Assessment of Chukar and Gray Partridge Populations and Habitat in Hells Canyon

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ASSESSMENT OF CHUKAR AND GRAY PARTRIDGE POPULATIONS AND HABITAT IN HELLS CANYON

Submitted to:

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Executive Summary

We conducted an assessment of chukar (*Alectoris chukar*) and gray partridge (*Perdix perdix*) and habitats in Hells Canyon along the Snake River, bordering Idaho and Oregon, during 1999 and 2000. Our assessment included an extensive literature review from published data and agency reports. Most literature and data (i.e., previous research projects) were from outside the Hells Canyon region. Our literature review included reports on systematics, distribution, reproductive ecology, survival, habitat, nesting, brood rearing, wintering, foraging, security cover, habitat quality and connectivity, food habits, and movements. We reviewed or considered social, economic, and ecological significance of partridge populations in Hells Canyon, and available data on population trends, limiting factors, and management.

Relative to other upland game birds in North America, partridge have received little research attention, especially chukar. Most gray partridge research has been conducted in mid-western states in agricultural environments, and only a few chukar studies have been completed in western states. Chukar and gray partridge are closely related species, and a rigorous study of comparative ecology with sympatric populations has never been completed in North America. Consequently, most of the conclusions in this report are from relatively few research projects (none from Hells Canyon) and the qualitative data we collected for this assessment. It is a well-known paradigm in wildlife ecology that professional wildlife management requires scientific data from the local region. Thus, research on both species in Hells Canyon would benefit local management programs.

We also conducted an extensive on-site assessment, which included 26 5-hour fall and winter surveys over a 2-year period (1999 and 2000). Our survey sites were systematically distributed throughout the study area, which included over 100 miles of the Snake River from approximately Weiser, Idaho to the Hells Canyon dam. We also conducted site visits during the spring of 2000 to most of the fall-winter survey sites. During surveys, we counted all chukar and gray partridge coveys, estimated covey size, recorded data on a number of habitat variables, and obtained color photographs of "typical" habitat conditions for each survey site. Although these data were "qualitative" in nature (i.e., we did not collect data designed for statistical tests of specific hypotheses), we obtained a significant amount of information and experience with the region for completion of our assessment objectives.

We concluded that chukar and gray partridge populations and habitats in the Hells Canyon region are in good condition. Our long-term prediction (for the immediate future of 5-10 years) is positive. We did not detect, nor did we suspect, any problems associated with hydroelectric operations in the canyon, or with the reservoirs. Our primary ecological and anthropogenic concerns were 1) invasions by 2 exotic plants, yellow-star thistle and medusahead, and 2) effects on habitat from overgrazing livestock. Thus, our management and mitigation recommendations were to maintain active programs for preventing the spread of exotic plants, and programs that reduced overgrazing and associated range damage.

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ASSESSMENT OF CHUKAR AND GRAY PARTRIDGE POPULATIONS AND HABITAT IN HELLS CANYON

1. Introduction

In June 1999, Dr. John Ratti (Department of Fish and Wildlife Resources, University of Idaho) responded to a request for proposal from Idaho Power Company to conduct an "Assessment of Chukar and Gray Partridge Populations and Habitat in Hell Canyon." In September 1999 a contract was signed between the University of Idaho and Idaho Power Company for this assessment to be conducted by Dr. Ratti. Project completion (i.e., draft report due) was scheduled for 1 April 2001. Author resumes are in Appendix A.

Objectives of the study were to conduct a review and evaluation of chukar (*Alectoris chukar*) and gray partridge (*Perdix perdix*) populations and habitat in Hells Canyon to: 1) characterize the social and ecological significance, 2) describe natural- and life-history requirements, 3) assess the current status of populations and habitat quality, 4) identify the relative significance of natural and anthropogenic limiting factors as they currently affect habitat quality and population stability, 5) project how habitat quality and population stability may change in the future, and 6) suggest opportunities for mitigating limiting factors in order to benefit these 2 species in the evaluation area.

2. Study Area

This review focused on the area surrounding the 3-dam complex and corresponding reservoir system that comprises Idaho Power Company's Hells Canyon Hydroelectric Complex. Longitudinally, the evaluation area extends north from approximately Weiser, Idaho at river mile 351 on the Snake River to Hells Canyon Dam at river mile 247 (Figure 1). Laterally, the evaluation area extended from the canyon rim in Oregon to the rim in Idaho (Figure 1). This area encompasses approximately 1,600 km^2.

3. Methods

3.1. Literature Review

We attempted to locate all literature associated with the biology and ecology of chukar and gray partridge in North America, with emphasis on Hells Canyon and the Intermountain West. Our search for literature included: 1) computerized literature-search services, 2) use of the University of Idaho special-documents library (e.g., government reports), 3) personal contacts with state and federal biologists with experience or responsibility in or adjacent to Hells Canyon, and 4) review of literature cited in key publications on the target species.

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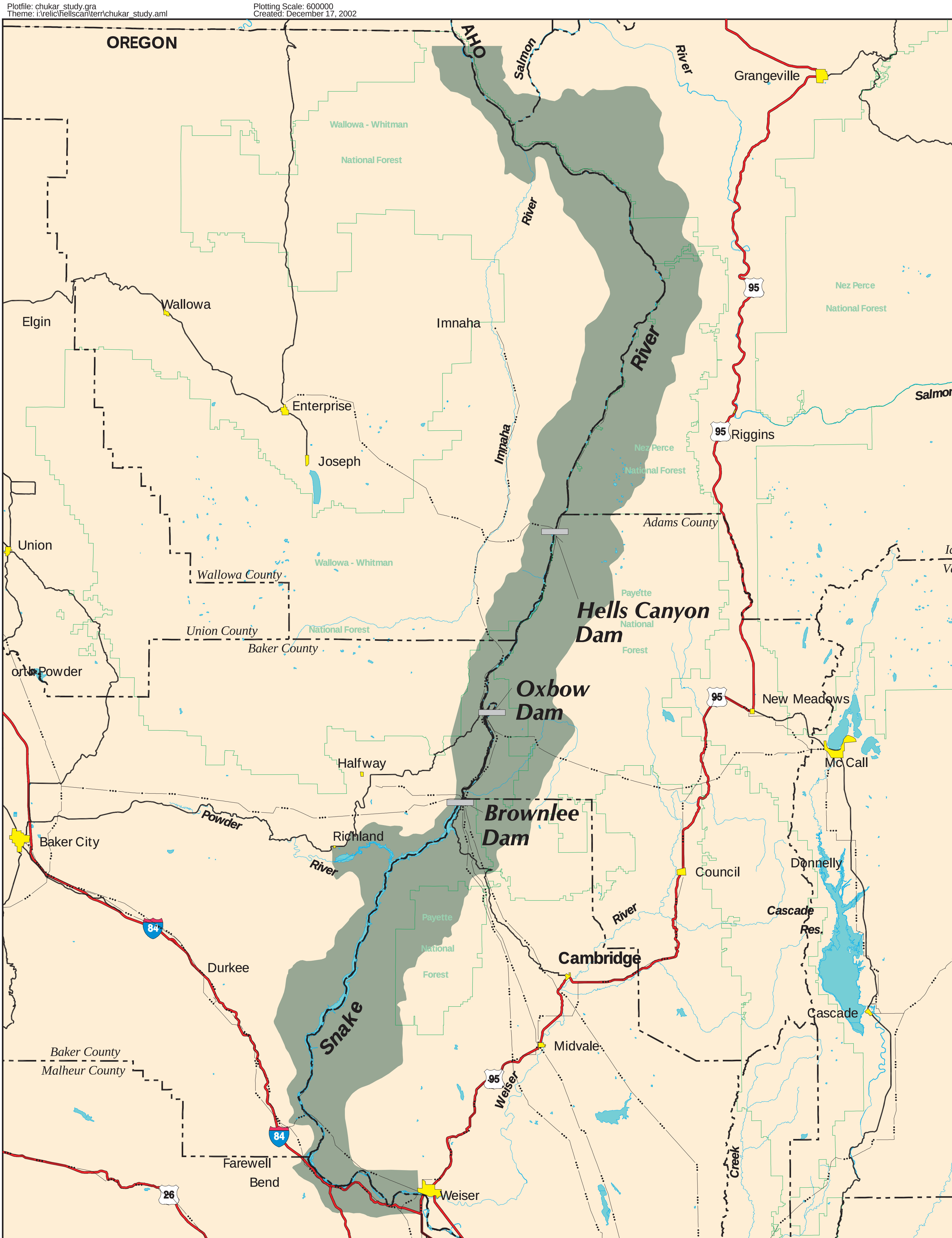

Features Legend

- Primary Route
- Secondary Route
- Transmission Lines
- County Boundary
- U.S. National Forest Service
- Rim - to - Rim Study Area

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Vicinity Map

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Hells Canyon Project - FERC No. 1971
Tech. Report E.3.2- 7 Figure 1

Hells Canyon Study Area Map

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3.1.1. Computerized Literature Services

- ❒ ABSEARCH Databases (wildlife, ecology, conservation biology, Canadian zoology, ornithology)
- ❒ AGRICOLA
- ❒ Applied Science and Technology Abstracts (SilverPlatter)
- ❒ Biological and Agricultural Index
- ❒ BIOSIS
- ❒ Dissertation Abstracts
- ❒ Life Sciences
- ❒ Natural Resource Metabase (NISC DISC)
- ❒ Wildlife Worldwide (NISC DISC)

3.1.2. University of Idaho Library and Other Sources (vis access to CARL)

- ❒ University of Idaho Card Catalogue
- ❒ U.S. Government Documents Archive
- ❒ Special Collections Archive
- ❒ Interlibrary Loan Services

3.1.3. Personal Contacts (listed alphabetically)

- ❒ Bryan Helmich, Idaho Department of Fish and Game, Andrus WMA, ID
- ❒ James Hermes, Oregon State University, Corvallis, OR
- ❒ Craig Johnson, Bureau of Land Management, Cottonwood, ID
- ❒ Tom Keegan, Washington Department of Fish and Wildlife, Olympia, WA
- ❒ Andy Ogden, Idaho Department of Fish and Game, Nampa, ID
- ❒ Eric Rickerson, Oregon Department of Fish and Wildlife, Portland, OR
- ❒ Hanspeter Walter, University of Idaho, Moscow, ID

3.1.4. Review of Key Literature

In addition to review of literature located from the sources listed above, we also examined the Literature Cited listed in major publications on chukar and gray partridge in North America. This exercise was basically redundant to our efforts above. However, review of literature cited in major publications provided a "double check" for important works that may have been missed by other methods. These citations were included in the Pro-Cite® database provided with this report and were cited in the sections below; thus, most will not be repeated here. However, examples of "key publications" included publications or review works such as Christensen (1970, 1996), Weigand (1980), Smith et al. (1982), Ratti et al. (1983), Carroll (1993), and theses such as Mendel (1979), Lindbloom (1998), and Walter (2000).

3.1.5. 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.

3.1.6. ProCite® Database and Hard-Copies of Literature

We used Pro-Cite® for Windows, version 3.4., to create the computerized database (Chuk-Hun) provided with this report. Pro-Cite® is a literature-management program available in Windows, DOS, and Macintosh formats. This program allows an efficient and quick search of the computerized database.

It is important to note that the Chuk_Hun database does not contain all literature on chukar and gray partridge (i.e., not all publications from outside North America are included). However, ***all*** literature that we located on the target species specific to Hells Canyon or the Hells Canyon region has been included in the database. Key terms that may be useful for searching the database are listed in Appendix C.

Hard copies of selected literature (major publications and research reports germane to the Intermountain West) were also provided with this report. Each hard copy was numbered in the upper-right corner. This number corresponds to a Pro-Cite® entry number under the "Note" field. Hard copies were filed sequentially.

3.2. Site Visits

Site visits were conducted during the fall and winter of 1999, spring of 2000, and fall and winter of 2001. Site visits included surveys to obtain partridge counts, assessment of habitat, and photographic records for each survey site. Details of site-visit methods are presented in section 5.0 below.

4. Literature Review

Other than annual population surveys, only limited data exist on chukar and gray partridge populations in Hells Canyon (rim-to-rim from Weiser to Hells Canyon Dam). Only 4 chukar studies have been conducted in or near Hells Canyon. Mackie and Buechner (1963) described the reproductive cycle of the chukar along the Snake River in southeast Washington. Oelklaus (1976) described distribution and habitat use of chukar along the middle and lower Snake River. Lindbloom (1998) described habitat use, reproduction, movements, and survival of chukar along the Lower Salmon River in west-central Idaho. Walter (2000) described reproduction, movements, habitat use, and diet of chukar in Succor Creek State Park, Malheur County, Oregon. Information on chukar ecology and management in North America is based mostly on studies conducted in Nevada, Utah, and California (see Christensen 1996). Likewise, information on ecology and management of gray partridge is based mostly on studies conducted in agricultural areas of Europe (e.g., Potts 1986) and North America (e.g., Weigand 1980, Smith et al. 1982, Ratti et al. 1983, Carroll 1993), including the Palouse Prairie of Idaho and Washington (Knott et al. 1943, Yocom 1943, Mendel 1979, Rotella and Ratti 1986). Mendel (1979) also estimated hatching phenology for birds inhabiting lower-elevation rangelands and canyons along the Potlatch, Clearwater, and Snake rivers. However, very little information exists on gray partridge populations inhabiting Hells Canyon or other canyon grasslands. Even less is known about interactions involving sympatric populations of chukar and gray partridge in North America. Consequently, much of the following information is based on studies conducted outside the Hells Canyon study area. Given major differences in regional habitats, the application of research findings from other geographic areas to Hells Canyon should be viewed cautiously.

4.1. Systematics

4.1.1. Chukar

Chukar partridge are placed in the family Phasianidae, subfamily Phasianinae, and tribe Perdicini (AOU 1998). The genus *Alectoris* consists of 7 species and 24 subspecies worldwide, including 14 subspecies of *A. chukar* (del Hoyo et al. 1994). Birds originally introduced into North America were probably Indian chukar (nominate *A. c. chukar*), which occur from eastern Afghanistan east through northern India to western Nepal. Two other subspecies, *A. c. korovia-kovia* and *A. c. pallescens*, found in adjacent areas to the north and west could have been captured and exported through the ports of Karachi and Calcutta, India. If so, these subspecies probably intermixed as a result of game-farm practices. During the 1950s, the U.S. Fish and Wildlife Service began introducing Turkish chukars (*A. c. cypriotes* and *A. c. kurdestanica*) into North America (Christensen 1996). Turkish chukars were propagated on a game farm in New Mexico, where the various subspecies probably interbred. Progeny were released primarily in New Mexico, Utah, and California. Most introductions failed or were swamped by Indian chukars (Christensen 1996). There are 6 additional species of *Alectoris* that also have an extensive distribution across southern Europe, northern Africa, and southern Asia: red-legged partridge (*A. rufa*) of southern Great Britain (introduced) and southwestern Europe; the Barbary partridge (*A. barbara*) of North Africa and Sardinia; the rock partridge (*A. graeca*) of southeastern Europe; Philby's partridge (*A. philbyi*) of western Saudi Arabia and Yemen; the Arabian partridge (*A. melanocephala*) found in western and southern Saudi Arabia and Yemen; and Przevalski's partridge (*A. magna*) of eastern Tibet and western China (Watson 1962a, b; Johnsgard 1988).

Alectoris species in the Palearctic are morphologically similar despite having relatively little sympatry over the total range of the genus, which suggests *Alectoris* partridge has a narrow niche (Watson 1962a). Historical sympatry and allopatry of congeners and possibly, *Perdix*, may have influenced the distribution and evolution in *Alectoris* (Watson 1962a). Recent genetic analysis indicated a high degree of differentiation exists among allopatric populations of *Alectoris* in Israel, Europe, and Asia (Randi et al. 1992). Geographic barriers and isolation may also act on North American populations, creating local differentiation or adaptation in some chukar populations (Walter 2000).

4.1.2. Gray Partridge

Gray partridge are closely related to chukar partridge, i.e., they are both commonly placed in the family Phasianidae, subfamily Phasianinae, and tribe Perdicini (AOU 1998). However, recent analysis using protein electrophoresis suggested *Perdix* were more closely related to pheasants (*Phasianus*) than Old World partridges and quails (Randi et al. 1991). The gray partridge has 8 recognized subspecies and 2 color phases, tending to be browner in the west and paler and grayer in the east (Carroll 1993). However, a long history of introductions and game-farm breeding has obscured subspecific taxonomy in North America and Europe (Carroll 1993). Most populations of gray partridge in North America probably belong to *P. p. perdix*, which has origins in Hungary, Czechoslovakia, and Austria (Carroll 1993).

4.2. Distribution

4.2.1. Chukar

Native distribution.— Resident in Eurasia from southeastern Europe and Asia Minor east to southern Manchuria, northern China, Turkestan, and the western Himalayas (AOU 1998).

North America.— Distribution center located in the Great Basin, which includes northeast California, most of Nevada, southeast Oregon, western Utah, and a portion of southwest Idaho. Substantial populations also found in suitable habitat in eastern Utah, western and central Idaho, northeast Oregon, eastern Washington, and portions of south-central California. Spotty populations occur in western Colorado, southwest and north-central Arizona, and central, northwest, and southeast Montana (Christensen 1996). Birds were also introduced to the Hawaiian Islands, but are no longer on Oahu (AOU 1998).

Idaho and Oregon.— Chukars were first introduced into Idaho in 1933 in Nez Perce County (Salter 1952). Between 1938 and 1942, 3,000 chukar partridge were successfully introduced into 18-20 counties in Idaho (Lever 1987). Twenty-five counties in Idaho now have viable chukar populations (Lindbloom 2000). The first large-scale introduction of chukars in Oregon occurred in 1952 near John Day River in Gilliam County (Masson 1954). Between 1951 and 1955, 50,000 chukars were released in Oregon with such success that a hunting season was established in 1956 (Lever 1987). For information on the current distribution of chukar in Hells Canyon, see Section 5: On-site Assessment, below.

4.2.2. Gray Partridge

Native distribution.— Resident in Eurasia from the British Isles, southern Scandinavia, and northern Russia south to southern Europe, Turkey, northern Iran, Turkestan, and Mongolia (AOU 1998). *Perdix* is largely sympatric with *Alectoris* in the Palearctic, although *Perdix* range is slightly farther north and includes flatter terrain and agricultural landscapes (Watson 1962).

North America.— Primary range is the northern plains from northwest Iowa to southern Alberta. Northern limit in aspen parklands and even into boreal forest where cultivated; western populations mostly in agricultural valleys. Small isolated populations in New York, Vermont, Ontario, Quebec, Prince Edward Island, and Nova Scotia (Carroll 1993).

Idaho and Oregon.— Serious efforts to introduce gray partridge in the United States began in 1900 when 97 birds were released in the Willamette Valley, Oregon (Lever 1987). By 1914, gray partridge had been released into 23 counties in Oregon, and by 1934 the birds were established over much of the eastern part of Oregon (Lever 1987). Gray partridge first appeared in Idaho in the early 1900s. The first birds in Idaho probably dispersed from eastern Washington after 1914-16 introductions into Garfield, Spokane, and Whitman counties of Washington

(Mendel 1979). Earliest documented introduction of gray partridge into Idaho occurred in 1922. By the early 1930s, gray partridge may have spread from Oregon into southwestern Idaho, where they were introduced in 1913-14 (Mendel 1979). For information on the current distribution of gray partridge in Hells Canyon, see Section 5: On-site Assessment, below.

4.3. Reproductive Ecology

4.3.1. Chukar

Chukars are primarily monogamous, although Mackie (1960) observed 1 male occasionally mating with 2 females. Calling by both sexes is common, although the male initiates courtship display. This species usually breeds the first spring after hatching and pair formation usually occurs in February-March. In southeast Washington (1958-60), pairing occurred from early February to late March, with birds over 1 year of age being the first to form pairs (Mackie and Buechner 1963). Male usually remains with female during incubation, hatching, and brood rearing; but some males may desert female after completion of clutch. During drought years, breeding and pairing may be restricted to a small portion of the population, with non-breeding birds remaining in coveys (Christensen 1996). Unsuccessful females may join groups of deserted males after mid-Jun. Chicks and adults have strong tendency to mix at water sources. Thus, late summer and fall coveys often consist of >1 family group (Christensen 1996).

First eggs are usually laid in March-April. Persistent renester; thus, nesting period may extend over 5 months, with hatching from early May to mid-August (Christensen 1996). In western Idaho (1995-96), nesting period extended from 16 April to 20 Aug; latest nest-initiation date (2nd nest) was 27 July and hatching date ranged from 31 May to 20 August with peak hatch about 1-10 June (Lindbloom 1998). In eastern Oregon (1997-98), nesting period extended from 4 April to 18 July; latest nest-initiation was 25 May and hatching date ranged from 16 May to 18 July with average hatch date 10 June (Walter 2000).

Few data are available on clutch size, laying patterns, incubation, nest attentiveness, etc. of wild birds. In Washington, six captive females laid 221 eggs at a mean rate of 1.3 days/egg (Mackie and Buechner 1963). Clutch size was 10-21 eggs ($\bar{x}$ = 15.5) in southeast Washington (Mackie and Buechner 1963), 4-20 ($\bar{x}$ = 12.4, SE = 0.9, n =16) in western Idaho (Lindbloom 1998), and 9-16 ($\bar{x}$ = 12.7, n = 16) in eastern Oregon (Walter 2000). Average clutch size of first nests (12.7-14.5) usually greater than renests (10.4-11.5; Lindbloom 1998, Walter 2000). Incubation about 23-30 days, with average of about 24 days (Christensen 1996).

The chukar exhibits synchronous hatching, but scant data on brood-rearing behavior in wild birds. Chicks are down-covered at hatching and leave nest soon after hatching. Chicks stay with adults and other young until late winter or early spring. Only females appear to brood chicks, but a small percentage of males may incubate nests (Lindbloom 1998). Chicks feed with adults but there are no detailed studies of behavior. Chicks are capable of flight at <2 weeks of age and appear similar to adults by 18 weeks (Christensen 1993).

4.3.2. Gray Partridge

Gray partridge are monogamous. Both males and females attempt to breed in first year after hatch, but some excess males do not pair and presumably do not breed (Potts 1986). The female chooses the male. Established pairs may remain together for life; however, mortality of mates is common and both sexes readily remate (Carroll 1993). Dates of pair formation vary with region and weather conditions, but generally during January-February. Male stays with female throughout incubation and brood rearing. Basic social group outside of the breeding season is the covey. Coveys are usually family groups consisting of adult pairs and their offspring. Coveys composed of unsuccessful breeders will form during summer and can make up a substantial portion of coveys seen during fall and winter (Carroll 1993). Covey mixing during late fall has been documented (Mendel 1979, J. T. Ratti, unpublished data).

Egg laying usually begins in April-May. Peak clutch initiation occurs early to late May. Persistent renester when nest is destroyed, with as many as 4 nests in a single season (Jenkins 1961a, Birkan et al. 1990). Clutch size 10-20 eggs, with a mean of 13.8; however, clutch size declines during the season and with each successive renest (Carroll et al. 1990). Rate of egg laying about 1.1 days/egg (McCabe and Hawkins 1946). Incubation about 21-26 days; 25 days probably average (Carroll 1993). Peak of hatching varies annually but early to mid-June in eastern Washington during 1940-42 (Knott et al. 1943) and late June to early July in Idaho during 1976-78 (Mendel 1979). However, based on examination of wings collected from hunters, Mendel (1979) concluded that gray partridge inhabiting canyons along the Potlatch, Clearwater, and Snake rivers had more concentrated hatching dates and a later hatching peak than birds nesting on the Palouse Plateau, which probably reflected differences in farming disturbances and spring weather.

Gray partridge exhibits synchronous hatching, although 24 hours may elapse between emergence of first and last chick. Chicks completely down-covered at hatch and mobile within hours; usually leave nest with adults within 1 day. Both male and female brood young. Young do not feed for 24 hr after hatching. Adults induce chicks to feed by repeatedly dropping food in front of chicks, but not by passing food directly to them. Chicks are capable of short flights in <2 weeks and longer flights by 6-8 weeks. Young remain with adults until late winter or early spring (Carroll 1993).

4.4. Survival

4.4.1. Chukar

Eggs, nests, and chicks.— No data exists from Hells Canyon populations. The nearest studies of wild populations were conducted in the Salmon River drainage of Idaho (Lindbloom 1998) and in eastern Oregon (Walter 2000). Egg hatchability (91-98%) and nest success (41-51%) were relatively high in both studies. Hen success (i.e., the proportion of breeding females that successfully hatched a nest) was 64% in Idaho and 76% in eastern Oregon. No data on lifetime reproductive success. Likewise, rigorous estimates of brood and chick survival are lacking. Christensen (1970) estimated that average annual-brood size from 1960-69 varied from 8.5-12.5. Fall age ratios also indicated that annual production varied widely among years; e.g., in Nevada over 19-years period, young:adult ratios varied from 8.8:1.0 in 1951, 0.4: 1.0 in 1953, 0.7:1.0 in 1959, and 7.1:1.0 in 1969 (Christensen 1970). Low age ratios occurred during years of drought. In Oregon, Walter (2000) reported October age ratios of 1.3:1.0 in 1997 and 3.1:1.0 in 1998. Lindbloom (1998) observed 60% brood survival (n = 5) in 1996.

Juveniles and adults.— Although little data exists, general observations suggest chukars have high mortality rates and relatively short life spans. Walter (2000) reported 29-68% spring-fall survival in eastern Oregon. Lindbloom (1998) reported 48% (SE = 10%) spring-summer survival in western Idaho. About 51% of observed mortality in Oregon was due to predation (59% avian and 41% mammalian). In Idaho, avian and mammal predators accounted for 60% and 40% of known mortalities, respectively (Lindbloom 1998). Christensen (1970) concluded that over-winter survival was a potential limiting factor. However, Lindbloom (1998) suggested that spring-summer mortality might be more important than previously realized.

4.4.2. Gray Partridge

Eggs, nests, and chicks.— Church (1984) summarized 10 North American studies and mean nest success was 32% (range: 16-40%). In the Palouse Prairie of Idaho, nest success was 12% (n = 17) in 1976 and 63% (n = 8) in 1977 (Mendel 1979). In Whitman County, Washington, nest success was 37% (range: 32-44%; n = 113) during 1940-42 (Knott et al. 1943). Egg hatchability in North American studies ranged from 68-91% , but most studies reported rates of 85-90% (Carroll 1993). Estimated hen success ranged between 41-82%. No data on lifetime reproductive success. In North America, chick-survival rates varied among regions, e.g., 57-75% in North Dakota (Carroll et al. 1990), 50-66% in Wisconsin (Gates 1973, Church 1980, Church 1984), 59% in Washington (Yokom 1943), and 29-47% in New York (Enck 1987, Church 1993). Survival rates of chicks in Great Britain ranged from 19-67%, with variation due mostly to abundance of insect foods during the first few weeks of life (Potts 1986). Likewise, chick survival in New York was correlated with insect abundance and biomass (Enck 1987).

Juveniles and adults.— Gray partridge generally have a short life span and high mortality rates. For winter-captured birds in Montana, life expectancy was 1.8 years for adults, 0.9 years for immature males, and 0.8 years for immature females; maximum longevity was 4 years (Weigand 1980). For adults, highest mortality rates are for nesting females and during winter (Potts 1986, Carroll 1993). In Montana, relative survival (based on age and sex ratios of wings collected from hunters) of juvenile gray partridge was similar for males and females (Swenson 1985). Ratti et al. (1983), based on seasonal changes in density, estimated that post-hunting winter mortality was 56% (SE = 14) in South Dakota during 1979-80. Church and Porter (1990a) estimated 58% mortality (mostly subadults) over a 2-week period in early February in New York. Rotella et al. (1996) analyzed seasonal and long-term changes in *Perdix* density on the Palouse Prairie during 1940-85, and concluded that average fall-and-winter mortality was relatively low (29%). However, mortality was influenced by density-dependent and density-independent effects, e.g., winter mortality was 58% in a high-density year (1983-84) and 78% in the severe winter of 1984-85 (Rotella et al. 1996). In North Dakota, survival of radiotagged partridge (n = 55) from early January to 1 May (1985-87) was 28%. However, survival was influenced by release effect (34% mortality during 1st week post-release), body mass at capture (birds weighing ≥400 g had higher survival [50%] than those weighing <400 g [20%]), and sex (females had greater survival [59%] than males [19%]) (Carroll 1990). Potts (1986) and Carroll (1992) reviewed fall-and-winter mortality rates for populations throughout the world and reported a range of 49-86%. However, survival and reproductive success of gray partridge equipped with radio transmitters should be interpreted with caution because effects of handling and radio tagging may be complex, e.g., a function of physical condition at time of capture, radio tag design, and interactions mediated by environmental factors such as weather and predator abundance (Bro et al. 1999). Likewise, mortality estimates derived from seasonal changes in density may be biased if movements violate the closed-population assumption.

4.5. Habitat

4.5.1. General

4.5.1.1. Chukar. Most descriptions of chukar habitat include only general physiographic characteristics, e.g., cheatgrass (*Bromus tectorum*)-sagebrush (*Artemisia* spp.) vegetative type, steep topography, rock outcroppings, talus slopes, and arid climate (see Christensen 1996). The most detailed description was probably given by Galbreath and Moreland (1953), who specified optimum chukar habitat contained about 50% sage-cheatgrass-bunchgrass; 45% talus slopes, rock outcroppings, and cliffs and bluffs; and 5% brushy creek bottoms and swales. Lindbloom (1998) reported that chukars used rock and shrub cover types more than expected and grass/forb areas less than expected during both spring and summer ($P < 0.005$). However, chukars are extremely mobile and generally use or pass through most habitats available to them within the Snake River canyon each day (Oelklaus 1976).

In general, habitat use during the summer is greatly influenced by water availability, i.e., chukars concentrate at water sources during early morning and late evening hours (Galbreath and Moreland 1953, Harper et al. 1958, Christensen 1970, Oelklaus 1976). Differences in habitat use may also reflect seasonal variation in food availability (Moreland 1950, Galbreath and Moreland 1953, Sandfort 1954) and temperature. For example, Lindbloom (1998) reported that chukars along the Salmon River used areas of southeast aspect less ($P = 0.002$) and areas of northeast aspect more ($P = 0008$) during summer than in spring, ostensibly to find more favorable temperatures and succulent vegetation. Likewise, snow depth is believed to affect habitat use of chukars during winter, i.e., during periods of deep snowfall, chukars use wind-swept slopes and cultivated fields (Alcorn and Richardson 1951, Christensen 1970).

Detailed descriptions of micro- and macrohabitat characteristics, movements, home range, and seasonal differences in habitat use and selection are limited. Lindbloom (1998) investigated differences in habitat use due to season, sex, habitat quality (i.e., effects of yellow-star thistle [*Centauera solstitialis*]), and habitat availability (i.e., habitat selection). Walter (2000) described micro- and macrohabitat characteristics and habitat use during nesting, brood rearing, and spring-summer. Oelklaus (1976) described general habitat use and correlations between chukar density (relative) and vegetation distribution in Hells Canyon, including Brownlee Reservoir. Only Lindbloom (1998) and Walter (2000) used radio telemetry methods, which permitted more accurate estimates of movements, home range, and habitat use.

4.5.1.2. Gray Partridge. In North America, the best habitat appears to be where cereal grains dominate and where extensive hedgerows are present (Carroll 1993). However, availability of permanent nesting cover may be an important limiting factor in extensively cultivated landscapes (see 4.10 Limiting Factors, below). On the Palouse Prairie, permanent cover (e.g., fencerows, farmsteads, roadside and railroad right-of-ways, waterways, idle grass, brush and timber, pasture, and hay) was preferred during late spring, summer, and fall. Plowed stubble was preferred and winter wheat was generally avoided during winter (Mendel 1979). In summer, birds generally used grasslands and grain fields, but also used roadsides and shelterbelts. In winter, crop stubble (especially cereal grains) and woody cover were preferred (Carroll 1993). During severe winter weather with deep snow (>10 cm), woody cover near farmsteads may be important (Weigand 1980, Schulz 1980, Carroll 1993), although Smith et al. (1982) reported that birds in South Dakota shifted from use of row corps to pastures in a winter of deep snow (56 cm). Habitat use by gray partridge inhabiting canyons and mountainous areas, including Hells Canyon, has not been studied.

4.5.2. Nesting

4.5.2.1. Chukar. Limited research has been conducted on nest-site characteristics (Lindbloom 1998), probably because chukar nests are difficult to find (Galbreath and Moreland 1953). Nests usually are widely scattered and well concealed, but often are located within 183-366 m of a water source (Galbreath and Moreland 1953, Harper et al. 1958). In Nevada, Christensen (1970) found 3 inactive nests, 1 under sagebrush at base of hill and 2 hidden among rocks and brush. Harper et al. (1958) found 16 nests in California and concluded that nesting was not limited to any specific cover type. In contrast, Galbreath and Moreland (1953) reported nest preference for south-facing slopes in Washington. Mackie and Buechner (1963) found 24 nests in Washington, but did not describe nest distribution among cover types.

In Idaho, Lindbloom (1998) found 23 nests (10 renests) of radiotagged females. Cover types used by nesting chukars included grass/forbs (48%), rocks (43%) and shrubs (9%). Average slope and elevation was 58% (standard error [SE] = 2) and 905 m (SE = 22), respectively. Eighty-seven percent of nests were on south-facing slopes (30% southeast, 57% southwest). Rock outcrops were the most prevalent (57%) structure at nest sites, followed by grass-forbs (26%) and low shrubs (17%). Chukar nests were well concealed, with visual obstruction of 3.9 decimeters (SE = 0.5) and overhead canopy averaging 63% (SE = 9). Lindbloom (1998) concluded that nest placement of chukars was not affected by presence of yellow-star thistle (but see Brood-rearing, below) and nest-site quality probably was not limiting the chukar population inhabiting canyon grasslands along the Salmon River.

In Oregon, Walter (2000) found 17 nests of radiotagged females and 6 incidental nests. Cover types used for nesting included bunchgrass (42%), rock (38%), shrub (8%), and annual grass (8%). Fifty-seven percent of nests were concealed by vegetation (bluebunch wheatgrass [35%], basin wildrye [13%], or broom snakeweed [9%]) and 43% were located in or under rocks. Most nests were found on relatively steep (19.4° ± 3.3° [$\bar{x}$ ± SE]) south-facing slopes.

4.5.2.2. Gray Partridge. No information on gray partridge nests in Hells Canyon or other canyon grasslands is available. Data from other habitats report gray partridge use idle cover (pastures, fence rows, roadsides, and shelterbelts) and hay fields for nesting (see review by Carroll 1989). Nest-site selection by gray partridge in Europe occurs mainly in linear and permanent cover (Potts 1986). In Great Britain, gray partridge will also use cereal grains for nesting, although mainly for renesting (Carroll 1993). In North America, older studies showed greater use of hay fields than in Great Britain. However, in more recent studies, the trend is similar to that of Great Britain where most nesting occurred in some type of linear cover or field border (Carroll et al. 1990). In North Dakota, dominant vegetation at roadside nests included smooth brome (*Bromus inermis*) and several woody shrubs (e.g., *Rosa spp.* and *Symphoricarpos occidentalis*; Carroll and Crawford 1991). In South Dakota, nests sites were dominated by smooth brome (Hupp et al. 1980). In Great Britain, hedgerows were important, although the amount of dead grass at the base of hedgerows influenced breeding density (Potts 1986, Rands 1986). The importance of residual herbaceous growth for nesting cover (especially initial nesting attempts) was also noted by Yeatter (1934), Knott et al. (1943), McCabe and Hawkins (1946), and Mendel (1979). In Washington, Swanson and Yocum (1958) suggested high partridge populations were maintained because birds utilized wheat stubble in place of bunchgrass. In general, gray partridge selected grass-dominated nesting sites. Forb-dominated communities, such as alfalfa fields, were not preferred nesting habitat, but offer some of the earliest spring cover when residual grass cover is absent (Weigand 1980). Availability of permanent nesting cover may be an important limiting factor in intensively farmed areas such as the Palouse Prairie (Mendel 1979, Rotella et al. 1996), but nesting cover probably is not limiting in canyon grasslands such as Hells Canyon.

4.5.3. Brood-rearing

4.5.3.1. Chukar. Limited data are available on habitat use by chukars with broods. Oelklaus (1976) reported that as spring progressed into summer, unsuccessful hens joined male flocks and older broods began to aggregate. Summer heat and drought conditions drew smaller groups together near remaining available water. During this period, the greatest numbers of chukar were closely associated with the Snake River and its riparian habitats (Oelklaus 1976). Likewise, Christensen (1970) concluded the summer distribution of chukar in Nevada depended a great deal upon the distribution and availability of water. However, despite the tendency of birds to be near water during most of day in hot weather, occasional broods and accompanying adults were found during the early morning hours on hillsides >1 mile from the closest known surface water (Christensen 1970). In Washington, Galbreath and Moreland (1953) reported that during May and early Jun, broods were often found in small side canyons (i.e., tributaries to the main canyon).

Rock cover may be important for nesting, but it does not appear to be important for brood rearing. Galbreath and Moreland (1953) observed that young chukars ($\leq$4 weeks) did not use rocky terrain for escape as older chicks or adults. Likewise, Lindbloom (1998) reported that chukars with broods avoided open, rocky areas, whereas adult chukars did not. Only 11% of brood locations (from radio telemetry) were in rock cover types, compared to 42% in shrub and 47% in grass/forb cover, respectively (Lindbloom 1998). Walter (2000) also reported that broods used shrub cover types more and rock cover types less than adults without broods, and broods used gentler slopes than adults (although broods used steeper slopes as they aged). Shrub cover types may be an important component of brood-rearing habitat, but more research is needed. Lindbloom (1998) suggested that increased vulnerability to predation and/or decreased food availability (mostly insects) may explain why chukar broods generally avoided open, rocky areas. Chukars with broods also avoided grass/forb areas with >5% yellow-star thistle, but potential effects of yellow-star thistle on productivity needs further investigation (Lindbloom 1998).

4.5.3.2. Gray Partridge. Data are lacking on brood ecology of gray partridge in Hells Canyon or other canyon grasslands. However, habitat use by broods is thought to be mainly influenced by food availability (especially arthropods) and vertical habitat structure (Green 1984, Enck 1986). In North Dakota, Carroll et al. (1990) reported that young broods (<2 weeks) preferred habitats with greater amounts of herbaceous vegetation and insect abundance. Several studies have shown extensive use of cereal-grain fields and avoidance of row crops such as corn and sugar beets (Church 1980, Smith et al. 1982, Green 1984, Enck 1986). However, use of cereal fields probably is proportional to availability in most cases. Furthermore, young broods mostly utilize edges of grain fields, which usually contain higher insect populations (McCrow 1980, Carroll et al. 1990). After harvest, partridge may shift from small-grain fields to row crops (Smith et al. 1982) or brushy cover (Yocom 1943), depending on availability. The relationship among insect abundance, brood habitat use and survival, and agricultural practices has been well studied in Europe (Potts 1986), but less well studied in North America. Weigand (1980) suggested that broods in Montana preferred rangelands because they contained more insects than other available cover types.

4.5.4. Wintering

4.5.4.1. Chukar. After late fall and winter rains, when grasses begin germinating and succulent food becomes available, chukar flocks disperse throughout their range, including waterless sites that may have been unoccupied during summer (Christensen 1970, Oelklaus 1976). Snowfall accumulations may cause chukars to move to lower elevations where feed is available, but they return to higher elevations as the snow recedes (Christensen 1970). Chukars are frequently found at the lower fringe of the snowline, and commonly utilize exposed areas above the snowline such as south- and west-facing slopes and wind-swept ridges (Oelklaus 1976). Abnormally heavy snowfalls may force large numbers of chukars to concentrate on an extremely restricted range until the snow level returns to normal elevations. Oelklaus (1976) described exceptionally heavy snowfalls in the Hells Canyon-Oxbow area in January 1975, which forced numerous chukars to concentrate near the reservoir shorelines under shrubs and trees. As the weather warmed in mid-January, chukars followed the retreating snowline and redistributed themselves throughout their typical winter range.

4.5.4.2. Gray Partridge. In the open prairies of North America, gray partridge experience more severe winters than in their native European range; thus, habitat quality and climatic extremes hold the key to overwinter survival (Schultz 1980). In North Dakota and Montana, coveys utilized woody cover near farm or ranch sites extensively for winter roosting (Schultz 1980, Weigand 1980). Idle agricultural habitats were important in the Great Lakes region (Yeatter 1934, Gates 1973) and Montana (Weigand 1980). In South Dakota, habitat use during late summer through winter was characterized by use of row crops, except for 1 winter with deep snow, when birds used pastures (Smith et al. 1982). In North Dakota, association with agricultural land was highest in early winter (mainly for feeding), whereas use of habitats near or within farmsteads increased with winter severity, especially snow depth (Schultz 1980). In Latah County, Idaho, gray partridge used the lee side of hills, grass clumps, shrubs, and slight depressions in the ground to reduce wind-chill effects, and clumps of hawthorns (*Cragetus spp.*) were used on a daily basis, for varying lengths of time, when cold winter winds prevailed (Mendel 1979). Plowed stubble (usually the bottom of a furrow) was the preferred winter roosting cover on the Palouse Prairie (Haugen 1941, Mendel 1979); selection of depressions for roosting may reflect microclimate characteristics, protection from predators, or both (Mendel 1979). No published reports on winter habitat use by gray partridge inhabiting Hells Canyon or other canyon grasslands, but birds probably use a diversity of habitats because of the relatively mild winters.

4.5.5. Foraging

4.5.5.1. Chukar. Foraging activity generally is greatest during mid-morning and through the afternoon (Christensen 1970). Habitats used for foraging reflect seasonal changes in diet, nutritional requirements, and food/water availability (see 4.6 General Food Habits, below). Birds move continuously while feeding and range widely (Christensen 1970). In hot summer months, they are often found feeding close to water. During the summer and early fall, seeds are the primary food, with cheatgrass, rough fiddleneck (*Amsinckia tessellata*), and red-stem filaree (*Erodiumm cicutarium*) often dominating the selection (Christensen 1996). However, Lindbloom (1998) reported that chukars used northwest-facing slopes more in summer than in spring, ostensibly to find more favorable temperatures and succulent vegetation. In spring, when a large variety of plants germinate and insects start to appear, chukars turn to these sources of food, in addition to green grasses and forb leaves. Chukars with broods use shrub and grass/forb cover types, probably for both foraging and security cover (Lindbloom 1998, Walter 2000). In fall and winter, large numbers of birds are often found feeding together on favorite slopes or benches. Green grass leaves provide the bulk of the diet during late fall and winter, although remnant seeds of cheatgrass and red-stem filaree are also consumed. An opportunist, the chukar also uses cultivated grains (waste grain); however, the distribution and abundance of exotic plants and water have more influence on habitat use than availability of cultivated grains (Christensen 1996). Cheatgrass, a favorite food item, is extremely widespread and abundant along the Snake River and its tributaries (Oelklaus 1976). Nevertheless, the importance of other cover types, especially bunchgrasses, shrubs, and rocks, should not be underestimated (Walter 2000).

4.5.5.2. Gray Partridge. Also exhibits seasonal variation in foods consumed and, thus, foraging habitats: mostly insects in summer, seeds of wild plants in late summer and fall, seeds of crop plants in winter and early spring, and leafy vegetation during severe winter conditions (and spring (Yocom 1943, Kobriger 1980, Melinchuk 1981, Hupp et al. 1988). Summer foraging is usually concentrated within several hours of sunrise and sunset (Weigand 1980). Winter foraging may take place throughout the day, although more feeding and grit-picking activity occurs later in the day (Weigand 1980). Most food is picked from the ground, but birds will also pick apart plant heads to reach the seeds (Carroll 1993). During winter, birds will often tunnel in snow to reach waste grain (Carroll 1993). During hot, dry summers, gray partridge with broods may concentrate along brushy draws where water can be obtained from seepage or pools; however, young broods and adults have been observed away from water sources and, thus, probably can use succulent vegetation and insects to meet their water needs (Yocom 1943). Information on foods and foraging habitats is mostly from studies conducted in agricultural areas. We know of no published reports on food habits or foraging activity in canyon grasslands.

4.5.6. Security Cover

4.5.6.1. Chukar. Oelklaus (1976:30) described security cover, including roosting and loafing areas, in the Snake River canyon:

> "Flocks and individual birds may be found some distance from rock outcroppings as they feed or water during the day. When they feel threatened, or when preparing to roost for the night, the vast majority of chukar flocks seek the shelter of rock outcroppings or talus-covered slopes. The birds appear to prefer a promontory as a roost, not necessarily the highest point but more frequently an area that rises above most of the surrounding topography. These exposed roosts are abandoned in favor of more sheltered sites during inclement weather.
>
> Rock outcroppings, some Douglas hackberry (*Celtis douglasii*) and smooth sumac (*Rhus glabra*) communities, and occasionally east-west oriented ridges serve as loafing areas during the day. The shade provided by these areas is primarily important during the summer and fall, when temperatures are highest and drought conditions generally prevail. These same areas also provide protection from predators and inclement weather all year. Chukars remained in shaded areas, sleeping and loafing, for most of the day during the late summer and early fall. When weather conditions were more moderate the periods of chukar activity were greatly extended.
>
> Those tree-shrub habitats most heavily utilized in the fall provide a dense overstory canopy close to the ground. This results in a sparse understory of herbaceous cover, allowing good visibility and unencumbered movement of birds beneath the canopy. Smooth sumac stands and low growing Douglas hackberry trees were the vegetation most often found providing these conditions. Douglas hackberry occurs extensively along the banks of the free-flowing portion of the river, but is generally absent from reservoir shorelines. Hackberry and sumac associations near water sources serve as valuable resting areas in the summer and fall. Where these plants occur close to a water source, they almost always showed signs of chukar use throughout the drought season of 1974. Poison ivy clones also showed intensive use when they occurred near a water sources. In 1975 the birds were much less dependent on this shelter, primarily because of cooler temperatures."

Oelklaus (1976) also noted that flocks observed on Brownlee Reservoir generally were located well back from the reservoir; he suggested the lack of association with the river was probably due to the paucity and distribution of escape cover and shelter near the reservoir shoreline. Oelklaus (1976) concluded that chukar flocks along Brownlee Reservoir relied almost entirely on topographic relief and aspect differences for shelter.

4.5.6.2. Gray Partridge. The coloration of plowed-stubble fields blends well with the gray partridge's plumage and generally provides sufficient cover from predators in fall and winter (Mendel 1979), although idle habitats were more important in Montana (Weigand 1980). Selection of stubble versus permanent cover during winter may be a function of the rolling topography and relatively mild winters on the Palouse (Mendel 1979). Permanent cover, especially uncut grass and weedy areas, is important in spring and summer (Weigand 1980).

Grassy areas with small openings and scattered hawthorns or willows (*Salix sp.*) seemed to be the preferred cover types on the Palouse Prairie (Mendel 1979). Dense stands of reed canarygrass (*Phalaris arundinacea*) may be utilized occasionally, but birds generally prefer open-grass stands if available (Mendel 1979). During warm (>15-22° C) summer days, gray partridge actively seek shade during mid-day (Hunt 1974, Mendel 1979). No published information is available on habitat use by gray partridge in canyon grasslands, including Hells Canyon.

4.5.7. Habitat Quality and Connectivity

4.5.7.1. Chukar. The influence of landscape configuration and composition on the population ecology of chukar in North America has not been studied. However, considering the mobility of adult chukars and characteristics of the habitats they occupy, landscape configuration and composition may not be as important in less mobile species or birds occupying highly fragmented landscapes (e.g., Clark et al. 1999). On the other hand, juxtaposition of habitats may be important during specific life-history stages. For example, Walter (2000) suggested that proximity of water sources to shrub cover types may be important for chukar broods given their habitat requirements and short daily movements. Furthermore, connectivity or isolation at larger spatial scales (e.g., within the Intermountain West) may have important implications for the spatial structure (*sensu* Wells and Richmond 1995) and genetic structure (e.g., Randi et al. 1992, Randi and Alkon 1994, Kark et al. 1999) of chukar populations in western North America.

Chukar populations have both benefited and are threatened by changes in habitat quality. Populations in the Intermountain West benefited from degradation of canyon grasslands via overgrazing, range fires, and the widespread distribution of cheatgrass, an exotic plant. However, loss of bunchgrass habitats and recent invasions by 2 exotic plants, yellow-star thistle and medusahead (*Taeniatherum caput-medusae*), may threaten long-term viability of chukar populations in the Snake and Salmon River drainages (Lindbloom 1998, Washington Department of Fish and Wildlife 1999, Walter 2000). For more information, see 4.10.6 Habitat Degradation, below.

4.5.7.2. Gray Partridge. Effects of habitat degradation on gray partridge populations inhabiting Hells Canyon or other canyon grasslands are unknown because the populations have not been carefully studied or monitored. The factors believed to negatively affect gray partridge populations in agricultural habitats (e.g., pesticides, loss and fragmentation of permanent grass and shrub cover, hay mowing) probably are not important in canyon grasslands. On the other hand, loss of grassland habitat due to invasions by yellow-star thistle may negatively affect recruitment in gray partridge populations, although the data necessary to substantiate this concern are lacking. Very little is known about gray partridge populations inhabiting canyon grasslands. Even baseline data on habitat use and selection, movements, survival, recruitment, and population trends are lacking.

4.6. General Food Habits

4.6.1. Chukar

Plant food makes up the bulk of the chukar's diet (Alcorn and Richardson 1951, Christensen 1952a, Weaver and Haskell 1967, Zembal 1977, Walter 2000). In Nevada, seeds of cheatgrass, red-stem filaree, and rough fiddleneck were predominant food items, although green leaves of cheatgrass and bluegrass (*Poa* spp.) were a staple food during winter (Christensen 1996). Other important foods were seeds of Indian ricegrass (*Oryzopsis hymenoides*), piñon pine (*Pinus monophyllia*), sunflower (*Helianthus sp.*), and tansy mustard (*Desurania pinnata*). In Washington, the annual diet consisted mainly of cheatgrass seeds, grass leaves, and wheat (Galbreath and Moreland 1953). In eastern Oregon, the fall diet consisted mostly of cheatgrass seeds and leaves; however, a variety of foods were consumed, e.g., 72 food items were found in the crops, including bulbils of prairie starflower (*Lithophragma parviflorum*), which ranked fourth in frequency of occurrence and first in dry weight (Walter 2000). *Lithophragma* was also common (frequency of occurrence) in the fall diet of chukars in Washington (Knight et al. 1979) and Nevada (Weaver and Haskell 1967), but contributed <8% to wet volume. In Colorado, cheatgrass seeds, ricegrass seeds, and green shoots of cheatgrass, ricegrass, wheatgrass (*Agropyron sp.*), and horsetail (*Equisetum sp.*) were favored (Sandfort 1954). In Hawaii, available foods differ from those in North America; however, exotic (alien) plants were also important food items (i.e., they accounted for 31% of the diet; Cole et al. 1995). During summer and autumn, when the bulk of their diet is seeds, chukars may require access to drinking water (Degen et al. 1984).

Insects usually do not comprise a large portion of the diet of adult chukar, although locusts (*Melanoplus sp.*) are readily taken when available (Christensen 1996). La Rivers (1967) reported finding several hundred live specimens of a new species (*Margarodes chukar*) in the crop of 1 bird collected near Reno, Nevada. The species was named after the chukar because cheatgrass, a favorite chukar food, appears to be its host plant (Christensen 1996). *Margorodes* was also present in 15% of 45 crops from western Nevada (Weaver and Haskell 1967). Insects form the bulk of the early diet of chicks (Harper et al. 1958).

Christensen (1996) summarized the food habits of chukar partridge in North America:

> "Green grass leaves provide bulk of diet during fall and winter; diet is augmented by remnant seeds of cheatgrass and red-stem filaree. In spring, when large variety of plants germinate and insects start to appear, chukars turn to these sources of food in addition to green grasses and forb leaves. During summer and early fall, seeds are primary food, with cheatgrass, rough fiddleneck, and red-stem filaree often dominating the selection. Exotic plants are important, and cheatgrass in one form or another is eaten year-round. An opportunist, this bird uses cultivated grains when available but is not a serious threat to agriculture, since most of its habitat is outside agricultural areas and it takes only grain left over on the ground after harvest."

4.6.2. Gray Partridge

We found no published reports on food habitats of gray partridge inhabiting canyon grasslands. The following summary is based on studies conducted in agricultural landscapes in North America.

Gray partridge are opportunistic, thus a variety of foods are consumed including seeds of domestic crops (wheat, barley, oats, corn, and sunflower) and weeds in cropfields (foxtail [*Seatia spp.*], wild buchwheat [*Polygonum spp.*], ragweed [*Ambrosia spp.*], and Russianthistle [*Salsola kali*]) (Kobriger 1980, Melinchuk 1981, Hupp et al. 1988). The most important animal foods for adults in the northern plains include Orthoptera and Lepidoptera. Insects are important in early diet of chicks and include leafhoppers (Cicadellidae), flies (Diptera), ants (Formicidae), grasshoppers and crickets (Orthoptera), plant bugs (Miridae), sawfly larvae (Hymenoptera), Lepidoptera larvae, Carabidae, Staphylinidae, and cereal aphids (Aphidae) (Erpelding et al. 1987, Kobriger 1980, Potts 1986, Hupp et al. 1988). Diet varies by season: mostly insects in summer, seeds of wild plants in fall, seeds of crop plants in winter, and green leafy vegetation during spring (Carroll 1993).

4.7. Movements

4.7.1. Daily Movements and Home Ranges

Home range is the area used by an animal during a specified time period to satisfy food, cover, and reproductive requirements, excluding infrequent exploratory movements (Burt 1943, Walter 2000). Individual home ranges often are variable. Variability in home ranges may reflect differences in social status, season, weather, and landscape characteristics (Smith et al. 1982). Furthermore, comparisons among studies should be viewed with caution due to differences in acquiring and analyzing home-range data.

4.7.1.1. Chukar. Estimates of daily movements and home ranges of chukars in North America are limited. Anecdotal observations suggested that chukars frequently moved 1-3 mi/day (Bump 1951 and Phelps 1955, cited in Christensen 1996; Oelklaus 1976). During summer and early fall, daily movements often involved movements up and down the canyon walls (Oelklaus 1976). Estimates from 2 radio telemetry studies indicated that daily movements and home ranges were much smaller than previously thought. Lindbloom (1998) reported that average daily movement of chukars in the Salmon River drainage during March-August was 280 m (n = 19, SE = 44.5, range: 32-686), but no radiotagged birds moved from higher elevations to lower elevations near the river's edge. Average daily movements were similar between seasons (spring and summer) and sexes. Average distance between chukar locations and permanent water was 1,103 m (n = 31, SE = 95, range: 157-1,901). Average spring-summer home range was 39.8 ha (100% MCP method; n = 20 birds, 5-16 locations/bird; SE = 5.0, range: 6.0-78.8), which was similar between years and sexes. Walter (2000) reported that average daily movement in eastern Oregon during April-August was 282 m (n = 17, SE = 11.2, range: 181-415) and average spring-summer home range was 17-25 ha (90% MCP and 70% AK methods; n = 13 birds, $\geq$25 locations/bird). However, both Lindbloom (1998) and Walter (2000) cautioned that their studies were conducted during years of relatively high precipitation. Thus, chukars did not need to move great distances between habitats supporting food and water (Lindbloom 1998).

4.7.1.2. Gray Partridge. Gray partridge movements and home ranges have been widely studied using radio telemetry; however, no data were available for populations inhabiting Hells Canyon or other canyon grasslands. The following is based on studies conducted in agricultural landscapes.

Yeatter (1934), Yocom (1943), and Bishop et al. (1977) suggested that the home range of gray partridge was about 50 ha, while McCabe and Hawkins (1946) estimated that most partridge remained within 200 ha. However, home ranges are seasonally variable. Fall home ranges in North Dakota ranged from 16 to 310 ha (*n* = 4; Hupp et al. 1980). Average winter home ranges in North Dakota, South Dakota, and New York were 116.6 ha (SD = 101.5, *n* = 17), 96 ha (SD = 110.6, *n* = 8), and 105 (established range; SE = 7.6, *n* = 7) to 392 ha (translocated range; SE = 41.0; *n* = 15), respectively (Smith et al. 1982, Carroll 1989, Church and Porter 1990b). Mean home range in North Dakota during a severe winter (deep snow and cold temperatures) was 16.6 ha (range: 4.9-34.0, *n* = 8; Schulz 1980). Average spring home ranges in New York ranged from 82 ha (SE = 2.3, *n* = 5) to 672 ha (SE = 37.5; *n* = 10) for birds in established and translocated range, respectively (Church and Porter 1990b). Summer home ranges are influenced by presence and age of chicks (Carroll 1993). In North Dakota, mean home range of family groups with young chicks (<2 weeks) was 8.2 ha (SD = 9.0, *n* = 5), whereas family groups with older chicks (2-4 weeks) averaged 23.1 ha (SD = 17.7, *n* = 3; Carroll et al. 1990). In Wisconsin, mean home range of family groups with prefledged young was 19.7 ha (SE = 13.7, *n* = 5; Church 1980). In North Dakota, adults without young had a mean home range of 71.9 ha (SE = 64.2, *n* = 4; Carroll et al. 1990).

4.7.2. Seasonal Movements

4.7.2.1. Chukar. The only seasonal movements exhibited by this species are altitudinal movements (Christensen 1996). Water availability and snow cover appear to be the primary factors influencing chukar distribution and movements (Christensen 1970). In Nevada, birds that inhabited higher elevations (1,824-3,040 m) descended to or below the snow line during winter (Christensen 1954). Oelklaus (1976) described exceptionally heavy snowfalls in the Hells Canyon-Oxbow area that forced chukars to concentrate near the reservoir shorelines under shrubs and trees. In both cases, chukars redistributed themselves as the snowline retreated. Water availability is probably the ultimate reason for down-slope movements during the hot summer-fall season (Oelklaus 1976, Walter 2000). In Idaho and Oregon, chukars use tree-shrub communities adjacent to sources of drinking water as day roosts (Oelklaus 1976) and for brood-rearing (Walter 2000). Lindbloom (1998) reported that radiotagged chukars along the Salmon River did not exhibit altitudinal movements during summer-fall, but the study was conducted during a period of above-average precipitation and, thus, water was available at higher elevations. After the first fall rains, when grasses being germinating and succulent food is present, coveys move freely throughout their range and may inhabit waterless sites that were unoccupied during summer (Christensen 1970).

4.7.2.2. Gray Partridge. Gray partridge in North America are non-migratory and relatively sedentary, but pairs may move up to 25 km to find suitable nesting cover (Carroll 1993). Other directional movements observed in North Dakota in spring included (1) movement of birds from winter coveys in search of mates, and (2) movement of excess and unpaired males in search of mates (Carroll 1993; also see 4.7.3 Dispersal and Fidelity, below). Seasonal shifts in habitat use and home range were described above (see 4.5 Habitat and 4.7.1. Home Range). No data are available on seasonal movements of gray partridge inhabiting Hells Canyon or other canyon grasslands.

4.7.3. Dispersal and Fidelity

4.7.3.1. Chukar. During their establishment in North America (1950s-1970s), chukars moved long distances in a relatively short time. In California, Harper et al. (1958) documented movements of 32 km (20 mi) in 3 months and 52.8 km (33 mi) in 2 years. In Nevada, chukar populations became established as far as 128-224 km (80-124 mi) from initial or closest release sites; dispersions occurred in $\leq$19 years from sites where 8-50 birds were released (Christensen 1958). Christensen (1970) reported that 1 chukar traveled 28 km (17 mi) from its release site back to its capture site, which suggested that chukars have homing capabilities. Dispersal distances of several km have been documented in rock partridges (*A. graeca*) in Italy (Cattadori et al. 1999). Lindbloom (1998) and Walter (2000) did not observe movements >4 km, but their movement data were mostly from adult chukars during spring and summer. Dispersal behavior of juvenile chukars during fall to early spring needs further study.

Limited data are available on within-season dispersal (i.e., movements between nesting attempts and dispersal of brood from nest site) and between-year dispersal (site fidelity). In Oregon, distance from first nests to renests averaged 1,210 m (range: 186–4,066, *n* = 4; Walter 2000). Lindbloom (1998) reported that 1 chukar moved about 2 km after its initial nesting attempt failed. In Idaho, average dispersal distance of broods (1-66 days) from nest sites was 788 m (SE = 114, *n* = 27) and, as expected, older broods (>2 weeks) dispersed farther ($\bar{x}$ = 1061 m) than younger broods ($\leq$2 weeks, $\bar{x}$ = 448 m; Lindbloom 1998). Adult chukars may exhibit strong fidelity to spring-summer home ranges (*n* = 2 adult chukar; Lindbloom 1998), but more research is needed. We did not find any published data on nest-site fidelity or natal philopatry.

4.7.3.2. Gray Partridge. No data are available from populations inhabiting Hells Canyon or other canyon grasslands; the following is based on studies conducted in agricultural landscapes.

Within a breeding season, renesting usually occurs close to initial sites (Carroll 1993). Distance from first nests to renests averaged 150 m (SE = 97) in Wisconsin (Church 1984), and in North Dakota 2 renests were 154 and 363 m from previous nests (Carroll 1993). Little movement away from nesting site until the following breeding season, but data are limited (Carroll 1993). Church et al. (1980) reported that 56% (*n* = 9) of immature females nested within the winter home range of their covey; maximum distance moved averaged 2.2 km (SE = 0.4, range: 0.9-9.6 km). In Montana, spring movements away from winter trap sites varied from 0.177 km (SE = 0.433, *n* = 5) for adult females to 0.257 km (SE = 0.433, *n* = 59) for immature males (Weigand 1980). In Europe, spring dispersal rates were 28% (*n* = 81) for immature males, <1% (*n* = 116) for adult males, 5% (*n* = 81) for immature females, and 1% (*n* = 97) for adult females (Jenkins 1961a). In New York, unpaired males (*n* = 5) moved 5-15 km and females moved $\leq$3.6 km (Church and Porter 1990b). Carroll (1993) reported that pairs may move up to 25 km to find suitable nesting cover.

Weigand (1980) suggested that adult partridge in Montana exhibited strong fidelity to winter ranges; 100% (*n* = 4) of adults returned to their winter ranges during their second winter and 1 returned the third winter, whereas 74% (*n* = 19) of subadult males and 50% (*n* = 4) of subadult females returned to their original winter ranges in subsequent years. Weigand (1980) concluded that subadult males showed the greatest mobility and were the only sex-age group that showed continued seasonal-range expansion between initial and second winter ranges.

4.8. Species Significance in Hells Canyon

4.8.1. Social and Economic

4.8.1.1. Chukar. Chukars are probably the most important game bird in Hells Canyon in terms of recreational and economic value, and their importance will likely increase as nearby urban centers grow and private-lands access becomes more difficult and restricted. However, quantitative data on recreational and economic values of chukar are limited. Dorian (1958) estimated the economic value of chukar hunting in Nevada during 1951-63 was $2,704,550 or about $208,000/yr, and predicted increased economic and recreational values in the future. The chukar is the number 1 game bird in Nevada and Oregon, and number 2 and 3 in Washington and Idaho, respectively; >20 million birds were harvested during 49 years (1947-95) in Oregon, Idaho, Nevada, Washington, California, and Utah (states listed in descending order by size of harvest; Christensen 1996). In Idaho, the estimated statewide harvest of chukars during 1991-96 was 103,780 birds/year (range: 54,600 in 1992 to 208,600 in 1996; Idaho Department of Fish and Game 2000). In Oregon, 9,578 hunters spent 57,119 days afield and harvested 82,386 chukars in 1999-00 (ODFW 2000). Data specific to Hells Canyon are lacking.

4.8.1.2. Gray Partridge. No data on economic or recreational value of gray partridge in Hells Canyon are available. Gray partridge are often harvested by chukar hunters; thus, their social and economic significance in Hells Canyon is correlated with the chukar. In Idaho, the estimated statewide harvest of gray partridge during 1991-96 was 47,633 birds/year (range: 27,800 in 1992 to 109,300 in 1996; IDFG 2000). In Oregon, 3,386 hunters spent 16,660 days afield and harvested 19,061 gray partridge in 1999-00 (ODFW 2000). Data specific to Hells Canyon are lacking.

4.8.2. Ecological

Ecological significance of chukar and gray partridge in Hells Canyon may include (1) their relative importance as prey, especially for raptors; (2) interspecific interactions with other game birds, especially native species; and (3) their potential role as a disease vector. The 3 ecological concerns are briefly reviewed and discussed in the following paragraphs. In most cases, conclusions are based on anecdotal evidence from other populations and geographic areas; quantitative data are lacking for Hells Canyon.

4.8.2.1. Chukar. Major predators of adults and chicks in Hells Canyon are the golden eagle (*Aquila chrysaetos*), great horned owl (*Bubo virginianus*), and coyote (*Canis latrans*) (see 4.10.2 Predation, below). Adults are most vulnerable while nesting and during winters when heavy snows occur. Chicks are easier prey during first 2 weeks of life (Christensen 1996). Chukars avoid aerial predators by squatting beneath brush or rocks; individuals tend to run, then fly rapidly, when approached by terrestrial predators (Christensen 1996). Limited data are available on relative importance (frequency or % volume) of chukar in diets of main predators. Chukars were the fourth most common food item of nesting golden eagles in California and Nevada (Bloom et al. 1982). Use of chukar may be higher when main prey items are scarce. For example, red-legged partridge in Spain became a major component of goshawk (*Accipiter gentilis*) diets when the primary prey, European rabbits (*Oryctoloagus cuniculus*), was scarce (Manosa 1994, cited in Walter 2000:78). About 40% of spring-summer mortalities in Oregon were due to avian predators (Walter 2000). In Idaho, avian predators accounted for 59% of adult mortalities and the golden eagle was identified as the likely predator in 50% (n = 10) of the cases (Lindbloom 1998). Walter (2000) suggested that chukars may be an important component in the diet of raptors in some locations or during selected times of the year.

Nonpredatory-interspecific interactions would most likely involve other upland game birds. Introduced species of concern include the gray partridge, ring-necked pheasant (*Phasianus colchicus*), and California quail (*Callipepla californica*). Native species of concern that were historically or currently present in Hells Canyon include the mountain quail (*Oreortyx pictus*), sage grouse (*Centrocercus urophasianus*), and sharp-tailed grouse (*Tympanuchus phasianellus*). Blue grouse (*Dendragapus obscurus*) and spruce grouse (*Dendragapus canadensis*) are also present, but chukars generally avoid forested habitats (Oelklaus 1979). However, chukar and gray partridge have been observed in close proximity to blue grouse in Hells Canyon on open slopes near forested drainages (Ratti, unpublished data). Interspecific interactions are most likely to occur at watering and nesting sites (Christensen 1970), or during winter months when food or feeding areas are limited (Galbreath and Moreland 1953). Harper et al. (1958) observed an adult chukar killing a Gambel's quail (*Lophortyx gambeli*) chick at a waterhole in California. However, in general, documented cases of conflict between chukars and other birds are rare (Galbreath and Moreland 1953, Christensen 1970). Christensen (1970) did not know of any instance where there was serious competition between the chukar partridge and native game species. Likewise, Cole et al. (1995) did not observe any negative effects of chukar and ring-necked pheasant on the endangered Nene goose (*Branta sandvicensis*) in Hawaii, and concluded the chukar and ring-necked pheasant may play an important role in facilitating seed dispersal and germination of native plants (a role once played by native vertebrates). Interspecific interactions involving closely related species (gray partridge and ring-necked pheasant) are more likely to occur, although Galbreath and Moreland (1953) did not observe any serious interactions when chukar, gray partridge, and/or ring-necked pheasants mingled at feeding and watering sites. On the other hand, Watson (1962a) suggested that sympatry and allopatry may have influenced the distribution and evolution of *Alectoris* and *Perdix* in Europe and Asia. To our knowledge, there have been no studies of interspecific interactions involving sympatric populations of chukar and gray partridge in North America.

Wild chukars appear to be relatively free of disease, although infections of malaria (via the protists *Plasmodium sp.* and *Haemoproteus sp.*) and sarcosporidiosis (via *Sarcocystis sp.*) were reported in a several birds collected in Nevada during the 1950s. Small springs or seeps would probably be the primary source of contamination in spreading disease because chukars often concentrate at these sites during certain times of the year (Christensen 1970). However, we did not locate any reports that documented where disease or parasitism caused serious mortality in wild chukar populations or lead to epizootic outbreaks in other species via transmission from infected chukars.

4.8.2.2*. *Gray Partridge. No data exists for gray partridge populations inhabiting Hells Canyon or other canyon grasslands, but their ecological role as prey is probably similar to chukars. As noted above, lethal or negative interactions involving gray partridge and other game birds are rare. Jenkins (1961b) reported that male partridge attacked ring-necked pheasants and on 1 occasion a gray partridge attacked a lapwing (*Vanellus vanellus*). Ring-necked pheasants parasitize gray partridge nests, and pheasant chicks in mixed broods are usually dominant (Knott et al. 1943, McCabe and Hawkins 1946, Kimmel 1990). Gray partridge may be more susceptible to infections from other species, especially the ring-necked pheasant, than as a disease vector. Wright et al. (1980) reported the pheasant is a tolerant host of *Heterakis gallinarum* and *Histomonas meleagridis* (the causative agent of histomoniasis), and postulated that gray partridge and chukar partridge chicks were susceptible to infections transmitted from pheasants via earthworms. Although their findings were inconclusive, their hypothesis suggested a possible mechanism (low chick survival due to interspecific-disease transmission) to explain the negative correlation between pheasant and gray partridge abundance in Iowa. Susceptibility and infection rates of gray partridge in Hells Canyon are unknown. Nearest data are from the Palouse Prairie, where Yocom (1943) found *Heterakis gallinarum* in low numbers in wild partridge but observed no other endoparasites.

4.9. Population Status and Trends

4.9.1. Chukar

Population size and density can vary dramatically from year-to-year (Moreland and Lauckhart 1960, Christensen 1970, Molini 1976, Rippe 1998, Washington Department of Fish and Wildlife 1999). In Nevada, Molini (1976) estimated the average population size was 750,000 birds, which fluctuated from a low of 200,000 during poor reproduction years to a high of 2,000,000 during good reproduction years. In Asotin County, Washington, the number of chukar counted along aerial-survey transects ranged from 578 in 1993 to 2,930 in 1987 (first year of aerial surveys); however, aerial surveys were not conducted in 1998-99 (Washington Department of Fish and Wildlife 1998). Chukar harvest is also used as an index of population size. Chukar harvest fluctuated annually in Asotin County during 1991-98 (range: 2,790 in 1995 to 12,310 in 1991) and average harvest in the Snake River Basin (Asotin, Columbia, Garfield, and Whitman counties) declined 42% from 60,790 birds/year in the 1970s to 35,104 birds/year in the 1980s and 9,802 birds/year in the 1990s, respectively (Washington Department of Fish and Wildlife 1999). Estimated harvest in Idaho during 1991-95 averaged 35,300 chukars/year; estimated harvest in 1996 was 109,300 birds, which was 152% above the 5-year average (Idaho Department of Fish and Game 2000).

Roadside counts have been conducted of chukar and gray partridge in Baker County, Oregon, since 1973. Chukar counts (birds/10 miles) have ranged from a high of 88 to a low of 0.2. The 27-year mean was 29.4, and counts in 1999 and 2000 were 32.3 and 38.4, respectively.

Annual helicopter surveys are also used to monitor the chukar populations in Hells Canyon (Weiser to Brownlee Dam), Snake River drainage (Hellsgate State Park to Corral Creek), and Salmon River drainage (White Bird Creek to Billy Creek). Annual count data from Brownlee Reservoir are presented in Appendix D. Counts were conducted in late August by flying the same route annually, from Cottonwood Creek upstream to Sturgill Creek, and from the reservoir up slope to about the U.S. Forest Service boundary (Andy Ogden, IDFG, personal communication). The helicopter used 2 observers, and flew contour transects at 400 foot (125 meter) intervals. Total birds were counted and no attempt was made to separate chukar from gray partridge. These data are index counts that reflect relative changes in population size. The data reveal typical population fluctuations, and suggest that populations in recent years have been near or above the 15-year average.

The following data are from outside the study area but provide some indication of trends in chukar abundance (aerial-survey index). Chukar density (birds/mi^2) in the Salmon River drainage of Idaho (White Bird Creek RM 53.6 to Billy Creek RM 16.3) during 1991-99 ranged from 13.2 in 1995 to 116.5 in 1991, and averaged 67.6 birds/mi^2; chukar groups/mi^2 ranged from 4.0 in 1995 to 13.0 in 1992, and averaged 7.7 groups/mi^2 (C. Johnson, Bureau of Land Management, Cottonwood Resource Area office, unpub. data). Walter (2000) estimated that summer chukar density in Succor Creek State Park in eastern Oregon during 1997-98 was 62.5 birds/km^2 (161.9 birds/mi^2). Highest densities of chukar in Idaho generally occur in southwestern and west-central portion of the state (Rybarczyk and Connelly 1985).

Aerial survey results from 2000 indicated that chukar numbers along the Snake River were down 50% from the 1999 count and 43% below the 1995-1999 average (C. Johnson, BLM, and J. Crenshaw, IDFG, unpub. data). Along the Salmon River, chukar numbers were 28% below the 1999 count but 11% above the 1995-1999 average. Results from 2000 should be interpreted with caution because surveys along the Snake River and Salmon River were conducted about 2 weeks later than usual (due to local fires and lack of helicopters) and during abnormal weather conditions (cool temperatures and after significant amounts of rainfall) (Jay Crenshaw, IDFG, personal communication).

Breeding Bird Survey (BBS) trend results do not indicate significant changes in chukar abundance in Idaho, Oregon, or the Great Basin during 1966-99; however, results are inconclusive because of the low number of routes and detections (Patuxent Wildlife Research Center, BBS results, http://www.mbr-pwrc.usgs.gov/bbs, 27 Sep 2000). In general, aerial-survey and harvest data indicated chukar populations in Idaho, Oregon, and Washington declined during the mid-1990s and recovered slightly in the late 1990s, but remain below levels observed during the 1970s. However, long-term data on survival, recruitment, density, weather, habitat, and harvest are needed to adequately investigate patterns and factors related to population changes in Hells Canyon (e.g., Rotella et al. 1996).

4.9.2. Gray Partridge

Potts (1986) suggested the worldwide population has declined about 80% from about 110 million in 1953. However, long-term trends in North America are not understood well because few long-term studies have been conducted (Potts 1986, Rotella et al. 1996). Analysis of BBS data indicated that overall the North American population of gray partridge did not change significantly from 1966-99 (Patuxent Wildlife Research Center, BBS trend results, http://www.mbr-pwrc.usgs.gov/bbs, 27 Sep 2000), although the population steadily increased during 1968-88 (Droege and Sauer 1990). Evidence from individual studies indicated the population on the Palouse Prairie of Washington and Idaho may have experienced a long-term decline (Swanson and Yocom 1958, Poelker and Buss 1972, Rotella and Ratti 1986). However, an integrated analysis of data from 1940-92 indicated that gray partridge density on the Palouse

Prairie was higher during 1982-92 (average = 6.7 birds/km^2 in the spring) than 1940-54 (3.5 birds/km^2; Rotella et al. 1996). Gray partridge on the Palouse Prairie and in the Hells Canyon are not currently monitored through annual fish-and-game surveys. Harvest data may serve as a crude population index but few hunters target the gray partridge as their primary pursuit. Thus, harvest statistics may not be a reliable index of population size. Likewise, results of BBS data for Idaho, Washington, and Oregon are inconclusive because of the low number of routes and detections.

Gray partridge on the Palouse Prairie (Washington and Idaho) and portions of southwestern Minnesota, eastern South Dakota, and southern Saskatchewan have attained the highest reported density in North America (Vander Zouwen 1990). Fall population estimates include 32-54 birds/km^2 in Saskatchewan (Hunt 1974), 15-84 birds/km^2 in Idaho (Mendel and Peterson 1980), 48 birds/km^2 in South Dakota (Ratti et al. 1983), and about 1-29 birds/km^2 in eastern Washington (Rotella et al. 1996: fig. 1). Spring density on the Palouse Prairie of eastern Washington ranged from about 2-23 pairs/km^2 during 1940-90 (Rotella et al. 1996: fig. 1). Mendel and Peterson (1980) reported 22-32 birds/km^2 in Idaho during 1977-78. In comparison, Saskatchewan, which contained some of the best habitat in North America, averaged 4.3 pairs/km^2 (Hunt 1974, Carroll 1993). In Great Britain, spring density on managed estates was about 25 pairs/km^2 and declined to 5 pairs/km^2 by 1985 (Potts 1986). There are no published density estimates for gray partridge in Hells Canyon.

Reliable data on population dynamics of gray partridge in Hells Canyon are lacking. The nearest well-studied population is on the Palouse Prairie of eastern Washington. According to Rotella et al. (1996), gray partridge on the Palouse Prairie during 1940-93

> "… can be characterized as having had low recruitment, low fall-and-winter mortality, and moderately high average densities, which exhibit high annual variation. Low recruitment may have been caused by high nest-predation rates associated with sparse-nesting cover. Mild winter weather allowed relatively high overwinter survival. The population occasionally experienced large declines when density-independent random shocks were large, e.g., severe winter weather. Recruitment and winter mortality rates were density dependent. Thus, when populations were small, recruitment rates were high and the population quickly returned to moderately high density. If populations exceeded the return point, recruitment declined sharply, and winter mortality increased."

Whether gray partridge in Hells Canyon have similar vital rates and long-term population dynamics as the Palouse Prairie population is unknown. However, given the unique habitats, topography, and weather in Hells Canyon, data from the Palouse Prairie should not be used for management or assessment of Hells Canyon populations.

Population monitoring for most game bird species is usually accomplished with 1 of several approaches to obtaining an annual "index" count, and the annual change in the index measure is assumed to be directly related to changes in density. However, this direct relationship between actual density and index counts has seldom been tested with wild populations. The only test of this relationship for a North American game species (in the published literature as of this date) was with gray partridge (Rotella and Ratti 1986). This analysis revealed that early morning call counts are a reliable index to density, but that evening call counts are not related to density. These data reveal the danger in the above noted common assumption regarding the direct relationship between density and index values. Early morning call counts for gray partridge may be an appropriate method of monitoring gray partridge in Hells Canyon.

4.10. Limiting Factors

4.10.1. Weather

4.10.1.1. Chukar. Environmental conditions, which govern weather and food supply, play an important part in regulating nesting and hatching success and, subsequently, annual population density of chukars (Christensen 1996). Furthermore, given that basic habitats of chukar are found in arid or semi-arid regions, the primary factor influencing reproductive success and annual production is the amount of precipitation received during key periods of the year (e.g., Walter 2000). The effective precipitation in any given range largely determines the composition, abundance, and condition of essential food plants, which in turn play a major role in influencing annual production (Christensen 1958, 1970). In Nevada, chukar populations during 1951-69 typically exhibited a "boom or bust" pattern that was correlated with drought conditions and the subsequent lack of food (Christensen 1970). According to Christensen (1970:45), "when a population bottoms out, it seems to require a minimum of three good production years, back to back, to bring the population to a peak again. Such a sequence does not usually occur and the population may drift along at a mediocre level for several years." Although no quantitative data are available, comparisons of production data with timing of precipitation during nesting and hatching suggest that unseasonable rains and snows can significantly lower nest success and chick survival (Christensen 1970). Likewise, heavy snowfall in combination with cold temperatures can result in substantial overwinter mortality, especially in areas where elevational movements are restricted (Christensen 1952b). For example, Galbreath and Moreland (1953) estimated 65-75% mortality due to severe winter conditions in Washington during in 1949-50. However, heavy losses from winter storms are usually erratic in nature and populations often recover relatively quickly through immigration and the high reproductive potential of survivors (Galbreath and Moreland 1953, Christensen 1970).

4.10.1.2. Gray Partridge. Weather has been shown to have strong effects on recruitment and overwinter mortality in Wisconsin (Church 1980), New York (Church and Porter 1990a), Montana (Weigand 1980), and Great Britain (Potts 1986). Severe winter weather, especially deep or crusted snow, has been correlated with increased mortality (Potts 1986, Panek 1990). In contrast, weather variables explained little of the annual variation in population change on the Palouse Prairie of eastern Washington during 1940-92, but this area is characterized by consistently dry summers and moderate winters (Rotella et al. 1996). Nevertheless, brief intense storms or depth and hardness of snow pack could occasionally affect the Palouse Prairie population. There have been no studies on effects of weather on populations inhabiting Hells Canyon, but effects of drought and spring storms are probably similar to that described for chukars (see above). However, gray partridge are able to survive extreme winter temperatures by roosting in tight groups and in deep, soft snow, and they can burrow through about 1 m of soft snow to find food (Carroll 1993). Thus, gray partridge may not be as vulnerable to severe winter weather as chukars.

4.10.2. Predation

4.10.2.1. Chukar. Christensen (1970) suggested that predation was not an important limiting factor when birds are in good condition. However, only 2 studies have quantified predation-caused mortality. Lindbloom (1998) and Walter (2000) reported relatively high-mortality rates during spring and summer (see 4.4 Survival, above) and concluded that spring-summer losses to predation may be an important limiting factor. Important predators in the Idaho and Oregon studies were the golden eagle, great horned owl, and coyote. Other potential predators include the bobcat (*Lynx rufus*), prairie falcon (*Falco mexicanus*), sharp-shinned hawk (*Accipiter striatus*), Cooper's hawk (*Accipiter cooperii*), red-tailed hawk (*Buteo jamaicensis*), black-billed magpie (*Pica pica*), raven (*Corvus corax*), and gopher snake (*Pituophis melanoleucus*) (Christensen 1996). Avian predators accounted for about 60% of known mortalities during spring-summer in Idaho (Lindbloom 1998) and Oregon (Walter 2000). However, some of these data may be biased by increased vulnerability of birds with radio transmitters to predation.

4.10.2.2. Gray Partridge. Predation is an important source of mortality, especially during nesting, brood rearing, and winter (Potts 1980, Carroll 1990, Carroll 1992, Church and Porter 1990a). In North America, nests are destroyed by the striped skunk (*Mephitis mephitis*), red fox (*Vulpes vulpes*), raccoon (*Procyon lotor*), domestic dog (*Cans familiaris*), cat (*Felis domestica*), and American crow (*Corvus brachyrynchos*) (Carroll 1993). Adults are most often killed by raptors including great horned owl, snowy owl (*Nyctea scandiaca*), red-tailed hawk, prairie falcon, and northern harrier (*Circus cyaneus*) (Carroll 1993). In Hells Canyon, in addition to the great horned owl, the coyote and golden eagle probably are important predators of gray partridge. In New York and North Dakota, mortality due to avian predators corresponded with periods of limited availability of food (Carroll 1989, Church and Porter 1990a).

In Great Britain, Potts et al. (1995) concluded that in areas where predation levels on eggs are high, populations become more vulnerable to declines in chick survival, which may lead to population declines or collapse. In eastern Washington, low recruitment during 1940-92 may have been caused by high nest-predation rates associated with sparse nesting cover (Rotella et al. 1996). Likewise, Potts (1986:182) reported that nest predation and competition for nesting space were the most important regulatory factors in Sussex, Great Britain. Nesting cover may not be a limiting factor in Hells Canyon, although quantitative data are lacking. Intensive field studies are needed to determine whether nest success, survival of incubating birds, or survival of chicks limit recruitment in Hells Canyon or the Palouse Prairie (e.g., Potts 1986, 1995).

4.10.3. Diseases and Parasites

4.10.3.1. Chukar. Game-farm chukars are susceptible to many common fowl diseases such as gapeworm (*Syngamus trachea*), tapeworm (*Raillietina sp.*), infectious coryza, blackhead and caecal worms (*Heterakis sp.*), intestinal flagellates (*Texamita sp.*), *Trichomonas gallinarum*, and eastern viral encephalomyelitis (Christensen 1996). Christensen (1970) reported infections of malaria (via protists *Plasomidium sp*. and *Haemoproteus sp*.) and sarcoosporidiosis in several hunter-killed chukars in Nevada. In general, however, wild chukars appear to be relatively free of diseases (Christensen 1996).

4.10.3.2. Gray Partridge. Captive gray partridge are also susceptible to a large number of diseases and parasites (Beer 1990, cited in Carroll 1993). However, data on occurrence and effect of diseases and parasites on wild gray partridge in North America are limited. Yocom (1943) found *Heterakis gallinae* (*H. gallinarum*) in low numbers in wild birds on the Palouse Prairie of eastern Washington, but he observed no other endoparasites. Yeatter (1934) observed 1 bird with symptoms of avian tuberculosis and infection rates of 14.5% of *Heterakis spp.* and 31.6% of *Dispharynx spiralis* among wild partridge in the Great Lakes region. He also reported that *Syngamus nasuta* caused numerous fatalities among game-farm partridge. Bendell and Lisk (1957) observed *Dispharynx nasuta* in partridge populations in Ontario. Wright et al. (1980) reported that gray partridge chicks were susceptible to *Histomonas* infections via transmission of *H. gallinarum* from ring-necked pheasants. In Great Britain, diseases and parasites of gray partridge have been well documented (Carroll 1993). Potts (1986) reported parasitic worms (*Trichostrongylus tenuis*, *Syngamus trachea*, and *Heterakis gallinarum*) were associated with the deaths of a large percentage of partridge that died of natural causes in southern England. When partridge populations are dense, *T. tenuis* may be responsible for increased mortality of chicks via infected females (Carroll 1993).

4.10.4. Hunting

4.10.4.1. Chukar. Hunting is the most visible source of mortality for game birds, but not necessarily the greatest (Christensen 1996). Harper et al. (1958) calculated a 4% harvest rate for a heavily hunted chukar population in California. Galbreath and Moreland (1953) reported a harvest of 25% for a heavily hunted population in southeastern Washington. Molini (1976) estimated annual harvest was about 15% for a population in Nevada. Walter (2000) estimated that harvest mortality was 14-25% for an eastern Oregon population during 1997-98.

In Nevada, areas that held chukar seasons during a drought period (population low) recovered as quickly as those that did not have seasons (Molini 1976). Christensen (1996) reviewed attempts by IDFG to increase chukar harvest near the middle fork of the Salmon River:

> "The only access to the area was by boat and the season was from 9 August to 19 September, with a bag and possession limit of 10 and 20 birds, respectively. It was legal to hunt or kill chukar with a shotgun, rifle, or pistol of any kind, including air rifle or air pistol. This special hunt was followed by a regular hunting season from 20 September 1969 to 25 January 1970 (a total of 169 days), with a limit of 10 birds daily and in possession. Even inducements like this resulted in little or no harvest mortality in some of the more rugged and remote areas of the Great Basin."

Thus, hunting is believed to have a minimal impact on chukar populations, especially in areas with limited access and rugged terrain (e.g., Hells Canyon). However, potential secondary effects of hunting (e.g., lead-shot ingestion; Kendall et al. 1996) may warrant consideration in heavily hunted areas. For example, Walter (2000) reported that 7.1% of chukar crops (n = 140) and 5.9% of gizzards (n = 123) contained ingested shot pellets in eastern Oregon.

4.10.4.2. Gray Partridge.Hunting probably is not an important factor in most populations in North America because of low hunting pressure and interest (Vander Zouwen 1990, Carroll 1992, Carroll 1996). Idaho traditionally has one of the longest (ca. 4.5-mo long) and most liberal (10-bird limit) hunting seasons in North America, but gray partridge are primarily shot opportunistically while pursuing other game birds such ring-necked pheasant and chukar (Vander Zouwen 1990). Thus, gray partridge populations generally are harvested lightly and probably could sustain higher harvest levels. However, harvest rates and population levels need to be monitored more directly to provide accurate information regarding population dynamics and the influence of hunting (Rotella et al. 1996).

4.10.5. Accidents

4.10.5.1. Chukar. Accidental drowning can cause significant mortality, especially among young birds (Christensen 1996). Most such losses occur in dry desert areas, where water is limited and birds are forced to use stock-watering troughs, large open-top water storage tanks, and open pits or shafts (Christensen 1970). In Washington, Galbreath and Moreland (1953) reported mortalities due to birds flying into wires. Collisions with vehicles also occur, but are relatively rare because roads often are limited in areas inhabited by chukars. Range fires in spring and summer may result in nest and chick losses but adult mortalities are rare (Christensen 1970). Accidental deaths are probably an insignificant factor in most years and populations (Christensen 1970).

4.10.5.2. Gray Partridge. Losses of nests and nesting females to hay mowing may be an important factor in some populations (Carroll 1993). Analyses of the causes of nest loss from 15 studies in Europe and North America indicated there are 2 important causes of regular nest loss: predation and mowing (Potts 1980). In southeastern Washington during 1940-42, plowing and mowing accounted for >15% and 37% of nest losses, respectively (Knott et al. 1943). In Wisconsin, hay mowing coincided with the peak of hatching, which may partly explain low partridge densities observed during the 6-year study (McCabe et al. 1946). Use of hay fields for nesting and, subsequently, losses to hay mowing are probably more important in areas where permanent-nesting cover is limited (Potts 1986). Other causes of accidental deaths include collisions with vehicles and stationary objects (e.g., fences, wires, etc.). However, Yocom (1943) concluded that collisions with vehicles and stationary objects were relatively unimportant sources of mortality in eastern Washington and mostly involved juvenile birds.

4.10.6. Habitat Degradation

4.10.6.1. Chukar. Chukars generally inhabit areas disturbed and altered as a result of overgrazing and fire; thus, human activity in North America helped create habitat for this species (Christensen 1996). On many intermountain rangelands, cheatgrass, an introduced annual, has become the primary green forage utilized by livestock. Cheatgrass is also an important food item in the chukar diet in spring and fall, and availability of cheatgrass can have a significant impact on chukar populations (Washington Department of Fish and Wildlife 1999). However, the conditions that promote cheatgrass (i.e., overgrazing and fire disturbances) also provide conditions needed for yellow-star thistle, an introduced forb that has steadily increased in the Snake River basin. In Washington, the greatest declines in chukar populations over the last 6 years have occurred in areas infested with yellow-star thistle (Washington Department of Fish and Wildlife 1999). Lindbloom (1999), using radio-telemetry, reported that hens with broods avoided areas with >5% yellow-star thistle, although the distributions of nesting hens and adult chukar were not affected. Unpublished data collected during helicopter surveys along the

Salmon River suggested that relative use of star thistle was lower than use of other habitats in 1993-95; however, weather may explain more of the annual variation in chukar numbers than range expansion of star thistle, especially considering data from 1997 and 1999 (i.e., where 23 and 45% of chukar observations were in star thistle, respectively) (C. Johnson, Bureau of Land Management, Cottonwood Resource Area, ID, personal communication).

Medusahead, another introduced annual, is extremely competitive and can out compete cheatgrass in degraded grasslands (Hironaka et al. 1983, Franklin and Dyrness 1973). Western rangelands infested with medusahead have suffered 40-75% reductions in grazing capacity (Whitson et al. 1996:497). Chukars readily ingest the caryopses of both medusahead and cheatgrass, but Savage et al. (1969) reported that captive birds fed downy brome (*Bromus tectorum*) were in better condition than those fed medusahead. Thus, expansion of yellow-star thistle and medusahead and the subsequent decline in cheatgrass may pose a long-term threat in some areas currently inhabited by chukars (Walter 2000). However, more and better data are needed to adequately evaluate the relative importance of habitat degradation (via yellow-star thistle and medusahead) and weather on chukar populations in the Intermountain West.

4.10.6.2. Gray Partridge. Most gray partridge populations are closely associated with agricultural ecosystems; thus, they are affected by agricultural practices (Carroll 1993). In Europe, agricultural activities, including removal of hedgerow nesting cover, increased use of pesticides, and irrigation activities in cereal crops used for nesting, have negatively affected gray partridge populations (Potts 1980, 1986; Rands 1986, Birkan et al. 1990). Detailed studies in Great Britain indicated that nest success was density dependent (a function of habitat availability and predator levels), while chick mortality, influenced by pesticide use and abundance of invertebrates during summers, was density independent (Potts 1986:182-186). In North America, much less is known about impacts of different farming techniques on gray partridge (Carroll 1993). However, availability of permanent nesting cover has been reported to limit populations in North America (Hupp et al. 1980, Church 1984, Carroll et al. 1990), including the Palouse Prairie (Knott et al. 1943, Poelker and Buss 1972, Mendel 1979, Rotella et al. 1996). On the other hand, increases in some agricultural activities may have benefited partridge populations on the Palouse Prairie; e.g., fall-planted wheat fields provide better nesting cover than spring-planted wheat fields and may provide nesting habitat for a small portion of the population (Rotella et al. 1996). However, these factors may not be as important for gray partridge inhabiting mountainous areas such as Hells Canyon. For example, given the extensive grassland and shrub-steppe habitats in Hells Canyon, nesting cover may not be limiting, although quantitative data on habitat use are lacking. In general, effects from invasions of noxious weeds on the gray partridge population inhabiting Hells Canyon are unknown.

4.11. Conservation and Management

4.11.1. Chukar

The principal human effect on chukar populations is hunting, which can be controlled through proper regulation (Christensen 1996). Estimated harvest rates of most populations are substantially below the maximum-allowable rate of 40% recommended by Molini (1976; also see 4.10.4 Hunting, above). Thus, most chukar populations are probably underharvested (Christensen 1996). However, Walter (2000) cautioned that ingestion of lead shot may be concern in some locations and the issue warrants more research.

Vegetative control programs, since they are not usually conducted in prime chukar habitat, generally have no known adverse effects on the chukar (Christensen 1996). The exceptions may be invasions and control of yellow-star thistle and medusahead. However, reliable quantitative data on effects of yellow-star thistle and medusahead on chukar populations in the Intermountain West, including Hells Canyon, are lacking. Likewise, although grazing and wildfire disturbances supposedly helped create habitat for the chukar (Christensen 1996), quantitative data on these disturbances and their effects on chukar partridge in Hells Canyon are unknown. Lindbloom (1998) suggested that land-management practices such as grazing should be closely monitored to evaluate effects on shrub communities, which provide important chukar habitat in spring and summer. Likewise, Walter (2000) suggested that range-management practices that reduce bunchgrass, sagebrush, and other shrub cover may be detrimental to chukar reproduction by decreasing available nesting sites or brood habitats. In most cases, however, habitat management may be limited to water development and protection or improvement of existing water sources, which is a critical resource for chukars during hot, dry summer months (Harper et al. 1958, Christensen 1970, Christensen 1996).

4.11.2. Gray Partridge

Most recommendations regarding conservation and management of gray partridge in North America focus on agricultural practices and their effects on habitats and survival (see Carroll 1993). Most agricultural disturbances of concern (e.g., mowing, pesticides, loss of permanent cover) are absent in canyon grasslands; thus, it is doubtful that management recommendations derived from agricultural areas directly apply to the population in Hells Canyon. Unfortunately, basic life-history information on gray partridge populations inhabiting Hells Canyon or other canyon grasslands is lacking. Thus, any recommendations should be viewed with caution. However, in lieu of on-site data, issues of concern for conservation and management of gray partridge in Hells Canyon are probably similar to those described for chukar partridge (see above).

5. On-site Assessment

5.1. Methods

5.1.1. Preface

It is important to ***emphasize*** that the on-site study did **not** constitute a quantitative assessment, i.e., these data were collected primarily to assist with a professional qualitative evaluation of populations and habitat conditions. Limitations with time, funding, and data collection did not allow a rigorous research design with statistical tests of specific hypotheses. However, field surveys and site visits, in conjunction with the literature review, provided the best means of accomplishing the on-site evaluation.

5.1.2. Fall-Winter Surveys

The study area contained approximately 104 river miles (i.e., river miles 247 to 351). We attempted to survey every 4th river-mile segment from the water line to approximately 0.5 miles laterally from the river, and approximately perpendicular from the general river-flow direction. Surveys generally followed a circular pattern from the water edge to the nearest adjacent rim, and back to the starting point (but deviations from this pattern were common due to terrain that could not be safely traversed. Surveys were conducted on the Oregon and Idaho sides of the river. We conducted fall-winter surveys in 1999 and 2000. Surveys were distributed throughout the study area between Weiser and Hells Canyon Dam. A general organization of survey segments is provided in Table 1. We were prohibited from surveying some river segments due to access limitations (e.g., no trespassing designations, steep cliff walls and talus slopes too dangerous for foot access). In such cases we attempted use of the following selection process (in order of priority) to choose alternate sites: 1) change survey site to opposite side of river, 2) to ½ or 1 mile upstream, same side, 3) to ½ or 1 mile upstream, opposite side, 4) to ½ or 1 mile down stream, same side, or 5) to ½ or 1 mile down stream, opposite side.

Each survey consisted of 2 people walking from waterline toward the canyon rim, and meandering among habitats. All surveys were conducted during open hunting season for partridge in Idaho and Oregon. We used trained bird dogs (setters and retrievers) to assist with locating birds. Each survey consisted of 4-6 hours of walking (but did not exceed 6 hr). All birds observed were recorded by species and estimated flock size. However, as noted above, these data were intended only to assist with a qualitative assessment of populations and were not intended for statistical analysis or quantitative conclusions regarding populations.

During each survey we classified habitat conditions as 1) excellent, 2) good, 3) fair, or 4) poor. Habitat classifications were based on a qualitative assessment of a combination of 1) habitat structure (e.g., woody vegetation vs. grass and forbs, rock outcroppings, talus slopes, crop land), 2) presence of food-plants (e.g., grasses, forbs), and 3) overall habitat quality (e.g., density and height of cover, grazing impacts, etc.). Classifications were based on an ocular estimate of overall habitat conditions within the boundaries of our circular survey pattern. Overall habitat assessment considered needs for escape cover (e.g., from predators and severe weather), nesting

Table 1. Sampling design for on-site surveys for qualitative evaluations of chukar and gray partridge populations and habitats along the Snake River, Hells Canyon, from Weiser, Idaho (river mile 351) to Hells Canyon Dam (river mile 247).

1999 Survey Number	River Mile Segment	River Side	2000 Survey Number	River Mile Segment	River Side
1	250*	ID	1	254*	ID
2	258	OR	2	262	OR
3	266	ID	3	270	ID
4	274	OR	4	278	OR
5	282	ID	5	286	ID
6	290	OR	6	294	OR
7	298	ID	7	302	ID
8	306	OR	8	310	OR
9	314	ID	9	318	ID
10	322	OR	10	326	OR
11	330	ID	11	334	ID
12	338	OR	12	342	OR

* **Note:** The order of actual river segments surveyed was selected randomly during each year, i.e., sequential presentation in the table was provided to show the systematic distribution of surveys throughout the study duration.

and brood-rearing cover, and food. For each habitat classification, we recorded an ocular estimation of the percent of area, which totaled 100% (e.g., 40% fair, 50% good, 10% excellent). We classified (and scored) grazing as low (1), moderate (2), heavy (3), or severe (4). For each survey segment, we took a minimum of 2 color photographs of "typical habitat" for the general survey area. For each photo site we recorded date and river mile, and side of the river (i.e., Idaho or Oregon). General physiographic features and land-use patterns were described for each survey segment.

As noted for the population data, these data were general classifications and were intended for statistical comparison among survey sites or between sampling years. The information was intended as baseline information for a well-organized qualitative assessment of the environment and partridge habitat.

5.1.3. Spring Site Visits

During spring 2001, we conducted site visits to most fall-survey sites. Spring-site visits consisted of relatively brief visits to visually assess habitat conditions, and obtain comparative color photographs for the region. Our goal was to visit all fall-survey sites, however, water levels and other unforeseen factors prevented access to some sites. Because fall-winter surveys were conducted over a 2-year period, and spring surveys were conducted only in 2000, there was a split in the temporal sequence of visits to specific sites. That is, for sites surveyed in fall-winter 1999, we obtained fall 1999 and spring 2000 photos and other qualitative-assessment data. For the sites surveyed in fall-winter 2000, we obtained spring 2000 and fall-winter 2000 data.

5.2. Results

5.2.1. Survey Summary

We completed 26 surveys (12 in 1999 and 14 in 2000); surveys were conducted between 1 October and 30 December each survey season. Our 26 1-mile segments represented a 25% sample of the linear study-area zone. Sixteen surveys were conducted on the Idaho side and 10 on the Oregon side. Average survey duration was 4.8 hours, and ranged between 3 and 6 hours. Variation in survey duration was often dictated by terrain and weather conditions (e.g., survey duration was less on warm days due to health concern for the dogs). Table 2 provides a summary of survey locations and dates.

Table 2. Summary of fall-winter survey locations and dates for qualitative assessment of chukar and gray partridge populations and habitat, along the Snake River, Hells Canyon, from Weiser, Idaho (river mile 351) to Hells Canyon Dam (river mile 247).

River mile	Date	River side
256.75	15-Oct-99	ID
266.00	16-Oct-99	ID
314.00	17-Oct-99	ID
275.00	18-Oct-99	OR
298.00	23-Oct-99	ID
282.00	25-Oct-99	ID
290.00	26-Oct-99	ID
330.00	27-Oct-99	ID
295.00	28-Oct-99	ID
322.00	4-Nov-99	OR
306.00	5-Nov-99	OR
297.00	6-Nov-99	OR
278.00	14-Oct-00	OR
258.00	15-Oct-00	OR
262.00	16-Oct-00	OR
286.00	17-Oct-00	ID
302.50	22-Oct-00	ID
317.00	23-Oct-00	ID
307.50	24-Oct-00	ID
326.00	25-Oct-00	ID
276.00	28-Oct-00	ID
316.00	30-Oct-00	ID
296.00	1-Nov-00	OR
302.00	2-Nov-00	ID
263.00	3-Nov-00	OR
291.00	30-Dec-00	OR

5.2.2. Chukar and Gray Partridge Surveys

We observed 269 partridge coveys during 26 surveys in 2 field seasons. We counted 9.96 coveys/survey day, and 2.08 coveys/survey hour. Average covey size was approximately 12 birds. Our counts were slightly lower in 1999 than 2000. In 1999, we observed 109 coveys; 9.08 coveys/survey day and 1.90 coveys/survey hour. In 2000, we observed 160 coveys; 11.43 coveys/survey day, and 2.38 coveys/survey hour.

Overall, we observed 144 (54%) chukar coveys and 125 (46%) gray partridge coveys. However, the species ratio was different between years. In 1999, we observed 61% (67) chukar coveys and 39% (42) gray partridge coveys. In 2000 the ratio changed; we observed 48% (77) chukar coveys and 52% (83) gray partridge coveys. Count summaries are presented in Table 3.

Table 3. Summary of chukar (CP) and gray partridge (GP) surveys, Hell Canyon. Bird numbers are covey counts, and average covey size was approximately 12 birds. Counts were obtained during a 2-person survey with trained hunting dogs. Survey duration averaged 4.8 hours. Surveys included approximately 1 mile of linear area adjacent to the Snake River, and surveys followed a circular pattern from water line to the nearest canyon rim. Habitat score (HS) is the combined "excellent" and "good" scores from ocular estimates; see Appendix E.

River mile	Date	State	CP	GP	Total coveys	HS
256.75	15-Oct-99	ID	0	2	2	80%
266.00	16-Oct-99	ID	9	3	12	40%
314.00	17-Oct-99	ID	2	17	19	70%
275.00	18-Oct-99	OR	12	0	12	60%
298.00	23-Oct-99	ID	5	1	6	80%
282.00	25-Oct-99	ID	5	0	5	40%
290.00	26-Oct-99	ID	1	6	7	80%
330.00	27-Oct-99	ID	5	0	5	10%
295.00	28-Oct-99	ID	1	2	3	50%
322.00	4-Nov-99	OR	12	1	13	5%
306.00	5-Nov-99	OR	11	2	13	20%
297.00	6-Nov-99	OR	4	8	12	60%
	1999 Total		67 (61%)	42 (39%)	109	
278.00	14-Oct-00	OR	6	0	6	80%
258.00	15-Oct-00	OR	6	4	10	80%
262.00	16-Oct-00	OR	6	2	8	90%
286.00	17-Oct-00	ID	7	2	9	80%
302.50	22-Oct-00	ID	4	12	16	80%
317.00	23-Oct-00	ID	7	13	20	60%
307.50	24-Oct-00	ID	7	5	12	20%
326.00	25-Oct-00	ID	2	2	4	50%
276.00	28-Oct-00	ID	5	1	6	100%
316.00	30-Oct-00	ID	3	17	20	100%
296.00	1-Nov-00	OR	10	10	20	80%
302.00	2-Nov-00	ID	1	14	15	80%
263.00	3-Nov-00	OR	10	1	11	50%
291.00	30-Dec-00	OR	3	0	3	90%
	2000 Total		77 (48%)	83 (52%)	160	
	Grand Total (1999-2000)		144 (54%)	125 (46%)	269	

5.2.3. Habitat Evaluation

We estimated ground cover (100 – percent bare ground) using 3 categories; <50%, 50-80%, and >80%. Approximately 69% of our survey areas had 50-80% ground cover, and the remaining 31% had >80% cover. We also conducted an ocular estimate of the percent grass, forbs, woody plants, and non-vegetated talus and rock. Approximately 64% of the survey areas were classified as grass dominated, 5% forbs, 14% woody cover, and 17% talus and rock outcroppings. We caution that many of the forbs were difficult to detect during fall and percent cover was likely underestimated. We also estimated the frequency of rock outcroppings as few or none (1), occasional (2), or abundant (3); the overall average score was 2.25.

Our assessment of habitat quality was 22% excellent, 46% good, 23% fair, and 9% poor. Thus, we concluded that approximately 68% of the Hells Canyon region provided good to excellent habitat for both partridge species. We noted a trend toward poorer habitat scores on more southerly portions of the river. For river miles 256.75-282.0, the average percent of habitat with good or excellent ratings was 68.8%; for miles 286.0-302.5, the average was 66.7%; and for miles 306.0-330.0 the average was 41.9%. Poor ratings were generally the result of overgrazed sites, especially sites where cattle would congregate for access to water and loafing. Other "poor sites" typically were south-facing slopes with poor soils and sparse vegetation. We classified (and scored) grazing as low (1), moderate (2), heavy (3), or severe (4). Average grazing score was 1.96; we observed cattle during 10 (39%) of 26 surveys. However, nearly all sites had signs that indicated cattle grazing had occurred in recent years or earlier in the season. It is important to note that most survey sites had a range of grazing and habitat-quality scores; i.e., nearly all survey sites contained some high-quality habitat and some patches of poor habitat. We also noted a trend toward increased grazing with more southerly portions of the river, i.e., a direct relationship with grazing score and river mile (Appendix E, last 2 columns). For river miles 256.75-282.0, the average grazing score was 1.5; for miles 286.0-302.5, average score was 1.66; for miles 306.0-330.0 average score was 2.69. As noted above, our scores were based on an ocular estimate for the survey region, and did not represent systematic collection of habitat data.

We obtained 2-4 35-mm photographs of "typical" habitat conditions at each survey area. These photos may be useful to consider in conjunction with habitat-quality scores. In addition, these photos provide an archival record of general habitat conditions during 1999 and 2000. All photos were submitted with this report to the Environmental Affairs office of Idaho Power Company, Boise, Idaho. Appendix E provides a table of habitat scores.

5.2.4. Spring Site Visit

We also obtained 1-2 35-mm photographs of "typical" habitat conditions during spring site visits. As with fall-survey photos, these photos may provide an archival record of general habitat conditions during the spring of 2000. All spring site-visit photos were taken during a 3-day period 19-21 May 2000. All photos were submitted with this report to the Environmental Affairs Department of Idaho Power Company, Boise, Idaho.

5.3. Discussion

Given an average sighting of 2.08 coveys/survey hour, we would classify partridge populations in Hells Canyon during 1999 and 2000 as abundant. These observations were generally consistent with regional population estimates (from index counts) and from sportsmen reports.

Because our surveys usually started at the river edge and proceeded to the rim of adjacent ridges, we usually passed through several habitat types. The 2 most common general habitat types associated with partridge were (1) lower-altitude slopes that were grass dominated with relatively few rock outcroppings and talus slopes, and (2) higher and steeper slopes with talus and rock outcroppings and less vegetative ground cover. Our data indicated that chukar partridge were commonly observed in both habitat types, contrary to common opinion (most biologists and hunters consider steep-rocky slopes as primary chukar habitat). We also observed gray partridge in both habitat types, but we did note that partridge were clearly more abundant in the less-rocky slopes with good-quality stands of grass.

Our data suggested that the ratio of chukar to gray partridge in Hells Canyon was close to 50:50. These results are contrary to most reports from both biologists and hunters, who usually conclude that chukars are much more abundant than gray partridge in the Hells Canyon region. Based on conversations with various individuals, a common conclusion would be that chukars represent 70-75% of the partridge population. We feel that our random approach to surveys explains this difference. Chukars have always been the primary bird of choice by hunters and, thus, these birds are also the focus of annual index counts by agencies. Because chukars are commonly assumed to use (or prefer) steep-rocky slopes (that have fewer gray partridge), hunters likely encounter more chukars because they choose to hunt more often in that habitat.

The difference in the ratio of chukar and gray partridge between 1999 and 2000 (61:39 vs. 48:52) may be the result of our short-term sampling, but may also be the result of annual differences in productivity or mortality. These differences (and others noted above) emphasize the need for comparative ecological research in Hells Canyon. Nearly all research on gray partridge to date has been conducted in agricultural environments, and no studies have rigorously examined comparative ecology for sympatric chukar and gray partridge populations in North America.

Although we estimated that approximately 68% of the Hells Canyon region provided good to excellent habitat for chukar and gray partridge, we caution that these data may not reflect long-term trends in habitat condition. Two important factors likely influenced our assessment of habitat quality, precipitation and grazing. Timing and amount of both precipitation and grazing will have a significant effect on the quality and biomass of grass and other vegetation. Good precipitation years with moderate to low levels of grazing should benefit partridge populations. On the other hand, bird populations will likely decline significantly during periods of heavy grazing and below-average precipitation. Obviously, other factors affect partridge populations (e.g., predation, disease, winter weather and over-winter survival), but identifying and separating effects of interrelated factors was beyond the scope of this study.

6. Conclusions

6.1. Social and ecological significance of chukar and gray partridge populations in Hells Canyon.

Both chukar and gray partridge are prominent members of the faunal community in Hells Canyon. Chukars are commonly observed along the river and reservoir edge during summer and early fall by recreational boaters, and camping areas (e.g., Woodhead Park) often have a resident brood of gray partridge that are observed by visitors. In addition, both species (but especially chukar) are very vocal members of the animal community. Their calls echo among canyon walls and are widely recognized and cherished by outdoorsmen. Thus, these species are enjoyed by a large percentage of visitors to Hells Canyon, including campers, hikers, bird watchers, fishermen, and hunters.

Numerous hunters are attracted to Hells Canyon during fall and winter. Hunters seem to prefer pursuit of chukars over gray partridge, but both species are commonly harvested. Ring-necked pheasants are usually considered to be the most popular upland-game-bird species, especially in states with free-ranging wild populations. However, with declines in pheasant populations in recent decades throughout much of Idaho and Oregon, partridge are increasingly important to upland-bird hunters. For example, pheasant harvest in 1996 (most recent data available) was estimated at 166,000 birds, but chukar and gray partridge harvest (combined) was 318,000 (Idaho Department of Fish and Game 2000). The only Idaho upland bird harvest to exceed partridge was California quail with 350,000.

Due to the general lack of research on both partridge species (especially in Hells Canyon), we can only speculate about the ecological significance of these species. Numerous studies have noted declines in raptor populations throughout North America due to environmental toxicants (e.g., DDT), habitat loss, and illegal shooting . Many raptor species, including falcons, hawks, eagles, and owls occur in Hells Canyon. Although good data are lacking, partridge are probably an important food source for many raptor species during certain seasons of the year. Thus, maintaining healthy populations of partridge will likely benefits raptor populations, and help sustain biodiversity of the region.

6.2. Current status of populations and habitat quality in Hells Canyon.

Our survey data indicated that chukar and gray partridge populations in Hells Canyon are relatively high, and probably near or above the long-term average. Given that our survey techniques were unique, we cannot compare them directly with other surveys that have been conducted in Hells Canyon or other regions of Oregon and Idaho. However, given our field experience with partridge and quail species in many states and several Provinces of Canada, we concluded that partridge populations in Hells Canyon during 1999 and 2000 were best classified as "abundant." We did not detect any obvious problems with birds that were examined. (e.g., external parasites, other signs of disease, body condition, etc.), and coveys seemed to be evenly distributed throughout the study area. Mean covey size was consistent with data from other geographic regions, which indicated that reproductive success and its determinants (clutch size, hatching success, and brood survival) were probably average. However, additional research is needed, especially in Hells Canyon with focus on comparative ecology of the 2 species.

Habitat quality in Hell Canyon also seemed to be relatively good. Although some specific sites were classified as poor, most areas surveyed were classified as good or excellent habitat for chukar and gray partridge. Rigorous research is also needed on habitat use, selection, and requirements in Hells Canyon. Such research will provide land managers with the necessary information for proper habitat management, which will help safeguard and maintain healthy populations of partridge. These data are also needed to fully understand direct and indirect effects of livestock grazing on habitat.

6.3. Relative significance of natural and anthropogenic limiting factors in Hells Canyon.

As noted several times on related topics, it is difficult to assess limiting factors, especially in Hells Canyon, given the lack of good research information on partridge. However, we can make a number of speculative comments based on the limited local data available, data from other regions, research on other gallinaceous species, and from our general experiences with upland birds.

Among natural limiting factors we must consider those that affect recruitment and mortality. Precipitation affects vegetation, and vegetative cover and quality is directly related to overall recruitment. Habitat conditions also influence food availability, predation vulnerability, and effects of harsh winter weather. Thus, we would predict population fluctuations are related to precipitation (timing and amount) and temperature in spring-summer, and winter severity (which is commonly noted for many wildlife species). In the long term, if predictions of climate warming are correct, we may observe warmer winter conditions, which may reduce winter stress. But warmer climate may also result in less annual precipitation, which may reduce grass cover and allow drought tolerant weeds and other species to dominate. Such changes could greatly reduce populations to levels below current trends.

As noted above, loss of bunchgrass habitats and recent invasions by 2 exotic plants, yellow-star thistle and medusahead, may threaten long-term viability of chukar populations (but see BLM data and observations of Craig Johnson, 4.10.6.1.). Data on this issue with gray partridge are lacking. We also noted above that in Washington, the greatest declines in chukar populations over the last 6 years have occurred in areas infested with yellow-star thistle. Thus, research on this question is needed (including adaptive management or manipulative experiments).

The only anthropogenic issues that we observed that may be limiting to partridge were (1) the establishment of Brownlee, Oxbow, and Hell Canyon dams (and resulting reservoirs), and (2) livestock grazing. In general, we did not detect, nor do we suspect, any significant impacts from inundation of the Snake River (and hydroelectric operations) in Hells Canyon on partridge populations or habitat. On 1 occasion we flushed a covey of gray partridge near the river edge on the Idaho side of Brownlee Reservoir, and this covey crossed the reservoir and landed on the Oregon side. These birds seemed to have little difficulty with the long flight, even though it was a relatively wide section of reservoir (near the wide bend in the river at approximately mile 318). Thus, we feel certain the reservoirs have not completely restricted regional movements and gene flow. This question could easily be examined with a radio telemetry study.

Grazing intensity probably has the largest impacts on partridge populations in the Canyon. However, at this time it is not clear what the relationship is between livestock grazing and partridge ecology. It seems likely (from our data) that an inverse relationship exists between grazing intensity and gray partridge distribution and density. This relationship is not as apparent with chukar. We noted high chukar numbers on a few areas that were severely overgrazed; however, chukars were often in very steep and rocky portions of habitats that received little pressure from nearby livestock. However, our bird observations were during fall and winter. Spring and summer grazing may affect chukar (and gray partridge) reproductive success. General habitat conditions and vegetative composition are also influenced by grazing intensity. Grazing can influence exotic weed species (see Section 4.10.6.1 above) and various grass species used by partridge for food, nesting habitat, loafing, and escape habitat. Thus, much additional research will be needed to resolve questions on this potential impact on habitat and populations. Regardless, we strongly suspect a significant negative relationship exits between grazing intensity and partridge ecology, and recommend that grazing be considered with regard to partridge management.

6.4. Projected future status of chukar and gray partridge populations and habitat quality in Hells Canyon.

It is difficult to project the future status of any wildlife population, even for species that have been studied thoroughly. Many factors associated with our changing environment could effect partridge populations and habitats. For example, use of pesticides to control weeds and insects that compete for livestock forage may have significant effects on bird populations (e.g., reproduction). Few toxicology studies on wild populations have been completed, and chemical compounds change frequently (often annually). Other factors such as invasion of exotic weeds or climate warming could significantly change habitat conditions.

However, given the above caveat, the projected long-term status of partridge populations in Hells Canyon appears to be good. This region is very rugged, remote, and difficult to develop or use for agriculture. In addition, much of the land is in protected status, being owned and/or managed by natural-resource agencies. Hells Canyon is also a popular natural area and is heavily used for outdoor recreation. Thus, there likely exists strong public support for protection of the natural environment. For the immediate future (5-10 yrs), we are confident that partridge populations and habitat will remain in good condition.

6.5. Management opportunities to benefit chukar and gray partridge populations in Hells Canyon.

Careful management of livestock grazing is recommended (where possible) to benefit partridge populations. Grazing intensity should be limited to light or moderate in most regions. In addition, rotational grazing schemes should be employed. Some sites may benefit from being grazed on alternate years due to poor soil conditions, aspect, competing vegetation, or precipitation. Where possible, adjacent pastures should have different seasonal grazing pressure (e.g., spring and early summer vs. fall and early winter). We predict that these types of grazing management will decrease impacts on partridge habitat.

Control of yellow-star thistle and medusahead should be a high priority. Although much additional research is needed, it appears obvious from existing data that these exotic plants have a negative impact on partridge. It should also be noted that control of exotic plants will likely benefit many other wildlife species in Hells Canyon, and will protect grass pastures used for livestock grazing.

7. Acknowledgements

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***<u>Please Note</u>:* Citations not found in this section are listed in Appendix F.**

Appendix A: Author Information

SUMMARY RESUME
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In addition to teaching numerous wildlife ecology and management courses, Dr. Ratti has been awarded over $3,000,000 of grants and contracts for 33 separate research projects (as of January 2001), and has 70 professional publications (mostly in peer-reviewed journals). Dr. Ratti has experience with several ecological regions of North America, and has cooperative experience with many federal, state, and private natural-resource agencies.

Dr. Ratti has served on numerous national committees for The Wildlife Society, has served as Associate Editor for The *Journal of Wildlife Management*, and as President of the Northwest Section of The Wildlife Society.

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Appendix B: Search Terms Used to Locate Literature

NOTE: * = wild character.

1. Search terms used alone and in combination:

chukar	gray partridge
Alectoris	partridge
Hungarian partridge	Perdix
hun	Hells Canyon
gray partridge	

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

dams	forest management
wildlife	ecology
development	hunting
recreation	livestock
reservoir	management
vegetation	chukar
habitat	hun*
climate	partridge
mitigation	Alectoris
EIS or environmental impact statement	Perdix
flow fluctuation	bird*

3. Search term ***dam*** used in combination with:

wildlife	hun*
Idaho	partridge
Oregon	Alectoris
environment	Perdix
mitigation	bird*
chukar	

4. Search term ***Brownlee*** used in combination with:

reservoir	chukar
dam	hun*
hydroelectric	partridge
wildlife	Alectoris
mitigation	Perdix
EIS or environmental impact statement	bird*

Appendix C: Keywords in the Chuk_Hun ProCite® Database

NOTE: The following terms were used in the "Keywords" field.

Keyword	Description
Distribution	Range, introductions, translocations, history.
Systematics	Taxonomy, cladograms, DNA analysis, etc.
Movements	Annual migration, seasonal movements, dispersal, home range.
Habitat	Use, selection, seasonal requirements (breeding and wintering).
Food	Food habits, water requirements, foraging behavior, nutrition, energetics.
Sounds	Vocalizations, songs.
Behavior	Locomotion, maintenance, agonistic, spacing, sexual (mating system, sex ratio, pair bonds), interspecific (nonpredatory) interactions, response to predators.
Appearance	Weight, color, morphological variation, etc.
Demography	Age at first breeding, clutch size, reproductive success, lifespan and survivorship, diseases and body parasites, causes of mortality, dispersal (from natal site), home range, population status (counts, estimates, etc.), population regulation
Techniques	Population estimation, aging, sexing, capture, marking, artificial propagation.
Breeding	Breeding ecology including phenology, nest-site selection and characteristics, incubation and hatching behavior, growth and development, parental care, nest and/or brood parasitism, and behavior of immature stage.
Fall-winter	Fall-winter ecology.
Management	Population or habitat management, effectiveness of management activities, conservation.

Disturbance	Large-scale impacts on habitat or populations (e.g., due to fire, flooding, dams, invasions by star thistle, grazing, habitat alteration, pesticides, etc.). Also includes local disturbances such as contaminants, habitat loss/degradation, and disturbances at nest or roost sites.
Harvest	Harvest statistics or publications on effects of hunting.
Disease	Diseases, infections, etc. in both captive and wild birds.
SocioEcon	Social (e.g., hunting opportunities, hunting days, etc.) or economic implications of chukar or Hungarian partridge populations in Hells Canyon
HC	Hells Canyon (tier 2 of project area)
NW	WA, OR, or ID but not in or specific to Hells Canyon
NA	North America, excluding WA, OR, and ID
EA	Europe or Asia, including India and N. Africa
Perdix	
Alectoris	

Appendix D: Helicopter Survey Data

Appendix D. Partridge aerial survey results along Brownlee Reservoir[a] in the Southwest Region (these data include both chukar and gray partridge). The survey area is 12 square miles. Surveys were conducted in a Hiller 12E helicopter. Data provided by Idaho Department of Fish and Game, Boise.

Year	Partridge observed	Partridge groups	Groups/ mile^2	Partridge/ mile^2	Partridge/ group
1984	597	45	3.8	49.8	13.3
1985	872	62	5.2	72.7	14.1
1986	1686	94	7.8	140.5	17.9
1987	2652	115	9.6	221.0	23.1
1988	No counts	No counts	No counts	No counts	No counts
1989	643	57	4.8	54.1	11.4
1990	1313	77	6.4	109.4	17.1
1991	1321	103	8.6	135.1	15.7
1992	930	89	7.4	77.5	10.5
1993	211	24	2.0	17.6	8.8
1994	1056	65	5.4	88.0	16.2
1995	952	88	7.3	79.3	10.8
1996	949	90	7.5	79.1	10.5
1997	881	79	6.6	73.4	11.2
1998	1131	125	10.4	109.3	10.5
1999	1330	101	8.4	110.8	13.2
2000	1488	104	8.7	124	14.3
AVG	**1126**	**82.4**	**6.9**	**96.4**	**13.66**

[a] From Cottonwood Creek upstream to Sturgill Creek, and from the reservoir up slope to about the U.S. Forest Service boundary.

Appendix E: Habitat Data

Appendix E. Raw scores obtained during fall-winter surveys for qualitative assessment of general habitat conditions for chukar and gray partridge, Hells Canyon.

River Mile	Date	St	% Ex[a]	% Good	% Fair	% Poor	>80% GC[b]	50-80 GC	<50 % GC	% Grass	% Forb	% Wood	% Talus & rock	Rock out	Cattle observed	Grazing score
256.75	15-Oct-99	ID	20	60	20	0	1	0	0	65	10	10	15	2	No	1
258.00	15-Oct-00	OR	20	60	20	0	1	0	0	70	0	15	15	3	No	1.5
262.00	16-Oct-00	OR	50	40	10	0	1	0	0	80	0	10	10	2	No	1
263.00	3-Nov-00	OR	20	30	50	0	0	1	0	80	0	5	15	2.5	No	1
266.00	16-Oct-99	ID	10	30	30	30	0	1	0	60	15	20	5	2	No	2.5
275.00	18-Oct-99	OR	0	60	20	20	0	1	0	40	15	20	25	3	No	1.5
276.00	28-Oct-00	ID	50	50	0	0	0	1	0	65	0	5	30	3	No	1
278.00	14-Oct-00	OR	10	70	20	0	0	1	0	25	15	20	40	3	No	1
282.00	25-Oct-99	ID	0	40	60	0	0	1	0	35	5	20	40	3	No	3
286.00	17-Oct-00	ID	20	60	20	0	0	1	0	60	10	10	20	2	Yes	1
290.00	26-Oct-99	ID	20	60	20	0	1	0	0	90	0	5	5	1	Yes	1
291.00	30-Dec-00	OR	50	40	0	10	0	1	0	80	5	5	10	3	No	1
295.00	28-Oct-99	ID	10	40	30	20	0	1	0	45	5	45	5	1	Yes	1.5
296.00	1-Nov-00	OR	20	60	20	0	0	1	0	60	0	30	10	2	No	2
297.00	6-Nov-99	OR	20	40	40	0	1	0	0	80	5	5	10	2	No	1.5
298.00	23-Oct-99	ID	50	30	0	20	1	0	0	70	0	20	10	2	No	2
302.00	2-Nov-00	ID	0	40	40	20	1	0	0	90	0	5	5	2	Yes	2.5
302.50	22-Oct-00	ID	0	40	40	20	1	0	0	90	0	5	5	2	Yes	2.5
306.00	5-Nov-99	OR	0	20	20	60	0	1	0	60	5	25	10	2	Yes	3
307.50	24-Oct-00	ID	10	10	30	50	0	1	0	65	0	5	30	2	Yes	4
314.00	17-Oct-99	ID	50	20	20	10	0	1	0	75	5	10	10	1	Yes	2
317.00	23-Oct-00	ID	10	50	40	0	0	1	0	80	5	5	10	2	Yes	2
316.00	30-Oct-00	ID	40	60	0	0	0	1	0	80	5	5	10	2	No	2
322.00	4-Nov-99	OR	0	5	70	25	0	1	0	35	5	20	40	3	Yes	3
326.00	25-Oct-00	ID	10	40	30	20	0	1	0	60	20	10	10	3	No	2
330.00	27-Oct-99	ID	0	10	30	60	0	1	0	10	5	30	55	3	No	3.5
Avg			**19**	**41**	**26**	**14**	**31**	**69**	**0**	**64**	**5**	**14**	**17**	**2.25**		**1.92**

[a] During each survey we classified habitat conditions using ocular estimates as 1) excellent, 2) good, 3) fair, or 4) poor.

[b] Ground cover was estimated as (100 minus percent bare ground) using ocular estimates.

Appendix F: List of Publications in the Chuk_Hun ProCite® Database

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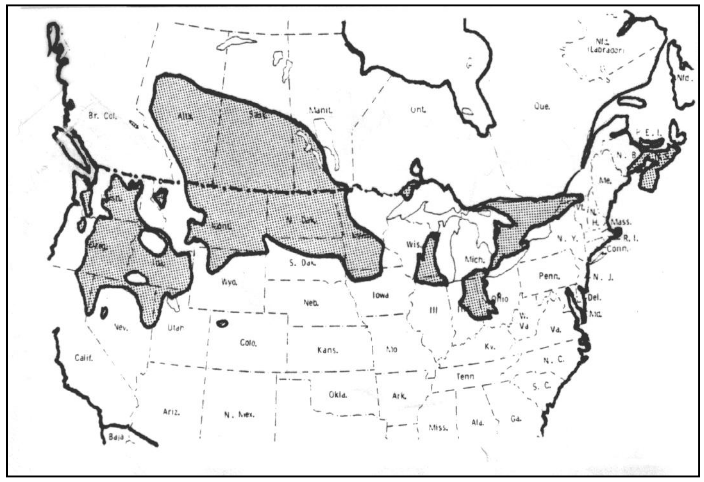
Appendix G: Sexing and Aging Techniques

Note: The following informational leaflets are not cited in the text above. They were prepared for Idaho Fish and Game personnel, who volunteered to collect age-sex data and crops from hunter-killed chukar and gray partridge in the Brownlee Reservoir area. Food habits data collected from birds during the partridge surveys and from crops collected by Fish and Game will be published separately.

Gray Partridge

SCIENTIFIC NAME: *Perdix perdix*

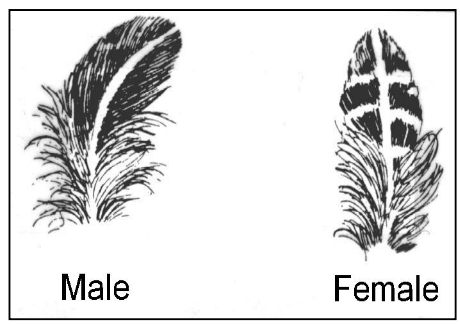


COMMON NAMES: Hungarian partridge, hun, gray partridge.

HISTORY: Exotic. Introduced to North America from Europe and Asia as early as 1790s. Introduced to Idaho and Oregon in early 1900s.

DESCRIPTION: 11-14" (28-35.5 cm). Round, stocky; breast and upper back gray; face and throat orange-brown; large dark spot on belly; reddish-brown bars on flanks; rufous outer tail feathers show in flight. **Voice**: A hoarse *keee-uk*; first note higher. A rapid cackle when flushed.

CRITERIA FOR DISTINGUISHING SEX:



Male: Shoulder feathers somewhat rust-colored with wide buff-colored stripe along shaft and broad rust-colored crossbars on some feathers (but lacks narrow-brown crossbars and mottling found on females). Dark brown patch on breast often more developed (i.e., horseshoe shaped).

Female: Shoulder feathers with buff-colored stripe along shaft and 2-4 buff- or brown-colored crossbars with black borders. Outer edges of scapulars show vermiculation.

CRITERIA FOR DISTINGUISHING AGE:

Early season

1a. Outer two (9th or 10th) primary wing feathers still growing.……………......................**Adult**

1b. Primaries 8 or 7 still growing…...……………....**Juvenile**

Mid- to late season (most birds will have fully grown wing feathers)

2a. Primaries 9 and 10 rounded. Covert of P9 rounded. Feet light blue-gray..............**Adult**

2b. Primaries 9 and 10 pointed and possibly frayed (re: juvenal P9 and 10 are not replaced by adult feathers until next summer). Feet yellow-brown........**Juvenile**

Leaflet prepared by John Giudice and John Ratti, Department of Fish and Wildlife, University of Idaho (9/20/00)

Gray Partridge

POPULATION STATUS: Little information available for reliable estimates. Reports of worldwide population decline, but 50-year trend on Palouse indicates relatively stable populations.

BODY MASS: 385-500 g. Varies greatly during the year. Also some regional variation (e.g., heavier populations in northern plains and lighter populations in Midwest and East).

SEX RATIO: Male biased in spring.

AGE OF FIRST BREEDING: Both males and females attempt to breed in first year after hatch, but some excess males do not pair and presumably do not breed.

MATING SYSTEM AND SOCIAL BEHAVIOR: Monogamous. Female chooses male. Established pairs may remain together for life; however, mortality of mates is common and both sexes readily remate. Dates of pair formation vary with region and weather conditions, but generally during January-February. Male stays with female throughout incubation and brood rearing. Basic social group outside of breeding season is the covey. Coveys are usually family groups consisting of adult pairs and their offspring. Coveys composed of unsuccessful breeders will form during summer and can make up a substantial portion of coveys seen during fall and winter. Covey mixing during late fall has been documented.

NESTING: Almost always on ground (ground scrape to which nesting material is added). Nests located in heavy herbaceous cover, often in hay fields and other grassy areas. Egg laying usually beings in April-May. Persistent renester when a nest is destroyed, with as many as 4 nests in a single season. Average nest success about 32% (range 16-40%).

CLUTCH SIZE: 10-20, with an average of 16.1 eggs/clutch. Clutch size declines during breeding season and with each successive renest. Rate of egg laying about 1.1 eggs/day.

INCUBATION: 21-26 days; average about 25 days.

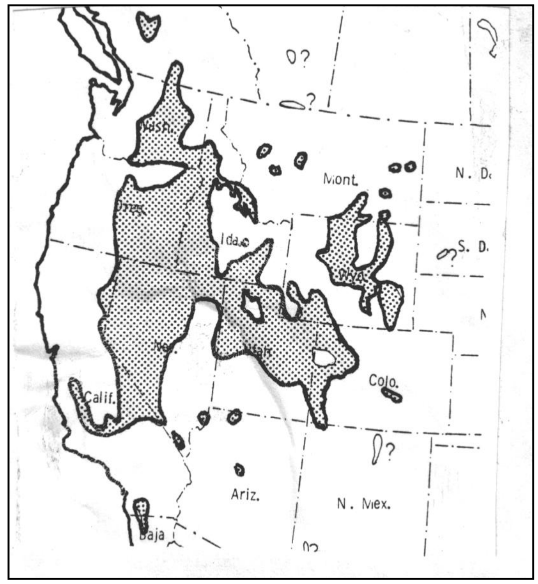
HATCHING AND BROOD REARING: Synchronous hatchers, although 24 hours may elapse for complete hatching. Chicks completely down-covered at hatch and mobile within hours; usually leave nest with adults within 1 day. Both male and female brood young. Young do not feed for 24 hr after hatching. Adults induce chicks to feed by repeatedly dropping food in front of chicks, but not by passing food directly to them. Chicks are capable of short flights in <2 weeks and longer flights by 6-8 weeks. Young remain with adults until late winter or early spring.

LIFESPAN AND SURVIVORSHIP: Short life span and high mortality rates. In Montana, life expectancy 1.8+ years for adults, 0.9 years for immature males, and 0.8 years for immature females. In North America, chick survival rates vary by region and year (e.g., 30-75%). Average winter mortality 56%. Able to survive extreme winter temperatures by roosting in tight groups and in deep, soft snow; can burrow through foot of snow to find food.

FOOD HABITS: In Hells Canyon, fall and winter food habits consist predominately of grass shoots and green vegetation, cheat grass seeds, grass bulbous stem bases, lithophragma root nodules, common sunflower seeds, and insects such as grasshoppers. In agricultural regions, food habits dominated by oats, barley, and wheat. Insects are very important in diet of chicks during first 5 weeks.

REFERENCE: Carroll, J. P. 1993. Gray partridge (*Perdix perdix*). *In* The Birds of North America, No. 58 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia; The American Ornithologists' Union, Washington, D.C.

Chukar



SCIENTIFIC NAME: *Alectoris chukar*

COMMON NAMES: rock partridge.

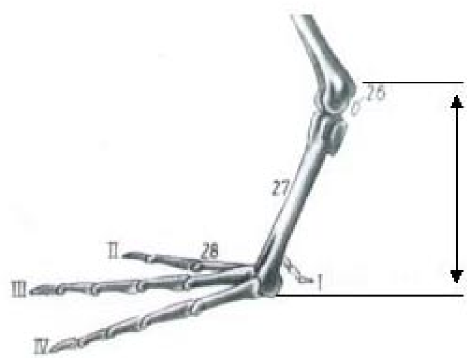
HISTORY: Exotic. Introduced to North America from Europe and Asia in early 1900s, although major introductions did not occur until after 1930. Introduced into Idaho in 1933 and considered established in all suitable habitats by 1957.

DESCRIPTION: 13" (33 cm). Grayish head , back, rump, and breast. The whitish throat and cheek is bordered by a lack necklace. The white flanks have black vertical bars. The rufous outer tail feathers show in flight. The bill, eye-ring, legs, and feet are pinkish-red. **Voice**: a loud *chuck-chuck-chuck*, often producing laughing effect.

CRITERIA FOR DISTINGUISHING SEX:

Sex determination of chukars is difficult because of a lack of plumage dimorphism. Two techniques have been suggested: (1) Weaver and Haskell (1968) recommended using length of P1, P2, and P3 (i.e., the first 3 inner primaries); and (2) Woodward et al. (1986) reported that tarsus length could be used as a criterion of sex. In Oregon, Walter (2000) reported that Weaver and Haskell's (1968) method was not accurate; however, tarsus length was accurate in the fall in 90.1% of the cases (n = 71 birds).

Tarsus Length (distance from foot pad to top of hock joint in legs flexed at 90° from the tibia).



Female: <61 mm **Male:** $\geq$61 mm

CRITERIA FOR DISTINGUISHING AGE :

Mid-September through December

1a. **Primary covert 9** measures >29 mm. **Primaries 9 and 10** faded, showing wear; or either primary 9 or 10 in stage of molt...**Adult**

1b. **Primary covert 9** measures <29 mm. **Primaries 9 and 10** pointed at tips, only slightly faded, showing little wear..**<u>Juvenile</u>**

<u>Note</u>**: Juveniles <14-weeks old** possess **mottled secondaries**, whereas secondaries of older juveniles and adults lack mottling. Some mottled secondaries may be present in juveniles up to 16-weeks old.

Leaflet prepared by John Giudice and John Ratti, Department of Fish and Wildlife, University of Idaho (9/20/00)

Chukar

POPULATION STATUS: Population levels can vary dramatically from year to year depending on habitat and environmental conditions (e.g., in Nevada, estimated population size ranged from a low of 200,000 birds during poor reproduction years to 2,000,000 during good reproduction years). Populations in Great Basin region relatively stable, but populations outside sagebrush-grassland habitat have not done as well.

BODY MASS: 550-675 g. Male slightly larger than female in length and mass.

SEX RATIO: In North America, about 1.1:1.0 (males:females); however, Walter (2000) reported female-biased harvest ratios (0.7:1.0) in Oregon during 1996-98.

AGE OF FIRST BREEDING: Breeds in first spring after hatching. However, during drought years, breeding and nesting may be severely limited. Nonbreeding birds may remain in coveys.

MATING SYSTEM AND SOCIAL BEHAVIOR: Monogamous. Calling by both sexes common, although male initiates courtship display. Timing of pair formation varies but generally February-Mar. Male usually remains with female during incubation, hatching, and brood rearing; however, some males may desert female after completion of clutch. Unsuccessful females may join groups of deserted males after mid-Jun. Chicks and adults have strong tendency to mix at water sources; thus, late summer and fall coveys often consist of >1 family group.

NESTING: Nests usually located in sagebrush-grassland habitats on south facing slopes. Nest usually a depression scratched in ground; lined with dry grasses and breast feathers. Egg laying usually begins in April. Will renest if first nest is destroyed. Little data on hatching success; in Oregon during 1997-98, Walter (2000) reported average nest success was 51% (range: 37-60%).

CLUTCH SIZE: 10-21, with an average of 15.5 eggs/clutch. Rate of egg laying in captive females is 1.3 eggs/day.

INCUBATION: 23-30 days, with an average of about 24 days.

HATCHING AND BROOD REARING: Little data. Synchronous hatching. Chicks down-covered; leave nest soon after hatching and stay with adults and other young until late winter or early spring. Only females appear to brood chicks. Chicks feed with adults but no detailed studies of behavior. Chicks capable of flight at <2 weeks of age; generally not distinguishable from adults by 18 weeks.

LIFESPAN AND SURVIVORSHIP: Little data but general observations suggest this species has high mortality rates and relatively short life spans. Walter (2000) reported spring-fall survival rates of 29-68%. Able to survive extreme winter temperatures by conserving heat through circle roosting (heads out, tails in), but are unable to feed when snow accumulates to more than a few inches. A major limiting factor for chukars is the lack of free water.

FOOD HABITS: In Hells Canyon, fall and winter food habits consist predominately of grass shoots and green vegetation, cheat grass seeds, grass bulbous stem bases, lithophragma root nodules, common sunflower seeds, and insects such as grasshoppers. Insects usually make up <15% of the diet, but probably important for development and growth of young chicks.

REFERENCE: Christensen, G. C. 1996. Chukar (*Alectoris chukar*). *In* The Birds of North America, No. 258 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia; The American Ornithologists' Union, Washington, D.C.

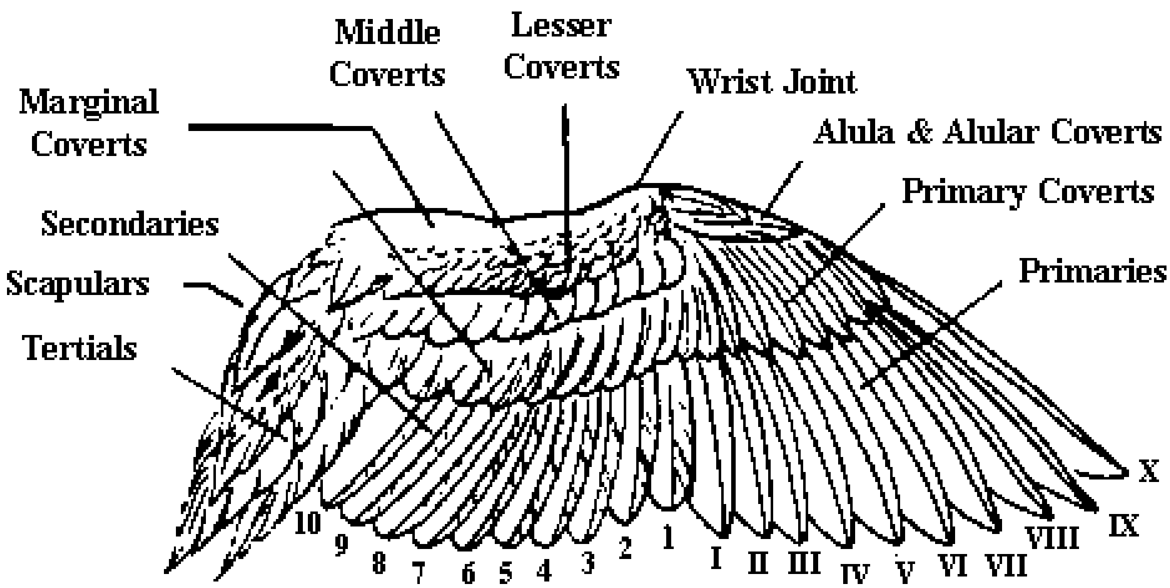


Fig. 11.10. Nomenclature and position of numbered feathers of a typical wing (from Godin 1960).

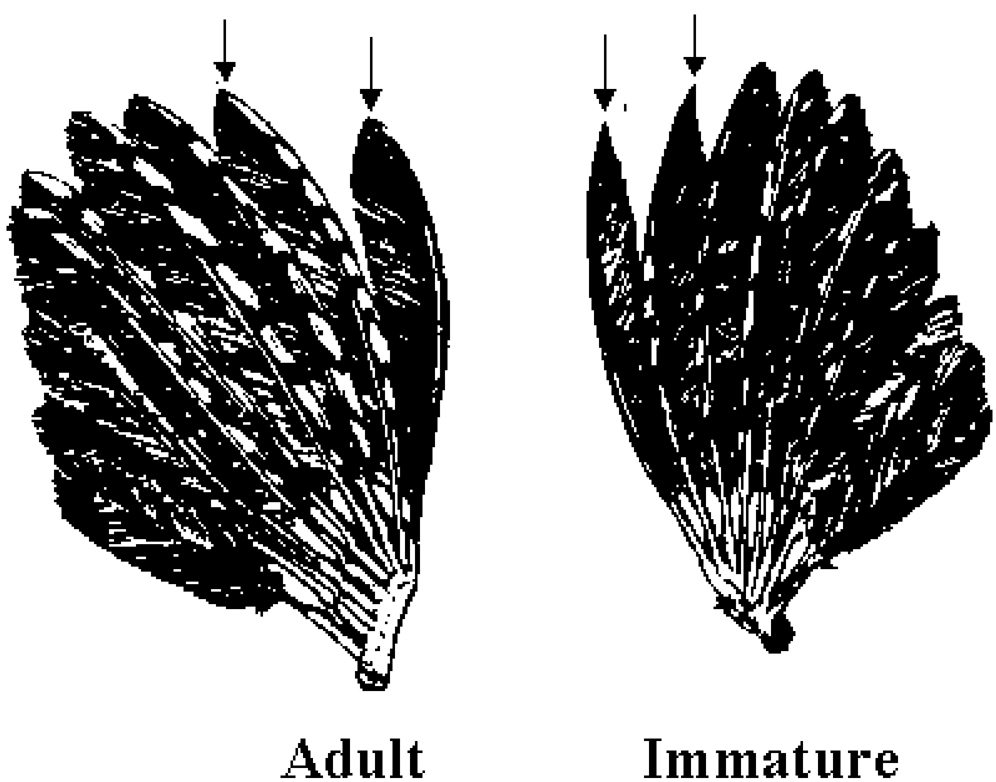


Fig. 11.11. The two outer primaries in immature gallinaceous birds (except the ring-necked pheasant) are retained through the first winter. The immature No. 9 and No. 10 primaries are pointed (*right*) as compared to the rounded tips of these feathers in adults (*left*), as shown in wings of the ruffed grouse above (from Godin 1960).