4 Limiting Factors and Conditions

4.1 Limiting Factors to Fish

4.1.1 Out-of-Subbasin Factors

All focal aquatic species are impacted to some degree by the effects of hydropower development on the Snake River both upstream and downstream of the Hells Canyon reach. Those impacts related to downstream hydropower development are considered to be "out-of-subbasin" effects since they only impact those fish moving to or from the subbasin. For organizational purposes, those impacts related to upstream hydropower developments are considered with in-subbasin effects and discussed below since they impact all aquatic species using the mainstem Snake River within the subbasin. Appendix G provides a regional overview of out-of-subbasin factors impacting anadromous fish in the Columbia Basin, including areas above Lower Granite Dam. Information presented here focuses on downriver impacts to Snake River stocks and, when possible, those populations or stocks specific to the Snake Hells Canyon subbasin.

It is generally accepted that hydropower development on the lower Snake River and Columbia River is the primary cause of decline and continued suppression of Snake River salmon and steelhead (WDFW et al. 1990; CBFWA 1991; Northwest Power Planning Council 1992; NMFS 1995, 1997; NRC 1995; IDFG 1998; Williams et al. 1998). However, less agreement exists about whether the hydropower system is the primary factor limiting recovery (Mamorek et al. 1998). This limiting factor keeps yearly effective population size low and increases genetic and demographic risk of localized extinction.

Currently, the estimated direct survival of Snake River spring/summer chinook smolts through the hydrosystem is between 40 and 60%, compared with an estimated survival rate during the 1970s of 5% to 40%. These improvements have occurred as a result of changes in the operation and configuration of the FCRPS, which include increased spill, barging, increased flow, changes in the operation of turbines, and new extended-length screens at McNary, Little Goose, and Lower Granite dams (NMFS 2000a).

Adult escapement of anadromous species remains low, even given significant hatchery production/reintroduction efforts. Low adult abundance has resulted in stocking at variable rates between years, depending on the availability of brood fish (Walters et al. 2001). Smolt-to-adult return rates (SAR), from smolts at the uppermost dam to adults returning to the Columbia River mouth, averaged 5.2% in the 1960s before the hydropower system was completed and only 1.2% from 1977 to 1994 (Petrosky et al. 2001) (Figure 48). These rates are below the 2 to 6% needed for recovery (Mamorek et al. 1998).

In contrast to the decline in SAR, numbers of smolts per spawner from Snake River tributaries did not decrease during this period, averaging 62 smolts per spawner before hydrosystem completion and 100 smolts per spawner afterward (Petrosky et al. 2001) (Figure 48). In this section, both spawner escapement and smolt yield are measured at the uppermost mainstem dam (currently Lower Granite). The increase in smolts per spawner was due to a reduction in density dependent mortality as spawner abundance declined. Accounting for density dependence, a modest decrease occurred in smolts per spawner from Snake River tributaries over this period but not of a magnitude to explain the severe decline in life-cycle survival (Petrosky et al. 2001).

The dams cause direct, indirect, or delayed mortality, mainly to emigrating juveniles (IDFG 1998, Nemeth and Kiefer 1999). As a result of this increased mortality, Snake River spring and summer chinook declined at a greater rate than downriver stocks, coincident with completion of the federal hydropower system (Schaller et al. 1999). Schaller et al. (1999) concluded that no other factors than hydropower development have played a significant role in the differential decline in performance between upriver and downriver stocks. The Snake River stocks above eight dams survived one-third as well as downriver stocks migrating through three dams for this time period, after taking into account factors common to both groups (Schaller et al. 1999; Deriso 2002). The additional decline in productivity of upriver stocks relative to downriver stocks indicates that this portion of the mortality is related to factors unique to upriver stocks. Patterns of Pacific Decadal Oscillation and salmon production would indicate that poor ocean conditions existed for Columbia River salmon after the late 1970s (Hare et al. 1999). However, the natural fluctuations of ocean productivity affecting all Columbia River stocks, in combination with mortality as a result of the hydrosystem, appear to have caused the severe declines in productivity and survival rates for the Snake River stocks. Temporal and spatial patterns of hatchery release numbers did not coincide with the differential changes in survival rates between upriver and downriver stocks (Schaller et al. 1999). Harvest rates were drastically reduced in the early 1970s, in response to declines in upriver stream-type chinook abundance. Given that changes in smolts per spawner cannot explain the decreases in SAR or overall survival rates for Snake River stocks, it appears that the altered migration corridor has had a strong influence on the mortality that causes these differences in stock performance.

The observations about SAR rates and smolts per spawner (Figure 48) indicate that the overall survival decline is consistent primarily with hydrosystem impacts and poorer ocean conditions (out-of-subbasin factors) rather than with large-scale impacts within the subbasins between the 1960s and present (Schaller et al. 1999, Petrosky et al. 2001). Because the smolt/spawner data represent aggregate populations from a mix of habitat qualities throughout the Snake River basin and are from a period after hydropower development, they do not imply that there is no room for survival improvement within the Salmon, Clearwater, Grande Ronde, and Imnaha subbasins. However, because of limiting factors outside the subbasin and critically reduced life-cycle survival for populations even in pristine watersheds, it is unlikely that potential survival improvements within the Snake River subbasins alone can increase survival to a level that ensures recovery of anadromous fish populations.

Predation of salmonid smolts by various species also represents a potential limiting factor to survival, particularly within reservoirs. Shively et al. (1996) found that pikeminnow predation would be minimized when water velocity was greater than 1 m/s and water depth exceeded 10 m, suggesting that predation by pikeminnow is not a significant threat to outmigrating salmon within the Snake Hells Canyon subbasin itself due to the riverine nature of the reach. However, predation by pikeminnow is substantial throughout all or portions of the downstream migration corridor. Northern pikeminnow, a native predator, have become well adapted to the habitat created by river impoundment and have been shown to have substantial predatory impacts on migrating salmonids (Beamesderfer and Rieman 1991, Petersen 1994, Collins et al. 1995).

Other key piscivorous fish species that may pose a potential limiting factor to anadromous salmonids include walleye, channel catfish, Pacific lamprey, yellow perch, largemouth bass, northern pike, and bull trout (NMFS 2000b). Although not necessarily associated with the Snake Hells Canyon reach, these species have been found to consume considerable numbers of outmigrating subyearling chinook and steelhead, and they are most closely associated with areas upstream and downstream of impoundments. Avian predator populations are also blamed for salmonid predation. These include the Caspian tern, double-crested cormorant, and three species of gulls (NMFS 2000b). Marine mammals, specifically members of the order Pinnepedia (e.g., Pacific harbor seals and California sea lions), represent additional threats to chinook and steelhead (NMFS 2000b).

Out-of-subbasin harvest of Snake River fall chinook, which were harvested up to a 70 to 80% exploitation rate in the lower Columbia River and the ocean (G. Mendel, WDFW, personal communication, May 2001), may have had substantial impacts to that population within the Snake Hells Canyon subbasin. Harvest on the Snake River stock was especially high during the years when they were mixed with particularly large returns of fall chinook salmon destined for the Hanford reach of the middle Columbia River. The listing of fall chinook under the ESA and renegotiations under the *Columbia River Fishery Management Plan* has substantially reduced the exploitation rate on the Snake River stock of fall chinook (G. Mendel, WDFW, personal communication, May 2001).

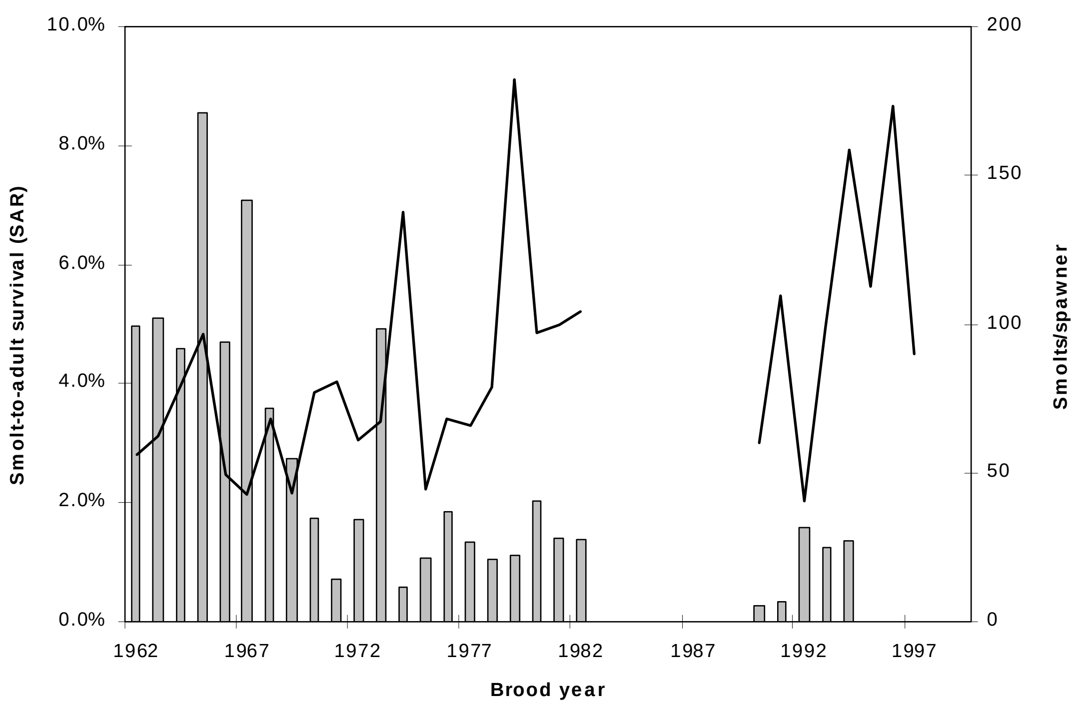

Figure 48. Smolt-to-adult survival rates (bars; SAR) and smolts/spawner (solid line) for wild Snake River spring and summer chinook. The SAR describes survival during mainstem downstream migration to adult returns, and the number of smolts per spawner describes freshwater productivity in upstream freshwater spawning and rearing areas (from Petrosky et al. 2001).

4.1.2 Local Limiting Factors—Overview

Hatcheries

The wild component of the Snake River spring/summer and fall chinook ESUs are currently considered to be at some risk of extinction due in part to the influence of hatcheries (NMFS 2000a). The hatchery contribution to Snake River fall chinook escapement has been estimated at greater than 47%[1] (Myers et al. 1998). Hatchery-origin spring/summer chinook comprise an estimated 80% of the Columbia River run (Lichatowich and Mobrand 1995).

The effectiveness of hatchery fish spawning in the wild has been considered to influence the growth rate of wild spring/summer and fall chinook (NMFS 2000a). NOAA Fisheries estimates the growth rate (lambda) of Snake River spring/summer chinook to be between 0.96 and 0.80; growth rate for Snake River fall chinook was estimated to be between 0.94 and 0.86.[2] For Snake River spring/summer chinook index stocks, extinction estimates 100 years from now range from 0.0 to 0.78, assuming that hatchery fish spawning in the wild have not reproduced (i.e., hatchery effectiveness = 0) and from 0.0 to 1.00, assuming that the hatchery fish spawning in the wild have been as productive as wild-origin fish (hatchery effectiveness = 100%). For fall chinook, extinction risk estimates 100 years from now range from 0.40, assuming that hatchery fish spawning in the wild have not reproduced (i.e., hatchery effectiveness = 0) to 1.00, assuming that the hatchery fish spawning in the wild have been as productive as wild-origin fish (hatchery effectiveness = 100%; see Tables B-5 and B-6 in McClure et al. 2000).

Hydropower/Water Storage

As mentioned earlier, all focal aquatic species are impacted to some degree by the effects of hydropower development on the Snake River both upstream and downstream of the Hells Canyon reach. Those impacts related to downstream hydropower development are considered to be "out-of-subbasin" effects since they only impact those fish moving to or from the subbasin. Those impacts related to upstream hydropower developments are considered with in-subbasin effects and discussed below since they impact all aquatic species using the mainstem Snake River within the subbasin. The major impacts of hydropower development are on those species that primarily use the mainstem Snake River for much of their life history, particularly fall chinook and white sturgeon.

Fall chinook are particularly susceptible to the effects of hydropower development because of inundation of preferred spawning and rearing habitats in mainstem rivers and because juveniles migrate to the ocean in late spring, summer, and fall during low summer flows and high water temperatures. The changes to habitat, flow, and thermal regimes have affected spawn timing, spawning location, and outmigration success of fall chinook in the Snake Hells Canyon subbasin.

---

[1] See Mendel (2000) for run composition at Lower Granite Dam. Initially, 67% of fish at Lower Granite Dam were hatchery origin, but with removal of hatchery fish at the dam, this value was reduced to 47% hatchery escapement past the dam.

[2] Estimates of median population growth rate, risk of extinction, and likelihood of meeting recovery goals are based on population trends observed during a base period beginning in 1980 and including 1999 adult returns (spring/summer chinook) or beginning in 1980 and including 1996 adult returns (fall chinook). Population trends are projected under the assumption that all conditions will stay the same.

Flow releases from Hells Canyon Complex were determined to play a significant role in shaping flow and temperature regimes in the Snake River downstream to RM 167 during fall chinook adult immigration, spawning, and egg incubation life history phases (Rondorf and Miller 1994; Rondorf and Tiffan 1994, 1996). Reservoir heating of water in upriver pools during summer months and its subsequent release out of Hells Canyon Dam likely contribute to documented higher water temperatures above the confluence of the Salmon River (Rondorf and Tiffan 1996). These temperatures may exacerbate fall chinook immigration and spawning delays, while accelerating egg incubation and juvenile emigration (Rondorf and Tiffan 1996). Consequently, the fish from the Snake Hells Canyon subbasin arrive at Lower Granite Dam, on average, up to four weeks later than they did before development of the Hells Canyon Complex and the four lower Snake River projects (NMFS 2000a). Johnson and Stangl (BLM 2000a) found that fall chinook fry emerging later than mid-May may not be large enough to begin their downstream migration as age 0 fish. Delays in chinook outmigration may also occur due to slack water impoundments (i.e., upper pool of Lower Granite Dam). Combined, the delays place juvenile migrants in reservoirs during periods when water temperatures approach chinook salmon's thermal tolerance (NMFS 2000a).

Studies examining smoltification timing suggest that the protracted emigration exhibited by Snake Hells Canyon subbasin fall chinook may confer a survival disadvantage to downstream migration life history phases (Rondorf and Tiffan 1997). Gill ATPase followed a trend of increasing activity until late June followed by a decline throughout the remainder of the summer (Rondorf and Tiffan 1997). Similarly, subyearling chinook exhibited the most net downstream movement at velocities of 6 to 18 in/s early in the season and less movement as the season progressed. This delay often places late-arriving fall chinook in unsuitable reservoir environments and may increase their susceptibility to predation.

Hydropower projects have isolated white sturgeon populations within the Snake Hells Canyon subbasin by restricting their movements into or out of the reach. Downstream impoundments have dramatically affected the historical food base of white sturgeon, as illustrated by the marked decrease in anadromous fish and lamprey returns following construction of the four lower Snake River dams (CBFWA 1999). The influence of upstream impoundments on flows may limit spawning and incubation success, alter thermal regimes, and decrease the amount of nutrients flowing downriver.

Harvest

Harvest of all wild chinook salmon has been curtailed in Idaho, Oregon, and Washington. The effects of in-subbasin harvest may not be a limiting factor to spring/summer or fall chinook within the Snake Hells Canyon subbasin. Out-of-basin harvest (as discussed previously) may, however, limit overall production of the species in the subbasin.

Incidental harvest of Snake River fall chinook by steelhead fisherman has been documented in the Snake Hells Canyon subbasin (BLM 2000a; G. Mendel, WDFW, personal communication, May 2001). The chance for hooking mortality or illegal harvest during the fall does exist and may represent a minor threat to the population.

The presence of steelhead fishermen and recreational jet boaters on reaches used during fall chinook migration, spawning, and rearing life history phases may pose a harassment or habitat disturbance threat to the species (BLM 2000a,b). This threat is greatest during spawning and incubation periods since boaters can cause disturbance or mortality to spawning fish and/or physical harm to redds and incubating eggs (BLM 2000a,b). Redds at highest risk are those constructed in shallow waters, but maintenance of Snake River flows from Hells Canyon Dam reduces the overall threat.

Predation

Predation in the Snake Hells Canyon subbasin constitutes a potential limiting factor to anadromous species. Although studies to date have focused on predation of fall chinook, other anadromous species migrating through the mainstem system may be similarly impacted, at least in the manner and locations of predation. The amount of predation may differ substantially by species, although data are not available for all species.

Studies of juvenile fall chinook loss to smallmouth bass predation in 1996 and 1997 determined that predation was greatest near hatchery release sites (i.e., Pittsburg Landing) directly after hatchery releases (Tiffan et al. 1999). The 1996–1997 study, which encompassed a 67-mile reach above Asotin, Washington (RM 147), estimated 256 smallmouth/mile measuring at least 175 mm; the greatest concentration of fish (254 fish/mile) occurred downstream of the confluence of the Salmon River (Tiffan et al. 1999).

Despite smallmouth bass concentrations, predation on wild subyearling fall chinook salmon by smallmouth bass in the Snake Hells Canyon subbasin was determined to be low and infrequent, yet it may represent a small portion of the mortality encompassed in survival estimates of the juvenile fall chinook outmigration to Lower Granite Dam (Tiffan et al. 1999). Predator–prey size relationships, such as those observed by Zimmerman (1997), may be related to the percentage of mortality realized by predation losses of subyearling chinook. Smallmouth bass were found to consume smaller chinook in the spring than did northern pikeminnow (see below), and they consumed far more subyearling chinook salmon in summer than they did yearling chinook salmon in spring (Zimmerman 1997). The size selectivity of smallmouth predation on chinook may reflect the degree and timing of habitat overlap, as suggested by Tabor et al. (1993), who attributed high levels of smallmouth bass predation on subyearling chinook salmon in the Columbia River to the overlap of rearing habitat of subyearling chinook with the preferred habitats of smallmouth bass in summer. The consequence of size-selective predation would be increased vulnerability of wild juvenile salmonids, which are smaller than chinook salmon and steelhead reared in hatcheries (Zimmerman 1997).

Prey Base

The loss of prey bases may limit both bull trout and white sturgeon in the Snake Hells Canyon subbasin, although this relationship is not clearly defined. For bull trout, this relates to the loss of the anadromous prey base (parr/smolts) on which bull trout become particularly reliant during subadult and adult life history stages (Rieman and McIntyre 1993). For white sturgeon, power peaking at Hells Canyon Dam may have reduced the usable habitat for food sources used by white sturgeon, including Pacific lamprey, aquatic insect larvae, and freshwater mussels.

Habitat Degradation—Snake River

The mainstem Snake River provides the primary habitat area for all life history stages of fall chinook and white sturgeon within the Snake Hells Canyon subbasin. Bull trout may use habitat in the mainstem Snake River during adult migration and/or subadult foraging and rearing life history phases (year-long). Steelhead and spring/summer chinook use the mainstem Snake River primarily as an important migration corridor. Primary spawning and rearing habitats for these species occur within the tributary systems.

The effects of the hydrosystem have considerably reduced fall chinook habitat. Preferred spawning and rearing habitats have been inundated, and water quality limited. Increased sediment deposition in mainstem Snake River substrate may limit spawning and rearing success, although amounts appear to be at acceptable levels currently (BLM 2000a). Reduced summer temperatures have restricted fall chinook spawning areas to those that will accumulate a minimum of 960 thermal units from November 15 (spawning phase) to early May (emergence/early rearing phase; BLM 2000a). Cool summer water temperatures are suboptimal for spring/summer chinook rearing as well (BLM 2000b).

Although white sturgeon appear to be reproducing successfully in the Snake Hells Canyon subbasin, the population may be limited by reductions or losses of certain life history pathways. Lack of available habitat for sturgeon in the 4- to 15-year-old age class (3- to 6-foot sturgeon) appears to be restricting the life history stage, as indicated by the excessively slow growth rates demonstrated by Coon (Coon et al. 1977, Coon 1978). The mechanism by which habitat condition is restricting the population is unclear.

Because bull trout primarily use habitat in the mainstem Snake River during adult migration (August–September) and/or subadult foraging and rearing life history phases (year-long), isolation and degradation of habitat (respectively) are considered to be primary limiting factors. Although currently undefined, the Imnaha/Snake River bull trout core population may be at risk if migratory connectivity is lost (M. Hanson, ODFW, personal communication, April 19, 2001). Bull trout occurring in smaller mainstem tributary streams, such as Granite and Sheep creeks, may be reliant on the refounding capacity of fluvial fish (e.g., Rieman and McIntyre 1993) originating from larger tributaries such as the Imnaha or Grande Ronde rivers. While this interaction currently represents a data gap (M. Hanson, ODFW, personal communication, April 19, 2001), studies have established the importance of the mainstem Snake as migration habitat (Buchanan et al. 1997; USFWS 2000b; Hemmingsen et al. 2001a,b) connecting the lower Salmon, Imnaha, Grande Ronde, and upriver portions of the Snake rivers (BLM 2000a,b). Inadequate water quality (i.e., excessive stream temperatures) or inadequate flow may jeopardize access to the smaller systems and limit potential utilization of mainstem habitat (see Appendix F).

Habitat Degradation—Tributaries

Information presented in this section complements that presented in sections 4.1.3 and 4.1.4. The intent is to provide an overview of findings from existing literature about the impacts of tributary habitat degradation on fish populations within the Snake Hells Canyon subbasin. Details regarding the relative importance of individual habitat characteristics are presented in the subsequent section detailing limiting factors to mainstem (section 4.1.3) or tributary habitats (Qualitative Habitat Assessment [QHA], section 4.1.4).

Habitat quality within tributaries of the Snake Hells Canyon subbasin may limit key life history phases for spring/summer chinook, bull trout, and steelhead (BLM 2000a,b). Since summer steelhead rely on tributary habitats for spawning and a majority of rearing, they are most limited by access and/or habitat suitability.

Tributary habitat within the subbasin is limited in both quantity and quality. The USFS, BLM, IDFG, WDFW, and ODFW have surveyed tributary creeks within the Snake Hells Canyon subbasin. Steep gradient, poor pool-riffle structure, limited spawning gravel, limited summer stream flows, and natural anadromous/resident fish barriers are believed to limit productivity in most of these creeks. A total of 409.4 miles of fish-bearing streams were identified in the HCNRA (USFS 1999). Nearly all fish-bearing tributaries within the HCNRA had high water quality, with good streamside cover and little streambank instability (USFS 1999).

Tributary habitats below the Salmon River confluence have been degraded by road construction, timber harvest, development in riparian areas and floodplains, agriculture, livestock grazing, mining, recreation, and water uses (i.e., irrigation and water diversions; BLM 2000b). These land uses have reduced the water quality, water quantity, and habitat diversity and quality, thereby limiting the amount and availability of migratory, spawning, and rearing habitat for spring/summer chinook, bull trout, and steelhead. Many tributaries have elevated levels of sediment and high summer water temperatures or low summer flows. High-flow events have also resulted in habitat degradation (BLM 2000b) by scouring spawning substrate, filling pool habitat, and in some cases exporting large organic material.

Habitat conditions in Granite and Sheep creeks are less limited than those in other tributaries due to their wilderness designation. Similar to the lower portion of the subbasin, high-flow events (such as those occurring in 1996) have caused severe channel scouring in some tributaries (BLM 2000a). Channel characteristics in the subbasin, such as high-gradient tributaries and low stream flow, are also considered to limit the amount of habitat usable by spring/summer chinook (Northwest Power Planning Council 1990; BLM 2000a,b).

4.1.3 Mainstem Limiting Factors

Local factors limiting focal fish species in mainstem habitats (Table 37) have been drawn from existing publications and supplemented with professional judgment to incorporate new and/or additional information. Information in Table 37 summarizes subsequent textual descriptions of impacts of hatcheries, hydropower, predation, prey base, and habitat degradation. This information also complements the results of QHA modeling efforts conducted to assess limiting factors in tributary habitat areas (see the above section).

Limiting factors have been assigned a value of 1 to 3, depending on the degree to which they are thought to limit specific species within each of two mainstem reaches (above/below the mouth of the Salmon River). A value of 1 indicates a principal or most influential limiting factor, whereas a value of 3 indicates a less influential factor limiting population(s). A value of 2 represents factors of intermediate influence on populations. While factors have been individually "ranked" to aid in interpretation, all factors listed in Table 37 are considered limiting to local populations, and cumulative impacts of several factors ranked as 2 or 3 may outweigh the influence of an individual factor ranked as 1. Bold type is used to highlight factors in Table 37 that function primarily outside the Snake Hells Canyon subbasin but serve to limit populations within mainstem habitats of the subbasin itself.

Table 37. Summary of factors limiting focal fish species within mainstem habitats of the Snake Hells Canyon subbasin. Scores indicate level of influence (1—greatest influence, 3—least influence). Factors shown in bold are out-of-subbasin issues limiting to populations within the subbasin.

		Low Temperature	**High Temperature**	**Base Flow**	**Flow Variation**	**Bedload**	**Connectivity/ Passage**	**Hatchery Influence**	**Harvest/Fishing**	**Predation**	**Harassment**	**Competitors**
Upper Mainstem Snake River (above Salmon River confluence)												
White Sturgeon	Egg-Larval				3					3		
	Juvenile						**1**		3	3		3
	Adult		3				**1**		3			
Bull Trout	Egg-Larval	—	—	—	—	—	—	—	—	—	—	—
	Juvenile											
	Adult						**1**		3			
Pacific Lamprey	Egg-Larval											
	Juvenile						**1**					
	Adult						**1**					
Redband/ Steelhead	Egg-Larval	—	—	—	—	—	—	—	—	—	—	—
	Juvenile						**1**			3		
	Adult						**1**					
Spring Chinook	Egg-Larval	—	—	—	—	—	—	—	—	—	—	—
	Juvenile						**1**			2		
	Adult						**1**					
Fall Chinook	Egg-Larval	3	3									
	Juvenile	3	1	2				3		1		
	Adult		**3**			3	**1**	3	**1**			
Lower Mainstem Snake River (below Salmon River confluence)												
White Sturgeon	Egg-Larval									2		
	Juvenile						**1**		3			3
	Adult		3				**1**		3			
Bull Trout	Egg-Larval	—	—	—	—	—	—	—	—	—	—	—
	Juvenile											
	Adult						**1**		3			
Pacific Lamprey	Egg-Larval											
	Juvenile						**1**					
	Adult						**1**					
Redband/ Steelhead	Egg-Larval	—	—	—	—	—	—	—	—	—	—	—
	Juvenile						**1**			3		
	Adult						**1**					
Spring Chinook	Egg-Larval	—	—	—	—	—	—	—	—	—	—	—
	Juvenile						**1**			2		
	Adult						**1**					
Fall Chinook	Egg-Larval	1			3							
	Juvenile	1	1	1				3		1		
	Adult		**3**				**1**	3	**1**		3	
Sockeye	Egg-Larval	—	—	—	—	—	—	—	—	—	—	—
	Juvenile						**1**					
	Adult						**1**					

4.1.4 Tributary Limiting Factors—Qualitative Habitat Assessment

Qualitative Habitat Assessment (QHA; Mobrand Biometrics 2003b) was used to evaluate the relative condition of habitat variables within 43 individual tributary streams or segments utilized by steelhead trout and to define relative protection versus restoration needs (limiting factors) of each stream. Steelhead trout were chosen because 1) information is most abundant regarding their distribution and habitat use within the subbasin, 2) they are more widely distributed throughout subbasin tributaries than most other focal species, and 3) their distribution overlaps that of bull trout and spring chinook in tributary habitats. Redband trout populations may be more widespread than steelhead as they exist in many tributaries above steelhead migration barriers. However, in completing QHA for steelhead, the habitat condition of the entire length of each occupied stream was evaluated since upstream factors dictate downstream habitat conditions (e.g., riparian degradation above a passage barrier may result in temperature limitations in reaches below the barrier). This decision functionally equalized the habitat areas/conditions evaluated for steelhead with the wider distribution of redband trout.

Information included in this section is not a direct reflection of QHA outputs (Raw data used in, and outputs from the QHA model are included in Appendix H). Adjustment was made to QHA restoration scores/ranks to account for relevant factors not considered within the QHA model itself (e.g., amount of available habitat). To account for the differing amount of habitat (length of stream used by steelhead) between streams, QHA restoration scores were standardized based on the average utilized length (2.0 miles) of streams used by steelhead within the subbasin. The estimated length utilized within each individual stream was divided by 2.0; the result was then multiplied by the original QHA restoration score for that reach. The streams were reranked according to the resultant scores. This weighting process is important in an area where few tributary reaches provide substantial amounts of habitat, and it emphasizes restoration of those that do. Since restoration for common issues within Hells Canyon tributaries will most commonly need to proceed along the length of the stream channel (not only the portion utilized by steelhead), this process should also build in some level of potential cost effectiveness to the results (For example, restoration of riparian habitat along 10 miles of channel to ameliorate high temperatures may have a fixed cost. Cost effectiveness is achieved by benefiting the largest amount of utilized habitat with that restoration effort/expenditure).

No adjustment was made to original QHA protection scores/ranks. Protection of both larger and smaller habitat areas used by steelhead is critical to maintaining population/habitat diversity, regardless of reach length. This concept is consistent with the guiding principles of the accompanying subbasin management plan and with the scientific principles of the Northwest Power and Conservation Council's Fish and Wildlife Program (Northwest Power Planning Council 2000).

Comparison of protection versus (adjusted) restoration ranks for each reach evaluated indicates that most reaches clearly delineate themselves for either protection or restoration as the primary objective (Table 38). Seven stream reaches fall into the "middle ground" with respect to both priorities and are therefore prioritized for both protection and restoration activities.

Reaches prioritized for restoration activities are presented in rank order in Table 39; those prioritized for protection are presented in rank order in Table 40. In each of these tables, habitat priority factors in need of restoration or protection (respectively) are highlighted using rankings drawn from the QHA model outputs[3].

In tributaries prioritized for restoration, the factors of greatest concern (limiting factors) are riparian condition, fine sediment, and channel stability (Table 39). Localized limiting factors prioritized for restoration in lesser numbers of tributaries include high and low flow, pollutants (associated with grazing activities), high and low temperature, channel form, and oxygen. Inherent in the definition of all restoration needs is the interim need to protect from further degradation those same issues until restoration activities can occur.

In tributaries prioritized for protection, priority issues include fine sediment, riparian condition, channel stability, and high flow (Table 40). In those streams prioritized for both protection (Table 40) and restoration (Table 39) actions, prioritized factors often overlap. In these cases, measures should be implemented to protect against worsening of the current situation, with a longer-term goal of restoration of the necessary conditions.

Due to the generally short nature of production reaches within Hells Canyon tributaries, substantial percentages of steelhead production may occur in relatively unprotected reach (Wild/Scenic corridor) of a seemingly well-protected watershed and focused restoration activities may be warranted (e.g., Kirkwook, Big Canyon, Saddle, and Salt creeks; Table 39). Approximately the lower 0.25 mile of most steelhead-bearing streams is within the Snake Wild/Scenic River corridor (exceptions are Redbird, Captain John, and Corral-N creeks and Cave Gulch). Although the existence of the Wild/Scenic River corridor offers some degree of protection, it is generally far less than that associated with wilderness or National Recreation Area status that encompasses the majority of many tributary watersheds (Table 39 and Table 40).

[3] Within QHA, a maximum of 11 ranks are possible within each reach (one for each habitat variable). Due to tie rankings, the number of unique ranks observed in any reach considered in this assessment did not exceed 6. To extract only priority information from the QHA matrix, the following rules were applied in creating Table 39 and Table 40: If 2 to 3 unique ranks existed for a given reach, the singlemost important issue is highlighted in summary tables; if 4 to 6 unique ranks existed, the two most important issues are highlighted in summary tables. When two ranks are presented, they are presented as “1” and “2” in the summary tables to more clearly illustrate relative priority; original ranks from the QHA model may differ, depending on tie scores, and are presented in Appendix H.

Table 38. Comparative restoration versus protection value for streams within the Snake Hells Canyon subbasin based on (modified) QHA ranks for each activity.

Protection Rank **Restoration Rank**[1]	**High (1-10)**	**Moderate (11-25)**	**Low (26-43)**
High (1-10) (Note: Cells in this row have streams listed in order of Restoration Rank)			Priority = Restore Captain John Creek Getta Creek Dry Creek Divide Creek Cave Gulch Redbird Creek Kirkwood Creek Corral Creek (N) Wolf Creek Big Canyon Creek
Moderate (11-20) (Note: Cells in this row have streams listed in order of Restoration Rank)		Priority = Protect & Restore Saddle Creek Salt Creek Sand Creek Sluice Creek Battle Creek Somers Creek Two Corral Creek	Priority = Restore Cottonwood Creek Corral Creek (S) Jones Creek Kirby Creek
Low (21-27) (Note: Cells in this row have streams listed in order of Protection Rank)	Priority = Protect Granite Creek Little Granite Creek Sheep Creek Temperance Creek Cook Creek Deep Creek Lookout Creek Tryon Creek Rush Creek Rattlesnake Creek Rough Creek Wild Sheep Creek Bull Creek	Priority = Protect Pleasant Valley Creek Durham Creek North Fk Battle Creek Stud Creek Hells Canyon Creek Bernard Creek Three Creeks	Priority = Protect Brush Creek West Creek

[1] A total of 43 streams/reaches were rated for both protection and restoration. Multiple ties in restoration rankings result in a maximum restoration rank of 27.

Table 39. Restoration ranks[1] for streams and habitat variables within each, for streams prioritized primarily for restoration within the Snake Hells Canyon subbasin.

Restoration Rank	Stream Name[2]	State	Length [3]	Watershed Protection[4, 5]	Riparian Condition	Channel form	Channel Stability	Fine sediment	High Flow	Low Flow	Oxygen	Low Temperature	High Temperature	Pollutants [6]	Obstructions
1	Captain John Creek	ID	8.8	Craig Mtn	1	—	2	2	2	2	—	—	—	—	—
2	Getta Creek	ID	4.8	None	2	—	2	2	2	2	—	—	2	1	—
3	Dry Creek	ID	4.8	None	1	—	1	1	1	1	—	—	—	—	—
4	Divide Creek	ID	2.8	None	1	—	1	1	2	2	—	—	—	2	—
5	Cave Gulch	ID	4.6	Craig Mtn	1	2	1	1	2	—	2	2	2	2	—
6	Redbird Creek	ID	3.2	Craig Mtn	1	—	2	2	2	—	—	—	—	—	—
7	Kirkwood Creek	ID	3.9	NRA	1	—	2	2	—	—	—	—	—	1	—
8	Corral Creek (N)	ID	1.8	Craig Mtn	2	—	1	2	—	—	—	—	—	—	—
9	Wolf Creek	ID	0.6	None	2	—	2	1	—	—	—	—	—	—	—
10	Big Canyon Creek	ID	1.5	NRA	1	—	—	1	—	—	—	—	—	—	—
11	Cottonwood Creek	ID	0.9	Craig Mtn	2	—	2	1	2	—	—	—	—	—	—
12	Saddle Creek *	OR	5.7	Wild.	1	—	—	—	—	—	—	—	—	—	—
13	Salt Creek *	OR	2.8	Wild.	1	—	—	1	—	—	—	—	—	—	—
14	Corral Creek (S)	ID	0.7	NRA	1	2	1	1	—	2	2	2	—	2	—
14	Sand Creek *	OR	2.1	Wild.	1	—	—	—	—	—	—	—	—	—	—
16	Jones Creek	ID	0.7	NRA	—	—	—	1	—	—	—	—	—	—	—
17	Sluice Creek *	OR	2.2	Wild.	1	—	—	—	—	—	—	—	—	—	—
18	Battle Creek *	OR	1.5	Wild.	1	—	—	—	—	—	—	—	—	—	—
18	Somers Creek *	OR	1.4	Wild.	—	—	—	1	—	—	—	—	—	—	—
20	Kirby Creek	ID	1.0	NRA	—	—	—	1	—	—	—	—	—	1	—
20	Two Corral Creek *	OR	0.5	Wild.	1	—	—	1	—	—	—	—	—	—	—

[1] Uses "adjusted" reach ranks (previously described) to give weight to amount of usable habitat (stream length). When two variable ranks are presented, scores of 1 and 2 are used to illustrate relative priority; original ranks from the QHA model may differ, dependent on tie scores, and are presented in Appendix H.

[2] Streams prioritized as "protect and restore" in Table 38 are included in both Table 39 and Table 40 and are marked with an asterisk (*).

[3] Measurement is an estimate of the length of channel utilized by steelhead rather than the overall channel length.

[4] Signifies the dominant protection status of the contributing watershed: Wild. = Wilderness Area; NRA = National Recreation Area; Craig Mtn.= Craig Mountain wildlife mitigation or study area. See section 1.5.2 for descriptions of protected status of these areas.

[5] Approximately the lower 0.25 mile of most streams is within the Snake Wild/Scenic River corridor and not afforded the greater protection often associated with the majority of the watershed. Exception sare Redbird, Captain John, Corral (N) creeks and Cave Gulch do not have portions contained within the WSR corridor.

[6] For this exercise, pollutants include inputs related to grazing activities.

Table 40. Protection ranks[1] for streams and habitat variables within each, for streams prioritized primarily for protection within the Snake Hells Canyon subbasin.

Protection Rank	Stream Name[2]	State	Length [3]	Current Protection[4,5]	Riparian Condition	Channel form	Channel Stability	Fine sediment	High Flow	Low Flow	Oxygen	Low Temperature	High Temperature	Pollutants	Obstructions
1	Granite Creek	ID	14.9	Wild.	1	—	1	1	1	—	—	—	—	—	—
1	Little Granite Creek	ID	1.3	Wild.	1	—	1	1	1	—	—	—	—	—	—
1	Sheep Creek	ID	2.3	Wild.	1	—	1	1	1	—	—	—	—	—	—
4	Bull Creek	OR	0.3	Wild.	1	—	2	1	2	—	—	—	—	—	—
4	Cook Creek	OR	0.6	NRA	1	—	2	1	2	—	—	—	—	—	—
4	Deep Creek	OR	0.5	Wild.	1	—	2	1	2	—	—	—	—	—	—
4	Lookout Creek	OR	0.3	Wild.	1	—	2	1	2	—	—	—	—	—	—
4	Rattlesnake Creek	OR	0.4	Wild.	1	—	2	1	2	—	—	—	—	—	—
4	Rough Creek	OR	0.3	Wild.	1	—	2	1	2	—	—	—	—	—	—
4	Rush Creek	OR	2.0	Wild.	1	—	2	1	2	—	—	—	—	—	—
4	Temperance Creek	OR	2.5	Wild.	1	—	2	1	2	—	—	—	—	—	—
4	Tryon Creek	OR	0.3	Wild.	1	—	2	1	2	—	—	—	—	—	—
4	Wild Sheep Creek	OR	0.3	Wild.	1	—	2	1	2	—	—	—	—	—	—
14	Battle Creek *	OR	1.5	Wild.	2	—	2	1	2	—	—	—	—	—	—
14	Durham Creek	OR	0.1	Wild.	2	—	2	1	2	—	—	—	—	—	—
14	Hells Canyon Creek	OR	0.2	Wild.	2	—	2	1	2	—	—	—	—	—	—
14	N.Fk. Battle Creek	OR	0.3	Wild.	2	—	2	1	2	—	—	—	—	—	—
14	Pleasant Valley Cr.	OR	0.3	Wild.	2	—	2	1	2	—	—	—	—	—	—
14	Saddle Creek *	OR	5.7	Wild.	2	—	2	1	2	—	—	—	—	—	—
14	Sluice Creek *	OR	2.2	Wild.	2	—	2	1	2	—	—	—	—	—	—
14	Somers Creek *	OR	1.4	Wild.	1	—	2	2	2	—	—	—	—	—	—
14	Stud Creek	OR	0.3	Wild.	2	—	2	1	2	—	—	—	—	—	—
23	Bernard Creek	ID	1.5	Wild.	2	—	2	1	2	—	—	—	—	—	—
23	Salt Creek *	OR	2.8	Wild.	1	2	1	1	1	—	2	2	2	2	—
23	Sand Creek *	OR	2.1	Wild.	—	—	2	1	2	—	—	—	—	—	—
23	Three Creeks	ID	Unk	Wild.	2	—	2	1	2	—	—	—	—	—	—
23	Two Corral Creek *	OR	0.5	Wild.	1	2	1	1	1	—	2	2	2	2	—

[1] Uses "adjusted" reach ranks (previously described) to give weight to amount of usable habitat (stream length). When two variable ranks are presented, scores of 1 and 2 are used to illustrate relative priority; original ranks from the QHA model may differ, dependent on tie scores, and are presented in Appendix H.

[2] Streams prioritized as "protect and restore" in Table 38 are included in both Table 39 and Table 40 and are marked with an asterisk (*).

[3] Measurement is an estimate of the length of channel utilized by steelhead rather than the overall channel length.

[4] Signifies the dominant protection status of the contributing watershed: Wild. = Wilderness Area; NRA = National Recreation Area; Craig Mtn.= Craig Mountain wildlife mitigation or study area. See section 1.5.2 for descriptions of protected status of these areas.

[5] Approximately the lower 0.25 mile of most streams is within the Snake Wild/Scenic River corridor and not afforded the greater protection often associated with the majority of the watershed. Exception sare Redbird, Captain John, Corral (N) creeks and Cave Gulch do not have portions contained within the WSR corridor.

4.2 Limiting Factors to Wildlife

4.2.1 Out-of-Subbasin Factors

Many of the wildlife species of the Snake Hells Canyon subbasin spend a portion of their life cycle outside the subbasin boundaries. This can complicate and potentially reduce the effectiveness of wildlife management actions in the subbasin. Depending on the extent, location, and timing of seasonal movements, out of subbasin effects may range from limited to substantial.

Migratory birds are the species that travel the greatest distance outside of the subbasin. Two of the focal species in the subbasin are neotropical migrants that breed in the subbasin and winter in Mexico or Central America. Flammulated owls are the most migratory of all North American owls, going south of Mexico during most of the fall and winters. Grasshopper sparrows winter in the southern United States, south into Central America (Vickery 1996). Environmental toxins, and habitat degradation in these species winter habitats could have negative impacts on populations of the species in the Snake Hells Canyon subbasin. Birds migrating to Mexico and Central and South America, where environmental regulations are not as strong as in the U.S., continue to be exposed to relatively high levels of organochlorines. This group of chemicals includes DDT, the pesticide that caused egg shell thinning, reproductive failure and dramatic declines in bald eagle populations in the 1940s. DDT was banned in this country in 1972 but is still used in many other parts of the world (DeWeese et al. 1986).

Many other species in the subbasin make movements of smaller distance out of the subbasin. Large game species including the bighorn sheep, mountain goat, Rocky Mountain elk, and mule deer focal species may migrate into and out of the subbasin. This commonly results in crossing wildlife management units and potentially state boundaries and can complicate the setting of appropriate hunting seasons and harvest limits. Game species may experience greater hunting pressure when they move out of the subbasin into the more populated surrounding areas. Other potential out of subbasin impacts to game species include increased contact between bighorn sheep and domestic sheep and increased potential for disease transmission.

Species may migrate out of the subbasin in search of habitat and forage, finding high quality habitat may allow for increased populations in the subbasin, while use of unsuitable habitats may result in reduced populations. Agricultural areas are very limited in the subbasin but elk and particularly mule deer may migrate outside of the subbasin and forage on private agricultural lands. This results in reduced social carrying capacity and results in public pressure to reduce population management objectives. The relatively high quality grassland habitats of the subbasin provide suitable breeding habitats for grasshopper sparrow. But grasshopper sparrows are also documented to use agricultural areas and hayfields, these areas are not as suitable for breeding grasshopper sparrows and may serve as population sinks (Wisdom et al 2000).

Species with very large home ranges that occur in low densities may migrate into and out of the subbasin in search of prey and mates. Fisher, marten, and particularly lynx and wolverine are species with large home range sizes that may inhabit the Snake Hells Canyon subbasin. Maintaining and enhancing the integrity of movement corridors for these species may prove critical to maintaining genetic diversity and healthy populations of these species. For instance, mapping of documented wolverine sightings conducted by Edelmann and Copeland (1999) suggests that a narrow corridor in the Seven Devils mountain area of the subbasin may provide the only suitable habitat linking wolverine subpopulations in Idaho and Oregon. Reductions of dispersal rates through the corridor may impact the regional viability of wolverine by reducing genetic interchange and lowering the likelihood that all suitable habitat patches are continuously inhabited (Edelmann and Copeland 1999).

4.2.2 Local Limiting Factors

The primary limiting factors for wildlife in the Snake Hells Canyon subbasin were selected based on a comparison of threats identified for focal and concern species, with changes in habitat conditions identified at the scale of the WHT, structural condition and KEC in section 3.5.10. Addressing these habitat level limiting factors will provide the greatest benefit to the greatest number of species; the limiting factors were used as the starting point for the development of the objectives and strategies section of the *Snake Hells Canyon Management Plan.* There is a level of overlap between the limiting factors that is inherent to both this ecosystem level approach and the way the limiting factor were selected, for example, it was determined in section 3.5.10, that the loss and degradation of the grassland habitats in the subbasin was a primary limiting factor to the wildlife species that depend on these habitats. At the finer scale of the KEC it was determined that noxious weeds and invasive plant species were also primary limiting factor to the wildlife species of the subbasin. The impacts of noxious weed and invasive plant infestation have been most profound in the grassland habitats of the Hells Canyon subbasin and have been the primary mechanism for their degradation. The selection of both of these factors as limiting factors will result in some duplication in the development of objectives and strategies in the Management Plan but also provided an opportunity for the technical team to look at the issue from different perspectives and at different scales resulting in a more comprehensive plan for addressing these problems. A couple of limiting factors to focal species were identified that were not addressed at the habitat level, these species specific limiting factors are significant enough to the focal species to warrant consideration in the *Snake Hells Canyon Management Plan.* The approach chosen by the technical team of addressing coarse scale factors first and then looking for finer scale factors falling through the cracks has its president in numerous contemporary conservation ideas (TNC 2003).

Loss and degradation of grassland habitats

Grassland ecosystems have suffered the greatest losses of any habitats in the Columbia Plateau (Kagan et al.1999). The fescue-bunchgrass cover type which dominates the subbasins grasslands has declined by two thirds from historic levels across the Columbia Basin (Quigley and Arbelbide 1997). The subbasin falls at the edge of the Palouse Prairie, which has been identified as the most endangered ecosystem in the United States (Noss *et al.* 1995). Land conversion and livestock grazing coupled with the rapid spread of cheatgrass (*Bromus tectorum*) and a resulting change in the natural fire regime that has further altered the ecosystem (Altman and Holmes 2000 cited in Ashley and Stoval 2004).

The Snake Hells Canyon subbasin contains some of the healthiest grassland communities remaining in the Columbia Basin, but has still been affected by the disturbances that have eliminated most of these communities in the region (USFS 1999). Approximately 41,639 acres of the subbasin that once contained native grasslands have been converted to agriculture, pasture or urban environments. Most of this conversion has occurred in the northern/downstream portion of the subbasin (Figure 6). Much of the remaining grassland habitats in the subbasin have been altered due to livestock grazing, and the introduction of invasive plant species (BLM 2002).

Native grasslands of the region evolved without the heavy grazing pressures that occurred on the Great Plains (Mancuso and Moseley 1994). Heavy grazing in the late 1800s and early 1900s led to alterations in the community structure and aided in colonization by exotic annual grasses and noxious weeds (USFS 1999). Biological soil crusts are an important component of grassland habitats. Crusts reduce wind and water erosion by increasing soil stability, retaining moisture, and increase soil fertility through the addition of carbon, organic matter and soil micronutrients. Biological soil crusts develop slowly and are fragile in some areas crusts in the subbasin have been damaged through grazing, off-road vehicle use, invasion by exotic annual grasses, and fire (USFS 2003a).

Natural succession processes and changes in management have resulted recent upward trends in the condition of grassland habitats in much of the subbasin (USFS 2003a). However, many areas are still degraded and are reducing the subbasins ability to support grassland dependent wildlife species. Ten concern or focal wildlife species in the subbasin have been identified as being closely associated with grassland habitats, all of these species use these habitats for both feeding and breeding (Table 41; Johnson and O'Neil 2001).

Table 41. Concern and focal species closely associated with grassland habitats (Johnson and O'Neil 2001).

Common Name	Scientific Name
Burrowing Owl	*Speotyto canicularia*
Ferruginous Hawk	*Buteo regalis*
Grasshopper Sparrow	*Ammodramus savannarum*
Long-billed Curlew	*Numenius americanus*
Prairie Falcon	*Falco mexicanus*
Swainson's Hawk	*Buteo swainsoni*
Upland Sandpiper	*Bartramia longicauda*
Vesper Sparrow	*Pooecetes gramineus*
Western Pipistrelle	*Pipstrellus hesperus*
Western Small-footed Myotis	*Myotis ciiolabrum*

Additionally, two species that are thought to have been extirpated from the subbasin are closely associated with grassland habitats the sharp-tailed grouse and the white-tailed jackrabbit (Table 19). Grassland habitats are inhabited by numerous rare plant species in the subbasin including two species listed as Threatened under the Endangered Species Act, MacFarlane's four o'clock and Spalding's catchfly.

Two recent analysis of the condition of the grassland habitats have been conducted in the subbasin, one by the Forest Service in support of their HCRNA CMP (2003) and one by the Cottonwood office of the BLM in support of their lower Snake River EAWS (2002) (Figure 49 shows the areas considered in these analysis).

The Forest Service evaluates grassland seral stages to assess the current departure of a specific site from the Potential Natural Condition (PNC) for that site. A seral stage determination is an evaluation of the successional status of the plant community occurring on a site compared with the PNC that would occur on that site if succession progressed absent of outside influences. PNC is based on an evaluation of site characteristics including geology, soils, aspect, climate, elevation, etc., compared to similar site characteristics from areas evaluated and estimated by plant ecologists to be at or near their biotic potential. The types of vegetation associated with each seral class are described below; historically the grasslands in the HCNRA were dominated by mid to late seral-stage vegetation (USFS 2002a).

- Late- the natural/native species community perennial bunchgrasses dominate, with bare ground subordinate to other surface features (rock, gravel, microbiotic crusts, litter).
- Mid – native perennial forbs and grasses co-dominate with the potential natural community perennial bunchgrasses. Bare ground is subordinate or equivalent to other surface features.
- Early – native perennial forbs and other native grasses dominate over the potential natural community perennial bunchgrasses. Bare ground is equivalent to or more extensive than other surface features.
- Very early (Disclimax) – potential natural community perennial bunchgrasses are present on less than 5 percent of the stand. Bare ground is more extensive than other surface features.

Current information about the condition of HCNRA grasslands is limited and based on current and historic inventories (USFS 2002a). The USFS recently compared the existing grassland inventory information to the PNV to determine the ecological condition of grasslands on the HCNRA. Generally, satisfactory condition rangeland is in a mid-seral stage or later with a stable or improving condition trend. Two techniques were used to assess the condition of grasslands in the HCRNA. The first technique evaluated the ecological status and condition of permanent monitoring points on suitable or capable grazing lands. This technique identified that 76 percent of the sites were in satisfactory condition. The second technique analyzed ecological condition inventories on eight allotments, which included one vacant allotment selected to represent the diversity of conditions throughout the HCNRA. Analysis of capable and suitable acres on these allotments indicates 97 percent of the grazing allotments on the HCNRA are in satisfactory condition. Both analysis excluded areas such as historic homesteads, benches (plowed and farmed), and some of the flatter bottomlands and ridges where livestock were historically concentrated and where site potentials have been permanently altered; these areas contain the majority of early and very-early seral grasslands in the HCRNA (USFS 2003). Alternative E, the selected alternative in the Hells Canyon National Recreation Area Comprehensive Management Plan, focuses grassland restoration efforts in the HCNRA on deep soil benches in early seral condition (USFS 2003a).

The Cottonwood BLM assessed the condition of grasslands in their EAWS study area based on the percentage of the grassland dominated by noxious weeds and non-native grasses. Areas containing more than 70% native species were considered to be in good condition. Good condition grasslands were found to account for between 29 and 89 percent of the grassland habitats in the unit. The highest proportion of good condition grasslands was found to occur in the cottonwood creek subwatershed while mainstem Snake River subwatersheds tended to contain the lowest percentage of grasslands in good condition (Table 42). Although the methodology employed by the Cottonwood BLM in their assessment of grasslands in the middle sections of the subbasin is not directly comparable to those used by the Forest Service their analysis seems to indicate that overall grassland conditions in the middle portions of the subbasin are in inferior condition when compared to upstream areas. This is not surprising considering the higher rate of historic disturbance in these areas.

Table 42. Percent of grassland habitats in good condition (>70% native species) within Lower Snake River EAWS units

Unit Name	% of grassland in good condition
Captain John	61
Snake River and Tributaries 0303	29
Snake River and Tributaries 0401	49
Snake River and Tributaries 0402	49
Corral	61
Snake River, Cottonwood Creek	89

No quantitative information on the condition of grasslands in the lower subbasin was available but local knowledge indicates that grasslands in these areas are the most degraded. These areas are the most populated and land use has been the most intense (see Sections 1.6 and 1.7.) Most of the grassland habitats that have been converted to agriculture occur in the lower subbasin (Figure 6). And noxious weeds and invasive species are most prevalent in these areas (see section 1.7).

The loss and degradation of grassland habitats in the subbasin has the potential to impact the numerous wildlife species that depend on these habitats. Species that are closely associated with the eastside grassland WHT would be expected to be the most impacted but the numerous other species that use grassland habitats could also be affected. Strategies for the improvement of grassland habitat condition and protection of existing high quality grassland areas were developed by the Snake Hells Canyon technical team and are presented in the *Snake Hells Canyon Management Plan* (Objectives 10A and 10B).

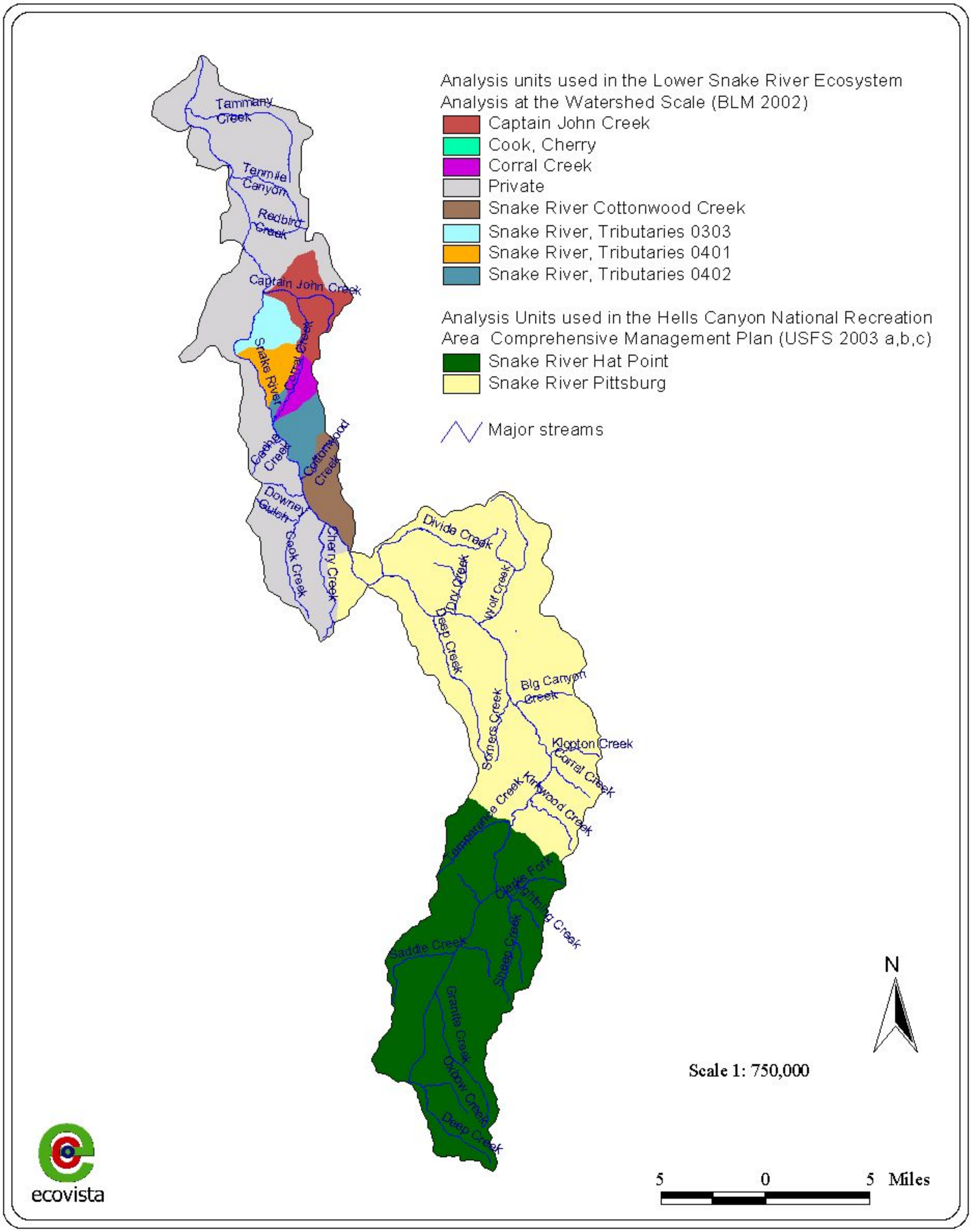

Figure 49. Location of analysis units used in two recent assessments of habitat conditions in the Snake Hells Canyon subbasin.

Riparian, Wetland and Spring Degradation

Riparian habitats in the Snake Hells Canyon subbasin have been altered through various human activities, most notably upstream hydropower development and livestock grazing. Riparian and wetland habitats are very important to both terrestrial and aquatic communities in the subbasin and these changes have the potential to impact numerous species. Twenty-eight concern or focal species have been identified as closely associated with the herbaceous wetland or interior riparian wetland WHTs (Table 43; Johnson and O'Neil 2002).

The Hells Canyon hydroelectric dam complex has altered flow and interrupted sediment processes within the mainstem Snake River. Historically, the upstream reaches of the Snake River and its tributaries provided sediment for the development and maintenance of fluvial and alluvial features within Hells Canyon. Clear water releases from Hells Canyon complex dams are reducing the abundance, size, and special distribution of fluvial and alluvial features, including beaches, within Hells Canyon. A comparison of sandbars before and after the installation of the Hells Canyon dam found that the surface area and number of beaches had declined by 75%, resulting in fewer depositional sites where riparian communities can develop (USFS 1999). Backwater areas, sandbars, and islands were always limited by the narrow, rocky canyon but a comparison of photos taken before the construction of Hells Canyon Dam (1950s) and current (1999) photographs indicate that fewer of these areas, especially smaller sites, may exist today than in the 1950s, and that they may have changed in extent. A reduction in the distribution of sandbar willow over this time period was also noted, while hackberry was found to be more abundant (Blair et al. 2001).

Below the confluence of the Salmon River 70 miles below Hells Canyon Dam, silt sand and gravel are more abundant on beaches and terraces along the river, due to deposition after peak flow events in the Salmon drainage. It is unclear whether these inputs to the downstream half of the subbasin compensate for the sediment trapping effect of Hells Canyon Dam (BLM 2002).

Reductions in the availability backwater pools has negative implications for amphibian species which use these for breeding and fish that use these areas as refugia. The reduced abundance of sandbars and islands and changes in the vegetative composition of riparian areas has implications for the numerous wildlife species that use these mainstem riparian habitats.

Heavy grazing has impacted the health of the riparian communities in the subbasin. Poor shrub regeneration was observed in the Craig Mountain area in riparian and shrubby draw habitats heavily used by livestock; this has reduced the suitability of these areas for yellow warblers and other shrub nesting birds (Mancuso and Moseley 1994). Damage to the hackberry communities along the Snake River is particularly damaging because of the many bird and other small animals that feed on their berries (Mancuso and Moseley 1994). Grazing pressure has aided in the colonization of the subbasins riparian zone by nonnative species. Conditions in riparian zones of much of the subbasin have generally improved in recent years and continue to exhibit an upward trend (USFS 1999).

Conditions in the riparian zones of much of the subbasin have shown recent improvements due to protection and restoration resulting from the 1992 listing of salmon as a threatened species (USFS 1999) and shifts in management focus in the Craig Mountain area after its purchase by BPA. Blair et al. (2001) found that the greatest change in wildlife habitat quality in the area of the subbasin above the Salmon confluence between 1950 and 1999 had been the improvement in the condition of tributary riparian zones. Canopy cover values, canopy height, and woody plant species diversity in these areas appears to have increased dramatically in many of the drainages. These changes are largely attributed to the elimination of grazing on most HCNRA allotments along the river (Blair et al. 2001). Strategies for further improvement of the condition of riparian and wetland habitats in the subbasin and the preservation of high quality areas were developed by the Technical Team in Objectives 11A and 11B of the *Snake Hells Canyon Management Plan.*

Table 43. Concern and focal species closely associated with herbaceous wetlands, and eastside riparian wetlands WHTs (Johnson and O'Neil 2001).

Common Name	Scientific Name
Bank swallow	*Riparia riparia*
Black-crowned night-heron	*Nycticorax nycticorax*
Bufflehead	*Bucephala albeola*
Caspian tern	*Sterna caspia*
Clark's grebe	*Aechmophorus clarkii*
Columbia spotted frog	*Rana luteiventris*
Common garter snake	*Thamnophis sirtalis*
Common loon	*Gavia immer*
Forster's tern	*Sterna forsteri*
Great blue heron	*Ardea herodias*
Great egret	*Ardea alba*
Harlequin duck	*Histrionicus histrionicus*
Horned grebe	*Podiceps auritus*
Long-legged myotis	*Myotis volans*
Northern leopard frog	*Rana pipiens*
Pallid bat	*Antrozous pallidus*
Pygmy nuthatch	*Sitta pygmaea*
Red-naped sapsucker	*Syhympicus nuchalis*
Red-necked grebe	*Podiceps grisegena*
Tailed frog	*Ascaphus truei*
Tiger salamander	*Ambystoma tigrinum*
Western grebe	*Aechmophorus occidentalis*
Western pipistrelle	*Pipistrelle hesperus*
Western small-footed myotis	*Myotis ciolabrum*
Western toad	*Bufo boreas*

Willow flycatcher	*Empidonax traillii*
Woodhouse's toad	*Bufo woodhousii*
Yellow-billed cuckoo	*Coccyzus americanus occidentalis*

Loss of Ponderosa Pine Habitats

Ponderosa pine forests have decreased across the Columbia Basin with an even more significant decrease in mature ponderosa pine (Quigley and Arbelbide 1997). Similar reductions have occurred in the Snake Hells Canyon Subbasin. In the BLM EAWS study area ponderosa pine habitats have experienced a significant decline due to timber harvest of mature ponderosa pine and fire suppression (BLM 2002). Reductions in this habitat type are thought to be less severe in the HCRNA than in other areas of the Columbia Basin. This is primarily due to the large areas designated as wilderness where timber harvest is now precluded and the uneven-aged forest management practices adopted on the HCNRA in 1975; however declines in the ponderosa pine habitat have occurred (USFS 1999).

Before the initiation of logging and fire suppression, ponderosa pine was maintained by regular underburning and contained relatively more shrubs than at present. Many areas of the subbasin covered by open ponderosa pine habitats are now dominated by denser stands of shade-tolerant tree species. In the Lower Snake River EAWS study area (Figure 49) mature stands of ponderosa pine were rare in all subwatersheds but most prevalent in the Captain John and Corral Creek subwatersheds. Protecting areas of existing mature ponderosa pine and facilitating the development of additional areas of ponderosa pine habitat is an important issue for the ponderosa pine dependent wildlife in the subbasin. Strategies for maintaining existing and developing additional mature ponderosa pine habitat were developed by the terrestrial subcommittee of the Snake Hells Canyon technical team and are outlined in the *Snake Hells Canyon Subbasin Management Plan* (Objectives 12A and 12B).

Table 44. Percent of forest stands comprise by mature ponderosa pine within Lower Snake River EAWS units

Unit Name	Mature Ponderosa % of Forest stands
Captain John	1-2%
Snake River and Tributaries 0303	<1%
Snake River and Tributaries 0401	none
Snake River and Tributaries 0402	none
Corral	1-2%
Snake River, Cottonwood Creek	none

These changes have likely impacted populations of ponderosa pine dependent wildlife species in the subbasin. Ponderosa pine habitats are important to a variety of wildlife in a variety of ways. Nearly all bald eagles observed in the Craig mountain area were perched in mature ponderosa pine trees along the Salmon and Snake rivers (Cassirer 1995). The focal species, white-headed woodpecker is completely dependant on the seeds of the Ponderosa pine for winter feeding and show a preference for these habitat types for nesting and foraging during other seasons of the year. Flammulated owl habitat includes open stands of fire-climax ponderosa pine or Douglas-fir forests (See Section 0 for details). Six focal or concern wildlife species in the subbasin are closely associated with ponderosa pine habitats and many more use these habitats.

Table 45. Concern and focal species closely associated with ponderosa pine habitats (Johnson and O'Neil 2001).

Common Name	Scientific Name
Flammulated Owl	*Otus flammeolus*
Great Gray Owl	*Strix nebulosa*
Long-legged Myotis	*Myotis volans*
Northern Goshawk	*Accipiter gentilis*
Pygmy Nuthatch	*Sitta pygmaea*
White-headed Woodpecker	*Picoides albolarvatus*

Changes in disturbance regime and vegetative structure

Timber harvest, fire suppression, livestock grazing and invasive plants have altered disturbance regimes and changed the abundance and distribution of both grassland and forest structural conditions in the subbasin from what was historically present (see sections 1.7.10 fire suppression and 3.5.10 habitat conditions for details). These changes have decreased the suitability of the subbasin to many species adapted to forest and grassland habitats with natural distributions and abundances of structural conditions (see section 3.5.10).

Harvest patterns in the upper elevation plateau area of Craig Mountain have resulted in moderate fragmentation and some isolation of old growth and mature stands (BLM 2002). Where past harvest has occurred on the HCRNA, most biophysical regions are deficit in the late and old structural stages. Therefore, improving the representation of late and old structural stages and increasing the number of large trees available for old growth-associated species harvest are objectives in the HCRNA CMP (USFS 2003a).

Fire suppression has resulted in increased accumulation of fuels, higher vegetation densities, a major shift in species composition and size class distribution of trees. The accumulation of duff, as well as increased density of vegetation and fuels, has created conditions in which even light severity fires can be damaging due to the concentrated heating of the tree bole. The accumulation of ground fuels along with denser, multi storied stand conditions has also created "fuel ladders" that cart fire into the tree canopy, resulting in high intensity crown fires. Unlike the moderate severity fires that burned historically, many wildfires now have the potential to impact soil productivity and increase erosion through the consumption of organic matter and high temperature that may result. In mid elevation forests, fire exclusion and other factors (e.g., timber harvest) have resulted in a shift from young and old single layer stands dominated by shade-tolerant tree species (e.g., Douglas-fir and grand fir). The development of dense, multi-layered stands has resulted in larger, more frequent stand-replacing fires and a greater susceptibility to insects and disease. Higher fuel loads also increase the potential for soil heating and higher mortality of trees and understory vegetation. The net result is wildfires that are more severe and more difficult to control (BLM 2002).

Approximately 60 percent of the lower Snake River EAWS study area is beyond the historic fire free interval and an additional 25% is at the upper limit of its fire free interval. A stand-replacing fire could cause significant damage to resource values and investments. The area should now be managed on a prescribed fire interval to maintain the historic integrity of this watershed (BLM 2002). Similar changes have occurred in other portions of the subbasin (Figure 21; Figure 22).

Exclusion of fire as a forest process has significantly changed wildlife habitat conditions. Lack of areas with fire-killed or weakened trees has impacted the black-backed woodpecker and other snag-dependent species in some areas. Lack of thinning effects of ground fires has allowed shade tolerant-tree species to crowd out important forage plants and compete for moisture and nutrients, discouraging the growth of large trees and maintenance of old growth conditions (BLM 2002).

Due to dense forest conditions the possibility of large-stand replacing fires is now greater than it was historically. These types of fires can negatively impact wildlife species that require mature stands or associated KECs. Large fires result in a more homogenous distribution of structural conditions and can reduce the diversity of species an area can support. Returning to a more natural fire regime through prescribed burning would reduce the threat of large-stand replacement fires and promote large diameter trees and snags. Strategies for restoring more natural disturbance regimes and forest structural conditions were developed by the Snake Hells Canyon technical team in Objective 13A of the *Snake Hells Canyon Subbasin Management Plan.*

Introduced plant species

The introduction of nonnative plant and animal species to the Snake Hells Canyon subbasin has reduced its ability to support native wildlife and plant species. Introduced plants in the subbasin often out compete native plant species and alter ecological processes reducing habitat suitability (Quigley and Arbelbide 1997). Many invasives are not palatable to either livestock or wildlife, nor do they provide suitable habitat for wildlife species. For example, purple loosestrife is not readily eaten nor does it provide nesting habitat. However, it replaces aquatic species, which provide quality habitat (USFS 2003a).

Weed problems in the subbasin are most severe in the grassland habitats. The naturally open structure of the subbasins grassland vegetation, its soils, and climate, and the transport provided by the Snake River, have predisposed it to invasion by weeds, especially by species of Mediterranean origin. Invasive plant species are more established in the lower areas of the subbasin where disturbance has been the most intense. Invasive species in the subbasin are spreading and are becoming increasingly prevalent in the HCRNA and wilderness areas of the upper subbasin (USFS 2003a). Yellow starthistle and cheatgrass are the invasive species currently having the greatest impact on the subbasin. These plants easily invade low elevational rangelands in poor ecological condition and are widespread in the lower subbasin (BLM 2001). Numerous other non native plants inhabit the subbasin, of the 650 plant species documented for Craig Mountain, about 150 (23%) are nonnative (Mancuso and Moseley 1994).

Yellow starthistle

Yellow-star thistle is most prevalent in the area of the subbasin downstream to Frenchy Creek (BLM 2002). In some areas it forms a monoculture and completely dominates, yellow starthistle limits the quality of big game habitat in the lower subbasin. Yellow starthistle is considered the greatest threat to the habitat of the Black Butte bighorn sheep herd of Washington. (WDFW 1999c). Yellow starthistle infestations may also explain why deer populations along the Snake River Breaks portions of GMU 181 have not increased compared to other deer populations in the area. Efforts to control the spread of yellow-star by using aerial application of herbicide have been fairly aggressive in this area but are failing to slow its advance (WDFD 1999c).

Cheatgrass

Cheatgrass, an annual grass native to the Mediterranean, was one of the first invasive plants in the subbasin and was first documented about 1890 (BLM 2002). Cheatgrass has an enormous seed-producing capacity, rapid and flexible germination behavior, and ability to out-compete seedlings of bluebunch wheatgrass (Harris 1967, Mack and Pyke 1983). The natural open spaces in bunchgrass communities predisposed them to invasion after disturbance and cheatgrass was well adapted to the climate and soils of the area. Livestock grazing was the disturbance that most commonly allowed for the establishment of cheatgrass into the bunchgrass communities of the subbasin. Once established cheatgrass easily out-competes native bunchgrass seedlings on harsher sites, and decreases replacement of older grass plants which may be dying out of the community (BLM 2002). Cheatgrass dries out earlier in the season than bunchgrasses and can cause an earlier more frequent fire regime burning bunchgrasses before they have a chance to set seed and furthering its own spread. Cheatgrass is very widespread in the subbasin but is most prevalent in areas of historic overgrazing (USDA 2003a).

Cheatgrass has degraded conditions for wildlife species adapted to native bunchgrass communities. In addition, areas where cheatgrass has replaced the more deep rooted perennial species have a higher susceptibility to surface erosion, and lower organic matter production below ground (BLM 2002). Cheatgrass has also been demonstrated to negatively impact biotic crusts which can further enhance erosion rates and reduce water quality (USFS 2003a).

Other noxious weeds

Numerous other invasive species have been documented in the subbasin and are becoming increasingly prevalent, others are documented to occur in surrounding areas and the potential for establishment within the subbasin is of great concern. The Invaders database (2002) has documented the occurrence of 73 plant species legally designated as "noxious" by Idaho, Oregon or Washington State in the five counties partially contained in the Snake Hells Canyon subbasin (Figure 1). Not all of these 73 species have been documented to occur within the Snake Hells Canyon subbasin, but because of their proximity to the subbasin the noxious weed species presented in (Appendix I) have the greatest potential to establish in the subbasin. The potential impacts of the establishment of these species on the ecosystem of the subbasin are not well understood but have the potential to be devastating. The results of two survey efforts for noxious weeds within the subbasin were provided to the subbasins project team, these efforts were completed in support of the HCRNA CMP, and the Hells Canyon Dam relicensing effort (USFS 2003a; Krichbaum 2000).

As part of the FERC relicensing process the Idaho Power Company contracted Eagle Cap Consulting Inc. to conduct noxious weed surveys along the Snake River from the confluence of the Salmon River upstream to Weiser, Idaho during 998 and 1999. The survey length was broken into five reaches; from the salmon confluence upstream to Hells Canyon Dam, Hells Canyon Reservoir, Oxbow Reservoir, Brownlee Reservoir and Brownlee Dam to Weiser. Surveys were conducted using a subsampling scheme in which one quarter-mile segment was randomly selected for sample in each shoreline mile. Each one-quarter mile survey segment extended 50 meters upslope from the mean high water mark and is referred to as a unit. The study area contained 405 units (Krichbaum 2000).

For the purposes of this study, 'noxious weeds' were defined as those on either Idaho or Oregon's state noxious weed lists. In addition, to these species four invasive riparian species were also considered, *Amorpha fruticosa* (false indigo), *Elaeagnus angustifolia* (Russian-olive), *Phalaris arundinacea* (reed canarygrass), and *Tamarix* spp. (tamarisk). The survey reach from the confluence of the Salmon to Hells Canyon Dam falls within the Snake Hells Canyon Subbasin. The reach within the subbasin had the lowest average number of different weed species per unit (2.4 species/unit), while the Oxbow Reservoir reach had the highest (8.4 species/unit) (Krichbaum 2000). Nineteen of the noxious weed/invasive riparian species surveyed for were found in the Salmon to Hells Canyon Dam Reach (Table 46). Thirteen species were detected in the upstream reaches of the study that were not located in the Salmon to Hells Canyon Dam Reach. (St. Johns wort (*Hypericum perforatum*), common houndstounge (*Cynoglossum officinale*), and Scotch thistle (*Onopordum acanthium*) represented the greatest number of populations in the Hells Canyon Dam Reach while St. Johns wort, Scotch thistle, and erect cinquefoil (*Potentilla recta*) cover the greatest average are per unit (Table 46; Krichbaum 2000).

Table 46. Size and species of noxious weed populations found in surveys from the Salmon confluence to Hells Canyon Dam (Krichbaum 2000).

Scientific Name	Common Name	# of Weed Populations Found	Average Total Net Area per unit (mi^2)
Agropyron repens	quackgrass	1	0.004
Ambrosia artemisiifolia	annual ragweed	1	0.002
Amorpha fruticosa	false indigo	11	0.7
Cardaria draba	whitetop	4	7
Chondrilla juncea	rush skeletonweed	6	0.7
Cirsium arvense	Canada thistle	2	0.2
Cirsium vulgare	bull thistle	28	1
Conium maculatum	poison hemlock	1	0.008
Convolvulus arvensis	field morning glory	22	1
Crupina vulgaris	common crupina	1	8
Cynoglossum officinale	common houndstounge	48	8
Cyperus esculentus	yellow nut sedge	6	0.2
Equisetum arvense	common horsetail	9	2
Hypericum perforatum	St. Johns wort	112	200
Linaria dalmatica	dalmatian toadflax	3	0.1
Onopordum acanthium	Scotch thistle	38	30
Phalaris arundinacea	reed canarygrass	3	0.2
Potentilla recta	erect cinquefoil	21	20
Tribulus terrestris	puncturevine	4	0.1

The Wallowa-Whitman National Forest maintains a GIS base documenting the locations of noxious weeds in the forest. Not all USFS lands in the subbasin have been surveyed for noxious weeds and not all areas have had equal intensities of survey. The Snake River/Pittsburg 5th field HUC had significantly more species of noxious weeds documented and a greater area of coverage than the Snake River/Hat point 5th field HUC (Table 47).

Table 47. Distribution of noxious weed species in the HCRNA by 5th field HUC (REO 2003).

5th field HUC Name	Common Name	Scientific Name	Area documented infested (Acres)
Snake River/Pittsburg	Bull thistle	*Cirsium vulgare*	0.9
	Canada thistle	*Cirsium arvense*	7.3
	Diffuse knapweed	*Centaurea diffusa*	131.6
	Dodder	*Cuscuta*	7.2
	Hoary cress-whitetop	*Cardaria draba*	28.4
	Leafy spurge	*Euphorbia esula*	0.9
	Puncture vine	*Tribulus terrestris*	12.3
	Purple loosestrife	*Lythrum salicaria*	0.8
	Rush skeletonweed	*Chondrilla juncea*	0.8
	Scotch thistle	*Onopordum acanthium*	357.4
	Yellow starthistle	*Centaurea solstitialis*	34.4
	Total		**582.1**
Snake River/Hat Point	Rush skeletonweed	*Chondrilla juncea*	10.6

5th field HUC Name	Common Name	Scientific Name	Area documented infested (Acres)
	Scotch thistle	*Onopordum acanthium*	57.8
	Yellow starthistle	*Centaurea solstitialis*	0.9
	Total		**69.3**

Preventing the spread and establishment of noxious weeds and invasive plants in the subbasin is a high priority for the subbasins management agencies. The Snake Hells Canyon subbasin is within the Tri-State Weed Management Area (WMA). Numerous federal, state, county, tribal and private organizations are working together in the area to coordinate weed education, prevention and control efforts such as biological control insects and herbicide applications. Strategies for preventing the establishment of new invasive species and reducing the rate of spread or eliminating established invaders were developed by the terrestrial subcommittee of the Snake Hells Canyon technical team (Objectives 9A and 9B in the Management Plan). The introduction and spread of invasive species is tied to other activities in the subbasin including road construction and use, livestock grazing, fire, timber harvest and other soil disturbing activities. Strategies developed by the technical team to address these issues and included in the Management Plan will also help to reduce the impact of introduced plant species on the subbasin.

Nutrient Flow Reduction

The flow of nutrients into the subbasin has been altered by the construction of Hells Canyon Dam and the reduction of anadromous fish runs through the subbasin. The reduction of these nutrient flows has potentially impacted numerous wildlife species and the subbasins ecosystem as a whole.

Hells Canyon Dam effectively acts as a sediment trap; the reduced deposition of sediments and gravels to the beaches and terraces of the subbasin has resulted in fewer depositional sites where riparian communities can develop and a reduction in primary productivity and associated nutrient production. The potential repercussions of this are immense and could filter up the food chain to all of the lifeforms inhabiting the subbasin. Further research to quantify these impacts is necessary and was called for as a strategy under objective 15A of the *Snake Hells Canyon Subbasin Management Plan*.

The concept of Key Ecological Functions (KEFs) refers to the main ecological roles of a species or group of species that influence diversity, productivity or sustainability of ecosystems (see section 3.1 and Appendix D for details). Salmonids provide a variety of KEFs in the subbasin and across the Columbia Basin and form an important link between marine, freshwater aquatic and terrestrial environments. Anadromous salmon help to maintain ecosystem productivity and may be regarded as a keystone species. Salmon runs input organic matter and nutrients to the trophic system through multiple levels and pathways including direct consumption, excretion, decomposition, and primary production. Direct consumption occurs in the form of predation, parasitism, or scavenging of the live spawner, carcass, egg, or fry life stages. Carcass decomposition and the particulate and dissolved organic matter released by spawning fish deliver nutrients to primary producers (Cederholm et al. 2000). Relationships between wildlife species and salmon vary in terms of their strength; the categories that have been developed to characterize these relationships and are briefly described below see (Cederholm et al. 2000 and Johnson and O'Neil 2001 for more details):

- Strong-consistent relationship-Salmon play or historically played an important role in this species distribution viability, abundance and or population/status. The ecology of this wildlife species is supported by salmon, especially at particular lifestages or during specific seasons.
- Recurrent relationship- The relationship between salmon and this species is characterized as routine, albeit occasional, and often in localized areas (thus affecting only a small portion of this species population).
- Indirect relationship- Salmon play an important routine, but indirect link to this species. The relationship could be viewed as one of a secondary consumer of salmon; for example salmon support other wildlife that are prey of this species.
- Rare relationship- Salmon play a very minor role in the diet of these species often amounting to less than 1 percent of the diet.

Salmon fishes (including their eggs) are a major source of high-energy food that allows for successful reproduction and enhanced survival of many wildlife species. Sixty-seven birds, twenty-three mammals, three reptiles and one amphibian species thought to inhabit the Blue Mountain Province consume salmon during one or more of salmon's lifestages (IBIS 2003). Twenty-five of the ninety-four total species in the province with a relationship to salmon are concern or focal species, these species and their relationship to salmon are displayed in Table 48, species with more than one type of relationship consume salmon during multiple salmon lifestages. The reductions in the salmon runs of the subbasin described in section 3.4, have reduced nutrient inputs into the ecosystem and probably the suitability of the subbasin for many of the wildlife species that consume salmon. Strategies for restoring salmon runs and salmon habitat in the subbasin were developed by the aquatic subcommittee in Objectives 1A, 2A, 3A, 3B, 8A, 8B, and 8C, in the Management Plan. Strategies for reducing the impact of nutrient losses on the wildlife of the subbasin were developed by the terrestrial subcommittee in Objective 15A in the Management Plan.

Table 48. Concern or focal species of the Snake Hells Canyon subbasin that consume salmon during one or more salmonid lifestages (IBIS 2003).

Common Name	Scientific Name	Relationship
American marten	*Martes americana*	Rare
American white pelican	*Pelecanus erythrorhynchos*	Recurrent
Bald eagle	*Haliaeetus leucocephalus*	Strong-consistent, indirect
Bank swallow	*Riparia riparia*	Indirect
Barrow's goldeneye	*Bucephala islandica*	Recurrent, Rare
Black-crowned night-heron	*Nycticorax nycticorax*	Recurrent
Caspian tern	*Sterna caspia*	Strong-consistent
Clark's grebe	*Aechmophorus clarkii*	Recurrent
Common garter snake	*Thamnophis sirtalis*	Rare

Common Name	Scientific Name	Relationship
Common loon	*Gavia immer*	Recurrent, Rare
Fisher	*Martes pennanti*	Rare
Forster's tern	*Sterna forsteri*	Recurrent
Gray wolf	*Canis lupus*	Recurrent
Great blue heron	*Ardea herodias*	Recurrent
Great egret	*Ardea alba*	Rare
Gyrfalcon	*Falco rusticolus*	Indirect
Harlequin duck	*Histrionicus histrionicus*	Strong-consistent, indirect
Horned grebe	*Podiceps auritus*	Rare
Osprey	*Pandion haliaetus*	Strong-consistent
Peregrine falcon	*Falco peregrinus*	Indirect
Red-necked grebe	*Podiceps grisegena*	Rare
Turkey vulture	*Cathartes aura*	Recurrent
Western grebe	*Aechmophorus occidentalis*	Recurrent, Rare
Willow flycatcher	*Empidonax traillii*	Indirect
Wolverine	*Gulo gulo*	Rare

Roads and habitat fragmentation

Even though road densities in the subbasin are relatively low, the transportation system of the Snake Hells Canyon subbasin is a limiting factor to wildlife populations in some areas of the subbasin. Road densities in the subbasin based on the distribution of 1:100,000 scale roads are illustrated in Figure 50. The dense road networks sometimes associated with timber harvest or private road network are not always captured at this scale and it is usually advisable to use 1:24,000 or finer scale road layers in analysis of road densities. The Wallowa-Whitman National Forest maintains a 1:24,000 scale roads layer (REO 2003), that was made available for this process, but this layer did not cover the entire subbasin. A comparison of the Wallowa-Whitman National Forest layer with the 1:100,000 layer available across the subbasin from ICBEMP (2003) did not reveal significant differences and so for consistencies sake the ICBEMP layer was used in calculating road densities across the subbasin.

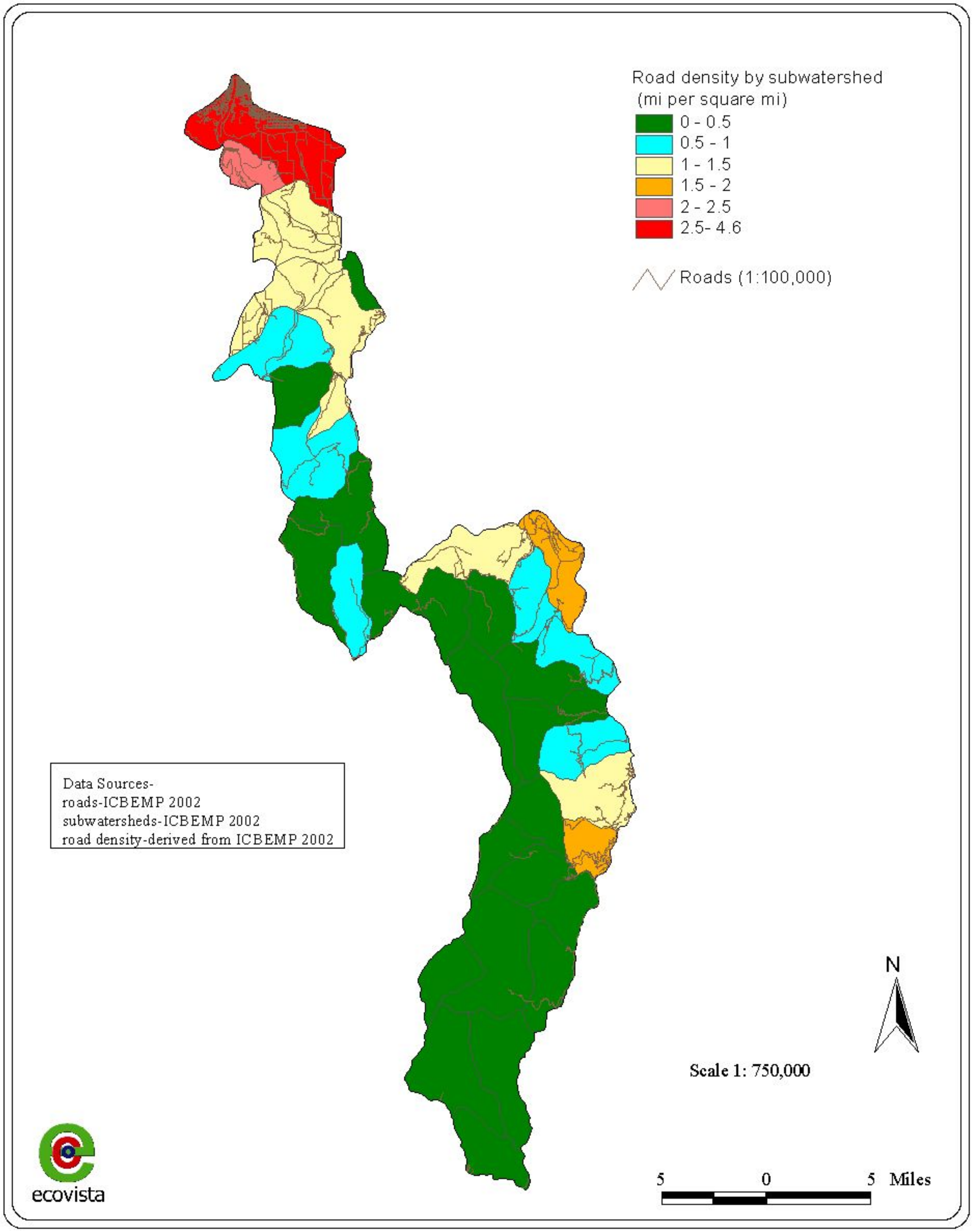

Figure 50. Roads and road densities in the subwatersheds of the Snake Hells Canyon subbasin

More than 65 species of terrestrial vertebrates in the interior Columbia River Basin have been identified as being negatively affected by road-associated factors (Wisdom et al. 2000). Road-associated factors can negatively affect habitats and populations of terrestrial vertebrates both directly and indirectly. Wisdom et al. (2000) identified 13 factors consistently associated with roads in a manner deleterious to terrestrial vertebrates (Table 49). The Wallowa-Whitman National Forest uses the following classes to quantify in general terms the impact of roads on wildlife sensitive to open roads: low impacts can be expected in areas with a density less than 1.0 mi./sq. mi, a moderate impact at densities between 1.0-2.5 mi./sq. mi., and a high impact when densities are greater than 2.5 mi./sq. mi. of open road (USFS 2003a). Based on this definition the only subwatersheds in the subbasin that contain high road densities are those associated with Lewiston in the lower subbasin. The Forest Service and other land management agencies in the subbasin, identify roads that are posing a threat to the subbasins fish and wildlife resources and impose restrictions, make closures, or have the road removed. The HCRNA CMP identified roads for closure in its selected alternative, the removal of these roads will help reduce the impact of roads on the wildlife populations of the subbasin. The technical team developed strategies for further reducing the impacts of roads on wildlife in the subbasin in Objective 14A of the Management Plan.

Table 49. Thirteen road-associated factors with deleterious impacts on wildlife (Wisdom et al. 2000).

Road-Associated Factor	Effect of Factor in Relation to Roads
Snag reduction	Reduction in density of snags due to their removal near roads, as facilitated by road access
Down log reduction	Reduction in density of large logs due to their removal near roads, as facilitated by road access
Habitat loss and fragmentation	Loss and resulting fragmentation of habitat due to establishment and maintenance of road and road right-of-way
Negative edge effects	Specific case of fragmentation for species that respond negatively to openings or linear edges created by roads
Overhunting	Nonsustainable or nondesired legal harvest by hunting as facilitated by road access
Overtrapping	Nonsustainable or nondesired legal harvest by trapping as facilitated by road access
Poaching	Increased illegal take (shooting or trapping) of animals as facilitated by road access
Collection	Collection of live animals for human uses (e.g., amphibians and reptiles collected for use as pets) as facilitated by the physical characteristics of roads or by road access
Harassment or disturbance at specific use sites	Direct interference of life functions at specific use sites due to human or motorized activities, as facilitated by road access (e.g., increased disturbance of nest sites, breeding leks or communal roost sites)

Road-Associated Factor	Effect of Factor in Relation to Roads
Collisions	Death or injury resulting from a motorized vehicle running over or hitting an animal on the road
Movement barrier	Preclusion of dispersal, migration or other movements as posed by a road itself or by human activities on or near a road or road network
Displacement or avoidance	Spatial shifts in populations or individual animals away from a road or road network in relation to human activities on or near a road or road network
Chronic negative interaction with humans	Increased mortality of animals due to increased contact with humans, as facilitated by road access

Species or Guild Specific

Improving the habitat level limiting factors discussed above will improve conditions for most of the subbasins wildlife species. After determining the broad habitat level factors that were limiting the subbasins wildlife the technical team reviewed the habitat requirements and threats to focal and T&E species discussed in sections 3.1 and 3.5. The group looked for important threats and limiting factors to these species that would not be corrected by addressing the habitat level limiting factors discussed above. These species or guild level limiting factors are discussed below.

Disease transmission between domestic sheep and bighorn sheep

Disease transmission from domestic sheep and goats has proven to be the largest threat to wild bighorn sheep populations in the tri-state region of Oregon, Washington, and Idaho. When bighorn sheep come in contact with infected domestic sheep, bighorns usually die of pneumonia within 3-7 days of contact (Martin et al. 1996, Schommer and Woolever 2001). Because exposed bighorns do not die immediately, infected individuals may return to their herd and infect other individuals, which can cause 70–100% of the herd to die (ODFW 2003d). The significant Hells Canyon die-off of 1995-96 was believed to have started when a feral goat interacted with wild bighorns in the Tenmile drainage south of Asotin (Cassirer et al. 1996). During the 1995-96 die-off, the Black Butte, Mtn. View, and Wenaha herds experienced 75, 65, and 50 percent mortality, respectively (Cassirer et al. 1996). The die off did not affect the Asotin Creek herd (Fowler 1999). The transmission of disease from domestic sheep populations to bighorns is the primary factor limiting bighorn sheep populations in the subbasin. Though research to estimate carrying capacity of the existing habitat is needed, grassland habitat quantity and quality appear to be adequate to support the herd (Cassirer, IDFG pers com. 2004).

Disturbance of bat roosts and hibernacula

Fifteen species of bats likely inhabit the subbasin during parts of the year (USFS 2003a, Appendix C). Bats in the subbasin have been documented to use caves with suboptimal temperature and humidity conditions that result in reduced reproductive success. This may indicate a shortage of suitable maternity roost sites in the area (Betts 1997). Protection of bat breeding, roosting and resting sites from disturbance is a management priority for the subbasin. The Townsend's western big-eared bat focal species is extremely sensitive to disturbance, especially in nursery colonies, with human intrusions often resulting in bats abandoning the area. Visitation to nursery caves should be avoided from May 1 through August 30 (Perkins and Schommer 1991 cited in USFS 2003a). Disturbance to a hibernating colony may cause the bats to stir and become active, which may cost them an excessive portion of their limited energy reserves. If repeated, disturbances may result in reproductive failure, abandonment of the site, or death from starvation. Eliminating human disturbance in nursery and hibernation habitat is crucial for big-eared bats during critical periods. Caves and mineshafts that are used for hibernation would be protected from disturbance from November 1 to April 1 each year. Four gates are in place in caves on the HCRNA, but three more are needed (USFS 2003a). Caves in other areas of the subbasin may also require protection.

5 References

Agee, James K. 1993. Fire Ecology of Pacific Northwest Forests. Island Press, Washington D.C.

Agricultural Air Quality Task Force. (AAQTF). 1999. [Online]. Recommendations to USDA. Available: http://fargo.nserl.purdue.edu/faca/Archives/2000/Policy/Burning%20Policy.htm

Akenson, H. A. 2000. Peregrine Falcon Surveys in Hells Canyon. Technical Report E.3.2-18. Idaho Power Company.

Akeson, J. J., and H. A. Akeson. 1992. Bighorn sheep movements and summer lamb mortality in central Idaho. Proceedings of the Biennial Symposium, Northern Wild Sheep and Goat Council **8**:14-27.

Alderice, D. F., W. P. Wickett, and J. R. Brett. 1958. Some Effects of Temporary Exposure to Low Dissolved Oxygen Levels on Pacific Salmon Eggs. Journal of the Fisheries Research Board of Canada **15**:229–250.

Anderson, J. J. 2000. Heat Budget of Water Flowing Through Hells Canyon and the Effect of Flow Augmentation on Snake River Water Temperature. <http://www.cbr.washington.edu/papers/jim/Srheatbudget.html>. Accessed May 9, 2001.

Anthony, R. G., R. L. Knight, G. T. Allen, B. R. McClelland, and J. I. Hodges. 1982. Habitat use by nesting and roosting bald eagles in the Pacific Northwest. Trans. N. Am. Wildlife Nat. Res. Conference 47: 332-342.

Altman, B. and A. Holmes. 2000. Conservation strategy for landbirds in the Columbia Plateau of eastern Oregon and Washington. Final Report Version 1.0. Oregon-Washington Partners in Flight, Boring, Oregon, USA.

American Ornithologists' Union (AOU), Committee on Classification and Nomenclature. 1983. Check-list of North American Birds. Sixth Edition. American Ornithologists' Union, Allen Press, Inc., Lawrence, Kansas.

AmphibiaWeb: Information on amphibian biology and conservation. [web application]. 2004. Berkeley, California: AmphibiaWeb. Available: http://amphibiaweb.org/. (Accessed: 2004).

Arno, S.F., D.G. Simmerman, and R.E. Keane. 1985. Forest Succession on Four Habitat Types in Western Montana. USDA Forest Service General Technical Report INT-177. 74 pp.

Arnold, T. W., and K. F. Higgins. 1986. Effects of shrub coverages on birds of North Dakota mixed-grass prairies. Canadian Field-Naturalist 100:10-14.

Ashley, P. and Stoval S. 2004. Southeast Washington Ecoregional Assessment. Prepared for the Northwest Power and Conservation Council.

Bailey, V. 1936. The Mammals and Life Zones of Oregon. North American Fauna, No. 55. U.S. Department of Agriculture, Bureau of Biological Survey, Washington, DC. 416 pp.

Banci, V. 1994. Wolverine. In: L. F. Ruggiero, K. B. Aubry, S. W. Buskirk, L. J. Lyon, and W. J. Zielinski (eds.) American marten, fisher, lynx, and wolverine in the western United States. USDA Forest Service General Technical Report RM-254. Rocky Mountain Forest and Range Experiment Station. Fort Collins, CO. p. 99 -127.

Barbour, R. W., and W. H. Davis. 1969. Bats of America. The University of Kentucky Press, Lexington, Kentucky.

Barbour, M.G. and W.D. Billings. 2000. North American Terrestrial Vegetation. 2nd Edition.Cambridge University Press, United Kingdom.

Barker, E. 2004. Disease decimates sheep. Lewiston Morning Tribune, p. 1C and 4C.

Basore, N. S., L. B. Best, and J. B. Wooley. 1986. Bird nesting in Iowa no-tillage and tilled cropland. Journal of Wildlife Management **50**:19-28.

Beamesderfer, R. C., and B. E. Rieman. 1991. Abundance and Distribution of Northern Squawfish, Walleyes, and Smallmouth Bass in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society **120**:439–447.

Behnke, R.J. 1992. Native Trout of western North America. American Fisheries Society Monograph 6. Bethesda, Maryland.

Bennett, D. L., T. L. Dresser, T. S. Curet, K. B. Lepla, and M. A. Madsen. 1993. Lower Granite Reservoir In-Water Disposal Test: Results of the Fishery, Benthic and Habitat Monitoring Program—Year 4. 1991. Completion Report. U.S. Army Corps of Engineers, Walla Walla,WA.

Bent, A. C. 1968. Life histories of north American cardinals, grosbeaks, buntings, towhees, finches, sparrows and allies. Dover Publications, Inc., New York, New York.

Best, L. B., H. Campa, III, K. E. Kemp, R. J. Robel, M. R. Ryan, J. A. Savidge, H. P. Weeks, Jr., and S. R. Winterstein. 1997. Bird abundance and nesting in CRP fields and cropland in the Midwest: a regional approach. Wildlife Society Bulletin **25**:864-877.

Betts, B.J. 1997. Microclimate in Hell's Canyon mines used by maternity colonies of *Myotis yumanensis*. Journal of Mammalogy 78:1240-1250.

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

Blankespoor, G. W. 1980. Prairie restoration: effects on nongame birds. Journal of Wildlife Management **44**:667-672.

Blood D.A. 1997. White-headed Woodpecker. Wildlife at Risk in British Columbia, Brochure. Province of British Columbia, Ministry of Environment, Lands and Parks.

Blunt, M. H., H. A. Dawson, and E. T. Thorne. 1972. The birth weights and gestation in captive Rocky Mountain bighorn sheep. Journal of Mammalogy **58**:106.

Bock, C.E., and J.H. Bock. 1974. On the geographical ecology and evolution of the three-toed woodpeckers, *Picoides tridactylus* and *P. arcticus*. American Midland Naturalist **92**(2):397-405.

Brannon, E., A. Setter, J. Altick and M. Miller. 1988. Columbia River White Sturgeon Genetics and Early Life History. Report to Bonneville Power Administration, Project No. 1983-31600. BPA Report DOE/BP-18952-3. 88pp.

Brennan, L. A. 1989. Report on a survey of mountain quail habitat in eastern Oregon, southeastern Washington, western Idaho and northern Nevada. Unpublished report prepared for the Chukar Foundation, Boise, ID, USA.

Brown, J.K., L.J. Lyon, M.H. Huff, R.G. Hooper, E.S. Telfer, D.S. Schreiner, and J.K. Smith. 2001. Wildland Fire in Ecosystems: Effects of Fire on Fauna. GTR-42-vol.1.United States Department of Agriculture, Rocky Mountain Research Station, United States Forest Service.

Buchanan, D. V.; Hanson, M. L. and Hooton, R. M. (1997). Status of Oregon's Bull Trout: Distribution, Life History, Limiting Factors, Management Considerations, and Status. Portland: Oregon Department of Fish and Wildlife.

Bull, E. L., and R. G. Anderson. 1978. Notes on flammulated owls in northeastern Oregon. Murrelet 59:26-28

Bull, E.L.; Peterson, S.R.; and Thomas, J.W. 1986. Resource partitioning among woodpeckers in northeastern Oregon. PNW-444. USDA, Forest Service.

Bull, E. L., A. L. Wright, and M. G. Henjum. 1990. Nesting habitat of flammulated owls in Oregon. J. Raptor Res. 24:52-55.

Bureau of Land Management (BLM). 2000a. Snake River Subbasin: Biological Assessment of Ongoing and Proposed Bureau of Land Management Activities on Sockeye Salmon, Fall Chinook Salmon, Spring/Summer Chinook Salmon, Steelhead Trout, Bull Trout, and BLM Sensitive Species. U.S. Department of the Interior, BLM, Cottonwood, ID.

Bureau of Land Management (BLM). 2000b. Lower Snake River Subbasin: Biological Assessment of Ongoing and Proposed Bureau of Land Management Activities on Sockeye Salmon, Fall Chinook Salmon, Spring/Summer Chinook Salmon, Steelhead Trout, Bull Trout, and BLM Sensitive Species. U.S. Department of the Interior, BLM, Cottonwood, ID.

Bureau of Land Management (BLM). 2002. Lower Snake River Ecosystem Analysis at the Watershed Scale. U.S. Department of the Interior, BLM, Cottonwood Field Office, Cottonwood, ID.

Bureau of Land Management (BLM) 2003a. Areas of Critical Environmental Concern http://www.ca.blm.gov/bakersfield/bkformp/rmpacec.htm

Bureau of Land Management (BLM). 2003b. Analysis of Management Situation and Conceptual Recreation Plan for Hells Canyon Complex,Oregon and Idaho BLM, file located at website. http://www.or.blm.gov/Vale/Valenews/newsreleases/news2000/conceptual_rec_plan.pdf.

Bureau of Land Management (BLM). 2004. Spatial data provided in support of the Snake Hells Canyon subbasin plan. Charles Dillon, BLM, Cottonwood Field Office, Cottonwood, ID.

Burgner, R.L. 1991. Life history of sockeye salmon (*Oncorhynchus nerka*). Pages 1-117 *In:* Groot, C. and L. Margolis (eds.). 1991. Pacific salmon life histories. Vancouver, British Columbia: University of British Columbia Press.

Busby, P., S. Grabowski, R. Iwamoto, C. Mahnken, G. Matthews, M. Schiewe, T. Wainwright, R. Waples, J. Williams, C. Wingert, and R. Reisenbichler. 1995. Review of the status of steelhead (*Oncorhynchus mykiss*) from Washington, Idaho, Oregon, and California under the U.S. Endangered Species Act. 102 p. plus 3 appendices.

Busby, P. J.; Wainwright, T. C.; Bryant, G. J.; Lierheimer, L. J.; Waples, R. S.; Waknitz, F. W. and Lagomarsino, I. V. 1996. *Status Review of West Coat Steelhead from Washington, Idaho, Oregon, and California*. Seattle: National Marine Fisheries Service.

Cannings, R. J.. 1995. Status of the White-headed Woodpecker in British Columbia. Wildlife Branch, Ministry of Environment, Lands and Parks, Victoria, BC. Wildlife Bulletin No. B-80. 8pp.

Cassirer, E. F. 1995. Wildlife Inventory, Craig Mountain Mitigation Area, Idaho. Idaho Department of Fish and Game, Nongame and Endangered Wildlife Program, Lewiston.

Cassirer, E. F., L. E. Oldenburg, V. L. Coggins, P. Fowler, K. Rudolph, D. L. Hunter, and W. J. Foreyt. 1996. Overview and preliminary analysis of a bighorn sheep dieoff, Hells Canyon 1995-96. Proceedings of the Biennial Symposium, Northern Wild Sheep and Goat Council, 10:78-86.

Caton, Elaine L. 1996. Effects of Fire and Salvage Logging on the Cavity-nesting Bird Community in Northwestern Montana. PhD thesis. University of Montana. Missoula, MT. 115pp.

Cederholm, C. J., D. H. Johnson, R. E. Bilby, L. G. Dominguez, A. M. Garrett, W. H. Graeber, E. L. Greda, M. D. Kunze, B. G. Marcot, J. F. Palmisano. 2000. Pacific Salmon and Wildlife-Ecological Contexts, Relationships, and Implications for Management. Washington Department of Fish and Wildlife, Olympia.

Chandler, J.A., S.R. Brink, S.K. Parkinson and M.G. Butler. 2001. Hells Canyon Instream Flow Assessment. Technical Report E.2.3-2. Idaho Power Company.

Chapman, D. 2001. Habitat of the Snake River Plain. *In* J. Chandler, editor. Feasibility of Reintroduction of Anadromous Fish above or within the Hells Canyon Complex. Technical Report E.3.1-2. Idaho Power Company.

Christensen A. 2001. Delineation and Assessment of Big Game Winter Range Associated with the Hells Canyon Hydroelectric Complex: Mule Deer, Elk, Mountain Goats, and Rocky Mountain Big Horn Sheep Idaho Power Company Technical Report Appendix E.3.2-31

Cichosz, T.A., and eight others. 2001. *Draft Clearwater Subbasin Summary*. Prepared for the Northwest Power Planning Council.

Close, D.A. 2000. Pacific Lamprey Research and Restoration Project. Annual Report 1998. DOE-BPA Project No 94-026 Contract No 00000248.

Close, D. A., M. Fitzpatrick,H. Li, B. Parker, D. Hatch, G. James. 1995. Status Report of the Pacific Lamprey (*Lampetra tridentata*) in the Columbia River Basin. Oregon State University, Department of Fisheries and Wildlife; Columbia River Inter-Tribal Fish Commission; Confederated Tribes of the Umatilla Indian Reservation, and Department of Natural Resources, Corvallis.

Cochnauer, T. and C. Claire. 2001. Evaluate Status of the Pacific lamprey in the Clearwater River drainage, Idaho. Annual Report 2000. Bonneville Power Administration. Project 2000-028-00.

Coggins, V. L. 1988. The Lostine Rocky Mountain bighorn sheep dieoff and domestic sheep. Proceedings of the Biennial Symposium, Northern Wild Sheep and Goat Council **6**:57-64.

Coggins, E. F. Cassirer, P. Mathews, and M. Hansen. 2000. Rocky Mountain bighorn sheep transplants in Hells Canyon. Proceedings of the Biennial Symposium, Northern Wild Sheep and Goat Council **12**:68-74.

Collins, K., R. E. Beaty, and B. R. Crain. 1995. Changes in Catch Rate and Diet of Northern Squawfish Associated with the Release of Hatchery-Reared Juvenile Salmonids in a Columbia Reservoir. North American Journal of Fisheries Management **15**:346–357.

Columbia Basin Research. 2004. Columbia River Dart. Data access in real time. <http://www.cqs.washington.edu/dart/dart.html>. Accessed January 26, 2004.

Columbia Basin Fish and Wildlife Authority (CBFWA). 1991. Integrated System Plan for Salmon and Steelhead Production in the Columbia River Basin. Columbia Basin System Planning for the Northwest Power Planning Council, 91-16. Portland, OR.

Columbia Basin Fish and Wildlife Authority. 1999. FY 2000 Draft Annual Implementation Work Plan. Submitted to the Northwest Power Planning Council. http://www.cbfwf.org/products.htm.

Connor, W.P., H.L. Burge, R. Waitt, and T. Andersen. 1998. Early life history and survival of Snake River natural subyearling fall chinook salmon in 1996. *In* J.G. Williams and T.C. Bjornn, (editors), Fall chinook salmon survival and supplementation studies in the snake river and lower snake river reservoirs, 1996. Annual Report to Bonneville Power Administration, Contract DE-AI79-93BP10891 and DEAI79-93BP21708.

Connor, W. P., and several coauthors. 2001. Estimating the Carrying Capacity of the Snake River for Fall Chinook Salmon Redds. Northwest Science **75**:363–370.

Connor, W. P., H. L. Burge, R. Waitt, and T. C. Bjornn. 2002. Juvenile Life History of Wild Fall Chinook Salmon in the Snake and Clearwater Rivers. North American Journal of Fisheries Management **22**:703–712.

Coon, J. C. 1978. Movement, Distribution, Abundance and Growth of White Sturgeon in the Middle Snake River. Dissertation. University of Idaho, Moscow.

Coon, J. C., R. R. Ringe, and T. C. Bjornn. 1977. Abundance, Growth and Movements of White Sturgeon in the Mid-Snake River. Research Technical Completion Report Project B-026-IDA. Idaho Water Resources Research Institute, University of Idaho, Moscow.

Cooper, S.V., K.E. Neiman, and D.W. Roberts. 1991. Forest Habitat Types of Northern Idaho: A Second Approximation. USDA Forest Service, Intermountain Research Station. GTR INT-236.

Copeland, J. P. 1996. The Biology of Wolverine in Central Idaho. Master's Thesis. University of Idaho, Moscow. 138 pp.

Cottam, D. F. 1985. Lamb production differences of bighorn sheep on Hart Mountain, Oregon. M.S. thesis, Oregon State University, Corvallis, OR.

Crane, M.F. and W.C. Fischer. 1986. GTR- INT-2198. Fire Ecology of the Forest Habitat Types of Central Idaho. United States Department of Agriculture, Intermountain Research Station, United States Forest Service.

Crawford, J. and M. Pope 1999. Game Bird Research Program Oregon State University Mountain Quail Research: Annual Report 1999 Oregon State University Corvallis, OR.

Csuti, B., J. A. Kimerling, T. A. O'Neil, M. M. Shaughnessy, E. P. Gaines, and M. M. P. Huso. 1997. Atlas of Oregon Wildlife: Distribution, Habitat, and Natural History. Oregon State University Press, Corvallis, OR.

Csuti, B., T. A. O'Neil, M. M. Shaughnessy, E. P. G. and, and J. C. Hak. 2001. Atlas of Oregon Wildlife: Distribution, Habitat, and Natural History, 2nd edition. Oregon State University Press, Corvallis, OR.

Currens, K.P. 1987. Genetic differentiation of resident and anadromous rainbow trout (*Salmo gairdneri*) in the Deschutes River Basin, Oregon. M.S. Thesis. Oregon State University, Corvallis, OR.

Daly, C., G. H. Taylor, and W. P. Gibson. 1997. The PRISM Approach to Mapping Precipitation and Temperature. Pages 10–12 *in* Reprints: 10th Conference on Applied Climatology, Reno, NV, American Meteorological Society.

Davidson C. 1995. Frog and Toad Calls of the Pacific Coast: Vanishing Voices. Ithaca, NY: Library of Natural Sounds, Cornell Laboratory of Ornithology. [Compact disc].

Deriso, R.B. 2002. Bayesian Analysis of Stock Survival and Recovery of Spring and Summer Chinook of the Snake River Basin. *In* J. M. Berksen, L. L. Kline, and D. J. Orth, editors. Incorporating Uncertainty into Fishery Models. American Fisheries Society, Bethesda, MD.

DeWeese, L. R., L. C. McEwen, G. L. Hensler, and B. E. Petersen. 1986. Organochlorine contaminats in Passeriformes and other avian prey of the Peregrine Falcon in the Western United States. Environmental Toxicology and Chemistry **5**:675-693.

Digital Atlas of Idaho (DAI) 2004. Idaho's Natural History Online-Biology http://imnh.isu.edu/digitalatlas/index.htm Accessed April 2004.

Dixon. R.D. 1995. Ecology of White-headed Woodpeckers in the Central Oregon Cascades. Masters Thesis, Univ. of Idaho, Moscow, ID. In Garrett. K. L., M.G. Raphael and R.D. Dixon. 1996. White-headed Woodpecker (*Picoides albolarvatus*). In The Birds of North America No. 252 (A. Poole and F. Gills, eds.) The Birds of North America Inc., Philadelphia, PA.

Dixon, R. D., and V. A. Saab. 2000. Black-backed Woodpecker (PICOIDES ARCTICUS). No. 509 IN A. Poole and F. Gill, editors. The birds of North America. The Birds of North America, Inc., Philadelphia, PA. 20pp.

Ducey, J., and L. Miller. 1980. Birds of an agricultural community. Nebraska Bird Review **48**:58-68.

Eaton, C., and D. H. Bennett. 1996. Evaluation of Substrate Quality for Embryo Incubation of Fall Chinook Salmon in the Snake River. Chapter 3 *in* D. W. Rondorff and K. F. Tiffan, editors. Identification of the Spawning, Rearing, and Migratory Requirements of Fall Chinook Salmon in the Columbia River Basin. Annual Report. Prepared for U.S. Department of Energy, Bonneville Power Administration. Project Number 91-029.

Edelmann, F., and J. Copeland. 1999 Wolverine Survey in the Seven Devils Mountains of Hells Canyon. Technical Report E. 3.2-29. Idaho Power Company.

Edelmann, F. B., and V. R. Pope. 2001. Distribution and Relative Abundance of Mammalian Carnivores and Furbearers in Hells Canyon. Technical Report E.3.2-28. Idaho Power Company.

Edelmann, F. B. and A. M. Rocklage 2001. Distribution and Abundance of Mountain Goats in Hells Canyon Technical Report Appendix E.3.2-33. Idaho Power Company.

Ehrlich, P.R., D.S. Dobkin, and D. Wheye. 1988. The Birder's Handbook. Simon and Schuster, New York. 785pp.

Engle, J.C. 2000. Columbia spotted frog Great Basin population (Owyhee Mountains subpopulation) long-term monitoring plan. Year 2000 Results. (draft). Boise, Idaho.

Engle, J.C. 2001. Columbia spotted frog project: the translocation of 2 male Columbia spotted frogs between breeding sites within an element occurrence in the Owyhee subpopulation of the Great Basin population. Idaho Department of Fish and Game Report. Boise, Idaho. 19pp.

Engle, J.C. 2002. Columbia spotted frog Great Basin population (Owyhee subpopulation) longterm monitoring plan. Year 2001 results. Idaho Department of Fish and Game Report. Boise, Idaho. 64pp.

Engle, J.C. 2004. Columbia Spotted Frog, Great Basin Population. Species profile on USFWS website: http://idahoes.fws.gov/fact/spotfrog.html

Engle, J.C. and J.C. Munger. 2000. Population fragmentation of spotted frogs in the Owyhee Mountains. Field Report from a cost share agreement between Boise State University and the Bureau of Land Management (DBP990048). Boise, ID.

Engle, J.C., and C.E. Harris. 2001. Idaho Species of Special Concern Element State Ranking Reviews. Nongame and Endangered Wildlife Program, Conservation Data Center, Idaho Department of Fish and Game. 104pp.

Eshelman B. D. 1998. Small and Medium-Sized Mammals of the Hells Canyon Area of the Snake River in Idaho/Oregon. Idaho Power Company Technical Report Appendix E.3.2-24

Faanes, C. A., and G. R. Lingle. 1995. Breeding birds of the Platte River Valley of Nebraska. Jamestown, ND: Northern Prairie Wildlife Research Center home page. http://www.npwrc.usgs.gov/resource/distr/birds/platte/platte.htm (Version 16JUL97).

Festa-Bianchet, M. 1988. Birthdate and survival in bighorn lambs (*Ovis Canadensis*). Journal of Zoology, London **214**:654-661.

Fiedler, P. 1986. Concepts of Rarity in Vascular Plant Species, with Special Reference to the Genus *Calochortus* Pursh (Liliaceae). Taxon **35**(3):502–518.

Fire Effects Information System (FEIS). 2004. [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory. Available: http://www.fs.fed.us/database/feis/.

Fischer, W.C. and A.F. Bradley. 1987. Fire Ecology of Western Montana Forest Habitat Types. U.S. Department of Agriculture, Forest Service, Intermountain Research Station. GTR INT 223.

Flagg, T.A. and Mahnken, C.V.W 1995. An assessment of the status of captive broodstock technology for Pacific Salmon. Final report to the BPA, Project No. 93-56, Contract No. DE-AI79-93BP55064. Portland, OR.

Fleming, I.A. and M.R. Gross. 1992. Reproductive behavior of hatchery and wild coho salmon (Oncorhynchus kisutch): Does it differ? Aquaculture **103**:101-121.

Fleming, I.A. and M.R. Gross. 1993. Breeding success of hatchery and wild coho salmon (*Oncorhynchus kisutch*) in competition. Ecological Applications **3**: 230-245.

Fowler, P. 1999. 1999 Status and trend report: bighorn sheep. Washington Department of Fish and Wildlife, Olympia, WA.

Frenzel, R. W. 1985. Environmental contaminants and ecology of Bald Eagles in southcentral Oregon. Ph.D. dissertation, Oregon State University, Corvallis.

Fulton, L. A. 1968. Spawning Areas and Abundance of Chinook Salmon, *Oncorhynchus tshawytscha,* in the Columbia River Basin—Past and Present. Special Scientific Report. Fisheries **571**:26. U.S. Fish and Wildlife Service.

Gabrielson, I. N., and S. G. Jewett. 1940. Birds of Oregon. Oregon State College, Corvallis. (Reprinted in 1970 as Birds of the Pacific Northwest by Dover Publishing, New York).

Garcia, A. P. 2000. Spawning Distribution of Fall Chinook Salmon in the Snake River. Annual Report to Bonneville Power Administration. Project No. 9801003.

Geist, V. 1971. Mountain sheep: a study in behavior and evolution. University of Chicago Press, Chicago, IL.

Gellman, S.T.; and Zielinski, W.J. 1993. Monitoring bat use of old-growth redwood forests: Preliminary results and a proposal for future work. Northwest Science **67**(2):129.

Goggans, R. 1986. Habitat use by flammulated owls in northeastern Oregon. Thesis, Oregon State University, Corvallis, Oregon, USA.

Goggans, R. 1989. Black-backed woodpecker. Pp. 88-89 in Clark, T. W., A. H. Harvey, R. D. Dorn, D. L. Genter, and C. Groves, editors. Rare, Sensitive and threatened species of the Greater Yellowstone Ecosystem. Northern Rockies Conservation Cooperative, Montana Natural Heritage Program, The Nature Conservancy and Mountain West Environmental Services. 153pp.

Goggans, R., R. D. Dixon and L. C. Seminara. 1989. Habitat use by three-toed and black-backed woodpeckers, Deschutes National Forest, Oregon. Ore. Dept. Fish Wildl.–Nongame Wildl. Prog. USDA Deschutes Natl. For. Tech. Rep. 87-3-02. 43pp.

Green, P. and M. Jensen. 1991. Plant Succession Within Managed Grand Fir Forests of Northern Idaho. Pp 232-236 In: Proceedings—Management and Productivity of Western Montane Forest Soils. USDA Forest Service General Technical Report INT-280.

Green, D.M., T.F. Sharbel, J. Kearsley, and H. Kaiser. 1996. Postglacial range fluctuation, genetic subdivision and speciation in the western North American spotted frog complex, Rana pretiosa. Evolution **50**(1):374-390.

Green, D.M., H. Kaiser, T.F. Sharbel, J. Kearsley, and K.R. McAllister. 1997. Cryptic species of spotted frogs, Rana pretiosa complex, in Western North America. Copeia 1997(1):1-8.

Gribskov, 2002a. Review by BLM Recreation Planner of "Past Recreation Issues and Use in the Hells Canyon Complex and the Hells Canyon National Recreation Area, Technical Report E.5-1, October.

Grobskov, 2002b. Review by BLM Recreation Planner of "Hells Canyon Complex Aesthetics Resource Inventory and Evaluation, Technical Report E.6-3, December.

Groves, P. A. 2001. The Timing and Distribution of Fall Chinook Salmon Spawning Downstream of the Hells Canyon Complex. Chapter 1 *in* P. Groves, editor. Evaluation of Anadromous Fish Potential within the Mainstem Snake River, Downstream of the Hells Canyon Complex of Reservoirs. Technical Report E.3.1-3. Idaho Power Company.

Groves, P. A., and J. A. Chandler. 1999. Spawning Habitat Used by Fall Chinook Salmon in the Snake River. North American Journal of Fisheries Management **19**:912–922.

Groves, P. A., P.A. Bates, and J.A. Chandler. 2001. A Description of Pacific Lamprey Life History, Physical Habitat and Water Quality Criteria, and Their Current Status Downstream of the Hells Canyon Complex. Chapter 4 *in* P. Groves, editor. Evaluation of Anadromous Fish Potential within the Mainstem Snake River, Downstream of the Hells Canyon Complex of Reservoirs. Technical Report E.3.1-3. Idaho Power Company.

Groves, P. A., and J. A. Chandler. 2001. The Quality and Availability of Fall Chinook Salmon Spawning and Incubation Habitat Downstream of the Hells Canyon Complex. Chapter 3 *in* P. Groves, editor. Evaluation of Anadromous Fish Potential within the Mainstem Snake River, Downstream of the Hells Canyon Complex of Reservoirs. Technical Report E.3.1-3. Idaho Power Company.

Haas, J. B. 1965. Fishery Problems Associated with Brownlee, Oxbow, and Hells Canyon Dams on the Middle Snake River. Investigational Report Number 4. Fish Commission of Oregon, Portland. 97208-3621.

Hass, C. C. 1989. Bighorn lamb mortality: predation, inbreeding, and population effects. Canadian Journal of Zoology **67**:699-705.

Hallock, L.A. and McAllister, K.R. 2002. Columbia Spotted Frog. Washington Herp Atlas. http://www.dnr.wa.gov/nhp/refdesk/herp/

Handley, C. O., Jr. 1959. A revision of American bats of the genera Euderma and Plecotus. Proceedings U.S. National Museum **110**:95-246.

Hanson, D. L., T. G. Cochnauer, J. D. DeVore, H. E. Forner, Jr., T. T. Kisanuki, D. W. Kolhorst, P. Lumley, G. McCabe, A. A. Nigro, S. Parker, D. Swartz, and A. Van Vooren. 1992. White Sturgeon Management Framework Plan. Pacific States Marine Fisheries Commission, Portland, OR.

Hayward, G. D., et al. 1987. Movements and home range use by boreal owls in central Idaho. Pages 175-184 in Nero, R. W., et al., eds. Biology and conservation of northern forest owls. USDA For. Serv., Gen. Tech. Rep. RM-142.

Hayward, G. D., and P. H. Hayward. 1993. Boreal Owl (AEGOLIUS FUNEREUS). In The Birds of North America, No. 63. A. Poole and F. Gill, (eds.). Philadelphia: The Academy of Natural Sciences; Washington, D.C.: The American Ornithologists' Union.

Hare, S. R., N. J. Mantua, and R. C. Francis. 1999. Inverse Production Regimes: Alaska and West Coast Pacific Salmon. Fisheries **24**:6–14.

Harris, Grant. A. 1967. Some competitive relationships between *Agropyron spicatum* and *Bromus tectorum*. Ecol. Monogr. **37**:89-111.

Harrison, H. H. 1975. A field guide to birds' nests Houghton Mifflin Co., Boston.

Harrison, C. 1978. A Field Guide to the Nests, Eggs and Nestlings of North American Birds. Collins, Cleveland, Ohio.

Harrison, J. 1995. The Forgotton Fish. Northwest Energy News **14**(3):7–10. Northwest Power Planning Council, Portland, OR.

Hash, H. S. 1987. Wolverine. Pages 575 -585 *in* Wild furbearer management and conservation in North America, M. Novak, J. A. Baker, M. E. Obbard, and B. Malloch, eds.). Ontario Ministry of Natural Resources, Toronto. 1,150pp.

Hayden, J. A. 1990. Mountain goat management plan: 1991–1995. Idaho Department of Fish and Game, Boise, ID, USA.

Healey, M.C. 1991. Life history of chinook salmon (*Oncorhynchus tshawytscha*). Pages 311-393 *In:* Groot, C. and L. Margolis (eds.). 1991. Pacific salmon life histories. Vancouver, British Columbia: University of British Columbia Press.

Hebert, D. M., and S. Harrison. 1988. The impact of coyote predation on lamb mortality patterns at the Junction Wildlife Management Area. Proceedings of the Biennial Symposium, Northern Wild Sheep and Goat Council **5**:283-291.

Heekin, P.E.; Reese, K.P.; and Zager, P. 1993. Movements, habitat use, and population characteristics of Mountain quail in west-central Idaho. Annual Report. University of Idaho. Moscow, ID.

Hells Canyon Bighorn Sheep Restoration Committee. 1997. Restoration of Bighorn Sheep to Hells Canyon: The Hells Canyon Initiative. Bureau of Land Management Technical Bulletin No. 97-14. 62 pp.

Hells Canyon Initiative. 2004. Hells Canyon bighorn sheep restoration Plan 2004.

Hells Canyon Natural Resource Area (HCNRA). 2003. http://www.fs.fed.us/r6/w-w/hcnra-25-celebration.htm

Hemmingsen, A. R., S. L. Gunckel, J. K. Shappart, B. L Bellerud, D. V. Buchanan, and P. J. Howell. 2001a. Bull Trout Life History, Genetics, Habitat Needs, and Limiting Factors in

Central and Northeast Oregon. 1997 Annual Report. Prepared for Bonneville Power Administration, Portland, OR.

Hemmingsen, A. R., B. L Bellerud, S. L. Gunckel, and P. J. Howell. 2001b. Bull Trout Life History, Genetics, Habitat Needs, and Limiting Factors in Central and Northeast Oregon. 1998 Annual Report. Prepared for Bonneville Power Administration, Portland, OR.

Henny, C. J., and M. W. Nelson. 1981. Decline and present status of Peregrine Falcons in Oregon. Murrelet 62: 43-53.

Herkert, J. R. 1994a. The effects of habitat fragmentation on midwestern grassland bird communities. J. Ecol. Appl. **4**:461-471.

Herkert, J. R. 1994b. Breeding bird communities of midwestern prairie fragments: the effects of prescribed burning and habitat-area. Nat. Areas J. **14**:128-135.

Hickey, W. O. 1975. Bighorn sheep ecology. Idaho Department of Fish and Game, Federal Aid Wildlife Restoration Project W-1600-R-2.

Higgins, Kenneth F., Arnold D. Kruse, and James L. Piehl. 1989. Effects of fire in the Northern Great Plains. U.S. Fish and Wildlife Service and Cooperative Extension Service, South Dakota State University, Brookings, South Dakota. Extension Circular 761. Jamestown, ND: Northern Prairie Wildlife Research Center Home Page. http://www.npwrc.usgs.gov/resource/2000/fire/fire.htm (Version 16MAY2000).

Hill, R. A. 1976. Host-parasite relationships of the Brown-headed Cowbird in a prairie habitat of west- central Kansas. Wilson Bull. 88:555-565.

Hill, J., and K. Gray. 2003. Conservation Strategy for *Silene spaldingii*. Draft Report. Prepared for U.S. Fish and Wildlife Service, Boise, ID. 104 pp.

Hillis M., A. Jacobs, and V. Wright. 2001. Flammulated Owl Assessment. U.S. National Fire Plan Cohesive Strategy Team. Forest Service, Region One.

Hillis M., A. Jacobs, and V. Wright. 2002. Black-Backed Woodpecker Assessment. U.S. National Fire Plan Cohesive Strategy Team. United States Forest Service, Region One.

Hoefs, N. J. 1997. Phase Two: Multi-Year Study Plan to Evaluate Potential Means of Rebuilding Sturgeon Populations in the Snake River Between Lower Granite and Hells Canyon Dams. Nez Perce Tribe, Department of Fisheries Resource Management, and Bonneville Power Administration, Portland, OR. Contract Number 97-AM-30423, Project 97-09.

Hoefs, N. J. 1998. Evaluation of Potential Means of Rebuilding Sturgeon Populations in the Snake River Between Lower Granite and Hells Canyon Dams. 1997 Annual Report. Prepared for Bonneville Power Administration, Portland, OR. Contract Number 97-AM-30423, Project 9700900.

Holmes, A.L. and G.R. Geupel. 1998. Avian population studies at Naval Weapons System Training Facility Boardman, Oregon. Unpubl. rept. submitted to the Dept. of Navy and Oreg. Dept. Fish and Wildl. Point Reyes Bird Observatory, Stinson Beach, CA.

Hooper, P.R. and Swanson, D.A., 1990, The Columbia River Basalt Group and associated volcanic rocks of the Blue Mountains province, in Walker, G.W., ed., Geology of the Blue Mountains region of Oregon, Idaho, and Washington: Cenozoic geology of the Blue Mountains region; U.S. Geological Survey Professional Paper 1437, pp. 63-99.

Hornocker, M. G., and H. S. Hash. 1981. Ecology of the Wolverine in Northwestern Montana. Canadian Journal of Zoology **59**:1286–1301.

Howle, R. R., and R. Ritcey. 1987. Distribution, habitat selection, and densities of flammulated owls in British Columbia. Pages 249-254 in R. W. Nero, R. J. Clark, R. J. Knapton, and R. H. Hamre, editors. Biology and conservation of northern forest owls. USDA Forest Service General Technical Report RM-142.

Hubbard, C. R. 1956. Geology and Mineral Resources of Nez Perce County. Idaho Bureau of Mines and Geology, Moscow.

Hughes, J. M. 1999. Yellow-Billed Cuckoo: *Coccyzus americanus*. In: A. Poole and F. Gill, editors. The Birds of North America, No. 418. The Birds of North America, Inc., Philadelphia, PA

Huntington, C., and 16 others. 2001. Draft Subbasin Summary for the Salmon River, ID. Prepared for Northwest Power Planning Council.

Hutto, R.L. 1995a. USFS Northern Region Songbird Monitoring Program: Distribution and habitat relationships. USDA Forest Service Northern Region internal report, Missoula, MT.

Hutto, R.L. 1995b. Composition of bird communities following stand-replacement fires in northern Rocky Mountain (U.S.A.) conifer forests. Conservation Biology 9:1041-1058.

IBIS. 2003. Interactive Biodiversity Information System. <http://ibis.nwhi.org>. Northwest Habitat Institute, Corvallis, OR.

Idaho Conservation Data Center (IDCDC). 2001. Element Occurrence Data in Arc/Info GIS format.

Idaho Department of Commerce (IDOC). 2003. County Profiles <http://www.idoc.state.id.us/idcomm/profiles/>

Idaho Department of Environmental Quality (IDEQ). September 2001. Tammany Creek Sediment TMDL: Subbasin Assessment and Total Maximum Daily Load Analysis. Available at <http://www.deq.state.id.us/water/tmdls/tammany_creek/>.

Idaho Department of Environmental Quality (IDEQ). 1998. Lower Snake River Subbasin, Snake River Subbasin, Lower Salmon River Subbasin and Little Salmon River Subbasin Bull

Trout Problem Assessment. Prepared for State of Idaho by Clearwater Basin Bull Trout Technical Advisory Team, Lewiston, ID. 72 pp.

Idaho Department of Environmental Quality (IDEQ) and Oregon Department of Environmental Quality (ODEQ). 2001. Draft Sub-Basin Assessment for the Snake River—Hells Canyon Total Maximum Daily Load (TMDL).

Idaho Department of Fish and Game (IDFG). 1998. Appendix 3.10 Idaho's Anadromous Fish Stocks: Their Status and Recovery Options–Issue Paper: Ocean and In-river Harvest. Report to the Director Idaho Fish & Game 5/1/98. Viewed at <http://www.bluefish.org/harvest.htm>.

Idaho Department of Fish and Game (IDFG). 1998. Idaho's Anadromous Fish Stocks: Their Dtatus and Recovery Options. Technical Report 98-13. IDFG, Boise.

Idaho Department of Fish and Game (2001). Six-Year Fisheries Management Plan 2001–2006. IDFG, Boise.

Idaho Department of Fish and Game. 2002. Bighorn sheep progress report July1, 2001 to June 30, 2002. Idaho Department of Fish and Game, Boise, ID. 75pp.

Idaho Department of Fish and Game (IDFG) 2003a. Access Query of License Database 2002, by County. Joe Kelly personal communication October 2003.

Idaho Department of Fish and Game (IDFG). 2003b. Idaho's Special Status Animals and Plants <http://www2.state.id.us/fishgame/info/cdc/ Accessed September 2003.

Idaho Department of Fish and Game (IDFG). 2003c. Draft White Sturgeon Management Plan. Status and Objectives of Idaho's White Sturgeon Resources in the Snake River.

Idaho Department of Fish and Game (IDFG). 2003d. ProjectW-170-R-27 Progress Report- Mule Deer, Study I, Job 2. IDFG, Boise, ID.

Idaho Department of Fish and Game (IDFG). 2003e. ProjectW-170-R-27 Progress Report- Elk, Study I, Job 1. IDFG, Boise, ID.

Idaho Department of Fish and Game(IDFG), Idaho Department of Parks and Recreation, Bureau of Land Management, Regions 1 and 4 of U.S. Forest Service, and U.S. Fish and Wildlife Service. 1995. Habitat Conservation Assessment and Conservation Strategy: Spotted Frog (Rana pretiosa). (Draft) Idaho State Conservation Effort.

Idaho Department of Fish and Game (IDFG), Oregon Department of Fish and Wildlife (ODFW), Washington Department of Fish and Wildlife, U.S. Forest Service, Bureau of Land Management, and Foundation of North American Wild Sheep. 1997. Restoration of the Bighorn Sheep to Hells Canyon—The Hells Canyon Initiative. Technical Bulletin No. 97-14.

Idaho Power Company (IPC). 1999. Hells Canyon Complex Total Dissolved Gas Study, Draft Project Progress Report, March 1999. IPC, Boise, Idaho. 29 p plus appendices.

Interior Columbia Basin Ecosystem Management Project (ICBEMP). 2003. Spatial Data. Available at www.ICBEMP.gov

Invaders Database System 2002. Comprehensive database of exotic plant names and weed distribution records for five states in the northwestern United States. University of Montana. Available at: http://invader.dbs.umt.edu/

Irving, J. S., and T. C. Bjornn. 1981. Status of Snake River Fall Chinook Salmon in Relation to the Endangered Species Act. Idaho Cooperative Fishery Research Unit, University of Idaho, Moscow. Prepared for U.S. Fish and Wildlife Service.

Isaacs, F. B., and R. G. Anthony. 1983. Ecology of wintering bald eagles in the Harney Basin, Oregon, 1982-1983. Report for U.S. Dept. of Interior, Bureau of Land Management, Burns, OR. Unpublished Manuscript 21 pp.

Isaacs, F. B., and R. G. Anthony. 2001. Bald Eagle nest locations and history of use in Oregon and the Washington portion of the Columbia River Recovery Zone, 1972 through 2001. Unpublished report, Oregon Cooperative Fish and Wildlife Resources Unit, Oregon State University, Corvallis.

Isaacs, F. B., and R. G. Anthony. 2003. Bald Eagle. Pp. 140-144 *in* Birds of Oregon: A General Reference. D.B. Marshall, M.G. Hunter, and A.L. Contreras, Eds. Oregon State University Press, Corvallis, OR.

Jenkins, J. M., and R. E. Jackman. 1993. Mate and nest site fidelity in a resident population of Bald Eagles. Condor 95: 1053-1056.

Johnson, C.G. 1998. Vegetation Response after Wildfires in National Forests of Northeast Oregon. USDA Forest Service General Technical Report R6-NR-ECOL-TP-06-98. 128pp. plus appendices.

Johnson, B., and 25 others. 2001. Draft Subbasin Summary for Asotin Creek. Prepared for Northwest Power Planning Council.

Johnson, D. H., and T. O'Neil. 2001. Wildlife-Habitat Relationships in Oregon and Washington. Oregon State University Press, Corvallis.

Johnson, R. G., and S. A. Temple. 1990. Nest predation and brood parasitism of tallgrass prairie birds. Journal of Wildlife Management **54**:106-111.

Jones, J.L. 1991. Habitat use of fisher in northcentral Idaho. Master's Thesis. University of Idaho.Moscow, ID.

Joy. J., R. Driessche and S. McConnell. 1995. 1995 White-headed Woodpecker Population and Habitat Inventory in the South Okanagan. Report For the BC Ministry of Environment, Lands and Parks. 21pp.

Joyce, J.E., R.M. Martin, and F.P. Thrower. 1993. Successful maturation of captive chinook salmon brood stock. Progressive Fish-Culturist **55**:191-194.

Kahl, R. B., T. S. Baskett, J. A. Ellis, and J. N. Burroughs. 1985. Characteristics of summer habitats of selected nongame birds in Missouri. Research Bulletin 1056. University of Missouri, Columbia, MO.

Kagan, J.S., J.C. Hak, B. Csuti, C.W. Kiilsgaard, and E.P. Gaines. 1999. Oregon Gap Analysis Project Final Report: A geographic approach to planning for biological diversity. OR Natural Heritage Program. 72pp. appendices.

Kan, T.T. 1975. Systematics, Variation, Distribution and Biology of Lampreys of the Genus *Lampetra* in Oregon. Ph.D. Thesis. Oregon State University, Corvallis, OR.

Kaspari, M. and H. O'Leary. 1988. Nonparental attendants in a north-temperate migrant. Auk **105**:792-793.

Kern, J. L. 1976. Inventory of Riparian Habitats and Associated Wildlife along the Columbia and Snake Rivers. U.S. Army Corp of Engineers.

Kilham, L. 1983. Life history studies of woodpeckers of eastern North America. Nuttall Ornithol. Club Pub. No. 20. vii + 240pp.

Kilpatrick M. 2001 A Pathfinder to Information on The Endangered Species Act of 1973. http://www.llrx.com/features/esa.htm Accessed: September 2003

Knapton, R. W. 1979. Birds of the Gainsborough-Lyleton region. Saskatchewan Natural History Society Special Publication 10. 72 p.

Krichbaum R. 2000. Inventory of Rare Plants and Noxious Weeds Along the Snake River Corridor in Hells Canyon—Weiser, Idaho, to the Salmon River. Idaho Power Company Technical Report Appendix E.3.3-2, Idaho Power Company

Kruckeberg, A. R. 1986. An Essay: Stimulus of Unusual Geologies for Plant Speciation. Systematic Botany **11**(3):455–463.

Kunz, T.H. and R.A. Martin. 1982. Plecotus townsendii. American Society Mamm., Mammalian Species No. 175. 6pp.

Larsen, E. M., and N. Nordstrom, editors. 1999. Volume IV: Birds. Management Recommendations for Washington's Priority Species. Washington Department of Fish and Wildlife, Olympia.

Leonard, W.P., Brown H.A., Jones, L.L.C., McAllister, Storm R.M. 1993. Amphibians of Washington and Oregon. Seattle, WA: Seattle Audubon Society. 168pp.

Leonard, W.P., Leonard N.P., Storm R.M., and P.E. Petzel. 1996. *Rana pretiosa* (spotted frog). Behavior and reproduction. Herpetological Review **27**(4):195.

Lepla, K. B. 1994. White sturgeon Abundance and Associated Habitat in Lower Granite Reservoir, Washington. Thesis. University of Idaho, Moscow.

Lepla, K. B., J. A. Chandler, and P. Bates. 2001. Status and Habitat Use by White Sturgeon Associated with the Hells Canyon Complex. Idaho Power Company, Boise, ID.

Lichatowich, J. A., and L. E. Mobrand. 1995. Analysis of Chinook Salmon in the Columbia River from an Ecosystem Perspective. Bonneville Power Administration, Division of Fish and Wildlife, Portland, OR.

Licht, L.E. 1975. Comparative life history features of the western spotted frog, *rana pretiosa*, from low- and high-elevation populations. Canadian Journal of Zoology **53**:1254-1257.

Llewellyn, R.L. and C.R. Peterson 1998. Distribution, Relative Abundance and Habitat Associations of Amphibians and Reptiles on Craig Mountain, Idaho Technical Bulletin No. 98-15 Idaho Bureau of Land Management.

Lorain, C. C. 1991. Report on the Conservation Status of *Silene spaldingii* in Idaho. Unpublished Report. Prepared for Idaho Department of Parks and Recreation by Natural Heritage Program. 28 pp. (On file at Idaho Department of Fish and Game, Idaho Conservation Data Center, Boise.)

Lukens, J. R. 1985. Hells Canyon White Sturgeon Investigations. River and Stream Investigations, Job Performance Report. Idaho Department of Fish and Game, Boise. Project No. F-73-R-7.

Lyon, J.L. and P.F. Stickney. 1976. Early Vegetal Succession Following Large Northern Rocky Mountain Wildfires. Tall Timbers Fire Ecology Conference **14**:355-373.

Mack, R.N., and D.A. Pyke. 1983. The demography of *Bromus tectorum*: variation in time and space. J. Ecol. **71**:69-93.

Mamorek, D. R., and C. N. Peters, editors, and 26 coauthors. (1998). Plan for Analyzing and Testing Hypothesis (PATH): Preliminary Decision Analysis Report on Snake River Spring/Summer Chinook. Draft Report. Compiled and edited by ESSA Technologies Ltd., Vancouver, B.C.

Mancuso, M. and R. Moseley. 1994. Vegetation description, rare plant inventory and vegetation monitoring for Craig Mountain, Idaho. U.S. Department of Energy, BPA Project No. 92-069. 146pp. plus appendices.

Marcot B. G., and R. Hill. 1980. Flammulated owls in northwestern California. Western Birds 11:141-149.

Marcot, B. G., W. E. McConnaha, P. H. Whitney, T. A. O'Neil, P. J. Paquet, L. E. Mobrand, G. R. Blair, L. C. Lestelle, K. M. Malone, and K. I. Jenkins. 2002. A Multi-Species Framework Approach to the Columbia River Basin. Northwest Power and Conservation Council, Portland, OR.

Marshall, D. B., M. Chilcote, and H. Weeks. 1996. Species at Risk. Oregon Department of Fish and Wildlife, Portland.

Martin, 2002. Review by Idaho State Office Economist of "Social and Economic Studies" Idaho Power Company Report for Relicensing, November.

Martin, A. C., H. S. Zim, and A. L. Nelson. 1951. American wildlife and plants, a guide to wildlife food habits. Dover, NY.

Martin, K. D., T. Schommer, and V. L. Coggins. 1996. Literature Review Regarding the Compatibility Between Bighorn and Domestic Sheep. Biennial Symposium of the Northern Wild Sheep and Goat Council **10**:72–77.

Matthews, G.M. and R.S. Waples. (1991). Status review for Snake River spring and summer chinook salmon. U.S. Department of Commerce, NOAA Technical Memorandum NMFS F/NWC-200, Seattle, WA., 75 p.

McCallum, D.A 1994. Review of Technical Knowledge: Flammulated Owls. Pages 14-46 In G.D. Hayward and J. Verner, ed. Flammulated, Boreal and Great Gray Owls in the United States: a Technical Conservation Assessment. For. Ser. Gen. Tech. Rep. GTR-RM-253, Fort Collins, CO.

McClelland, D. E., R. B. Foltz, W. D. Wilson, T. Cundy, R. Heinemann, J. Saurbier, and R. L. Schuster. 1997. Assessment of the 1995 and 1996 Flood on the Clearwater National Forest. Part I. U.S. Forest Service, Northern Region.

McClure, M., and 14 others. 2003. Independent Populations of Chinook, Steelhead, and Sockeye for Listed Evolutionarily Significant Units within the Interior Columbia River Domain—Discussion Draft. Interior Columbia Basin Technical Recovery Team.

McClure, M., B. Sanderson, E. E. Holmes, C. Jordan, P. Kareiva, and P. Levin. 2000. Revised Appendix B. *In* Standardized Quantitative Analysis of the Risks Faced by Salmonids in the Columbia River Basin. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, WA. September.

McKelvey, K. S., K. B. Aubry, and Y. K. Ortega. 2000a. History and Distribution of Lynx in the Contiguous United States. Chapter 8 *in* L. F. Ruggiero, K. B. Aubry, S. W. Buskirk, et al., technical editors. Ecology and Conservation of Lynx in the United States. University Press of Colorado, Boulder. 480pp.

Melland, J. 2002a. BLM Study Review of Hells Canyon Complex Studies: Influences of Human Activities on Terrestrial Resources Associated with the Hells Canyon Hydroelectric Project. *In* BLM Comments on Hells Canyon Complex Draft License Application, FERC Project #1971. September.

Melland, J. 2002b. BLM Study Review of Hells Canyon Complex Studies: Influences of Land Management Practices of IPC-Owned Land on Terrestrial Resources. *In* BLM Comments on Hells Canyon Complex Draft License Application, FERC Project #1971. September.

Miller, M. W. 2000. Pasteurellosis. *In* E. S. Williams and I. K. Barker, editors. Infectious Diseases of Wild Mammals. 3rd edition. Iowa State University Press, Ames.

Mobrand Biometrics, Inc. 2003a. Out of Subbasin Survival Factors in Ecosystem Diagnosis and Treatment. Memo to the Northwest Power and Conservation Council.

Mobrand Biometrics, Inc. 2003b. Draft QHA Users Guide. 6pp.

Moore, T. L., and G. P. Frederick. 1991. Distribution and Habitat of Flammulated Owls (*Otus flammeolus*) in West-Central Idaho. Unpublished Report. Cooperative Challenge Cost Share Project: Payette National Forest, Wallowa-Whitman National Forest, and Idaho Department of Fish and Game. On file at Idaho Department of Fish and Game, Idaho Conservation Data Center, Boise. 28 pp., plus appendices.

Morgan, P. and L.F. Neuenschwander. 1984. Modeling Shrub Succession Following Clearcutting and Broadcast Burning. Paper presented at the Symposium on Fire's Effects on Wildlife Habitat, Missoula, MT. March 21, 1984.

Morris, R. L. and W. W. Tanner. 1969. The ecology of the western spotted frog, Rana pretiosa pretiosa Baird and Girard, a life history study. Great Basin Naturalist **2**:45-81.

Moseley, R.K., and S. Bernatas. 1991. Confirmation of *Pentagramma triangularis* in Idaho. American Fern Journal **81**:66-67.

Munger, J.C., M. Gerber, M. Carroll, K. Madric, and C. Peterson. 1996. Status and habitat associations of the spotted frog (Rana pretiosa) in southwestern Idaho. Bureau of Land Management Technical Bulletin No. 96-1. Boise, ID.

Munger, J.C., A. Ames, and B. Barnett. 1997. 1996 Survey for Columbia spotted frogs in the Owyhee Mountains of southwestern Idaho. Technical Bulletin No. 97-13. Idaho Bureau of Land Management. Boise, Idaho.

Myers, J. M., R. G. Kope, G. J. Bryant, D. Teel, L. J. Lierheimer, T. C. Wainwright, W. S. Grant, F. W. Waknitz, K. Neely, S. T. Lindley, and R. S. Waples. 1998. Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle Washington. NOAA Technical Memorandum NMFS-NWFSC-35.

Narolski, S. W. 1996 Forest Inventory Peter J. Johnson Wildlife Mitigation Unit Craig Mountain, Idaho, Final Report. Idaho Department of Fish and Game.

National Marine Fisheries Service (NMFS). 1995. Endangered Species Act Section 7 Consultation. Biological Opinion. Reinitiation of Consultation on 1994–1998 Operation of the Federal Columbia River Power System and Juvenile Transportation Program in 1995 and Future Years. March 2, 1995. National Marine Fisheries Service, Northwest Region.

National Marine Fisheries Service (NMFS). 1997. In Digital Studios. Salmon Conflict. Position Statements. Response to questionnaire for Internet project by National Marine Fisheries

Service (R. Jones). CyberLearning Collection. <http://www.cyberlearn.com>. Ron S. Nolan, Aptos, CA. Posted March 22, 1997.

National Marine Fisheries Service (NMFS). 2000a. Endangered Species Act—Section 7 Consultation. Biological Opinion. Reinitiation of Consultation on Operation of the Federal Columbia River Power System, Including the Juvenile Fish Transportation Program, and 19 Bureau of Reclamation Projects in the Columbia Basin. Prepared for U.S. Army Corps of Engineers, Bonneville Power Administration, Bureau of Reclamation, National Marine Fisheries Service.

National Marine Fisheries Service (NMFS). 2000b. White Paper: Predation on Salmonids Relative to the Federal Columbia River Power System. Seattle, WA. 68pp.

National Marine Fisheries Service (NMFS). 2002. Endangered Species Act Status Reviews and Listing Information. <http://www.nwr.noaa.gov/1salmon/salmesa/index.htm>.

National Research Council (NRC). 1995. Upstream: Salmon and Society in the Pacific Northwest. Prepublication Copy. NRC, National Academy of Sciences. Washington, DC.

Natural Resources Conservation Service 2001. State Soil Geographic (STATSGO) Data Base for the Conterminous United States. http://soils.usda.gov/

NatureServe. 2003. NatureServe Explorer: An online encyclopedia of life [web application]. Version 1.8. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer.

Nemeth, D. J., and R. B. Kiefer.1999. Snake River Spring and Summer Chinook Salmon: The Choice for Recovery. Fisheries **24**(10):16–23.

Nero, R.W., R.J. Clark, R.J. Knapton and R.H. Hamre. 1987. Biology and Conservation of Northern Forest Owls: symposium proceedings. GTR-RM-142. Fort Collins, Colorado. United States Department of Agriculture, Rocky Mountain Forest and Range Experiment Station, United States Forest Service.

Northwest Habitat Institute. 2003. Website. <http://www.nwhi.org>. Northwest Habitat Institute, Corvallis, OR.

Northwest Power Planning Council (NPPC). 1986. Compilation of Information on Salmon and Steelhead Losses in the Columbia River Basin. Appendix D *in* 1987 Columbia River Basin Fish and Wildlife Program. Northwest Power Planning Council, Portland, OR.

Northwest Power Planning Council (NPPC). 1989. Salmon and Steelhead System Planning Documentation. Prepared by the Monitoring and Evaluation Group. Northwest Power Planning Council, Portland, OR.

Northwest Power Planning Council (NPPC). 1990. Presence/Absence Database from Northwest Power Planning Council's Subbasin Planning Process. Unpublished. (StreamNet Library).

Northwest Power Planning Council (NPPC). 1992. Columbia Basin Fish and Wildlife Program—Strategy for Salmon. Volumes 1 and 2. NPPC, Portland, OR.

Northwest Power Planning Council (NPPC). 2000. Columbia River Basin Fish and Wildlife Program. A Multi-Species Approach for Decision Making. Council document 2000-19

Northwest Power and Conservation Council (NPCC). 2003. Subbasin and Province Boundary layer downloaded using interactive mapper tool. Available at: www.NWPPC.org

Nowak, R. M. 1991. Walker's Mammals of the World, vol. 2. Fifth edition. The Johns Hopkins University Press, Baltimore and London.

Nowak, C. 2001. Draft Subbasin Summary for the Grande Ronde River. Prepared for Northwest Power Planning Council.

Nussbaum, R.A., E.D. Brodie Jr., and R.M. Storm. 1983. Amphibians and reptiles of the Pacific Northwest. University of Idaho Press. Moscow, Idaho. pp. 183-187.

Oliver, W.W. and R.A. Ryker. 1990. Silvics of North America. Agriculture Handbook 654. [Online].United States Department of Agriculture. Forest Service. Available: www.na.fs.fed.us/spfo/pubs/silvics_manual.

Oregon Department of Fish and Wildlife (ODFW). 1995. Biennial Report on the Status of Wild Fish in Oregon. Viewed at <http://www.dfw.state.or.us/ODFWhtml/Research%26Reports/WildFishRead.html>.

Oregon Department of Fish and Wildlife (ODFW). 2001. Fisheries Management and Evaluation Plan: Snake River Summer Steelhead ESU Summer Steelhead and Trout Sport Fisheries in Grande Ronde Basin, Imnaha Basin, and Snake Rivers.

Oregon Department of Fish and Wildlife (ODFW). 2003a. License database query 2002 by County. Chris Carter personal communication September 2003.

Oregon Department of Fish and Wildlife (ODFW). 2003b. Oregon Department of Fish and Wildlife Sensitive Species. <http://www.dfw.state.or.us/ODFWhtml/InfoCntrWild/Diversity/senspecies.pdf>. Accessed September 2003.

Oregon Department of Fish and Wildlife (ODFW). 2003c. Endangered Species Fact Sheet—Canada Lynx. <http://oregonfwo.fws.gov/EndSpp/FactSheets/Mammals/Lynx.dwt>. Accessed August 2003.

Oregon Department of Fish and Wildlife (ODFW). 2003d. Oregon's Bighorn Sheep & Rocky Mountain Goat Management Plan. June 10, 2003 Draft

Oregon Department of Fish and Wildlife (ODFW) and Washington Department of Fish and Wildlife (WDFW). 1998. Status Report Columbia River Fish Runs and Fisheries, 1938-1997. 299 pp.

Orman, M. 2002. Review by BLM Archaeologist of “Native American Oral History Study—Hells Canyon, Oxbow, And Brownlee Area”. Prepared by Brigette Whipple for Idaho Power Company, Technical Report Appendix E.4-13. Ch. 2. November.

Ormiston, J. H. 1966. The food habits, habitat and movements of mountain quail in Idaho. M.S thesis, University of Idaho, Moscow, ID, USA. 39pp.

Orr, E. L., and W. N. Orr. 1996. Geology of the Northwest. McGraw Hill Publishing Company. 409 pp.

Pacific States Marine Fisheries Commission (PSMFC). 2004. StreamNet On-Line: The Northwest Aquatic Information Network. http://www.streamnet.org.

Palouse EDC. 2003. Asotin County. <http://www.palouse.org/asotin.htm>

Parker, T. 1985. Bighorn sheep management plan 1986–1990. Idaho Department of Fish and Game, Boise.

Partners in Flight—U.S. (PIF). 2003. Partners In Flight- Physiographic Areas Plans Available at: <http://www.blm.gov/wildlife/pifplans.htm> Accessed October 2003

Patla, D.A. and C.R. Peterson. 1996. The effects of habitat modification on a spotted frog population in Yellowstone National Park in A summary of the conference on declining and sensitive amphibians in the Rocky Mountains and Pacific Northwest. Idaho Herpetological Society and U. S. Fish and Wildlife Service, Snake River Basin Office Report, Boise, Idaho. 96 pp.

Paul, K. 2004. Wildlife species summaries prepared for the Northwest Power and Conservation Council. Available at http://www.nwppc.org/

Pearson, O.P., M.R. Koford and A.K. Pearson. 1952. Reproduction of the lump-nosed bat (Corynorhinus rafinesquii) in California. J. Mamm. 33:273-320.

Petersen, J. H. 1994. The Importance of Spatial Pattern in Estimating Predation on Juvenile Salmonids in the Columbia River. Transactions of the American Fisheries Society **123**:924–930.

Petrosky, C. E., H. A. Schaller, and P. Budy. 2001. Productivity and Survival Rate Trends in the Freshwater Spawning and Rearing Stage of Snake River Chinook Salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fisheries and Aquatic Sciences **58**:1196–1207.

Pilliod, D., C.R, Peterson, and P. Ritson. 1996. Impacts of introduced fish on spotted frog populations in high mountain lakes of central Idaho. A Summary of the Conference on Declining and Sensitive Amphibians in the Rocky Mountains and Pacific Northwest Idaho Herpetological Society and U.S. Fish and Wildlife Service, Snake River Basin Office Report, Boise, Idaho, November 7-8, 1996.

Powers, L. R., A. Dale, P. A. Gaede, C. Rodes, L. Nelson, J. J. Dean, and J. D. May. 1996. Nesting and food habits of the flammulated owl (Otus flammeolus) in southcentral Idaho. Journal of Raptor Research 30:15-20.

Quigley, T. M. and Arbelbide, S. J., Eds. 1997. An Assessment of Ecosystem Components in the Interior Columbia Basin and Portions of the Klamath and Great Basins. U.S. Department of Agriculture, Forest Service, Portland, OR.

Reaser, J.K. 1997. Amphibian declines: Conservation science and adaptive management. Doctoral Dissertation. Stanford University.

Reese, K. P., and A. M. Smasne. 1996. Results of a pilot study: survey of mountain quail in Big Canyon Creek, Idaho. Department of Fish and Wildlife Resources, University of Idaho, Moscow, ID, USA.

Regional Ecosystem Office 2003. Geospatial Center-Forest Service GIS Data available at www.REO.gov

Rocklage, A. M., and F. B. Edelmann. 2001. A landscape-level habitat assessment for mountain quail in Hells Canyon. Technical Report E.3.2-6 *in* License application for the Hells Canyon Complex. Idaho Power Company, Boise, ID, USA.

Rudolph, K.M., D.L. Hunter, W.J. Foreyt, E.F. Cassirer, R.B. Rimler, and A.C.S. Ward. 2003, in press. Sharing of Pasurella spp. Between free-ranging bighorn sheep and feral goats. Journal of Wildlife Diseases.

Rabe, C., D. Saul and A. Davidson. (2001). *Draft Imnaha Subbasin Summary*. Prepared for the Northwest Power Planning Council.

Randolph, J. E., and M. Dahlstrom. 1977. Archaeological Test Excavations at Bernard Creek Rockshelter. University of Idaho Anthropological Research Manuscript Series No. 42. Laboratory of Anthropology, University of Idaho, Moscow. 12 pp.

Reynolds, R. T., and B. D. Linkart. 1987. The Nesting Biology of Flammulated Owls in Colorado. Pages 239-248. In R. W. Nero, R. J. Clark, R. J. Knapton, and R. H. Hamre, eds. Symp. On the Biology and Conservation of Northern Forest Owls. U.S. Dep. Ag., For. Serv., Rocky Mtn For. and Range Exp. Stn., Gen. Tech. Rep. RM-142. 248pp.

Reynolds, R. T., R. A. Ryder, and B. D. Linkart. 1989. Small Forest Owls. Pages 131-143. In National Wildlife Federation. Proc. Western Raptor Management Symposium and Workshop. Natl. Widl. Fed. Tech. Ser. No. 12. 317pp.

Rieman, B. E. and McIntryre, J. D. 1993. *Demographic and Habitat Requirements for Conservation of Bull Trout*. Ogden, UT: U.S. Forest Service, Intermountain Research Station.

Rodrick, E. and R. Milner. 1991. Management recommendations for Washington's priority habitats and species. Wash. Dept. Wildl., Olympia.

Rondorf, W., and W. H. Miller. 1993. Identification of the Spawning, Rearing and Migratory Requirements of Fall Chinook Salmon in the Columbia River Basin. 1991 Annual Report. Prepared for U.S. Department of Energy, Bonneville Power Administration, Portland, OR. 97208-3621.

Rondorf, W., and W. H. Miller. 1994. Identification of the Spawning, Rearing and Migratory Requirements of Fall Chinook Salmon in the Columbia River Basin. 1992 Annual Report. Prepared for U.S. Department of Energy, Bonneville Power Administration, Portland, OR. 97208-3621.

Rondorf, W., and K. F. Tiffan. 1995. Identification of the Spawning, Rearing and Migratory Requirements of Fall Chinook Salmon in the Columbia River Basin. 1993 Annual Report. Prepared for U.S. Department of Energy, Bonneville Power Administration, Portland, OR. 97208-3621.

Rondorf, W., and K. F. Tiffan. 1996. Identification of the Spawning, Rearing, and Migratory Requirements of Fall Chinook Salmon in the Columbia River Basin. 1994 Annual Report. Prepared for U.S. Department of Energy, Bonneville Power Administration, Portland, OR. 97208-3621.

Rondorf, W., and K. F. Tiffan. 1997. Identification of the Spawning, Rearing, and Migratory Requirements of Fall Chinook Salmon in the Columbia River Basin. Prepared for Bonneville Power Administration by U.S. Geological Survey. Project Number 9 l-029.

Rowe, M., D. Essig and B. Jessup. 2003. Guide to Selection of Sediment Targets for Use in Idaho TMDLs. Idaho Department of Environmental Quality.

Rust, H. J. 1946. Mammals of Northern Idaho. Journal of Mammalogy **27**:308–327.

Saab, V. A. and J. G. Dudley. 1998. Responses of cavity-nesting birds to stand-replacement fore and salvage logging in ponderosa pine/Douglas-fir forests of southwestern Idaho. USDA Forest Service Rocky Mountains Research Station Research Paper RMRS-RP-11, Ogden, ID.

Saul, D., A. Davidson, and C. Rabe. 2001. Snake Hells Canyon Subbasin Summary. Prepared for Northwest Power Planning Council.

Sauer, J. R., J. E. Hines, and J. Fallon. 2003. The North American Breeding Bird Survey, Results and Analysis 1966–2002. Version 2003.1, USGS Patuxent Wildlife Research Center, Laurel, MD

Schaller, H. A., C. E. Petrosky, and O. P. Langness. 1999. Contrasting Patterns of Productivity and Survival Rates for Stream-Type Chinook Salmon (*Oncorhynchus tshawytscha*) Populations of the Snake and Columbia Rivers. Canadian Journal of Fisheries and Aquatic Sciences **56**:1031–1045.

Schommer, T. and M. Woolever. 2001. A process for finding management solutions to the incompatibility between domestic and bighorn sheep. USDA Forest Service. Washington, D.C.

Servheen, C. W. 1975. Ecology of the wintering bald eagles on the Skagit River, Washington. M.S. Thesis. University of Washington, Seattle. 96 pp.

Setter, A and E. Brannon. 1992. A Summary Of Stock Identification Research On White Sturgeon Of The Columbia River (1985-1990) Final Report January 1985–July 1991. Report to Bonneville Power Administration, Project No. 198904400. BPA Report DOE/BP-97298-1. 105pp.

Shackleton, D. M. 1985. *Ovis canadensis*. Mammalian Species b:1-9.

Shackleton, D.M., C.C. Shank, and B.M. Wikeem. 1999. Natural History of Rocky Mountain and California Bighorn Sheep pp. 78-138 *in* Valdez, R. and P. Krausman, eds. Mountain Sheep of North America. University of Arizona Press. 353pp.

Shank, C. C. 1982. Age-sex differences in the diets of wintering Rocky Mountain bighorn sheep. Ecology, 63:627-633

Simpson, J. C. and Wallace, R. L. 1982. Fishes of Idaho. Moscow: University of Idaho Press.

Shively, R. S., T. P. Poe, M. B. Sheer, and R. Peters. 1996. Criteria for Reducing Predation by Northern Squawfish near Juvenile Salmonid Bypass Outfalls at Columbia River Dams. Regulated Rivers: Research and Management **12**:493–500.

Slough, B. G. 1989. Movements and habitat use by transplanted marten in the Yukon Territory. J. Wildl. Manage. 53:991-997.

Smith, R. L. 1963. Some ecological notes on the Grasshopper Sparrow. Wilson Bulletin 75:159-165.

Smith, R.L. 1968. Grasshopper sparrow. Pp. 725-745 in Life Histories Of North American Cardinals, Grosbeaks, Buntings, Towhees, Sparrows, And Allies, Comp. A.C. Bent et al., Ed. O.L. Austin, Jr. U.S. Natl. Mus. Bull. No. 237, Pt. 2. Washington, D.C.

Smith, J. K. and W.C. Fischer. 1997. Fire Ecology of the Forest Habitat Types of Northern Idaho. United States Department of Agriculture, Intermountain Research Station, United States Forest Service.

Southwick Associates Inc. 2002. "The Economic Importance of Hunting in America." International Association of Fish and Wildlife Agencies.

Spahr, R., L. Armstrong, D. Atwood, and M. Rath. 1991. Threatened, endangered, and sensitive species of the Intermountain Region. U.S. Department of Agriculture, Forest Service, Fisheries and Wildlife. Management, Intermountain Region, Ogden, UT.

Stalmaster, M. V. 1976. Winter ecology and effects of human activity on bald eagles in the Nooksack River Valley, Washington. M.S. Thesis. West Washington State College, Bellingham, WA. 100 pp.

Stalmaster, M. V. 1987. The Bald Eagle. Universe Books, New York.

Stalmaster, M. V. and J. R. Newman. 1978. Behavioral responses of wintering bald eagles to human activity. Journal of Wildlife Management 43:506-513

Stebbins, R.C. 1985. A field guide to western reptiles and amphibians. Houghton Mifflin Co., Boston. 336pp.

Stoval, S.H., and twenty five others. (2001). *Draft Asotin Creek Subbasin Summary*. Prepared for the Northwest Power Planning Council.

StreamNet. 2003. StreamNet On-Line: The Northwest Aquatic Information Network. http://www.streamnet.org.

Strickland, M. A., C. W. Douglas, M. Novak, and N. P. Hunzinger. 1982. Marten. Pages 599-612 in Chapman, J. A., and G. A. Feldhamer, eds. Wild mammals of North America: Biology,management, and economics. Johns Hopkins University Press. Baltimore, MD.

Tabor, R. A., R. S. Shively, and T. P. Poe. 1993. Predation on Juvenile Salmonids by Smallmouth Bass and Northern Squawfish in the Columbia River near Richland, Washington. North American Journal of Fisheries Management **13**:831–838.

Taylor, D. L. and W. J. Barmore, Jr. 1980. Post-fire succession of avifauna in coniferous forests of Yellowstone and Grand Teton National Parks, Wyoming. Pp. 130-145 in R.M. DeGraaf and N.G. Tilghman, editors. Workshop proceedings: management of western forests and grasslands for nongame birds. USDA Forest Service Intermountain Research Station General Technical Report INT-GTR-86.

Terres, J. K. 1980. The Audubon Society encyclopedia of North American birds. Alfred A. Knopf, New York.

The Nature Conservancy (TNC) 2004. Garden Creek Ranch, Hells Canyon http://nature.org/wherewework/northamerica/states/idaho/preserves/art375.html

Thomas, C. A., H. C. Broom, and J. E. Cummans. 1963. Magnitude and Frequency of Floods in the United States: Part 13. Snake River Basin. U.S. Geological Survey, Washington, DC.

Tiffan, K. F., D. W. Rondorf, W. P. Connor, H. L. Burge. 1999. Post-release attributes and survival of hatchery and natural fall chinook salmon in the Snake River. Annual Report 1998. Prepared for Bonneville Power Adminstration, Portland, OR. <http://www.efw.bpa.gov/cgi-bin/efw/FW/publications.cgi>. Downloaded May 2001.

Tisdale, E. W. 1986. Canyon Grasslands and Associated Shrublands of West-Central Idaho and Adjacent Areas. Bulletin No. 40. Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow. 42 pp.

Todd, J. W. 1972. A literature review of bighorn sheep food habits. Colorado Department Game, Fish and Parks Coop. Wildlife Research Unit, Special report No. 27.

TREC, Inc. 2003. A Survey for Yellow-Billed Cuckoo in Recorded Historic and Other Likely Locations in Idaho. 2003 Summary Report. TREC, Inc., Rigby, ID. 18pp.

Tuell, M. A., and S. R. Everett. 2000. Evaluation of Potential Means of Rebuilding Sturgeon Populations in the Snake River between Lower Granite and Hells Canyon Dams. 1998 Annual Report. Prepared for Bonneville Power Administration, Portland, OR. Contract Number 97-AM-30423, Project 9700900.

Tuell, M. A., and S. R. Everett. 2001. Draft Evaluation of Potential Means of Rebuilding Sturgeon Populations in the Snake River between Lower Granite and Hells Canyon Dams. 1999 Annual Report. Prepared for Bonneville Power Administration, Portland, OR. Contract Number 97-AM-30423, Project 9700900.

Turley, N. J. S., and F. Edelmann. 2001. Spring distribution and relative abundance of upland game birds in Hells Canyon. Technical Report E.3.2-3 *in* License application for the Hells Canyon Complex. Idaho Power Company, Boise, ID, USA.

Turley, N. J., and A. M.Holthuijzen. 2002. A Description of State and Federal Species of SpecialConcern in Hells Canyon Idaho Power Company Technical Report Appendix E.3.2-38

Turner, F.B. 1958. Life history of the western spotted frog in Yellowstone National Park. Herptelogica 14:96-100.

U.S. Army Corps of Engineers. 2001. Lower Snake River Compensation Plan. <http://www.nww.usace.army.mil/html/pub/pi/navigation/lsrfwcp.htm>. Accessed May 12, 2001. Middle Snake District.

US Census Bureau. 2000a. Population estimates.<http://eire.census.gov/popest/estimates.php>

U.S. Census Bureau. 2000b. State and County Quickfacts.<http://quickfacts.census.gov/qfd/>

US Census Bureau. 2002. 2002 publications. <http://www.census.gov/prod/2002pubs/01statab/labor.pdf>

U.S. Fish and Wildlife Service (USFWS). 1979. Final Rule to List *Mirabilis macfarlanei* as Endangered. Federal Register **44**(209):61912–61913.

U.S. Fish and Wildlife Service (USFWS). 1982. Recovery plan for peregrine falcon (Pacific population). Prepared by the Pacific Coast American Peregrine Falcon Recovery Team.

U.S. Fish and Wildlife Service (USFWS). 1985. Recovery Plan for the MacFarlane's Four-o-Clock, *Mirabilis macfarlanei*. U.S. Fish and Wildlife Service, Portland Oregon. 47pp.

U. S. Fish and Wildlife Service (USFWS). 1986. Recovery Plan for the Pacific Bald Eagle. USFWS, Portland, Oregon.

U.S. Fish and Wildlife Service (USFWS). 1996. Final Rule to Reclassify *Mirabilis macfarlanei* from Endangered to Threatened Status. Federal Register **61**(52):10693–10697.

U.S. Fish and Wildlife Service (USFWS). 1999a. Endangered and Threatened Wildlife and Plants; Proposed Rule To Remove the Bald Eagle in the Lower 48 States from the list of Endangered and Threatened wildlife; Proposed Rule. Federal Register **64** (128):36454-36464

U.S. Fish and Wildlife Service (USFWS). 1999b. Endangered and Threatened Wildlife and Plants: Proposed Threatened Status for the Plant *Silene spaldingii* (Spalding's Catchfly). Federal Register **64**(232):67814–67821.

U.S. Fish and Wildlife Service (USFWS). 2000a. Revised Recovery Plan for Macfarlane's Four-O'clock (*Mirabilis macfarlanei*). U.S. Fish and Wildlife Service, Portland, Oregon. 46 pp.

U.S. Fish and Wildlife Service (USFWS). 2000b. Draft Recovery Plan for the Bull Trout and Proposed Critical Habitat.

U.S. Fish and Wildlife Service (USFWS). 2001. Endangered and Threatened Wildlife and Plants: Final Rule to List *Silene spaldingii* (Spalding's Catchfly) As Threatened. Federal Register **66**(196):51598–51606.

U.S. Fish and Wildlife Service (USFWS). 2002a. Bull Trout. <http://pacific.fws.gov/bulltrout/>

U.S. Fish and Wildlife Service (USFWS). 2002b. Section 7 Guidelines: Columbia Spotted Frog—Great Basin Population. United States Department of the Interior, Snake River Basin Office, Boise, Idaho.

U.S. Fish and Wildlife Service (USFWS). 2002c. Candidate and Listing Priority Assignment Form: Columbia Spotted Frog. United States Department of the Interior, Nevada Fish and Wildlife Office, Reno, Nevada.

U.S. Fish and Wildlife Service (USFWS). 2003a. Hells Canyon National Recreation Area Comprehensive Management Plan Multi-Species Biological Assessment, Snake River, Wallowa County, Oregon—Biological Opinion (1-17-03-F-0435).

U.S. Fish and Wildlife Service (USFWS) 2003b. Endangered and Threatened Wildlife and Plants: 90-day Finding for a Petition To List the Mountain Quail as Threatened or Endangered. Federal Register **68** (14):3000-3005

U. S. Fish and Wildlife Service (USFWS). 2003c. Oregon Fish and Wildlife Office website, Bald Eagle fact sheet: http://oregonfwo.fws.gov/EndSpp/FactSheets/Birds/BaldEagle.dwt.

U.S. Fish and Wildlife Service (USFWS) and U.S. Department of Commerce U.S. Census Bureau. 1993. 1991 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. < http://www.census.gov/prod/1/gen/interior/hunt.pdf>.

U.S. Fish and Wildlife Service (USFWS), Nez Perce Tribe, National Park Service, and USDA Wildlife Services. 2003. Rocky Mountain Wolf Recovery 2002 Annual Report. T. Meier, editor. USFWS, Ecological Services, Helena MT. 64pp.

U.S. Forest Service (USFS). 1978. Fire Regimes and Ecosystem Properties: Proceedings of the Conference. GTR WO-26. U.S. Department of Agriculture

U.S. Forest Service (USFS). 1981a. Appendix for Final Environmental Impact Statement: Hells Canyon National Recreation Area. U.S. Department of Agriculture.

U.S. Forest Service (USFS). 1981b. Final Environmental Impact Statement and Comprehensive Management Plan: Hells Canyon National Recreation Area. U.S. Department of Agriculture

U.S. Forest Service (USFS). 1995. *Big Sheep Creek Watershed Analysis* U.S. Department of Agriculture, USFS, Wallowa-Whitman National Forest.

U.S. Forest Service (USFS). 1996. Hells Canyon National Recreation Area Comprehensive Management Plan: Draft Environmental Impact Statement. U.S. Department of Agriculture

U.S. Forest Service (USFS). 1998. South Fork Clearwater River Landscape Assessment Vol. I U.S. Department of Agriculture, Nez Perce National Forest

U.S. Forest Service (USFS). 1999. Hells Canyon National Recreation Area Comprehensive Management Plan: Revised Draft Environmental Impact Statement. U.S. Department of Agriculture, USFS, Wallowa-Whitman National Forest.

U.S. Forest Service (USFS). 2000. Roadless Area Conservation-GIS Data http://roadless.fs.fed.us/documents/feis/data/gdata.shtml Accessed June 2003

U.S. Forest Service (USFS). 2001. Hells Canyon NRA. <http://www.fs.fed.us/r6/w-w/hcnra.htm#snake>. Accessed May 12, 2001. U.S. Department of Agriculture, USFS, Wallowa-Whitman National Forest.

U.S. Forest Service (USFS). 2003a. Hells Canyon National Recreation Area Comprehensive Management Plan Final Environmental Impact Statement, Volume 1. U.S. Department of Agriculture, USFS, Pacific Northwest Region.

U.S. Forest Service (USFS). 2003b. Hells Canyon National Recreation Area Comprehensive Management Plan, Biological Assessment. U.S. Department of Agriculture, USFS, Pacific Northwest Region.

U.S. Forest Service (USFS). 2003c. Hells Canyon National Recreation Area Comprehensive Management Plan, Biological Evaluation. U.S. Department of Agriculture, USFS, Pacific Northwest Region.

U.S. Geologic Survey (USGS). 2001. <http://waterdata.usgs.gov/nwis-w/OR/data.components>. Accessed May 15, 2001.

U.S. Geologic Survey. (USGS) 2003. Midwinter Bald Eagle Count Database http://ocid.nacse.org/qml/nbii/eagles/ on December 5, 2003.

Valdez, R., and P. R. Krausman. 1999. Description, distribution, and abundance of mountain sheep in North America. Pages 3-22. In. (R. Valdez and P. R. Krausman, eds.) Mountain sheep of North America. University of Arizona Press, Tucson.

Vallier, T. L. 1994. Geologic Hazards in Hells Canyon, Eastern Oregon and Western Idaho. U.S. Geological Survey Open-File Report 94-213. Denver, CO.

Vallier, T. L. 1998. Islands and Rapids: A Geologic Story of Hells Canyon. Confluence Press.

Vallier, T. L., and H. C. Brooks, editors. 1986. Geology of the Blue Mountains Region of Oregon, Idaho, and Washington: Geologic Implications of Paleozoic and Mesozoic Paleontology and Biostratigraphy, Blue Mountains Province, Oregon and Idaho. U.S. Geological Survey Professional Paper 1435. Denver, CO.

Vander Haegen, W. M., F. C. Dobler, and D. J. Pierce. 2000. Shrubsteppe bird response to habitat and landscape variables in eastern Washington, USA. Conservation Biology 14:1145-1160.

Van Dyke, W. A. 1978. Population characteristics and habitat utilization of bighorn sheep, Steens Mountain, Oregon. M.S. thesis, Oregon State University, Corvallis.

Verts, B.J. and L.N. Carraway. 1998. Land Mammals of Oregon. University of California Press.

Vickery, P. D. 1996. Grasshopper Sparrow (Ammodramus savannarum). In The Birds of North America, No. 239 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C.

Vickery, P. D., M. L. Hunter, Jr., and J.V. Wells. 1992. Use of a new reproductive index to evaluate relationship between habitat quality and breeding success. Auk **109**:697-705.

Vickery, P. D., M. L. Hunter, Jr., and S. M. Melvin. 1994. Effect of habitat area on the distribution of grassland birds in Maine. Cons. Biol. **8**:1087-1097.

Wallowa County Chamber of Commerce. 2003. Economy. <http://www.wallowacountychamber.com/economy.pdf>

Walters, J., J. Hansen, J. Lockhart, C. Reighn, R. Keith, and J. Olson. 2001. Idaho Supplementation Studies Five Year Report 1992–1996. Project Report. Idaho Department of Fish and Game Report 99-14. Prepared for Bonneville Power Administration, Portland, OR. Contract DE-BI19-89BP01466.

Waples, R. S., R. P. Jones, Jr., B. R. Beckman, and G. A. Swan. 1991a. Status Review for Snake River Fall Chinook. NOAA Technical Memorandum NMFS F/NWC-201. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Washington, DC. 73 pp.

Waples, R. S., R. P. Jones, Jr., B. R. Beckman, and G. A. Swan. 1991b. Status Review for Snake River Sockeye Salmon. NOAA Technical Memorandum NMFS F/NWC-195. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Washington, DC.

Washington Department of Fish and Wildlife. 1995. Washington state management plan for Rocky Mountain bighorn sheep and California bighorn sheep. Wildlife Management Program. Olympia, WA.

Washington Department of Fish and Wildlife (WDFW). 1999a. 1999 Game Status and Trend Report. WDFW, Olympia.

Washington Department of Fish and Wildlife (WDFW). 1999b. Priority Habitats and Species. <http://www.wa.gov/wdfw/hab/phspage.htm>.

Washington Department of Fish and Wildlife (WDFW). 1999c. Washington Gap Analysis Project 1999, Vertebrate Distribution Models. <http://www.wa.gov/wdfw/wlm/gap/vdm.htm>.

Washington Department of Fish and Wildlife (WDFW). 2001. Chief Joseph Wildlife Area. <http://www.wa.gov/wdfw/lands/r1cjoe.htm>.

Washington Department of Fish and Wildlife (WDFW). 2001b. 2001 Game status and trend report. Wildlife Program. Washington Department of Fish and Wildlife. Olympia Washington USA

Washington Department of Fish and Wildlife (WDFW). 2003a. Database query of resident Hunting and fishing licenses in 2002 for Asotin County. Information request from licensing section. Carol Turcott personal correspondence November 6.

Washington Department of Fish and Wildlife (WDFW). 2003b. Species of Concern in Washington State. <http://www.wa.gov/wdfw/wlm/diversty/soc/soc.htm>. Accessed September 2003.

Washington Department of Fish and Wildlife (WDFW). 2003c Game Management Plan. Washington Department of Fish and Wildlife, Olympia, WA.

Washington Department of Fish and Wildlife (WDFW), Confederated Tribes of the Umatilla Indian Reservation, Idaho Department of Fish and Game, Nez Perce Tribe, Oregon Department of Fish and Wildlife, and Shoshone-Bannock Tribes of Fort Hall. 1990. Snake River Subbasin (Mainstem from Mouth to Hells Canyon Dam) Salmon and Steelhead Production Plan.

Washington State Department of Transportation (WSDOT). 2000. Annual Traffic Report 1999.

Washington State University (WSU) 2003. Northwest Income Indicators Project. <http://niip.wsu.edu/oregon/emporpdf/tbe41063.pdf>.

Watson, J. W., M. G. Garrett, and R. G. Anthony. 1991. Foraging ecology of Bald Eagles in the Columbia River estuary. Journal of Wildlife Management 55: 492-499.

Watson, J. W., and D. J. Pierce. 2000. Migration and Winter Ranges of Ferruginous Hawks from Washington. Annual Report. Washington Department of Fish and Wildlife, Olympia.

Whitaker, J.O., S.P. Cross, J.M. Skovlin, and C. Maser. 1982. Food habits of the spotted frog (*Rana pretiosa*) from managed sites in Grant County, Oregon. Northwest Science 57(2): 147-154.

Whitehead, P. E., and E. H. McEwen. 1980. Progesterone levels in peripheral plasma of Rocky Mountain bighorn ewes (*Ovis Canadensis*) during the oestrous cycle and pregnancy. Canadian Journal of Zoology **58**:1105-1108.

Wiens, J. A. 1969. An approach to the study of ecological relationships among grassland birds. Ornithological Monographs **8**:1-93.

Williams, R.N and eleven coauthors. 1998. Response to the Questions of the Implementation Team Regarding Juvenile Salmon Transportation in the 1998 Season. ISAB Report 98-2. February 27, 1998. Independent Scientific Advisory Board, Northwest Power Planning Council, and National Marine Fisheries Service, Portland, OR.

Williams, C. and T. J. Schommer. 2001. Oregon bighorn sheep distribution. Wallowa-Whitman National Forest GIS Department. USDA Forest Service. Baker City, OR.

Wisdom, M. J., R. S. Holthausen, D. C. Lee, B. C. Wales, W. J. Murphy, M. R. Eames, C. D. Hargis, V. A. Saab, T. D. Rich, F. B. Samson, D. A. Newhouse, and N. Warren. 2000. Source Habitats for Terrestrial Vertebrates of Focus in the Interior Columbia Basin: Broad Scale Trends and Management Implications. U.S. Department Agriculture, Forest Service, Pacific Northwest Research Station General Technical Report PNW-GTR-485 Portland, OR.

Wray, T., II, K. A. Strait, and R. C. Whitmore. 1982. Reproductive success of grassland birds on a reclaimed surface mine in West Virginia. Auk **99**:157-164.

Wright, H.A. 1978. The Effect of Fire on Vegetation in Ponderosa Pine Forests. Department Of Range and Wildlife Management, Texas Tech University. Intermountain Forest and Range Experiment Station.

Wright, H.A., L.F. Neuenschwander, and C.M. Britton. 1979 The role and use of fire in sagebrush-grass and pinyon-juniper plant communities. USDA Forest Serv. Intermtn. Forest and Range Exp. Sta. Tech. Rep. INT-58., Ogden, Utah. 48 pp.

Wright, H.A. and A.W. Bailey. 1982. Fire Ecology: United States and Southern Canada. John Wiley and Sons Inc., New York.

Yasuda, S. 2001. California Partners in Flight: Coniferous Bird Conservation for the Flammulated Owl. USDA Forest Service, Eldorado National Forest, Placerville Ranger District, Camino, CA.

Yunick, R.P. 1985. A review of recent irruptions of the Black-backed Woodpecker and Three-toed Woodpecker in eastern North America. Journal of Field Ornithology **56**(2):138-152.

Zeiner, D. C., W. Laudenslayer Jr., K. Mayer, and M. White., eds. 1990. California's Wildlife, Vol. 2, Birds. Calif. Dep. Fish and Game, Sacramento. 732pp.

Zimmerman, M. P. 1997. Comparative food habits and piscivory of smallmouth bass, walleyes, and northern squawfish in the lower Columbia River Basin. *In:* D. L. Ward (ed.), Evaluation of the Northern Squawfish Management Program, Final Report of Research, 1990-96. Bonneville Power Administration, Portland, Oregon.

Zimmerman, M. P., and D. L. Ward. 1997. Index of Predation on Juvenile Salmonids by Northern Squawfish in the Lower Columbia River Basin from 1994–1996. *In* D. L. Ward, editor. Evaluation of the Northern Squawfish Management Program. Final Report of Research, 1990–1996. Bonneville Power Administration, Portland, OR.