3 Biological Resources Limiting Factors

Abundance, productivity, and diversity of organisms are integrally linked to the characteristics of their ecosystem. We assume a naturally functioning ecosystem provides the basis for sustainable populations of organisms native to that system. Ecosystems, their habitats, and fish and wildlife populations are expected to fluctuate and are more dynamic than stable. These variations demonstrate and rely on the resilience of ecosystems and their components. Resilience is generally greater in systems retaining all or the majority of their components.

Human activities may affect ecosystems in ways similar to natural occurrences, but human impacts tend to be chronic, directional, and long term rather than episodic. Therefore, human effects on ecosystem function tend to alter the system beyond the range of natural variation to which native organisms are adapted, resulting in decreases or limits in habitats, components, or processes that maintain native species.

The Interior Columbia Basin Ecosystem Management Project (ICBEMP) assessment concluded that development of the Interior Columbia River Basin over the last 150 years has greatly altered ecological processes to the detriment of many native fish and wildlife species (ICBEMP 1997). Information collected for the ICBEMP assessment was considered in the preparation of the terrestrial portion of this assessment. ICBEMP data presented here were intended for use at the broad scale, generally at a watershed level or larger scale. Watershed anthropogenic effects contributing to these detrimental changes include unrestricted or little-restricted livestock grazing, road construction, timber harvest and fire management, intensive agricultural practices, placer and dredge mining, dam construction, and stream channelization. The ICBEMP assessment broadly concluded that anthropogenic disturbances such as these cause risks to ecological integrity by reducing biodiversity and threatening riparian-associated species across broad geographic areas.

We suggest that reduction of habitat quality and quantity and habitat fragmentation are impacting focal fish and wildlife species in the Upper Snake province. The causes and effects of the reductions in habitat quantity and quality are presented in Figure 3-1. In section 3.1, we discuss watershed-specific impacts to aquatic habitats in terms of the degree to which altered ecosystem components impact habitat quality or quantity for focal fish species in the subbasins. The technical teams relied on existing information and professional judgment to make these assessments. Watershed level assessments of terrestrial focal habitats are presented largely in terms of how habitat quality and quantity has been affected by identified causes.

Figure 3-1. Expression of limiting factors and their causes for each focal habitat type in the Upper Snake province. This table is representative rather than comprehensive. The classification of exogenous material in this assessment generally refers to nonnatural physical barriers to migration or sediment, chemical impacts, and introduction of nonnative plants or animals (aquatic habitat information modified from Gregory and Bisson [1997]).

Focal Habitat	Limiting Factor	Cause of Limiting Factor	Expression of Limiting Factor
Aquatic			
	Habitat quality		
		Alteration of channel structure	
			Loss of floodplain access alters hydrology by preventing energy dissipation of high flows, reduces organic matter input from riparian interaction Change in pool to riffle ratio reduces rearing/overwinter habitat Loss or reduction in large woody debris reduces cover for fish, alters sediment storage and pool formation, reduces production of macroinvertebrates, changes salmon carcass transport rates Changed substrate reduces salmonid egg survival and causes loss of interstitial space for rearing, reduces macroinvertebrate production Changes in interaction with groundwater/hyporheic zone reduces nutrient exchange, reduces potential for recolonizing disturbed substrates
		Alteration of hydrology	
			Changes timing of discharge-related lifecycle, changes food availability, alters sediment and organic matter transport, may reduce biodiversity, leads to juvenile crowding, reduces primary/secondary productivity, increases predation, changes sediment transport by reducing stream power, may result in stranding, increases water temperature
		Increased sedimentation	
			Reduces salmonid egg survival, affects macroinvertebrate production, reduces rearing area, reduces pool volumes
		Change in water temperature	
			Alters migration patterns, changes emergence timing, may result in behavioral avoidance, increases susceptibility to disease/parasites, changes mortality in macroinvertebrate community
		Altered riparian areas	

Focal Habitat	Limiting Factor	Cause of Limiting Factor	Expression of Limiting Factor
			Reduce cover, reduce large woody debris recruitment thereby changing channel structure, reduce production of macroinvertebrates, reduce access to terrestrial invertebrates for food, reduce growth, decrease shading, increase water temperature (see ecosystem effects to riparian/herbaceous wetlands below)
		Exogenous materials	
			Chemical pollution reduces invertebrate production, can kill fish Exotics increase competition, displacement, introgression of population, predation, disease risk; alter nutrient cycles
Aquatic			
	Habitat quantity		
		Exogenous materials	
			Barriers reduce access to suitable habitat either completely or seasonally, affect behavior by preventing migration and colonization, lead to loss of thermal refuge, result in population fragmentation for resident fish species Chemical pollution makes habitat uninhabitable
Riparian/herbaceous wetlands			
	Habitat quality		
		Altered fire regime	
			Reduces food, cover, shading, and sediment filtering
		Grazing/browsing	
			Changes soil condition, results in introduction of nonnative vegetation and loss of native vegetation, reduces species diversity and vegetative density, increases water temperature, results in excessive sedimentation due to bank and upland instability, results in high coliform bacterium counts, alters channels, reduces water table, alters aquatic nutrient cycling
		Altered hydrology	
			Increases water temperature, degrades water quality, alters sediment movement, results in streambank erosion and blockage of material and organisms, reduces habitat complexity, results in stream channelization, results in wetland drainage or filling, leads to inundation, reduces amount of mature riparian vegetation, reduces number of beavers, increases overland flow, reduces filtration capability, increases effects due to pollution

Focal Habitat	Limiting Factor	Cause of Limiting Factor	Expression of Limiting Factor
		Timber harvest	
			Results in bed scour and streambank erosion; alters sediment movement and aggregation; destabilizes streambanks; reduces instream woody debris; alters snow depth and timing and rate of runoff; leads to wetter soils, resulting in later summer runoff; accelerates runoff on roads, trails, and landings; degrades water quality
		Land use/conversion/development	
			Seasonal recreation and tourism increase disturbance from road and trail networks
		Exotic invasive species	
			Reduce biodiversity, productivity and foragability, while physically fragmenting habitats
Riparian/herbaceous wetlands			
	Habitat quantity		
		Altered hydrology	
			Reduces amount of habitat due to channel alteration and lowered water table
		Land use/conversion/development	
			Results in conversion of habitat to agriculture or “urban” areas
Riparian/herbaceous wetlands			
	Fragmentation/ connectivity		
		Altered hydrology	
			Reduces amount of habitat due to channel alteration and lowered water table
		Land use/conversion/development	
			Results in loss of linkage and corridor habitats, increases patch and edge habitats, creates linear barriers related to road/trail development
Shrub-steppe			
	Habitat quality		

Focal Habitat	Limiting Factor	Cause of Limiting Factor	Expression of Limiting Factor
		Altered fire regime	
			Results in vegetative uniformity and loss of perennial herbaceous understory, increases susceptibility to noxious weed spread, leads to unmanageable fuel loading, results in conversion to annual grassland habitat
		Grazing/browsing	
			Alters vegetative community, ecosystem structure and function, and species composition; leads to trampling of vegetation and soil; alters fire regime; decreases soil organic matter aggregates, decreases infiltration capacity; increases overland flow; results in localized habitat fragmentation due to "trailing"
		Altered hydrology	
			Decreases infiltration capacity, increases overland flow, increases potential for nonpoint source pollution
		Land use/conversion/development	
			Results in habitat fragmentation from conversion and road networks, increases disturbance from road and trail networks, negative impacts to winter range
		Exotic invasive species	
			Displace native species, alter predator–prey relationships, decrease ecosystem resiliency, reduce biodiversity, reduce soil productivity, reduce aesthetic quality, reduce forage
Shrub-steppe			
	Habitat quantity		
		Altered fire regime	
			Results in habitat loss due to stand-converting fire
		Land use/conversion/development	
			Results in conversion of habitat to dryland or irrigated agriculture or to development, leads to exclusion due to increased human–wildlife conflict at the wildland interface

Focal Habitat	Limiting Factor	Cause of Limiting Factor	Expression of Limiting Factor
Shrub-steppe			
	Fragmentation/ connectivity		
		Altered fire regime	
			Fragments habitat due to stand-converting fire
		Land use/conversion/development	
			Results in loss of linkage and corridor habitats, increases patch and edge habitats, creates linear barriers related to road/trail development
Pine/fir forest			
	Habitat quality		
		Altered fire regime	
			Reduces landscape complexity and habitat diversity, alters nutrient flow and other ecosystem processes, alters successional stages and associated plants and animals, elevates insect and disease risk
		Grazing/browsing	
			Alters fire regime and forest structure, reduces herbaceous understory, alters understory cover and composition, results in introduction of noxious weeds, reduces plant litter, alters nutrient cycling, compacts soils, reduces infiltration, increases soil erosion, results in dietary conflicts between wildlife and domestic ungulates
		Timber harvest	
			Reduces productivity, results in loss of nutrients, compacts soil, increases soil erosion, disrupts microorganism processes, results in fragmentation
		Land use/conversion/development	
			Increases disturbance from road and trail networks
		Exotic invasive species	
			Outcompete native plant species, reduce native plant and animal biodiversity, decrease forage production, increase soil erosion, increase sedimentation
Pine/fir forest			
	Habitat quantity		

Focal Habitat	Limiting Factor	Cause of Limiting Factor	Expression of Limiting Factor
Pine/fir forest	Fragmentation/ connectivity	Timber harvest	Results in loss of habitat such as old growth, alters habitat structural components due to harvest regimes
		Altered fire regime	Fragments habitat due to stand-altering fire
		Land use/conversion/development	Results in loss of linkage and corridor habitats, increases patch and edge habitats, creates linear barriers related to road/trail development
Native grasslands	Habitat quality	Altered fire regime	Results in shrub/conifer encroachment, alters nutrient cycling, leads to vegetative uniformity, increases susceptibility to noxious weed invasion, results in conversion to annual grassland habitat
		Grazing/browsing	Alters vegetative community, ecosystem structure and function, and species composition; leads to trampling of vegetation and soil; alters fire regime; decreases soil organic matter aggregates; decreases infiltration capacity; increases overland flow; results in localized habitat fragmentation due to “trailing”
		Timber harvest	Results in localized erosion, soil compaction, and fragmentation; leads to introduction of noxious weeds
		Land use/conversion/development	Results in habitat fragmentation from conversion and road networks
		Exotic invasive species	

Focal Habitat	Limiting Factor	Cause of Limiting Factor	Expression of Limiting Factor
			Displace native species, alter predator–prey relationships, decrease ecosystem resiliency, reduce biodiversity, reduce soil productivity, reduce aesthetic quality, reduce forage
Native grasslands	Habitat quantity	Altered fire regime	Results in habitat losses due to conversion to shrub/conifer types
		Land use/conversion/development	Results in conversion of habitat to dryland or irrigated agriculture or to development, leads to loss due to road/trail development and disturbance
Native grasslands	Fragmentation/ connectivity	Land use/conversion/development	Results in loss of linkage and corridor habitats, increases patch and edge habitats, creates linear barriers related to road/trail development
Aspen	Habitat quality	Altered fire regime	Reduces post-fire regeneration, reduces fine fuels to carry fire, results in conifer encroachment/change in successional processes
		Grazing/browsing	Reduces aspen habitat due to excessive grazing of regenerative stands
		Altered hydrology	Results in localized habitat degradation due to water table reduction
		Timber harvest	Reduces size and structure of stands
Aspen	Habitat quantity		

Focal Habitat	Limiting Factor	Cause of Limiting Factor	Expression of Limiting Factor
		Altered fire regime	
			Reduces aspen habitat due to successional processes
		Grazing/browsing	
			Reduces aspen habitat due to excessive grazing of regenerative stands
		Altered hydrology	
			Reduce aspen habitat due to dysfunctional hydrology
Juniper/mountain mahogany			
	Habitat quality		
		Altered fire regime	
			Results in conifer encroachment/change in successional processes; leads to landscape dominated by overly mature, decadent stands and high fuel loading, resulting in “hot” fires with slow regenerative ability
		Grazing/browsing	
			Results in high palatability and nutrition, resulting in overbrowsing; increases water runoff and erosion; reduces regeneration
		Exotic invasive species	
			Displace native species, decrease ecosystem resiliency, reduce biodiversity, reduce soil productivity, reduce forage
Juniper/mountain mahogany			
	Habitat quantity		
		Altered fire regime	
			Results in habitat losses due to conifer encroachment
		Grazing/browsing	
			Inhibits regeneration
Whitebark pine			
	Habitat quality		
		Altered fire regime	
			Results in interspecific site competition/successional processes; leads to landscape dominated by overly mature, decadent stands

Focal Habitat	Limiting Factor	Cause of Limiting Factor	Expression of Limiting Factor
		Exotic invasive species	Result in direct mortality due to blister rust
Whitebark pine	Habitat quantity	Altered fire regime	Reduces habitat due to lack of regeneration
		Exotic invasive species	Result in landscape habitat losses due to blister rust

3.1 Limiting Factors by Watershed

Aquatic habitats are created and maintained by natural processes within the watersheds that surround them: watershed size, vegetation, slope, geology, and climate combine to form the aquatic habitat (Doppelt *et al*. 1993). In addition to reflecting the nature of their watersheds, flowing waters shape watersheds over time by cutting channels, terracing floodplains, depositing sediment, and transporting materials from highlands to lowlands (Stanford 1996). Ward (1989) describes the nature of stream networks, indicating that any point along a stream has four dimensions (longitudinal, lateral, vertical, and temporal) that combine to form that particular location. The longitudinal dimension is related to the location of the point in the profile of the stream (from headwaters to mouth). The lateral dimension encompasses the transition of the stream into the terrestrial environment. The movement of water as subsurface or interstitial flow within the river and its floodplain is the vertical link, and the naturally associated changes in the system over time of all the above components is the temporal dimension.

The distribution and abundance of aquatic animals and invertebrates are determined by their distinct preferences and tolerances for specific habitat conditions. As discussed above, the conditions of a stream at any point along the stream are determined by the conditions upstream of that point; therefore, the distribution and abundance of aquatic species must be examined in the context of the stream and associated watershed.

The functional components of aquatic ecosystems are made up of several ecosystem "features" that are interrelated and interdependent. These features can generally be classified into the following categories: channel structure, hydrology, sediment, and water quality. In addition to the natural variation present in the processes that form ecosystems, human actions have altered the ecosystem components. The degree of alteration can range from minor to severe, with varying lengths of effects.

However, it is not always easy to clearly quantify or qualify the effects of the causes of limiting factors on focal habitats or species. Difficulties encountered in the analysis of the limiting factors for each habitat type and by watershed are due, in part, to either information gaps or differences in information-collection methods and/or interpretation or to data limitations (Appendix 2-1). Therefore, this assessment relies on expert opinion as much as information and data.

For example, experts evaluated the impacts of limiting factor causes to terrestrial focal habitats for each watershed in the Upper Snake province (Table 3-1). Results from these deliberations suggest that, in general, altered fire regime has resulted in the greatest impacts across all watersheds within the Province, followed by introduced invasive/exotic species, grazing and browsing by domestic animals, land-use conversion, and timber harvest. More specifically, at the watershed level, the Birch Creak and Big Lost River watersheds are impacted the most through six causes of habitat limiting factors but this assessment is based on watershed level data combined with site-specific knowledge.

Table 3-1. Rankings of the impacts of limiting factor causes for terrestrial resources in each watershed in the Upper Snake province (rankings by the technical team: 0 = none to insignificant, 1 = low, 2 = moderate, and 3 = high).

Watershed	Altered Fire Regime	Grazing/ Browsing	Altered Hydrologic Regime	Timber Harvest	Land-Use Conversion	Invasive/ Exotics
Snake Headwaters subbasin						
Greys–Hoback (GHB)	3	?	1	1	2	?
Gros Ventre (GVT)	3	1	1	1	2	?
Palisades (PAL)	3	2	3	2	3	3
Salt (SAL)	3	2	1	?	3	3
Snake Headwaters (SHW)	3	2	3	2	3	3
Upper Snake subbasin						
American Falls (AMF)	1	3	3	0	2	3
Blackfoot (BFT)	2	3	3	2	3	3
Goose (GSE)	3	3	3	0	3	3
Idaho Falls (IFA)	3	3	3	0	3	3
Lower Henrys Fork (LHF)	3	3	3	0	3	3
Portneuf (PTF)	3	3	3	1	3	3
Raft (RFT)	2	3	3	0	3	3
Teton (TET)	3	2	2	2	3	3
Upper Henrys Fork (UHF)	3	2	3	3	3	2
Upper Snake–Rock (USR)	3	3	2	2	2	3
Lake Walcott (LWT)	1	3	3	0	3	3
Willow (WIL)	3	3	3	2	2	3
Closed Basin subbasin						
Beaver–Camas (BCM)	3	2	2	2	2	3
Birch (BCK)	3	2	2	0	2	2
Big Lost (BLR)	3	2	3	2	2	3
Little Lost (LLR)	3	2	2	1	2	3
Medicine Lodge (MDL)	3	2	2	0	2	3

3.1.1 Snake Headwaters Subbasin

Information for waters in Wyoming is provided by Wyoming Game and Fish Department Staff and Jackson Fish Management. Subbasin Management Plans (WG&F 2004) provided information on the aquatic habitat conditions and limiting factors in this section. For purposes of this discussion, the boundaries established and used by the Wyoming Game and Fish Department have been preserved.

Table 3-2 ranks the impacts of altered ecosystems for fish in the Snake Headwaters subbasin. While some altered components are not detrimental to fish populations at the watershed level, specific problems do inhibit fish populations. Watersheds in good condition are most probably a function of a large amount of protected lands (e.g., U.S. Forest Service Roadless Areas, Yellowstone National Park, Grand Teton National Park) (Figure 1-16) combined with many organizations assisting in maintaining the natural state of the region.

Causes of terrestrial limiting factors by watershed (Table 3-3, Table 3-4, Table 3-5, Table 3-6, and Table 3-7) illustrate negative impacts to aquatic focal habitats at the watershed level. Dominant concerns in the Upper Snake Headwaters basin (Snake Headwaters subbasin) include altered fire regime and land-use conversion. Analysis for altered fire regime in this subbasin was restricted to Idaho, so the watersheds that cross state boundaries are assessed only for the Idaho portion. Where data exist, altered fire regime is characteristically moderate to high, primarily due to over 100 years of intense fire suppression that created a greater potential for large, stand replacement fires. Population density in this subbasin is largely recreational and tourism based, although some agriculture exists.

Table 3-2. Ranked impacts of altered ecosystem features impacting habitat quality and quantity for focal fish species in tributaries to the 5 watersheds of the Snake Headwaters subbasin. Degree of impact on habitat quality or quantity ranked as P (component is functioning properly, needs protection), 1 (least influence), 2 (moderate influence), and 3 (greatest influence, highest priority).

Ecosystem Feature	Altered Component	Palisades	Salt River	Greys–Hoback	Gros Ventre	Snake Headwaters
Channel structure	Floodplain	P	P	P	P	3
	Pool/riffle ratio	P	P	P	P	3
	Large woody debris	P	P	P	P	P
Hydrology	Discharge	3	P	P	P	3
	Low flow/ dewatering	3	3	1	1	3
Sediment	Increased fines	P	P	P	P	P
Water quality	Temperature	P	P	P	P	P
Riparian	Shade	P	3	P	P	P
	Streambank stability	P	3	P	P	P
Exogenous	Reservoir operations	3	P	P	P	3
	Barriers	3	2	1	1	3
	Exotics	3	3	P	P	1

3.1.1.1 Greys–Hoback (GHB)

In the Greys River drainage, sediment loading from timbering/grazing practices, as well as natural soil movements from periodic heavy precipitation, limits aquatic habitat quality (Table 3-2). The area has a high gradient, with ice problems in the winter. The Greys River proper has a poor pool to riffle ratio (< 30% pools). High runoff and low late summer flows result in high stream flow variation. There are limited spawning sites and nursery areas. Tributaries are generally high gradient and have substrate that is too large for spawning to occur. We identified 5 points of water diversion[1] in the watershed.

In the Hoback River drainage, lack of wintering habitat (anchor and frazil ice problems) is the primary limiting factor in the basin. There is also poor pool development (< 30%) and a general lack of spawning areas in the mainstem and tributaries alike. Heavy runoff during the spawning season limits recruitment. Unstable channels in meadow sections without pool development also limit fish populations. In addition, there is a lack of large woody debris and considerable silt/sediment loading with precipitation or avalanche events.

The terrestrial causes of limiting factors in the Greys–Hoback watershed are dominated by human population density and timber harvest, followed by grazing and browsing by domestic animals. Population in the watershed is concentrated near the resort area of Jackson, Wyoming, and strongly influenced by tourism during summer and winter. Of the area grazed by livestock, cattle graze about 55%; sheep, 41% (Appendix 3-1). While 56% of the area is not harvested for timber (Table 3-3), most of the area that is harvested has at least a moderate impact to focal habitats. One effect has been the fragmentation of aspen stands and the replacement of spruce-fir habitats with lodgepole pine, an early seral species (Figure 3-2 and Appendix 3-1). Species composition changes affect both habitat quantity and quality and result from timber harvest activities and altered fire processes. Data were not available to assess the state of fire regime alteration in this watershed.

[1] The points of water diversion (PODs) summed are actually water rights with surface water irrigation PODs associated with them. The total consists of the Snake River Basin Adjudication recommended rights, the claims they are or will be processing, and any other licensed and permitted rights currently recognized. There can be more than one POD associated with a water right and vice versa, so the count is an estimate. Also, because the amount of water that can be diverted at any one time depends on available water and many other factors, no diversion rates or volumes have been given. Models are being developed to estimate diversion rates or volumes, but the findings can only be verified and used in areas where there is a substantial effort at gauging the flow.

Table 3-3. Comparison of the relative percentages of area impacted by the causes of limiting factors in the Greys–Hoback watershed for terrestrial resources (ICBEMP 1997[a]).

Causes of Limiting Factors	Very Low	Low	Medium	High	Very High
Human population density	($x < 1$)	($1 < x > 10$) 17	($10 < x > 60$) 58	($60 < x < 100$) 15	($100 < x > 300$) 10
Habitat fragmentation		78	22	<1%	
Altered fire regime	?	?	?	?	?
Timber harvest (56% no harvest)		7	33	5	
Grazing/browsing (27% no grazing or unknown status)		24	48	1	

[a] For information about ICBEMP data limitations, see Appendix 2-1.

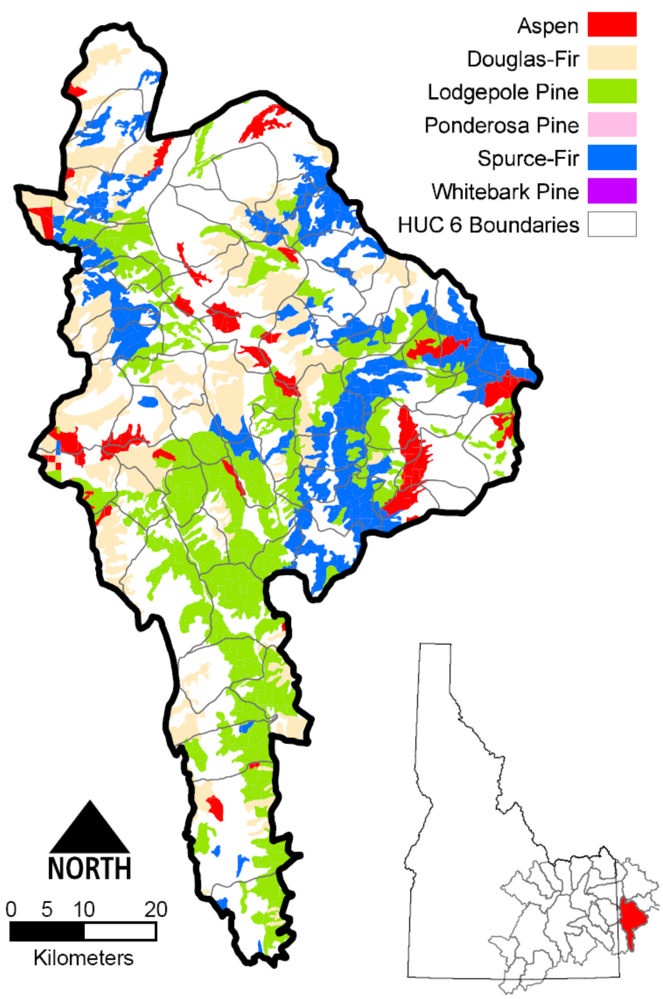

Figure 3-2. Current distribution of forest species compositions in the Greys–Hoback watershed, Snake Headwaters subbasin, Wyoming (GAP II, Scott *et al*. 2002).

3.1.1.2 Gros Ventre (GVT)

In the Gros Ventre watershed, there is a general lack of pools and suitable spawning sites due mostly to high gradient and variation in stream flow. Heavy silt/sediment loading associated with precipitation events also limits populations (Table 3-2). There is poor bank cover and limited riparian system development. Dewatering occurs lower in the system from 26 known water diversions, but the system may have also have been subject to periodic dewatering based on the geology of the area.

The major cause of terrestrial limiting factors in the Gros Ventre watershed is population density. While there are no major population centers in this watershed, it is near Jackson, Grand Teton National Park, and Yellowstone National Park. Most of the population distribution in this area consists of small developments of recreational and seasonal-use homes mixed with small local population centers. Although human population is high, habitat fragmentation, timber harvest, and grazing all have had a relatively low effect on ecosystems in this area. And although 81% of the watershed is grazed, grazing allotments are primarily for cattle, and the projected impact of this grazing is minimal (Table 3-4 and Appendix 3-1). Data were not available to assess the state of alteration to the fire regime in this watershed.

Table 3-4. Comparison of the relative percentages of area impacted by the causes of limiting factors in the Gros Ventre watershed for terrestrial resources (ICBEMP 1997[a]).

Causes of Limiting Factors	Very Low	Low	Medium	High	Very High
Human population density	($x < 1$)	($1 < x > 10$) 9	($10 < x > 60$) 66	($60 < x < 100$) 23	($100 < x > 300$) 3
Habitat fragmentation		93	7		
Altered fire regime	?	?	?	?	?
Timber harvest (65% no harvest)			31	4	
Grazing/browsing (19% no grazing or unknown status)		64	17		

[a] For information about ICBEMP data limitations, see Appendix 2-1.

3.1.1.3 Palisades (PAL)

The South Fork Snake River is one of the last remaining strongholds for Yellowstone cutthroat trout, though naturalized rainbow trout are seen as a major threat to the long-term persistence of this population. Altered flow timing/magnitude are thought to contribute to the increasing rainbow trout population, which had been present at low levels for many years. Most tributary habitats are in good shape and provide the primary spawning habitat for Yellowstone cutthroat trout. Rainey Creek (one of the spawning tributaries) is periodically dewatered. There are 351 points of water diversion (Figure 3-3) in the watershed. Palisades Dam alters the magnitude and timing of flows in the mainstem South Fork Snake River and forms an upstream passage barrier to fish (Table 3-2).

Terrestrial limiting factors in the Palisades watershed are dominated by riparian limitations imposed by regulated flows from Palisades dam. Forested riparian areas below Palisades dam depend on seasonal flooding to renew and rejuvenate cottonwood regeneration, nutrient enrichment, and disturbance. Since the construction of Palisades dam, this highly important forested riparian area has been subject to ongoing decline through water flow management and flood control at Palisades dam. A moderate degree of population, timber harvest, and grazing occurs within the watershed (Table 3-5). As with the Gros Ventre watershed, there are no major population centers in the Palisades watershed, but there are many small rural populations and a moderate degree of seasonal and recreation-oriented population. Low to moderate grazing occurs over most of the watershed, but it is dominantly sheep grazing, and does not appear to produce an extreme effect on ecosystems (Appendix 3-1). However, a combination of land-use conversion, timber harvest, altered fire regime practices, and grazing by domestic animals has led to some changes in forest species composition. Aspen habitats appear extremely fragmented, and lodgepole pine has replaced spruce-fir habitat (Appendix 3-1). These changes in habitat quality and quantity have increased the probability that the watershed will experience a fire event in the near future (Figure 3-4).

Table 3-5. Comparison of the relative percentages of area impacted by the causes of limiting factors in the Palisades watershed for terrestrial resources (ICBEMP 1997[a]).

Causes of Limiting Factors	Very Low	Low	Medium	High	Very High	Extremely High
Human population density	(x < 1)	(1 < x > 10) 17	(10 < x > 60) 74	(60 < x < 100) 8	(100 < x > 300) 1	(x > 300) <1%
Habitat fragmentation		53	41	6	<1%	
Altered fire regime		22	31	33		
Timber harvest (36% no harvest)		24	36	4		
Grazing/browsing (22% no grazing or unknown status)		22	55	1		

[a] For information about ICBEMP data limitations, see Appendix 2-1.

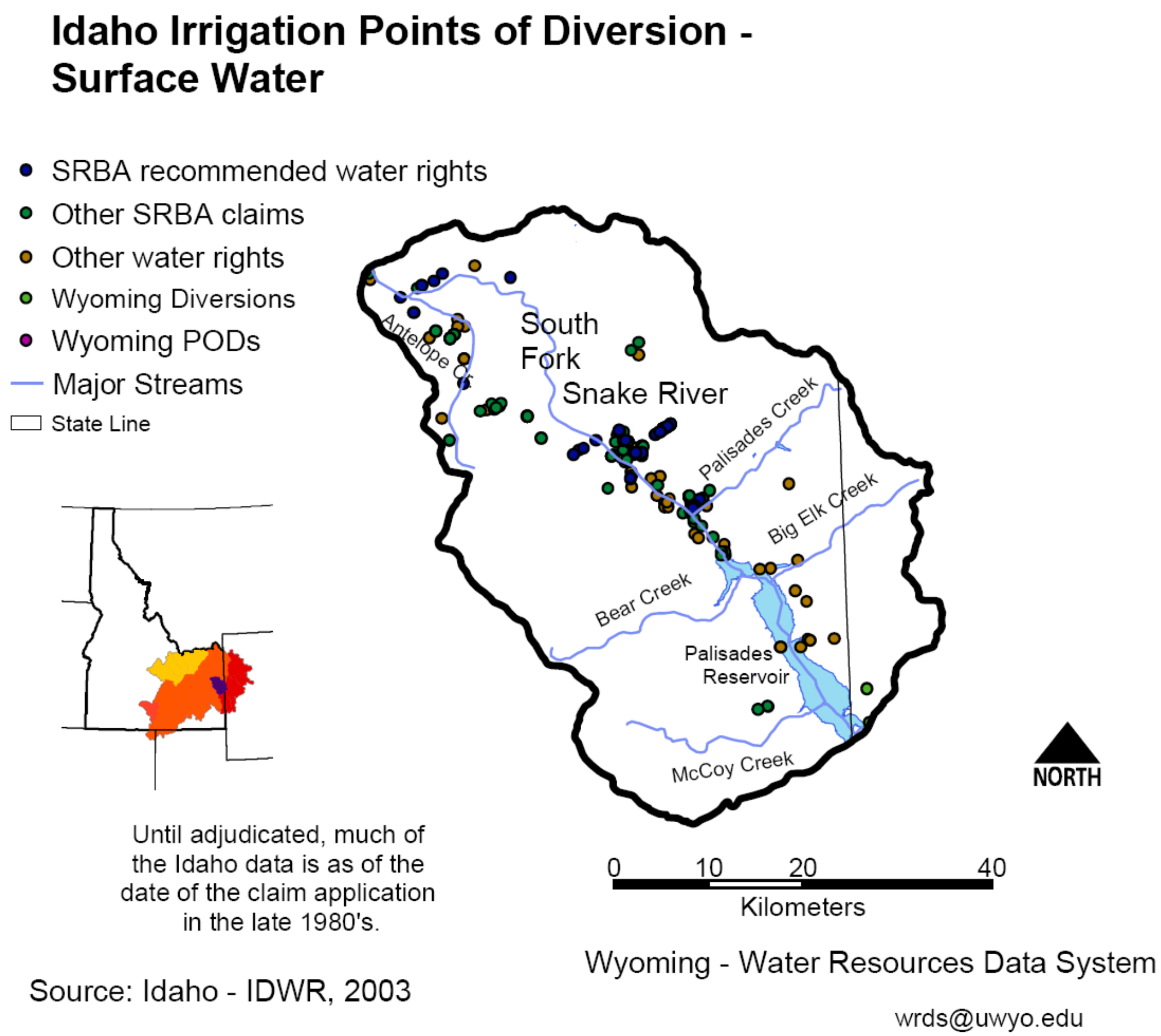

Figure 3-3. Idaho Department of Water Resources points of water diversions in the Palisades watershed, Snake Headwaters subbasin.

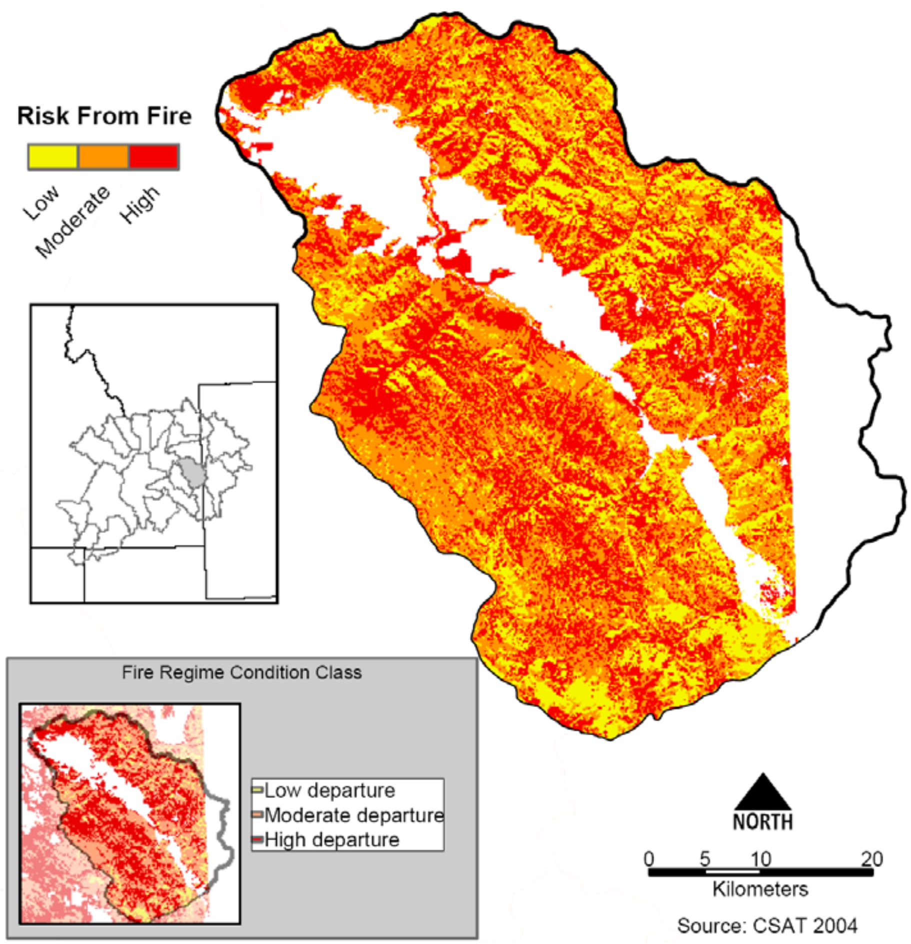

Figure 3-4. Predicted areas within the Palisades watershed, Snake Headwaters subbasin, most likely to be at risk for severe fire effects, taking into account fire regime condition class, ignition probability, and fire weather hazard. Ecosystems-at-risk integrates ignition probability, fire weather hazard, rate-of-spread, and fire regime condition class (the probability of severe fire effects). Source: Northern Regional National Fire Plan Cohesive Strategy Assessment Team, Flathead National Forest (CSAT 2004).

3.1.1.4 Salt (SAL)

Bank damage caused by periodic flooding is a limiting factor in the Lower Salt River Basin (Salt watershed) (Table 3-2). As a result, there is limited bank cover in the form of stable undercuts or streamside shrubs/trees. There are limited spawning areas for Snake River cutthroat trout. Some stream dewatering occurs due to about 298 known diversions that occur during the irrigation season. These effects are lessening due to conversion to sprinkler irrigation systems. The tributary streams are high gradient and have high variation in stream flow. Water temperatures in Swift Creek above the reservoirs are naturally cold, and the creek below the reservoirs is dewatered. Nonnative species are a concern in the Salt River drainage as brown trout make up most of the biomass in the river's mainstem. Rainbow trout spawning occurs in a spring located on private land on the lower Salt River. Efforts to negotiate removal of rainbow trout from this area have been unsuccessful. These trout are confined primarily to the lower end of the river.

The Salt watershed contains the population center of Afton, Wyoming and surrounding communities, an important cause of terrestrial limiting factors in the watershed. Associated activities have resulted in a moderate degree of habitat fragmentation and timber harvest (Table 3-6). Most of the intense timber harvest activities have occurred near waterways in the watershed (Figure 3-5). In the Salt watershed, about 70% of the area is grazed, predominantly by sheep (Appendix 3-1).

Table 3-6. Comparison of the relative percentages of area impacted by the causes of limiting factors in the Salt watershed for terrestrial resources (ICBEMP 1997[a]).

Causes of Limiting Factors	Very Low	Low	Medium	High	Very High	Extremely High
Human population density	(*x* < 1)	(1 < *x* > 10) 13	(10 < *x* > 60) 55	(60 < *x* < 100) 21	(100 < *x* > 300) 11	(*x* > 300)
Habitat fragmentation		28	72			
Altered fire regime		22	34	36		
Timber harvest (5% no harvest)		49	32	14		
Grazing/browsing (28% no grazing or unknown status)		35	37			

[a] For information about ICBEMP data limitations, see Appendix 2-1.

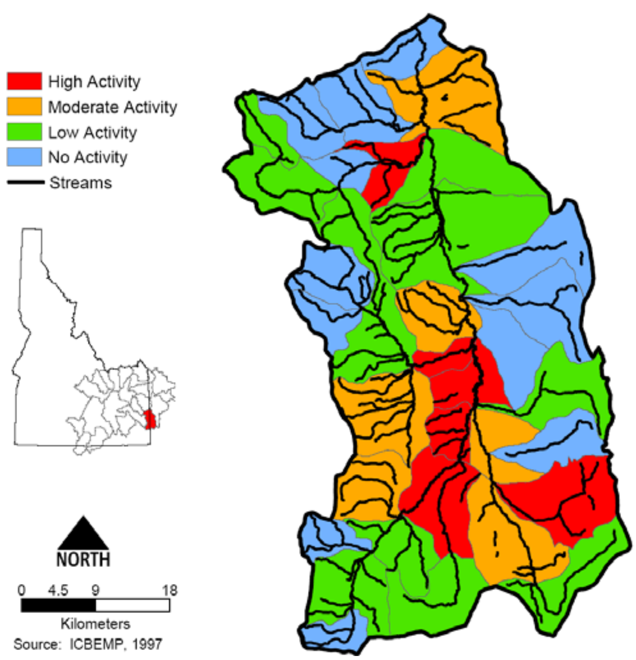

Figure 3-5. Status of timber harvest activity in the Salt watershed, Snake Headwaters subbasin, Idaho and Wyoming (ICBEMP 1997).

3.1.1.5 Snake Headwaters (SHW)

The Snake Headwaters watershed includes the mainstem Snake River from Jackson Lake downstream to the slack water in Palisades Reservoir, excluding major tributaries. This area is part of the area that the Wyoming Game and Fish Department terms the Lower Snake Basin. The primary limiting factors in the Lower Snake Basin are winter flows, loss of instream habitat, and loss of spawning areas (Table 3-2). Reduced winter flow below Jackson Lake Dam limits the amount of available wintering habitat. Dikes encourage aggradation and loss of instream structure and prevent cottonwood regeneration within the riparian areas. Spawning habitat is degraded where livestock and wildlife winter along spring creeks. Also, flooding and gravel rejuvenation in tributary spring creeks have been eliminated by dike construction, resulting in continuing loss of spawning areas.

The Wyoming Game and Fish Department refers to the Snake Headwaters watershed from Jackson Lake Dam upstream to the boundary with Yellowstone National Park as the Upper Snake Basin. A high degree of annual stream flow variation, limited spawning areas, and poor pool development (< 30%) for winter habitat are the primary limiting factors within the Upper Snake River Basin. There is limited access to the upper Snake River. The use of Jackson Lake water for irrigation will continue to alter lake elevations on an irregular basis.

The Snake Headwaters watershed within the boundary of the Teton Wilderness is termed the Wilderness Waters of the Snake Basin by the Wyoming Game and Fish Department. Human impacts in this area are considered minor.

The Buffalo Fork drainage within the Snake Headwaters watershed has high annual stream flow variation and overall high gradient that limits trout populations. Heavy silt loads from precipitation events limit trout populations in the lower reaches of the basin. Blackrock Creek is diverted above the Blackrock Ranger Station to irrigate the Hatchet Ranch area. Insufficient winter flows limit trout populations above North Fork Falls, while low year-round water temperatures are limiting in Joy Creek. Soda Fork and North Fork Meadows are subject to overexploitation during summer/fall seasons, but trout can be found in the canyon reaches.

Mass movement and erosion are limiting factors in the Cub Creek drainage. Also, a high annual streamflow variation, high gradient, and poor pool to riffle ratio (< 30% pools) limit the trout population. Spawning is limited in long reaches of the mainstem of Cub Creek since the predominant substrate is rubble-boulder. Tributaries provide spawning that favors brook trout, and Snake River cutthroat trout have essentially been displaced. However, there probably never was a strong population of cutthroat trout due to natural limiting factors.

The Snake Headwaters watershed contains portions of Yellowstone and Grand Teton National Parks and does not contain any large population centers. This area is well protected by various state and federal agencies and has very low impacts from most causes of terrestrial limiting factors (Table 3-7). Still, considerable change has occurred in the distribution and composition of forest species within the watershed (Appendix 3-1). Large aspen forests have disappeared from the central areas of the watershed, and lodgepole pine dominates in areas that were once spruce-fir forests (Figure 3-6). Data were not available to assess the state of alteration to the fire regime in this watershed.

Table 3-7. Comparison of the relative percentages of area impacted by the causes of limiting factors in the Snake Headwaters watershed for terrestrial resources (ICBEMP 1997[a]).

Causes of Limiting Factors	**Very Low**	**Low**	**Medium**	**High**	**Very High**	**Extremel y High**
Human population density	$(x < 1)$ <1%	$(1 < x > 10)$	$(10 < x > 60)$ 20	$(60 < x < 100)$ 76	$(100 < x > 300)$ 4	$(x > 300)$ <1%
Habitat fragmentation		95	5	<1%		
Altered fire regime		?	?	?	?	?
Timber harvest (81% no harvest)			12	7		
Grazing/browsing (84% no grazing or unknown status)		6	10			

[a] For information about ICBEMP data limitations, see Appendix 2-1.

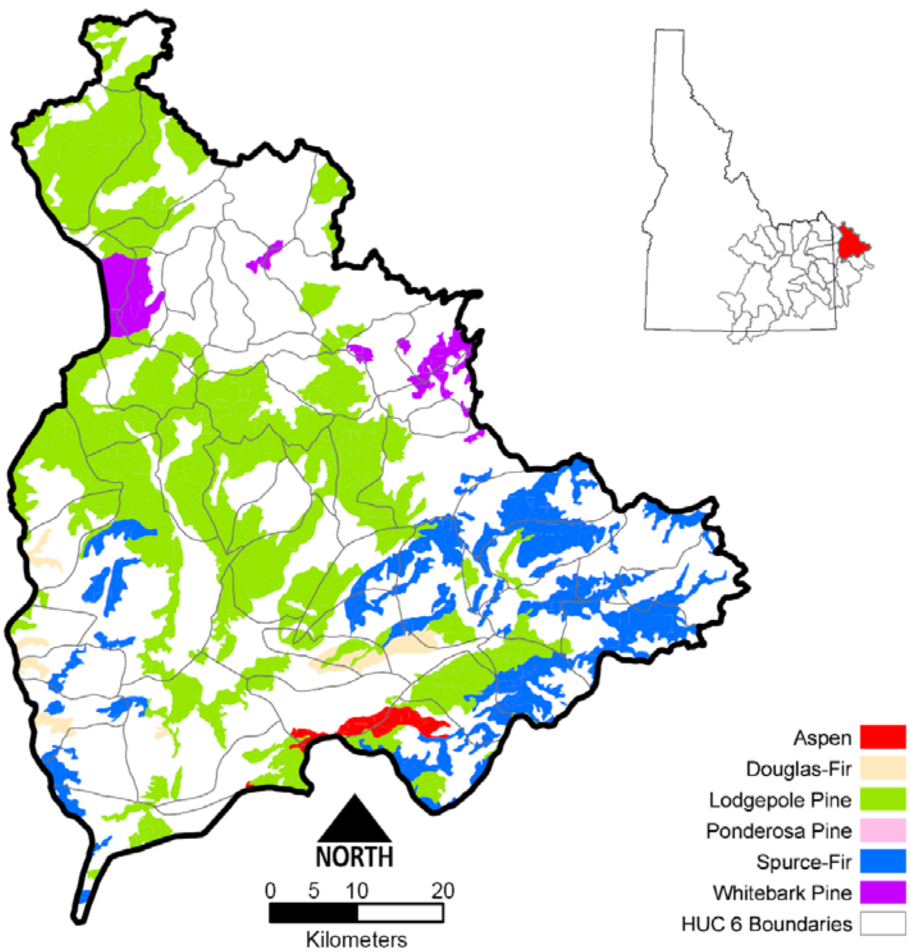

Figure 3-6. Current distribution of forest species compositions in the Snake Headwaters watershed, Snake Headwaters subbasin, Wyoming (GAP II, Scott *et al.* 2002).

3.1.2 Upper Snake Subbasin

High desert ecosystem types characterize the Upper Snake subbasin, with some transition into forested and alpine regions to the east and south. The environment is typically dry, with hot summers and cold, windy winters. Riparian resources within the subbasin vary by watershed, but there are consistent problems with low flow waters, water temperatures, and sediment contamination (Table 3-8). We discuss watersheds individually in context with both riparian and terrestrial causes for limiting factors.

Shrub-steppe habitat is the most significant habitat component in the Upper Snake subbasin. Significant reductions in shrub-steppe habitat quantity and quality has occurred due to the compounding affects of grazing and browsing, altered fire regimes, conversion to other land uses and invasive exotic weeds.

Anthropogenic impacts to the subbasins began with the exploration and settlement of the province during the mid 19^{th} century. By the end of the 1800's grazing and browsing activities had fundamentally altered the structure and function of shrub-steppe habitats across the province (Crawford et al. 2004). Subsequent to human settlement, irrigation technological advances, transformed the subbasins from desert to some of the most agriculturally productive lands in the West. Expansive tracts of land were converted to cropland resulting in increased fragmentation in all but the most remote areas of the province.

At the same time that irrigation was transforming the province, fire suppressive policies and methodology began to lay the foundation for the next stage of shrub-steppe altering influences (Appendix 3.1). Since 1980, nearly 29,000 km^2 of shrub-steppe habitat has been burned in the Upper Snake Province. Of that total, nearly 19,000 km^2 has burned in the Upper Snake subbasin alone. Nearly 1/3 of the remaining shrub-steppe habitat in the Upper Snake subbasin is characterized as either moderately or at high risk of severe fire.

As the population in the province began to grow, associated urban and rural development began to have greater impact upon the natural resources within the subbasins. Approximately 749 hectares of shrub-steppe habitat was converted to urban/rural uses during the last 2 decades. The invasion and spread of exotic invasive weeds further exacerbates the factors limiting shrub-steppe habitat quality and quantity.

Causes of terrestrial limiting factors by watershed (Table 3-9, Table 3-10, Table 3-11, Table 3-12, Table 3-13, Table 3-14, Table 3-15, Table 3-16, Table 3-17, Table 3-18, Table 3-19, and Table 3-20) illustrate negative deviations from the natural state at the watershed level. Dominant concerns in the Upper Snake subbasin include altered fire regime and habitat fragmentation. Analysis of altered fire regime in this subbasin was restricted to Idaho, so the watersheds that cross state boundaries are assessed only for the Idaho portion. Where data exist, altered fire regime is characteristically moderate to high, primarily due to over 100 years of intense fire suppression that created a greater potential for large, devastating fires. Currently, on the high desert, seasonal wildfires that are sparked by humans or dry lightning burn large tracts of primarily shrub steppe habitats each year. This disturbed land is of primary concern for invasion of noxious and exotic weeds, such as cheatgrass. Cheatgrass is highly flammable in summer months and thrives with frequent burns, while other native vegetation is inhibited. Habitat fragmentation in this watershed is largely a function of agriculture, with the Snake River and interstate corridors being highly developed. Water supply concerns are at heightened levels in recent years, mainly due to many sequential years of below-average precipitation in combination with consistent increases in water consumption due to agricultural development (including an increased dependence on environmentally inefficient irrigation techniques such as sprinkler irrigation). Water rights users sometimes demand an increase in water diversions for consumptive use, and such increases dewater rivers, degrading the quantity and extent of pre-existing terrestrial habitats.

Table 3-8. Ranked impacts of altered ecosystem features impacting habitat quality and quantity for focal fish species in tributaries of the 12 watersheds in the Upper Snake subbasin. Degree of impact on habitat quality or quantity ranked as P (component is functioning properly, needs protection), 1 (least influence), 2 (moderate influence), or 3 (greatest influence, highest priority).

Ecosystem Feature	Altered Component	Upper Snake–Rock	Goose Creek	Raft River	Lake Walcott	Willow Creek	Idaho Falls	Teton	Lower Henrys Fork	Upper Henrys Fork	American Falls	Portneuf	Blackfoot
Channel Structure	Floodplain	P	P	P	P	3	P	P	P	P	P	P	3
	Pool/riffle ratio	P	P	P	P	3	P	3	P	3	3	P	3
	Large woody debris	P	P	P	P	P	P	P	P	P	P	P	
Hydrology	Discharge	3	P	P	3	2	3	P	2	3	P	3	3
	Low flow/ dewatering	3	3	3	P	P	3	3	P	P	P	3	3
	Peak	P	P	P	P	P	P	P	P	P	P	P	P
Sediment	Increased fines	P	3	3	2	3	P	3	P	3	3	3	3
Water Quality	Temperature Dissolved oxygen	3	P	P	3	P	P	P	P	P	P	P	P
Riparian	Shade	P	3	3	2	3	P	3	P	3	3	3	3
	Streambank stability	P	3	3	3	3	P	3	P	3	3	3	3
Exogenous	Reservoir operations	3	P	P	3	2	3	3	P	3	3	3	3
	Exotics	3	3	3	3	P	P	3	3	3	3	1	3

3.1.2.1 American Falls (AMF)

The American Falls watershed includes tributaries to American Falls Reservoir and the Snake River from American Falls Dam upstream to a point approximately halfway between the Shelley Diversion Dam and the falls at Idaho Falls, including most streams on the Fort Hall Reservation. Streams in this watershed have altered riparian habitat from land use and conversion. There are an estimated 500 points of water diversion in the watershed. Rapid flooding and drafting of American Falls Reservoir negatively impacts bank stability on the lower reaches of streams in the area where reservoir water inundates the lower ends of the streams. Several Yellowstone cutthroat trout populations exist in the watershed, but naturalized rainbow trout and hybrid rainbow cutthroat populations are common (Table 3-8).

The American Falls watershed contains several larger agricultural-based communities along the interstate corridor, including the cities of American Falls, Aberdeen, and Shelley and rural areas outside of Blackfoot and Idaho Falls. The elevated population in this area combined with large areas of high-intensity agricultural use elevates anthropogenic causes of limiting factors. About 70% of the area is ungrazed (Table 3-9 and Appendix 3-1).

Table 3-9. Comparison of the relative percentages of area impacted by the causes of limiting factors in the American Falls watershed for terrestrial resources (ICBEMP 1997[a]).

Causes of Limiting Factors	Very Low	Low	Medium	High	Very High	Extremely High
Human population density	(x < 1) <1%	(1 < x > 10) <1%	(10 < x > 60) 73	(60 < x < 100) 8	(100 < x > 300) 17	(x > 300) 1
Habitat fragmentation		<1%	39	45	16	
Altered fire regime		2	25	31		
Timber harvest (92% no harvest)		2	5	2		
Grazing/browsing (70% no grazing or unknown status)		29	1			

[a] For information about ICBEMP data limitations, see Appendix 2-1.

3.1.2.2 Blackfoot (BFT)

The upper Blackfoot River from headwaters to tributaries is subject to riparian habitat alteration from land use, resulting in channel alterations, decreased depths, and increased fine sediments (Table 3-8). There are an estimated 550 points of water diversion in the watershed. Blackfoot Reservoir has no minimum pool; total volume is 350,000 acre-feet and the reservoir can be drawn down to approximately 1,400 acre-feet. Downstream of Blackfoot Reservoir, flows are run at bank-full discharge through much of the summer as irrigation water is transferred downstream, which impact riparian focal habitat. Drought conditions have reduced winter outflows in the river to nearly 10 cfs, while releases of 300 cfs in winter occurred during water years when storage was ample. Riparian areas in the lower Blackfoot River and tributaries are impacted by land use, resulting in reduced cover and increased sedimentation. The lower section of the Blackfoot River has been channelized, which reduced the habitat complexity and suitability for Yellowstone cutthroat trout.

The Blackfoot watershed contains the city of Blackfoot and several smaller, agriculturally based areas. Population as a cause of limiting factors in this watershed is not a significant concern, but habitat fragmentation resulting from well-developed agriculture and road infrastructure in the area has significantly changed the habitat in the watershed from historical conditions (Table 3-10). The southern portion of this watershed in Caribou County is heavily forested, while the northern portion of the watershed is not. High timber harvest activity, however, does occur in scattered areas throughout the watershed (Figure 3-7), and this activity near waterways may cause increases in fine sediments. Over half of the Blackfoot watershed is allotted for grazing, which is done mainly by cattle and sheep (Appendix 3-1).

Table 3-10. Comparison of the relative percentages of area impacted by the causes of limiting factors in the Blackfoot watershed for terrestrial resources (ICBEMP 1997[a]).

Causes of Limiting Factors	Very Low	Low	Medium	High	Very High	Extremely High
Human population density	($x < 1$)	($1 < x > 10$) 3	($10 < x > 60$) 70	($60 < x < 100$) 19	($100 < x > 300$) 9	($x > 300$) <1%
Habitat fragmentation		2	48	39	12	
Altered fire regime		8	31	39		
Timber harvest (35% no harvest)		19	22	24		
Grazing/browsing (43% not grazed or unknown status)		41	16			

[a] For information about ICBEMP data limitations, see Appendix 2-1.

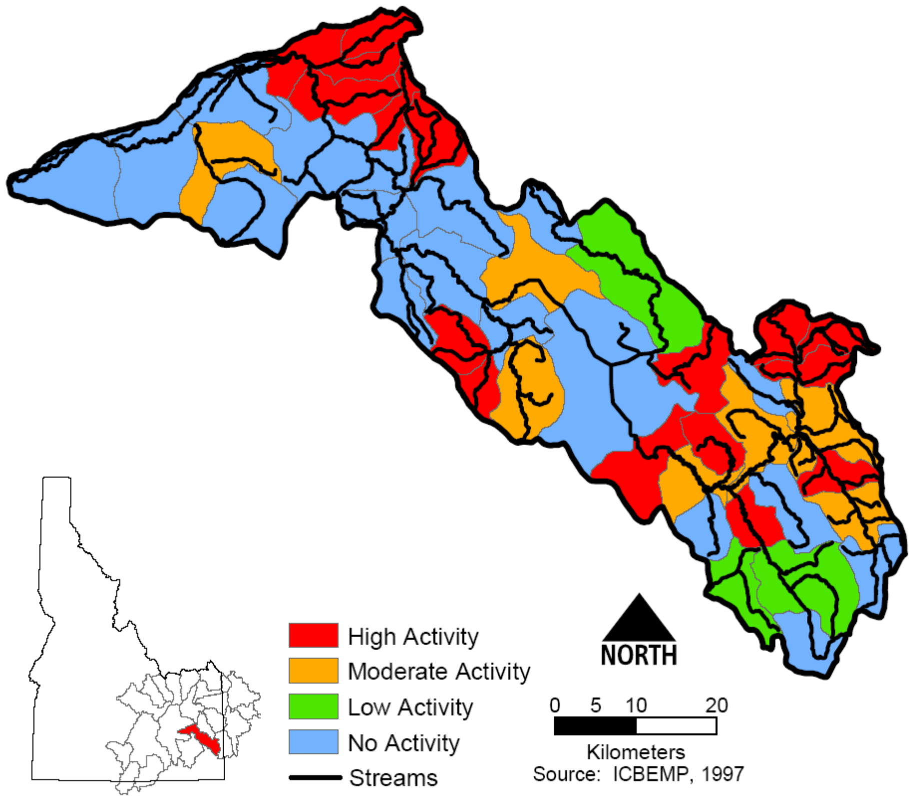

Figure 3-7. Status of timber harvest activity in the Blackfoot watershed, Upper Snake subbasin, Idaho (ICBEMP 1997).

3.1.2.3 Goose (GSE)

The mainstem of Goose Creek still maintains some areas of intact riparian habitat. However, impacts to riparian habitat from land use are noted on both the mainstem and tributaries, and increased fine sediments are apparent (Table 3-8). Downstream of Oakley Reservoir, Goose Creek was officially declared by Idaho law to no longer be a stream.

There are about 1,100 points of water diversion (Figure 3-8) in the Goose watershed. We only identified 10 road culverts in the Goose watershed that block fish passage, and one that allows adult fish passage (Appendix 3-1), however, many culverts have not been surveyed so these numbers are incomplete.

Populations of cutthroat in the headwater areas are isolated for most of the year by water diversion or dewatering. Nonnative salmonids (brook trout and rainbow trout) are present in the drainage and considered a threat to the long-term persistence of Yellowstone cutthroat trout populations.

The Goose watershed contains the population center of Oakley, as well as several small agricultural areas. Agricultural development in this watershed has resulted in a high degree of habitat fragmentation and loss (Table 3-11), and timber harvest in the hills on the outskirts of the Snake River Plain has a moderate effect on existing ecosystems. Even though most of the area is grazed by cattle (Figure 3-9), the exact impact of grazing is unknown (Appendix 3-1).

Table 3-11. Comparison of the relative percentages of area impacted by the causes of limiting factors in the Goose watershed for terrestrial resources (ICBEMP 1997[a]).

Causes of Limiting Factors	Very Low	Low	Medium	High	Very High
Human population density	($x < 1$) <1%	($1 < x > 10$) <1%	($10 < x > 60$) 74	($60 < x < 100$) 12	($100 < x > 300$) 14
Habitat fragmentation		28	49	10	13
Altered fire regime		7	25	44	
Timber harvest (40% no harvest)		2	56	2	
Grazing/browsing (21% no grazing or unknown status)		78	1		

[a] For information about ICBEMP data limitations, see Appendix 2-1.

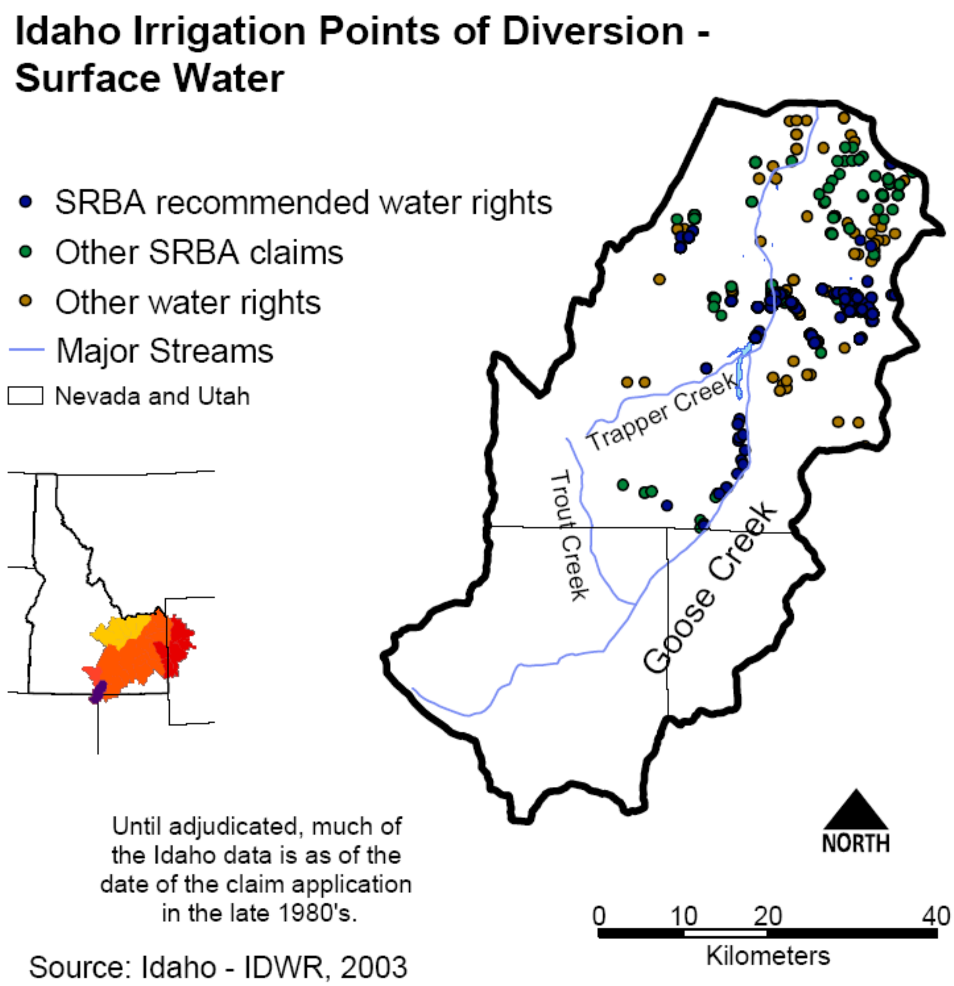

Figure 3-8. Idaho Department of Water Resources points of water diversions in the Goose watershed, Upper Snake subbasin.

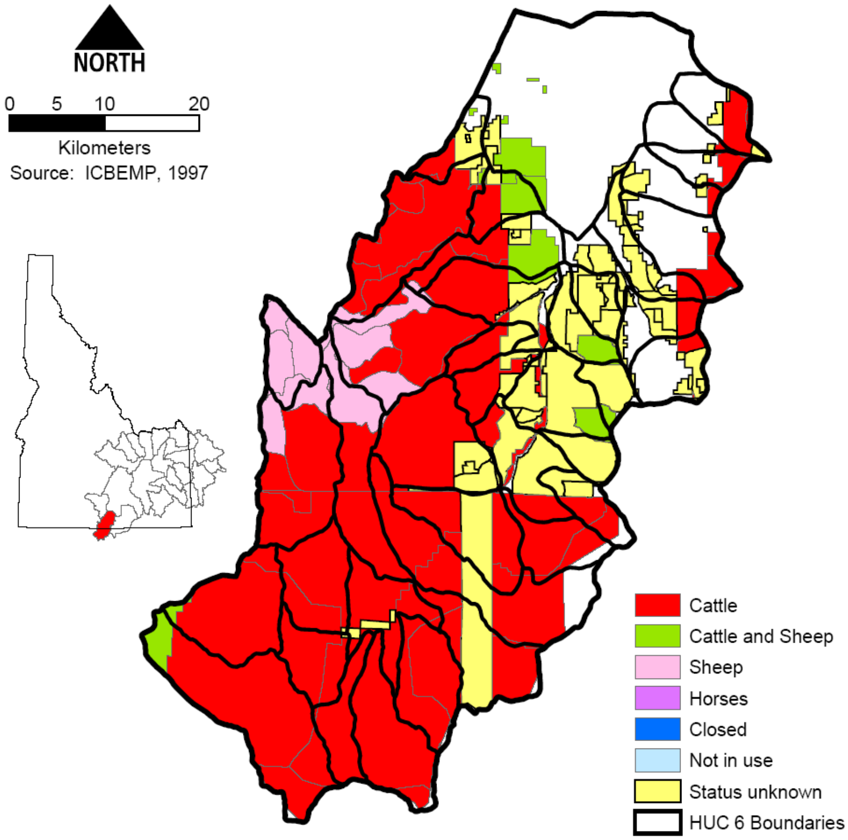

Figure 3-9. Status of grazing and browsing by domestic animals in the Goose watershed, Upper Snake subbasin, Idaho, Utah, and Nevada (ICBEMP 1997).

3.1.2.4 Idaho Falls (IFA)

This watershed includes the South Fork Snake River from the Heise Cable downstream to a point approximately halfway between the Shelley Diversion Dam and the falls at Idaho Falls. Primary impacts to focal aquatic habitats in this area include the impassable dam on the falls at Idaho Falls and dewatering of the "dry bed," a natural channel that has had a headgate installed on the upper end and now serves as an irrigation water delivery canal (Table 3-8). Substantial irrigation withdrawals occur in this watershed, and none of the diversions are screened for fish passage. There are an estimated 1,250 points of water diversion in the Idaho Falls watershed. Palisades Dam controls flows in this section. Five low-head dams exist, and no fish passage is provided. The Idaho Falls watershed contains the agricultural areas of Idaho Falls, Rigby, and Ammon, as well as several other small agricultural and industrial population centers. Thus, human population density and agriculture use is a cause of terrestrial limiting factors and correlates strongly to an increase in habitat fragmentation (Table 3-12). There is no significant timber harvest in this region and the dominant (65%) portion of the watershed is not grazed (Table 3-12 and Appendix 3-1).

Table 3-12. Comparison of the relative percentages of area impacted by the causes of limiting factors in the Idaho Falls watershed for terrestrial resources (ICBEMP 1997[a]).

Causes of Limiting Factors	Very Low	Low	Medium	High	Very High	Extremely High
Human population density	(*x*<1)	(1 < *x* > 10) 2	(10 < *x* > 60) 37	(60 < *x* < 100) 19	(100 < *x* > 300) 36	(*x* > 300) 7
Habitat fragmentation			4	60	36	
Altered fire regime			29	10		
Timber harvest (85% no harvest)			12	3		
Grazing/browsing (65% no grazing or unknown status		34	1			

[a] For information about ICBEMP data limitations, see Appendix 2-1.

3.1.2.5 Lower Henrys Fork (LHF)

The Falls River is the largest tributary in the Lower Henrys Fork watershed. Falls River is impacted by irrigation diversions and one hydropower plant. The upper end of the drainage is within the boundary of Yellowstone National Park. Rainbow trout are the dominant trout in the drainage. About 550 unscreened irrigation diversions exist throughout the Lower Henrys Fork watershed. Riparian condition has been impacted through conversion from development. Ashton and Chester dams do not have fish passage, and fish passage is not a high priority in this area due to lack of cutthroat trout. Downstream from the mouth of the Teton River to the mouth of the Henrys Fork, there are major sediment impacts from the collapse of Teton Dam (Table 3-8).

The Lower Henrys Fork watershed contains several agriculturally based population centers, including Ashton, St. Anthony, and Sugar City. The presence of these population centers elevates the concern for population density as a cause for limiting factors, and a large percentage of habitats in the watershed are fragmented, mainly from agricultural development (Table 3-13). Grazing in this watershed is not a significant concern, primarily due to a lack of persistent forbs for domestic animals to eat in the watershed (Table 3-13 and Appendix 3-1).

Table 3-13. Comparison of the relative percentages of area impacted by the causes of limiting factors in the Lower Henrys Fork watershed for terrestrial resources (ICBEMP 1997[a]).

Causes of Limiting Factors	Very Low	Low	Medium	High	Very High	Extremely High
Human population density	(*x* < 1)	(1 < *x* > 10) 37	(10 < *x* > 60) 29	(60 < *x* < 100) 18	(100 < *x* > 300) 16	(*x* > 300) <1%
Habitat fragmentation		28	37	35	<1%	
Altered fire regime		9	25	36		

Causes of Limiting Factors	Very Low	Low	Medium	High	Very High	Extremely High
Timber harvest (52% no harvest)		7	39	3		
Grazing/browsing (67% no grazing or unknown status)		25	7	1		

[a] For information about ICBEMP data limitations, see Appendix 2-1.

3.1.2.6 Portneuf (PTF)

The Portneuf watershed contains numerous pure populations of Yellowstone cutthroat trout that are mostly located in tributary streams. Most tributary streams to the Portneuf River are disconnected, isolating these populations from the mainstem and other populations. Most of the restoration potential for Yellowstone cutthroat trout in the Portneuf watershed is in the tributary streams. The upper mainstem Portneuf River contains a naturally reproducing rainbow trout population that is competing with the native Yellowstone cutthroat trout population. Approximately 10 miles (16 km) of the upper Portneuf River is channelized and dewatered for a portion of the year, severely reducing the quality of the area's focal aquatic habitat.

The middle section of the Portneuf River is subject to approximately 3,100 diversions that allow water to warm considerably during summer (Figure 3-10), and Yellowstone cutthroat trout are mostly absent from this section. The lower section of the Portneuf runs through a concrete flume for 6 miles (10 km), with absolutely no fish habitat and no fish passage during low flows (and passage is unlikely at most flows). Below the concrete flume section, the river begins to cool when springs enter the system. Considerable inputs of phosphorous to this lower section result in substantial aquatic macrophyte growth. Many of the tributaries have impacted riparian habitat from land use or conversion (Table 3-8).

The Portneuf watershed contains the major population centers of Pocatello and Chubbuck and the second largest population center in Idaho. Aside from the Pocatello area, where industry and agriculture dominate the labor force, there are also many smaller agricultural communities in the watershed. Combined, these population centers give rise to large concern over population density as a cause of terrestrial limiting factors (Table 3-14). In addition, the intensive agriculture in the region has heavily fragmented natural systems. There is some timber harvest in the foothills on the southern end of the watershed. Much of the watershed is not grazed, and grazing is not projected to be a large cause for limiting factors in the watershed (Table 3-14 and Appendix 3-1). However, due to heavily fragmented and altered habitats, the Portneuf watershed is at risk of a fire event in the near future (Figure 3-11).

Table 3-14. Comparison of the relative percentages of area impacted by the causes of limiting factors in the Portneuf watershed for terrestrial resources (ICBEMP 1997[a]).

Causes of Limiting Factors	Very Low	Low	Medium	High	Very High	Extremely High
Human population density	(*x* < 1) <1%	(1 < *x* > 10) <1%	(10 < *x* > 60) 52	(60 < *x* < 100) 19	(100 < *x* > 300) 21	(*x* > 300) 7
Habitat fragmentation		6	13	72	9	
Altered fire regime		5	20	47		
Timber harvest (37% no harvest)		21	32	10		
Grazing/browsing (61% no grazing or status unknown)		32	7			

[a] For information about ICBEMP data limitations, see Appendix 2-1.

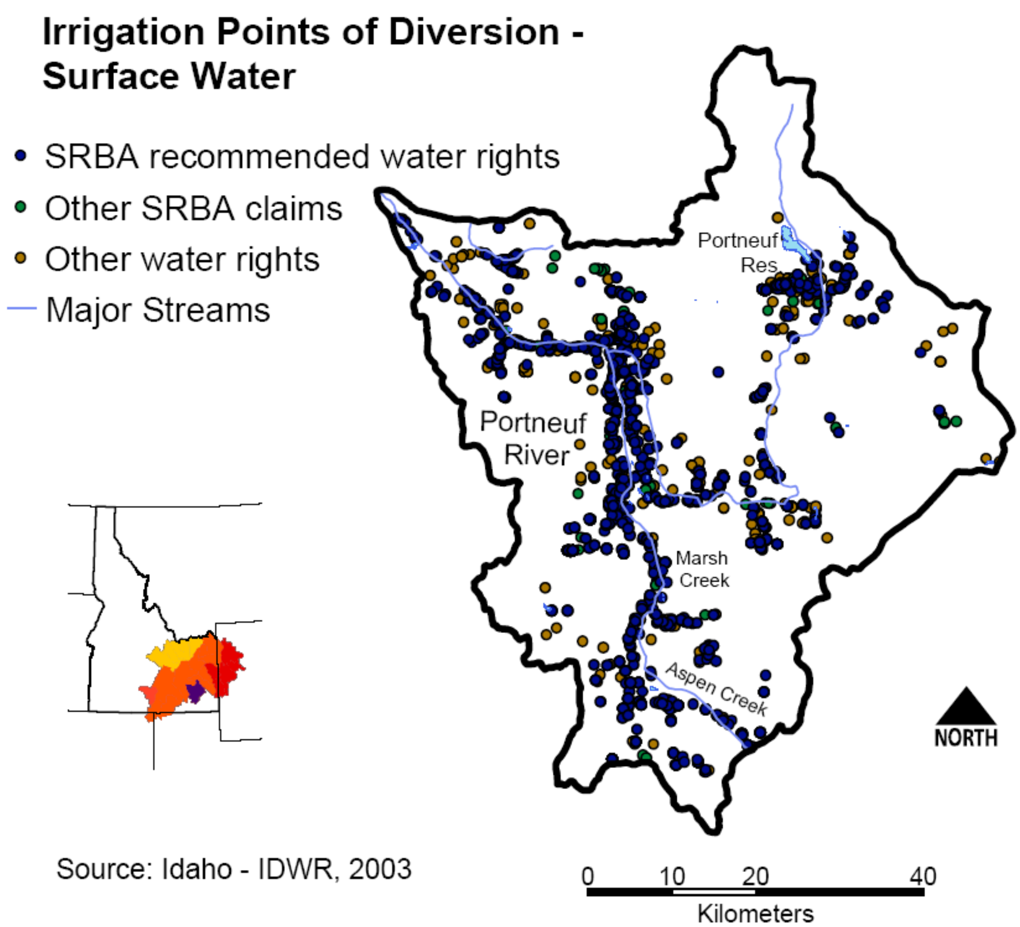

Figure 3-10. Idaho Department of Water Resources points of water diversions in the Portneuf watershed, Upper Snake subbasin.

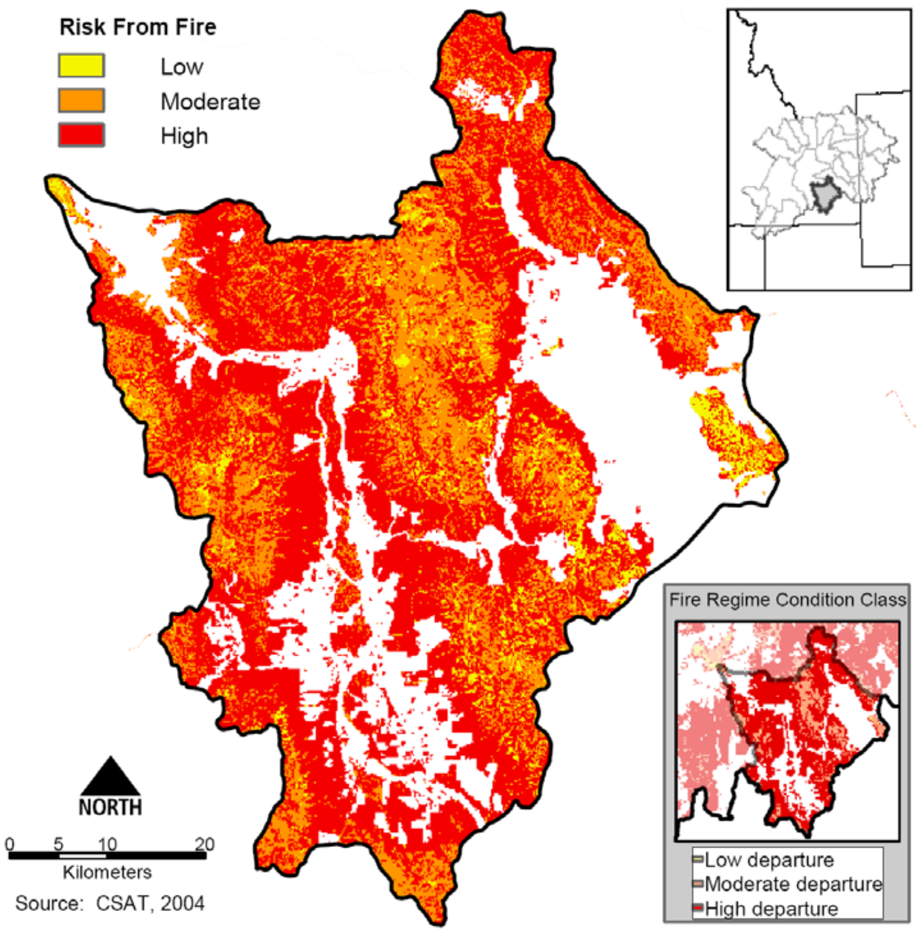

Figure 3-11. Predicted areas within the Portneuf watershed, Upper Snake subbasin, most likely to be at risk for severe fire effects, taking into account fire regime condition class, ignition probability, and fire weather hazard. Ecosystems-at-risk integrates ignition probability, fire weather hazard, rate-of-spread, and fire regime condition class (the probability of severe fire effects). Source: Northern Regional National Fire Plan Cohesive Strategy Assessment Team, Flathead National Forest (CSAT 2004).

3.1.2.7 Raft (RFT)

The Raft watershed connects to the mainstem Snake River only during periods of high flow in the spring and is subject to reduced flows or dewatering from 2,100 water diversions. Yellowstone cutthroat trout populations are isolated from the mainstem by dewatering (Table 3-8).

A characteristically dry area, the Raft watershed has only a few streams that may be diverted for irrigation. There is grazing over much (61%) of the area (Table 3-15 and Appendix 3-1). It is estimated that much of the habitat in the watershed is vulnerable to the effects of grazing and browsing by domestic animals because much of the rangeland is in good (high and very high) condition (Figure 3-12).

Table 3-15. Comparison of the relative percentages of area impacted by the causes of limiting factors in the Raft watershed for terrestrial resources (ICBEMP 1997[a]).

Causes of Limiting Factors	Very Low	Low	Medium	High	Very High
Human population density	($x < 1$)	($1 < x > 10$) 6	($10 < x > 60$) 65	($60 < x < 100$) 14	($100 < x > 300$) 15
Habitat fragmentation		1	63	36	
Altered fire regime		6	25	47	
Timber harvest (66% no harvest)		11	19	5	
Grazing/browsing (39% no grazing or status unknown)		53	8		

[a] For information about ICBEMP data limitations, see Appendix 2-1.

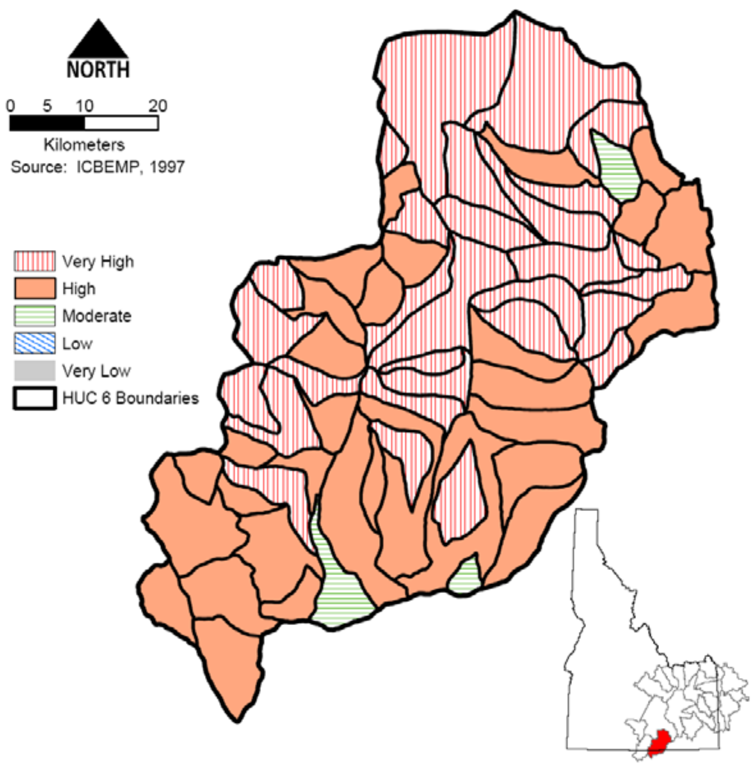

Figure 3-12. Rangeland condition in the Raft watershed, Upper Snake subbasin, Idaho and Utah (ICBEMP 1997).

3.1.2.8 Teton (TET)

The Teton watershed has been impacted by land use, development, riparian alterations, loss of connectivity, and increased fine sediments. The Teton River is generally divided into three sections. The lower river section runs from the river mouth to the Teton Dam site. Dewatering from 2,160 irrigation diversions impacts this lower section (Figure

3-13). Two channels are located here and used alternately for water delivery, which can directly impact fish populations in the area that are subject to stranding and dewatering. The canyon section of the Teton River runs from the Teton Dam site upstream to the top of the canyon. This section was severely impacted when the Teton Dam collapsed. Most riparian vegetation in the section was removed, and the extreme water velocity caused changes to the habitat. Riparian vegetation is slowly returning to the area, but there are large amounts of undesirable species (e.g., cheatgrass). Rainbow trout have recently become more common than Yellowstone cutthroat trout in the main Teton River. In the upper river section of the Teton River, numerous tributaries are dewatered from irrigation diversions (Table 3-8). When the Teton Dam collapsed, all banks were supersaturated and then sloughed, damming the system and creating pools separated by high-gradient, high-velocity areas. The cottonwood riparian area was completely eliminated.

The Teton watershed contains several population centers, including the towns of Driggs, Victor, Madison, and Rexburg, along with several smaller, developed areas along the interstate and highway corridors. These population centers account for increased concern for population as a cause for limiting factors (Table 3-16). There is also a high degree of habitat fragmentation, due to agricultural development in this area. A moderate degree of timber harvest activity occurs in the higher elevations of this watershed, but there is very little grazing, and grazing is not projected to be a significant cause for limiting factors in the watershed (Appendix 3-1).

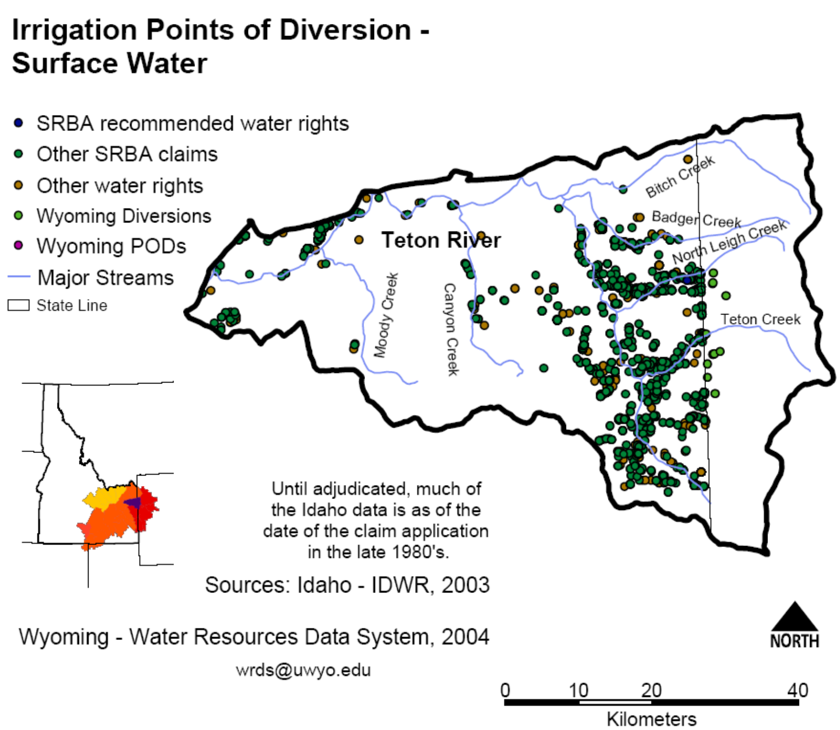

Figure 3-13. Idaho Department of Water Resources points of water diversions in the Teton watershed, Upper Snake subbasin.

Table 3-16. Comparison of the relative percentages of area impacted by the causes of limiting factors in the Teton watershed for terrestrial resources (ICBEMP 1997[a]).

Causes of Limiting Factors	Very Low	Low	Medium	High	Very High	Extremely High
Human population density	($x < 1$)	($1 < x > 10$) 4	($10 < x > 60$) 57	($60 < x < 100$) 19	($100 < x > 300$) 15	($x > 300$) 5
Habitat fragmentation		11	23	45	21	
Altered fire regime		15	13	11		
Timber harvest (30% no harvest)		16	40	14		
Grazing/browsing (59% no grazing or status unknown)		1	29	11		

[a] For information about ICBEMP data limitations, see Appendix 2-1.

3.1.2.9 Upper Henrys Fork (UHF)

The upper end of the Henrys Fork watershed includes Henrys Lake, Henrys Lake Outlet, and tributaries to both. This watershed has altered riparian areas from land use, increased fine sediments, and channel alterations (Table 3-8). There are an estimated 750 points of water diversion in the Upper Henrys Fork watershed. The Big Springs area is highly unproductive from nutrient standpoint, and this situation may limit recruitment in the area. Island Park Dam controls discharge in the Box Canyon section of the Henrys Fork and forms an upstream fish passage barrier. Fine sediment that was flushed out of the reservoir into the Box Canyon section in 1992 is still thought to be a problem. Tributaries to Henrys Lake still support natural spawning by Yellowstone cutthroat trout, and Yellowstone cutthroat trout are spawned at the Henrys Lake Fish Hatchery and released back to the lake (along with intentionally produced hybrids). Although rainbow trout are dominant downstream of Island Park Dam, Yellowstone cutthroat trout are still found in the drainage. Tributaries to Island Park Reservoir are in relatively good condition.

The Upper Henrys Fork watershed contains the relatively small and remote population centers of Island Park and Warm River. There is a moderate degree of habitat fragmentation in the area (Figure 3-14), primarily due to agricultural development and grazing (Table 3-17). This watershed is also heavily used for agriculture and seasonal recreation, which may further contribute to habitat fragmentation. There is a moderate degree of timber harvest in this watershed, which contains abundant ponderosa and lodgepole pine forests. Grazing in this watershed is common, with allotments evenly distributed between cattle and sheep (Appendix 3-1).

Table 3-17. Comparison of the relative percentages of area impacted by the causes of limiting factors in the Upper Henrys Fork watershed for terrestrial resources (ICBEMP 1997[a]).

Causes of Limiting Factors	Very Low	Low	Medium	High	Very High
Human population density	(*x* < 1)	(1 < *x* > 10) 78	(10 < *x* > 60) 22	(60 < *x* < 100) <1%	(100 < *x* > 300) <1%
Habitat fragmentation		4	91	5	
Altered fire regime		45	17	33	
Timber harvest (11% no harvest)		32	42	15	
Grazing/browsing (27% no grazing or status is unknown)			65	8	

[a] For information about ICBEMP data limitations, see Appendix 2-1.

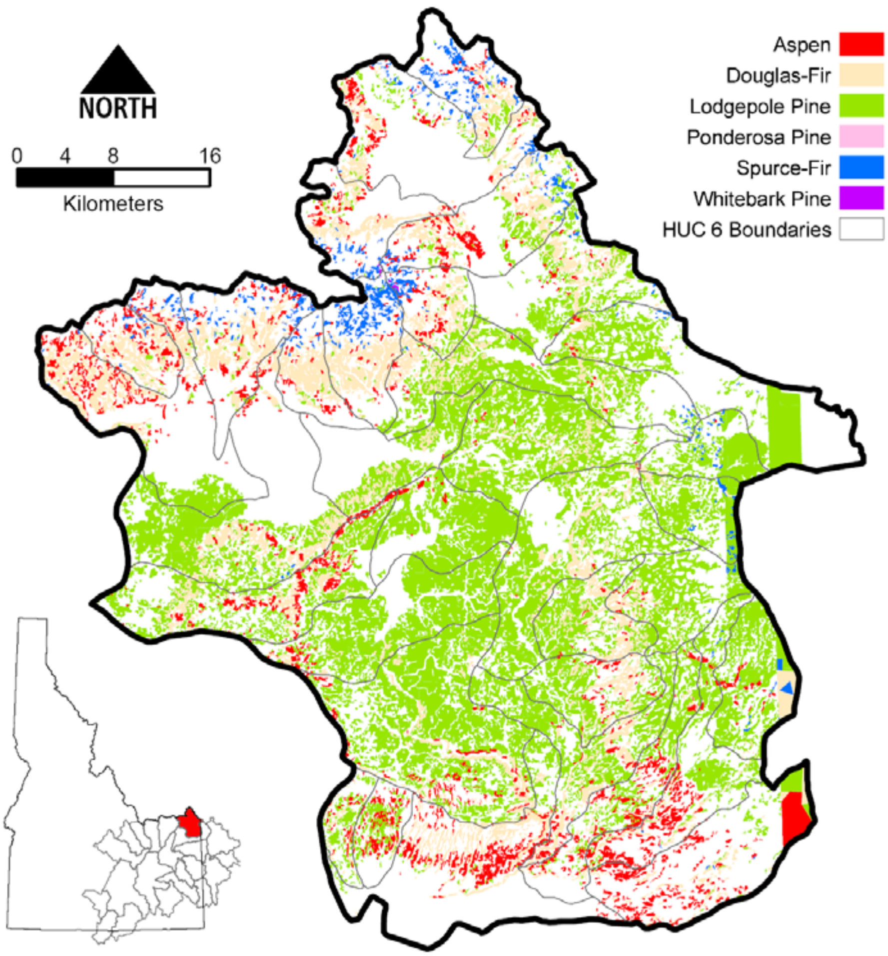

Figure 3-14. Current distribution of forest species compositions in the Upper Henrys Fork watershed, Upper Snake subbasin, Idaho and Wyoming (GAP II 2003, Scott *et al.* 2002).

3.1.2.10 Upper Snake–Rock (USR)

For the purposes of this assessment, the Upper Snake–Rock watershed includes only the area upstream of Shoshone Falls.

There are 350 points of water diversion and an unknown number of road culverts in the Snake–Rock watershed. It is also unknown whether the road culverts allow adult fish passage.

The mainstem Snake River has very few Yellowstone cutthroat trout due to water temperature and water quality (Table 3-8). Vinyard Creek and Dry Creek contain Yellowstone cutthroat trout populations and likely once supported fluvial populations. Dry Creek is dewatered, and no longer connects to the Snake River. Vinyard Creek is still connected to the Snake River. Rainbow trout are present in the watershed.

The western extent of the Upper Snake–Rock watershed sits just east of Twin Falls, Idaho. Urban sprawl from Twin Falls eastward along the interstate corridor generates an elevated concern for population as a cause for limiting factors. While some residents of this area rely on commerce and industry related to Twin Falls and the interstate corridor, the area is also heavily used for agriculture, and this use is reflected by a high degree of habitat fragmentation (Appendix 3-1). While most of this watershed is allocated for grazing, most allocations are not in use, and the effect of grazing is considered minimal (Table 3-18 and Appendix 3-1).

Table 3-18. Comparison of the relative percentages of area impacted by the causes of limiting factors in the Upper Snake–Rock watershed for terrestrial resources (ICBEMP 1997[a]).

Causes of Limiting Factors	Very Low	Low	Medium	High	Very High
Human population density	($x < 1$)	($1 < x > 10$) <1%	($10 < x > 60$) 63	($60 < x < 100$) 24	($100 < x > 300$) 13
Habitat fragmentation		4	5	65	26
Altered fire regime		1	14	40	
Timber harvest (almost 100% no harvest)		<1		<1	
Grazing/browsing		94	6		

[a] For information about ICBEMP data limitations, see Appendix 2-1.

3.1.2.11 Lake Walcott (LWT)

The Lake Walcott watershed is dominated by reservoirs created by Minidoka and Milner dams, and flows in the mainstem Snake River upstream are controlled by American Falls Dam. Water quality between Lake Walcott and Milner dam has been impaired enough at times to kill mountain whitefish. Yellowstone cutthroat trout are rare but present in Lake Walcott and the mainstem Snake River upstream. Rock Creek, the largest tributary in the watershed, contains a highly introgressed population of Yellowstone cutthroat trout in its East Fork (Table 3-8). Tributaries in this drainage are impacted by altered riparian habitat from land use and conversion and increased sedimentation. There is also an estimated 1,050 points of water diversion in the watershed.

The Lake Walcott watershed contains several population centers, including the towns of Burley, Rupert, and Minidoka. Although these areas are large population centers, the Lake Walcott population center is not large, and so population is not a significant cause for limiting factors at the watershed level. There is, however, a large amount of agriculture in the area, resulting in a significant amount of habitat fragmentation (Table 3-19). In addition, over half of the watershed is grazed; however, the information gathered is not complete enough for judgment to be made on the typology of grazing (Appendix 3-1).

Table 3-19. Comparison of the relative percentages of area impacted by the causes of limiting factors in the Lake Walcott watershed for terrestrial resources (ICBEMP 1997[a]).

Causes of Limiting Factors	Very Low	Low	Medium	High	Very High
Human population density	($x < 1$)	($1 < x > 10$) 42	($10 < x > 60$) 40	($60 < x < 100$) 9	($100 < x > 300$) 9
Habitat fragmentation		16	48	22	14
Altered fire regime		1	19	40	
Timber harvest (95% no harvest)		2	3	<1	
Grazing/browsing (34% no grazing or status unknown)		66			

[a] For information about ICBEMP data limitations, see Appendix 2-1.

3.1.2.12 Willow (WIL)

Willow Creek is listed by the Natural Resources Conservation Service as one of the most serious soil erosion areas in the United States (NRCS 2001). Nearly every segment of the stream is on Idaho's 303(d) list. The Willow Creek drainage has significant impacts to riparian areas, increased fine sediment loads and channel alterations, and increased width to depth ratios because of bank instability and the fine sediment load (Table 3-8). There are about 300 points of water diversion in the Willow watershed. The headwaters are on public land, but the majority of the drainage is privately owned. The drainage still supports core populations of Yellowstone cutthroat trout. Willow Creek downstream of Ririe Reservoir is dewatered during winter, a condition that prevents the occurrence of stable populations of Yellowstone cutthroat trout.

The Willow watershed lies just east of Idaho Falls and has a population flux resulting from the sprawl of that nearby area. This watershed is heavily used for agriculture, resulting in habitat fragmentation being a higher cause for limiting factors than population is (Table 3-20). Some timber is harvested in the watershed, and effects may be significant at the watershed level, especially where timber harvest activity occurs adjacent to waterways. Grazing is not a large concern as a cause of limiting factors because most of the watershed is not grazed, and the grazing that occurs seems to have a low impact (Table 3-20 and Appendix 3-1).

Table 3-20. Comparison of the relative percentages of area impacted by the causes of limiting factors in the Willow watershed for terrestrial resources (ICBEMP 1997[a]).

Causes of Limiting Factors	Very Low	Low	Medium	High	Very High
Human population density	($x < 1$)	($1 < x > 10$) 28	($10 < x > 60$) 53	($60 < x < 100$) 17	($100 < x > 300$) 1
Habitat fragmentation		<1%	77	17	6
Altered fire regime		5	33	34	
Timber harvest (22% no harvest)		48	5	25	
Grazing/browsing (67% no grazing or status unknown)		20	12	1	

[a] For information about ICBEMP data limitations, see Appendix 2-1.

3.1.3 Closed Basin Subbasin

The Closed Basin subbasin is characterized by high desert ecosystem types, with some transition to juniper and pine forest types occurring at higher elevations. The environment is typically dry, with hot summers and cold, windy winters. Riparian resources within the subbasin vary by watershed, but there are consistent problems with low flow waters and exotic species (Table 3-21). We discuss watersheds individually in context with both riparian and terrestrial causes for limiting factors.

Causes of terrestrial limiting factors by watershed (Table 3-22, Table 3-23, Table 3-24, Table 3-25, and

Table 3-26) show impacts to focal habitats and species. at the watershed level. Dominant concerns in the Closed Basin subbasin include altered fire regime and habitat fragmentation. Altered fire regime is characteristically moderate to high, primarily due to over 100 years of intense fire suppression that created a greater potential for large, devastating fires. Currently, on the high desert, seasonal wildfires sparked by humans or dry lightning burn large tracts of land each year. This disturbed land is of primary concern for invasion of noxious and exotic weeds, such as cheatgrass. Cheatgrass is highly flammable in summer months and thrives from frequent burns, while other native vegetation is inhibited. Habitat fragmentation in this watershed is largely a function of agriculture, with the Snake River and interstate corridors being highly developed. Water supply concerns are at heightened levels in recent years, mainly due to many sequential years of below-average precipitation in combination with consistent increases in water consumption due to agricultural development (including an increased dependence on environmentally inefficient irrigation techniques such as sprinkler irrigation). Water rights users sometimes demand an increase in water diversions for consumptive use, and such increases dewater rivers, degrading the quantity and extent of pre-existing terrestrial habitats.

Table 3-21. Ranked impacts of altered ecosystem features impacting habitat quality and quantity for focal fish species in tributaries to the 5 watersheds of the Closed Basin subbasin. Degree of impact on habitat quality or quantity ranked as P (component is functioning properly, needs protection), 1 (least influence), 2 (moderate influence), and 3 (greatest influence, highest priority).

Ecosystem Feature	Altered Component	Beaver–Camas	Birch	Big Lost	Little Lost	Medicine Lodge
Channel structure	Floodplain	P	P	P	P	P
	Pool/riffle ratio	P	P	P	P	P
	Large woody debris	P	P	P	P	P
Hydrology	Discharge	P	P	3	3	P
	Low flow/ dewatering	3	3	3	3	P
Sediment	Increased fines	3	2	2	2	3
Water quality	Temperature	P	P	2	P	P
Riparian	Shade	3	2	2	2	P
	Streambank stability	3	2	2	2	P
Exogenous	Reservoir operations	P	P	3	P	P
	Barriers	P	P	P	3	P
	Exotics	3	P	P	3	3

3.1.3.1 Beaver–Camas (BCM)

This upper end of the Beaver–Camas watershed is considered to be in good shape despite some localized grazing impacts. Nonnative species (rainbow trout and brook trout) are a concern for the long-term persistence of Yellowstone cutthroat trout. In the lower end of the watershed, water diversions significantly reduce flows, riparian areas have been altered through land use, and increased sediment reduces habitat quality (Table 3-21). There are about 900 points of water diversion in the watershed.

There is significant habitat fragmentation in the watershed, mainly a function of agricultural development and, to some degree, grazing (Appendix 3-1). Some timber harvest occurs in the higher elevations and to the north in this watershed, and effects of this harvest may be of concern for causes of limiting factors (Table 3-22). All of these causes of limiting factors may contribute to increased risk of a fire (Figure 3-15).

Table 3-22. Comparison of the relative percentages of area impacted by the causes of limiting factors in the Beaver–Camas watershed for terrestrial resources (ICBEMP 1997[a]).

Causes of Limiting Factors	Very Low	Low	Medium	High	Very High
Human population density	(*x* < 1)	(1 < *x* > 10) 79	(10 < *x* > 60) 19	(60 < *x* < 100) 1	(100 < *x* > 300)
Habitat fragmentation		4	46	50	
Altered fire regime		6	32	52	
Timber harvest (19% no harvest)		14	55	12	
Grazing/browsing (14% no grazing or status unknown)		70	22	4	

[a] For information about ICBEMP data limitations, see Appendix 2-1.

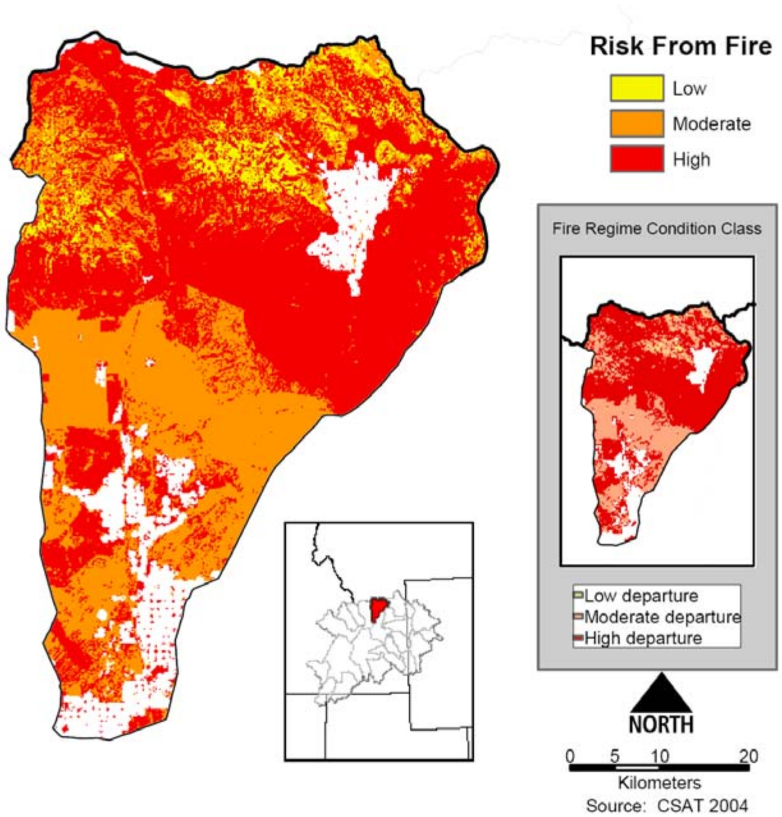

Figure 3-15. Predicted areas within the Beaver–Camas watershed, Closed Basin subbasin, most likely to be at risk for severe fire effects, taking into account fire regime condition class, ignition probability, and fire weather hazard. Ecosystems-at-risk integrates ignition probability, fire weather hazard, rate-of-spread, and fire regime condition class (the probability of severe fire effects). Source: Northern Regional National Fire Plan Cohesive Strategy Assessment Team, Flathead National Forest (CSAT 2004).

3.1.3.2 Birch Creek (BCK)

The Birch Creek watershed has no native salmonids. The shorthead sculpin is thought to be the only fish native to the watershed. The watershed has some localized grazing impacts, increased sedimentation, and altered riparian areas from land use (Table 3-21). Currently, the stream is seasonally dewatered at the lower end. An estimated 100 water diversions occur within the watershed.

The main sources for population in the Birch Creek watershed are a result of agricultural development, and population and habitat fragmentation are moderate causes of limiting factors (Table 3-23). There is some timber harvest activity, but it is strongly restricted by the occurrence of timber. Although most of the watershed is grazed and much of the grazing is by cattle, the grazing status for about 32% of the watershed is unknown (Figure 3-16 and Appendix 3-1). Moreover, most of the watershed is rated highly vulnerable to grazing and browsing impacts by domestic animals.

Table 3-23. Comparison of the relative percentages of area impacted by the causes of limiting factors in the Birch Creek watershed for terrestrial resources (ICBEMP 1997[a]).

Causes of Limiting Factors	Very Low	Low	Medium	High	Very High
Human population density	($x < 1$)	($1 < x > 10$) 15	($10 < x > 60$) 83	($60 < x < 100$) 2	($100 < x > 300$)
Habitat fragmentation		12	88	<1%	
Altered fire regime		11	57	28	
Timber harvest (79% no harvest)		21			
Grazing/browsing (10% no grazing)		51	39		

[a] For information about ICBEMP data limitations, see Appendix 2-1.

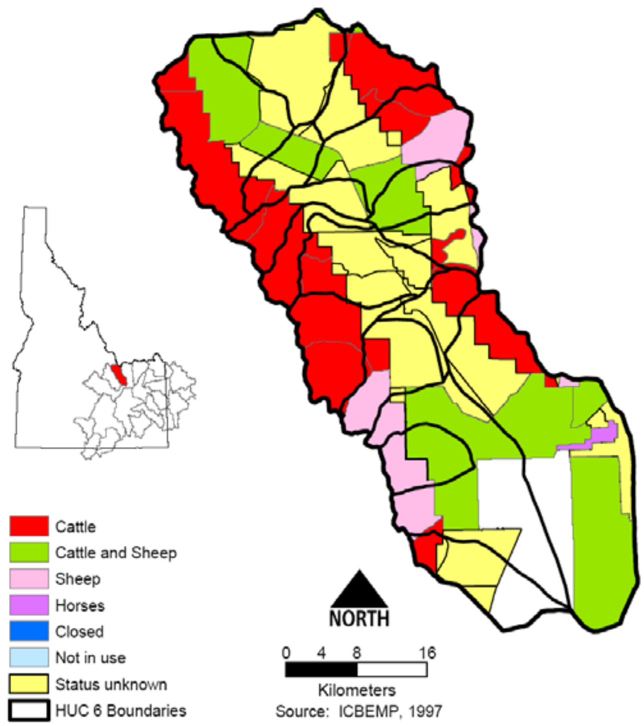

Figure 3-16. Status of grazing and browsing by domestic animals in the Birch Creek watershed, Closed Basin subbasin, Idaho (ICBEMP 1997).

3.1.3.3 Big Lost River (BLR)

Mountain whitefish are the only native salmonid in the watershed, and they have suffered substantial declines in recent years. Dewatering from water diversions and altered discharge regimes from Mackay Dam are the primary concerns in this watershed (Table 3-21). Numerous reaches are completely dewatered, a problem that is exacerbated by the natural geology of the area, as well as water withdrawals. There are about 3,800 water diversions (Figure 3-17) and an unknown number of road culverts in the Big Lost River watershed.

Mountain whitefish have also declined in areas higher in the drainage that are not dewatered, but these areas are thought to be marginal habitat for mountain whitefish, habitats that are used when populations are large and more suitable habitat is needed.

Historically, the Big Lost River flowed seasonally onto a series of playas on the Big Desert, where it would then drain through highly fractured basalts and enter the groundwater system. Currently, the stream is completely dewatered seasonally, and the natural playa system is no longer watered on a regular basis.

There is a moderate degree of agriculture in this area, resulting in a moderate degree of habitat fragmentation as a cause of limiting factors in the watershed (Table 3-24). There is no extensive timber harvest and there are no extensive effects from grazing. While most of the area is allotted for grazing, it is unclear how or for what the allotments are used, a situation that complicates this assessment (Appendix 2-1 and Appendix 3-1).

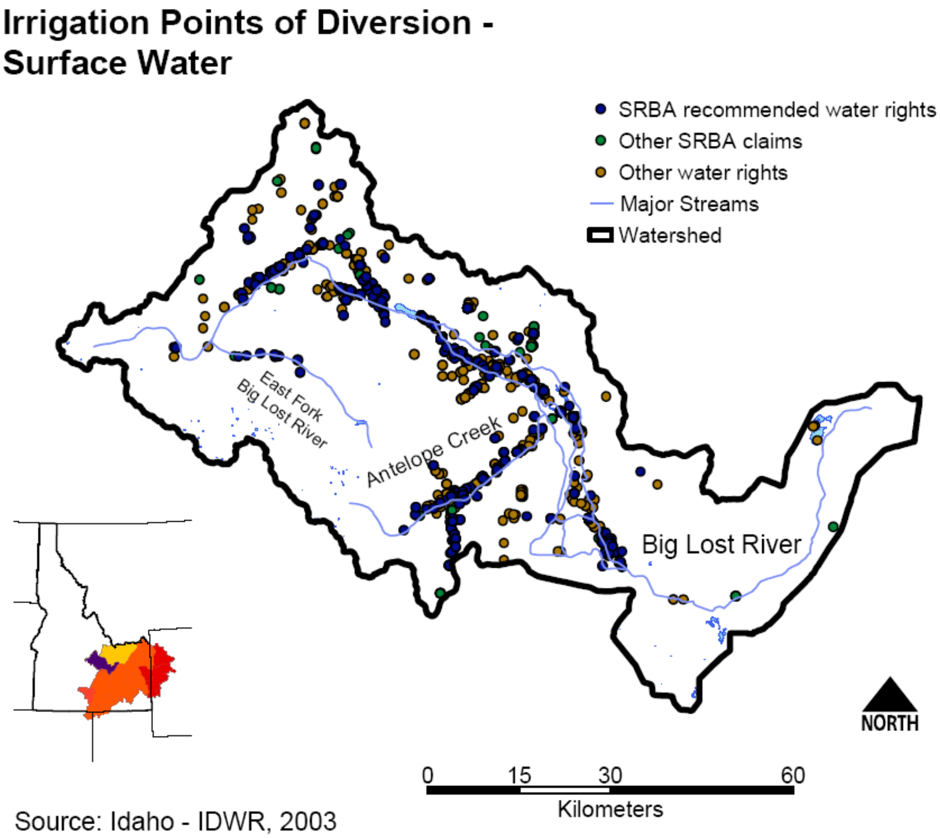

Figure 3-17. Idaho Department of Water Resources points of water diversions in the Big Lost River watershed, Closed Basin subbasin.

Table 3-24. Comparison of the relative percentages of area impacted by the causes of limiting factors in the Big Lost River watershed for terrestrial resources (ICBEMP 1997[a]).

Causes of Limiting Factors	Very Low	Low	Medium	High	Very High	Extremely High
Human population density	(x < 1)	(1 < x > 10) 21	(10 < x > 60) 67	(60 < x < 100) 10	(100 < x > 300) 1	(x > 300) <1%
Habitat fragmentation		30	63	7		
Altered fire regime		19	61	11		
Timber harvest (62% no harvest)		14	11	12		
Grazing/browsing (26% no grazing or status known)		40	27	7		

[a] For information about ICBEMP data limitations, see Appendix 2-1.

3.1.3.4 Little Lost River (LLR)

Habitat conditions in the Little Lost River watershed have been improving over the last 10 years, especially in areas where bull trout are found. The biggest threats to long-term persistence of bull trout in this watershed are nonnative species (i.e., brook trout) and isolation and small population sizes. The Wet Creek population has declined severely, but the cause of the decline is unknown. The Badger/Williams creek populations are isolated by dewatering from stream withdrawal, and access to additional habitat has been blocked by legacy mine effects (Table 3-21). Approximately 650 points of water diversion are present in the watershed. Riparian impacts and water diversions are secondary concerns throughout the remainder of the watershed (except Badger/Williams Creek).

The Little Lost River watershed has no large population centers, and its relatively low population density results from agricultural development. This development results in a moderate effect for habitat fragmentation as a cause of limiting factors (Table 3-25. Grazing is also a moderate cause for limiting factors. While most of the area is allotted for grazing, it is unclear how or for what the allotments are used, a situation that complicates this assessment (Appendix 2-1 and Appendix 3-1).

Table 3-25. Comparison of the relative percentages of area impacted by the causes of limiting factors in the Little Lost River watershed for terrestrial resources (ICBEMP 1997[a]).

Causes of Limiting Factors	Very Low	Low	Medium	High	Very High
Human population density	($x < 1$)	($1 < x > 10$) 15	($10 < x > 60$) 77	($60 < x < 100$) 8	($100 < x > 300$)
Habitat fragmentation		31	56	13	
Altered fire regime		15	60	16	
Timber harvest (54% no harvest)			33	13	
Grazing/browsing (2% no grazing or status unknown)		49	46	2	

[a] For information about ICBEMP data limitations, see Appendix 2-1.

3.1.3.5 Medicine Lodge (MDL)

The Medicine Lodge watershed is considered to be in good shape. A fire in the upper part of the watershed is a concern for increased sediment impacts. Nonnative species are a concern for the long-term persistence of Yellowstone cutthroat trout populations in the drainage (Table 3-21). Still, there are approximately 500 points of water diversion in the watershed.

The Medicine Lodge watershed has a few notable population centers, including the towns of Spencer, Dubois, and Hamer. These towns provide a small increase in concern for causes of limiting factors due to population density. The economy in this area is dominantly driven by agriculture, as reflected by habitat fragmentation as a cause for limiting factors. There is some timber harvest, and where timber harvest occurs, it has a moderate to high effect on ecosystem integrity. Finally, the entire watershed is grazed by domestic animals (Table 3-26); however, the status of this grazing is unknown for about 43% of the watershed (Figure 3-18 and Appendix 3-1).

Table 3-26. Comparison of the relative percentages of area impacted by the causes of limiting factors in the Medicine Lodge watershed for terrestrial resources (ICBEMP 1997[a]).

Causes of Limiting Factors	Very Low	Low	Medium	High	Very High
Human population density	($x < 1$)	($1 < x > 10$) 10	($10 < x > 60$) 84	($60 < x < 100$) 6	($100 < x > 300$)
Habitat fragmentation		20	46	34	
Altered fire regime		5	37	36	
Timber harvest (71% no harvest)			19	10	
Grazing/browsing or status unknown		71	29		

[a] For information about ICBEMP data limitations, see Appendix 2-1.

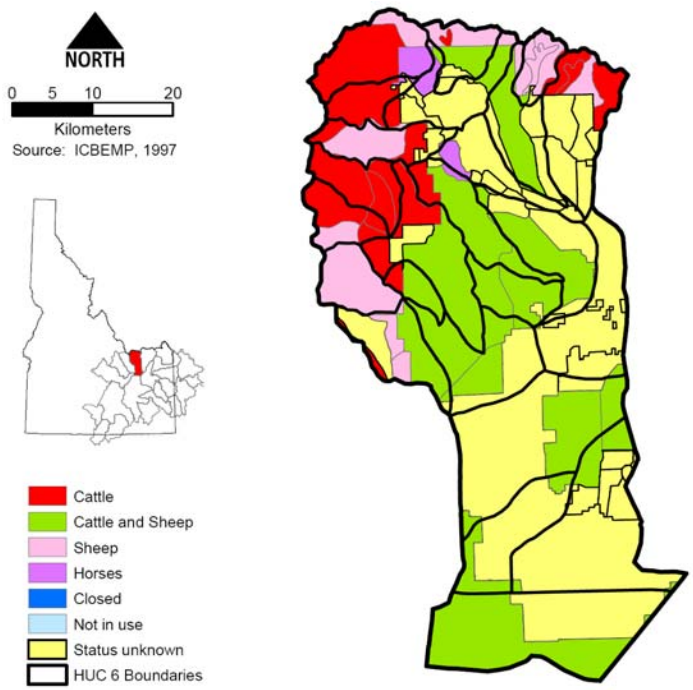

Figure 3-18. Status of grazing and browsing by domestic animals in the Medicine Lodge watershed, Closed Basin subbasin, Idaho (ICBEMP 1997).

3.2 Out-of-Basin Effects

3.2.1 Aquatic Resources

Dams within the Upper Snake and Snake Headwaters subbasins are operated to meet irrigation needs and generate electricity. Most of the points of use for irrigation water are within the subbasins, but the hydropower generated within the subbasins is part of the larger generating networks of the Federal Columbia River Power System (FCRPS), Idaho Power Company, PacifiCorp, other private entities, and rural cooperatives. Due to the interconnected nature of the power systems, reservoir operations for power production are influenced by power needs and generating capacities within and outside the subbasins. In addition to power generation, water from the upper Snake River basin (i.e., upstream of Lower Granite Dam) is used for flow augmentation for salmon migration in the lower Snake and Columbia rivers. Approximately 427,000 acre-feet of water are provided annually by the U.S. Bureau of Reclamation to meet flow-augmentation requirements of the 2000 biological opinion (NMFS 2000). The Bureau of Reclamation is obligated to ensure a high likelihood of providing this amount of water each year. To attain the requirement of 427,000 acre-feet, the Bureau of Reclamation has initiated a program to acquire reservoir storage space and natural flow rights throughout the drainage above Lower Granite Dam. This water can come from anywhere in the Snake River basin, including reservoirs in the Upper Snake or Snake Headwaters subbasins.

We were unable to identify any out-of-basin effects in the Closed Basin subbasin.

3.2.2 Terrestrial Resources

For terrestrial assessment purposes, out-of-basin effects in the Upper Snake province are discussed in terms of the following categories:

- Noxious weeds
- Insect and disease outbreaks—natural and unnatural
- Invasive exotic wildlife
- Habitat loss and linkages
- Genetic linkages
- Development
- Climate cycles—short term and long term

3.2.2.1 Noxious and Invasive Exotic Weeds

The issues of noxious and invasive exotic weeds and the effects they are having on the Upper Snake province have been discussed in detail in other sections (section 1.7.4, Appendix 1-6 and in Appendix 3-1, section 6). Regarding noxious weeds in the Upper Snake province, out-of-basin effects result from the influx of people, livestock, and equipment into the subbasin for various occupational or recreational activities (Karl *et al*. 1996). The Upper Snake province is recognized by many as a premier recreational destination because of its fishing, hunting, and water sports opportunities. The rapid spread of many noxious weeds in the Upper Snake province can be primarily attributed to human activities that bring "contaminated" equipment, gear, livestock, and livestock supplies into the subbasin from other areas (Karl *et al*. 1996, NISC 2003). State, federal, and nongovernmental organizations are collaborating to document and track the spread of noxious weeds (USNAL 2004). The science of invasive species management seeks to develop management tools, technologies, and strategies to effectively control noxious weeds at the appropriate landscape scales (TNC 2003).

3.2.2.2 Insect and Disease Outbreaks

Both insect and disease outbreaks are natural and common events in the Upper Snake province. Generally, most insect infestations are localized occurrences that have little impact or ramifications at larger scales (Amman and Cole 1983). However, given the altered functionality of some aspects of the environment, each additional disruption of ecological function becomes cumulative and leads to further decline of environmental integrity (section 2.4).

Deleterious disease outbreaks in the form of whitebark pine blister rust are discussed in detail in section 2.3.6. Regarding insect and disease outbreaks in the Upper Snake province, out-of-basin effects may be discussed in terms of vectors and pathways (NISC 2003). Pathways are the means by which species are transported from one location to another. Natural pathways include wind, air and water currents, and other forms of dispersal that specific species have developed morphologically and behaviorally (NISC 2003). Manmade pathways are those that are enhanced or created by human activity. These are characteristically of two types (NISC 2003).

The first type is intentional or the result of a deliberate action to translocate an organism. Examples of intentional introductions include the intended movement of living seeds, whole plants, or pets. A specific intentional pathway can only be judged by the positive or negative impact of the organisms being moved (NISC 2003).

The second type is the result of unintentional movement of organisms. Examples of unintentional pathways are ballast water discharge (e.g., red-tide organisms), soil associated with the trade of nursery stock (e.g., fire ants), fruit and vegetable importation (e.g., plant pests), and the international movement of people (e.g., pathogens). In these and countless other unintentional pathways, the movement of species is an indirect byproduct of our activities (NISC 2003).

For the purposes of the National Invasive Species Council (NISC), the term "vector" is viewed as a biological pathway for a disease or parasite (i.e., an organism that transmits pathogens to various hosts) and is not completely synonymous with the much broader definition of a pathway (NISC 2003).

3.2.2.3 Invasive Exotic Wildlife

Invasive exotic wildlife may have significant impacts on aquatic and terrestrial habitats and species of the Upper Snake province. Two species of exotic wildlife with potential negative impacts to the province watersheds include the New Zealand mudsnail and bullfrog.

Around 1986, the New Zealand mudsnail was most likely introduced to Idaho from imported products at a fish hatchery near Hagerman, Idaho, from which it was widely disseminated through trout stocking (Bowler 1991). This western American strain is clonal and apparently did not bring the normally associated trematode parasites with it. Without its natural enemies, the mudsnail has spread uncontrolled through some of the most productive waters in North America (Bowler 1991). The mudsnail has a tremendous propensity to populate its environment rapidly, and upward of 700,000 mudsnails per square meter have been found in some waters. The mudsnail does not appear to be self-limiting from density-dependent effects. Sheer numbers of the mudsnail dominate the base of the food web, and they can consume over 80% of a river's productivity (Bowler 1991). Introduced predators such as the bullfrog can have devastating effects on faunas that evolved without equivalent predatory types (Schwalbe and Rosen 1988). The bullfrog, as an exotic in the absence of key original enemies (the basses, pikes, snapping turtles, and water snakes of the eastern United States), attains tremendous population densities. Such nonnative predators, in core population areas of native species, can lead to regional extinctions and may account for some unexplained amphibian declines (Schwalbe and Rosen 1988).

3.2.2.4 Habitat Losses and Linkages

Wildlife habitat losses due directly to the construction of Palisades and Minidoka dams have been identified in the BPA Wildlife Mitigation Program. Although mitigation for lost fish and wildlife habitats and populations has been primarily focused on terrestrial habitats, identified and quantified wildlife habitat mitigation for these projects is incomplete. Resident fish losses due to the construction and inundation of these two projects have not been mitigated for. Although habitat loss assessments and mitigation efforts have occurred in downstream sections of the lower Snake River, both direct and secondary/indirect fish and wildlife habitat and population losses in the Upper Snake province have not been assessed or mitigated for. We provide a resident fish loss assessment for Palisades and Minidoka projects in this assessment. The Northwest Power and Conservation Council has a funding process whereby terrestrial and aquatic habitats can potentially receive funding for restorative work. However, the aquatic and terrestrial components of the landscape in the Upper Snake province, although undermitigated and under assessed, have received comparatively little funding (NPCC 2004).

Maintaining wild habitats that support the long-term survival of native wildlife populations throughout the Columbia River basin and providing for the continued course of the region's large-scale evolutionary and ecological processes require scientific and conservation action at the continental scale (Noss and Soule 1998, Robinson *et al*. 2004).

Habitat fragmentation has been recognized as a major threat to the survival of natural populations and the functioning of ecosystems. The reduction of large, more or less continuous habitats to small and isolated patches may affect the abundance and species composition of populations living in the area (Martin *et al*. 2000). Some factors that may contribute to this decline include changes in predation or food availability, microclimatic effects, loss of genetic variation, and lack of recolonization following local extinctions (Noss and Soule 1998, Robinson *et al*. 2004).

Unfortunately, the effects of this widespread habitat fragmentation on populations remain unknown. Further, some of the species affected may be dominant carnivores and act as "keystone predators." These carnivores are species whose removal dramatically alters the composition of ecological communities by resulting in the decline and extinction of some species and marked increases in others (Noss and Soule 1998, Carroll *et al.* 2001, Robinson *et al*. 2004).

Although certain species have much more influence than others do on an ecosystem's structure, not all ecosystems include a single species that exerts such a pervasive influence. In fact, most ecosystems are somewhat sensitive to the loss of any one of many species, though some losses have greater impact on the system than others (Noss and Soule 1998, Woodroffe and Ginsberg 1998, Gittleman *et al*. 2001, Mattson and Merrill 2002, Robinson *et al*. 2004).

One of the approaches that conservation biology implements to mitigate the effects of habitat fragmentation is the development of habitat reserves and wildlife corridors. All species require a minimum amount of habitat for survival. Wildlife habitat reserves are established to meet these requirements for as many species as possible. Some national parks, wilderness areas, and other protected habitats are suitable for the survival of a wide range of species (Noss and Soule 1998, Haila 1999, Robinson *et al*. 2004). Maintaining connectivity or “linkage” between wildlife populations across the landscape will make for healthier populations and could prevent many of the detrimental consequences of habitat fragmentation. Maintaining opportunities for wildlife movement across the landscape preserves the natural processes that animals have used for centuries (Servheen and Sandstrom 1993, Ruediger *et al*. 1999, Ruediger *et al*. 2000).

The physical representation of a subbasin or watershed is defined primarily by the geomorphology of the landscape and secondarily by humans seeking to understand complex ecosystem structure and function in a context that is comprehensible. The functional components of the landscape do not necessarily “recognize” the anthropogenic or natural boundaries that are used to describe the environment. Habitat fragmentation, either natural or anthropogenic, may become an out-of-basin effect, if a specific functional components becomes limited outside of the subbasin, thereby increasing the importance or significance of that component inside the subbasin.

3.2.2.5 Genetic Linkages

Other effects of habitat fragmentation can be changes in population structure resulting from changes in dispersal patterns. As fragmentation proceeds, dispersal from one habitat fragment to another becomes more difficult. Many studies have addressed the threats to the small populations resulting from the fragmentation of formerly large populations (Noss 1991). The basic idea is that local populations become separated so widely that their demography and genetic dynamics become independent of one another, a situation that may eventually lead to local extinctions and/or loss of genetic variation (Noss and Soule 1998, Robinson *et al*. 2004).

Regional groups of interconnected populations are called metapopulations. These metapopulations are connected to one another over broader geographic ranges. As local populations within a metapopulation fluctuate in size, they become vulnerable to extinction during periods when their numbers are low. Extinction of local populations is common in some species, and the regional persistence of such species is dependent on the existence of a metapopulation (Flather *et al*. 1998). As a result, the elimination of a portion of the metapopulation structure of some species can increase the chance of regional extinction of the species (Noss and Soule 1998, Robinson *et al*. 2004).

Out-of-basin losses of metapopulation structure may have important ramifications to aquatic and terrestrial components of the landscape within the Upper Snake province.

It is relatively easy to comprehend the significance of the loss of prominent species such as the Chinook salmon or grizzly bear. It is much more difficult to comprehend the role that less conspicuous species have in metapopulation structure and ecosystem function. Conserving genetic diversity at landscape scales is essential because genetic variation allows species to adapt and survive environmental changes (Noss and Soule 1998, Robinson *et al*. 2004).

Ecosystem diversity is thought of as the broadest means for protecting species diversity and genetic diversity (Noss 1983). To protect an ecosystem, all the species within that ecosystem must be protected

(Groves *et al*. 2002). Populations of many species are not completely isolated but are connected by the movement of individuals (immigration and emigration). Consequently, the dynamics and evolution of many local populations are determined by both the populations' life histories and individuals' patterns of movement between populations (Noss and Soule 1998, Robinson *et al*. 2004).

3.2.2.6 Development

Human impacts on wildlife and habitats have been accelerated in the Upper Snake province because of development of federal hydropower projects in the Columbia River basin. Having a reliable and affordable power source, irrigation water supply, and employment opportunities provided impetus for development of agriculture and other industry (NPCC 2003).

This development has led to increased human disturbance of wildlife populations, increased human use of wildlife, and accelerated habitat losses across the Upper Snake province. Extirpation of anadromous fishes in adjacent provinces has led to increased harvest pressure on wildlife for subsistence and cultural and recreational uses in the Upper Snake province. Factors limiting terrestrial resources in the Upper Snake province are dominated by modification of forested stands through timber management and combined effects of mining, grazing, agriculture, and residential development, including roads (NPCC 2003). Development, including agriculture, has converted 2.9% of lands in the Upper Snake province to unvegetated habitats (IBIS 2003).

An artifact of continued development outside of the Upper Snake province is the increased effect the populaces of those out-of-basin provinces have within the Upper Snake province. A domino effect of sorts occurs as development in this province places greater demand for resources in adjacent subbasins.

While difficult to quantify, the indirect effects of hydropower development can be far-reaching. Mitigation for these effects seeks to address a broad array of habitats and species. Protection of existing high-value habitats and restoration of habitats are viewed as primary goals (NPCC 2003).

3.2.2.7 Climate Cycles

Climatic variation is identified as an out-of-basin effect since research is beginning to show that land-use practices can influence regional climate and vegetation in adjacent natural areas in predictable ways (Pielke *et al*. 1994, Stohlgren *et al*. 1998). Northern ecosystems are expected to be particularly sensitive to climatic changes. In addition, climatic changes are predicted to be most pronounced in the North, with implications for biodiversity, annual growth pattern, forage quality, and carrying capacity for terrestrial species (UNEPWCMC 2004). Climate change is likely to have considerable impacts on most or all ecosystems. The distribution patterns of many species and communities are determined, to a large degree, by climatic parameters, but the responses to changes in these parameters are rarely simple (UNEPWCMC 2004).

At the simplest level, changing patterns of climate will change the natural distribution limits for species or communities. In the absence of barriers, it may be possible for species or communities to migrate in response to changing conditions. Vegetation zones may move toward higher latitudes or higher altitudes following shifts in average temperatures. In most cases, natural or manmade barriers will impact the natural movement of species or communities (UNEPWCMC 2004).

Rainfall and drought will also be of critical importance. Extreme flooding will have implications for large areas, especially riverine and valley ecosystems. Rates of change will also be important, and these rates will vary at regional and even local levels. The maximum rates of spread for some sedentary species, including large tree species, may be slower than the predicted rates of change in climatic conditions (UNEPWCMC 2004). In many cases, further complications will arise from the complexity of species interactions and differential sensitivities to changing conditions among species. Certain species may rapidly adapt to new conditions and act in competition with others (UNEPWCMC 2004). Negative impacts may include increased ranges of insect pests and diseases, as well as failure of crops in some regions from drought or flooding (UNEPWCMC 2004).

Mesoscale atmospheric/land-surface modeling, short-term trends in regional temperatures, forest distribution changes, and hydrology data indicate that the effects of land-use practices on regional climate may overshadow larger-scale temperature changes commonly associated with observed increases in carbon dioxide and other greenhouse gases (Pielke *et al.* 1994, Stohlgren *et al*. 1998).