APPENDIX 3-1—OVERVIEW OF THE MAJOR CAUSES LIMITING THE HABITATS AND FISH AND WILDLIFE IN THE BOISE, PAYETTE, AND WEISER SUBBASINS

1 Background

The Boise, Payette, and Weiser subbasins have many causes limiting the habitats and fish and wildlife—the intensity of which varies with geography. Expressions of causes can be complex. The purpose of this section is to address some of the major causes of limiting factors in the Boise, Payette, and Weiser subbasins. Attempts have been made to address local and global variability of each cause; however, geographic, economic, temporal, and political barriers restrict how much can actually be done in this context. Where applicable, the limitations of each source of spatial data include a statement of limitations, which is located in Appendix 1-2 of this assessment. This assessment identifies six causes of limiting factors affecting wildlife habitat in the Boise, Payette, and Weiser subbasins (Table 1 and Table 2). These causes include 1) altered hydrologic regimes (impoundments, channel modifications, and diversions), 2) invasive and exotic species introductions, 3) land-use conversion (both urban and agricultural), 4) altered fire regimes (primarily fire suppression practices), 5) grazing/browsing by livestock, and 6) timber harvest. These six causes have altered the composition and distribution of the four focal habitats and the species with which they are associated in the Boise, Payette, and Weiser subbasins. This alteration is illustrated by comparing the current (see Figure 2-16 in the assessment) and historical (see Figure 2-17 in the assessment) occurrences of the four focal habitats in the three subbasins.

Table 1. Focal habitats and their associated causes of limiting factors[a] in the Boise, Payette, and Weiser subbasins, as identified by the technical team.

Focal Habitat	Altered Fire Regime	Grazing/ Browsing	Altered Hydrologic Regime	Timber Harvest	Land-use Conversion	Invasive/ Exotics
Riparian/herbaceous wetlands		X	x	x	x	X
Shrub-steppe	x	X	x	X	x	X
Pine/fir forest (dry, mature)	x		x	X	x	X
Interior mixed conifer	x	X	x	x	x	X

[a] The capital X represents a larger impact, while the lowercase x represents a lesser impact.

It is not always easy to clearly quantify or qualify the impacts of limiting factors on focal habitats or wildlife species. Difficulties encountered in the analysis of limiting factors for each habitat type and by watershed were due, in part, to information gaps, differences in information collection methods and/or interpretation, and limitations to data (Appendix 1-2). Therefore, this assessment relies on information gleaned from data sets and expert opinion. Relative rankings of impacts of limiting factors from terrestrial and fisheries technical teams suggest that the Weiser and Payette watersheds, followed by the Lower Boise, Boise–Mores, and South Fork Boise watersheds, are impacted the most by the six causes of limiting factors mentioned earlier (Table 2).

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

Watershed[a]	Altered Fire Regime	Grazing/ Browsing	Altered Hydrologic Regime	Timber Harvest	Land-Use Conversion	Invasive/ Exotics
NMB	3	1	3	1	1	2[b]
BMO	3	2	3	2[b]	3	3
SFB	3	3	3	2[b]	1	3
LBO	3	3	3	1	3	3
SFP	3	1	1	1	0	3
MFP	3	1[b]	1	2	1	2
PAY	3	3	3	2	3[b]	3
NFP	3	1	3	1[b]	3	3
WEI	3	3	3	2	3	3

[a] NMB = North and Middle Fork Boise, BMO = Boise–Mores, SFB = South Fork Boise, LBO = Lower Boise, SFP = South Fork Payette, MFP = Middle Fork Payette, PAY = mainstem Payette, NFP = North Fork Payette, and WEI = Weiser.
[b] More information is necessary to confirm this rating.

2 Causes of Limiting Factors

2.1 Altered Hydrologic Regime

Hydrologic regimes play a major role in determining the biotic composition, structure, and function of aquatic, wetland, and riparian ecosystems. In recent decades, growing concern for the protection of biological diversity has led to increased scrutiny of the consequences of human-induced hydrologic alteration to natural ecosystems (Richter *et al.* 1996). Both natural events and human activities affect watersheds. Natural events such as storms, fires, and droughts can suddenly alter watershed conditions at large scales. Individual human activities typically have smaller and more predictable impacts, but their cumulative impact can be far greater. Increases in population, land development, and economic activity increase demands for water, waste disposal, and raw materials (Meiman and Schmidt 1994). These activities increase pollutant releases to water and air and degrade or fragment natural habitats (USEPA 2001). This assessment focuses on the impacts of anthropogenic alterations to the Boise, Payette, and Weiser subbasins' hydrologic regime.

An estimated 62% of area in the Boise, Payette, and Weiser subbasins is highly impacted by anthropogenic alterations to hydrologic regimes (Table 3). The most severely impacted watersheds in the Boise, Payette, and Weiser subbasins are the Lower Boise, Payette, Weiser, and North Fork Payette watersheds (Figure 1). In the Boise subbasin, the Lower Boise, Boise–Mores, and South Fork Boise watersheds appear to have the most severe impacts, as do the Payette and the North Fork Payette watersheds in the Payette subbasin. The entire Weiser subbasin appears to be severely impacted by altered hydrologic regimes. Because of their dependence on and relationship with hydraulic systems, riparian/herbaceous wetlands are of particular interest in the context of altered hydrologic regimes (Table 4). See Appendix 1-2 for statements about data limitations.

Table 3. Relative percentages of area impacted by altered hydrologic regimes in the Boise, Payette, and Weiser subbasins (ICBEMP 1997).

Relative Category	Major Hydrologic Unit (Watershed)									
	NMB	BMO	SFB	LBO	SFP	MFP	PAY	NFP	WEI	Estimated Area (km^2)
Very high			2	20			19	19	21	2,774
High	30	71	25	64	10	50	61	49	74	11,858
Medium		8	7	8	6		4	19	1	1,417
Low	24	4	23	8	33	39	16	8	3	3,483
Very low	45	18	43		51	11		4		3,908

Table 4. Relative percentages of impacts to focal habitats by altered hydrologic regimes in the Boise, Payette, and Weiser subbasins (GAP II Scott *et al*. 2002).

Focal Habitat	Very High	High	Medium	Low	Very Low
Riparian/herbaceous wetlands	18	49	7	12	15
Shrub-steppe	11	46	5	19	19
Pine/fir forest (dry, mature)	13	69	3	13	3
Interior mixed conifer	4	37	5	23	31
Other	14	54	7	11	14
Total area (km^2)	**2,773**	**11,857**	**1,416**	**3,483**	**3,906**

Farm, forestry, and other rural road construction; streamside vehicle operation; and stream crossings can result in significant soil disturbance and also create a high potential for increased erosion processes and sediment transport to adjacent streams and surface waters. Road construction involves activities such as clearing existing native vegetation along the road right-of-way; excavating and filling the roadbed to the desired grade; installing culverts and other drainage systems; and installing, compacting, and surfacing the roadbed.

Although most erosion from roadways occurs during the first few years after construction, significant impacts may result from maintenance operations using heavy equipment, especially when the road is located adjacent to a water body. In addition, improper construction and lack of maintenance may increase erosion processes and the risk for road failure (USEPA 2001).

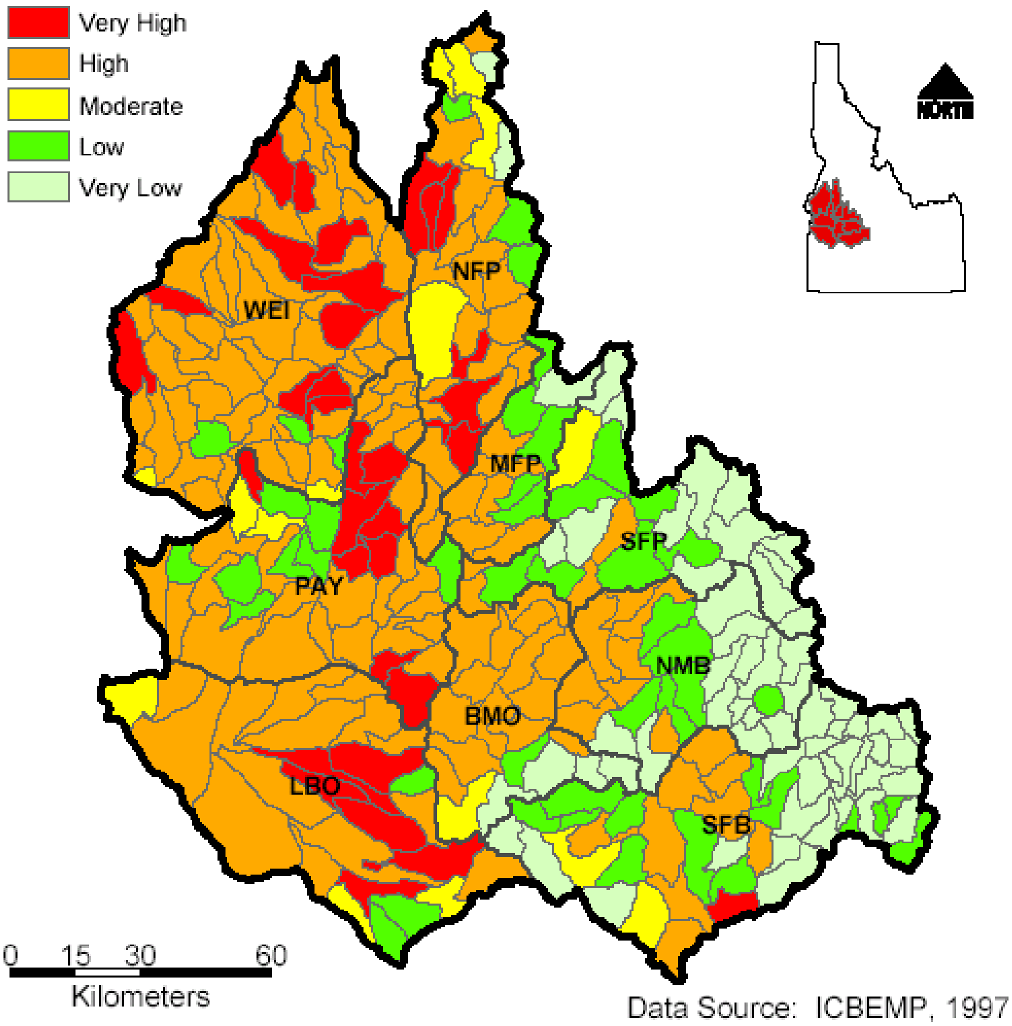

Figure 1. Relative impacts of altered hydrologic regimes in the Boise, Payette, and Weiser subbasins (ICBEMP 1997).

Hydromodification

Stream flow fluctuations and stream barriers can affect many plant and animal species (USFS 1994). These changes can also affect recreational opportunities. Hydromodification is widespread due to efforts to capture, control, store, and divert water. These alterations support drinking water supplies, hydropower, irrigation, flood control, manufacturing uses, and recreation. Few human actions have more significant impacts on a river system than dam construction. Dams change upstream and downstream habitats, water temperatures, water quality, and sediment movement. They also block or slow the movement of materials and organisms throughout a watershed (USEPA 2001) and increase flooding and subsequent loss of property.

More than 9,900 points of water diversion are present in the Boise, Payette, and Weiser subbasins (Figure 2). The majority of these diversions are estimated to occur in the Lower Boise (~1,900), Payette (~2,000), North Fork

Payette (~1,350) and Weiser (~3,400) watersheds. The diversions in the mainstem waters accessible to fish are not screened. These water diversions will require fish screens when connectivity is restored to blocked mainstems and tributaries. Also, the estimated numbers of water diversions are actually water rights with surface water irrigation points of diversions associated with them. This consists of the recommended rights under the Snake River Basin Adjudication; the claims they are or will be processing; and any other licensed and permitted rights currently recognized. There can be more than one point of diversion associated with a water right and vice versa, so the count is an estimate. No diversion rates or volumes can be given because the amount of water that can be diverted at any one time is dependent on available water and many other factors. Models can be developed for this, but these models can only be verified and used in areas where there are substantial efforts at gauging the flows.

The Boise, Payette, and Weiser subbasins have a total of at least 332 culverts (Figure 3). Of these, 113 block adult fish passage, and 125 block juvenile fish passage (Table 5). Of the remaining culverts, most have an unknown effect on fish passage, however it is assumed that since most of the known culverts block fish passage to some degree, most of the remaining culverts will block passage as well.

Channelization, which is river and stream channel engineering undertaken for the purpose of flood control, navigation, drainage improvement, and reduction of channel migration potential, includes activities such as straightening, widening, deepening, or relocating existing stream channels, as well as clearing or snagging operations (Brookes 1990). These forms of hydromodification typically result in more uniform channel cross-sections, steeper stream gradients, a reduction in average pool depths, and altered stream/river flow (USEPA 1993).

Channel-modification activities deprive wetlands of enriching sediments, change the ability of natural systems to both absorb hydraulic energy and filter pollutants from surface waters, and cause interruptions in the different life stages of aquatic organisms (Sherwood *et al.* 1990). A frequent result of channelization and channel-modification activities is a diminished suitability of instream and riparian habitat for fish and wildlife. Hardening of banks along waterways eliminates instream and riparian habitat, decreases the quantity of organic matter entering aquatic systems, and increases the movement of non-point source (NPS) pollutants (USEPA 1993). Increased or fluctuating temperatures can harm fish and other aquatic organisms whose life cycles and breeding success are inextricably linked to water temperature. Thermal modification can eliminate fish species and other aquatic organisms from streams (USEPA 2001).

Completed channel-modification projects usually require regularly scheduled maintenance activities to preserve them. These maintenance activities can result in continual disturbance of instream and riparian habitats. In some cases, substantial displacement of instream habitat due to the magnitude of the changes in surface water quality, morphology and composition of the channel, stream hydraulics, and hydrology can occur (USEPA 1993).

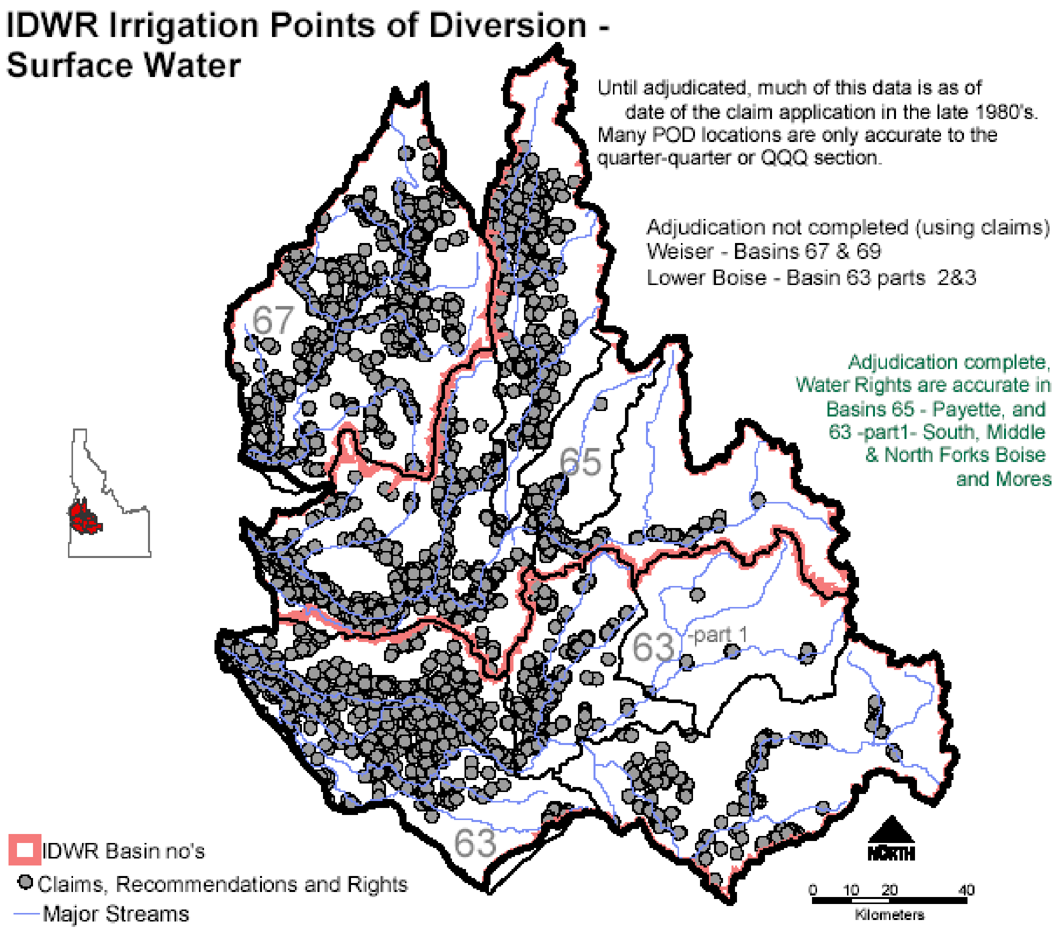

Figure 2. **Locations of approximately 10,000 water diversions in the Boise, Payette, and Weiser subbasins (IDWR 2003).**

Table 5. **Fish passage at road crossings in the Boise, Payette, and Weiser subbasins (National Forest Assessments 2003).**

Life Stage	Culvert Fish Passage	Watershed								Totals
		NMB	BMO	SFB	SFP	MFP	PAY	NFP	WEI	
Juvenile	No fish passage	9	8	40	36	4	12	11	5	125
	Passage unknown	21	13	72	49	14	19	18	0	206
	Allows fish passage	0	1	0	0	0	0	0	0	1
	Totals	30	22	112	85	18	31	29	5	332
Adult	No fish passage	9	8	31	34	4	12	10	5	113
	Passage unknown	21	13	78	51	14	19	19	0	215
	Allows fish passage	0	1	3	0	0	0	0	0	4
	Totals	30	22	112	85	18	31	29	5	332

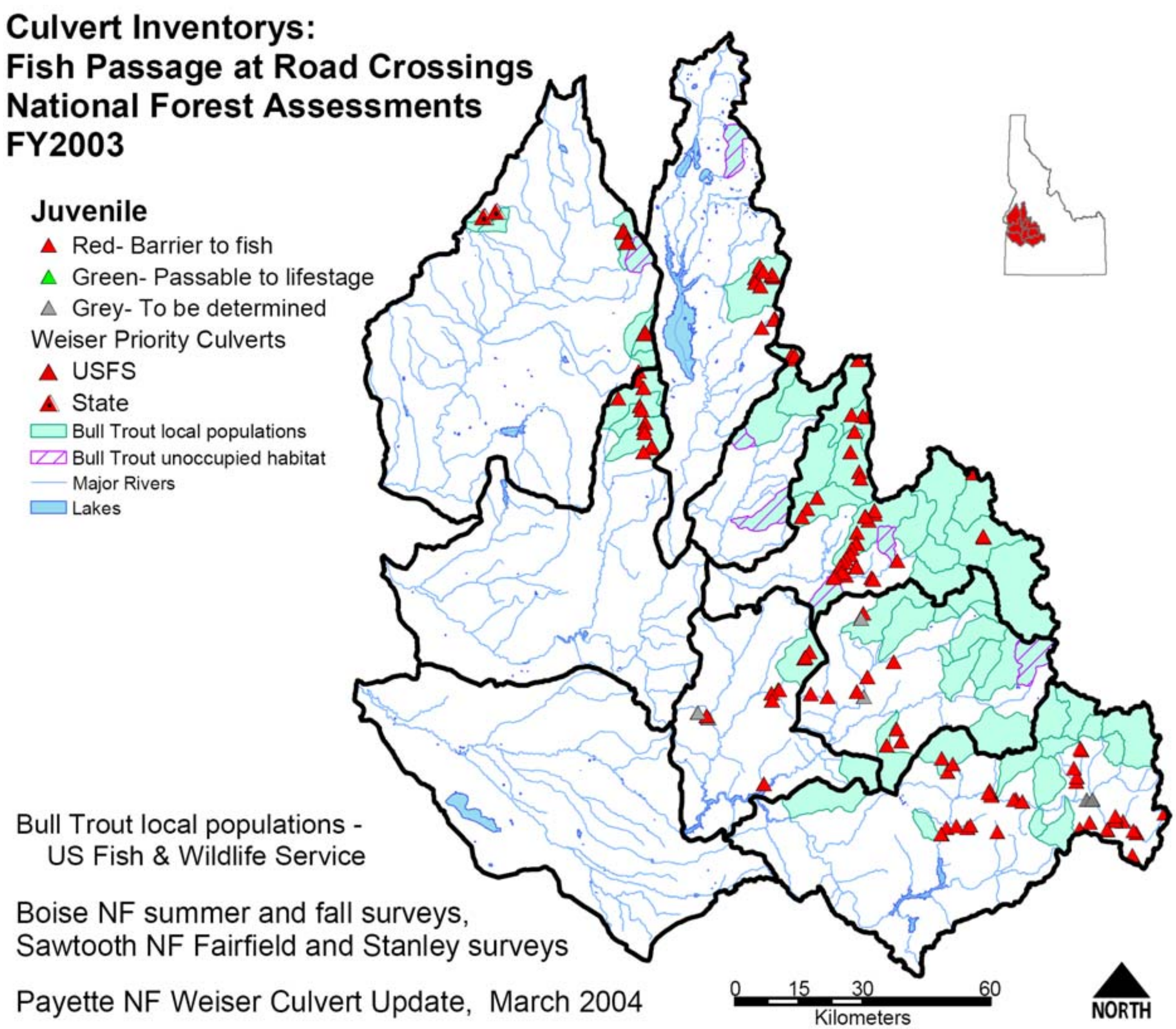

Figure 3. Culvert inventory for the Boise, Payette, and Weiser subbasins (Boise and Sawtooth National Forest culvert inventories).

Instream hydraulic changes as affected by stream alterations can decrease or interfere with surface water contact to stream bank areas during floods or other high-water events. Channelization and channel-modification activities can result in reduced pollutant filtering by streamside area vegetation and soils. Steam bank areas that are dependent on surface water contact (i.e., riparian areas and wetlands) may change in character and function as the frequency and duration of flooding change. Drainage rates from streamside areas are 2.6 times higher in channelized areas than in undisturbed areas, and 5.3 times higher following stream alteration construction (Erickson *et al.* 1979). Schoof (1980) reported impacts of channelization, including drainage of wetlands, reduction of oxbows and stream meander, clearing of floodplain hardwood, lowering of groundwater levels, and increase in erosion (USEPA 1993).

Channelization and channel-modification activities can lead to loss of instream and riparian habitat and such ecosystem benefits wildlife migration pathways and suitable conditions for reproduction and growth. Problematic flow modifications have resulted in reversal of flow regimes of some California rivers or streams, and led to the disorientation of anadromous fish that rely on flow to direct them to spawning areas (USEPA 1993). Eroded sediment may cover benthic communities or alter instream habitat (Sherwood *et al*. 1990).

Channelization and channel-modification projects (Figure 4) can lead to an increased quantity of pollutants and accelerated rate of delivery of pollutants to downstream sites. Alterations that increase the velocity of surface water or flushing of the streambed can lead to more pollutants being transported to downstream areas at possibly faster rates. Channelization and channel-modification projects can also lead to an increased quantity of pollutants and accelerate the rate of delivery of these pollutants to downstream sites. Alterations that increase the velocity of surface water or flushing of the streambed leads to pollutant transport downstream at possibly faster rates. Urbanization has been linked to downstream channelization problems (Anderson 1992).

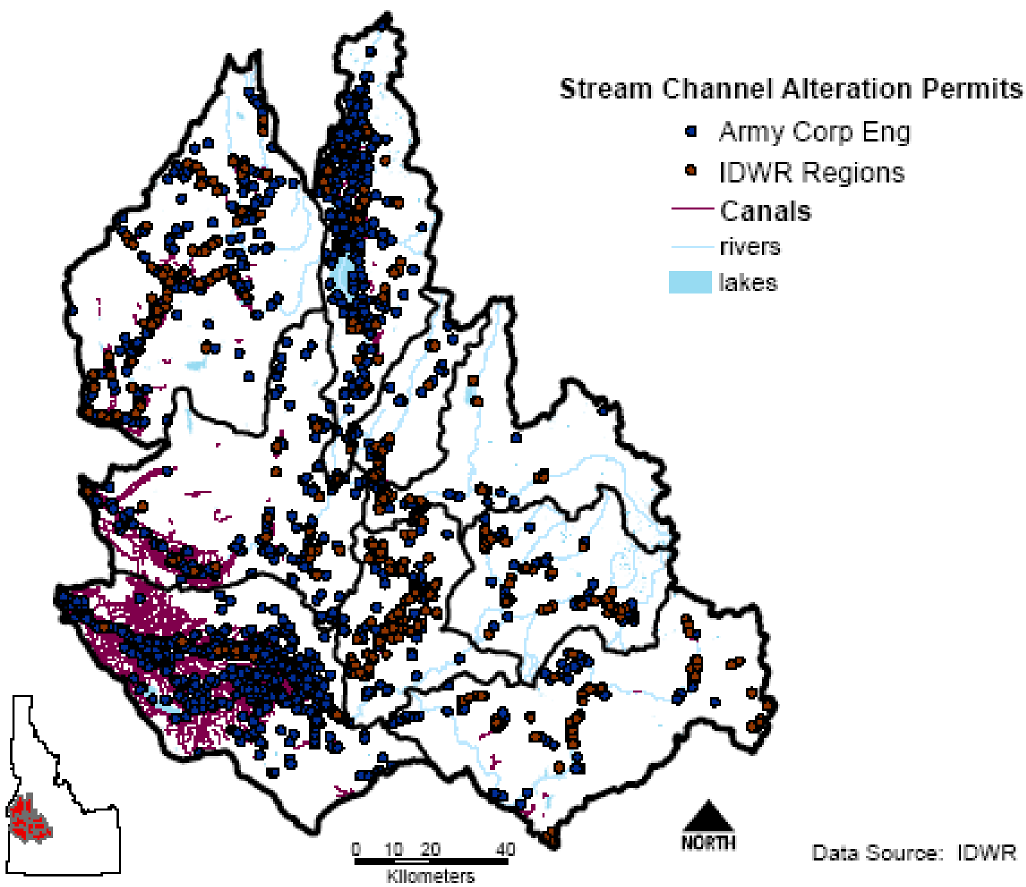

Figure 4. **Channel-modification projects in the Boise, Payette, and Weiser subbasins (IDWR 2003).**

One of the more significant changes in instream habitat associated with channelization and channel modification is in sediment supply and delivery. These changes in sediment supply can include shifts in erosion and deportation areas and increased sedimentation in some areas (Hynson *et al*. 1985, Merigliano 1996). Excessive volumes of sediments entering water bodies can diminish water clarity, alter habitats, impair fish spawning success, and increase drinking water treatment costs. Timber harvest, mining, agriculture, and construction cay cause excessive sedimentation. The removal of vegetation and manipulation of soils by these activities allows wind or water to carry loosened sediments to nearby water bodies.

Increases in impervious surfaces decrease infiltration of rainwater into soils and increase surface runoff. These increases in surface runoff increase soil erosion and sediment transport to streams, rivers, and lakes (USEPA 2001). Approximately 19% of the streams—a total of 89 waterways, in the Boise, Payette, and Weiser subbasins—are sediment impaired (Figure 5, Table 6, and Table 7).

Table 6 Total lengths (km) of streams impacted by sediments in the Boise, Payette, and Weiser subbasins (ICBEMP 1997, USEPA 1998).

Watershed	Total Stream Length (km)	Stream Length (km) impacted by sediments	% of Streams Affected by Sediments
North and Middle Boise	1,041	148	14.2
Boise–Mores	1,173	199	17.0
South Fork Boise	471	279	59.2
Lower Boise	1,110	371	33.4
South Fork Payette	1,210	264	21.8
Middle Fork Payette	1,394	164	11.8
Payette	1,911	162	8.5
North Fork Payette	1,221	188	15.4
Weiser	1,807	341	18.9
Totals	**11,338**	**2,116**	**18.6**

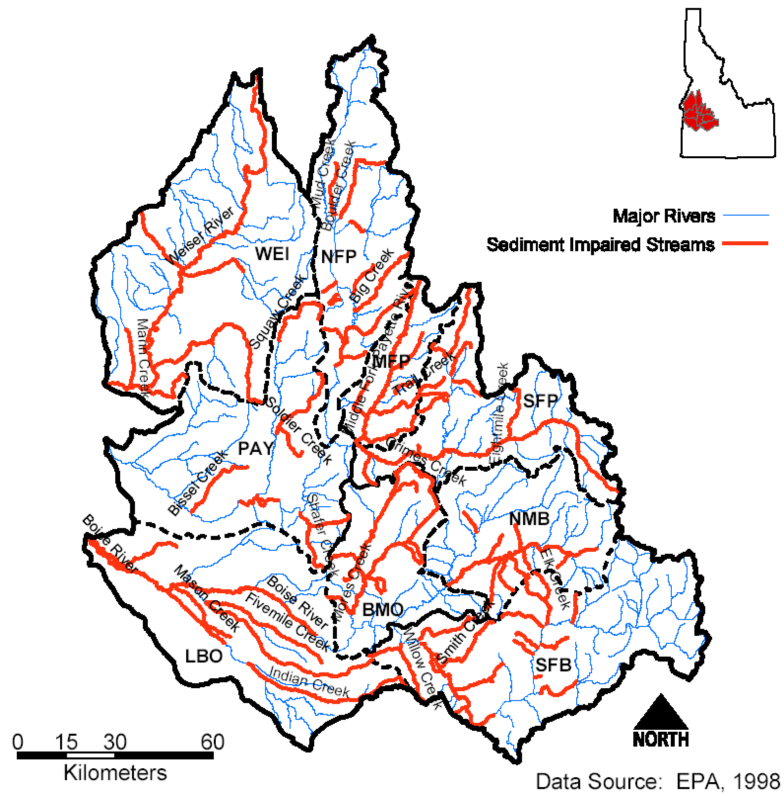

Figure 5. Locations of sediment-impaired streams in the Boise, Payette, and Weiser subbasins (USEPA 1998).

Table 7. Sediment-impaired streams by watershed in the Boise, Payette, and Weiser subbasins (USEPA 1998).

Watershed	Sediment-Impaired Stream	
North and Middle Boise	Browns Creek	Phifer Creek
	Buck Creek	Roaring River
	James Creek	Swanholm Creek
	Lost Creek	Browns Creek
	Lost Man Creek	Buck Creek
	Middle Fork Boise River	
Boise–Mores	Bannock Creek	Middle Fork Boise River
	Clear Creek #1	Minneha Creek
	Clear Creek #3	Mores Creek
	Granite Creek	Robie Creek
	Grimes Creek	South Fork Minneha Creek
	Macks Creek	
South Fork Boise	Bear Creek	Meadow Creek
	Cayuse Creek	Rattlesnake Creek
	Deer Creek	Rock Creek

Watershed	Sediment-Impaired Stream	
	Dog Creek	Shake Creek
	Elk Creek	Smith Creek
	Feather River	South Fork Boise River
	Green Creek	Trinity Creek
	Grouse Creek	Willow Creek
	Lime Creek	Wood Creek
Lower Boise	Blacks Creek	Mason Creek
	Boise River	Sand Hollow Creek
	Fivemile Creek	Tenmile Creek
	Indian Creek	
South Fork Payette	Alder Creek	Scott Creek
	Basin Creek	South Fork Payette River
	Big Pine Creek	Trail Creek
	Deadwood River	Tyndall Creek
	Eightmile Creek	Whitehawk Creek
	Ninemile Creek	Wilson Creek
Middle Fork Payette	Anderson Creek	Scriver Creek
	Bulldog Creek	Silver Creek
	Lightning Creek	South Fork Payette River
	Middle Fork Payette River	
Payette	Bissel Creek	Shafer Creek
	Black Canyon Reservoir	Soldier Creek
	Harris Creek	South Fork Payette River
	Little Squaw Creek	Squaw Creek
	Middle Fork Payette River	
North Fork Payette	Beaver Creek	French Creek
	Big Creek	Gold Fork River
	Boulder Creek	Hazard Creek
	Campbell Creek	Mud Creek
	Clear Creek	North Fork Payette River
	Fawn Creek	Round Valley Creek
Weiser	Cove Creek	North Crane Creek
	Crane Creek	Pine Creek
	Crane Creek Reservoir	Scott Creek
	Little Weiser River	Snake River
	Mann Creek	Weiser River

2.2 Invasive/Exotics

Invasive plant and animal species—also referred to as exotics, nonnatives, introduced, or nonindigenous species—are organisms that have expanded beyond their native range or have been introduced from other parts of the world. Species are considered invasive if their presence in an ecosystem will cause environmental harm, economic harm, or harm to human health. Invasive species can displace native species, alter predator-prey relationships, destroy crops, and decrease ecosystem resiliency (USEPA 2001). Some species were introduced into the wild intentionally, while others have been introduced unintentionally and expanded on their own. Invasive species are usually nonnative species, and are often exotic species from another part of the world. Native species can also be characterized as invasive if they dominate their ecosystem because of human-induced changes to that ecosystem (USEPA 2001).

Noxious weeds in the Boise, Payette, and Weiser subbasins have been documented in all watersheds (Table 2 in this Appendix 1-1 and Figure 1-19 in the assessment).

Impacts to Riparian/Herbaceous Wetlands

One pest weed in Idaho's aquatic environment is the European purple loosestrife (*Lythrum salicaria*), which was introduced as an ornamental plant in the early nineteenth century (Malecki *et al*. 1993). Purple loosestrife is a listed noxious weed in the state of Idaho that grows abundantly in wetlands and near river channels. It is a perennial that grows up to 2 m tall with 30 to 50 stems that form a dense canopy, choking out native vegetation. A single plant can produce more than 2 million seeds per year, and seedling density can exceed 20,000 plants per square meter. Large taproots sustain the plant and make weed eradication very difficult.

Purple loosestrife is capable of invading many wetland types, including freshwater wet meadows, tidal and non-tidal marshes, river and stream banks, pond edges, reservoirs, and ditches. It has been spreading at a rate of 115,000 hectare per year and is changing the basic structure of most of the wetlands it has invaded (Thompson *et al*. 1987). Competitive stands of purple loosestrife have reduced the biomass of 44 native plants and have endangered wildlife (Gaudet and Keddy 1988). Loosestrife now occurs in 48 states and costs $45 million per year in control costs and forage losses (ATTRA 1997, Pimentel *et al*. 1999).

A second aquatic weed of concern in the Boise, Payette, and Weiser subbasins is Eurasian watermilfoil (*Myriophyllum spicatum L*.). Eurasian watermilfoil can form large, floating mats of vegetation on the surface of lakes, rivers, and other water bodies, preventing light penetration for native aquatic plants and impeding water traffic. The plant thrives in areas that have been subjected to various kinds of natural and manmade disturbance. Eurasian watermilfoil in the Boise subbasin has been documented by Ada County Weed and Pest control to invade standing water bodies (e.g. residential ponds) at uncharacteristically high rates.

Leafy spurge (*Euphorbia esula*) is a robust invasive weed that occupies a variable host of ecological conditions. It is grows to 3 feet tall, has alternate, narrow, hairless, glaucous leaves, and produces a milky latex that is toxic to animals. The weed is unpalatable to grazing livestock and wildlife, and has been highly correlated to decreases in foragability. Its root systems can grow to 40 feet deep, and it may reproduce by highly viable seeds or creeping root systems. Leafy spurge is an emerging problem in this region; once established, it can form communities that are thousands of hectares square, choking out all native vegetation.

Impacts to Shrub-Steppe

A change in the natural fire regime is decreasing the extent of sagebrush ecosystems, and the populations of wildlife species that depend on sagebrush (*Artemisia* spp.) are undergoing steep declines because of habitat loss (Connelly *et al*. 2000). The invasion of cheatgrass (*Bromus tectorum*) is fueling larger and more frequent fires that are outcompeting sagebrush as well as the associated forb and grass species that are native components of that ecosystem (Pyke 2002). It has been estimated that 25% of the original sagebrush ecosystem is now annual cheatgrass/medusahead (*Taeniatherum caput-medusae*)/rye grassland, and an additional 25% of the sagebrush ecosystem has only cheatgrass as an understory constituent (Perryman 2003).

Impacts to Pine/Fir Forests

An ecologically significant weed to forested habitats in Boise, Payette and Weiser subbasins is spotted knapweed (*Centaureai maculosa*). This species infests a variety of natural and semi-natural habitats including barrens, fields, forests, prairies, meadows, pastures, and rangelands. It outcompetes native plant species, reduces native plant and animal biodiversity, and decreases forage production for livestock and wildlife. Spotted knapweed may degrade soil and water resources by increasing erosion, surface runoff, and stream sedimentation. It is estimated to have increased at a rate of 27% per year since 1920 and has the potential to invade about half of all of the rangeland (35 million acres) in Montana alone (Carpinelli 2003). Spotted knapweed is capable of establishing itself into undisturbed sites; however, disturbance allows for rapid establishment and spread.

2.3 Land-Use Conversion, Development, and Fragmentation

The Columbia River basin ecosystem escaped significant human land-use impacts until the nineteenth century when settlers and their livestock began to move into the region during the late 1800s.

A major population boom occurred after World War II and has continued since, particularly in metropolitan areas. These urban populations have tapped the water and energy resources of the region and contributed to heavy recreational use, particularly at popular destinations. With more and more people claiming their share of the region’s water, energy, and recreational resources, conflicts between mutually exclusive uses such as eco-tourism, recreational off-road vehicles, and ranching are becoming widespread and chronic (Reisner 1993, Ringholz 1996, Talbot and Wilde 1989).

The population of the Columbia River Basin has increased six-fold since the turn of the century and has more than doubled since the mid-1960s. This growth rate is two-and-a-half times greater than the nation’s rate of 39% for that same period. Population growth in some areas of the Columbia River Basin is outpacing growth in the western United States as a whole, as people flee the urbanization of the Pacific Coast to the intermountain west (USFS 1996).

Idaho is the fastest growing area in the Columbia River Basin, with a population growth rate of 28.5%, followed by Washington and Oregon with population growth rates of 21.1 % and 20.4% respectively (CensusScope 2003). Ada County in southwestern Idaho saw its population rise from 205,000 people in 1990 to 300,000 people in 2000, an increase of 46% in just ten years (CensusScope 2003).

Recreation, tourism, and quality of life issues play a significant role in population increases across the region. The population growth trend and its related development directly challenge community and environmental quality in many ways. Communities throughout the basin are struggling to deal with the impacts of this population growth to agricultural lands, water quality, forests, wildlife, and habitat (Worster 1985).

In the Boise, Payette, and Weiser subbasins, the majority of the population resides in the Lower Boise, Payette, North Fork Payette, and Weiser watersheds (Table 8 and Figure 6). Fewer people reside in the South Fork Boise, North/Middle Boise, South Fork Payette, and Middle Fork Payette watersheds.

Table 8. Percentage population density classifications by watershed in the Boise, Payette, and Weiser subbasins (ICBEMP 2003).

Population Density Classification (population per square mile)	Major Hydrologic Unit (Watershed)									Total Area (km^2)
	NMB	BMO	SFB	LBO	SFP	MFP	PAY	NFP	WEI	
Extremely High ($x > 300$)				35					<1%	1,243
Very High ($100 < x > 300$)		2		55			16	1	4	2,687
High ($60 < x > 100$)		12	3	7	1		27	17	13	2,374
Medium ($10 < x < 60$)	25	80	46	3	34	46	57	74	82	11,760
Low ($1 < x > 10$)	75	7	52		65	54		6		5,335
Very Low ($x < 1$)								2		40

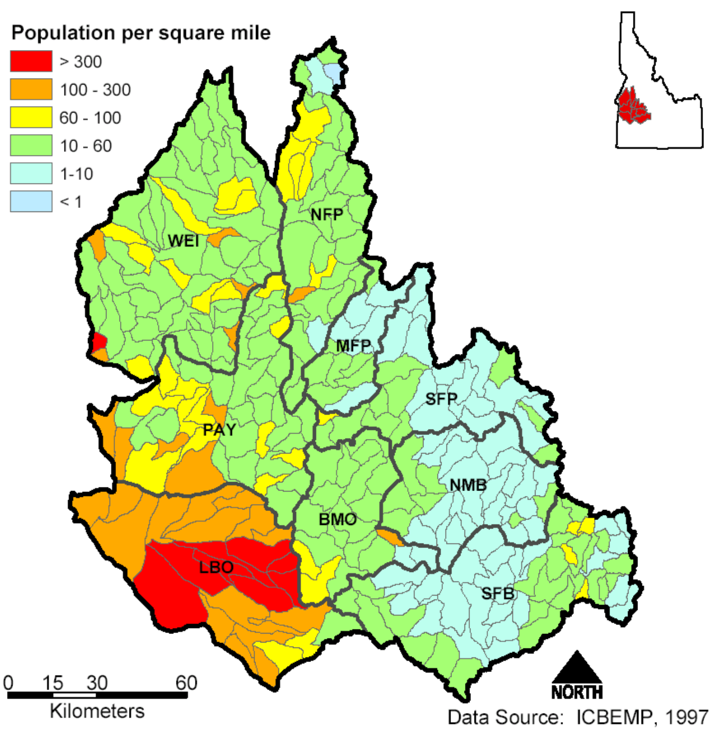

Figure 6. Relative population densities in the Boise, Payette, and Weiser subbasins (ICBEMP 1997).

Utility Corridors—Human desire to develop relatively secluded areas is generally immediately followed by the introduction of utility corridors for energy supply. These corridors physically fragment ecosystems and habitats by directly removing native vegetation. Additionally, corridors serve as a vector for invasive species, and enhance the potential for human activities. Figure 7 illustrates present and proposed utility corridors in the Boise, Payette, and Weiser subbasins.

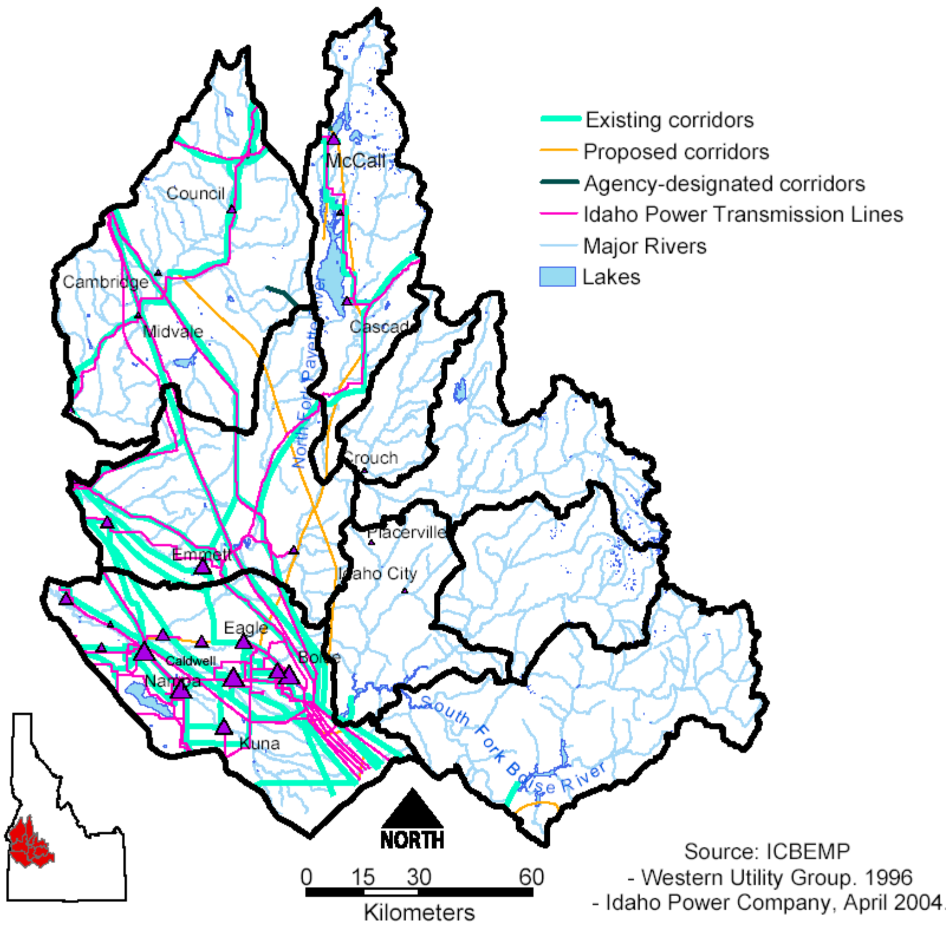

Figure 7. Existing and proposed utility corridors in the Boise, Payette, and Weiser subbasins (ICBEMP: Western Utility Group, 1996).

Development

Land conversion on the urban fringe, also called "sprawl," is an important issue to address because it has a number of impacts on the natural environment and human activity. Farm and ranch lands, forests, and other open space are transformed into subdivisions, ranchettes, shopping areas with expansive parking lots, and roads. This carves away at wildlife habitat and frequently diminishes wetland/ riparian areas. The Natural Resources Conservation Service (NRCS) estimates that 6,461,210 hectares were converted in the western states between 1992 and 1997. NRCS further estimates that

2,234,658 hectares of conversion, or about one-third, occurred in non-metropolitan areas (NRCS 2001). Much of the Boise, Payette, and Weiser subbasins are impacted by urban development (Figure 8). The watersheds most impacted by development include the Lower Boise, Boise–Mores, North and South Fork Boise, North/Middle Boise, Middle Fork Payette, South Fork Payette, and Payette (Figure 8). Of these, and based on data collected in 1994, the greatest impacts by urban development are in the Lower Boise, Boise–Mores, and Payette watersheds with 89%, 73% and 89% of the watershed area, respectively (Table 9).

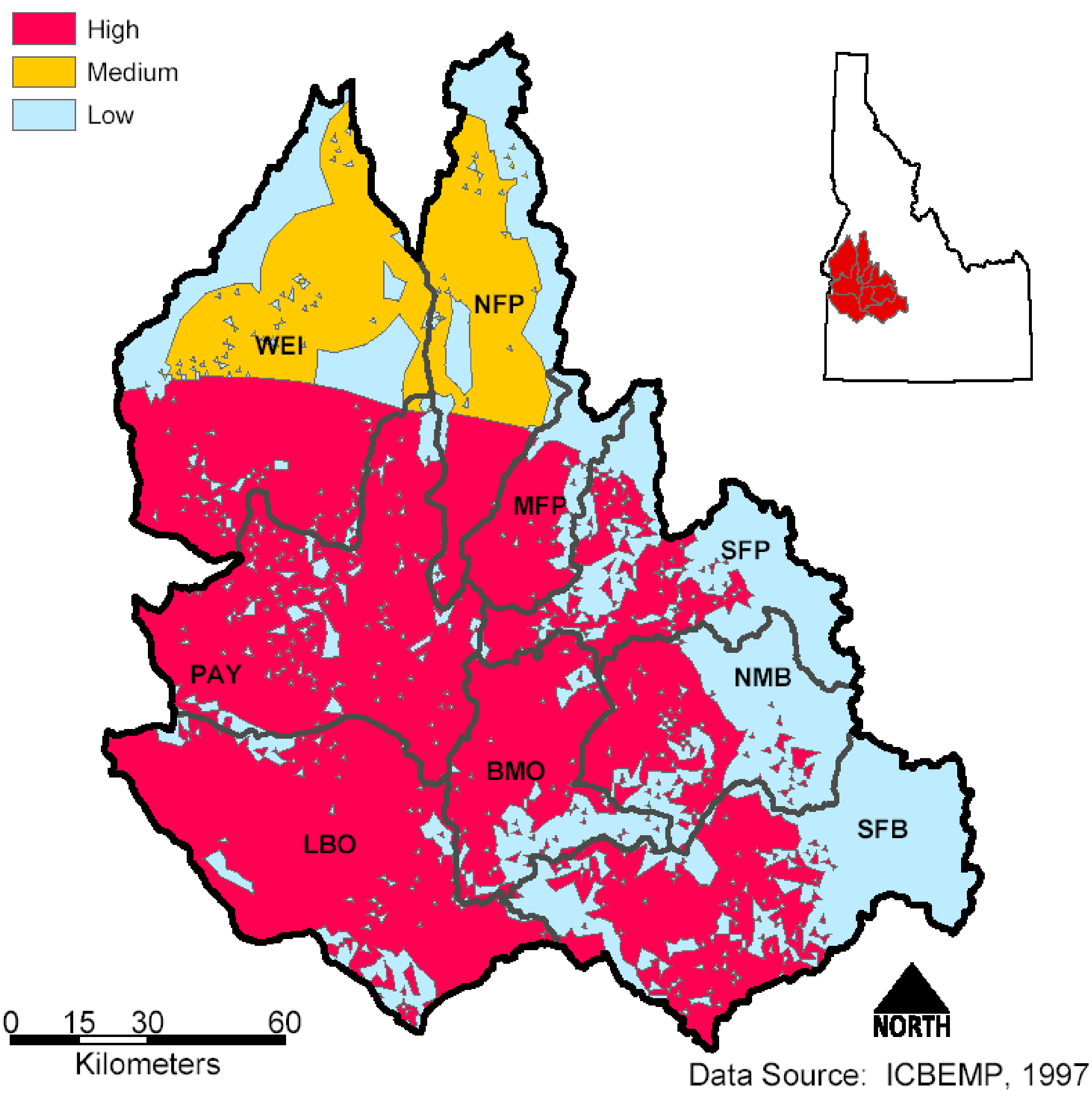

Figure 8. **Estimate of the regional effects of sprawl and recreation in the Boise, Payette, and Weiser subbasins (based on data collected in 1994 [ICBEMP 1997]).**

Table 9. Summary of impact of urban-rural development in the Boise, Payette, and Weiser subbasins (ICBEMP 1997).

Watershed	Land Use	BLM	BOR	Private/ Water	State/ County/ City	USFS	USFWS	Total Area (km^2)
BMO	Forest	16		264	189	842		1,311
	Rangeland	21	1	73	49	135		279
	Water	<1	<1	8	2	3		13
LBO	Dryland Agriculture	<1	<1	48	1			50
	Forest	<1		16	2	16		34
	Irrigated-Gravity Flow	2	0	1,281	5			1,287
	Irrigated-Sprinkler	7	7	151	4			168
	Rangeland	428	119	910	129	22	<1	1,609
	Riparian			7				7
	Urban			323	<1			324
	Water			30			<1	31
MFP	Forest	34	40	571	309	1728		2,682
	Irrigated-Gravity Flow	<1	<1	356	3	6		366
	Irrigated-Sprinkler			15				15
	Rangeland			72	2	<1		74
	Riparian	<1		66	<1			67
	Urban			3				3
	Water			74	4			78
NMB	Forest		<1	2		1959		1,963
PAY	Forest	37	11	157	44	376		624
	Irrigated-Gravity Flow	<1		375	<1			376
	Irrigated-Sprinkler	3		86	<1			89
	Rangeland	616		1,301	94	81		2,091
	Riparian			7	<1			8
	Urban			19	<1			19
	Water	<1		6		<1		8
SFB	Forest	17		102	52	1,611		1,781
	Irrigated-Gravity Flow	<1		6		<1		7
	Irrigated-Sprinkler			4				4
	Rangeland	15	20	351	84	1,098		1,567
	Riparian			<1				<1
	Water	<1	<1	19		2		22
	Forest	2	38	19	7	1,915		1,982
	Irrigated-Gravity Flow		<1	7				7
	Irrigated-Sprinkler		<1	2				2
	Rangeland		23	2		92		117
	Urban			<1				<1

Watershed	Land Use	BLM	BOR	Private/ Water	State/ County/ City	USFS	USFWS	Total Area (km^2)
	Water		1	10		<1		12
WEI	Dryland Agriculture			11	<1			11
	Forest	20		241	104	1117		1,481
	Irrigated-Gravity Flow	4	<1	240	9	<1		254
	Irrigated-Sprinkler	<1	<1	62	<1			63
	Rangeland	562	1	1,736	79	155		2,533
	Riparian			4	<1			5
	Urban			3				3
	Water			7		2		9

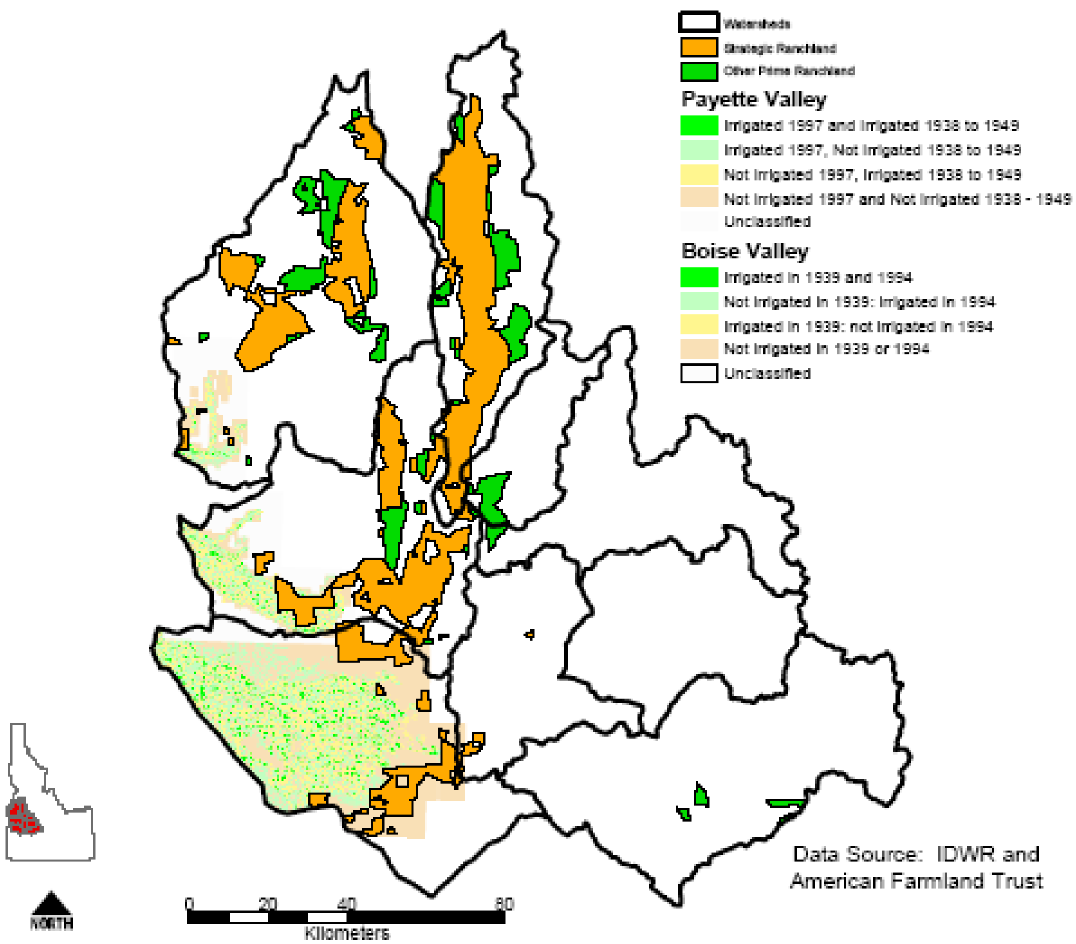

Figure 9. Land use in the Boise, Payette, and Weiser subbasins (IDWR 2002, American Farmland Trust 2003).

Urban lands in Idaho grew from an estimated 88,600 hectares in 1982 to 172,100 hectares in 1997. This growth primarily affected natural resource lands—cropland, pastureland, rangeland and forestland. From 1982 to 1997, conversions of resource lands to urban lands were estimated at 38,161 hectare of cropland, 16,551 hectare of pastureland, 9,388 hectare of rangeland, and 15,620 hectare of forestland. This is an estimated total of 79,723 hectare removed from the rural land base for urban uses. The rate of conversion increased from an estimated 4,552-hectare per year between 1982 and 1992 to 6,701 hectare per year from 1992 to 1997. This is an increase of 47.2%. The rate of increase was highest on rangeland, followed by pastureland, cropland, and forestland (Table 10). Historic land use and land-use conversion in portions of the Boise, Payette, and Weiser subbasins is illustrated in Figure 9 through Figure 11. These analyses were generated by comparing color-infrared imagery from different time periods.

Table 10. Estimated conversion rates of natural resource lands to urban lands in Idaho, 1982 to 1992 vs. 1992 to 1997 in hectares per year (NRCS 2001).

Natural Resource Land Type	1982-1992	1992-1997	% Change
Crop Land	2,278	2,930	+28.6
Pasture Land	1,019	1,513	+48.4
Range Land	360	1,109	+207.9
Forest Land	894	1,149	+28.5
Total	**4,552**	**6,701**	**+47.2**

Habitat fragments when new developments (sprawl) divide undisturbed habitat. The resulting fragmentation is particularly harmful to wide ranging species that rely on large territories to draw food and cover. Without adequate continuous habitat, a population of large, wide-ranging animals will eventually disappear from an area, with harmful ripple effects felt throughout the ecosystem (USDA NRCS 2001). Sprawl inevitably translates into more roads, which in turn open up previously undisturbed habitat and open space to additional development.

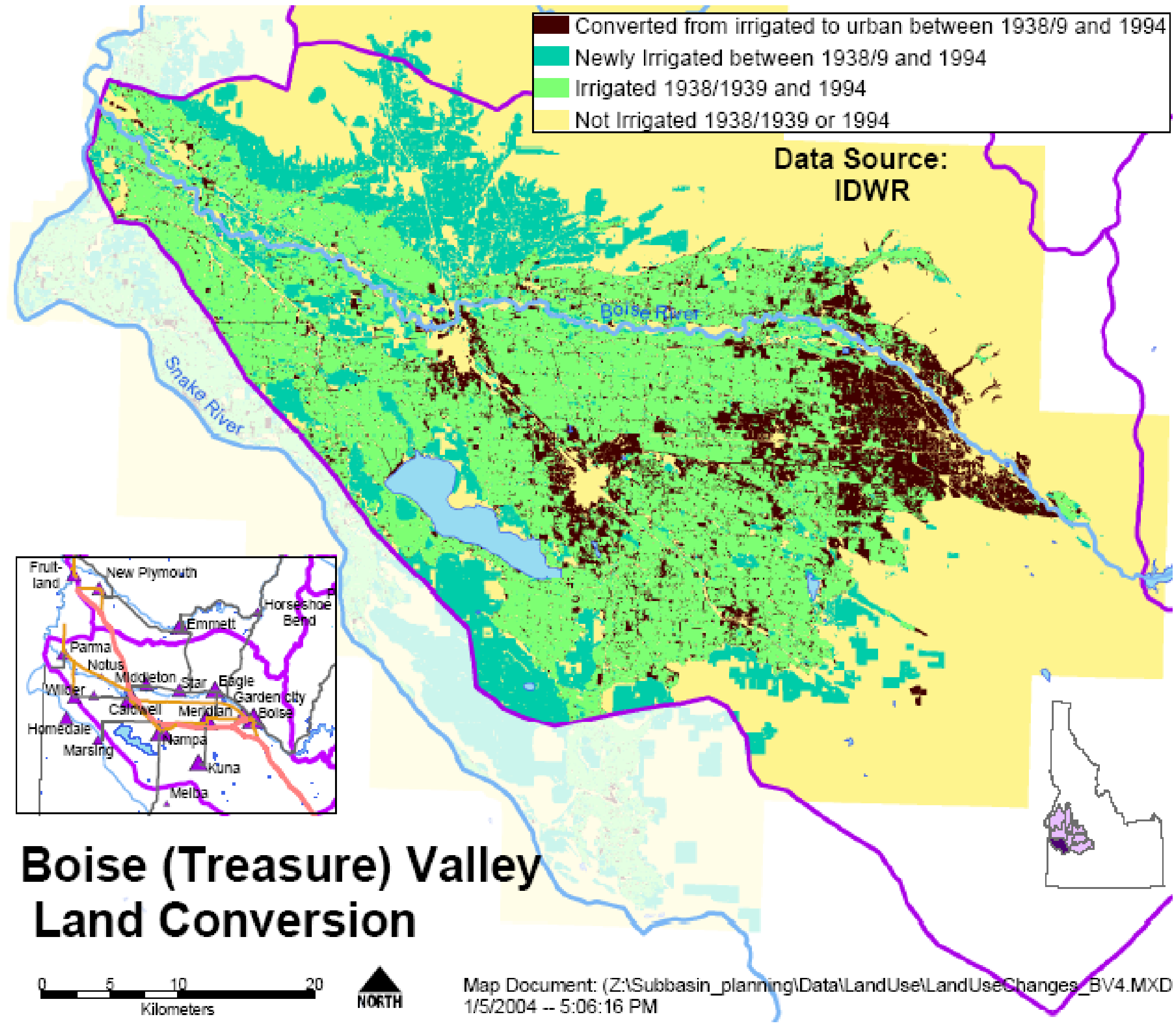

Figure 10. **Land converted from irrigated agricultural to urban uses in the Lower Boise watershed, Boise subbasin (IDWR 2002).**

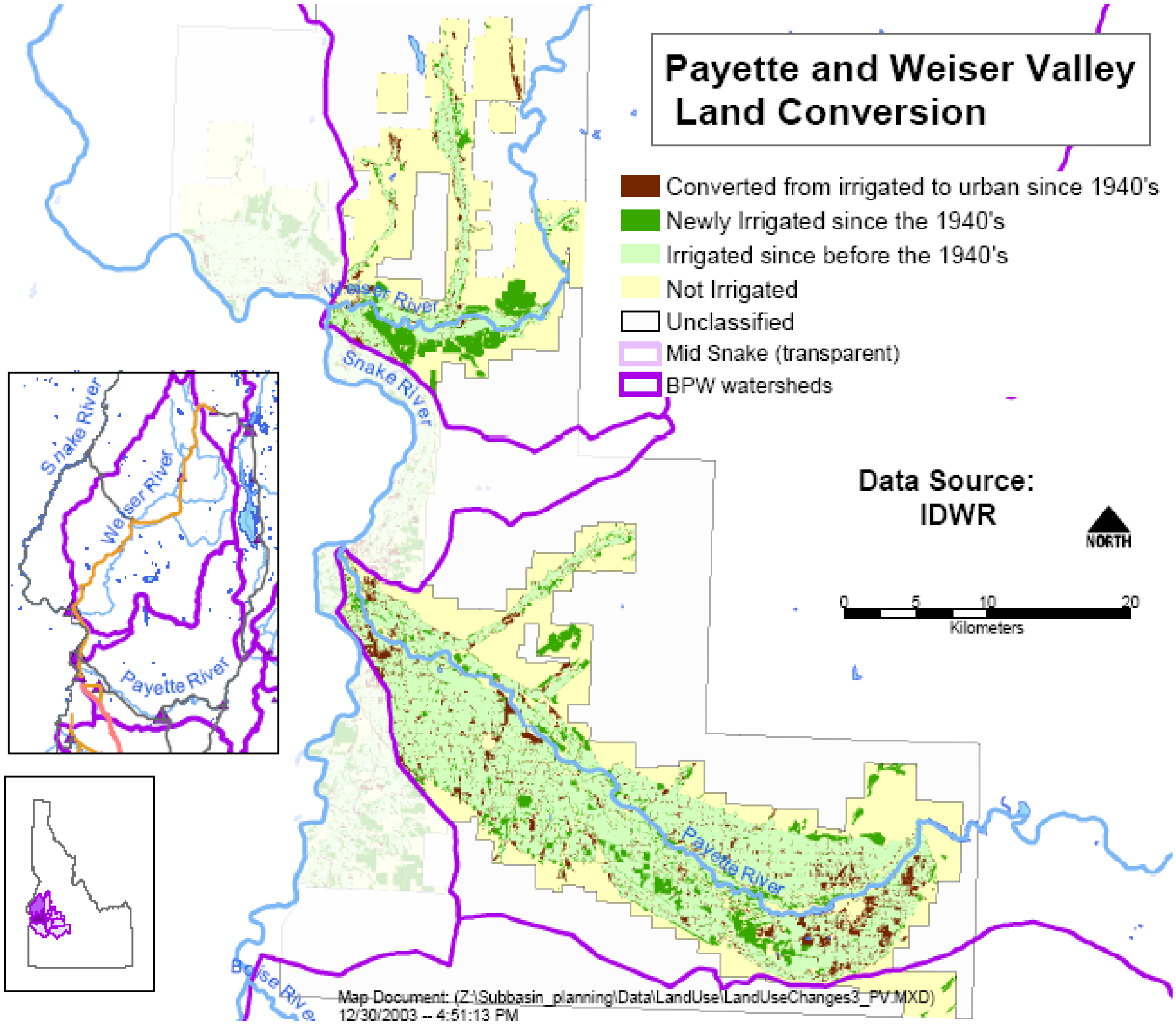

Figure 11. Land converted from irrigated agricultural to urban uses in the Payette and Weiser watersheds (IDWR 2002a, IDWR 2002b).

Table 11. Patterns in irrigated land use for select watersheds in the Boise, Payette, and Weiser subbasins between 1938 and 2000 (IDWR 2002a, IDWR 2002b).

Land Use	LBO	PAY	WEI	Grand Total
Irrigation halted (developed)	302.1	38.8	6.7	347.7
Newly irrigated	791.5	46.9	27.9	866.4
Stable irrigated	390.0	277.8	37.8	705.6
Stable non-irrigated	1310.8	804.9	158.7	2274.3
Grand Total	2794.4	1168.5	231.1	4194.0
Total Area (km^2)	3510.8	3217.1	4359.5	

Table 11 illustrates trends in irrigation in Lower Boise, Payette and Weiser watersheds from 1938 to 2000. Approximately 348 km2 of irrigated cropland in the analyzed watersheds were developed into urban and rural development, while an additional 866 km2 of rangeland were converted to irrigated cropland. During the survey period, 706 km^2 of irrigated cropland remained classified as such, while 4,194 km^2 of non-irrigated lands remained unconverted. The Idaho Department of Water Resources (IDWR) developed this database by analyzing historical aerial photographs of the watersheds with present day images.

Fragmentation

Habitat fragmentation involves the division of large, contiguous areas of habitat into smaller patches more isolated from one another. Some habitats (lakes, riparian zones, archipelagos) are naturally fragmented. Some habitat fragmentation results from natural processes such as fires, floods, and insect outbreaks. Habitat fragmentation is an increasingly important issue in conservation biology as human activities shape the environment and landscape (Weclaw 1998).

A key hypothesis is that a reduction in the area of a habitat patch can decrease its suitability for animals to a disproportionately greater degree than the actual reduction in area (Johnson 2001). It is obvious that the numbers of a species are likely to decline if its habitat is reduced; fragmentation effects imply that the value of the remaining habitat is also diminished (Johnson 2001).

Three types of fragmentation effects have been distinguished: patch-size, edge, and isolation (Faaborg *et al*. 1993, Johnson and Winter 1999). Patch-size effects are those that result from differential use or reproductive success associated with habitat patches of different sizes (Johnson 2001). Some patch-size effects may be induced by edge effects, including avoidance, reduced pairing success, predation, interspecific competition, prey availability, and parasitism that may differ near the edge of a habitat from in the interior of a patch (Faaborg *et al*. 1993). Finally, isolation from similar habitat can influence use of a particular habitat patch because of reduced dispersal opportunities. Each of these factors—patch size, edge effects, and isolation—affects the occurrence, density, or reproductive success of animals in a habitat patch.

Habitat fragmentation results in both biotic and abiotic changes to the landscape. Fragmentation affects predator-prey relationships, species composition, dispersal, density, distribution, and population genetics, as well as microclimatic variables such as sunlight penetration and temperature (Whitcomb *et al.* 1981, Johnson and Temple 1990, Knopf 1994, Paton 1994, Donovan *et al*. 1995, Greenwood *et al*. 1995, Robinson *et al*. 1995, Weclaw 1998, Winter *et al*. 2000). Although there is insufficient evidence to suggest that habitat fragmentation is entirely undesirable (Schmiegelow *et al*. 1997), it often results in habitat loss that in turn has contributed to extinction of species (Turner 1996).

Because of large population centers primarily in the Lower Boise watershed, and urban development (sprawl) in the Boise, Payette, and Weiser subbasins, the total amount of habitat fragmentation is relatively high to moderate throughout the three subbasins (Figure 12 and Table 12). The greatest habitat fragmentation occurs in the Lower Boise, Payette, and Weiser watersheds (Figure 12).

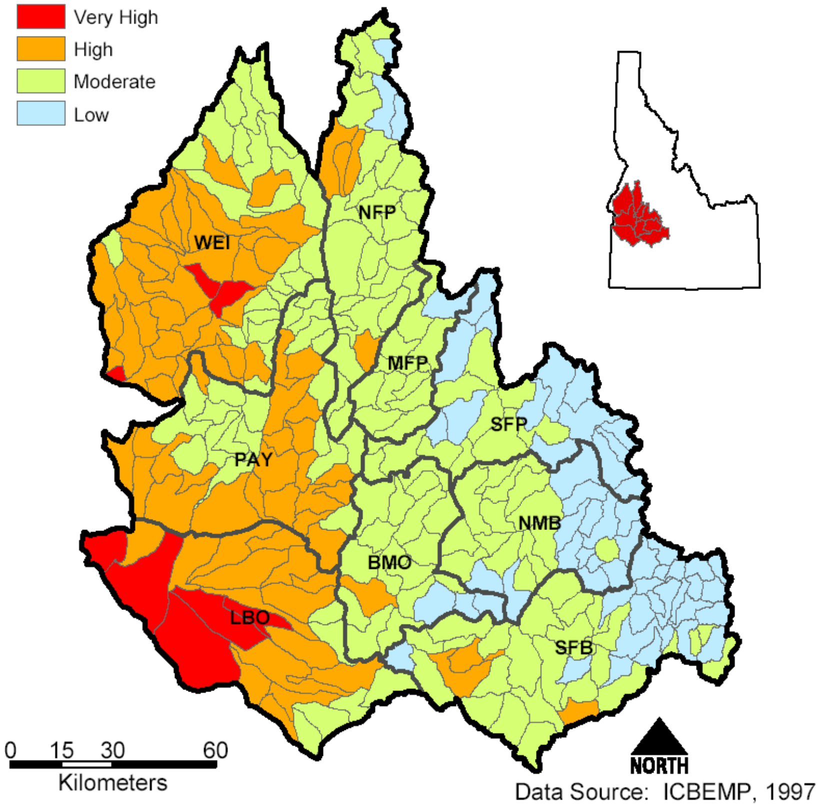

Figure 12. Estimated habitat fragmentation in the Boise, Payette, and Weiser subbasins.

Table 12. Relative percentages of habitat fragmentation by watershed in the Boise, Payette, and Weiser subbasins (ICBEMP 1997).

Relative Category	Major Hydrologic Unit (Watershed)									
	NMB	BMO	SFB	LBO	SFP	MFP	PAY	NFP	WEI	Total Area (km^2)
Very High				33					3	1,312
High		7	7	51			60	12	62	7,070
Moderate	55	80	60	16	43	89	40	79	35	11,339
Low	45	13	33		57	11		8		3,719

Impacts to Winter Range

Land development in big game winter range (i.e., shrub-steppe, native grasslands, and juniper/mountain mahogany habitat types) is a significant wildlife habitat issue, particularly for focal species such as mule deer and Rocky Mountain elk. Subdivision development in winter ranges cohnstitutes a permanent loss of habitat and a permanent reduction in the carrying capacity of the land for big game. The loss of a habitat component already in short supply results in fewer deer and elk for hunters (Trent 2000).

Winter range provides two needs: shelter and food. Although food resources are important, they are not the single reason for winter range selection. Of equal, or more importance is the microclimate of the winter range and how it enhances the ability of animals to minimize their energy loss during a time of food shortage (Trent 2000).

Slope, elevation, aspect, and vegetative cover combine to make some places warmer, more secure, and less snowy. Animals wintering in these areas do not deplete their fat reserves as quickly and are therefore more likely to survive the winter. When winter ranges are lost to subdivisions, this important "place" is lost and cannot be replaced or mitigated by enhancing vegetation in an adjacent area (Trent 2000). Figure 13 illustrates the current winter range within the Boise, Payette, and Weiser subbasins.

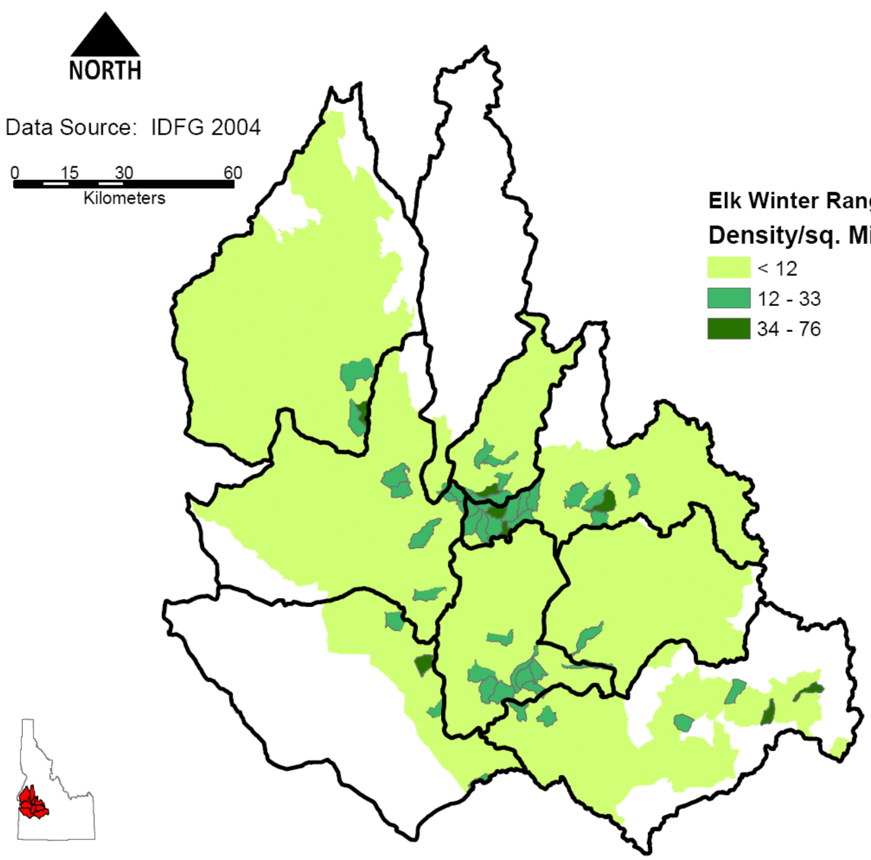

Figure 13. Winter range population estimates for Rocky Mountain elk in the Boise, Payette and Weiser subbasins, Idaho (IDFG unpublished 2004, source: aerial survey data collected during 1984-2003).

Roads and Trails

Roads and trails have profound impacts on forest ecosystems. These include direct and indirect effects on individual plant and animal species, as well as broadscale changes in ecosystem structure and function. Askins (1994), Benninger-Truax *et al.*

(1992), Ercelawn (1999), Lonsdale (1999), Neumann and Merriam (1972), and Saunders *et al.* (1991) summarize the following impacts of roads and trails:

- Create barriers to dispersal
- Create a significant source of direct mortality due to collisions
- Cause displacement of sensitive wildlife species
- Cause habitat loss
- Cause loss of ecological complexity
- Reduce reproductive success
- Act as a vector of disease, pest infestations, and/or invasive/exotic plants and animals

- Cause degradation of ecosystem function
- Cause degradation of soil resources and water hydrology due to road-building, use and maintenance activities
- Increase sediment and altered streamflows
- Increase disturbance and harvest of big game animals (both legally and illegally)

Recreational road and trail use is typically defined in terms of hiking, biking, horseback riding, ATVs, snowmobiles, hunting/fishing, and skiing. Impacts typically associated with these activities include trampling; habitat disturbance or modification due to noise, erosion, and soil compaction; introduction of invasive exotics; nutrient loading from animal and human waste; pollution from food waste, litter, and air quality; and increased access to the resource and subsequent human conflict between competing resource user groups.

Roads and trails are found throughout the Boise, Payette, and Weiser subbasins (Figure 14). Although few roads occur in the protected areas in the North, Middle and South Fork Payette, North/Middle Boise, and South Fork Boise watersheds, access can still be gained through extensive trail systems. Roads and their associated impacts are significant factors in the Lower Boise, Boise–Mores, Payette, North Fork Payette, and Weiser watersheds (Figure 14). The greatest impact occurs in the Lower Boise watershed where the majority of Idaho's population resides.

Trampling—The effects of trampling are usually limited to one meter from the trail's edge (Dale and Weaver 1974). Some plant species decrease near trails, especially woody plants because they are brittle (Tonnesen and Ebersole 1997). Grasses and sedges are most tolerant of trampling (Dale and Weaver 1974). Trampling causes compaction of leaf litter and soil, and compaction by horses is greater than by hikers (Whittaker 1978). Trail width increases linearly with logarithmic increase in number of users (width doubles with a 10-fold increase in use). Meadow trails are a little wider than forest trails, and trails with both horse and foot traffic are similar in width or slightly narrower than those receiving foot traffic alone. Additionally, trails used by horses and people are deeper than those used by people alone (Dale and Weaver 1974).

Nonnative Vegetation— Trail edges have been found to have significantly less native plant cover, and more exotic plant species (Benninger-Truax *et al.* 1992). Benninger-Truax *et al.* (1992) documented the introduction of exotics along trails by horses and people—notably where horse manure contained viable seeds of at least eight exotic species. ATVs also are documented to be a significant factor in the spread of exotic weeds across the landscape (Griggs and Walsh 1981, Trunkle and Fay 1991, Ahlstrand and Racine 1993).

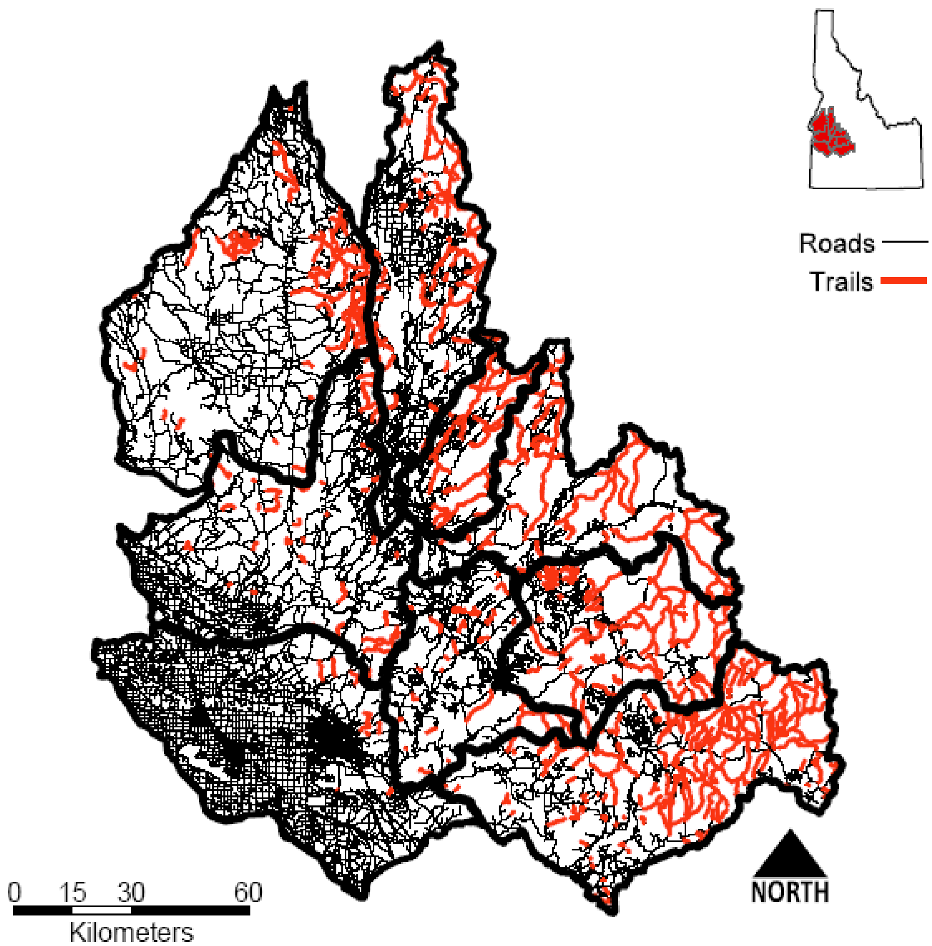

Figure 14. Distribution of roads and trails within the Boise, Payette, and Weiser subbasins. (Sources: Boise National Forest Roads and Trails, Payette National Forest Roads and Trails, Tiger Roads, and, Idaho Fish and Game Trails).

Nutrient Enrichment—Nutrient enrichment from horse manure and urine likely favors invasion of weedy species along horse trails. Research has shown that experimentally fertilized grasslands undergo a dramatic species change resulting in increased abundance of nonnative grasses, decline of native grasses, and decreased diversity (Wedin and Tilman 1996).

Pollution—Air and water pollution from off-road vehicles can be severe. By design, off-road vehicles expel 20% to 30% of their unburned oil and gasoline into the air and water (Harrison 1976). ATV and snowmobile motors produce 118 times as many pollutants as automobiles on a per-mile basis (California Air Resources Board 1998). And pollution in the form of litter and waste becomes more marked as participation in off-road vehicle activities increases.

2.4 Altered Fire Regime

Wildfires were once common occurrences throughout the grasslands and forests of the Columbia River Basin (Figure 14). Frequent fires maintained an open forest structure in the region's middle-elevation forests, prevented tree encroachment into mountain meadows and grasslands, and in some areas, replaced forested land with grassland (CPLUHNA 2003).

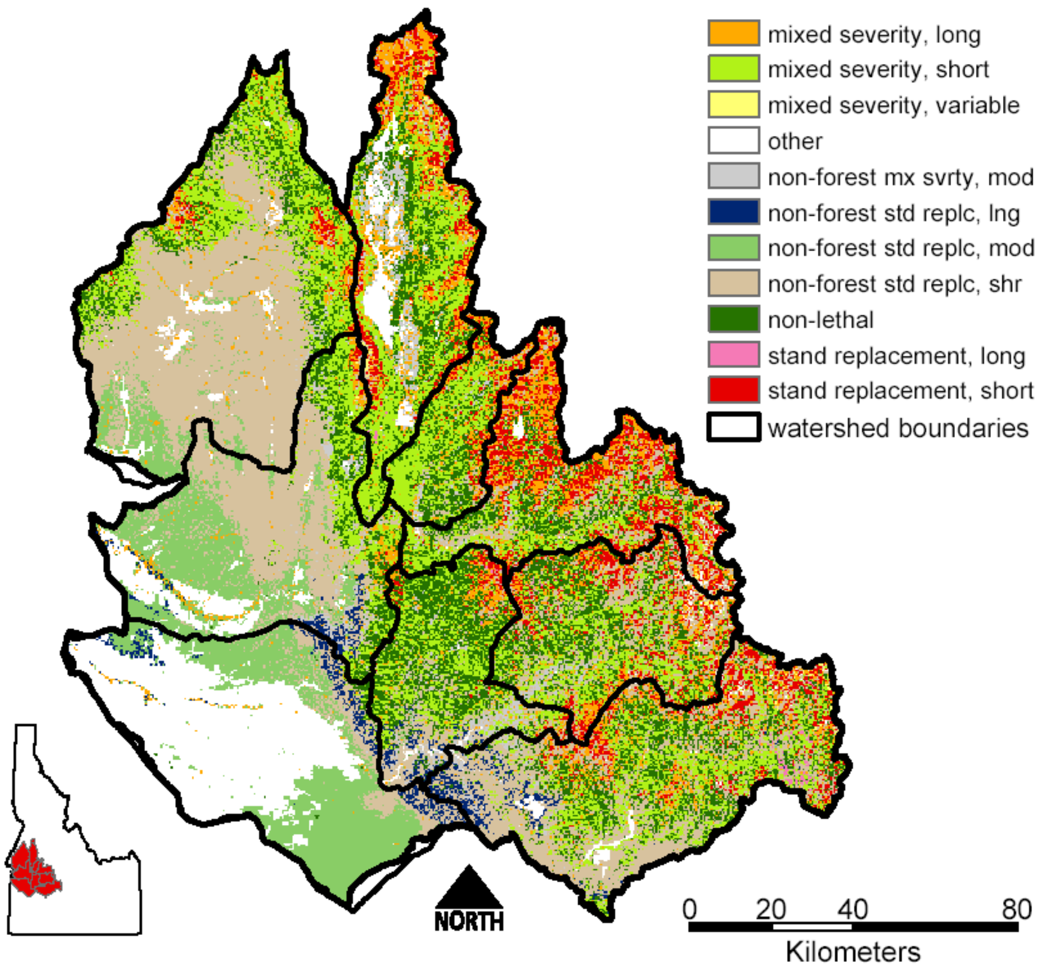

Figure 15. **Historic fire regime in the Boise, Payette, and Weiser subbasins (Northern Regional National Fire Plan Cohesive Strategy Assessment Team, Flathead National Forest).**

Prior to white settlement, fires likely burned through the region's extensive juniper woodlands every 10 to 30 years, through ponderosa pine communities every 1 to 47 years, through Rocky Mountain lodgepole pine every 25 to 300+ years, through Rocky Mountain Douglas-fir every 25 to 100 years, through quaking aspen every 7 to 100 years, and through mixed-conifer forests every 5 to 25 years (INFMS 2003). The much wetter and cooler spruce-fir forests atop the highest mountains and plateaus of the region probably went 150 years or more between fires (Fire Sciences Laboratory 2003), but these fires were generally stand-replacing events. Suppression of wildfires in recent years has altered the fire regimes (Figures 14–18) and resulted in larger, hotter, and more damaging wildfire patterns (Figure 16).

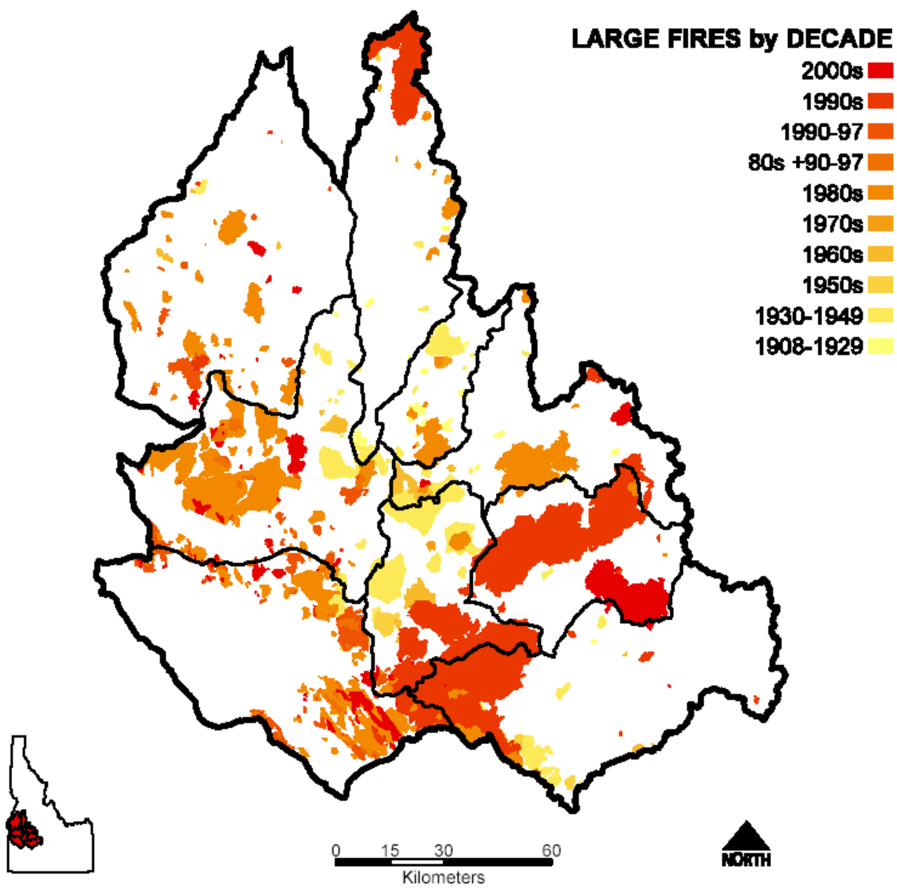

Figure 16. **Locations of large fires within the Boise, Payette, and Weiser subbasins, between 1908 and 2003 (BNF 2003, IDCDC 2003, SNF 2003, and SWIEG 2003).**

The historical fire regimes changed dramatically with the arrival and settlement of Euro-Americans. Livestock grazing removed much of the grassy fuels that carried frequent surface fires or encouraged annual grasses, and roads and trails broke up the continuity of forest fuels and further contributed to reductions in fire frequency and size. Also, the introduced exotic, cheatgrass (*Bromus tectorum*), results in unnatural shortened fire-return intervals. Because settlers saw fire as a threat, they actively suppressed it whenever they could. Fire suppression has been one of the great success stories of land management organizations. Over the last 100 years or so, public fire-fighting agencies such as the U.S. Forest Service, Bureau of Land Management, Bureau of Indian Affairs, and National Park Service have developed an impressive array of fire-fighting technologies that have remarkably reduced acreage burned by wildfires (Pyne 1982).

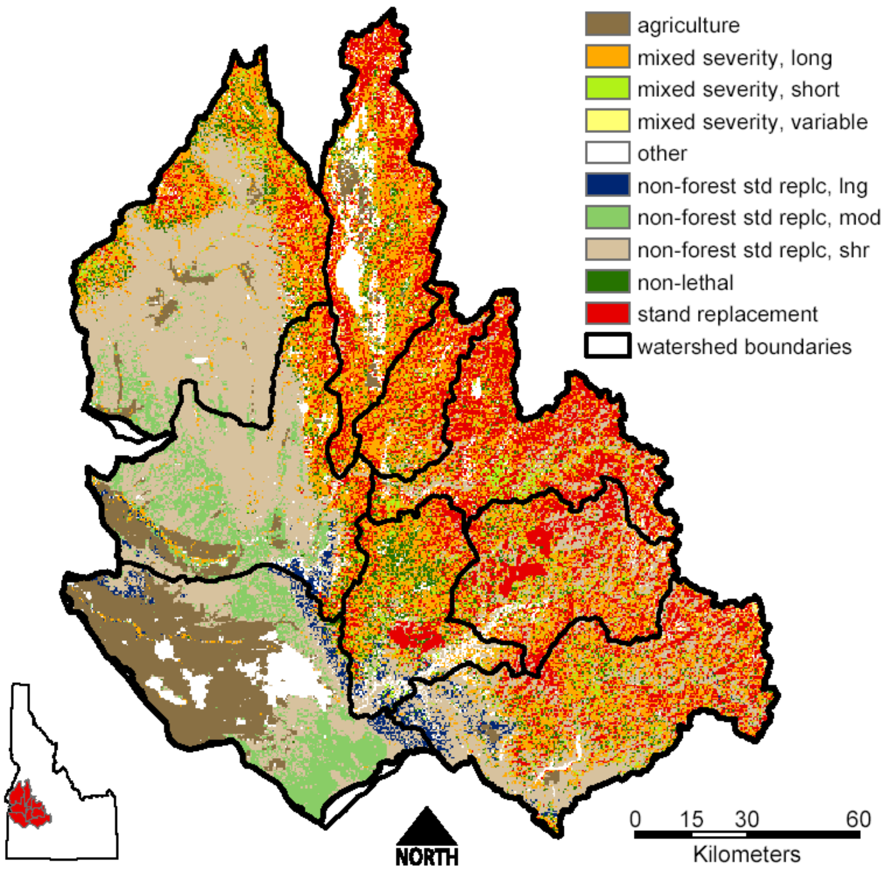

Figure 17. Current fire severity in the Boise, Payette, and Weiser subbasins, by watershed. (Northern Regional National Fire Plan Cohesive Strategy Assessment Team, Flathead National Forest 2002).

Initially, fire suppression was very successful because of low fuel loadings, but without fires to consume them, large fuel loads have accumulated over time (CPLUHNA 2003). Because of heavy fuel accumulations, fires occuring now are more intense and more difficult to contain (Figure 16). In recent years, fires that burned tens and hundreds of thousands of acres have occurred in California, Idaho, Montana, Oregon, Washington, and Wyoming (Martin and Sapsis 1992, Agee 1993, Covington *et al*. 1994, Johnson *et al*. 1994). While most ecosystems occasionally experience very large fires (Romme and Despain 1989), the present-day frequency of large fires is increasing. Figure 17 and Table 13 illustrate areas that may be at increased risk for ecosystem changing wildfire propagation.

Before the era of fire suppression, fires burned across the landscape at a variety of intensities, sizes and fire-return intervals based on localized climate, with intervals on a cold/wet to warm/dry gradient. This created a mosaic of stand ages and a variety of vegetation conditions, from meadow and savannah to dense, old forest. Of the various frequencies and intensities of fire, it seems there are few that are entirely detrimental to all organisms. Natural landscapes are often created or maintained by burning, and the plants on these landscapes have ways of dealing with natural fire (INFMS 2003).

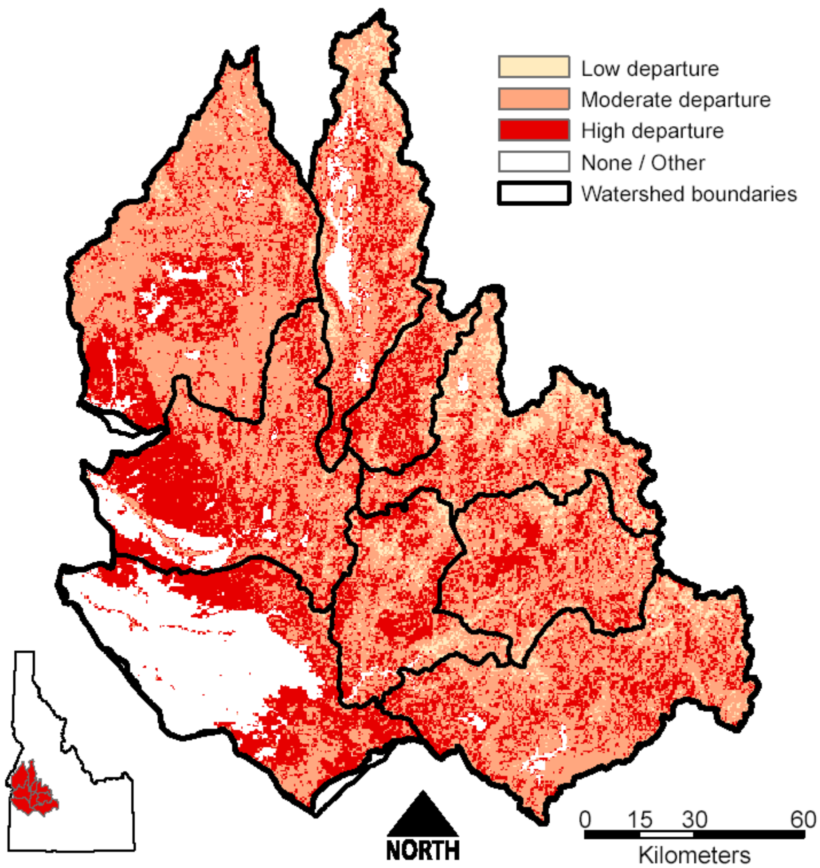

Figure 18. Probability of severe ecological fire effects in the Boise, Payette, and Weiser subbasins. Fire regime condition class (FRCC) is an approximation of ecosystem departure resulting from a change in fire regimes. (Northern Regional National Fire Plan Cohesive Strategy Assessment Team, Flathead National Forest 2002).

Each species has a unique set of characteristics that determines how it is affected by fire. Many plants have adapted to fire by evolving protective mechanisms such as thick bark. Fire may stimulate a positive response in other species, which may get bigger and produce more seeds. Even plants that are killed by fire may have coping mechanisms allowing the species to survive fire, even when individuals are burned. They may have hard seeds that survive until fire readies them to grow, or light, easily dispersed seeds that can quickly reinvade a burned area. Most employ some combination of these strategies (INFMS 2003).

Table 13. Relative percentages of risk by altered fire regimes by watershed in the Boise, Payette, and Weiser subbasins (ICBEMP 1997).

Relative Category	Major Hydrologic Unit (Watershed)								
	NMB	BMO	SFB	LBO	SFP	MFP	PAY	NFP	WEI
Low risk	30	28	22	3	42	24	13	29	13
Moderate risk	41	42	57	46	37	40	69	41	76
High risk	28	28	19	0	19	35	8	20	8
No risk	1	1	2	50	2	0	10	10	4

The greatest effect of fire suppression on biological diversity is not on the diversity within a particular habitat (Whittaker 1977), but on the diversity of habitats across a landscape. Landscapes with high diversity resulting from fire perpetuate high species diversity by providing opportunities for the establishment and maintenance of early successional species and communities (Connell 1978, Reice 1994). Fire suppression, on the other hand, increases uniformity in habitats as competition eliminates early successional species and leaves only shade-tolerant understory plants to reproduce. Burned landscapes include habitat types dominated by early successional pines, shrubs, or herbaceous species, whereas unburned landscapes were more uniform in their cover of later successional fir-dominated communities (Stuart 2003).

Fire suppression has helped change the ecosystem dynamics of communities adapted to frequent, low-intensity wildfire. Complex landscapes are made simpler; some early and mid-successional plants and animals are extirpated; shade-tolerant tree populations rapidly expand; and the relative importance of fire as a disturbance agent is reduced, while the importance of insects and pathogens is elevated (Covington *et al*. 1994).

Sagebrush-steppe ecosystems of the Great Basin in the western United States are examples of fire prone ecosystems. Many wildlife species depend on sagebrush-steppe ecosystems for survival (Knick and Van Ripper III 2002). Unfortunately, a change in the natural fire regime is decreasing the extent of sagebrush ecosystems, and the populations of wildlife species that depend on sagebrush are undergoing steep declines because of habitat loss (Connelly *et al*. 2000, Pyke 2002).

Two major problems resulting from past fire suppression activities are common to the sagebrush ecosystem (Perryman 2003). Longer time periods between fires (lengthened fire intervals) at higher elevations (higher precipitation zones) have allowed various junipers and/or pinyon pines and Douglas-fir/lodgepole pine to encroach into mountain sagebrush–grassland communities. In the Great Basin, juniper and pinyon are relatively long-lived species (approximately 1,000 and 600 years, respectively).

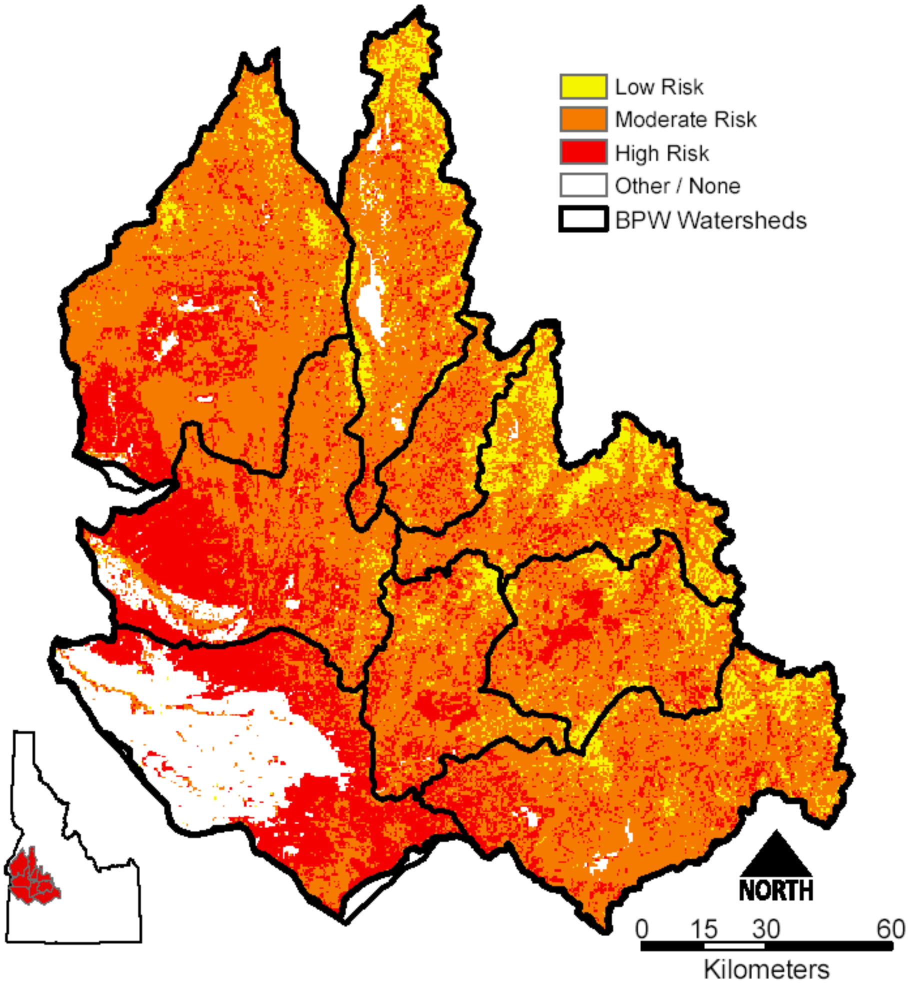

Figure 19. **Predicted areas within the Boise, Payette, and Weiser subbasins most likely to have severe burns, taking into account FRCC, ignition probability, and fire weather hazard. (Northern Regional National Fire Plan Cohesive Strategy Assessment Team, Flathead National Forest, 2004).**

Depending on specific location, 66% to more than 90% of individual trees are less than 130 years old. Fire-return intervals have increased from 12 to 25 years to over 100 years. These communities lose the perennial herbaceous understory as the canopy closes in large part because of competition from the encroaching conifers. This encroachment further leads to unmanageable fuel loads and very intense fires resulting in final loss or elimination of perennial herbaceous understory species, and loss of the original sagebrush habitat. Without a healthy herbaceous understory, these disturbed communities become susceptible to cheatgrass or other invasive species establishment, further reducing habitat quality for sagebrush obligates and other species—both wild and domestic—that utilize sagebrush habitats.

At mid and lower elevations, longer fire intervals have created decadent, climax sagebrush systems that dominate very large areas on the landscape. These communities have lost the perennial herbaceous understory in large part because of competition from dense competitive sagebrush plants. The shrub overstory in these systems is continuous and contiguous leading to fuel continuities that burn hotter and more extensively than normal. These areas have also been invaded by cheatgrass. This species is very successful because there are no perennial, herbaceous species with which to compete. After extensive fires in these systems, cheatgrass proliferates even more because fire removes sagebrush (and other shrubs), the only competitor in the system. As fire intervals become shorter from the fuel loading of the annual brome, areas that were sagebrush grasslands a single generation ago could be converted to annual grasslands dominated by cheatgrass.

2.5 Grazing/Browsing

One of the most significant human induced affects on the western landscape has been the widespread introduction of domestic livestock. Brought to the Southwest by the Spanish in the late 1500s, cattle and sheep began to have a significant impact on the region's biota with their large-scale transportation into the region via the railroad in the late 1800s. By 1890, hundreds of thousands of cattle and/or sheep were grazing on the rangelands of the west (CPLUHNA 2003).

By the time federal forest reserves were proclaimed in the 1890s, ranchers had become accustomed to unregulated use of public lands as range for livestock. As a result of these excessive stocking numbers, once-rich grasslands were seriously degraded before the end of the 1800s, after less than a human generation of use. By the early 1900s, overstocking of sheep in the region's highlands had brought forest regeneration to a halt. The forest floor in some places was "as bare and compact as a roadbed." The fire ecology of the region's forests, particularly the once grass-rich ponderosa pine forests, was drastically altered, causing significant long-term changes to their structure and composition. By 1912, livestock pressures had penetrated the most remote, timbered and mountainous areas. More than 100 years later, the effects of intense grazing in the latter part of the nineteenth century can still be readily seen in many parts of the West (Figure 19) (CPLUHNA 2003). Today in the Boise, Payette, and Weiser subbasins, strategic and prime ranchland occurs primarily in the South Fork Boise, Lower Boise, Payette, and Weiser watersheds (Figure 21).

Livestock have played and continue to play an important role in changes to ecosystems in the West. Ninety-one percent of the public land in the western United States is grazed (Belsky and Blumenthal 1997) and 67% of the total area in the Boise, Payette, and Weiser subbasins is impacted by grazing and browsing by domestic animals (Table 14). Undisturbed herbaceous ecosystems across the western United States are rare. Still, a precise determination of the ecological effects of grazing often is difficult to obtain because ungrazed land is extremely rare; exclosures are small; exact figures on grazing intensities are scarce; and approaches for evaluating the effects of grazing are not standardized (Flather *et al.* 1994, Fleischner 1994, Belsky and Blumenthal 1997). For example, the status of the grazing and browsing by domestic animals in the Boise, Payette, and Weiser subbasins is unknown for approximately 32% of the total area (Table 14).

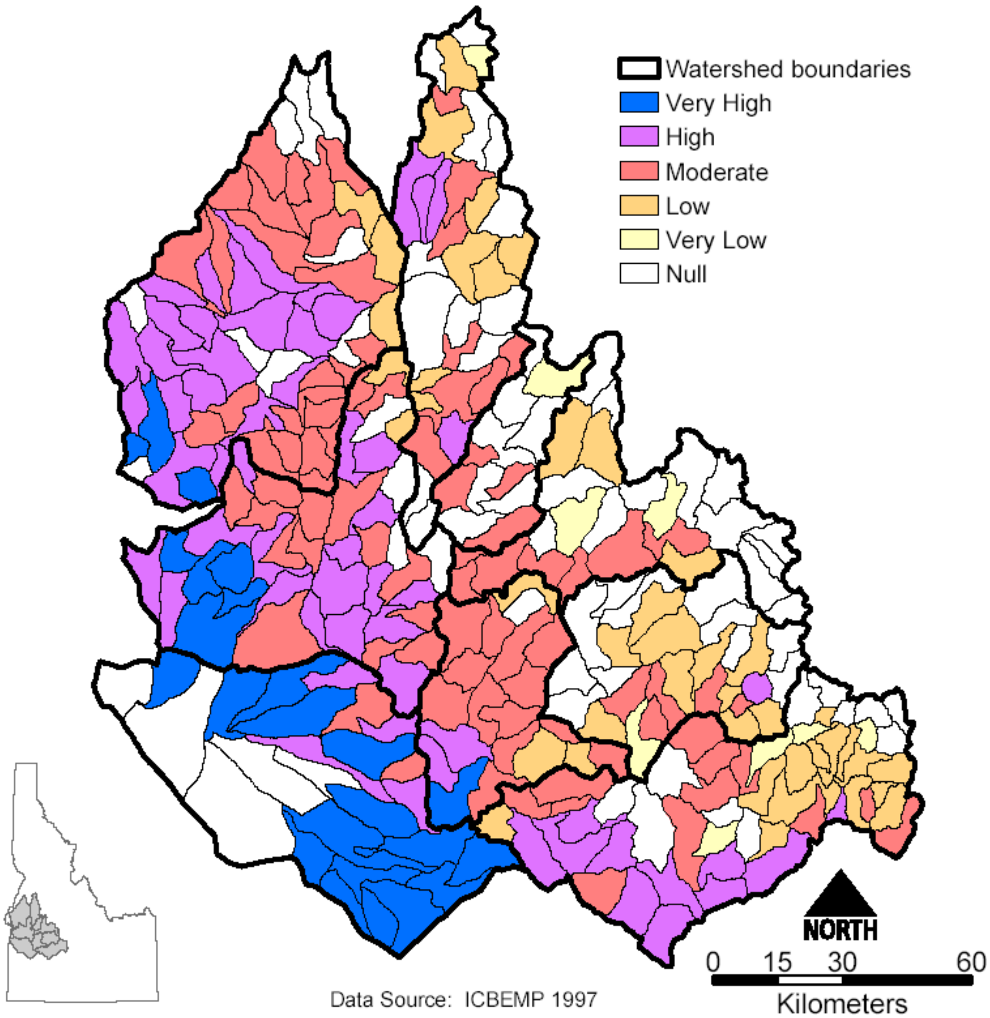

Figure 20. Rangeland health vulnerability in the Boise, Payette, and Weiser subbasins (ICBEMP 1997).

Grazing/Browsing Activity in the Boise, Payette, and Weiser Subbasins

Grazing and browsing activities by domestic animals occurs throughout the Boise, Payette, and Weiser subbasins. The majority of the grazing and browsing activities occur in the Lower Boise, Payette, and Weiser watersheds (Table 14 and Figure 21).

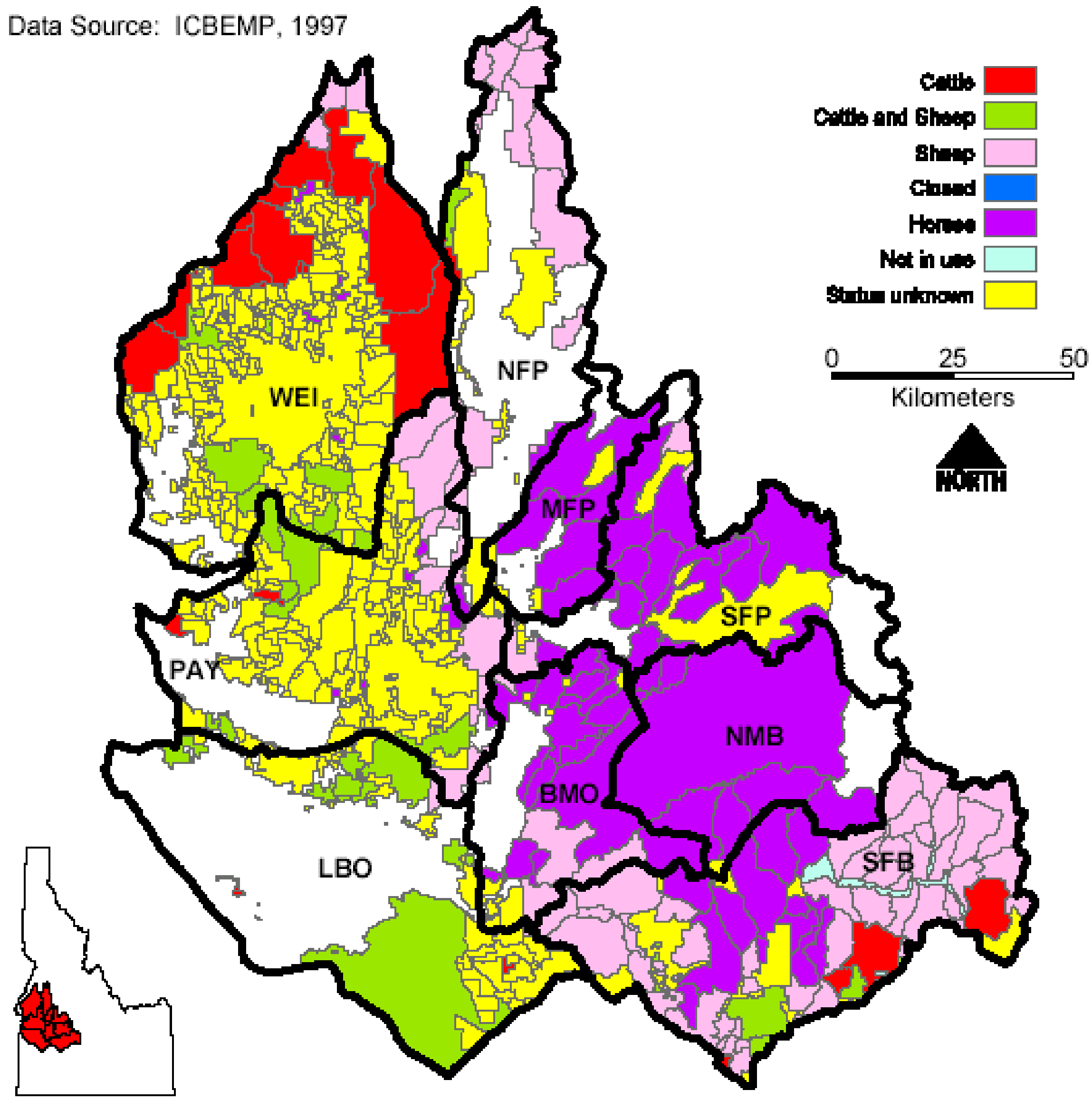

Figure 21. **Occurrences of grazing and browsing activities by domestic animals in the Boise, Payette, and Weiser subbasins (ICBEMP 1997).**

Table 14. **Percentage of area impacted by grazing/browsing livestock by watershed in the Boise, Payette, and Weiser subbasins (ICBEMP 1997, GAP II Scott *et al*. 2002).**

Focal Habitat Type	Major hydrologic unit (watershed)									Total Area (km^2)
	NMB	BMO	SFB	LBO	SFP	MFP	PAY	NFP	WEI	
Cattle			7	<1%			1	2	32	1,587
Cattle and Sheep			4	62			10	4	7	1,703
Horses	99	71	23	<1%	69	90	2	5	1	5,271

Focal Habitat Type	Major hydrologic unit (watershed)									Total Area (km^2)
	NMB	BMO	SFB	LBO	SFP	MFP	PAY	NFP	WEI	
Sheep			2							70
Not in use	<1%	22	54	2	7	<1%	21	59	3	3,615
Status unknown	<1%	7	10	36	24	10	66	30	57	5,872

Table 15 shows the percentage of area impacted by grazing for each of the four terrestrial focal habitats in the Boise, Payette, and Weiser subbasins. Grazing by cattle and sheep appear to have the greatest impact in the shrub-steppe habitat. The majority of these grazing and browsing activities occur in the South Fork Boise, Lower Boise, and Weiser watersheds. Cattle and sheep are the primary type of grazing impact in those watersheds, whereas grazing by horses occurs primarily in the South Fork Boise, North/Middle Boise, Boise–Mores, South Fork Payette and Middle Fork Payette watersheds (Figure 21).

Table 15. Percentage of area impacted by grazing domestic animals for each of the four focal habitats in the Boise, Payette, and Weiser subbasins (ICBEMP 1997, GAP II Scott *et al*. 2002). (Note: ungrazed land is not included in the table.)

Focal Habitat	Cattle	Cattle and Sheep	Sheep	Horses	Not in Use	Status Unknown	Total Area (km^2)
Riparian/Herbaceous Wetlands	2	1	2	2	11	3	431
Shrub-steppe	18	53	28	38	57	34	6,256
Pine/Fir Forest (Dry, Mature)	15	1	9	8	2	3	1,181
Interior Mixed Conifer	15	1	15	25	13	5	2,427
Other	49	44	45	27	17	55	7,821

Impacts to Riparian/Wetland Habitats

Riparian areas are critical ecosystems in the semiarid landscape of the West. Yet, many have been seriously degraded and others entirely lost due to human activities and land use. The abundance of food, water, and shade, which attracts wildlife to these areas, also attracts livestock. Despite widespread recognition of the problem and attempts to remove or restrict livestock from riparian areas, riparian degradation from overgrazing is a serious problem (Belsky *et al.* 1999).

The direct effects of livestock grazing on the wetland riparian habitats have been summarized as follows (Harper *et al*. 2003):

- Higher stream temperatures from lack of sufficient woody streamside cover
- Excessive sediment in the channel from bank and upland erosion

- High coliform bacterium counts
- Channel widening from hoof-caused bank sloughing and later erosion by water
- Change in the form of the water column and the channel in which it flows
- Change, reduction, or elimination of vegetation
- Elimination of riparian areas by channel degradation and lowering of the water table
- Gradual stream-channel trenching or braiding depending on soils and substrate composition with concurrent replacement of riparian vegetation with more xeric plant species

Riparian systems at lower elevations are now increasingly characterized by a reduction of plant species diversity and density. Overgrazing of palatable native species such as willows and cottonwood saplings, combined with the introduction of less palatable nonindigenous species such as Russian olive (*Elaeagnus angustifolia*), have also contributed to changes in overall plant community structure. Road construction associated with grazing operations has caused additional degradation of riparian areas, especially through bank erosion. The carrying capacity of the habitat and fish survival have been reduced by land and water management activities within the subbasin that have affected hydrology, sedimentation, habitat distribution and complexity, and water quality (CBFWA 1999).

Livestock may directly affect fish through trampling or ingestion of adults, larvae, or eggs (Roberts and White 1992). Livestock waste is potentially poisonous to some fish (Cross 1971, Taylor *et al*. 1991), and may increase nitrogen levels, thereby affecting nutrient cycling and encouraging algae growth. High-quality freshwater habitats are critical to the long-term strength and persistence of native resident and anadromous salmonid populations in the Columbia River Basin. These fish have generally fared best in areas that are least disturbed by humans. Grazing and browsing by domestic livestock have the potential to impact salmonid spawning and rearing success.

Impacts to Shrub-Steppe

Livestock may graze plants that are listed, forage for listed species, or provide cover or protection for listed species. Grazing can also affect the vegetative community and ecosystem functioning (Shreve 1931, Niering *et al.* 1963, Abouhalder 1992).

Livestock grazing alters the species composition of communities, disrupts ecosystem functioning, and alters ecosystem structure (Fleischner 1994). The main direct impacts from cattle are the grazing of plants and trampling of vegetation and soil (Marlow and Pogacnik 1985). Grazing can alter the prey availability of certain predators by removing herbaceous vegetation, which serves as food and cover for small mammals (Ward and Block 1995). Grazing can also alter fire regimes, a circumstance that is generally deleterious to ecosystem functioning (USFWS 1999).

A reduction in vegetation cover increases raindrop impact, decreases soil organic matter and soil aggregates, and decreases infiltration rates (Blackburn 1984, Orodho *et al*. 1990). Other detrimental impacts include increased overland flow, reduced soil water content, and increased erosion (DeBano and Schmidt 1989, Guthery *et al*. 1990, Orodho *et al*. 1990). Continuous yearlong grazing can result in large bare areas around water sources and established trails to and from points of livestock concentrations (Platts 1990).

Watershed condition and function can be affected by impacts to vegetation and litter from livestock grazing (Gifford and Hawkins

1978, Busby and Gifford 1981, Blackburn 1984, DeBano and Schmidt 1989, Belnap 1992, Belsky and Blumenthal 1997). Heavy grazing effects are well known and can be severe (Guthery *et al*. 1990, Platts 1990).

Impacts to Forests

Over the last 100 years, the structure, composition, and dynamics of western, semiarid, interior forests have changed dramatically. These forests, dominated at low elevations by ponderosa pine (*Pinus ponderosa*) and at middle elevations by Douglas-fir (*Pseudotsuga menziesii*), grand fir (*Abies grandis*), and western larch (*Larix occidentalis*), were once commonly described as open woodlands of widely spaced, majestic trees, underlain by dense grass swards (Cooper 1960, Peet 1988, Habeck 1990, Covington and Moore 1994). Over the last century, most of these forests have been clearcut, roaded, and fragmented so that only a small fraction of the original forests remains (Belsky and Blumenthal 1997).

Livestock grazing is occasionally mentioned as contributing to "forest health" problems, but it is simply noted as one of many factors reducing the frequency of surface fire (Belsky and Blumenthal 1997). Nevertheless, a large number of authors have suggested that fire began to decline in frequency and forests began to increase in density soon after livestock were first introduced into the Interior West (Leopold 1924, Weaver 1950, Cooper 1960, Madany and West 1983, Peet 1988).

By the early 1800s in the Southwest, and the late 1800s in the Northwest, virtually all plant communities that supported grass and sedge production, including ponderosa pine and mixed-conifer forests, were heavily stocked with cattle and sheep (Savage and Swetnam 1990, Oliver *et al*. 1994). After they were clearcut and seeded with grasses, even previously dense forests provided "transitory" range for livestock. As shade, drought, water stress, and pests kill small and large trees alike, fuel loads increase. These woody fuels cause what otherwise might be low intensity surface fires to develop into intense conflagrations, resulting in high tree mortality (Belsky and Blumenthal 1997).

Herbaceous Understory

Livestock affect understory species composition directly by grazing and trampling herbaceous species. This differs from the more indirect effects they have on overstory trees (Belsky and Blumenthal 1997). Impacts vary with animal density and distribution: the more evenly grazers are distributed, the lower their impact on any given area (Gillen *et al*. 1984). Unfortunately, cattle show strong preferences for certain environments, leading to high use in some areas and little or no use in others (Belsky and Blumenthal, 1997). This is particularly true in western, interior forests, where steep slopes and increasingly dense forests make much of the landscape unattractive (Clary 1975, Roath and Krueger 1982).

Understory Cover and Composition

Livestock also alter understory plant composition by eating the more palatable species, leaving the less palatable ones to increase in dominance (Smith 1967, Hall 1976, Skovlin *et al*. 1976). The effects of livestock grazing on understory composition and biomass are sometimes difficult to distinguish from the effects of tree canopy closure (Smith 1967), which creates shadier, cooler, and moister conditions. However, when Arnold (1950) separated the effects of livestock grazing from those of tree canopy closure, he found that grazing alone was sufficient to reduce the cover of most native bunchgrass species.

Domestic livestock, as well as agriculture, logging, road construction, and other practices that disturb soils, have been instrumental in the establishment of alien weedy species in western forests (Franklin and Dyrness 1973, Johnson *et al*. 1994). Livestock act as vectors for seeds, disturb the soil, and reduce the competitive and reproductive capacities of native species. Exotic weeds have been able to displace native species, in part, because native grasses of the Intermountain West and Great Basin are not adapted to frequent and close grazing (Stebbins 1981, Mack and Thompson 1982). Consequently, populations of native species have been severely depleted by livestock, allowing more grazing-tolerant weedy species to invade. It is possible that in some areas aggressive alien weeds such as cheatgrass (*Bromus tectorum*) and Kentucky bluegrass (*Poa pratensis*) have permanently replaced native herbaceous species (Smith 1967, Laudenslayer *et al*. 1989).

Forest Soils and Plant Litter

By consuming aboveground plant biomass, domestic livestock also reduce the amount of biomass available to be converted into litter and, therefore, increase the proportion of bare ground (Belsky and Blumenthal 1997). Schulz and Leininger (1990) found, for example, that grazed areas of a riparian meadow had 50% lower litter cover and 400% more bare ground than ungrazed areas. Johnson (1956) reported that litter biomass in a ponderosa pine/bunch grass ecosystem was reduced 40% and 60% by moderate and heavy livestock grazing, respectively. Such reductions in litter may have severe consequences on forested ecosystems because litter is critical for slowing overland flow, promoting water infiltration, serving as a source of soil nutrients and organic matter, and protecting the soil from freezing and the erosive force of raindrops (Thurow 1991, Facelli and Pickett 1991).

Compaction and Infiltration

The rate at which water penetrates the soil surface governs the amount of water entering the ground and the amount running off. Livestock alter these rates by reducing vegetative and litter cover and by compacting the soil (Lull 1959). As a result, livestock grazing is usually associated with decreased water storage and increased runoff (Belsky and Blumenthal 1997). Lower soil moisture contents in turn reduce plant productivity and vegetative cover, creating negative feedback loops that further degrade both the plant community and sod structure (Belsky and Blumenthal 1997). These changes in soil structure may also lead to increased water stress and tree mortality during dry periods, exacerbating the water stress resulting from the higher tree densities. Therefore, disturbance and compaction of forest soils by cattle and sheep may contribute to the increased incidence of water-stress, tree mortality, and fire in western forests (Belsky and Blumenthal 1997).

Runoff and Erosion

As livestock reduce plant cover and compact the soil, the volume of overland water flow increases (Belsky and Blumenthal, 1997). With increasing runoff, soil erosion also increases (Dunford 1954). Smith (1967), for example, found that grazed pastures in a ponderosa pine/bunchgrass range lost 3 to 10 times more sediment than ungrazed pastures. The strong relationship between runoff and erosion also was demonstrated by Forsling (1931), who found that summer rainstorms on grazed subalpine hillsides accounted for 53 to 85% of annual sediment loss. Following elimination of livestock from the watershed, vegetative cover increased 150%, whereas the proportion of annual runoff from summer rainstorms dropped 72%, causing a corresponding 50% drop in sediment loss (Forsling 1931).

Big Game Impacts and Dietary Overlap with Livestock

Numerous studies have documented the impact of grazing and browsing by big game animals upon habitats (Clark 2003). Heavy browsing by big game animals may inhibit shrub and grass cover, alter the plant composition, alter vegetative structure, prevent adequate plant reproduction, or cause direct mortality (Gaffney 1941, Korfhage *et al*. 1980, Edgerton 1987, Irwin *et al*. 1994, Nolte and Dykzeul 2000). Generally, big game impacts to the habitat become significant when the animals become so numerous as to exceed the carrying capacity of the habitat. This may occur at spatial and temporal scales depending upon the season and the condition of the habitat (e.g., winter range or naturally or artificially altered habitat) (Begon and Mortimer 1986).

Dietary overlap between big game animals and livestock is subject to the specific forage components required by the animals and the timing of ungulate use. Dietary overlap between elk and cattle is most likely to occur on fall cattle range that is used by elk later in the year as winter range (Clark 2003). Dietary overlap between elk and domestic sheep occurs during the summer when both species rely heavily on forbs; however, elk tend to be more selective among forb species than do are (Clark 2003). Elk tend to remain on a forb-dominated diet throughout the summer, while sheep diets transition from forbs to grasses and browse as the season progresses (Clark 2003).

The diets of cattle and mule deer are most prone to overlap during the spring when mule deer diets contain a substantial amount of graminoids. However, spring mule deer diets are primarily dominated by forbs and browse while spring cattle diets contain mostly graminoids. Consequently, the degree of diet overlap between cattle and mule deer is relatively small (Clark 2003). The diets of domestic sheep and mule deer overlap during the spring and fall when both ungulates are using browse and forbs. When browse is limited, both domestic sheep and mule deer rely heavily upon graminoids (Clark 2003).

Winter bighorn sheep diets and summer-fall cattle diets have the greatest potential for overlap of any seasonal diet combination between these two ungulates. Under this combination, the diets of both cattle and bighorn sheep are dominated by graminoids. However, as with elk and cattle, the differences in seasonal habitat use displayed by cattle and bighorn sheep minimizes the potential for dietary competition between these species (Clark 2003). Dietary overlap between domestic sheep and bighorn sheep is not understood as well (Clark, 2003).

Dietary overlap between cattle and pronghorn is generally considered minimal, as the two ungulates do not share significant food sources or ranges (Clark 2003). Dietary overlap between domestic sheep and pronghorn is typically the highest during the spring and fall when both species are consuming sizable quantities of browse. However, as with cattle and pronghorn, the degree of similarity between the diets of pronghorn and sheep is generally quite low (Clark 2003).

2.6 Timber Harvest

Logging began in the vast forests of the west in the 1870s and 1880s when materials and supplies were needed for construction of the transcontinental railroad. Subsequent settlement of the frontier by pioneers and immigrants increased the demand for timber products. In the early 1900s, new technologies allowed greater harvest on terrain previously unavailable for logging. In mid-century, dramatic increases in timber harvest and road building occurred in the

National Forests and private lands throughout the West. An agricultural model of sustainable forestry favoring even-aged stands became the standard of timber-harvest operations. During this time, typical harvests removed one-third to two-thirds of the available volume. At these residual-stocking rates, stem density increased while tree size and age decreased (CPLUHNA 2003).

Idaho forests have undergone significant changes in tree species composition since 1952 (O'Laughlin *et al*. 1993). Historically, the most important timber species in Idaho were ponderosa pine and western white pine (*Pinus monticola*). Both have declined since 1952, ponderosa pine by 40% and western white pine by 60%. Byler *et al*. (1994) estimated that the extent of western white pine might now be only 10% of what it was in 1900.

Douglas-fir increased by roughly 1.2 billion cubic feet, or 15%, holding its position as the largest component of Idaho forests. The second largest component is the aggregation for Engelmann spruce (*Picea engelmannii*), western larch, and other softwoods, primarily western red cedar (*Thuja plicata*) and western hemlock (*Tsuga heterophylla*). Taken together, spruce, larch, cedar, and hemlock increased by more than 30% from 1952 to 1987 (O'Laughlin *et al*. 1993). Lodgepole pine, an early seral species, has declined dramatically (Figure 23 and Figure 24).

Timber harvest has occurred throughout the Boise, Payette, and Weiser subbasins (Figure 22 and Table 16). Very high to medium harvest activities have occurred in the central Boise, Payette, and Weiser subbasins. The most significant timber-harvest activities have occurred in the North Fork Payette, Middle Fork Payette, and Boise–Mores watersheds (Figure 22 and Table 16), dominantly within government owned lands. Very low to medium harvest activities have occurred in protected areas, primarily the eastern portions of the South Fork Boise and North/Middle Fork Boise and South Fork Payette watersheds.

Impacts to Soil

Soil is a primary determinant of long-term site productivity, and timber harvest can produce a variety of changes in soil properties that affect long-term site productivity.

Timber harvest and subsequent site preparation usually result in microclimate changes that influence subsequent biological processes. The most important of these include changes in light, temperature, and moisture. Soil chemistry and microbial processes can be affected in either a beneficial or detrimental manner.

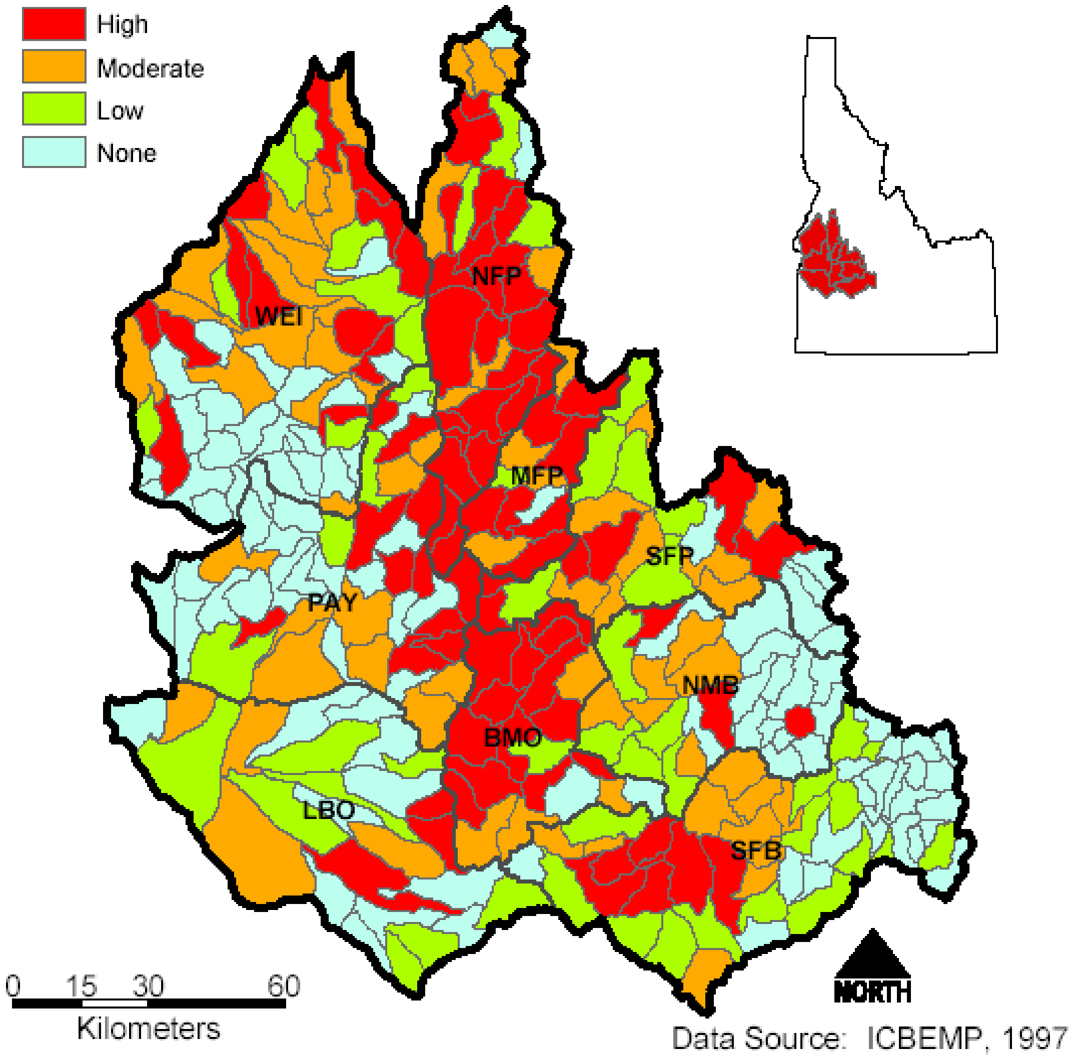

Figure 22. **Relative timber-harvest impacts in the Boise, Payette, and Weiser subbasins (ICBEMP 1997).**

Table 16. **Relative percentages of timber harvest by watershed in the Boise, Payette, and Weiser subbasins (ICBEMP 1997).**

Relative Category	Major hydrologic unit (watershed)								
	NMB	BMO	SFB	LBO	SFP	MFP	PAY	NFP	WEI
High	9	64	18	9	24	66	21	67	24
Low	23	21	20	23	29	26	29	19	33
Medium	23	4	34	35	32	4	13	10	15
No harvest	45	10	29	33	15	5	37	5	29

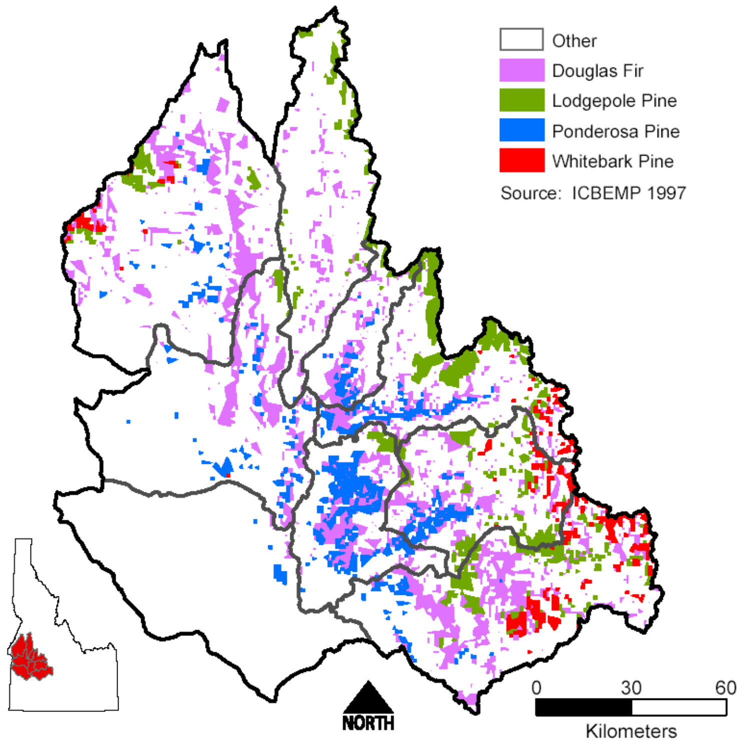

Figure 23. Historical forest species compositions in the Boise, Payette, and Weiser subbasins (ICBEMP 1997).

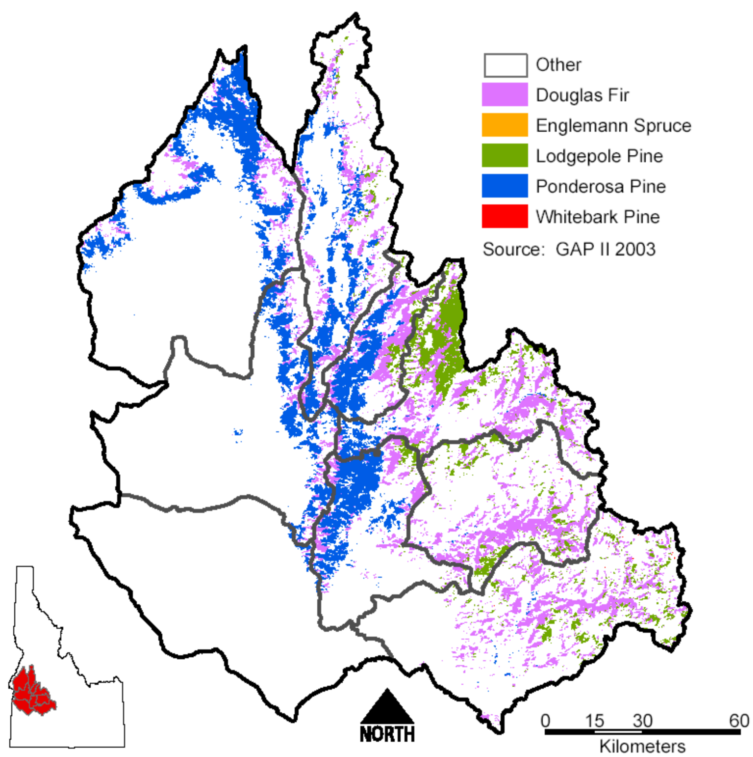

Figure 24. Current forest species compositions in the Boise, Payette, and Weiser subbasins (GAP II Scott *et al*. 2002).

Timber harvest can cause extensive losses and disturbances of surface organic matter. This potential has important implications for soil chemical, biological, and physical properties (Jurgensen *et al*. 1990). Timber harvest reduces soil organic matter both by physical loss at time of harvest and by increased microbial activity caused by soil disturbance (Jurgensen *et al*. 1990). Site-preparation techniques, particularly slash piling and windrowing, can cause productivity problems related to organic matter because of the disturbance of large areas of the forest floor. Substantive losses of surface organic matter lead to declines in productivity (Powers 1991).

Forest management activities, especially timber harvest and road construction, have been shown to increase erosion rates on forest lands (Megahan 1991). Skid trails and other high-traffic areas are particularly susceptible to erosion (Megahan 1991). Debris landslides and gullying cause serious and long-term reductions in site productivity, but the areas affected are small. Surface erosion occurs over much larger areas and reduces site productivity, but the magnitude of the reduction is poorly defined because of the compounding effects of compaction on logged areas and the water repellency of burned areas (Megahan 1991).

Impacts to Fish Habitat

Timber harvest can affect both the processes and structures that result in fish habitat. Habitat alterations can adversely affect all life stages of fishes, including migration, spawning, incubation, emergence, and rearing (Lee *et al*.1997). The effects of timber harvest on fish habitat are likely to be varied and dynamic.

Structure

Four major effects of timber harvest on stream structures can be summarized as follows (Chamberlin *et al*. 1991):

1. Increases in peak flows or the frequency of channel-modifying flows from increased snowmelt or rain-on-snow events can increase bed scour or accelerate bank erosion.

2. Increases in sediment supply from mass movements or surface erosion, bank destabilization, or instream storage losses can cause aggradation, pool filling, and reduction in gravel quality.

3. Streambank destabilization from vegetation removal, physical breakdown, or channel aggradation adds to sediment supply and generally results in a loss of the channel structures that confine flow and promote the habitat diversity required by fish populations.

4. Loss of stable instream woody debris by direct removal, debris torrents, or gradual attrition as streamside forests are converted to managed stands of smaller trees will contribute to loss of sediment storage sites, fewer and shallower scour pools, and less effective cover for rearing fish.

Streamflow

The hydrologic effects of timber management activities vary with many environmental factors, but Chamberlin *et al*. (1991) suggest that the following broad generalizations apply:

1. Harvest activities such as road building, falling, yarding, and burning can affect watershed hydrology and streamflow

much more than can other management activities such as planting and thinning.

2. Clearcutting causes increased snow deposition in forest openings and advances the timing and rate of snowmelt. The effect lasts several decades until stand aerodynamics approach those of the surrounding forest. Snowmelt can be accelerated by large wind-borne energy inputs of warm rain falling on snow.

3. Harvested areas contain wetter soils than unlogged areas do during periods of evapotranspiration and therefore have higher groundwater levels and more potential late-summer runoff. The effects last 3 to 5 years until new root systems occupy the soil.

4. Road systems, skid trails, and landings accelerate slope runoff, concentrate drainage below them, and can increase soil water content.

Water Quality

Stream temperature is affected by eliminated streamside shading, disrupted subsurface flows, reduced stream flows elevated sediments, and morphological shifts toward wider and shallower channels with fewer deep pools (Lee *et al*. 1997). Harvest activities that impose large oxygen demands on streams exacerbate the normal stresses that low flows place on fish (Chamberlin *et al*.1991).

Sediment

Timber harvest can influence both upland erosional processes and the way that forest streams process sediment in their channels. Forest management activities that substantially change the magnitude, timing, or duration of sediment transport and overwhelm the ability of fish to cope with or avoid resulting stress are of most concern (Chamberlin *et al*. 1991). Roads and mass movements associated with roads are the largest sources of sediment production stemming from timber-harvest activities (Cook and O'Laughlin 2000).

Large Woody Debris

Because the supply of large woody debris to stream channels is typically a function of the size and number of trees in riparian areas, it can be profoundly affected by timber-harvest shifts in the composition and size of trees within the riparian area. Large woody debris influences channel morphology, especially in forming pools and instream cover, retaining nutrients, and storing and buffering sediment. Reduction in the amount of large woody debris within streams, or within the distance equal to one site-potential tree height from the stream, can reduce instream complexity. Large woody debris increases the quality of pools by providing hiding cover, slow water refuges, shade, and deep-water areas (Maser *et al*. 1988).

Roads

By far the greatest concerns about timber harvest and water quality result from the issue of roads. Serious degradation of fish habitat can result from poorly planned, designed, located, constructed, or maintained roads. Roads directly affect natural sediment and hydrologic regimes by altering streamflow, sediment loading, sediment transport and deposition, channel morphology, channel stability, substrate composition, stream temperatures, water quality, and riparian conditions within a watershed (Chamberlin *et al*. 1991, Furniss *et al*. 1991, Lee *et al*. 1997).

Impacts to Wildlife

Timber harvest can have positive, negative, and neutral effects on wildlife habitat, depending on the life requirements of the species inhabiting the area (Cook and O'Laughlin 2000).

One important aspect of the relationship between wildlife and timber harvest is not how many trees are removed but how much vegetation remains as food and cover for the species inhabiting the area. Populations of animals of low mobility and specific habitat requirements (e.g., amphibians, reptiles, small birds, and small mammals) can be adversely affected at the time of a timber harvest, even if the cut is limited to a small area or a single tree. Highly mobile animals (e.g., large birds and mammals) are less affected. The age and size classes of trees that remain after harvest and their spatial relationship is important (Patton 1992).

Impacts to Scenery

Scenery may be one of the most common, yet often under-appreciated, resources that humans obtain from forests. High scenic quality fosters psychological and physiological benefits to individuals, and thus benefits communities and society at large (Galliano and Loeffler 1995). Beautiful scenery can attract people to visit and live in an area, which can encourage economic and social development. Landscapes with a high degree of natural appearing character are most attractive (Galliano and Loeffler 1995). Timber harvest and other timber-management activities influence the scenic character of landscapes, and the scenic impacts of timber management influence public perceptions of forestry (Brunson and Reiter 1996).

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