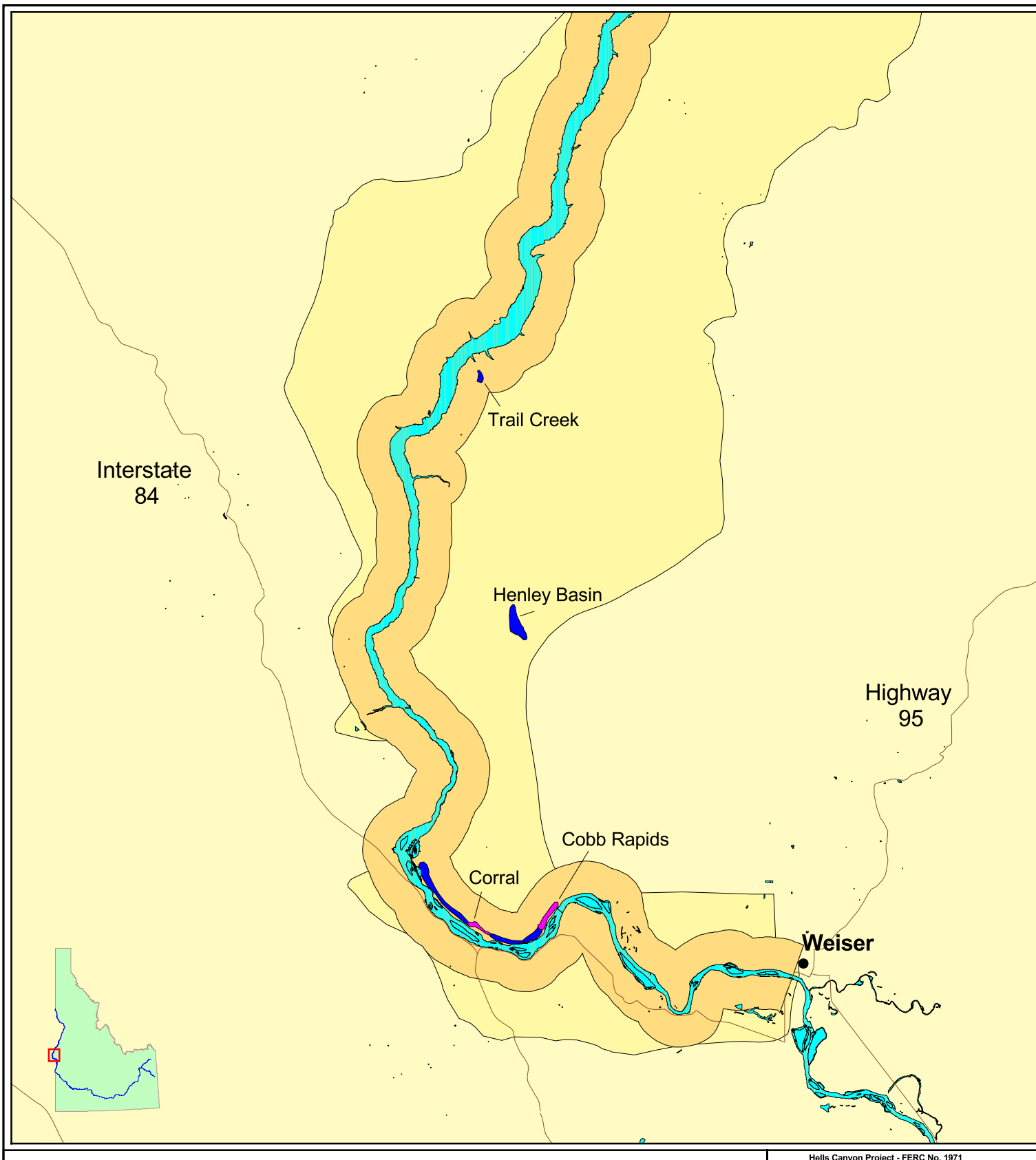


Hells Canyon Project - FERC No. 1971

Tech. Report E.3.2.-26

Figure 3. Sites surveyed and populations of the northern Idaho ground squirrel located along the HCC Rim-to-Rim Reach of the study area.

This page left blank intentionally.



Roads
Cities
Snake River
Absent
Present
Intensive Study Area
Rim-to-Rim Study Area

UTM GRID AND 1987
MAGNETIC NORTH
DECLINATION AT CENTER
OF OXBOW QUADRANGLE

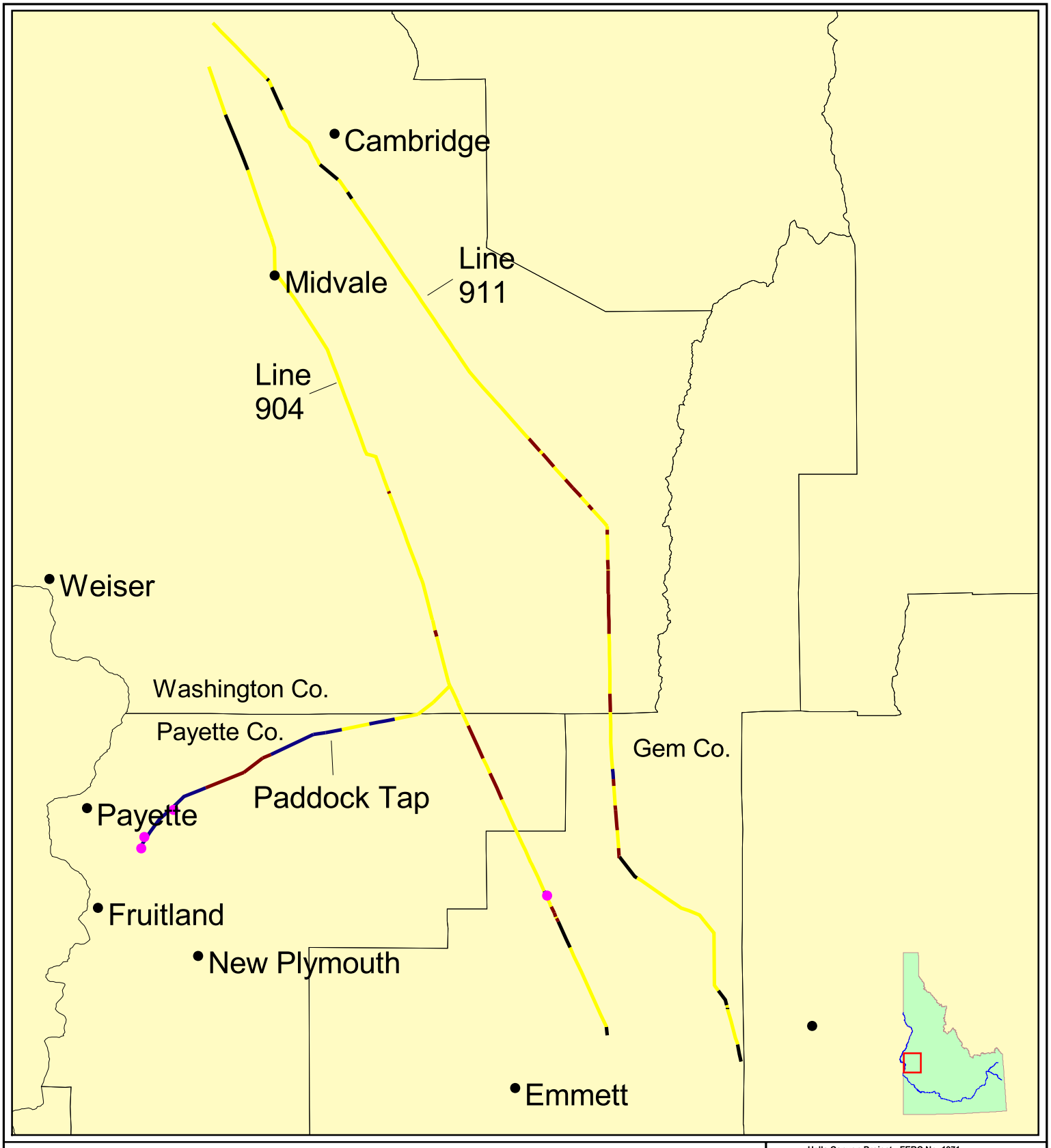
1 0 1 2 3 4 Miles

IDAHO POWER
An IDACORP Company

Hells Canyon Project - FERC No. 1971
Tech. Report E.3.2-26

Figure 4. Sites surveyed and populations of the southern Idaho ground squirrel located along the upper Brownlee Reservoir to Weiser reach of the study area.

This page left blank intentionally.



IDAHO POWER
An IDACORP Company

Hells Canyon Project - FERC No. 1971
Tech. Report E.3.2-26

Figure 5. Habitat quality and populations of the southern Idaho ground squirrel located along the rights-of-way, access roads, and tower sites of the Paddock Tap Line and Lines 904 and 911 in the study area.

This page left blank intentionally.

Appendix 1. Idaho ground squirrel survey recommendations.

IDAHO GROUND SQUIRREL SURVEY RECOMMENDATIONS FOR IDAHO POWER COMPANY TRANSMISSION LINE CORRIDORS

A Report for

Environmental Affairs Department

Idaho Power Company

P. O. Box 7070

Boise, ID 83707

by

Eric Yensen

Albertson College

22 February 2000

INTRODUCTION

In a meeting on 21 January 2000 with Idaho Power Company biologists Dr. Anthonie M. A. Holthuijzen, Brett Dumas, and Kelly Wilde, I was requested to 1) provide some general comments on the distribution of the southern Idaho ground squirrels relative to the two existing and one proposed transmission lines in Washington, Gem, and Payette counties, 2) comment on the distribution of the northern Idaho ground squirrel in the Brownlee-Oxbow-Cuprum areas, 3) comment on the most appropriate search strategies along the transmission lines, and 4) make recommendations for surveying along the transmission lines. I am pleased to provide the requested information.

BACKGROUND ON THE IDAHO GROUND SQUIRREL

The Idaho ground squirrel (*Spermophilus brunneus*) has the smallest geographic distribution of any species of ground squirrel in the world. It is restricted to Adams, Valley, Washington, Payette, and Gem counties, Idaho. The entire range measures about 125 x 90 km (Yensen, 1991), but only a small portion of this area is actually occupied by ground squirrels at present (Yensen and Sherman, 1997; Gavin et al., 1999).

Surprisingly, within this small region there are two distinct types of Idaho ground squirrels, and these are currently classified as subspecies: the northern Idaho ground squirrel (*Spermophilus brunneus brunneus)* and the southern Idaho ground squirrel (*Spermophilus brunneus endemicus*) (Yensen, 1991). However, Yensen (1991) thought that the two were close to species-level separation, and subsequent work has indicated that they are probably good species (Gill and Yensen, 1992; Gavin et al., 1999; Harrison et al., unpublished MS.; Yensen et al., in prep.). The two are separated by differences in pelage coloration, pelage length and

texture, cranial and external morphometrics, bacula, allelic frequencies, DNA sequences, timing of the life history cycle, and behavior.

Because of the limited geographic distribution, the Idaho ground squirrel was considered a "species of special concern" by the Idaho Department of Fish and Game in 1978. The northern Idaho ground squirrel was proposed as a candidate for "endangered" status and the southern Idaho ground squirrel for "threatened" status by the U.S. Fish and Wildlife Service in 1985 (Yensen, 1991). All "threatened" (category 2) species were summarily dropped from further consideration by the U.S. Fish and Wildlife Service, but the northern Idaho ground squirrel is in the process of being listed as "threatened" by the U.S. Fish and Wildlife Service and a final rule is expected soon.

The northern Idaho ground squirrel was considered "critically endangered" and the southern Idaho ground squirrel "vulnerable" by the IUCN (Yensen, 1998). A recent resurvey of southern Idaho ground squirrel localities (Yensen, unpublished report) indicates a catastrophic decline in population levels in the past three years, and thus it may be a candidate for listing very soon also.

RANGE OF THE NORTHERN IDAHO GROUND SQUIRREL

The northern Idaho ground squirrel occurs in an area of about 100 x 30 km in Adams and Valley counties, although nearly all localities are in an area of about 10 x 30 km. As small as this area is, the figures are misleading. The total area occupied is < 500 ha. Yensen (1991) listed 17 known localities. Since 1991, a number of additional sites have been discovered. *S. b. brunneus* is currently known from approximately 40 sites, all in Adams and Valley counties, Idaho.

Known sites are between 1050-1570 m elevation. The habitat is drier meadows, frequently surrounded coniferous forest, particularly in the ponderosa pine (*Pinus ponderosa*) zone. They are in competition with a larger congener, the Columbian ground squirrel (*S columbianus*) that wins in competitive situations (E. Yensen and P. W. Sherman, ms). Consequently, they live in areas with lower productivity not utilizable by the Columbian ground squirrels. Thus, the sites typically have a mixture of deeper soils for nesting, often with big sagebrush (*Artemisia tridentata*) ground cover, and shallower soils ("scab soils") with stiff sage (*A. rigida*) or other plants that indicate poorer, rocky soils with low productivity not utilizable by Columbian ground squirrels. In the absence of Columbian ground squirrels, Idaho ground squirrels can inhabit lush meadows.

The geographic range is primarily between the Cuddy and Seven Devils mountains, east to New Meadows in Adams County, and formerly south through Long Valley to Round Valley in Valley County. We have not found them in close proximity to the rim of Hells Canyon, nor in the canyon itself, but extensive inventories have not been undertaken in these areas, and apparently suitable habitat exists in this area. The closest known approaches to Hells Canyon are Summit Gulch, 3 km S and 3 km W of Bear (44°59'N, 116°43'W), Rocky Comfort Flat, and Paradise Flat. No sites are known south of Cuddy Mountain, but there is habitat is several places.

The northern Idaho ground squirrel is threatened primarily due to forest encroachment on meadows and changes in forest structure resulting from decades of fire suppression. The existing 30 sites (10 of 40 known sites are extinct) all have small populations. One has perhaps 200 individuals, two or three have around 75, and the rest have populations of fewer than 30 individuals. These are obviously not viable in the long term, and extinction of this ground squirrel is highly probable with 10-20 years and nearly certain if current efforts to reverse these

trends are not successful. Lack of fires to renew succulent vegetation is a widespread phenomenon; thus, I do not expect to find many more inhabited sites that are of large size. However, any that could be found would be valuable for conservation efforts for the species.

RANGE OF THE SOUTHERN IDAHO GROUND SQUIRREL

The southern Idaho ground squirrel currently occurs in an area of 70 x 30 km in Gem, Payette, and Washington counties. Yensen (1991) listed 24 localities, but subsequent fieldwork has increased this to nearly 200 sites as of 1999. Unfortunately, many of these are not presently inhabited by the species (Yensen, unpublished report for U. S. Fish and Wildlife Service, 1999). It was originally widespread over this entire area, rather than restricted to discrete sites (Yensen, 1991).

The habitat is rolling hills on lacustrine and fluvial sediments between 670-975 m elevation. The vegetation was formerly big sagebrush–bunchgrass–forb associations, with bitterbrush in sandier places. In recent decades, much of this area has been converted to exotic annual-dominated associations, especially of cheatgrass (*Bromus tectorum*) and medusahead (*Taeniatherium asperum*). The latter two species have highly variable annual productivity that should destabilize ground squirrel populations (Yensen et al., 1992), and medusahead is a poor quality food source (Savage et al., 1969). Conversion of rangeland to exotic annuals has hurt sage grouse, sharp-tailed grouse, sage sparrows, sage thrashers, Brewer's sparrows, and other species of wildlife and is the most probable explanation for the decrease in southern Idaho ground squirrel populations (Prescott and Yensen, unpublished report to Idaho Department of Fish and Game).

Nearly all of the known sites in the geographic distribution occur in a roughly triangular area between Emmett, Payette, and Henley Basin northwest of Weiser. This portion of the range lies southwest of a line running from Midvale Hill in a southeastern direction to the southern base of Squaw Butte north of Emmett. The transmission corridor that runs from Paddock Jct. to Ontario is the only one that crosses this area.

However, there are also four records to the north of this area: Midvale, Goodrich, 14 mi. E of. Midvale on Crane Creek, and just south of Indian Valley. This is the area of interest as far as the two existing and one proposed transmission lines are concerned. This region has not been searched intensively for southern Idaho ground squirrels, but some isolated populations should be expected. Reconnaissance indicates that suitable habitat exists many places in this region. The area northwest of US 95 along the three transmission corridors has not been surveyed for southern Idaho ground squirrels, but an overflight some years ago indicated that there are pockets of suitable habitat in the area.

SEARCH STRATEGIES

At high population densities, the presence of southern Idaho ground squirrels is evident. Ground squirrels and their burrows will be readily observed. Also, there will be many badger digs, which are a good sign of ground squirrel activity, although badgers will also excavate burrows while hunting for other prey, including pocket gophers. Badger digs can readily be seen from a distance and even from an aerial survey.

At low population densities, which is the case at the present time, ground squirrels can be difficult to locate. An individual squirrel will spend much of the day underground, so squirrels may not be observed even though the site is active. They do not make conspicuous mounds

which can be seen from a distance. Instead, soil is scattered as it is brought to the surface. (A specific burrow system will be inhabited by only a single individual.) Thus, the burrows may not be as obvious as when populations are high. For these reasons, it is easy to walk right past a small active site without noticing that ground squirrels live there.

Signs of ground squirrels can be used by trained personnel as reliable indicators that ground squirrels occupy an area. These signs include active burrows, feces, and alarm vocalizations.

The only species in the area that could be confused with the southern Idaho ground squirrel is the Columbian ground squirrel. The two can be readily differentiated by a number of characteristics including 1) the larger size of the Columbian ground squirrel, 2) the rusty reddish throat of the Columbians, and 3) the longer, “frosted” tail of the Columbian [Idaho tails are short and stiff] (Yensen and Sherman, 1997).

Ground squirrel burrows can be reliably recognized after appropriate training in about 80-90% of the cases. Burrows of voles and pocket gophers are found in the same habitats, and field personnel need to learn how to distinguish these. However, southern Idaho ground squirrels, voles, and gophers sometimes use each other's burrows, and some burrows are ambiguous in any case, so not every burrow is identifiable. Nevertheless, with practice, most burrows can be identified with confidence. When suspected southern Idaho ground squirrel burrows are found, other signs, or the animals themselves, can be searched for to confirm the identification.

Searching for burrows is fast, and does not depend upon ground squirrels being active at the time the searcher passes through an area. This allows field personnel to cover a lot of ground

rapidly. Searchers do not need to be limited by time of day or bad weather, which influence ground squirrel activity.

The droppings of Idaho ground squirrels are distinctive. Trained personnel can identify them reliably after a single training session. Further, like other feces, they change color with time, facilitating determination of freshness, which can in turn be used to determine recent activity at a site.

Vocalizations are distinctive, and can be used reliably by trained personnel. However, vocalizations are rare prior to the emergence of pups in the spring. Thus, their usefulness will depend upon the time in the active cycle of the squirrels when the survey is conducted.

Several habitat variables are weakly associated with presence of southern Idaho ground squirrels. These include remnant big sagebrush in areas converted to exotic annuals, badger digs, deep soils with remnant stands of sagebrush, and fence lines next to alfalfa, among others. These variables probably have a strong association, except that the population levels are low now.

There are about 300 km of habitat along the three transmission corridors. The most efficient way to search the transmission corridors would be via an aerial reconnaissance, either by light aircraft or helicopter. Obviously, neither squirrels nor their burrows can be seen from the air. However, obviously unsuitable habitat could be quickly eliminated, saving valuable crew time on the ground later. Further, suitable habitat could be selected and identified with GPS coordinates to allow field crews to return quickly to the most promising sites. Trained field crews can visit the pre-selected sites, check for signs of southern Idaho ground squirrels, and continue to the next site via a predetermined route. Helicopter survey would have the advantage of flying slower and permit more detailed observations, but would be more expensive.

Field crews will need to be trained to recognize suitable habitat, southern Idaho ground squirrel burrows, and other signs. This can be done in one to two days, depending upon the skills of the crews. A half-day second session a few days or a week later has proven valuable for refining skills on other occasions and confirming field identification of sites.

RECOMMENDATIONS

I recommend the following actions to facilitate the survey process:

- Rapid aerial reconnaissance of the transmission line corridors as soon as snowmelt in the survey permits. This means that the entire transmission corridor should be snow free. During aerial reconnaissance, areas should be eliminated from the search and the most likely places selected, along with access routes.

- 1-2 days training (as needed).

- Route planning.

- Field crews should examine most likely sites first.

LITERATURE CITED

Gavin, T. A., P. W. Sherman, E. Yensen, and B. May. 1999. Genetic population structure of the northern Idaho ground squirrel (*Spermophilus brunneus brunneus*). Journal of Mammalogy 80:156-168.

Gill, A. E., and E. Yensen. 1992. Biochemical differentiation in the Idaho ground squirrel, *Spermophilus brunneus*. Great Basin Naturalist 52:155-159.

Savage, D. E., J. A. Young, and R. A. Evans. 1969. Utilization of medusahead and downy brome caryopses by chukar partridges. Journal of Wildlife Management 33:975-978.

Vander Haegen, W. M., S. M. McCorquodale, C. R. Peterson, G. A. Green, and E. Yensen. 2000. Wildlife communities of eastside shrubland and grassland habitats. Pages xx-xx *in* D. H. Johnson and T. A. O'Neil, editors. Wildlife-habitat relationships in Oregon and Washington. University of Oregon Press, Corvallis, Oregon. (in press).

Yensen, E. 1991. Taxonomy and distribution of the Idaho ground squirrel, *Spermophilus brunneus*. Journal of Mammalogy 72:583-600.

Yensen, E. 1998. *Spermophilus brunneus. In*: D. J. Hafner, E. Yensen, and G. L. Kirkland, editors. North American rodents: status survey and conservation action plan. International Union for Conservation of Nature, Gland, Switzerland.

Yensen, E., and D. L. Quinney. 1992. Can Townsend's ground squirrels survive a diet of exotic annuals? Great Basin Naturalist, 52:269-277.

Yensen, E., D. L. Quinney, K. Johnson, K. Timmerman, and K. Steenhof. 1992. Fire, vegetation changes, and population fluctuations of Townsend's ground squirrels. American Midland Naturalist 128:299-312.

Yensen, E., and P. Sherman. 1997. *Spermophilus brunneus*. Mammalian Species 560:1-5.