2 Characterization of Biomes

For the purposes of this assessment, we divided the subbasin into six biomes: aquatic, riparian, wetland, grassland/shrub, xeric forest, and mesic forest (figures 2.1 and 2.2). In this part, we describe the critical functional processes in each of these biomes and how humans have altered those processes. We then describe four reference conditions: presettlement (1850), present (2004), future potential (2050), and future no action (2050 with no change in current management).

2.1 Aquatic Systems

2.1.1 Critical Aquatic Functional Processes[1]

Landform and vegetation are the most important large-scale physical features that affect watershed function and process. Landforms determine how and where water travels across the landscape, while vegetation influences the erosional processes that occur within the landscape (USFWS 2000).

At finer spatial scales water, sediment, solutes, and organic matter from terrestrial systems flow into and through streams and rivers. The shape and character of stream channels is dynamic, constantly undergoing adjustments to the flow of these materials by forming distinctive patterns of pools and riffles, meanders, and braids (Leopold et al. 1964). The varied topography within the subbasin, along with channel-affecting processes and irregular disturbance (i.e. environmental stochasticity: fire, debris flows, landslides, drought, and extreme flood events) have resulted in a range of river and stream conditions that, under natural conditions, are constantly in flux (Reeves et al. 1995). Most of these disturbances result in pulses of sediment and large woody debris into streams. In response to these episodic inputs, the streams and rivers in the subbasin undergo cycles of channel change on a timescale ranging from years to hundreds of years. Having evolved under and adapted to such conditions, aquatic and riparian species are dependent on the dynamic nature of stream channels (USFS 2003).

Makepeace (2000) described how landforms affect channel and floodplain processes in watersheds like those found in the Kootenai. The descriptions of headwater and valley floor areas that follow are adapted from that discussion. Figure 2.3 shows general downstream trends for subbasin streams.

Snapshot

During presettlement times aquatic and hydrologic processes and functions were intact. Dams, dikes, diversions, groundwater withdrawls, roading, channelization, logging, agricultural and grazing practices, the introduction of non-native species, developments, and other human activities have altered these functions and processes. Consequently, water quality, streamflows, streambank stability, sedimentation, channel diversity and other habitat attributes have been degraded, and native fish species have declined.

[1] *Biophysical features and their associated processes are interrelated and interlinked; processes in one place or time may be influenced or controlled by adjacent processes (Stanford and Hauer 1992).*

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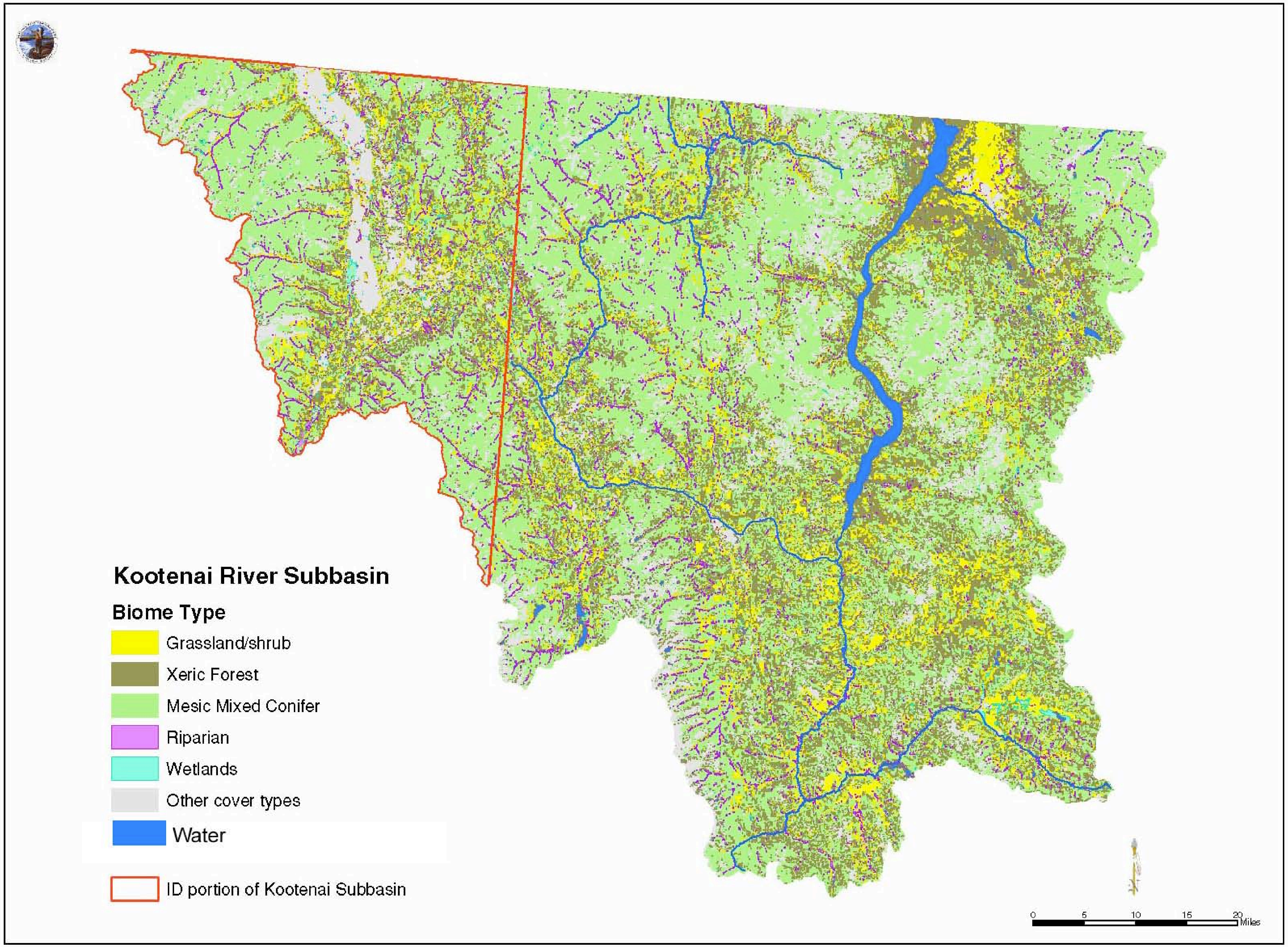

Figure 2.1. Biomes in the U.S. portion of the Kootenai River Subbasin.

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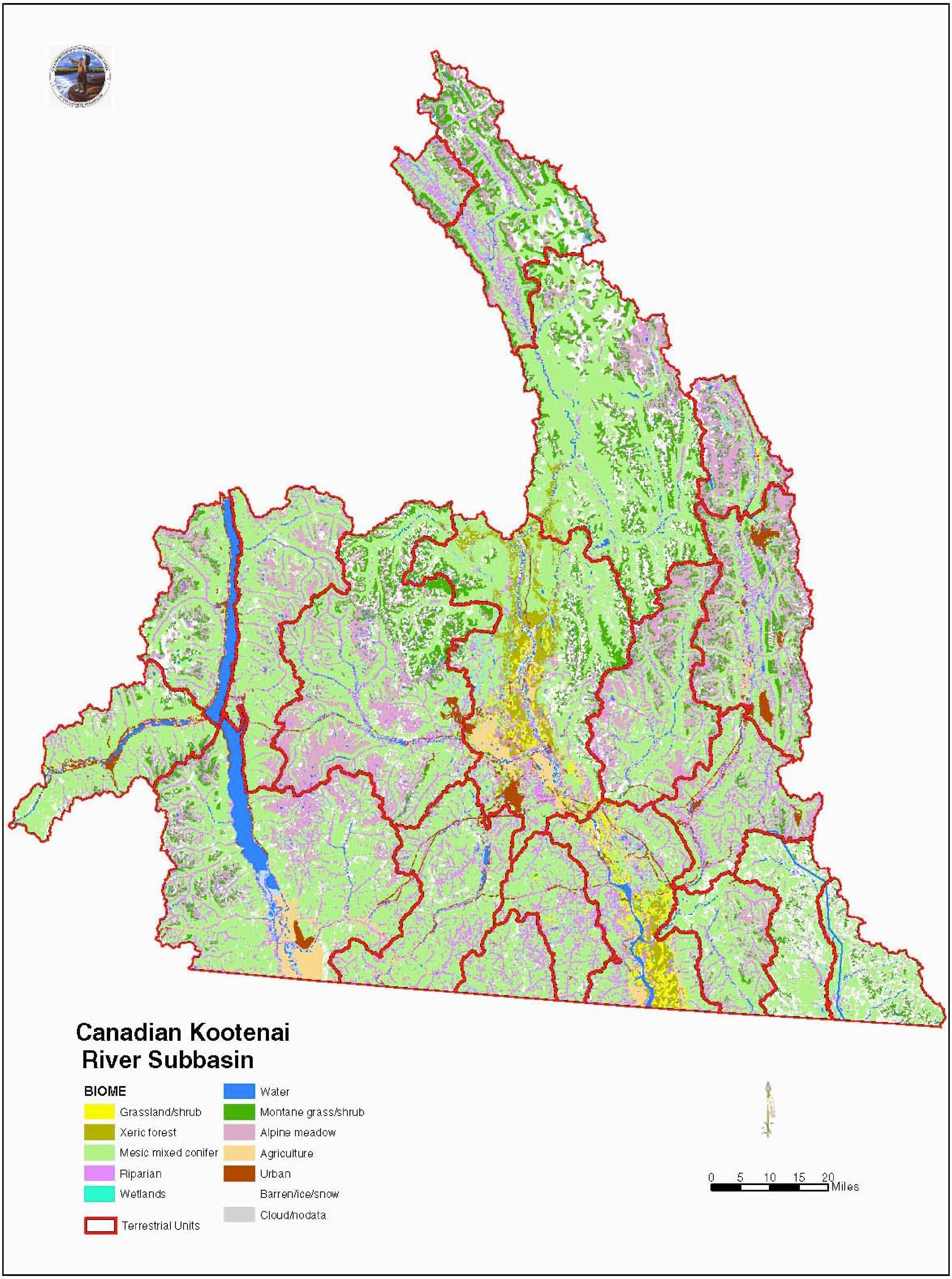

Figure 2.2. Biomes in the Canadian portion of the Kootenai River Subbasin.

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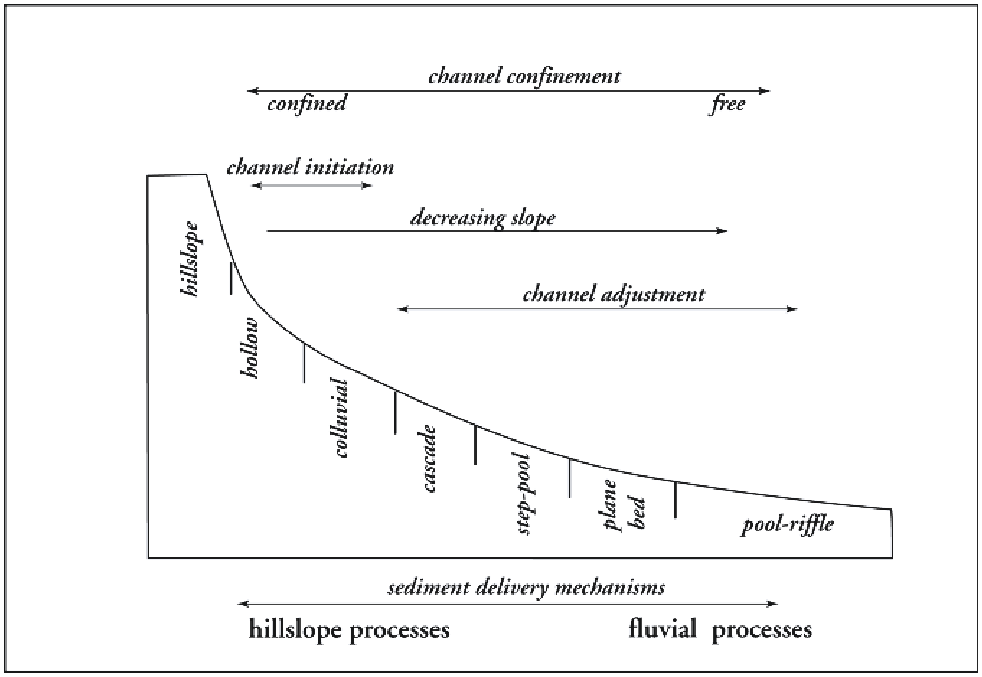

Figure 2.3. Idealized longitudinal profile through a channel network (redrawn from Makepeace 2000, after Montgomery and Buffington 1997).

Headwater Areas

Hillslope or terrestrial processes dominate water and sediment movement in the headwater portions of subbasin watersheds. Water flows beneath the surface and accumulates in depressions, hollows and colluvial till areas at the base of individual hillslopes. At some point on the slope, enough water moves through a depression to develop an incised channel, the general form of which is often a simple scoured channel (Dunne and Leopold 1978).

Downslope, these channels combine, and the duration of streamflow increases. A more complex channel pattern, typically a cascade channel develops. Cascade and reaches are formed by irregularly spaced boulders and accumulations of wood. The channels are generally incised and there is limited floodplain development.

Step-pool channels develop downstream of and are often separated by cascade reaches. They are composed of generally discrete, spaced accumulations of boulders and woody debris that form steps. The steps in turn are separated by lower gradient pool areas with accumulations of gravel-size substrates (Grant et al. 1990). Most forested watersheds and forested stream reaches contain cascade and step-pool channel morphologies.

As channel morphologies change in a downstream direction and the width of the floodplain increases, there is a shift in the origin of the sediment carried by the stream from hillslopes to fluvial, or near-channel sources. Hillslope sediment delivery mechanisms include dry gravel from hillslopes, shallow-seated earthflows, and debris flows, all of which are typically episodic, occurring during or after extreme weather events. Fluvial sediment comes from the scouring of floodplain channels or from the floodplain itself when flows overtop banks. In forested reaches streambank sediment sources are often limited because of the dense vegetation growing along channel margins (Makepeace 1998).

It should be noted that even though most surface runoff in the subbasin results from annual spring peak discharges caused by melting snow, aquatic systems in the subbasin are also affected periodically by rapid snowmelt augmented by rain (rain-on-snow events). These events, a consequence of the warm, moist Pacific air masses that flow into the area in winter, can lead to sharp midwinter peak flows (USFS 2003).

Valley Floor Areas

As streams emerge onto valley floors, geomorphic processes and channel responses change. Valley and floodplain widths increase. Channels tend to flow over materials eroded and deposited by the current stream, and there is a significant decrease in the influence that large, immobile bed elements have on the channel pattern. With the increase in floodplain width and the presence of underlying, unconsolidated aquifer systems, the interconnectivity between the stream and groundwater increases.

As channels migrate laterally within their associated floodplains, they develop a sinuous or meandering pattern characterized by alternating pools and riffles (Leopold et al. 1964). There are generally three end-member, pool-riffle stream types found within the subbasin:

- Laterally unconstrained gravel-bedded streams;
- Free meandering, fine bedded streams that flow through glacial lacustrine silts and other fines; and
- Gravel-bedded streams with well developed alluvial floodplains that are entrenched within wide canyons/valleys.

Stream channel movement across broad valleys also tends to correspond with an increase in the diversity of landform types, such as alluvial bars, levees, low-lying wetlands, and riparian and wetland meadows.

Flooding, Floodplains and the Hyporheic Zone[2]

Flooding, a normal, natural, and necessary phenomenon and function in watershed systems, occurs when a stream or river flow exceeds the bed and banks that the stream normally occupies and spills over onto its surrounding lands. This flooded area, which should be viewed as a normal extension of the stream channel, is often called the floodplain or flood prone area. Generally, in the Kootenai, floods of some magnitude occur one to four times in any ten-year period. On a less frequent basis, larger runoff events fill greater proportions of the stream's flood prone areas. Flooding permits the stream system to adjust to changes in stream flow and sediment delivery, and remain in a dynamic equilibrium with its watershed.

Native flora and fauna of the Kootenai Subbasin evolved and adjusted to the natural flood history they experienced over many centuries. Larger scale floods in the basin are not unusual. They have occurred in 1894, 1903, 1913, 1916, 1927, 1928, 1933, 1938, 1947, 1948, 1950, 1954, 1956, 1959, 1961, 1964, 1966, 1967, 1971, 1974, 1976, 1981, 1987, 1996, and 1997—an average frequency of more than one every 10 years. The largest recorded floods occurred in 1894, 1916, 1933, 1948, 1954, 1956, 1961, 1974, and 1996. Large and frequent flooding has not been an unusual event in recent history, and the watershed systems (physical components) have subsequently been able to readjust toward a more steady state. Likewise, the aquatic systems and their biological and ecological communities have historically adjusted and persisted.

Thus, flooding is a fundamental aquatic system process in the Kootenai. Spring flushing flows sort river gravels, define channels, and remove tributary deltas. In so doing, they create a healthy environment for native fish and the food organisms they depend on. They also restore nutrient cycles and floodplain function. Black cottonwood is one of the primary species that benefit from floods, and black cottonwood galleries support many species. Floods alter channels and create backwater sloughs and log jams, providing resting areas and hiding cover for fish and other organisms. Floods also move fine sediments out of the river and onto floodplains where they alter the nutrient flux in riverside meadows and riparian communities used by foraging bears, deer, and elk. Floodplains are highly productive for small rodents such as deer mice, which in turn feed a variety of predators (Long 2000). The near-shore habitat is productive and critical to fish, and a healthy riparian zone substantially reduces the erosion of silt into the river in many systems.

However, floods are not the only force shaping floodplains and the plant communities that grow on them. The flow of water between the channel and the

[2] *Paragraphs on flooding adapted from Deiter 2000.*

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floodplain during periods of normal flow also plays a major role. In fact, groundwater flow and recharge of surface waters in expansive floodplain settings is an important ecological function in montane river systems like the Kootenai (Stanford and Ellis 2002). Studies in the Flathead system by Stanford and others on the Nyack floodplain have shown that as the river leaves the narrow part of a canyon, as much as 20 percent of its water penetrates the porous gravels of the river bottom and flows underground, beneath the bed and floodplain of the river in what is known as the hyporheic zone. Downstream, near the bottom of the floodplain, where the canyon begins to constrict again, there is an upwelling of this same water as it is forced up by the encroaching underlying bedrock. Spring brooks appear on the floodplain, and overflow channels begin to flow as far as one-quarter mile away from the actual bed of the river.

LINKS

For fish and water information about the Kootenai in British Columbia, go to: http://srmwww.gov.bc.ca/aib/

Click Here

For an electronic library of aquatic information for the B.C. portion of the subbasin, go to: http://srmwww.gov.bc.ca/appsdata/acat/html/deploy/acat_p_home.html

Click Here

For more information on critical functional processes of aquatic systems, see Appendix 22.

Click Here

Wells drilled into the gravel of the floodplain have revealed a community of organisms living and thriving in the hyporheic zone up to half a mile from the river channel. That community includes midge and mayfly larvae, riffle beetles, water mites, stonefly larvae, archiannelids, bathynellids, and amphipods. At the base of this web of life is a subterranean film of fungi and bacteria that coats the alluvial gravels. This film, grazed by the higher organisms, survives by consuming dissolved organic matter from the decomposition of leaves, twigs, algae, insects, and fish. The processing of all this material as it moves through the subsurface gravels releases large amounts of previously unavailable nutrients, especially phosphates and nitrates, into the water. The result is that relatively infertile waters can become charged with bio-available nutrients and emerge on the floodplain surface in the form of springs, sometimes several hundred yards from the river, where they fertilize the riparian zone. Aerial photographs reveal that the most productive, vigorous plant communities on the floodplain occur where there are these upwellings.

The complex interactions between ground water and surface water are key attributes of high quality riverine habitat for both bull trout and westslope cutthroat trout and help to shape wetland and riparian habitats for numerous terrestrial species.

Rain on Snow[3]

The Kootenai Subbasin is susceptible to rain-on-snow events. Basin-wide, the largest peak flows are related to spring snowmelt, or snowmelt supplemented by direct rainfall. However, in susceptible areas, midwinter rain-on-snow events result in stream flows that approach or exceed bank-full discharge during many years.

[3] *Adapted from Deiter 2000.*

On several gauged streams, the largest floods on record are related to midwinter rain-on-snow events. North Idaho, from the North Fork of the Clearwater River to the Canadian border is under a strong maritime influence, where warm moist fronts invade in the winter from the Pacific coast. Because of the prevailing maritime influence on the winter air masses and storms of the region, the basin accumulates a deep, but often not a very cold, snowpack. Therefore, there is not often a great thermal deficit to overcome before the pack becomes isothermal, the free-water content of the pack to be satisfied, and for melt to begin. The results are that midwinter snowmelt and thaws and rainfall are common in the region, even during the times when a significant snow pack is established. Within the north Idaho Panhandle, the frequency and magnitude of these events tends to increase as the latitude decreases from the Canadian border.

In the subbasin, the snow pack that is most often susceptible to rain-on-snow[4] melt response appears to lie approximately in the 3,000 to 4,500 foot elevation range. Below 3,000 feet, the snow pack is often transitional during the winter—accumulating and dissipating several times during the season. At this elevation, snow pack may not be a significant contributor to overall basin runoff. In many years the snow pack above about 4,500 feet is usually "cold", with a large thermal deficit in the midwinter months. There are times when a significant proportion of some watersheds, or at least some tributary basins, are setup for rain-on-snow events.

Rain-on-snow response is a climate-dominated process under which the streams in the Kootenai Subbasin have historically developed. The percentage of a watershed that lie within the transient snow zone is an important factor of rain on snow flooding susceptibility (Kjelstrom and Moffatt 1981). Tables 2.1 and 2.2 show the portion of each of the watersheds in the Idaho and Montana portions of the Kootenai Subbasin (respectively) in the sensitive snow zone as defined by the Idaho Panhandle (elevations between 3,000 and 4,500 feet) and Kootenai (elevations below 4,500 feet) National Forests.

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[4] *Rain-on-snow is a bit of a misnomer because the phenomena is more complicated than the name implies. The energy transfer from warmer rain water to frozen snow, or from the change of state of liquid rain to ice does tend to raise the temperature of a snow pack. This transfer is greater than the energy transfer associated with the snow surface contact with a warm air mass. But, it is the change of state of water vapor (like fog) over snow that can have the most tremendous effect. In fact, the condensation, freezing, and sublimation associated with a moist air mass has perhaps seven times greater thermal energy available than just in rain.*

Table 2.1. The portion of each of the watersheds in the Idaho portion of the Kootenai Subbasin in the sensitive snow zone (the area more susceptible to rain on snow events).

Descriptive Name	% Watershed in Senstive Snow Zone	Descriptive Name	% Watershed in Senstive Snow Zone
Kootenai River blw Yaak River	**24%**	**Kootenai R blw Bonn Ferry (cont.)**	
Kootenai R abv Curley Cr	28%	Ball Cr	19%
Kootenai R abv Curley Cr	15%	Trout Cr	15%
Pine Cr	37%	Parker Cr	12%
Curley Cr	34%	Long Canyon Cr	18%
Boulder Cr	40%	**Mission Cr**	31%
Boulder Cr abv MF Boulder Cr	33%	**Smith Cr**	24%
Boulder Cr blw MF Boulder Cr (incl	52%	Smith Cr abv Cow Cr	17%
EF Boulder Cr	39%	Cow Cr	20%
Kootenai River abv Bonners Ferry	18%	Smith Cr blw Cow Cr	43%
Deep Cr	37%	**Boundary Cr**	16%
Deep Cr abv McArthur Lake outlet	40%	Boundary Cr abv Grass Cr	9%
Deep Cr abv Brown Cr	39%	Grass Cr	16%
Fall Cr	51%	Boundary Cr blw Grass Cr	20%
Ruby Cr	45%	**Moyie River**	
Deep Cr blw Brown Cr	7%	**Moyie River in Idaho**	34%
Brown Cr (incl Twentymile Cr)	31%	Hawkins Cr	5%
Caribou Cr	37%	Moyie River abv Placer Cr	34%
Snow Cr	39%	Round Prairie Cr	41%
Kootenai River blw Bonners Ferry	17%	Meadow Cr	61%
Kootenai Valley	14%	Lower Moyie River	37%
Myrtle Cr	28%	Deer Cr	36%

Table 2.2. The portion of each of the watersheds in the Upper Kootenai of the Montana portion of the Kootenai Subbasin in the sensitive snow zone (the area more susceptible to rain on snow events).

Subunit(s) within Watershed	Watershed Number & Name	% Watershed in Senstive Snow Zone	Subunit(s) within Watershed	Watershed Number & Name	Percent Sensitive Snow Zone	Subunit(s) within Watershed	Watershed Number & Name	% Watershed in Senstive Snow Zone
Wigwam	170101010101 Wigwam R	0	Ksanka	170101010406 Tobacco R	46	Crazy Treasure	170101010704 Big Cherry Cr	41
Dodge	170101010201 Bloom Cr	0	Boulder	170101010501 Boulder Cr	16	Crazy McSwede Treasure	170101010705 Lower Libby Cr	48
Dodge	170101010202 Sink Cr	53	McSutten	170101010502 Sutton Cr	19	Treasure	170101010801 Flower Cr	32
Dodge	170101010203 Young Cr	29	Ubig	170101010503 Up So Fk Big	2	Treasure	170101010802 Parmenter Cr	37
Dodge	170101010204 Dodge Cr	32	Big Ubig	170101010504 Low So Fk Big	27	Pipestone	170101010803 E Fork Pipe Cr	34
Ksanka	170101010205 Phillips Cr	10	Big	170101010505 Big Cr	27	Pipestone	170101010804 Up Pipe Cr	64
Boulder	170101010206 Sullivan Cr	26	McSutten	170101010506 McGuire Cr	20	Pipestone	170101010805 Low Pipe Cr	55
Pinkham	170101010207 Upper Pinkham	13	Parsnip	170101010508 Parsnip Cr	33	Pipestone	170101010806 Bobtail Cr	60
Pinkham	170101010208 Lower Pinkham	72	McSutten	170101010509 Tenmile Cr	19	Quartz	170101010807 Quartz Cr	47
Swamp	170101010301 Swamp Cr	42	Cripple	170101010601 Fivemile Cr	45	Spar	170101010901 Ross Cr	32
Fortine	170101010302 Upper Fortine Cr	47	Bristow	170101010602 Bristow Cr	55	Spar	170101010902 Stanley Cr	44
Swamp	170101010303 Edna Cr	60	Bristow	170101010603 Barron Cr	68	Lake Spar	170101010903 Upper Lake Cr	24
Swamp Trego	170101010304 Mid Fortine Cr	75	Cripple	170101010604 Warland Cr	66	Spar	170101010904 Keeler Cr	48
Murphy	170101010305 Deep Cr	39	Cripple	170101010605 Cripple Horse Cr	48	Lake Spar	170101010905 Lower Lake Cr	22
Meadow	170101010306 Meadow Cr	86	Bristow	170101010606 Jackson Cr	67	OBrien	170101011001 OBrien Cr	39
Meadow Murphy Swamp Trego	170101010307 Lower Fortine Cr	80	Cripple	170101010607 Canyon Cr	58	Callahan	170101011002 So Callahan Cr	31
Grave	170101010401 Upper Grave Cr	8	Cripple	170101010609 Dunn Cr	51	Callahan	170101011003 No Callahan Cr	33
Grave	170101010402 Lower Grave Cr	36	Alexander	170101010610 Rainy Cr	78	Callahan	170101011004 Callahan Cr	58
Ksanka	170101010403 Therriault Cr	42	Crazy	170101010701 Upper Libby Cr	56	Callahan	170101011005 Ruby Cr	61
Ksanka	170101010404 Sinclair Cr	40	McSwede	170101010702 Swamp Cr	65	Callahan	170101011006 Star Cr	40
Ksanka	170101010405 Indian Cr	32	Treasure	170101010703 Granite Cr	27			

Other Influences

Beaver damming of streams is a major natural process on many subbasin streams, both in headwater and valley-bottom areas. Historically, beaver dams occurred on river channels, perennial and intermittent streams, and ponds. The dams regulated runoff in watersheds and stored water in river systems without disrupting watershed connectivity. On some stream types, beaver dams, and to a lesser degree, large woody debris, control stream gradient. When the dams are breached, these systems become susceptible to rapid stream downcutting and water table lowering (USDA FNF 1995).

Large downed trees[5] and coarse woody debris located in the channel and on alluvial floodplain surfaces are key to providing habitat, particularly in the alluvial reaches. Along with riparian vegetation, which provides bank stability, flow resistance and added nutrients (e.g., leaf litter), these materials deflect flows creating low-velocity flow refugia, scouring deep pools, and trapping sediments and fine organic material that contributes to aquatic food webs. They provide a diverse and stable habitat mosaic used heavily by many kinds of organisms, including salmonid fishes (Sedell and Froggatt 1984; Naiman 1992). Debris accumulations may also play a direct role in forcing surface flows into alluvial aquifers and promoting the movement of hyporheic flows and shallow groundwater back to the surface (Ebersole 1994). Debris jams also function to divert or break up ice accumulations in winter, preventing the downstream propagation of ice drives that tend to naturally channelize rivers in colder, interior areas (Smith 1979). Debris jams can create temporary obstructions in rivers that, during peak flows, cause local channels to move and floodplains to be inundated. These processes in turn create and rejuvenate the diverse mosaic of main channel, backwater, slough, springbrook, and hyporheic habitats common to natural alluvial rivers (Sedell and Froggatt 1984; Stanford and Ward 1993), and they help to sustain the diversity in floodplain vegetation.

LINKS

For a discussion of the importance of woody debris and groundwater upwellings to aquatic habitat, see Appendix 22.

Click Here

In naturally functioning large river-floodplain systems, sufficient hydraulic energy is periodically unleashed to produce significant parafluvial and orthofluvial avulsions (lateral and longitudinal movement of substrate materials and associated large woody debris and fine organic material). These physical habitat changes produce a shifting mosaic of habitat characteristics, and naturally increase structural complexity and diversity of habitats. It is this physical habitat diversity and its dynamic nature that provide for the increased biological diversity (biodiversity) associated with natural ecosystems. This biodiversity, along with its underlying genetic variation, provide the required base for adaptation, natural selection, and evolutionary change—mechanisms required for population viability and persistence over time and changing environmental conditions.

[5] *This paragraph is adapted from Williams et al. (2000).*

Geographic Area Descriptions[6]

For a thorough description of watershed process in the Upper Kootenai at the HUC-6 scale, see Appendix 23. Much of the information presented there, as well as additional information for the Idaho portion of the Kootenai, is consolidated into two spreadsheets, which are included as Appendix 9.

Confined Reaches Segment

The Confined Reaches (figure 2.4) are characterized by steeper gradients and narrower bedrock valleys relative to downstream segments of the river. The river is restricted by bedrock or narrow glacio-fluvial terraces. Kootenai Falls is the boundary between the two reaches in this segment. The curving valley wall imparts a moderate degree of sinuosity to the channel.

Downstream from Libby Dam, the Kootenai River flows generally east to west across the structural grain of the landscape. The valley becomes slightly wider, the inner gorge less deep. The narrow valley widens at Troy and Libby where tributary valleys cross the river. One-hundred to four-hundred foot high terraces of glacial silt and glaciofluvial deposits line the river valley in these embayments, but the river continues to be confined within an inner gorge inset between the terraces. Lacustrine silt terraces also line the south-side tributary valleys of the Fisher River, Libby Creek, and Lake Creek. Landslides and bank erosion of the terraces contribute a high fine sediment load to the Kootenai River. The Fisher River also is considered to have a high sediment load due to forest practices within that watershed (PWI 1999).

Where the valley broadens between Kootenai Falls to the Moyie River, the Kootenai River has access to small deposits of glacial outwash and lacustrine silts. In this reach, the channel widens and meander bends provide slower moving backwaters and eddies.

Kootenai River downcutting (postglacial and probably pre-glacial) has been faster than downcutting of the smaller tributaries. For instance, the Moyie River has a hanging valley with a high bedrock waterfall near the mainstem. This characteristic (falls creating migration barriers in their lower reaches) is typical of the larger tributaries. Libby Creek, Lake Creek, Callahan Creek and others flow across terraces before finally dropping down to the level of the Kootenai River. Gradual downcutting through the terraces destabilizes the banks and contributes to the sediment load.

In the Idaho portion of Confined Reach 2, the river flows generally northwest, parallel to the Belt Series bedrock structure along the Moyie-Leonia

LINKS

For a good description of the various functional and process measures of the Upper Kootenai at the HUC-6 scale, go to Appendix 23.

Click Here

For a description of human impacts and responses to those impacts framed in terms of the 4-Hs (hydropower, habitat, harvest, and hatcheries), go to Appendix 24.

Click Here

Appendix 9 contains spreadsheets with scores for a large number of watershed attributes for Kootenai River tributaries in the Upper Kootenai in Montana and the lower Kootenai in Idaho.

Click Here

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[6] *Reach/Segment descriptions are adapted from Tetra Tech (2003) and Pacific Watershed Institute (1999)*

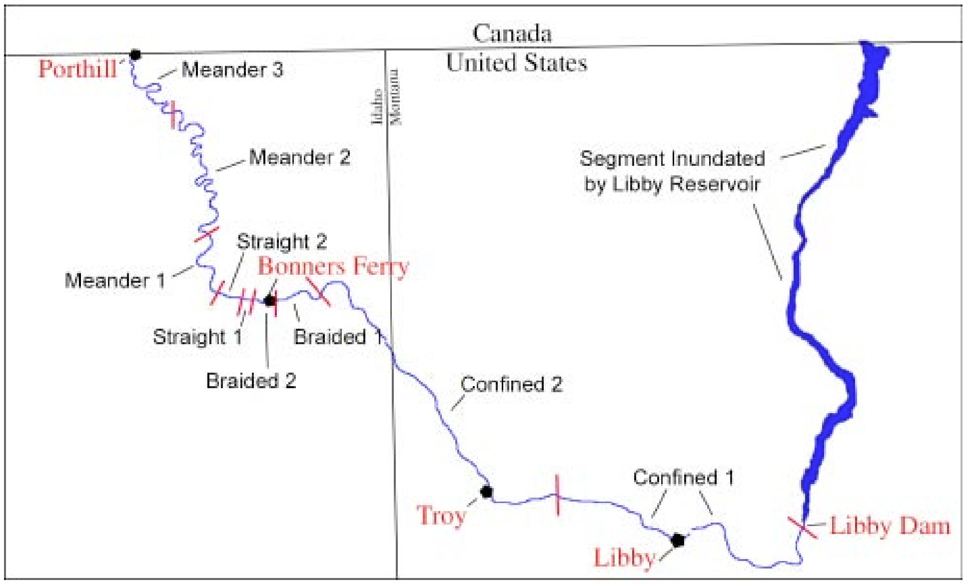

Figure 2.4 Reach delineations. After Tetra Tech (2003).

fault. The inner gorge is deep and narrow in this reach, just wide enough for the river. Boulder Creek, a steep south-side tributary at the Idaho-Montana line, reportedly has an elevated sediment load from erosion from past mines and, to a lesser extent, forest roads (PWI 1999).

Braided Reaches Segment

The Braided Reaches are characterized by multiple channels separated by gravel bars and vegetated islands. The floodplain shows numerous scars that are traces of braided channels. This short river reach is different from the other segments because of its lack of confinement either within natural levees or bedrock-controlled canyon walls. Here the river flows through Belt-rock geology and is reworking lacustrine deposits and routing glacial till deposits carried in by the Moyie River. Hence, there is an increased range of substrate particle sizes. The change in geomorphology and hydraulic character cause these braided reach segments to be natural sediment deposition zones. As it reworks this sediment, the channel widens, forming multiple channels somewhat like a braided channel. It is suspected that this is a "response reach" for upstream alterations, either in flow or sediment regime.

The first Braided Reach has a somewhat narrower floodplain than the second Braided Reach, and in places the river abuts the valley wall or the glacial terrace just south of the railroad grade. The channel pattern has been stable from 1928 through 2000, with a braided channel in some places and a single-thread channel in others. The high floodplain south of the railroad in Braided Reach 2 is believed to have been an active river channel during glacial recession and subsequent downcutting (Alden 1953). The lack of channel scars suggests that it has not been occupied by the river since glacial recession except for over-bank flooding.

The second braided reach has a wider, more active set of channels with higher rates of bank erosion. The river has a mile-wide valley, but is moderately confined by setback levees on the north side and a railroad embankment on the south side. The river cut through a large bend sometime between 1928 and 1963. This reduced channel sinuosity and was followed by lateral bank erosion as the new channel adjusted its course. The former bend, on the north side of the floodplain, still carries flow in several narrow channels.

Straight Reaches Segment

Between the sand-bedded, gravel-bedded braided reaches and the meander reaches, which stretch to Canadian border, the river enters a transition zone that consists of two short straight reaches. Both have man-made levees. In the first, the floodplain necks down between highlands formed by glacial deposits underlain in places by bedrock. The reach includes the City of Bonners Ferry and the highway and railroad bridges. The second reach flows east to west across the Purcell Trench, where the river has broad natural levees formed by thousands of years of fine sediment deposition from flows that overtopped the banks. The presence of these natural levees suggests that little or no channel migration occurred in this reach under presettlement conditions. The broad floodplain (the former bed of the glacial lake) is up to 10 feet lower than the natural levees. There are well-established flood channels that run parallel to the river and also have natural levees.

Meander Reaches Segment

Tributaries on the west side of the valley are high gradient and flow through granitic substrate until they reach the valley. There they change to low gradient, meandering streams with lacustrine substrate. Eastside tributaries are mostly moderate gradient with glacial till, Belt Series metasedimentary, and granitic substrates with some low-gradient terrain in the uppermost reaches. Eastside tributaries have downcut through a high lacustrine terrace above the valley floor where substrates are mixed with fine sediment and gravel/cobble. The lowest reaches are similar to westside valley floor reaches. Falls and cascades are common on most east and westside tributaries. These are migration barriers to fish. Deep Creek is a unique and very important tributary in that it provides approximately 10-15 times more of the continuous low-gradient habitat than any of the other tributaries. Substrates are a mosaic of sandy glaciolacustrine and ancestral shoreline materials and Belt Series and granitic gravels and cobbles that would be more favorable to redd development than the silty substrates in the valley floor.

The first 7.9 miles of the Kootenai River downstream of Deep Creek are somewhat less sinuous than downstream reaches. There is a split channel around Shorty's Island. Well-developed scrollbars exist on the west side of the floodplain, but are mostly lacking on the east side that has a wide natural levee. In the upstream half of this reach, there is no historic or geomorphic evidence of channel migration. The floodplain is dominated by large sloughs that carried a large portion of the river's floodwaters prior to Libby Dam. The next 22.4 miles have the highest sinuosity and well-developed scrollbars corresponding with higher rates of lateral channel migration, possibly a result of the slightly higher bed gradient. A cutoff occurred sometime between 1965 and 1983, reducing the sinuosity and increasing the bed gradient. The meander belt occupies over half the floodplain in most locations. The last 14.5 miles to the border are almost without bars, and scrollbar topography is lacking due to lower channel migration rates. In addition, channel migration processes have probably been operating for a shorter length of time, since this area was more recently a lake bed.

Table 2.3 shows the various aquatic habitat types found on the Kootenai River between Libby Dam and Kootenay Lake.

Table 2.3. Total distance (miles) and percentages of various habitat types in the Kootenai River between Libby Dam and Kootenay Lake. Source: Hoffman, et al. 2002.

	Libby Dam to Kootenai Falls		Kootenai Falls to Bonners Ferry		Bonners Ferry to Kootenay Lake	
	Distance	Percent	Distance	Percent	Distance	Percent
Pools	5.87	23.3	10.87	31.8	28.02	31.8
Riffles	0.4		1.82	5.3	0.17	0.2
Glides	7.18	28.5	12.6	36.9	50.39	57.2
Runs	3.87	15.4	4.16	12.2	0	0
Rapids	1.89	7.5	1.29	3.8	0	0
Side Channel	4.4	17.5	1.6	4.7	0	0
Excluded	1.56	6.2	1.85	5.4	9.55	10.8
Totals	**25.17**		**34.19**		**88.13**	

2.1.2 Human Alterations to Critical Aquatic Functional Processes

In a geomorphic assessment of the Kootenai River below Libby Dam, Tetra Tech (2003), identified the primary human alterations affecting Kootenai River fluvial geomorphic processes as diking and dam operations (both Corra Linn and Libby Dams). Not surprisingly, these factors have also had some of the most significant impacts on biological processes associated with the river.

From a purely physical standpoint, diking has resulted in confinement of flows to the main channel, an increase in the water surface elevation for floods (because post-dam flood waters can no longer spread out onto the floodplain), an increase in energy in the main channel during floods, an increase in sediment transport and erosion during floods, and the elimination of the transfer of sediments from the main channel to the floodplain for deposition (Tetra Tech 2003). The bank stabilization that has occurred to protect the dikes has also changed the dynamics of the system by preventing the river from continuing to meander, the processes that in the past reworked the floodplain and created the diverse over-bank topography containing sloughs, oxbows, wetlands and marshes (Tetra Tech 2003).

During flood-rise and recession, which occurred on a regular and periodic basis during presettlement times, the floodplain and extensive wetland system contributed substantial amounts of nutrients and carbon to the river. The impact to floodplain wetland and riparian areas from flood control and river operations and diking and bank stabilization has substantially impaired this dynamic ecosystem, lowering the productivity of the river downstream from Bonners Ferry (PWI 1999).

Tetra Tech (2003) found that the primary changes in hydrology from Libby Dam included a decrease in annual peak discharges on the order of 50 percent, a decrease in the duration of high and low flows, an increase in the duration of moderate flows, and a redistribution of seasonal flow characteristics. Together, these changes have affected the stage, velocity, depth and shear stress within the river, which in turn have altered sediment transport conditions. Corra Linn Dam has also impacted the hydraulics and sediment transport conditions in the Kootenai River as far upstream as Bonners Ferry (Tetra Tech 2003).

Libby Dam operations have influenced biological processes in the Kootenai River by affecting nutrient and carbon transport, altering thermal regimes, causing rapid changes in water levels, diminishing hydrological connectivity, and altering natural hydrographs. Koocanusa Reservoir has acted as a nutrient sink, decreasing the productivity and overall carrying capacity of the system downstream (Tetra Tech 2003). Dam operations have drastically altered natural down-river discharge patterns on a seasonal and sometimes daily basis.

LINKS

See Appendix 25 for a concise summary of Libby Dam impacts on Kootenai River macrozoobenthos.

Click Here

The lack of seasonal peak flows has allowed delta formation at the mouths of some tributaries, and that has impeded fish movement (USFWS 2002). It has also allowed fine sediments to deposit over the cobble and gravel substrates, affecting fish spawning. Wider varial zones caused by dam operations have further diminished overall system health in the Kootenai. Aquatic and terrestrial vegetation that would have normally provided secure habitat along river margins and stabilized soils has not been able to fully reestablish each summer, and fine sediment materials are more easily eroded and swept back into the channel. The result of all these changes has been significant impacts to periphyton, aquatic insects, and fish populations (USFWS 2002). See Appendix 25 for a concise summary of Libby Dam impacts on Kootenai River macrozoobenthos.

These and other activities that have altered the function of aquatic biome processes in the Kootenai River and its tributaries are summarized in table 2.4 (PWI 1999).

Table 2.4. Major human activities that have altered ecosystem processes in the aquatic biome of the Kootenai Subbasin. Source: Pacific Watershed Institute (1999)

Human actions	Date	Alteration	Effect
Beaver trapping	late 1800s	Removal of beaver ponds	Modified flow regime Reduced hydrologic storage & retention Reduction in pond habitat Reduction in trout habitat Reduced nutrient & carbon storage & cycling
Wetland drainage and conversion to agriculture	early 1900s	Removed approx. 5000 acres of wetland Increase in pollutants from agricultural runoff	Reduction in nutrient and carbon storage exchange Reduction in slough habitat Increase in non-point pollution e.g. sediment, fertilizer residue, pesticides, herbicides Decrease in groundwater recharge Decrease in flood storage
Floodplain diking below Bonners Ferry	early 1900	Removed the interaction between the floodplain and the channel. Confined river to a static meander pattern Confined tributaries to a static channel Removed riparian vegetation.	Reduction in allocthonous inputs Reduction in nutrient and carbon storage & inflow Reduction in side-channel habitat Reduction in lateral migration and associated inputs from migration Decreased channel complexity Increased channel incision Increased temperature in channelized tributaries Reduced aquatic habitat structure
Cominco Fertilizer plant	1952	High influx of phosphorus	Created an imbalance in nutrient relationships and created nitrogen limitations Increased algal growth and lead to shift in fish populations
Libby Dam, construction phase	1968 - 1972	Increased levels of sedimentation Rerouting of transportation corridors into lacustrine deposits along Fisher River	Increase in fine sediments in channel Increase in fine sediment levels in Fisher River & Kootenai
Libby Dam regulation	1972-1976	Impoundment and hypolimnion release Artificial barrier to upstream migration	Fish kills from Gas Bubble Disease Altered flow regime Altered thermal regime Retained some sediment and dissolved constituents Isolated fish populations, changing gene pool Reproductive isolation Restricted access to spawning Eliminated the dominant discharge function

Table 2.4 (cont.). Major human activities that have altered ecosystem processes in the aquatic biome of the Kootenai Subbasin. Source: Pacific Watershed Institute (1999)

Human actions	Date	Alteration	Effect
Libby Dam regulation	1976 - present	Impoundment selective release Hydropeaking operation during winter. Artificial barrier to upstream migration	Reversed river hydrograph Large, unpredictable fluctuations in winter discharge leading to increased macroinvertebrate drift and fish egg dewatering Improved thermal regime over hypolimion release, but warmer in winter Retained more sediment & dissolved constituents Isolated fish populations, changing gene pool Reproductive isolation Restricted access to spawning Temporal effects of gas bubble disease
Mining	Late 1800s to 1970s	Unregulated release of heavy metals and other toxins in water column and in sediments	Mortality of vulnerable aquatic species exposed to toxic levels near the source. Reduced resistance in aquatics species exposed to chronic levels near source and downstream. Bioaccumulation effecting the food web.
Mining	1980s to present	Residual chronic levels in sediments Regulated release of heavy metals and other toxins	Co-mingling of residual metals and organic compounds, creating new toxic compounds in water column. Regulated releases reducing resistance of less tolerant aquatic species. Bioaccumulation affecting the food web. Localized mortality of aquatic species exposed to toxic levels from unmitigated acid mine drainage from small mines in tributary streams.
Introduction of non-native aquatic species	Late 1800s to 1960s	Stocking of Mysis shrimp Stocking of various strains of rainbow trout, kokanee, and brook trout	Increased competition for habitat and foodbase. Dilution of gene pool through hybridization Increased predation.
Commercial harvest of aquatic species	1900 to 1960s	Reduce population base of burbot and sturgeon	Dilution of gene pool. Reduced numbers for reproduction Change balance in population dynamics.
Forest Practices (extraction and milling)	Early 1900s to present	Removal of riparian vegetation Increased sedimentation Polluted runoff and infusion into groundwater from millsites Historic delivery systems (e.g. splash dams) and road systems within channel migration zones	Decrease in habitat complexity. Increased water temperature. Increased fine sediment embedded in substrates. Local but dispersed barriers to fish migration from stream crossings. Degradation of stream margin habitat. Reduced long-term recruitment of large woody debris important to tributary habitat. Periodic or chronic levels of phenolic compounds released to aquatic habitat.

2.1.3 Presettlement Aquatic Conditions[7]

Prior to dam construction, the Kootenai River and its tributaries flowed freely. The natural hydraulic cycle in the headwaters of the Columbia River included a high-flow event during the spring melt (late May through early June) and relatively constant low flows throughout the remainder of the year (Marotz et al. 2002). Waters were cold and clean (except during the spring freshet), and stream substrates consisted of clean, stable, and permeable gravels. Non-native species were absent.

Much of the historical habitat complexity of streams in the subbasin was associated with natural accumulations of large woody debris and areas of groundwater upwelling. These and other key habitat elements would have been in optimal condition. There were pulses of sediment associated with natural disturbances, but the magnitude and frequency would have been within the natural range of variability. High springtime flows flushed fine sediments from river gravels creating interstitial habitat for insects and improving conditions for fish spawning.

Beavers altered the environment by building dams on river channels, perennial and intermittent streams, and ponds, and these dams created an aquatic environment that sustained a rich community of companion species including insects, fish, amphibians, waterfowl, herons, mink, muskrat, otters, and many types of aquatic vegetation. The dams helped to regulate runoff in watersheds and buffered the downstream transport of organic matter, nutrients, and sediment. Beaver dams were a way to store water in river systems without disrupting watershed connectivity. Mainstem river flows during the low-flow period were relatively stable, and the portion of channel affected by flow fluctuation (varial zone) was a narrow band along the shoreline.

Riparian areas were intact and fully functional. In a natural stream environment, the near-shore habitat provides food and security cover critical to fish. High flows defined the channels and removed deltas that form at tributary mouths, creating a healthy environment for fish and their food organisms. Fine sediments were deposited on the river margins providing a fertile medium for water-tolerant plants. Riparian vegetation withstood annual flooding or reestablished seasonally, providing secure habitat along river margins, dropping water velocities, creating natural levees (e.g., sediments buildup where riparian vegetation slows water), and reducing erosion of silt into the river. Fluctuating or abnormally frequent high discharges disrupt this natural floodplain process. (Marotz et al. 2002)

Since glacial times, aquatic communities of the Kootenai River have adapted to consistent, temporal variations in flow and temperature regime that

LINKS

The QHA assessment estimates presettlement (reference) conditions for eleven stream and thirteen lake habitat attributes at the 6th-code HUC scale. Go to Appendix 32 and 33.

Click Here

[7] *Presettlement conditions are defined as the state of the environment at the time of European settlement or 1850.*

changed with climatic patterns. These variations, in conjunction with underlying geomorphic features, played a fundamental role in nutrient distribution, population dynamics, and habitat conditions. In most winters, cold water temperatures slowly increased in the spring, favoring winter spawning for burbot in stable baseflows. High spring flows from snowmelt runoff flushed nutrients stored in riparian areas and flushed fine sediments from spawning gravels depositing onto floodplains. Stable, cool, temperatures during summer and winter low-flow periods sustained fall spawning and enabled aquatic communities to recover from flood disturbances and benefit from increasing flow of nutrients, ambient temperatures and light.

It is thought that the Kootenai River in presettlement times had two barriers to upstream and downstream fish passage: (1) Bonnington Falls is a major fish barrier on the Kootenai River a short distance upstream from the confluence with the Columbia River, and (2) Kootenai Falls, located in northwest Montana 13.7 miles upstream of the Idaho border. The historical importance of Kootenai Falls as a barrier to fish movement is unknown, although recent radio telemetry information indicates that this series of falls is traversed by adult bull trout at certain flows (USFWS 2002). Alternatively, during periods of historical highwater (> 100 kcfs), Kootenai Falls was undoubtedly more submerged and to an unknown degree perhaps resembled more of a riffle than falls, which are currently observed under post-dam hydraulic conditions, during which < 50 kcfs may constitute (post-dam) flooding.

Brief descriptions[8] of presettlement conditions on individual river segments (figure 2.4) follow:

River Segment now Inundated by Koocanusa Reservoir

The river in this segment was characterized by a single-thread channel in a steep valley with few side channels from Rexford to Libby, with a braided alluvial floodplain above Rexford up into Canada to the inflow of the Elk River. Above the Elk River it was a multichannel system with many forested islands (B. Jamieson, pers. comm. 2004). Pre-dam, this segment was described as prime cutthroat trout habitat, and even in historic times it supported one of the most productive cutthroat fisheries in North America (Knudson 1994). The segment also provided high quality bull trout and Mountain whitefish habitat.

[8] *Reach/Segment descriptions are adapted primarily from Pacific Watershed Institute (1999)*

Confined Reaches Segment

Prior to settlement, the habitat in this segment and the Braided Reaches Segment had more overhanging vegetation along its banks and large trees providing recruitment of large woody debris from the riparian areas and hillsides. Large debris probably only offered habitat structure in side channels and along slower moving eddies and backwaters of the mainstem while overhanging vegetation offered the majority of margin cover for aquatic species. Habitat characteristics along with a high diversity of macroinvertebrates in the reach from the Moyie River to Kootenai Falls suggest that it was very productive for burbot, bull trout, rainbow trout, and westslope cutthroat trout. White sturgeon were also found in the reach (Moyie River confluence to Kootenai Falls).

Braided Reaches Segment

During presettlement times, this reach likely have had an unstable channel and a high degree of lateral migration and bedload movement. Much of the bedload is stored in the channel as the channel migrates laterally to maintain its capacity. If the rate of change was high every year, spawning substrate would have been vulnerable to scour or dewatering. If the rate of change was low, spawning substrate would have been relatively stable and would only have been vulnerable during high flow years when bedload movement was greater.

Meander Reaches Segment

Prior to European-American settlement, this river segment had the highest habitat and aquatic species diversity. The river meanders across the nearly-flat Purcell Trench, a former glacial lake bed. The river's 2- to 3-mile-wide floodplain is situated between terraces of lacustrine silt. The river is very sinuous and has high-amplitude meander bends that migrate laterally. Cutoffs occur occasionally when a migrating bend cuts through the neck of the next bend downstream. These processes left behind a scrollbar topography and oxbow lakes on the floodplain. Thousands of years of fluvial deposition have built the meander belt up to about elevation 1,760, feet, which is the height of natural levees and presumably about the pre-dam bank-full elevation. These river deposits are at least 3 feet higher than the former lake bed that comprises the rest of the floodplain.

Prior to settlement, the river underwent frequent flood events, and shallow groundwater supported wetlands that extended across the valley floor. The large expanses of wetlands, sloughs, and meandering, low-gradient reaches of tributaries provided a diversity of habitat from the mainstem that supported the specific needs of different life stages and species. Channels through wetlands and

LINKS

For a general discussion of how reservoir storage and dam operations affect aquatic habitats, see Appendix 22.

Click Here

For a description of current conditions of aquatic habitats on the Kootenai National Forest, go to Appendix 23.

Click Here

For a description of current conditions of aquatic habitats on the Idaho Panhandle National Forests, go to Appendix 26.

Click Here

For the list of surface waters included in the Montana and Idaho 303(d) water quality assessment databases go to: http://www.epa.gov/owow/tmdl/

Click Here

For summaries of hydrologic data showing daily flow values, pre- and post-dam comparative hydrograph charts, pre- and post-dam flow duration charts, and pre- and post-dam peak flow values charts for any one of fourteen USGS gaging stations in the subbasin, go to Appendix 8.

Click Here

meandering tributaries with overhanging shrubs along the banks favored bull trout, cutthroat trout, kokanee (Bursik and Moseley 1995) and probably Columbia River redband trout and other natives. These populations were likely distinct from populations that exist today in the upper, steeper gradient portions of tributary streams (Behnke 1992). Slow moving, deep waters of sloughs with overhanging shrubs and continual recruitment of deciduous and coniferous trees favored burbot and juveniles of numerous species including white sturgeon.

LINKS

To skip ahead to presettlement riparian and wetland conditions, go to:

Click Here

To gain a more complete picture of presettlement conditions, some readers may want to skip ahead to the section on riparian and wetland presettlement conditions (see the link in the links column).

2.1.4 Present Condition

Two key measures of the present condition of the aquatic biome in Kootenai River are the status of zoobenthos and fish species. Hauer and Stanford (1997) reported that most macroinvertebrates in the Kootenai river have reduced abundance compared to the long-term or to other rivers in the region. Kootenai River fish populations have also declined over the past several decades (Duke et al. 1999; USFWS 1999; Paragamian 2002; Anders et al 2002; Hammond and Anders 2003; Soults and Anders 2003; Paragamian et al. In Press). See focal species accounts in this assessment for more detailed discussions of native fish populations declines in the Kootenai River Subbasin. Bull trout in the subbasin are part of the Columbia River population, listed as threatened under the Endangered Species Act (ESA). According to the Bull Trout Draft Recovery Plan (USFWS 2002), the historic distribution of bull trout is relatively intact within the Kootenai River Recovery Unit, but the abundance of the species in portions of the watershed has been reduced, and remaining populations are fragmented. Native kokanee salmon (*Oncorhynchus nerka*) runs in lower Kootenai River tributaries in Idaho have experienced dramatic population declines during the past several decades (Partridge 1983; Ashley and Thompson 1993;). Total population numbers of native Columbia River redband trout are thought to be down from pre-Libby Dam years (Hoffman et al. 2002). The burbot population has also declined during recent decades (Hoffman et al. 2002; Hammond and Anders 2003). Due to low population abundance and failing natural recruitment, Kootenai River burbot in the Idaho portion of the Kootenai Subbasin were petitioned as threatened under the U.S. Endangered Species Act (http://www.wildlands.org/w_burbot_pet.html). However, the USFWS 12-month finding for the petition reported that: "After reviewing the best available scientific and commercial information, we find that the petitioned action [listing] is not warranted, because the petitioned entity is not a distinct population segment (DPS) and, therefore, is not a listable entity" (http://a257.g.akamaitech.net/7/257/2422/14mar20010800/edocket.access.gpo.gov/2003/pdf/03-5737.pdf). Burbot have been extirpated from Kootenay Lake's West Arm, and are not abundant enough in other riverine portions of the subbasin to be reliably estimated. The lower Kootenai River population is estimated at between 50 and 500 fish (KVRI Burbot Committee 2004). The Kootenai River population of white sturgeon was listed as endangered under the ESA on September 6, 1994 (59 FR 45989). The population has been in general decline since the mid-1960s (Duke et al. 1999; USFWS 1999; Anders et al. 2002; Paragamian et al. In Review). In 1997 the population was estimated to be approximately 1,468 wild fish with few individuals less than 25 years of age (USFWS 1999). The most robust and current (2003) population abundance estimate for the adult population is approximately 600 individuals, following an average aging correction factor of 1.6 (Paragamian et al. In Press). Table 2.5 reports the estimated abundance of native species in the Kootenai River (Hoffman et al. 2002).

Table 2.5. Fish species in the Kootenai River and their general, river-wide abundances (A=abundant, C=common, R=rare). Abundances vary by river segement and reach. Source: Hoffman et al. (2002)

Common Name	Scientific Name	Abundance
Native Species		
Westslope cutthroat trout	*Oncorhynchus clarki lewisi*	C
Columbia River redband trout	*Oncorhynchus mykiss gairdneri*	R
Bull trout	*Salvelinus confluentus*	C
Kokanee (Kootenay Lk & tribs)	*Oncorhynchus nerka*	C
Mountain whitefish	*Prosopium williamsoni*	A
Burbot	*Lota lota*	R
Redside shiner	*Richardsonius balteatus*	C
Peamouth chub	*Mylocheilus caurinus*	A
Northern pikeminnow	*Ptychocheilus oregonensis*	A
Largescale sucker	*Catostomus macrocheilus*	A
Longnose sucker	*Catostomus catostomus*	R
Longnose dace	*Rhinichthys cataractae*	R
Torrent sculpin	*Cottus rhotheus*	R
Slimy sculpin	*Cottus cognatus*	C
White sturgeon	*Acipenser transmontanus*	R
Non-Native Species		
Brook trout	*Salvelinus fontinalis*	R
Rainbow trout	*Onchorynchus mykiss*	A
Kokanee (Koocanusa Res.)	*Oncorhynchus nerka*	A
Brown trout	*Salmo trutta*	R
Largemouth bass	*Micropterus salmoides*	R
Northern pike	*Esox lucius*	R
Brown bullhead	*Ictalurus nebulosus*	R
Black bullhead	*Ictalurus melas*	R
Pumpkinseed sunfish	*Lepomis gibbosus*	R
Yellow perch	*Perca flavescens*	R

LINKS

For a description of the various functional and process measures of the Upper Kootenai at the HUC-6 scale, go to Appendix 23.

Click Here

Appendix 9 contains spreadsheets with scores for a large number of watershed attributes for Kootenai River tributaries in the Upper Kootenai in Montana and the lower Kootenai in Idaho.

Click Here

The QHA assessment estimates current conditions for eleven stream and thirteen lake habitat attributes at the 6th-code HUC scale. Go to Appendix 32 and 33.

Click Here

LINKS

For a brief discussion of the biological effects of Libby dam operations†, see Appendix 27.

Click Here

† The Kootenai Tribal Council has not approved the Fisheries Mitigation and Implementation Plan for Losses Attributable to the Construction and Operations of Libby Dam (1998) (Libby Loss Statement). Specifically, the Tribe maintains that the quantification methodology used to estimate annual fish production losses had not been approved by the regional fish and wildlife managers before being accepted. The lack of consensus for the Libby Loss Statement, however, does not modify the measures, strategies and objectives included in the Kootenai Subbasin Plan. While the precise amount of losses attributable to the construction and operation of Libby Dam may lead to differing levels of restoration in the Kootenai Subbasin, sufficient data exists to address the limiting factors in the subbasin and chart the path toward restoration. See also, Reservation of Rights, p. iii.

Tributaries

Aquatic habitats in headwater reaches of the subbasin have been impacted to varying degrees by the cumulative effects of logging, road building, dams, diking, irrigation and cropland agriculture, and urban, suburban and rural development. The magnitude and persistence of these impacts varies widely.

In its assessment of the entire Kootenai River Subbasin, the Pacific Watershed Institute (1999) characterized tributary aquatic habitat conditions as ranging from moderately altered to highly altered. This conclusion was based on qualitative observations.

In 2002, the Kootenai National Forest finished its assessment of the Upper Kootenai in Montana (defined as the 2,250 square mile Kootenai River drainage extending from the Canadian border south-southwest to the Idaho border, but excluding the Fisher and Yaak watersheds). The assessment rated the watershed condition or integrity[9] of sixty-two 6th-field HUCs and found that six HUCs (10%) had high integrity, twenty-three (37%) moderate integrity, and thirty-three (53%) low integrity. See Appendix 9 for the spreadsheet showing scores for all the watershed evaluation factors.

In its 2003 *Analysis of the Management Situation for Revision of the Kootenai and Idaho Panhandle Forest Plans* (AMS), the USFS described the condition of HUC-6 watersheds in the Kootenai: " … human activity has extensively altered stream channels by direct modification such as canalization, wood removal, diversion, dams, log drives, and encroaching structures such as roads, railways, bridges, and culverts. Humans have also indirectly affected the incidence, frequency, and magnitude of disturbance events. This has affected inputs and outputs of sediment, water, and vegetation. These factors have combined to cause pervasive changes in channel conditions throughout many parts of the Kootenai and Idaho Panhandle National Forests (KIPNF), resulting in aquatic and riparian habitat conditions measurably different from those that existed prior to human development. Natural (primarily wildfire) and human-caused (timber harvest and road construction, mining, dams, introduction of non-native species, recreation, and grazing) disturbances over the last century have led to changes in the physical watersheds and in the fish and amphibians dependent on them (Lee et al. 1997). Roads can have some of the greatest effects to watersheds and aquatic biota … Although current BMPs for road construction are designed to minimize the damage to watersheds, many miles of road existing on the landscape were not built to these standards or are no longer maintained. As a result, these roads

[9] Watershed condition or integrity is based on six factors: percent equivalent clearcut area, percent intact riparian area, stream crossing density (number/mi^2 of watershed), percent detrimental compaction, riparian area road density, and mean annual precipitation.

either continue to degrade watersheds through chronic erosion or are at risk for mass failure from crossings or locations on sensitive landtypes."

In their AMS, the Kootenai and Panhandle National Forests *estimate* the expected or apparent watershed condition[10] of the 166 sub-watersheds in the Kootenai River Subbasin. In the Idaho portion, 69% were functioning at risk or not properly functioning; in Montana the number was 83% (table 2.6 and figure 2.5).

Table 2.6. Apparent or expected watershed condition for the ID and MT portions of the subbasin. Source: USFS KIPNF (2003)

Watershed Condition	Idaho (32 watersheds)	Montana (144 watersheds)
Properly Functioning	31%	17%
Functioning at Risk	53%	61%
Not Properly Functioning	16%	22%

LINKS

Appendix 28 describes watershed and stream characteristics for major upper Kootenai River tributaries (in the Montana portion of the subbasin).

Click Here

Appendix 23 summarizes Kootenai National Forest fisheries information for tributaries of the upper Kootenai.

Click Here

The EPA lists 31 impaired waterbodies in the US portion of the Kootenai Subbasin (Figure 2.6). Table 2.7 summarizes the probable sources of impairment for each of those streams. Information on probable sources and causes is available for the upper Kootenai by mile of stream impaired. That information is presented in tables 2.8 and 2.9. Note that in these two tables, causes and sources are related but are not linked. Together, the three tables are generally representative of the sources and causes of aquatic habitat impairment across the subbasin when viewed on a broad scale (i.e., percentages would not reflect the situation on specific reaches or individual streams).

[10] *A variety of physical measures that reflect the inherent (i.e., natural) sensitivity and resiliency of watersheds, combined with measures based on human-caused disturbance histories of those watersheds were used to estimate the overall condition at the sub-watershed (6th- code hydrologic unit) scale. The measures focus on slopes (the land system), riparian areas, and streams and lakes within the watershed. This information is further refined using additional field measurements, monitoring, and professional judgment. "Properly functioning condition" means watersheds are in good condition in terms of physical, hydrologic, and water quality characteristics and function, adjusting to disturbances within their apparent natural ranges of variability. Watersheds defined as "functioning at risk" have adequate physical, hydrologic and water quality integrity; however, present or ongoing adverse disturbances are likely to compromise that integrity if not modified or corrected. They have at least moderate physical, hydrologic, and water quality integrity even though they may have been substantially compromised by adverse disturbances. "Not properly functioning" watersheds are operating and adjusting outside what can be considered dynamic equilibrium. Physical, hydrologic, or water quality integrity has been so compromised that restoration efforts may be difficult without significant funding and very long recovery time periods. They are not physically capable of fully supporting beneficial uses and will likely require substantial intervention and/or extremely long recovery periods to restore their capability to fully support beneficial uses. They may contain aquatic resources that are seriously degraded or that are not likely to sustain themselves over time.*

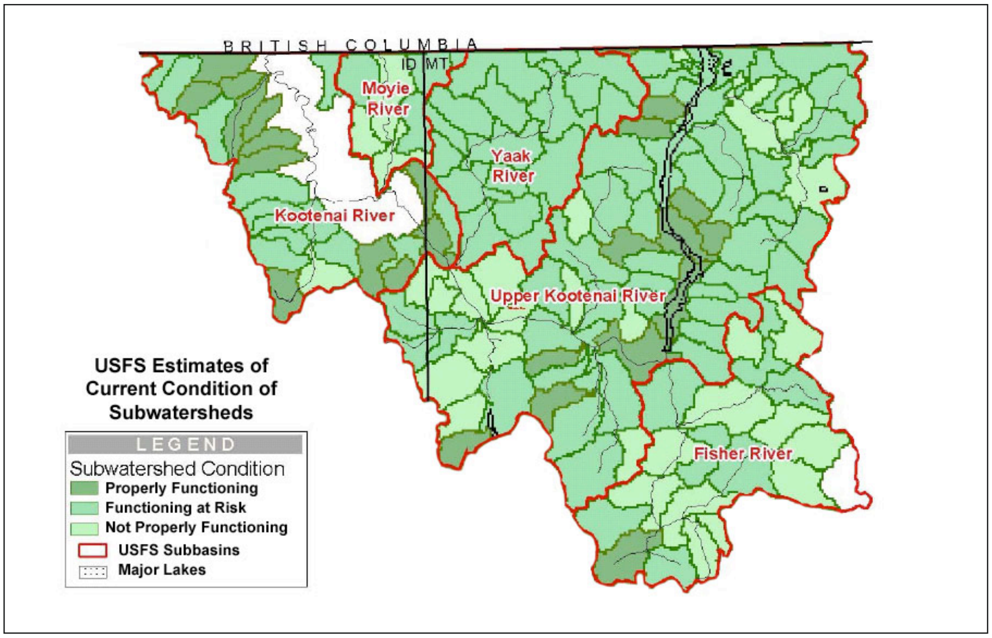

Figure 2.5. Estimated Current Condition of Sub-Watersheds as determined by the USFS. Source: USFS KIPNF (2003).

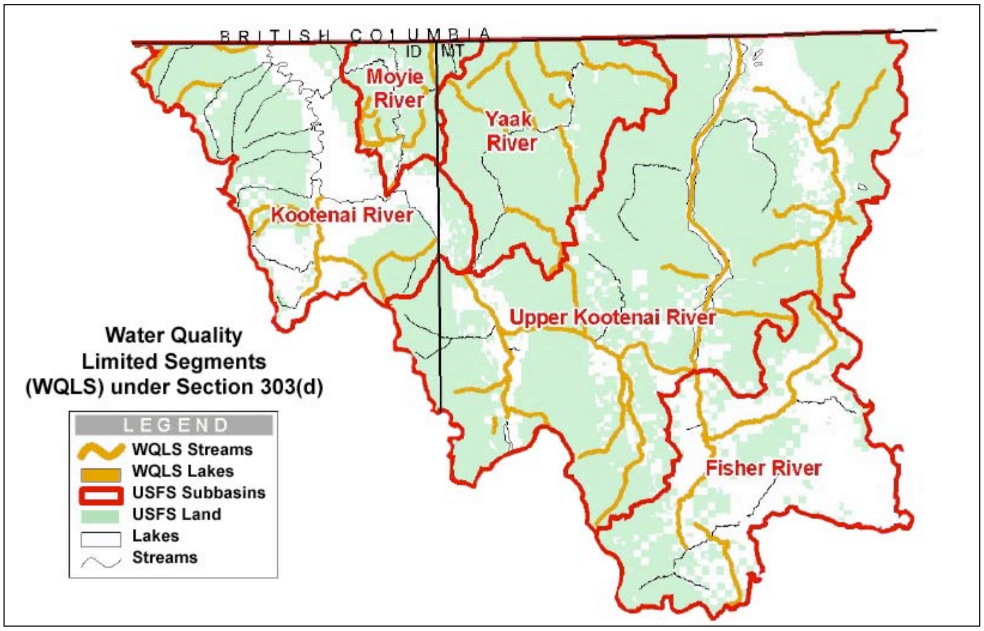

Figure 2.6. Section 303(d) Water Quality Limited Segments in the Kootenai Subbasin. Source: USFS KIPNF (2003).

Table 2.7. Probable sources of impairment for 303(d) impaired waterbodies in the Kootenai Subbasin. Source: http://www.epa.gov/owow/tmdl/

Impairment	# of Impairments	% of Impairments
Other Habitat Alterations	16	52%
Siltation	11	35%
Fish Habitat Degradation	10	32%
Flow Alteration	10	32%
Metals	7	23%
Sediment	7	23%
Streambank Destabilization	5	16%
Nutrients	4	13%
Flow Modifcation/Regulation	3	10%
Thermal Modifications	3	10%
Temperature	2	6%
Nitrogen	1	3%
Turbidity	1	3%
Zinc	1	3%
Riparian Habitat Alteration	1	3%
Lead	1	3%
Other	1	3%
Salinity/TDS/Chlorides	1	3%
pH	1	3%

Table 2.8. Probable sources of impairment for the Upper Kootenai (this is a subset of table 20). Source: http://nris.state.mt.

Source	Miles
Other habitat alterations	162
Flow alteration	124
Siltation	113
Fish habitat degradation	98
Bank erosion	83
Dewatering	47
Thermal modifications	45
Metals	38
Nutrients	28
Nitrogen	18
Zinc	13
Turbidity	10

Forestry and forestry-related activities have had a major impact on the aquatic habitats of tributaries in the Kootenai River Subbasin. Although current forestry practices have improved, impacts continue because of the existing road system, mixed land ownership, lingering results of past activities, and inconsistent application of best management practices (MBTSG 1996c). One of the chief

Table 2.9. Probable causes of impairment for the Upper Kootenai. Source: NRIS

Cause	Miles
Silviculture	129
Flow Regulation/Modification	91
Hydromodification	91
Logging Road Construction/Maintenance	86
Agriculture	73
Grazing Related Sources	73
Resource Extraction	50
Upstream Impoundment	45
Mine Tailings	35
Abandoned Mining	29
Range Grazing - Riparian	29
Habitat Modification-other than Hydromodification	28
Construction	16
Dam Construction	16
Bank or Shoreline Modification/Destabilization	15
Land Development	15
Source Unknown	15
Pasture grazing - Riparian and/or Upland	14
Placer Mining	12
Other	10
Highway/Road/Bridge Construction	1

forestry-related impacts has been an increase in the amount of fine sediments entering streams. Fine sediments accumulating in spawning substrates reduce egg-to-fry survival. In some areas sedimentation has reduced success of natural reproduction to the point that it is insufficient to fully seed available rearing habitat with juvenile fish. Pools and rearing habitat have become clogged with sediment, reducing the productive capacity of the stream. Sediment has also killed aquatic insects and algae. All of these changes have affected the food base for the many wildlife species that feed on aquatic organisms (NWPPC 2001).

Extensive forestry-related road construction in both the Grave Creek and Wigwam River drainages has resulted in increased water and sediment yields (MBTSG 1996c). Sediment from roads and logging sites was so severe in the Elk River watershed in British Columbia that for a while water quality investigators thought settling basins would be necessary to protect the river's water quality (USFWS 2002). However, new logging practices in British Columbia, conducted under the current Forest Practices Code, are much more stringent than they were 25 years ago and conditions have improved. High-water events continue to cause sedimentation, and new roads and harvest blocks are planned (USFWS 2002).

In the Montana portion of the subbasin, there are substantial areas of land owned by Plum Creek Timber Company (formerly timberlands of Champion

International), much of which have been heavily roaded and logged. This is especially true in the Fisher River drainage in Montana, the largest tributary drainage in the reach between Libby Dam and Kootenai Falls, and the Lake and O'Brien Creek watersheds (MBTSG 1996c). Plum Creek lands are now covered by the Native Fish Habitat Conservation Plan, which the U.S. Fish and Wildlife Service agreed to with Plum Creek Timber Company in 2000. Conditions in these aquatic habitats are expected to improve.

Libby Creek the second largest tributary between Libby Dam and Kootenai Falls, has been altered by logging and roads, and is often dewatered during crucial summer months due to channel aggradation. Other large tributaries in this reach include Dunn Creek, Pipe Creek, Bobtail Creek, Cedar Creek and Quartz Creek, which all have experienced varying levels of alteration (Hoffman et al. 2002). The channel of Keeler Creek, in Montana, is in a destabilized condition because of extensive timber harvesting activities and poorly constructed roads, built primarily between 1941 and 1970 (MBTSG 1996c). During that period, over 100 million board feet were clear-cut from 23 square kilometers (5,780 acres). Serious flooding occurred during 1974 and 1980 (USFWS 2002). Almost two-thirds of the Kootenai National Forest has problems with watershed instability, resulting infrequent flooding and concentrated high water yields, sedimentation, and small slumps below clear-cuts and roads (MBTSG 1996a).

A 1998 study of watersheds important to bull trout in the Idaho portion of the Kootenai Subbasin found road densities averaged 2.4 miles per square mile, and 2.8 miles per square mile in riparian areas and with about 1.8 road crossings per mile of stream (Panhandle Basin Bull Trout Technical Advisory Team 1998). A total of 16 percent of the watersheds had been logged.

Mining and related activities in the subbasin have also degraded aquatic habitats, although active mining was more of a problem in the past than it is today. The Cominco, Ltd. phosphate plant in Kimberly, British Columbia, closed in 1987, and phosphorus levels in Koocanusa Reservoir are now much lower (USFWS 2002). Until 1979, acid mine drainage and heavy metals from the Sullivan Mine and concentrator at Kimberly, British Columbia, were discharged untreated into Mark, Kimberly, and James Creeks, tributaries of the St. Mary River (MBTSG 1996c). In 1979, wastewater treatment facilities significantly decreased the discharges, and the Sullivan Mine is now closed. The mining company is committed under Canadian law to a long term monitoring and waste water management regime to ensure that acid mine drainage and heavy metals do not enter these creeks in the future (B. Jamieson, pers. comm. 2004).

Five open-pit coal mines operate in the Elk River drainage in British Columbia, and they contribute nitrogen residuals from explosives and increase

LINKS

For a Biological Assessment of Trout Creek go to Appendix 104.

Click Here

For an interim monitoring report on Trout Creek, go to Appendix 105.

Click Here

For a biological Assessment of Parker Creek, go to Appendix 106.

Click Here

LINKS

For a discussion of the impacts of Libby Dam operations on the geomorphology of the Kootenai River, go to Appendix 29.

Click Here

the amount of suspended sediment entering the Elk River and its tributaries. Levels of both have been reduced in recent years, but impacts are likely to continue, at least on a localized scale (USFWS 2002).

Some small, private mining operations continue in the Lake Creek drainage and in some tributaries in Canada. Water quality impairment in Lake Creek is the result of the now-closed ASARCO, Inc. copper and silver mine, mill, and tailings impoundment (USFWS 2002). Acid mine drainage from the Snowshoe Mine in the Libby Creek drainage has affected trout populations in 3 miles of Snowshoe Creek and 15 miles of Big Cherry Creek for over 70 years (MBTSG 1996a). Historic mining operations in the Fisher River drainage have contributed to channel degradation. Several other drainages in the basin have historical impacts from small mining operations (USFWS 2002). Two streams in Idaho—Boulder Creek, and Blue Joe Creek—have suffered impacts from mining activities, and Blue Joe and Boundary Creeks experience periodic episodes of toxic runoff from the Continental Mine (USFWS 2002).

Residential development has also been a problem on tributaries. Many streams flow through private land, especially in the valley bottoms, and the human population in Canadian and U.S. portions of the subbasin have been increasing. Domestic sewage and changes to stream morphology caused by building in the floodplain has reduced the quality of aquatic habitats' (USFWS 2002). In some streams, human-caused barriers such as road culverts, dewatered stream reaches, and irrigation diversions have blocked fish migrations.

Another major impact on headwater aquatic habitats has been the introduction of non-native species. Non-native species now threaten the diversity and abundance of native species and the ecological stability of ecosystems in many areas of the Kootenai Basin (Hammond 1999).

The removal of riparian vegetation, especially trees and overhanging shrubs, has changed stream water temperatures, making the water warmer in the summer and colder in the winter. These changes have interfered with fish spawning and generally degraded the quality of stream habitats for native fish and other aquatic life. This has affected the food base for the many wildlife species that feed on aquatic organisms (NWPPC 2001).

Habitat conditions in specific tributaries, including the distribution of non-natives, are assessed later in this document as part of the QHA habitat assessment.

Koocanusa Reservoir and Mainstem Kootenai

In a review and synthesis of Kootenai River studies, the Pacific Watershed Institute (1999) identified the following changes as the most significant to the sustainability of aquatic life in the basin:

- Loss of fisheries habitat structure and area;
- A broad swing in nutrient levels brought on by artificially elevated levels of phosphorous and reduction of retention area throughout the subbasin;
- Alteration of flow by the operation of Libby Dam caused stranding or flushing of redds and fry;
- Alteration of temperature and discharge from Libby Dam disrupting natural patterns of winter spawning and spring rearing, and;
- Heavy metals contamination and effects of sublethal amounts on aquatic life cycles.

LINKS

Appendix 8 summarizes hydrologic data from 14 Canadian and USGS gauging stations in the subbasin.

Click Here

Appendix 18 is MFWP comments on the Draft Mainstem Amendments Document 2002-16

Click Here

Other changes identified by the Institute as being significant to fish population dynamics and that are considered to have an effect on biological integrity include:

- Introduction of nonnative species and stocks that compete for similar foodbase and habitat or contaminate the native gene pool;
- Reduced availability and overall quality of habitat in the mainstem and tributary streams;
- Lack of recovery from large fisheries harvest levels of the mid-century.

For a discussion of the impacts of Libby Dam operations on the geomorphology of the Kootenai River, see Appendix 29.

In their loss statement[11], Montana Fish, Wildlife & Parks and the Confederated Salish and Kootenai Tribes quantified the following changes to fisheries habitats caused by the construction and operation of Libby Dam:

Koocanusa Reservoir

- 109 miles (175 km) of the Kootenai River lost to inundation by the reservoir
- An annual loss of 15,000 trout and 377,000 mountain whitefish from the inundated river

[11] *The Kootenai Tribal Council has not approved the Fisheries Mitigation and Implementation Plan for Losses Attributable to the Construction and Operations of Libby Dam (1998) (Libby Loss Statement). Specifically, the Tribe maintains that the quantification methodology used to estimate annual fish production losses had not been approved by the regional fish and wildlife managers before being accepted. The lack of consensus for the Libby Loss Statement, however, does not modify the measures, strategies and objectives included in the Kootenai Subbasin Plan. While the precise amount of losses attributable to the construction and operation of Libby Dam may lead to differing levels of restoration in the Kootenai Subbasin, sufficient data exists to address the limiting factors in the subbasin and chart the path toward restoration. See also, Reservation of Rights, p. iii.*

LINKS

For a maps showing road densities throughout the subbasin see figure 2.16 and 2.17.

Click Here

Environmental baseline conditions for bull trout are summarized in Appendix 31.

Click Here

The Kootenai Subbasin Aquatic Technical Team scored aquatic habitat attributes for streams at the HUC-6 scale and results are presented in Appendix 32.

Click Here

The Kootenai Subbasin Aquatic Technical Team scored aquatic habitat attributes for selected lakes. Results are presented in Appendix 33.

Click Here

- 83 miles (134 km) of tributary stream habitat lost to inundation
- An annual loss of 57,000 juvenile *Oncorhynchus* spp from inundated tributaries
- 15.5 miles (25 km) blocked by road construction around the reservoir
- An annual loss of 5,990 juvenile *Oncorhynchus* spp from blocked tributaries

Kootenai River (downstream of the dam)

- An annual loss of 2,100 juvenile westslope cutthroat trout
- A 90 percent reduction in the burbot fishery.
- An endangered listing under the ESA for the white sturgeon
- An threatened listing under the ESA for the bull trout

MFWP (2000d) also noted that a major change occurred when British Columbia Ministry of Environment personnel from the Wardner Fish Hatchery inadvertently released kokanee salmon (*Oncorhynchus nerka*) into Koocanusa Reservoir between 1975 and 1979. Kokanee have since become well established in Koocanusa Reservoir. By 1997, this non-native population, (accidentally) founded from an admixed Okanagan stock) sustained a 48,000 angler-day/year fishery. In addition, more than 1 million kokanee (age 0+ to 2+) may be entrained through Libby Dam each year. Based on expansions of empirical entrainment studies, most of these kokanee (79%) survive (Skaar et al. 1996). Kokanee are the main food source for a trophy rainbow trout fishery (up to 33 pounds) in Koocanusa Reservoir, and for bull trout as far as four miles downstream from Libby Dam.

A description of the present condition of each of the mainstem segments follows[12].

Confined Reaches Segment

The most significant changes in the condition of the reach from Libby Dam to Kootenai Falls result from Libby Dam altering water temperatures and creating extreme flow fluctuations. These changes are: (1) altered water quality, and (2) the magnitude and shape of the annual hydrograph. Water chemistry has improved in recent decades because Libby Dam retains contaminated sediments from upstream sources, and because contaminated sediments deposited prior to the dam have likely been transported downstream. Channel bank erosion and other upstream sources of erosion in lacustrine deposits in the Fisher River continue to contribute significant sources of fine sediment to the mainstem. Because of Libby

[12] *Adapted and condensed from Pacific Watershed Institute (1999).*

Dam, fish in this reach have been isolated. Also, the effects of dam construction and operations (e.g., gas bubble disease, temperature alterations, and flow fluctuation) remain more pronounced in this segment than in downstream river segments.

In the reach from Kootenai Falls to the Moyie River confluence, the river has been constricted by railroad and road alignments in several locations, but the ecological effects of these changes are likely insignificant. Industrial and mining pollution from sources miles upstream have been transported to this reach and to downstream segments, although the influx of those pollutants has been greatly reduced by more stringent regulation of effluent and the construction of Libby Dam. Riparian vegetation and stream margin habitat is recovering from scour during log-drive days. Similar to the reach above Kootenai Falls, the alteration of temperature and flow regime by Libby Dam has also had a major influence. In the past, flow fluctuations from hydropeaking during fall spawning stranded or flushed redds, causing devastating declines in populations of affected species. These fluctuations still occur, but not at the magnitude or over as short a duration as in the past. Regulated flows have eliminated channel maintenance flows, which creates conditions for embedded spawning gravels and macroinvertebrate habitat quality. The elevation of the mouths of tributaries has increased as well; with lower discharge, tributary bedload deposits at the confluence with the mainstem are not transported downstream.

Hauer and Stanford (1997) reported that river regulation by Libby Dam has had numerous deleterious effects on Kootenai River zoobenthos. With the exception of the density of net-spinning caddisflies and blackflies in the dam tail waters, most species declined in abundance after the dam. Below the dam is a wide varial zone essentially devoid of zoobenthos whenever the dam is operated with dramatic flow fluctuation. The dominant species in this zone are those that emerge as adults off the surface of the water column (e.g., trichoptera, diptera), rather than crawling out on the lateral margins of the river (e.g., plecoptera), where they must deal with the harsh varial zone environment created by Libby Dam operations (Hauer and Stanford 1997).

Studies on fish populations in the reach from Kootenai Falls to the Moyie River confluence have found a shift in species abundance (PWI 1999). Both cutthroat and bull trout were displaced from this reach early on when rainbow and brook trout were introduced (PWI 1999). They were undoubtedly affected by contaminants prior to the dam. Neither species is tolerant of large changes in water quality, temperature, or habitat complexity. Log drives in tributaries and the mainstem probably simplified and or eliminated the complex edge habitat that juveniles rely on for refugia and feeding stations. Neither of these species tends to

LINKS

For the USGS report summarizing lower Kootenai River channel conditions and changes in suspended-sediment transport and geometery in white sturgeon habitat, go to: http://id.water.usgs.gov/PDF/wri034324/index.html

Click Here

For the USGS surveys of lower Kootenai River cross sections, go to: http://id.water.usgs.gov/PDF/ofr041045/index.html

Click Here

rebound once habitat is degraded and more tolerant species such as rainbow expand into their range. For the small populations of cutthroat and bull trout that remain, there is little connectivity to headwater populations, reducing the influx and/or exchange of genetic material between resident and fluvial populations. It is not known if these fish are adfluvial (lake population) or fluvial (mainstem migratory). There is probably some limited downstream recruitment from tributaries and accidental dispersal through Libby Dam and over Kootenai Falls.

LINKS

For a description of how large rivers in general and the lower Flathead River in particular interact with their floodplains and riparian zones, see Appendix 28.

Click Here

Throughout this river segment there has been a decrease in the amount of overhanging vegetation along the river's banks and a loss of large trees, which provide a source of large woody debris. Overall habitat structure has been simplified. Large fluctuations in discharge from Libby Dam have created detrimental elevation changes in water levels along stream margins, stranding spawning habitat and disrupting rearing and escapement habitat. Changing water levels along stream banks creates a swing in soil moisture and erodes banks, which has hampered riparian habitat recovery. Today's habitat provides less security cover in the mainstem for juveniles and less protection from stream margin stranding or flushing.

Braided Reaches Segment

The current habitat and sediment conditions in this segment are maintained and controlled by: (1) natural geomorphic constriction at Bonners Ferry and a sharp 90 degree constriction upstream just above the Moyie River; (2) a backwater effect from Lake Kootenay during high flow and times of water storage; (3) the first major depositional environment below the canyon reaches; and (4) artificial confinement by levees and the railroad.

Construction of dikes near Bonners Ferry and construction of a rail line have confined channel migration to a minor degree. The most significant changes include removal of riparian vegetation, changes in flow/temperature from Libby Dam operations, and possible contamination by metals. An influx of sediment over natural background probably occurred shortly after the wildfires in the early 1900s during recovery and salvage logging operations. As forest extraction began in higher portions of the basin and roads became a major part of the forest landscape, sediment influx probably increased. A slight decline in sediment influx is shown with less harvest, retention by Libby Dam, and recovery from the initial road construction phase in more recent years.

Traditionally, a braided reach would have unstable channels and high degree of lateral migration and bedload movement. Much of the bedload is stored in the channel as the channel migrates laterally to maintain its capacity. If the rate of change was high every year, spawning substrate would be vulnerable to scour or dewatering. If the rate of change was low, spawning substrate would be relatively stable and only be vulnerable during high flow years when bedload movement was greater. Although one might think that regulated flow regimes from Libby Dam operations might reduce the rate of change in this segment, this does not appear to be the case. The gravel bars and side channel areas are still continually shifting probably due to the backwater influence of Kootenay Lake and reduction in the active floodplain by dikes on the north side. This latter factor could lead to increased aggradation since the channel no longer can migrate to the north.

Riparian vegetation and stream banks are easily eroded and frequent channel migration limits species succession and growth. The most likely change as a result of regulated flows is that gravel/cobble substrate has been covered by incoming gravel/sand substrate, which would be more mobile under the reduced flood regime than larger substrate. Despite the instability and potential for fine sediment deposition and embedded substrates, this reach may provide the only remaining "slough-like" habitat that used to occur downstream in the Meander Segment. The large abandoned meanders and split channels in this reach still provide juvenile rearing habitat and refugia. Unfortunately, the retention of nutrients and debris is probably not near what it would have been in the sloughs downstream in the Meander Segment due to the instability of these features. Macroinvertebrate sampling indicates a fairly diverse community, but low densities and a lack of long-lived and scour-resistant species. The lack of channel maintenance flows may be a substantial factor in increasing embeddedness or changing the size of streambed particles in spawning habitat, which would affect survival of larvae and benthic food base (PWI 1999).

Meander Reaches Segment

This segment shows the most significant changes in aquatic habitat, wetland/riparian vegetation, nutrient function, temperature, and hydraulic and channel characteristics.

Dikes line the mainstem channel of the lower Kootenai River where larger stream beds pass through constructed openings, and smaller tributaries and canals are completely disconnected from the river (e.g., drainage pipes and pumping stations). Levees confine the river to a narrow corridor. Alterations made at the Creston Valley Wildlife Management Area in British Columbia and the Kootenai National Wildlife Refuge in Idaho have also reduced the abundance of side-channel slough habitats and isolated floodplains from connection with the main channel (Tetra Tech 2003).

Lower reaches of tributary streams have been straightened and cleared reducing their length and changing channel hydraulics and retention capacity.

Extensive forested and shrub/sedge wetlands, now drained, provided extensive meandering off channel habitat for trout species, kokanee, burbot and possibly sturgeon. Natural processes have been disrupted such as groundwater recharge, side channel habitat maintenance and rejuvenation, and nutrient production and exchange. Sloughs and wetlands provided low velocity, deep-water habitat with a high amount of security cover for juvenile fish as well as slow water for burbot and white sturgeon larvae.

Indications from water column and sediment testing are that industrial and mining pollution from sources miles upstream has been transported to this segment (PWI 1999). The influx of this pollution has been greatly reduced by stricter regulation of mining effluent. Also, Libby Dam probably retains metal-laden sediments from upstream sources. Although water quality is most likely recovering, wastewater from sewage treatment facilities, streamside industry, and abandoned mines probably maintain water pollution levels higher than natural background. Habitat availability may be limited locally near effluent outflows where concentrations are highest. It is not well understood what effects residual metal-laden sediments may be having on important food web biota that exist in substrate sediments.

LINKS

The declining population of Kootenai River white sturgeon has prompted an assessment of the feasibility of various habitat enhancement scenarios to reestablish white sturgeon populations. For the first phase in this assessment, go to Appendix 95.

Click Here

Temperature and flow regimes changed abruptly with the onset of Libby Dam. The change from hypolimnetic release to selective release in 1976 have moderated the dramatic effects on the temperature regime. Although, winter temperatures remain higher than historic levels (figure 2.7).

The greatest change to the aquatic biome in this segment has been caused by the removal of sloughs and wetlands, the elimination of the flood pulse, debris removal, and the channelization of tributaries. The effect of reducing nutrient exchange by these alterations has affected not only this segment but also downstream, particularly Kootenay Lake. When comparing the other factors, it appears that the change in fish habitat has been acute, while other departures from the reference condition have been incremental. Changes in temperature and flow appear to have been acute following construction and operation of Libby Dam. Temperature has been moderated somewhat by adjustment to the rule curve and releasing water from higher in the lake water column.

2.1.5 Potential Aquatic Habitat Condition[13]

Under this scenario, Libby Dam would be operated in a manner that would restore and maintain normative hydrologic conditions (conditions that mimic natural

[13] *The potential condition is defined as the desired end state or optimal condition for this subbasin in the year 2050.*

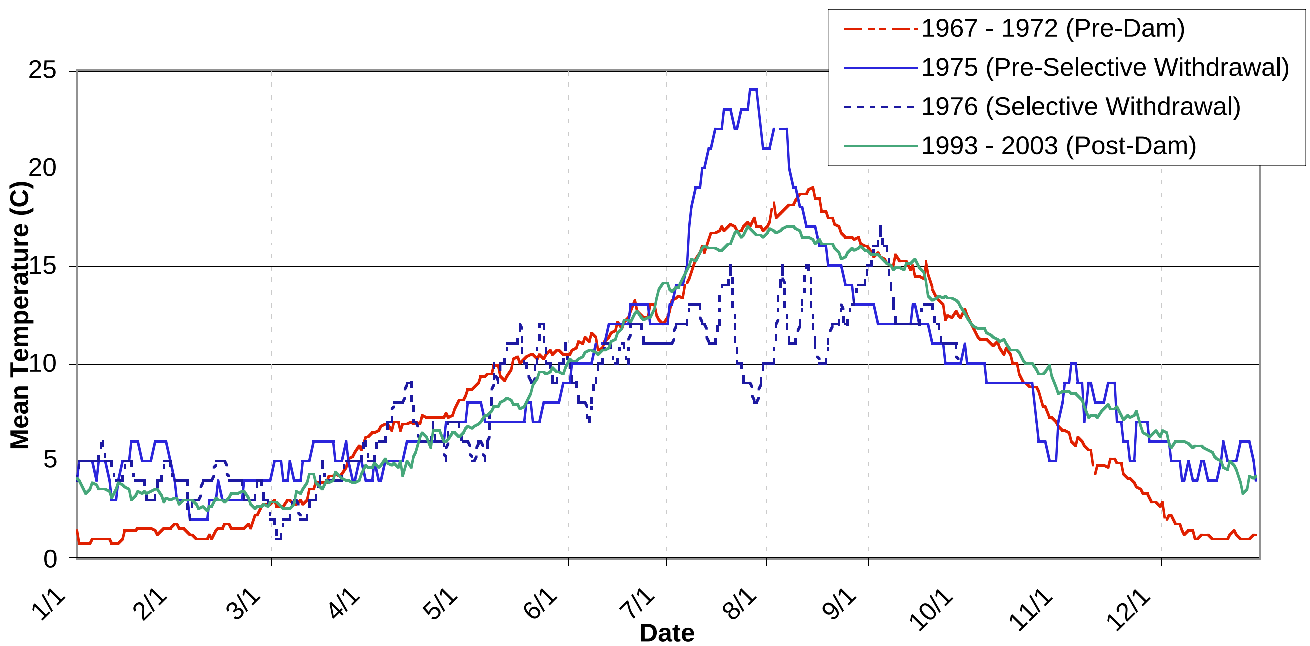

Figure 2.7. Kootenai River temperatures in Meander Reach in Idaho Pre- and Post- Libby Dam.

processes and minimize impacts on fish and wildlife). Reservoir refill would promote biological productivity in the reservoirs, and downstream there would be a gradual ramp-down of river flows after the spring runoff to maintain stable discharges, especially during the biologically productive summer months. Varial zones below and above the dam will have been restored to the maximum extent possible.

Self-supporting native fish populations will have been protected or reestablished in areas where their habitat had been maintained or restored. Wherever possible, reestablishment will have been accomplished through natural colonization. Where wild stocks had been extirpated, appropriate source populations will have been established through imprint planting of genetically compatible eyed eggs or fry.

Passage to migratory fish will have been reestablished in all tributaries blocked by human-caused barriers. Fine sediments will have been reduced in critical spawning areas (this will have been achieved through better compliance with existing habitat-protection laws, lowering forest road densities, the implementation of stream bank stabilization measures and riparian restoration projects, and by agitating embedded gravels to remove silts and fine sands in areas where needed). Normative surface-water runoff patterns will have been restored in upland areas using the best management practices and habitat improvement measures. Natural stream channel function and form will have been restored using techniques such as bank stabilization, streambank and riparian revegetation, riparian fencing, and in-stream channel habitat structures. For example, the natural frequency of pools on disturbed streams will have been returned to that of undisturbed referenced reaches by placing large rocks and woody debris in the channel to restore the appropriate channel morphometry.

Nonnative or hybridized populations will have been eradicated where possible, and suppressed where eradication is not possible. Wherever necessary, native populations in headwater areas will have been protected from nonnatives through the installation of barriers to upstream invasion by nonnative species. Negative nonnative species interactions will have been substantially reduced wherever possible.

TMDL goals will have been reached throughout the subbasin, and water-quality impaired streams and lakes will have been restored.

Ecologically significant wetland and riparian habitats will have been protected, restored, and enhanced through acquisition, conservation easements, and restoration projects. This will have resulted in water temperatures that are more within the tolerance range of native fish species.

2.1.6 Future/No New Action Aquatic Habitat Condition[14]

Under this scenario headwater aquatic habitats will have continued to decline to varying degrees by the cumulative effects of a variety of human activities. The magnitude and persistence of the impacts will vary depending on the type and degree of disturbance. The amount of fine sediments entering streams will have increased slightly and continue to impair the natural reproduction of native fish and reduce the productive capacity of streams. The miles of water-quality-impaired stream segments and lakes will have increased due to impacts from silviculture, habitat modification, construction, land development, urban runoff and storm sewers, removal of riparian vegetation, bank and shoreline modification and destabilization, logging-road construction and maintenance, industrial point sources, and agriculture. In addition to increasing fine sediments in streams, silvicultural practices will have increased peak flows, increase affects on stream temperatures, and reduce woody debris and channel stability.

Between 2004 and 2050, the population of Lincoln County in Montana and Boundary County in Idaho will continue to grow, and many of the people moving in will have chosen to live in scenic rural areas rather than within cities and towns. Many will have built along streams, altering the bed or banks. Domestic sewage from these developments and changes to stream morphology caused by

[14] *The future/no new action condition is the state of the environment in 2050 assuming that current trends and current management continues.*

building in floodplains will have further reduced the quality of aquatic habitats from their current (2004) conditions. Significant amounts of riparian areas will have been converted to other uses, potentially altering stream-water temperatures.

At the same time, projects to remove fish passage barriers on streams will have been successfully completed on most blocked streams. Restoration projects will have improved habitats on a number of streams and acquisitions will have protected other areas. However, these efforts will have been outpaced by impacts caused by residential developments and other human disturbances.

Illegal and unintentional introductions of nonnative fish species will have continued, and existing populations of nonnatives will have expanded and grown. As a consequence, nonnative species will have reduced the abundance of native species and disturbed the ecological stability of ecosystems.

Libby Dam will be operated in a manner that will more closely mimic natural processes and minimize impacts on fish and wildlife. Reservoir refill will have promoted biological productivity in the reservoirs, and downstream, there will have been a gradual ramp-down of river flows after the spring runoff to maintain stable discharges, especially during the biologically productive summer months. Varial zones below and above dams will have been restored to the maximum extent possible.

Due to the cumulative impacts of various human activities, populations of the species most highly adapted to a narrow range of conditions—white sturgeon, burbot, and bull trout—will have continued to decline and may in fact have become extinct. Other species that are slightly more tolerant—westslope cutthroat trout, Columbia River redband trout, and kokanee—will also have declined.

2.2 Riparian and Wetland Systems

SNAPSHOT

Prior to European settlement, ecological functions and processes in riparian and wetland areas were intact. Over the past 100 years humans have reduced beaver populations; logged, cleared, and grazed riparian zones; filled wetlands; built dams and dikes; and initiated erosion control efforts, irrigation withdrawals, and road building. This has caused the loss of structural elements, floodplain processes, and vegetative diversity. It has eliminated thermal cover from areas, reduced streambank stability, and reduced vegetative cover and vigor. The result is wider and more open channels with lower, warmer, more turbid summer flows, more extensive ice conditions in winter, and flashier more turbid flows during runoff. Dams have inundated riparian habitats, eliminated flood pulses, changed stream temperatures, and created unvegetated varial zones. This in turn has adversely affected fish and wildlife species that use these areas.

2.2.1 Critical Riparian and Wetland Functional Processes[15]

Riparian zones and wetlands perform a number of key ecological functions, which include sediment filtering, streambank building, storing water, aquifer recharge, and dissipating stream energy. Healthy riparian vegetation stabilizes stream banks, making them less likely to erode during high flow events; helps control sediment transport; influences bank morphology; provides long-term resistance to channel migration; acts like a sponge to soak up and hold water; and aids in reducing streambank damage from ice, log debris, and animal trampling (Karr and Schlosser 1978; Plats 1979; Marlow and Pogacnik 1985). Streambank stabilization is important because much of the sediment carried by a stream, particularly during high flows, is often the result of bank erosion.

The health of riverine floodplains can be linked to the integrity of numerous processes and functions including, but is not limited to, hydrological connectivity, flooding, nutrient cycling, retention of organic and inorganic particles, generation and export of organic carbon, and groundwater processes (Hauer et al. 2002; Heiler 2003).

Floodplain woodlands depend on broadscale interactions of channel movement, flooding, creation of depositional sites, recharge and decline rates of water tables, and temporal changes in seedling regeneration events (Hughes 2001; Amlin and Rood 2002). Winward (2000) describes riverine riparian areas in their natural state as being subject to continual change as river channels migrate within a valley floor. These fluctuations in river channels, along with flow levels, drive successional processes and create opportunities for early pioneering species like cottonwood and willow to become established on areas of open ground and bare mineral soils.

By temporarily storing surface water, wetlands prevent flooding and allow water to soak into the ground or evaporate, which reduces peak water flows by slowing the movement of water into tributary streams and allowing potential floodwaters to reach mainstem rivers over a longer period of time. The water stored in wetlands is released into the ground where it serves to recharge water tables and aquifers, extending the period of stream flows. Wetlands and riparian areas also reduce flood damage by dissipating stream energy. As floodwaters spread across the floodplain, wetland and riparian plants absorb much of the force of the water (NRCS 1996).

[15] *Portions of this general discussion of riparian system function have been adapted from Hansen et al. (1995).*

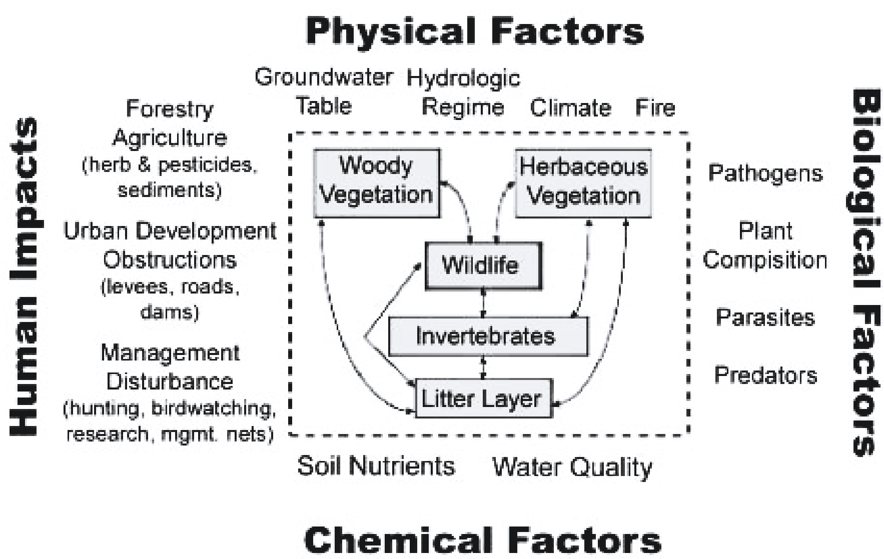

Figure 2.8. Wetland model depicting the influence of physical, chemical, and biological factors and human impacts that affect wetland function (Arkansas Wetland Strategy 1997).

Wetlands also improve water quality by removing nutrients, pesticides, and bacteria from surface waters as they are absorbed or broken down by plants, animals, and chemical processes within the wetland. They filter out sediments and particles suspended in runoff water, preventing lakes, reservoirs, and other resources from being affected by downstream sediment loading, and they enhance the decomposition of organic matter, incorporating nutrients back into the food chain (NRCS 1996). In addition, the expansive floodplain system in the lower Kootenai (estimated by Cole and Hanna (2000) to cover approximately 70,000 acres prior to European settlement) probably contributed substantially to the influx of carbon and nutrients to the Kootenai River, increasing the system's overall productivity (PWI 1999). Figure 2.8 summarizes the physical, chemical, and biological factors and human impacts that affect wetland function.

Riparian and wetland ecosystems are likely the most productive wildlife habitats in the subbasin, benefiting the greatest number of species. Many wildlife species reach their highest densities in these habitats (Braumandl and Curran 2002). In western Montana, 59 percent of the land bird species use riparian and wetland habitats for breeding purposes, and 36 percent of those breed only in riparian or wetland areas (Mosconi and Hutto 1982). In the Kootenai Subbasin, it is estimated that wetland and riparian areas in general contain 75 percent of the total plant and animal diversity. Lower elevation floodplain sites are particularly productive (NWPPC 2000). The influence of riparian areas on wildlife is not limited to species restricted to the riparian zone, upland species benefit as well. A number of Idaho's and Montana's special concern animals use riparian areas for foraging and during migration and local movements. The list includes great blue heron, trumpeter swan, northern goshawk, great gray owl, black-backed woodpecker, and all special concern mammals except northern bog lemming. Predators like the gray wolf, grizzly bear, North American wolverine, and Canada lynx may use riparian areas and wet or mesic meadows during seasonal and annual movements.

Riparian and wetland habitats are important to wildlife because they provide lush vegetation for forage and cover, invertebrate populations important as forage for many bird and mammal species, a water source for drinking, and a more moderate and stable microclimate than the surrounding upland habitats (Doyle 1990). As shown in table 2.10, riparian zones also provide horizontal and vertical diversity with abundant niches for wildlife, and they serve as naturally diverse and highly productive travel corridors (Malanson 1993). For example, low elevation riparian systems are especially important for nesting songbirds due to the complexity and diversity of habitats provided and to migrating songbirds since they provide insect food sources later and earlier in the season than are provided at higher elevations.

Even small changes in the structure and composition of wetland and riparian areas can adversely affect populations of a large number of species, including organisms not directly dependent on these habitats (MFWP 2002). Therefore, the welfare of riparian and wetland areas can have the greatest influence (relative to other parts of the system) over the biological health of watersheds.

Wetlands and riparian areas provide important habitat to fish, as well. In the Kootenai Subbasin as elsewhere in the Columbia Basin, the natural habitat complexity of streams is in large measure due to accumulations of large woody debris, particularly in the alluvial reaches where substratum size is smaller and interstitial cover more limited than in the boulder-dominated channels of high gradient streams (Williams et al. 2000). Along with the bank stability and flow resistance provided by living riparian vegetation, coarse woody debris acts to deflect flows, creating low-velocity flow refugia, scouring deep pools, locally trapping sediments and fine organic material that contributes to aquatic food webs, and providing a diverse and stable habitat mosaic used heavily by many kinds of organisms (Williams et al. 2000).

Riparian vegetation provides shade and thereby helps to maintain the cool summertime water temperatures necessary for native aquatic life, everything

Table 2.10. Riparian features important to wildlife (after Malanson 1993).

Riparian features valuable for wildlife habitat:
Woody plant communities
- structural variation
- woody debris
Surface water and soil moisture
- Increased productivity
Spatial heterogeneity
- Edges/ecotones
Corridors
- Migration/dispersal
Riparian features that would differentiate among wildlife species:
Vegetation type
- food availability
Size and shape
- interior and edge
Hydrological regime
- flooding disturbances (food/cover)
Adjacent land use
- food in adjacent areas
Elevation
Climate and topography

from macroinvertebrates to fish (Meehan et al. 1977). It also helps to moderate water temperature extremes during winter. Riparian vegetation filters out nutrients and improves water quality. It produces most of the detritus that provides as much as 90 percent of the organic matter necessary to support stream aquatic communities (Campbell and Franklin 1979). In forested ecosystems, up to 99 percent of the stream (biological) energy input may come from bordering riparian vegetation with only 1 percent coming from instream photosynthesis by algae and mosses (Cummins 1974). Most of the food consumed by fish in large rivers, too, often comes from riparian vegetation (Kennedy 1977).

Sloughs, wetlands, and side channels provide deep-water habitats with a high amount of security cover, critical for juvenile fish. Additionally, off channel habitats provide refuge from unmanageable high water velocities typical of the Kootenai River mainstem. These habitats allow for nutrient assimilation and provide optimal habitat for aquatic invertebrates. Primary and secondary production is relatively high in sloughs versus the river mainstem (Soults 2002). Productive sloughs allow juvenile fish, specifically sturgeon, to achieve relatively high growth rates and prepare them for a successful transition to mainstem habitats (Partridge 1983; Paragamian et al. 1995; PWI 1999; and USFWS 1999).

Riparian areas generally respond differently to fire than surrounding upland areas. They may not burn at all, or may not burn as hot or as completely

(USFS 1998). Consequently, after major fires, riparian zones in burned areas retain more litter, down material, and live vegetation, which can provide diversity and cover to wildlife and serve to protect sensitive fisheries while watersheds recover. Because of their resistance to fire, riparian and adjacent upland sites tend to develop old growth characteristics and to provide linkages between upland old growth stands (USFS 1998).

2.2.2 Human Alterations to Critical Riparian and Wetland Functional Processes

Council document 2000-12 *Return to the River* (Williams et al. 2000), summarizes the effects of various human activities on riparian and wetland areas and their key ecological functions (see Appendix 22). Many of these directly apply to the Kootenai Subbasin. For example, the trapping and killing of beaver has significantly reduced beaver populations, resulting in widespread loss of structural elements, floodplain processes, and vegetative diversity. Past commercial logging, the indirect effects of river diking, and the clearing of floodplains and bottomlands has eliminated wildlife cover from areas and removed the sources of large woody debris, which is fundamental to the maintenance of stream and river habitat complexity and productivity. Reducing the acres of riparian forests has affected the stability of stream banks and floodplain and toeslope surfaces. In some places, heavy grazing by domestic livestock has reduced vegetative cover and vigor, suppressed or eliminated some vegetation species, non-native noxious weeds, and reduced canopy cover over the channel. Snyder (2002) states that "extensive stands of black cottonwood were once present throughout the [Kootenai River] floodplain, but have been virtually eliminated due to grazing in riparian areas and channel and flood control," and the floodplain shows a reduction of native species. Out of one hundred plant species identified, ninety-three were identified to the species level, 61 percent of those were non-native, and 39 percent native. On tributaries, these changes have often caused wider and more open channels with lower, warmer, more turbid surface flows in summer, more extensive ice conditions in winter, and flashier more turbid flows during runoff periods. Dams have inundated high quality riparian habitats, created unvegetated varial zones and altered the natural hydrograph. Snyder (2002) reports in her assessment of dike riparian vegetation: "Because (dikes) are constantly being eroded and reshaped, bank faces and boundaries of designated landforms can change significantly in a very short period of time. Significant changes were noted between the 2001 and 2002 field seasons, after just one winter season of high flow levels. Lower and mid-elevation riparian areas have also been impacted by the pressures of erosion control efforts, irrigation withdrawals, and road building.

LINKS

For a summary of the effects of various human activities on riparian and wetland areas and their key ecological functions see Appendix 22.

Click Here

The TBA assessment estimates changes to riparian and wetland biomes, many of which affect functional processes. Go to Appendix 80.

Click Here

The loss of riparian habitats and the associated decline in the amount of large, instream woody debris has directly impacted bull trout in the subbasin (USFWS 2002; McPhail and Baxter 1996). Nakano and others (1992) report that focal sites for juvenile bull trout are strongly associated with overhanging vegetation, and woody debris provides cover for juveniles, stream-resident adults, and migratory spawners. In addition, the loss of riparian vegetation shade can increase summer water temperatures to above 59 °F because of the loss of shade. The importance of vegetation and large wood debris for maintaining the physical channel form varies by stream type (Rosgen 1996), but riparian vegetation and instream woody debris can influence stream bank protection, channel grade, sediment storage, and energy dissipation (Deiter 2000). The loss of riparian vegetation can result in increased variation in flow, resulting in low flows in summer and fall, scouring flash floods in spring, and substrate freezing in winter (McPhail and Baxter 1996).

LINKS

For summaries of hydrologic data showing pre and post-dam flow duration charts and pre and post-dam peak flow values charts for USGS gaging stations in the subbasin, go to Appendix 8.

Click Here

According to Jamieson and Braatne (2001), the lower Kootenai River floodplain probably supported one of the largest and richest riparian-forest and wetland complexes in the Pacific Northwest. In the mainstem and valley tributaries of Idaho, approximately 50,000 acres of lowland floodplain have been lost (EPA 2004). Twenty-three thousand acres of ephemeral and perennial wetlands have been lost since 1890 (EPA 2004). The substantial wetland losses are attributed to a combination of factors that include the operations of Libby Dam, reductions in hydrologic connectivity (diking and land leveling), draining associated with agricultural development, and tributary channelization (Richards 1997). KTOI has documented the changes in waterway distribution in the Kootenai River floodplain that have occurred since 1928 by tracking increases in stream miles, which correlates with wetland draining (e.g., new drainage ditches included in waterway miles, table 2.11 and figure 2.9) and by tracking channelization (stream straightening), which has resulted in lower "natural" stream miles (KTOI unpublished).

Similar losses and alterations of riparian and wetland areas elsewhere have decreased plant and wildlife diversity (Gresswell et al. 1989; Ebert and Balko 1987; Hodorff et al. 1988; Naiman et al. 1993; Wiggins et al. 1980). The Kootenai River valley as well as surrounding mid-high ecosystems are considered historic ranges for woodland caribou and grizzly (Soults pers. comm. 2004). As an example, woodland caribou historically used the lowland floodplains for early winter habitat in the lower Kootenai portion of the subbasin. Additionally, significant grizzly bear use of the floodplain in the lower Kootenai River drainage has been detected during the spring. Bears move to low-elevation areas immediately upon exiting the den to feed on the relatively high-protein succulents and to search for winter-killed ungulates (NWPPC 2000).

Table 2.11. Changes in waterway distribution in the Kootenai River floodplain 1928 to 1985.

TYPE	Function	Modified	1928	1985
Dtiches				
Ditch	Intermittent	manmade	64.66	91.99
Ditch	Perennial	manmade	7.81	51.75
Subtotal Ditches			**72.47**	**143.74**
Intermittent Streams				
Stream	Intermittent	modified natural	50.49	77.66
Stream	Intermittent	natural	24.67	5.6
Subtotal Int. Streams			75.16	83.26
Perennial Streams				
Stream	Perennial	modified natural	20.01	23.02
Stream	Perennial	natural	14.53	15.29
Subtotal Per. Streams			**34.54**	**38.31**
Subtotal Natural Streams			**39.2**	**20.89**
Subtotal Modified Natural Streams			**70.5**	**100.68**
Total Stream Length			**109.7**	**121.57**
Waterway Miles			**182.17**	**265.31**

LINKS

Appendix 34, A Conservation Strategy for Northern Idaho Wetlands (Jankovsky-Jones 1997) summarizes the status of wetlands in northern Idaho as well as how various impairments and type changes affect wetland function.

Click Here

In its geomorphic assessment of the Kootenai River, Tetra Tech (2003) summarizes the impacts that diking and stabilization efforts along the lower Kootenai have had on key geomorphic processes and how diking diminished floodplain connectivity. From a hydraulic and sediment transport point of view, this results in confinement of flows to the main channel, an increase in the water surface elevation for floods when they cannot spread out onto the floodplain, an increase in energy in the main channel during floods, increased sediment transport and erosion during floods and the elimination of the transfer of sediments from the main channel to the floodplain for deposition. Bank stabilization also changes the dynamics of the system where the meandering channel no longer meanders. This eliminates the processes that in the past reworked the floodplain and created the diverse over-bank topography containing sloughs, wetlands, and marshes.

Similar to other large river-floodplain ecosystems, the Kootenai River was historically characterized by seasonal flood pulses that promoted the nutrient exchange among a mosaic of habitats. This nutrient exchange enhances biological productivity and habitat diversity (BPA 2003). Prior to the construction of Libby Dam, diking alone could not contain frequent high spring flows along the Kootenai River. Those overland flows supplied a natural source of river nutrient inputs created low velocity, backwater, and side-channel habitats and non-native pioneering riparian species (Johnson et al. 1976; Miller et al. 1995). The flood

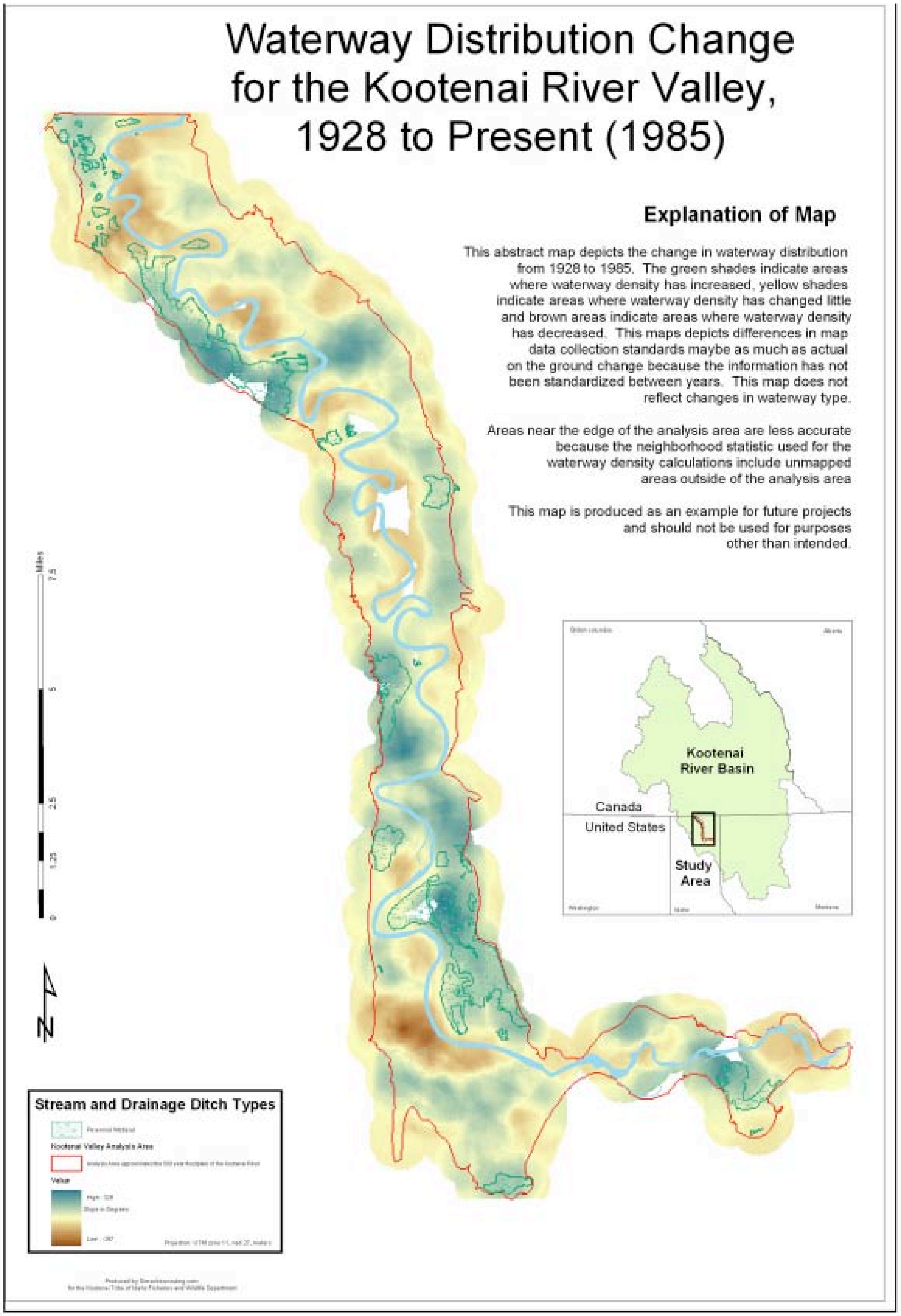

Figure 2.9. Waterway distribution change, Kootenai River Valley, 1928 to present.

pulses and overland flows ended when the dam was built. And just as dam operations have had dramatic impacts on aquatic habitat structure, so, too, do they effect adjacent riparian habitats and successional processes in those communities. Sediments that are building up in river cobbles were normally deposited in floodplain zones that provided the seedbeds necessary for establishment of willow, cottonwood and other riparian plant communities. Young cottonwood stands are needed to replace mature stands that are being lost to natural stand aging as well as adverse human activities such as hardwood logging and land clearing. Of the two species of cottonwood present within the Kootenai River ecosystem—plains cottonwood (non-native) and black cottonwood (native)—the latter is considered the largest native broadleaf tree in Idaho. The Forest Service has identified the lack of cottonwood in riparian areas as a problem in the subbasin (USFS KIPNF 2003).

In their study of the impacts of flow regulation on Kootenai River riparian cottonwood forests, Jamieson and Braatne (2001) found that relatively minor land use changes have occurred in an upstream alluvial reach of the Kootenai River in B.C., but that major impacts have resulted from the operations of Libby Dam, diking, and agricultural development of the floodplain in downstream reaches in the U.S. For the Skookumchuck to Wardner alluvial reach in B.C., Jamieson and Braatne report that the Kootenai River is in a relatively natural condition, and while some clearing occurred in the past for agriculture, there is relatively little human settlement on the floodplain and natural fluvial processes are intact. Regular flood events are resulting in cottonwood and willow recruitment throughout the reach. The reach from Wardner to Libby Dam, which once supported significant areas of alluvial floodplain and cottonwood stands, is now inundated. The canyon area downstream of Libby Dam to the confluence with the Moyie River historically supported few cottonwood stands because of its relatively narrow floodplain. The reach between the confluence of the Moyie River and Bonners Ferry has dikes, but the river is able to migrate between them. In this reach, Jamieson and Braatne found large stands of mature cottonwood. They also found that the recruitment of new cottonwood stands had occurred in recent years as a result of the spring flow releases for white sturgeon in the 1990-2000 period. In the reach between Bonners Ferry and Kootenay Lake, where the river is restricted by dikes for most of its length, they found that there has been little recruitment since the construction of Libby Dam (though this reach once supported extensive cottonwood stands). Some cottonwood recruitment has occurred on point bars below the dikes where the dikes cut across the neck of meander loops. Their conclusion is that diking for agricultural use has severely restricted the hydrological connectivity between the river and the active floodplain, but the operation of Libby Dam has been the major factor affecting cottonwood recruitment. Other studies express similar conclusions, but historical information shows that the hydrologic disconnection of the floodplain is more related to Libby Dam flood control than dike construction. As an example, Snyder states "The process of diking was completed, in large part, by 1947, (Richards 1997; EPA 2004; BCHS 1987), but spring flooding continued to occur until the construction of Montana's Libby Hydroelectric Dam in 1972." History of Boundary County (1987) states there were multiple accounts of dike breaching, topping, and related overland flows, for example: "Several districts flooded each high water year by spring runoffs over the next forty years" page 43; " … in seven days all the districts and the town were flooded" page 43; "Drainage District #5 - Year after year we fought the high waters, then in 1948 it flooded and wiped us out" page 46; "District #6 went out in 1948" page 37; "Dike in District #11 breaks" page 33; and "May, 1956 the river … was topping from Irvings to Harts, a distance of about a mile" page 31 (figure 2.10).

In its assessment of the Kootenai River, the Pacific Watershed Institute (1999) hypothesizes that the wetland system in the lower Kootenai probably contributed substantially to the influx of carbon and nutrients to the river. Under unaltered conditions, nutrients and carbon would be added to the river from the adjacent wetlands and floodplain during flood and recession. They conclude that human activities such as the draining of wetlands, the diking of the floodplain, the straightening of stream channels, the clearing of vegetation, and other alterations such as those caused by log drives have probably contributed as much as Libby Dam to the reduced productivity in the aquatic ecosystem downstream of Bonners Ferry.

Riparian and wetland habitat-forming processes affected by Libby Dam operations include erosion and sediment deposition, nutrient cycling, and plant succession. Under natural flow conditions, flushing flows sort bottom sediments. Fine sediments are deposited along the river margins and on the tails of islands, providing nutrients and soils for riparian vegetation. Unnatural flow fluctuations have disrupted these habitat-forming processes, resulting in a larger varial zone that is biologically unproductive (Hauer and Stanford 1997). When the Kootenai River was unregulated, the normal pattern was for the varial zone to be wetted and dried only once, as spring meltwaters flooded all of the channel perimeter and then subsided. Aquatic life in the river was adapted to this pattern. With regulation, however, the varial zone has been watered and dewatered unpredictably, giving life in the river little chance of naturally colonizing new areas during high water or of migrating when the water volume decreases (Stanford 1990). In addition, terrestrial plants have been less likely to take root in a fluctuating system because seedbeds necessary for establishment of willow, cottonwood and other riparian plant communities are absent. Snyder (2002) reports that the dikes are "colonized in a seemingly homogenous manner by aggressive, pioneering, weedy plant species."

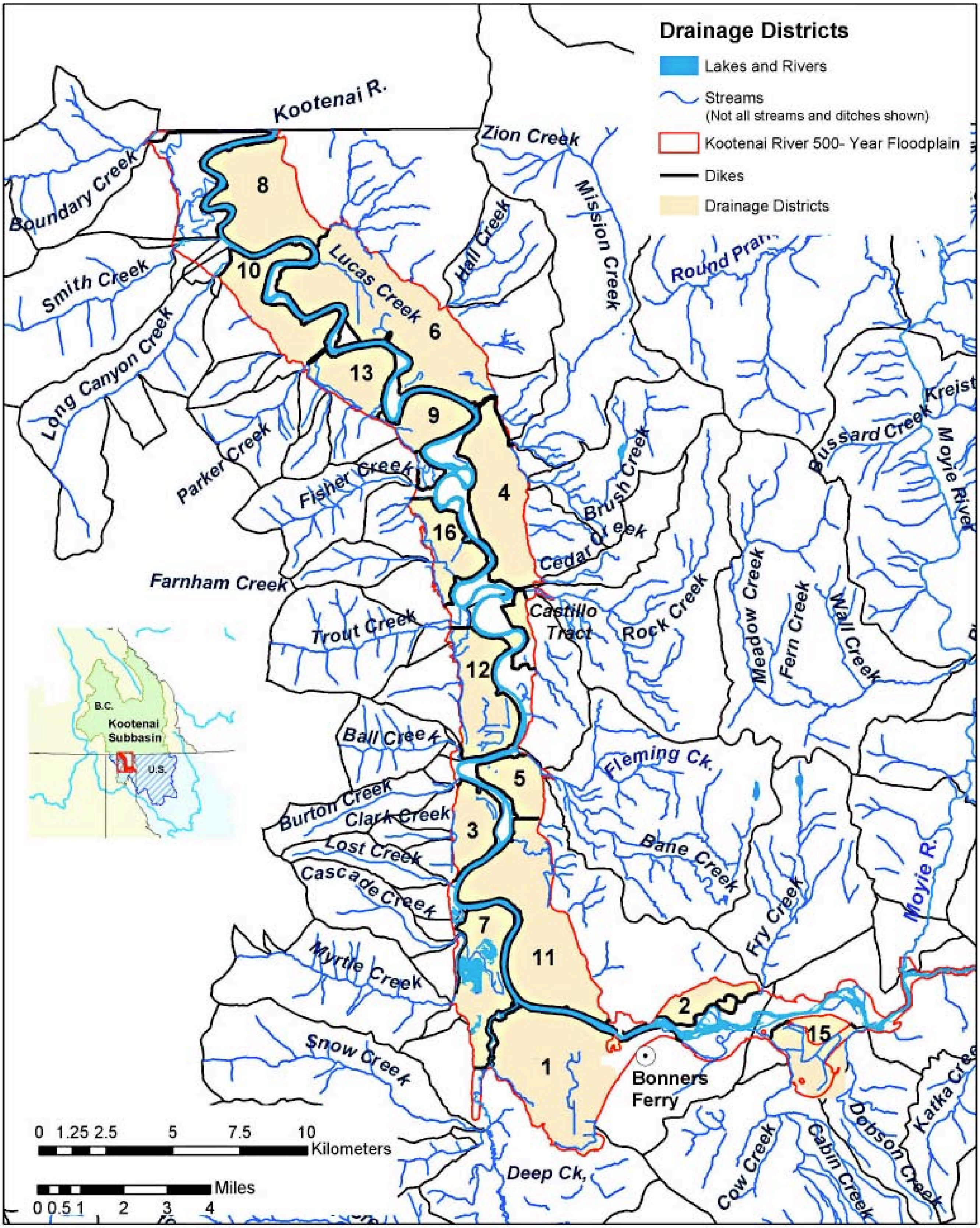

Figure 2.10. Drainage Districts along the lower Kootenai. Source: EPA (2004).

Young cottonwood and willow stands are needed to replace mature stands that are being lost to natural stand aging as well as human activities such as hardwood logging and land clearing. Fine sediments that would normally become stabilized by shoreline vegetation are more easily eroded into the river channel.

2.2.3 Presettlement Riparian and Wetland Habitat Conditions[16]

During presettlement times, riparian and wetland plant and animal communities in the Kootenai Subbasin were generally in excellent condition with minimal anthropogenic influences, so riparian functions were largely intact and, by definition, within their historic ranges of variability. The uplands bordering riparian areas were also in pristine condition and thus helped to maintain the hydrologic regime and habitat connectivity.

LINKS

The TBA assessment estimates presettlement riparian and wetland biome acres. Go to Appendix 80.

Click Here

During presettlement times the floodplain of the lower Kootenai River[17] (the portion of the subbasin in Idaho and downstream in British Columbia) included approximately 70,000 acres of contiguous floodplain ecosystem and related wetlands. This expanse of wetlands was created and maintained by spring floodwaters from the Kootenai River watershed. The magnitude and duration of the annual flooding depended on the accumulation of snow at high elevations. First, low-elevation snowmelt and rainfall partially filled depressions on the floodplain. Then, in May, flows in tributary streams peaked. When they reached the relatively flat floodplain, their rates of flow diminished and they lost energy. Large boulders, gravel and sand accumulated in alluvial fans at the foot of the mountains, while in the floodplain, tributary flows swelled to fill the deeply incised stream channels and overtopped their banks. They spread out across the floodplain, depositing silt along the stream banks and forming natural levees of higher ground. In mid May of 1808, David Thompson described the annual flood event: "The water from the melting snow in the mountains had risen upwards of six feet and overflowed all the extensive fine meadows of this country" (Rockwell 1984).

Tributary flows throughout the watershed were still very high in June, and they would eventually bring the Kootenai River to its maximum annual elevation. The flows filled Kootenay Lake due to the restriction at Grohmann Narrows and backed up the Kootenai River to Bonners Ferry. Floodwaters spread across the floodplain in what was a still-water segment of the river, depositing silt on the river banks, forming natural levees higher than the adjacent floodplain (B. Jamieson pers. comm. 2004). The finest material, high in clay content, was

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[16] *Presettlement conditions are defined as the state of the environment at the time of European settlement or 1850.*

[17] *Adapted from Cole and Hanna (2000).*

deposited on the floodplain farthest from the river's channel. Over thousands of years, this cycle of annual river flooding resulted in deep accumulations of rich alluvial soil on the floodplain.

In July, the annual flooding receded and the wetland basins on the floodplain were left filled with water but isolated from the tributary streams and the main river by the natural levees built up by the deposition of sediments. The length of time the wetland basins retained water varied annually depending upon summer temperatures, precipitation, and the depth of the wetland basins.

LINKS

For an assessment of Kootenai River dike vegetation, go to Appendix 102.

Click Here

The natural hydrodynamics and the resultant floodplain landscape created diverse plant communities and habitats. Amos D. Robinson, a surveyor for the General Land Office (now the Bureau of Land Management), a branch of the US Department of the Interior, provided a basic description of the Boundary Creek area in August 1894: "The body of this township is composed of marsh lands and a narrow strip of rich alluvial bottom along the Kootenai River slightly above ordinary high water … Land, level bottom, and marsh; soil, alluvial, first rate; timber, cottonwood with dense brush" (GLO Notes 1894).

The General Land Office survey of the Boundary Creek property was completed by A.W. Barber in December 1898 (GLO Notes 1898). Barber noted that higher land in the floodplain was occupied by cottonwoods, some as large as three to four feet in diameter, aspen, "dense snowy brush" (probably snowberry), "bearberry" (?), "thorn" (probably hawthorn), and willow. Timber and brush varied from "dense" and "heavy" to "a scattering." Lower portions of the floodplain were described as "meadow", "marshy meadow," "wet marsh," "tule marsh" (probably cattails), "tules and deepmarsh," and "open slough." According to Barber, the steep, forested land adjacent to the floodplain at Boundary Creek was composed of heavy timber including cedar, larch, pine, fir and cottonwood.

A US Forest Service (USFS) photograph taken near Smith Creek prior to 1916 provides documentation of what the natural vegetation of the Kootenai River floodplain looked like over 80 years ago (figure 2.11). The coarse material of the Smith Creek alluvial fan (lower right portion of the photograph) was densely forested and included cottonwoods and conifers. Wetland basins were vegetated by herbaceous species. The natural levee associated with Long Canyon Creek, the next drainage upstream from Smith Creek, runs across the center of the photograph while the natural levee associated with the Kootenai River occurs farther out on the floodplain. These natural levees were vegetated by stringers of cottonwoods and shrubs.

LINKS

To skip ahead to presettlement grassland conditions, go to:

Click Here

To gain a more complete picture of presettlement conditions, some readers may want to skip ahead to the section on grassland presettlement conditions (see the link in the links column).

Figure 2.11. US Forest Service photograph of the Kootenai River floodplain near Smith Creek prior to 1916.

2.2.4 Present Riparian/Wetland Habitat Conditions

General

A number of human activities have caused significant losses in riparian and wetland acres or substantially impaired riparian function. Some of the most serious impacts have come from water impoundment and diversion, river diking, stream channel straightening, wetland draining, livestock grazing, urban and suburban development, land clearing for agriculture, road development, heavy recreational demand, fires that burn outside the range of natural variability, the elimination or reduction of populations of native organisms such as beavers, the introduction of non-native species, and overall watershed degradation. Wetlands and riparian areas have also been impacted by the development of surrounding uplands (especially cabins and rural subdivisions along shorelines), contaminants, invasion of nonnative and noxious plants, introduction of nonnative animals, livestock grazing, and disturbance from increasing recreational use (NWPPC 2000).

LINKS

The TBA assessment estimates riparian and wetland biome acres and assesses various impacts by subunit. Go to Appendix 80.

Click Here

Upper Kootenai[18]

The Kootenai National forest has developed an Aquatic Response Unit (ARU) classification system to characterize and inventory the composition, structure,

[18] *The first two paragraphs of this section are adapted from USFS KIPNF (2003).*

LINKS

Appendix 35, The Impact of Flow Regulation on Riparian Cottonwood Forests along the Kootenai River in Idaho, Montana, And British Columbia, describes how Libby Dam and other human impacts to the floodplain affect riparian communities.

Click Here

Appendix 29, Kootenai River Geomorphic Assessment (2003) discusses the impacts that diking and flow regulation have had on lower Kootenai River wetlands.

Click Here

Appendix 23, excerpted from the Kootenai National Forest's Upper Kootenai River Subbasin Review assesses riparian and channel disturbances on tributary streams in Montana.

Click Here

and function of riparian vegetation. ARUs are determined by temporal and spatial patterns of hydrologic and geomorphic processes within defined valley bottoms of predetermined widths. Departure from a range of variability and/or a proper functioning condition can be determined by either comparison to reference stream reaches within a given valley bottom type (or ARU) undisturbed by human influence or from an understanding of aquatic processes developed through ARUs.

Table 2.12 is a summary description of ARUs on the forest. Additional information can be found in the draft ARU document on file at the Supervisor's Office in Libby. The ARUs have been grouped based on overall similar descriptive characteristics. Each ARU is coded so the first number reflects the dominant stream order. The second and third letters reflect the overall gradient (stream gradient) where "A" is the highest gradient and "C" is the lowest gradient (these classes follow the Rosgen system gradient breaks).

Humans have introduced a number of non-native grasses and forbs within riparian shrublands of the subbasin, (USFS KIPNF 2003). Extensive populations of non-native species—mainly reed canary grass and common tansy—border the Kootenai River. The invasions reduce the value of the areas as wildlife habitat and displace native plants. These non-native species are also common along other riparian systems where exposure is relatively open. Flower Creek has an infestation of Japanese knotweed along the portion that flows through Libby (USFS KIPNF 2003).

Road construction and development has caused a reduction in riparian, wetland and lakeshore habitat as well as vegetation-composition changes in riparian areas, some of which is due to the noxious weeds that typically accompany roads.

Other riparian and wetland losses occurred from the construction (as opposed to the operations) of Libby Dam.

Lower Kootenai[19]

Semipermanent to permanent emergent wetlands, poor to rich fens, paludified forests, and ombotrophic bogs in the subbasin harbor some of the region's rarest wetland-associated plants and animals. Acres of wetland as inventoried by the National Wetland Inventory (NWI) are presented in Table 2.13. This includes 800 acres that have been rehabilitated on the 2,774 acres Kootenai Refuge (Marotz et al. 2000). In her summary of ownership and protection status of northern Idaho (Bonner and Boundary Counties) wetlands, including deepwater habitat, Jankovsky-Jones (1997) found that nearly 25 percent of wetlands are in private ownership. Seventy–one percent are classified open water and fall under the jurisdiction of the state of Idaho. The USFS is the largest public land manager of

[19] *Adapted from USFS KIPNF (2003).*

Table 2.12. Summary of ARUs on the Kootenai National Forest. The Idaho Panhandle National Forest does not have an ARU classification and inventory at this time.

Group	ARU	Proportion of the KNF	Description	Vegetation
1	1A	33%	First and some second order, very steep streams. Commonly found at elevations between 3000-5500 . Major landtype groups are 300 and 400 series. Valley bottoms are narrow.	Grand fir, Black Cottonwood, Western Redcedar, Western Hemlock, Common Snowberry,
1	1AB	19%	First and 2nd order, steep streams. Commonly found at elevations between 2500-5500 . Major landtype group is 300 series. Valley bottoms are fairly narrow.	Western Redcedar, Mountain Alder, Sitka Alder, Fools's Huckleberry, Drummond Willow, Arnica
1	3AB	1%	Third order, steep streams. Commonly found at elevations below 4500 . Major landtype groups are 300 and 400 series, followed by 100 series. Valley bottoms are fairly narrow.	Grand fir, Western Redcedar, Rocky Mountain Maple, Common Prince s-pine, Twinflower, Thimbleberry
2	1B	17%	First and second order, moderate gradient streams. Mainly found at elevations between 2500-5000 . Most common landtype group is 300 series, followed by the 100 then the 400 series. Valley bottoms are moderately wide.	Engelmann Spruce, Western Redcedar, Sitka Alder, *Sphagnum sp.*, Ticklegrass, Oak-fern
2	1B	17%	First and second order, moderate gradient streams. Mainly found at elevations between 2500-5000 . Most common landtype group is 300 series, followed by the 100 then the 400 series. Valley bottoms are moderately wide.	Engelmann Spruce, Western Redcedar, Sitka Alder, *Sphagnum sp.*, Ticklegrass, Oak-fern
2	3B	4%	Third order, moderate gradient streams. Mainly found at elevations between 2500-4500 . Most common landtype group is the 300 series, followed by the 100 and 400 series. Valley bottoms are moderately wide.	Grand fir, Paper Birch, Western Redcedar, Western Hemlock, Sitka Alder, Fools's Huckleberry, Devil's Club,

LINKS

Appendix 36 describes Kootenai National Forest peatlands and assesses the effects of forest management activities on these areas.

Click Here

Appendix 37 is an Ecological Inventory of Wetland Sites in the Thompson-Fisher Conservation Easement.

Click Here

Appendix 38 reports on rare wetland plants of the Bonners Ferry Ranger District.

Click Here

Appendix 39 lists Wetland and Riparian Plant Species of the Kootenai River Valley.

Click Here

Appendix 40 is a report on moonworts of the Kootenai National Forest.

Click Here

Table 2.12 (cont.). Summary of ARUs on the Kootenai National Forest. The Idaho Panhandle National Forest does not have an ARU classification and inventory at this time.

Group	ARU	Proportion of the KNF	Description	Vegetation
2	4B		Characteristics of this group include 1st, 2nd, and 3rd order streams with low gradient, higher sinuosity, and wide valley bottoms.	
3	1C	7%	First and second order, low gradient streams. Commonly found at elevations between 2000-4000 . Major landtype groups are 100 and 300 series. Valley bottoms are wide.	Spruce, Sitka Alder, Thimbleberry, Reedgrass, Ladyfern,
3	3C	5%	Third order, low gradient streams. Commonly found at elevations between 2000-4500 . Major landtype groups are 100 and 300 series. Valley bottoms are wide.	Grand fir, Engelmann Spruce, Black Cottonwood, Red-osier Dogwood, Douglas Spiraea, Ticklegrass,
4	4C	6%	Fourth order, low gradient streams. Mainly found at elevations below 4000 . Major landtype groups are 100 and 300 series. Valley bottoms are wide.	Paper Birch, Paper Birch, Balsam Poplar, Scouler Willow, Bentgrass, Beaked Sedge, Reed Canarygrass, Fowl Bluegrass

Table 2.13. National Wetlands Inventory acres of wetland in the Lower Kootenai.

Lentic Environments	Total Acres	0 - 2500 ft	2500 - 4500 ft	4500+ ft
NWI-Palustrine	6002.9	3199.00	2257.6	546.3
NWI-Lacustrine	1044	635.10	303.8	105.9
Total	**7046.9**	**3834.10**	**2561.4**	**652.2**

wetland habitat at 2.9 percent. Jankovsky-Jones found that only about 3.3 percent of wetland and deepwater habitats are currently protected in a manner intended to maintain natural resource values.

In the lower Kootenai River system, roughly 50,000 acres of lowland floodplain and 23,000 acres of ephemeral and perennial wetlands in the U.S. have been converted into agricultural row crop and pastureland (EPA in press

2004; Richards 1997). Jankovsky-Jones (1997) writes: "Prior to settlement the Kootenai River spread across the wide valley bottom between the Purcell and Selkirk Mountains and supported forested and shrub wetlands, ponds, wet meadows, and marshes. In the 1920s dikes were created to contain spring floods. Cottonwood forests were removed and wetlands were filled for agriculture development. Cottonwoods forests and shrublands along the Kootenai River are currently restricted to streamside bands within the levees and to islands. Loss to road construction and home building has surpassed agricultural loss in recent years." Smaller wetland communities can be found in Idaho and Montana along the canyon and braided reaches of the Kootenai River system and on geologic features such as cirques, kettles, scours, and outwash channels. The 1992 National Resource Inventory indicated that in all, nearly 60 percent of non-federal wetlands in the Kootenai-Pend Oreille-Spokane subbasins are now used for cropland and pastureland (Jankovsky-Jones 1997). Losses of perennial wetlands along the Lower Kootenai River are shown in figure 2.12.

The river often topped dikes and flooded agricultural grounds. These overland flows supplied a natural source of river nutrient inputs and created low velocity, backwater and side-channel habitat (PWI 1999). Additionally, flood events increased the diversity of the riparian community by creating shallow-water areas with high concentrations of hydrophilic plants, both emergent and submerged. The events also created areas of fluvial deposition for cottonwood and willow recruitment. Today, the Kootenai Tribe of Idaho and the Idaho Department of Fish and Game are forming partnerships with local communities and state and federal agencies to design projects which mitigate hydropower losses in the Kootenai Subbasin, in addition to protecting and enhancing critical wildlife habitat for species dependent on wetland and riparian habitats. Tables in Appendix 34 give the percentage of different wetland types in Boundary County, Idaho and list wetland sites in Boundary County and wetland and deepwater habitat for the lower Kootenai River drainage (Idaho portion of the Kootenai Subbasin).

2.2.5 Potential Riparian/Wetland Habitat Condition[20]

Under this scenario, Libby Dam would be operated in a manner that would substantially restore normative hydrologic conditions (conditions that mimic natural processes and minimize impacts on fish and wildlife). Stabilizing summer flows will have allowed some reestablishment of riparian vegetation in the varial zones of regulated rivers. An operational impact assessment and plans to mitigate

[20] *The potential condition is defined as the desired end state or optimal condition for this subbasin in the year 2050.*

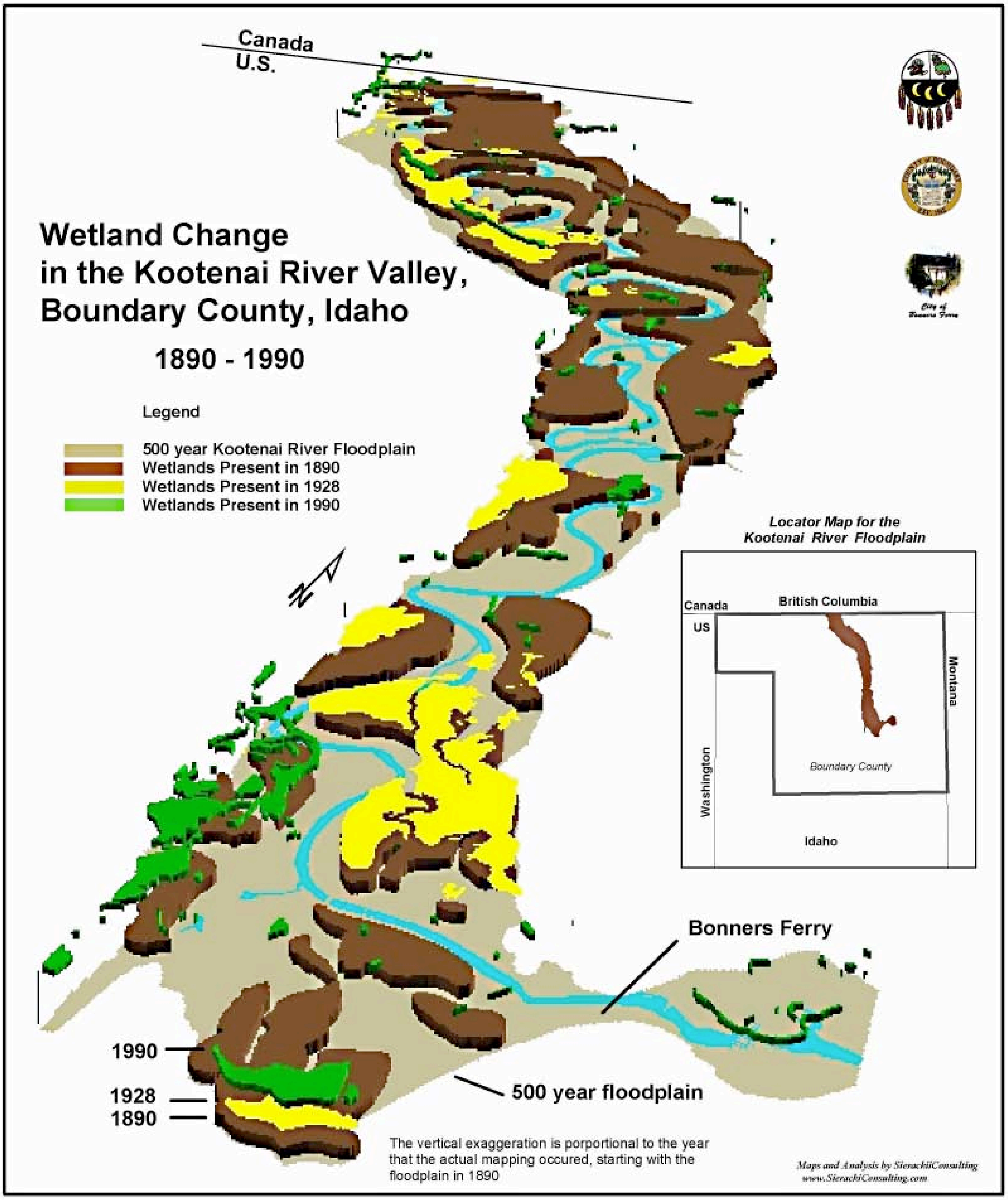

Figure 2.12. Time-series analysis of wetland change, 1890-1990. Source: EPA (2004).

for ecological impacts caused by the operations of Libby Dam, including but not limited to successional riparian wildlife habitats and their associated aquatic components, will have been completed and fully implemented. Off-channel floodplain habitats in the lower Kootenai River ecosystem critical to the survival of white sturgeon will have been identified and reconnected to the river.

Across the subbasin, the best available remaining riparian and wetland habitats will have been identified and protected through the use of conservation easements and land acquisitions. In areas where easements or acquisition is not possible, land use activities that are presently degrading these habitats or that are preventing them from recovering will have been modified through education. Education and better enforcement will result in better compliance with existing habitat-protection laws. Riparian fencing and revegetation projects will have protected and effectively restored impacted areas. Collectively, these measures will have resulted in the reestablishment of riparian vegetation, the reconnection of artificially fragmented habitats, and the protection of key migration corridors from future development. Natural stream channel function and form will have been restored using methods such as bank stabilization, streambank and riparian revegetation, riparian fencing, and in-stream channel habitat structures. The miles of road passing through riparian habitats will have been significantly reduced, with roads being relocating out of floodplains and stream bottoms. Minimum flows would be maintained through the purchasing and leasing of water rights and water conservation agreements.

2.2.6 Future/No New Action Riparian and Wetland Habitat Condition[21]

Riparian and wetland habitats will continue to be impacted or further degraded to varying degrees by silvicultural activities, roads, grazing, noxious weeds, land development, bank and shoreline modification and destabilization, agricultural practices, and hydropower operations. The degradation will have resulted in further impairment of key ecological functions, including sediment filtering, streambank building, water storage, aquifer recharge, dissipation of stream energy, nutrient retention, and fish and wildlife habitat. Disconnected wetland habitats such as sloughs will, for the most part, remain disconnected, further threatening the survival of white sturgeon.

Human populations will have continued to grow, and many more people will have built first and second homes along streams. These and other recreational

[21] *The future/no new action condition is the state of the subbasin environment in 2050 assuming that current trends and current management continues.*

and development pressures will have affected thousands of acres of riparian areas and wetlands, converting them to other uses or seriously reducing their value to fish or as wildlife habitat. Tied to this increasing human population will be a corresponding increase in noxious weeds, which also reduce the value of these key habitats to native fish and wildlife species.

2.3 Grassland Systems

2.3.1 Critical Grassland Functional Processes

One of the most basic processes in grassland ecosystems involves the production and transfer of nutrients such as carbon (C), nitrogen (N), and phosphorus (P) — elements critical to the biochemical processes of plant and animal life (Connor et al. 2001). Animals use these nutrients in their organic form by consuming the plants. Some of the nutrients are then transformed back to inorganic forms through the by-products of digestion and respiration. This "mineralization" process is critical to grassland ecosystem function because so much of the essential nutrients in the system are bound with organic matter within the soil and cannot be absorbed by plants until they are transformed to inorganic forms through microbial decomposition (Briske and Heitschmidt 1991).

Organisms in and on the surface of grassland soil—cyanobacteria, bacteria, algae, microfungi, lichens, bryophytes, protozoa, and nematodes—are also key to grassland ecosystem function. Native grassland soils in the Inland Northwest typically have well-developed microbiotic (or cryptobiotic) crusts which affect surface stability, soil fertility and structure, water infiltration, seedling establishment, and plant growth (Weddell 2001). Similarly, mycorrhizae also play an important part in the maintenance of grassland communities because they affect nutrient uptake, growth, and reproduction in associated vascular plants (Dhillion and Friese 1992; Harnett and Wilson 1999).

Grasslands evolved with frequent disturbances. Prior to European settlement, fire and drought were the major forces shaping and maintaining Columbia Basin grasslands. The mean presettlement fire-return interval for fires on western Montana grasslands was under 9 years (Barrett and Arno, 1982). The pre-fire structure of grassland vegetation is quick to return after a burn as a new stand of grass shoots up from surviving root systems. Fire converts standing and fallen dead plant matter to ash, and within a year or two the proportion of forbs usually increases (Smith 2000). Within about 3 years, the grassland structure has returned at least to pre-fire levels, as have faunal populations (Smith 2000).

A successional process of major importance to pre-1850 grasslands was the continual checking and reduction of woody-plant encroachment. Without fire, subbasin grasslands give way to stands of ponderosa pine and/or Douglas-fir. Fire not only halted encroachment and reduced the buildup of dead material, it performed many other critical ecosystem functions, such as recycling nutrients that might otherwise be trapped for long periods of time in dead organic matter, stimulating the production of nutrients, and providing the specific conditions critical for the reproduction of fire-dependent species.

Snapshot

During presettlement times, natural fire frequencies cleared organic debris, encouraged perennial grasses, and played key thermal and nutrient cycling roles. Over the past one hundred years fires have been mostly excluded, there have been invasions of woody and non-native plant species. Areas have been overgrazed and converted to cropland or other uses. Soils crusts have been disturbed, adversely affecting the rates of nitrogen fixation and soil stability, fertility, structure, and water infiltration. Native plant species have been significantly reduced as has the value of grasslands to native wildlife.

Grasslands perform a number of important ecological functions. Grasslands, especially those found on basic soils formed on calcium-rich parent material, are capable of sequestering relatively large amounts of carbon. The carbon is held both in organic and inorganic forms. While this function is maintained under light to moderate grazing, grassland soils are likely to lose between 20 and 50 percent of their original organic carbon within the first 40 to 50 years under cultivation (Conner et al. 2001).

LINKS

The TBA assessment estimates changes to the grassland biome, many of which affect functional processes. Go to Appendix 80.

Click Here

2.3.2 Human Alterations to Critical Grassland Functional Processes

Wood and Manley (1993) found the greatest losses of native grasslands within the Tobacco Valley (the largest area of grassland in the U.S. portion of the Kootenai) were from conversion to agricultural uses and development. Conversion has also had the greatest impact on critical functional processes. Cultivation or conversion to non-grassland types also disrupts the “mineralization” process by displacing native animal species. It typically removes or damages the cryptobiotic crusts of the soils, which alters the rates of such fundamental processes as nitrogen fixation (Evans and Belnap 1999) and adversely affects soil stability, fertility, structure, and water infiltration. Conversion can cause the loss of arbuscular mycorrhizae essential for growth, reproduction, and nutrient uptake of native plants.

The conversion of grasslands also increases the potential for soil loss from wind and water erosion. Average annual soil loss differences of 10 to greater than 60 times have been measured for similar watersheds with perennial grass cover versus continuous cropping (Conner et al. 2001; Krishna et al. 1988). As the potential for erosion increases, so does the potential for water quality impairment which results from increases in dissolved solids, nutrients, pesticides and sediment (Huntzinger 1995). Finally, conversion often substantially reduces or destroys wildlife habitat values.

Grazing, the elimination of regular, periodic burning by Indian people, and fire exclusion policies have disrupted the disturbance regime of grassland systems and all but eliminated the important ecological role played by fire. In grassland ecosystems where both fire and grazing are excluded, thatch or dead herbaceous litter accumulates, which depresses herbage yields and the number of plant species (Wright and Bailey 1982). Fire can help control encroaching shrubs and trees; increase herbage yield, the utilization of coarse grasses, and the availability of forage; and improve habitat for some wildlife species (Paysen et al. 2000). Removing fire has also reduced the diversity of herbaceous species and slowed the recycling nutrients trapped in dead plant matter. The change in fire regime combined with grazing, the invasion of nonnative plants, and the draining of wetlands and destruction of riparian areas within the subbasin's remaining grasslands has changed once-rich ecosystems that were used year-round by a variety of wildlife species to seasonal rangelands of less value to wildlife.

The spread of noxious weeds has also impaired grassland function. Weeds have further reduced the value of grasslands to wildlife and caused a decline in species diversity and native threatened rare plants. Spotted Knapweed is a major problem in the remaining grasslands in the Tobacco plains area. Lesser infestations occur in grasslands in the Canadian portion of the basin (B. Jamieson pers. comm. 2004).

2.3.3 Presettlement Grassland Habitat Condition[22]

Except in certain areas (for example, the Tobacco Valley and southerly aspects of the lower Fisher in Montana and places such as Wycliffe and Skookumchuck Flats in B.C.) grasslands were not a major component of the Kootenai Subbasin during presettlement times. They accounted for probably less than one percent of the total subbasin landscape (IBIS 2003). However, in the 1930s, following logging and large fires in valley-bottom open-canopy ponderosa pine and Douglas fir forests, large areas of the Trench were converted to seral grasslands with trees as a minor component of the system. This conversion resulted in an expansion of ungulate, wild horse and cattle numbers that has subsequently declined as a result of regrowth of forests on these landscapes. This was a factor from the Tobaccco Plains and Tobacco River areas north to Invermere in B.C. (B. Jamieson, pers. comm. 2004)

LINKS

The TBA assessment estimates presettlement grassland biome acres. Go to Appendix 80.

Click Here

Presettlement grasslands in the U.S. portion of the subbasin were similar to the fescue-wheatgrass-needlegrass community that occurs today in the Tobacco Plains. This type of grassland is transitional between Palouse Prairie typical of eastern Washington and Oregon and native grasslands of the Northern Great Plains (Antos, McCune, and Bara, 1983). Lesica (1996) found native grasslands were dominated by rough fescue *(Festuca scabrella)* and needle and thread grass (*Stipa comata*) . Other native grasses included bluebunch wheatgrass (Agropyron *spicatum),* Idaho fescue *(Festuca idahoensis),* and Sandberg bluegrass *(poasandbernii).* Grasslands in the B.C. part of the subbasin upstream from Montana, include the northern extension of the Tobacco Plains, which is primarily in the Tobacco Plains Reserve and the Wycliffe and Skookumchuck Flats. These areas are dominated by bunchgrasses and other grasses; shrubs occur in valley bottoms and on several plateaus throughout the Kootenai Valley (Meidinger and Pojar 1991). *Agropyron spicatum* (bluebunch wheatgrass) is the most widespread

[22] *Presettlement conditions are defined as the state of the subbasin environment at the time of European settlement or 1850.*

and dominant species. Other abundant or frequent species include *Festuca scabrella* (rough fescue), *F. idahoensis* (Idaho fescue), *Poa sandbergii* (Sandberg's bluegrass), *Koeleria macrantha* (junegrass), *Bromus tectorum* (cheatgrass), *Stipa comata* (needle-and-thread grass), *S. richardsonii* (spreading needlegrass), *S. spartea* (porcupinegrass), *Poa pratensis* (Kentucky bluegrass), *Artemisia tridentata, A. frigida* (pasture sage), and *Chrysothamnus nauseosus* (Meidinger and Pojar 1991).

During presettlement times, fire and drought were the major disturbance forces shaping grasslands in the subbasin. Fires, ignited by lightning as well as Native Americans, played a key role in structuring grassland vegetation by preventing the establishment of woody vegetation (Koterba and Habeck 1971; Dorey 1979; Barrett and Arno 1982). Mean presettlement fire-return interval for western Montana valleys was about 9 years (Barrett and Arno 1982) and was estimated to be 6.4 years (range of 2–13 years) for the north end of the Tobacco Valley in southeast British Columbia (Dorey 1979).

In spite of their limited extent, grassland habitats in the subbasin provided important wildlife habitat, including spring nesting habitat for ground-nesting waterfowl, raptors, and songbirds and winter range for bighorn sheep, elk, mule deer, and white-tailed deer. Columbian sharp-tailed grouse (*Tympanuchus phasianellus*) and trumpeter swan (*Cygnus buccinator*), both later extirpated from the subbasin, used grassland habitats and associated wetlands. Grasslands are also essential for the survival of species such as burrowing owl, Brewer's sparrow, badger, and Great Basin pocket mouse, which are unusual or rare in much of the subbasin.

To gain a more complete picture of presettlement conditions, some readers may want to skip ahead to the section on forest presettlement conditions (see the link in the links column).

LINKS

To skip ahead to presettlement forest conditions, go to:

Click Here

2.3.4 Present Grassland Habitat Condition

The grasslands of the western United States have undergone tremendous changes since European settlement began, with corresponding changes in the habitats and the wildlife species that inhabit them. The same has been true in the Kootenai Subbasin where native grassland areas have been lost due to subdivision and other developments, inundation by Libby Dam, intensive use by livestock, conversion to cropland, forest encroachment, and invasive nonnative species. As a result, populations of many grassland-dependent wildlife species, such as the Columbian sharp-tailed grouse, have been severely impacted.

Threats and impacts to grasslands in B.C. have been very similar to those in the U.S. Less than 1 percent of B.C. grasslands have any protection, although the Nature Trust of British Columbia has purchased grassland for conservation in the East Kootenay (Living Landscapes 2003). In some areas, overgrazing of grasslands

LINKS

The TBA assessment estimates grassland biome acres and assesses various impacts by subunit. Go to Appendix 80.

Click Here

has reduced the highly nutritious native perennial bunchgrasses and promoted less nutritious, weedy (often non-native) annual grasses and forbs. Trampling by cattle has damaged the surface soil cover of lichens, bryophytes, and cyanobacteria, which has promoted germination of weed seeds and resulted in loss of soil moisture, further stressing native vegetation. Overgrazing by livestock (first horses and later sheep and cattle) was serious in the early settlement period, and by 1900 had resulted in considerable damage to rangelands (Pitt and Hooper 1994). Since the 1940s, grassland range conditions in British Columbia have generally improved because of better management (Living Landscape 2003).

Throughout the subbasin, but especially in B.C., there here has been a considerable loss of grassland by forest encroachment (Ministry of Forests, 1995). While difficult to quantify, it is estimated that 30% of the Kootenai grasslands in B.C. have been lost to forest encroachment. Weeds have affected grassland health. The Kootenai National Forest reports that the primary causes for decline of native grassland habitats on the forest has been the invasion of non-native plants. Non-native species have reduced the value of wildlife and rare plant habitat (USFS KIPNF 2003). The rare perennial forb, Spalding's catchfly (*Silene spaldingii*), listed as a threatened species under the Endangered Species Act, is found within the Tobacco Plains and may be the largest population known. It occurs in the bottom of shallow swales and on cool slope exposures with relatively deep soil (Lesica 1997).

Another factor affecting the extent of grasslands in the subbasin was the construction of Libby Dam, which inundated important segments of the Ural-Tweed bighorn sheep spring and winter range. The resulting formation of Koocanusa Reservoir inundated approximately 4,350 acres of crucial winter and spring ranges for this species, the last remnant native bighorn sheep population in northwest Montana.

LINKS

For a list of grassland/ rangeland areas in the BC portion of the Kootenai and monitoring activities in each, go to: http://www.for.gov.bc.ca/nelson/research/rra/intro.htm

Click Here

Appendix 41 gives an overview of history of open forest and grassland habitat in East Kootenay.

Click Here

2.3.5 Potential Grassland Condition[23]

Under this scenario, the best remaining tracts of grassland will have been protected from subdivision and conversion to other vegetation types through conservation easements, purchase, and restoration. Management plans for these protected grassland areas will have been developed and implemented to restore appropriate plant and animal species composition and vertical and horizontal vegetative structure. Natural fire regimes will have been restored through the use of prescribed fire, and the introduction and spread of noxious weeds will have been held in check. Grazing will be used as a tool to enhance the native grassland community.

[23] *The potential condition is defined as the desired end state or optimal condition for this subbasin in the year 2050.*

Public education efforts and incentive programs will have improved land use practices on remaining grasslands. These efforts will have substantially reduced the conversion of native grasslands to other land cover types. Management agencies will have used prescribed fire to return encroached acres to grassland and to enhance existing grassland habitats. Riparian areas and wetlands within grassland habitats will have been fenced and protected from development activities.

2.3.5 Future/No New Action Grassland Condition[24]

The small pockets of grassland currently under protection by federal, Tribal, state, or provincial governments and organizations like The Nature Conservancy will remain protected, although expanding weed infestations will likely continue to degrade many of them. Some of these areas will have seen general improvements in grassland species composition and structure from ongoing restoration efforts. Unprotected grasslands, however, will continue to be converted into tame pastures, croplands, or residential developments, and these areas will see continued and significant declines in biological diversity and productivity. Subdivisions, especially, will have increased as the human population in the subbasin expands, and these developed areas will have lost virtually all of their value as wildlife habitat. Although there will have been some efforts to restore fire to grassland habitats, fire frequencies will have remained well outside of the historical range of variability. Poor grazing practices will have continued on the majority of unprotected grassland acres, and there will be significant increases in the spread of invasive and nonnative plants. All these factors will have contributed to the decline of native grassland species and will have resulted in the further decline of listed species. In Canada, in the Tobacco Plains, Wycliffe and Skookumchuck grasslands, it is unlikely that sufficient native grassland will remain to support any of the larger grassland animals of concern (badger, sharp-tailed grouse) (B. Jamieson, pers. comm. 2004).

[24] *The future/no new action condition is the state of the environment in 2050 assuming that current trends and current management continues.*

2.4 Coniferous Forest Systems

2.4.1 Critical Coniferous Forest Functional Processes

Table 2.14 lists major natural disturbance processes occurring within the forest biome. The most significant of these are fire and insects and disease (Monnig and Byler 1992), which are intrinsic components of forested ecosystems, affecting species composition, forest structure, landscape patterns, forest succession, nutrient cycling, and many other fundamental ecological processes. Both fire by itself and the interplay of fire and insects can affect forest communities by delaying or redirecting succession, which in turn affects the productivity and biological diversity of plant and animal communities (McCullough et al. 1998).

SNAPSHOT

During presettlement times, low-elevation dry forests were characterized by large, widely spaced ponderosa pine trees maintained by frequent, low-intensity fires. At mid and higher elevations, cool, moist sites supported fire-dependent, seral old growth trees. Wildlife easily moved across large habitat blocks. Over the last 100 years, large trees have been harvested and fires have been excluded. Shade tolerant species, more prone to disease and lethal fires have increased. Habitats have been roaded. Now, stands tend to be overstocked compared to historic conditions, especially on drier sites. Fire regimes have shifted to more lethal fires. Patch sizes are smaller, and the amount of interior habitat is less than historic conditions. Existing forests are more fragmented.

Table 2.14. List of Natural Disturbance Factors and Consequences (adapted from Ecological Planning and Toxicology, Inc. 1997)

Factor	Soil Effects	Direct Veg. Effects	Indirect Veg. Effects
Fire Nonlethal	Removal of soil litter; increase in available phosphorous, potassium, and other cations; decrease in soil organic matter and soil nitrogen	Removal of previously dead, above-ground biomass; kills sensitive trees and shrubs; removes accumulated litter	Fire resistant (surviving) plants generally experience rapid growth due to release from competitive interference and increase in nutrients from ash.
Fire Stand Replacement	Hot spots may alter the physical and biological composition of the soil; removal of surface litter; increase in available phosphorous, postassium and other cations; decrease in soil organic matter and soil nitrogen	Removes virtually all of above ground biomass (living and dead) leaving charred stumps and snags.	Opens area for secondary succession; highly dependent on propagule source and prevailing microclimate conditions.
Insects	None	Selective death of typically a single dominant forest species; increase in standing dead; increases potential for fire.	Loss of dominant species typically results in altered microclimate conditions (forest gaps) that may shift to greater ground cover or favor non-affected tree species.
Avalanche/ Landslide	Removal of surface soils	Localized loss of vegetation and top soil	Susceptible to continued erosion; slow re-colonization
Ice Storm	None	Selective breakage of trees and shrubs; increased debris on the forest floor	May alter succession by favoring either early or late successional species

Fire

The specific ecological effects of forest fires vary and are influenced by fire behavior, vegetation type, topography, climate, pre- and post-burn weather, and a number of other factors (McCullough et al. 1998). Fischer and Bradley (1987) synthesize what is known about typical forest community responses to fire in western Montana forests.

Among the changes that fire can trigger in forests are modifications of the microclimate, increases in the range of soil temperatures, changes in soil nutrients and microbial activity, the regeneration of vegetation, forest succession and new vegetation patterns, changes in plant growth rates and competitive interactions, changes in wildlife habitat and the activities of invertebrates and vertebrates, and changes in water storage capacity and the pattern of runoff (Paysen et al. 2000). Generalized plant succession patterns in western Montana following fires and the effect of fire on other key ecological process are summarized in Appendix 42.

LINKS

Generalized plant succession patterns in western Montana following fires and the effect of fire on other key ecological process are summarized in Appendix 42

Click Here

For detailed descriptions of disturbance processes and functions of the habitat groups in the Kootenai Subbasin, go to Appendix 43.

Click Here

Just as the ecological effects of fires vary, so do the characteristics of the fires themselves—the frequency, season, and size. General patterns do occur, however, and these describe what are called fire regimes. Historical fire regimes were important disturbance processes in western forest ecosystems (Agee 2001) prior to European settlement. They served to alter species composition, nutrient cycling, and other ecosystem structure and function attributes, and acted as one of the primary "coarse filters" that directed the natural diversity of the ecosystem (Hunter 1990). The primary fire regimes in the Kootenai Subbasin are the *stand-replacement*, the *mixed* and the *low severity or nonlethal*. Understanding these three fire regimes is critical to understanding fundamental ecological processes in Kootenai Subbasin forests. The following descriptions of the fires that dominated each regime are excerpted from USFS KIPNF (2003). Figures 2.13 and 2.14 show historic fire regimes.

Stand-Replacement Fires

Stand-replacing fires remove more than 90 percent of overstory tree canopy over a significant area and restart the successional sequence. Historically, on landscapes dominated by moist habitat types (as found on the Kootenai National Forest (KNF) and Idaho Panhandle National Forests (IPNFs), the mean fire return interval was approximately 200 years, with drier sites burning more frequently and wetter sites burning less frequently (Smith and Fischer 1997; Zack and Morgan 1994).

Major fire years occur most commonly during regional summer droughts. Lightning storms and wind contribute to the likelihood of a major fire year.

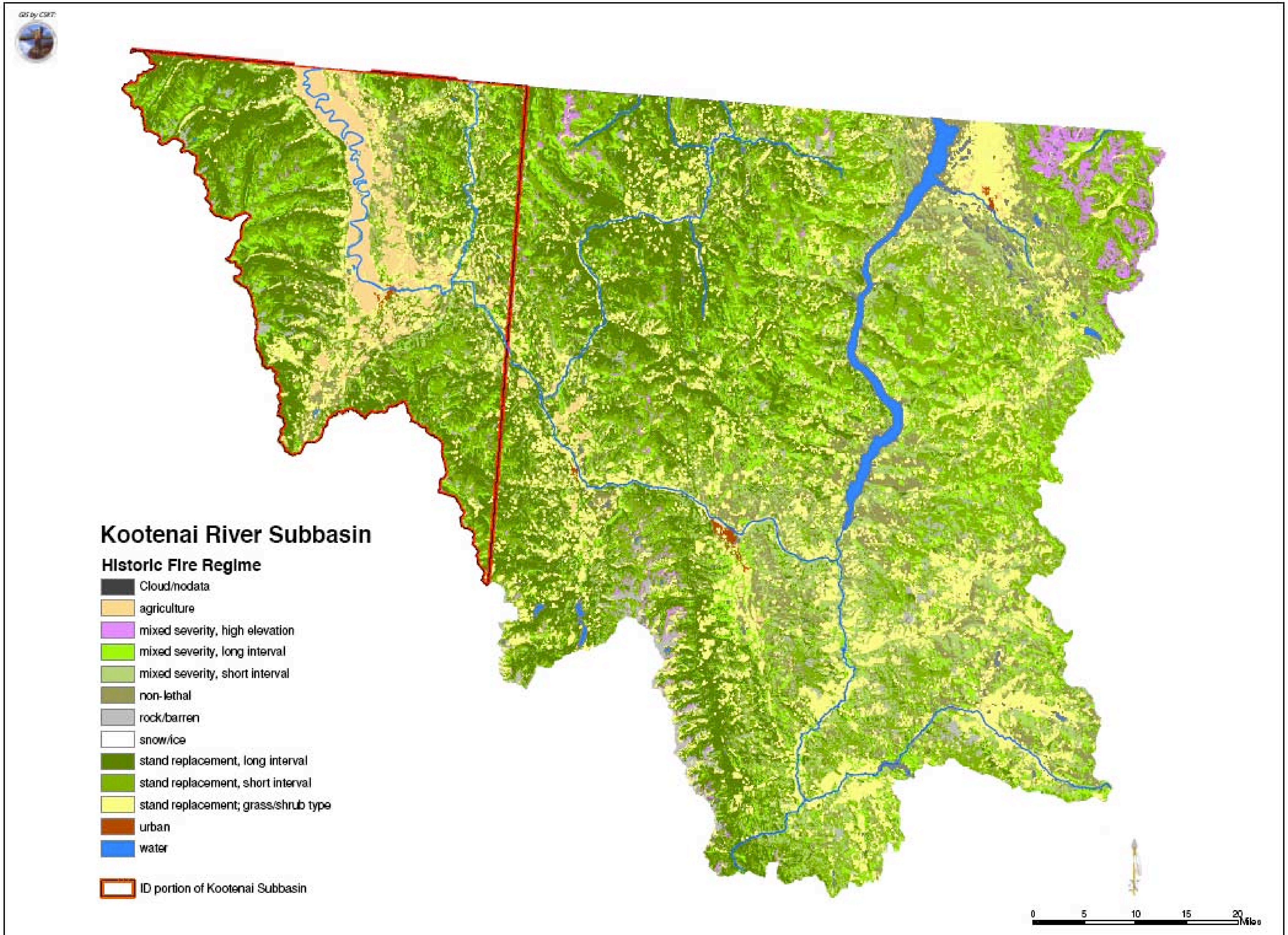

Figure 2.13. Historic fire regimes in the U.S. portion of the Kootenai River Subbasin.

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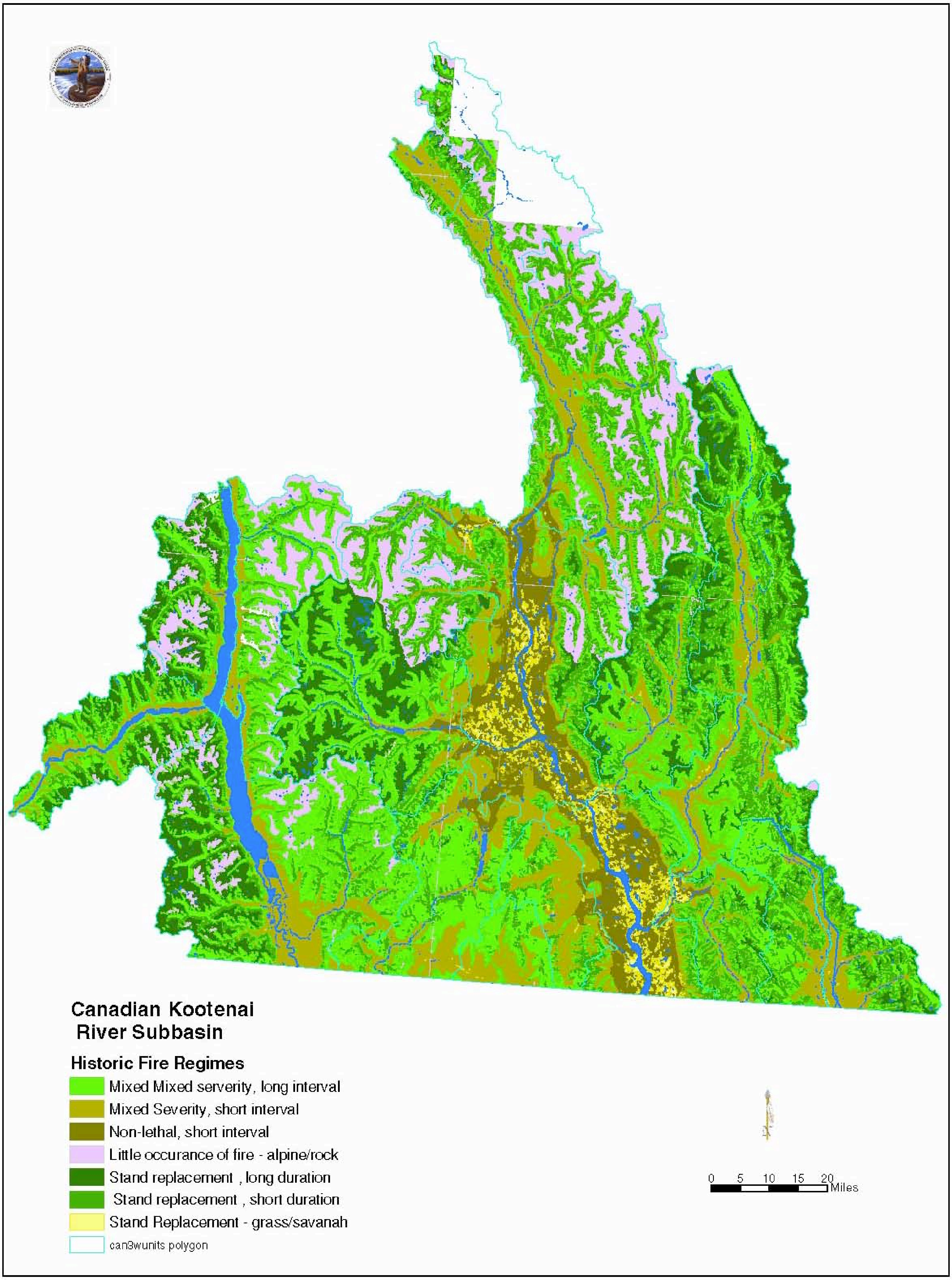

Figure 2.14. Historic fire regimes in the Canadian portion of the Kootenai River Subbasin.

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During major fire years, stand-replacing fires were commonly on the order of tens of thousands of acres, with some individual fire patches at 50,000 acres or larger (Pyne 1982; Zack and Morgan 1994). The Coeur d'Alene Fire Study, (based on approximately 1500 tree records) shows that over the last 450 years, there was one-major stand replacing fire episode an average of once every 19 years somewhere in that 570,000 acre river basin.

During major fire events some watersheds were almost entirely burned over, while other large areas were unaffected. In any particular watershed, major stand-replacing disturbances came in pulses, with long intervals between the pulses.

While stand-replacing fires favor long-term dominance by early successional, shade-intolerant tree species, the mean time interval between stand replacing fires was long enough to allow development of mature and old growth forest structural stages, particularly in landscapes where fire intervals tended to be longest.

Re-burns of fires have occurred throughout history. Re-burns have been associated with, and have normally followed, severe fire years that have burned in high intensity conditions. Stand-replacing fires can create a high fuel loading in both standing and down wood. When these fuels season after several years, the load becomes a strong candidate for re-burn when high temperatures, low humidity, and winds combine.

LINKS

The TBA assessment estimates changes to the forest biome, many of which affect functional processes. Go to Appendix 80.

Click Here

Mixed-Severity Fires

Mixed-severity fires kill at least 10 percent of the overstory tree canopy, but do not replace the whole stand. Mean fire return intervals typically ranged from 55-85 years, depending upon landscape location. On very moist sites they may have been significantly less common, while on drier sites return intervals were 25 years or less (Smith and Fischer 1997; Zack and Morgan 1994). Mixed-severity fires create an irregular patchy mosaic of small to moderate-sized openings, thinned areas, underburned areas, and unburned areas. Mixed severity fires generally prolonged the period of dominance by early successional fire-adapted species and at a larger scale, allowed for the development of mature and old growth structural stages dominated by large trees. Fire also played many additional ecological roles as a carbon and nutrient recycling agent, dormancy breaking and stimulating agent for herb and shrub seeds and sprouts, and creator of tree cavities and snags (used by wildlife). Historically, mixed-severity fires were extremely variable in size (less than one acre to more than 1,000 acres) and introduced both variable sized patches and internal diversity within larger blocks created by the less frequent stand-replacing fires.

Low-Severity or Nonlethal Fires

Low-severity fires are typically underburns that kill less than 10 percent of the overstory tree canopy. They are most important on drier habitat types where conditions are dry enough to burn more frequently. Mean fire return intervals typically range from 10 to 30 years (Smith and Fischer 1997). Low-severity fires typically remove most small understory trees, particularly the more shade-tolerant, fire-intolerant species. On drier habitat types where these fires are common, the frequent burns maintain a large portion of the landscape in relatively open stands of large, shade-intolerant, fire-tolerant species (larch and ponderosa pine with lesser amounts of Douglas-fir).

Effects of Historic Stand-replacing Fires

These disturbances of large, infrequent stand-replacing wildfires created a dynamic shifting mosaic of forest successional stages on a very large scale. In between the stand-replacing fires, vegetation, aquatic systems, and wildlife habitat had long periods to develop. Intermediate disturbances (low and mixed severity fire; some insect, pathogen, and weather events) introduced finer scale variability within these larger patches. As a result, blocks of wildlife habitat tended to be large, and blocks of mature/late-successional forest also tended to be large, but internally diverse. Terrestrial/aquatic interactions meant that watershed conditions and fish habitat also tended to form a dynamic, large-scale, shifting mosaic. Over time any individual watershed could vary from predominantly mature/old forest (with wildlife and fish habitat that results) to almost all recently burned over. However, at any given time, at the larger scale (500,000 – 2,000,000 acres), the whole range of these conditions was represented in watershed-sized blocks of thousands to tens of thousands of acres.

Insects and Disease

Historically, insects and pathogens played a significant role in shaping forests. Mountain pine beetles (and occasionally spruce beetles) in white pine and lodgepole pine at times served as stand-replacing agents. They sometimes opened canopies enough to provide regeneration opportunities for climax species. Most often they served to release early seral species, creating fuels and increasing the probability of large stand-replacing fires. In some situations, Douglas-fir bark beetle can have the same effect on a smaller scale (USFS KIPNF 2003).

Episodic outbreaks of major defoliating insects may have played a similar and harmonizing role to that of surface fires with respect to forest succession (Holling 1981; Wickman 1978). For example, while western spruce budworm (*Choristoneura occidentalis*) and Douglas-fir tussock moth (*Orygia pseudotsugata*) feed on late successional Douglas fir and true firs (species that are relatively susceptible to fire); they do not attack seral pine species (which are fire resistant) (McCullough et al. 1998). Swetnam and others (1995) suggest that prior to European settlement, both low-intensity outbreaks of defoliators and surface fires probably kept fuel accumulations low, which would have prevented, or at least postponed, catastrophic stand-replacing outbreaks or fire. Recent outbreaks of western spruce budworm and Douglas-fir beetle (*Dendroctonus pseudotsugae*) are thought to have effectively slowed the rate that Douglas-fir replaced seral pines. Thus the insects are playing a role analogous to that of frequent surface fires (Hadley and Veblen 1993).

Historically, root pathogens also acted as thinning agents. In natural mixed-species stands, root pathogens caused the greatest mortality in Douglas-fir, followed by true firs. White pine and larch were the most resistant tree species to these diseases (Hoff and McDonald 1994; Monnig and Byler 1992). Hence root pathogens favored the pines and larch, increasing the amount of those species over the first 150 years or so of stand life (USFS KIPNF 2003).

Because insects affect the accumulation and distribution of fuels and vegetation in profound ways, they often determine the risk of fire ignition, behavior, and intensity (Mccullough et al. 1998). The interplay between insects and fire often directs the process of forest succession after a disturbance (Mccullough et al. 1998).

Trees killed by fire, insects, and disease play a key ecological role in subbasin forests. Dead and defective trees are known to be one of the most important contributors to wildlife diversity within forest ecosystems. About 25 percent of bird species in the Rocky Mountains are cavity nesters (McClelland et al. 1979). On adjacent forest lands in northwestern Montana, it is estimated that 42 species of birds and 10 species of mammals use cavities found in dead or defective trees for nesting, feeding, or shelter. Dead and defective trees also serve as habitat refugia, enabling species such as lichens to persist that might otherwise be lost from the area; enrich the subsequent forest stand structure by providing a source of large snags and coarse woody debris; and improve the connectivity of the managed forest landscape (USFS 1998).

Landscape Patterns[25]

Landscape patterns affect wildlife habitat and dispersal, plant habitat and dispersal, disturbance (fire, insects, pathogens) spread and size, ecosystem response to disturbance, and human esthetic values.

Some important, interrelated concepts used to assess landscape patterns are patches, interior habitat, and fragmentation. A patch is defined as an area of

[25] *Condensed from USFS KIPNF (2003)*

continuous habitat or as an area capable of facilitating particular habitat functions for given species or species groups. Patches can be identified according to key habitat features of forest structure, composition, and process. Interior forest habitat is defined as the conditions typical of the central or interior part of a habitat patch, usually relatively stable and uninfluenced by the changing climatic conditions and other variables associated with edge conditions. In general, interior habitat is the opposite of fragmentation (the greater the fragmentation, the fewer acres of interior forest habitat). The size and shape of forested areas largely determines the size of interior habitat. Obviously, the larger the forested patch is the larger the interior habitat would be. The shape of the forested patch is also important. Interior habitat is maximized when the shape of the forested patch is circular and minimized when the forested patch is linear. Some forested patches may be so narrow that they only provide edge habitat and no interior habitat.

LINKS

For detailed descriptions of disturbance processes and functions of the habitat groups in the Kootenai Subbasin, go to Appendix 43.

Click Here

Compared to the historical condition, there are several important changes in landscape patterns. Generally, patch sizes are smaller today than they were historically. Analysis on the Idaho Panhandle National Forests shows that early and late-successional patches are smaller and more homogenous in size than historic. Compared to the historical situation, the late successional structural stages are much more fragmented. They are divided into smaller patches with generally more edge and less interior and they are more homogeneous in patch size (fewer large patches). In contrast, the medium size class is a larger percent of the landscape; however, the large patches of medium size class are internally fragmented by numerous small patches of early successional stages created by timber harvest, or patches of medium-sized trees linked together by long skinny leave strips.

The Upper Kootenai Subbasin Review, an analysis conducted on the KNF, shows that patch sizes have decreased across all patch types, including early successional patches (USFS 2002). Corresponding with smaller patch sizes are less interior habitat and greater fragmentation. On the KNF, the cool and the moist habitat types seem to have deviated most from historic conditions although all habitat types have declined in amount and size of interior habitat (USFS 2002).

2.4.2 Human Alterations to Critical Coniferous Forest Functional Processes

Through fire exclusion, logging, the introduction of non-natives, climate change and other perturbations, Kootenai Subbasin forests have, over the last fifty to one hundred years, undergone a series of significant changes. The most important coarse-scale changes in coniferous forests include[26]:

1. The shift away from early seral species (species that generally need high quantities of sunlight to persist, i.e. more sun loving) to those that can tolerate denser and more shaded forest conditions. This condition is considered to be a factor in reducing the resilience and sustainability of the forest.

   - Beginning in the 1930s, the loss of western white pine in the more moist forest environments (due to the combination of mountain pine beetle, and subsequent white pine blister rust that can continue to cause massive mortality of this species) is particularly significant in forested ecosystems throughout the US portion of the subbasin. This forest type has been replaced by fairly large expanses of Douglas-fir, western hemlock, and fir/spruce/mountain hemlock type. Due to the current composition of dense forest conditions and the subsequent susceptibility to bark beetles and root disease, these current types will likely experience future insect, disease and fire disturbance that will effect sustainability of a large portion of the forest ecosystem.

   - A similar situation exists in the higher elevation settings of subbasin forests with whitebark pine. A combination of mountain pine beetle, whitepine blister rust and fire exclusion has resulted in a replacement to Engelmann spruce/subalpine fir forests. These dense, multi-storied forests are now highly susceptible to very large scale fires and have greatly declined levels of whitebark pine compared to 20-30 years ago.

   - In both the moist and cool potions of subbasin forests, the shade-intolerant western larch was much more prevalent than today. Large overstory western larch trees were a preferred species for historic logging, and with fire suppression, this species is in decline as a predominant forest type in many areas. This type has been replaced by dense Douglas-fir, and fir/spruce/mountain hemlock forest types that are much less resistant to insects, diseases, and moderate intensity fire.

[26] *Adapted from USFS KIPNF (2003)*

- Within the drier portions of subbasin forests, less large ponderosa pine are present than occurred historically. These large, relatively open grown pines were easily accessible to historic lower elevation logging and with the combination of subsequent fire suppression, many areas have been replaced by dense Douglas-fir. These current conditions are much more susceptible to Douglas-fir beetle, root disease, and severe wildfire.

2. A shift in forest structure including the pattern or arrangement of the forest communities has occurred, and could affect resilience and the sustainability of historic ecological relationships.

   - In some areas, increases in density have created conditions that make the forest more susceptible to insects, diseases, and severe wildfire, especially when one considers the species-compositional changes that have occurred during the same timeframe.

   - The pattern and arrangement of forest structures have changed as well. Due to the small-scale pattern of timber harvest during the past several decades, large, spatial "patches" historically common, are now replaced by smaller patches less typical of historical conditions.

These changes have in turn caused fire regimes to shift. For example, areas that were formerly classified as nonlethal are now classified as stand replacement (Figure 2.15).

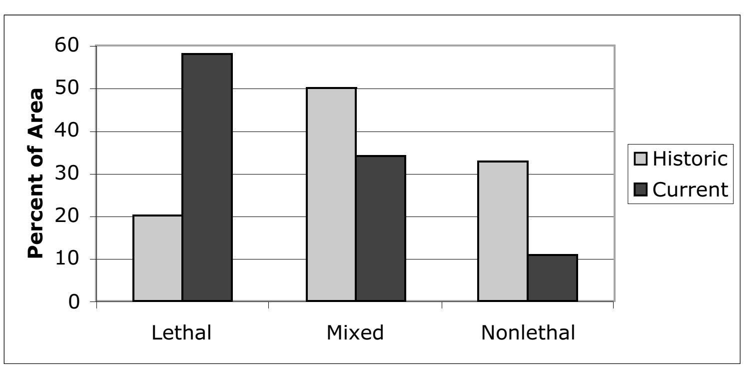

Figure 2.15. Fire severity for FS and BLM administered Forested Potential Vegetation Groups in western Montana and Idaho (after Quigley et al. 1996).

2.4.3 Presettlement Coniferous Forest Habitat Condition

Historically, approximately 20 percent of the overall, generalized landscape of the forests in the U.S. portion of the subbasin was in an "old growth", or late seral condition (Losensky 1993). The pattern (frequency and intensity) of disturbance events determined the distribution of this successional stage at any given point in time. In moist riparian areas and upper elevation cool, moist sites this old growth took the form of a multi-story, multi-age forest, while on warm, dry sites that experienced frequent, low-intensity fire events, stands were open and park-like and composed of mature trees with light understory. Twenty percent of the landscape was also in an early seral state (Losensky 1993), and in these stands, stand-replacing fires occurred at different rates and created different patch sizes. Intervals between stand-replacing events varied from 150 to 400 years in the cool, moist environment and 150 to 200 years in warm, moist habitats (Leavell 2000). The balance—sixty percent—of the U.S. portion of the subbasin is thought to have been in a varied, mixed-age, mixed-height, mixed-conifer, and mid-seral condition (Losensky 1993) (figures 2.13 and 2.14).

LINKS

For more information on historic forest conditions, see Appendix 46.

Click Here

For descriptions of the historic condition of Vegetation Response Unit Groups (analogous to PVGs), go to Appendix 44.

Click Here

The TBA assessment estimates presettlement coniferous (xeric and mesic) forest biome acres. Go to Appendix 80.

Click Here

Habitat Groups and VRUs

Table 2.15 summarizes the presettlement characteristics of Vegetation Response Unit (VRU) Groups in the U.S. portion of the Kootenai Subbasin (USFS KNF 1999).

Narrative and quantitative descriptions of the historic condition of Vegetation Response Unit Groups, which are analogous to Potential Vegetation Groups (PVGs), are provided in Appendix 44.

2.4.4 Present Coniferous Forest Habitat Condition

Basic information about current forest conditions for the Kootenai National Forest (forest types, habitat groups, number of trees, tree sizes, etc.) is summarized in Appendix 45 (an equivalent publication for the Idaho portion of the Kootenai is not available). Narrative and quantitative descriptions of the current condition of Vegetation Response Unit Groups, which are analogous to Potential Vegetation Groups (PVGs), are provided in Appendix 44. Maps showing the distribution of Vegetation Response Units for each geographical area in the U.S. portion of the subbasin can be found in Appendix 1.

Table 2.15. Summary of historic conditions of Vegetation Response Unit (VRU) Groups

VRU Group	Habitat Type Group	Predominant Fire Regime	Historic Patch Size	Historic Species Comp.	Historic Stand Structure
Warm and Dry	1	Nonlethal low severity 5 to 25 year FRI	<5 ac small openings, within 20-200 ac patches	PP with lesser amounts of WL and DF	Diverse mix, open stand, well spaced trees (5-20 tpa) interspersed with larger openings and dense patches, multi-aged, 1-2 stories. Ave. basal area 50-80 sq. ft/ac
Warm and Dry	2	South aspect- nonlethal, low severity 15-45 yr. FRI North aspect- nonuniform mixed severity 15-45 yr. FRI Nonuniform lethal stand replacement ave. 225 yr. FRI	variable size small openings (0-5 ac), within 20-200 ac patches created by mixed and lethal fires	PP/DF dry, lower elevations WL/LP with PP moist upland	Diverse mix, open stand well spaced trees (15-30 tpa) interspersed with larger openings and dense patches, multi-aged and 1-2 stories. north slopes more even-aged and single storied with some variety in size/age. Ave. basal area 60-100 sq.ft/ac
Warm and Dry	3	Nonlethal, low severity 25-50 yr. FRI Mixed severity, 70-250 yr. FRI on cool, wet sites. 30 yr. FRI on warm, moist sites. 75-80 yrs in LP stands Nonuniform, lethal stand replacement 100-250 yr. FRI	5 to 50 ac	WL/DF/PP dry, lower elev WL/DF/LP moist, uplands	Variable gaps to large even-aged single storied patches to larger area multi-aged multistory and single story open grown stands. Ave. basal area 80-120 sq ft/ac, more in riparian areas. tpa ranged from 15-60
Warm and Moist	4	South aspects nonuniform, mixed severity 30-85 yr. FRI North aspects nonuniform, lethal stand replacement, ave. 200 yr. FRI	20-75 ac 100-300 ac or more	WL/DF with LP,GF,WP, PP	Varies with topography. two storied, even and uneven-aged in lowlands. single and two storied, even-aged in upland areas. Basal area ave. 150-200 sq ft/ac and 30-50 overstory tpa in upland areas to over 200 sq ft/ac in valley bottoms
Warm and Moist	5	North aspects nonuniform, lethal stand replacement 250+ FRI (110-340 yr. range) South aspects nonuniform, mixed severity 75 yr. FRI (17-113 yr. range)	100-300 ac w/ potential for larger 100 ac or less	WL/DF with WP, ES,LP,GF,WRC,WH	Varies with topography. two storied, even and uneven-aged in lowlands. often two-aged and storied in upland areas. Basal area ave. 150-200 sq ft/ac and 30-50 overstory tpa in upland areas to over 200 sq ft/ac in valley bottoms

Table 2.15 (cont.). Summary of historic conditions of Vegetation Response Unit (VRU) Groups

VRU Group	Habitat Type Group	Predominant Fire Regime	Historic Patch Size	Historic Species Comp.	Historic Stand Structure
Cool and Moist	**7**	Lethal, stand replacement >100 yr. FRI in LP/DF, 120-268 yr. in L/DF, up to 300 yrs in spruce bottoms Less prevalent nonuniform mixed severity, 50-70 yr. FRI in LP/DF, 38-120 yrs in L/DF, up to 120 yr. in ES	5,000 to 100,000 ac 100 ac or less	WL,LP,WP,ES, DF with GF,SAF	Mostly even-aged single storied and two storied, some dense LP stands Basal area ave. 80-120 sq ft
Cold Moist	**9**	Nonuniform stand replacement 100-115 yr. FRI Some mixed severity, nonuniform burns 50-71 vr. FRI	5,000 to 100,000 ac 50-300 ac	LP,SAF in frost pockets LP,SAF,ES,DF, WL on moist upland sites	Even-aged LP with scattered relic overstory WL, some stands mixed with DF, SAF Basal area ave. 80-120 sq ft
Cold	**10**	Low -mixed severity 35 300+ years * stand replacement 200+ years	overall 200-30,000 ac, averages 2,400 ac	WBP, ES, LP with SAF,MH	Fairly open stands with clustered trees uneven-aged, mosaic
	11	Low-mixed severity 35-300+ yrs stand replacement 200+ years	overall 200-30,000 ac, averages 2,400 ac	alpine larch, WBP, ES,SAF	Mosaic vegetative patterns, open stands with clustered and shrublike trees, uneven-aged
Riparian	**6**	Fire is not a significant disturbance agent Infrequent, low severity or stand replacement 300-400 yr. FRI	Varies with stream channel and disturbances from adjacent stands	WRC,WH,WP, WL, ES	Old growth characteristics, multi-aged, fairly dense but multi-storied canopy of large trees with shade tolerant understory
	8	Fire is not a dominant disturbance agent infrequent low severity or stand replacement 150-250 yr. FRI (ave. 220 yrs)	Varies with stream channel and disturbances from adjacent stands	WRC,WH,WP, WL, ES	Old growth characteristics, multi-aged, fairly dense but multi-storied canopy of large trees with shade tolerant understory

Fire Disturbance Process

The Forest Service has been suppressing wildfires for many decades. Suppression efforts have been particularly effective for low and mixed-severity fires, virtually removing this agent as a significant disturbance process for the last 60 years. Rapid suppression of all fire starts has also removed most opportunity for fires to grow in size and intensity to become stand-replacing fires. For example, over the last 60 years on the northern portion of the IPNFs, there were only a few stand-replacing fires greater than 1,000 acres. Only two of those were greater than 10,000 acres, and they occurred in the same month during an extreme weather event.

The success of fire suppression efforts and the extent of resource management activities over the last 100 years has had a large influence on the structure and composition of forest and rangeland fuel conditions. The function and process of ecological systems has changed.

LINKS

For descriptions of the historic condition of Vegetation Response Unit Groups (analogous to PVGs), go to Appendix 44.

Click Here

For basic information about current forest conditions on the Kootenai National Forest, go to Appendix 45.

Click Here

Maps showing the distribution of Vegetation Response Units for each geographical area in the U.S. portion of the subbasin can be found in Appendix 1.

Click Here

Timber Harvesting

Timber harvests peaked on National Forest lands in the 1970s and then began to decline. Because of fire suppression, regeneration timber harvests are the current, predominant stand-replacing disturbance process. The majority of acres treated for timber harvest under the goals and objectives of the 1980s forest plans were even-age, regeneration prescriptions.

Regeneration harvest systems (clearcut, seed-tree, shelterwood) followed by prescribed fire can emulate to a certain degree some of the functions of stand-replacing fire, but not all of them. These silvicultural systems are generally successful in regenerating mixed species stands dominated by early successional shade-intolerant species. However, traditional regeneration harvest created unnaturally uniform conditions, and did not leave the scattered residual snags, residual live-tree patches and scattered fire-tolerant large live trees (larch and ponderosa pine) that were characteristic of historic fires. In addition, the size of regeneration harvest units (2 to 40 acres) has been much smaller than patches created by historic, natural-fire regimes. This is now beginning to change, with greater utilization of snag retention standards, new silvicultural systems such as irregular seed-tree and shelterwood systems with reserves, and increasing size of regeneration harvest units. Results of even-age, regeneration prescriptions primarily limited to 40 acres in size while deferring all acres in between from any disturbance have shaped the landscape and modified habitat and processes all across the KIPZ.

Salvage and partial cut harvesting (sanitation harvest, individual tree selection, commercial thin) somewhat emulate the effects of low and mixed-severity fire in terms of thinning stands. However, these harvest systems also differ from low and mixed-severity natural fire. The salvage and sanitation harvests remove larger dead and dying trees that historically remained to contribute to nutrient cycling, wildlife habitat, and aquatic functions. In most cases, partial cuts maintain a dense overstory canopy.

Road densities in the U.S. and Canadian portions of the subbasin are shown in figures 2.16 and 2.17. For a description of the effects of roads on focal and target species, see Trombulak and Frissell (2000).

Insects and Disease

With the impact of white-pine blister rust (an introduced disease) and the decrease in fire, the role of insects and pathogens as disturbance agents is growing and changing. White-pine blister rust accounts for major changes in forest successional patterns, having removed more than 90% of two conifer species (white pine and whitebark pine). With the absence of white pine and decreased amounts of ponderosa pine and larch, root pathogens have been transformed from thinning agents into major stand-change agents in Douglas-fir and true fir stands. Root pathogens now produce significant canopy openings on many sites. Depending upon the habitat type, root pathogens may either stall stands in a diseased shrub/sapling/open pole successional stage, or strongly accelerate succession towards shade-tolerant species.

Bark beetles have also changed their role. Because there is more Douglas-fir relative to historical conditions, Douglas-fir bark beetles are now more important change agents than they were historically. In all but the driest habitat types, Douglas-fir bark beetles accelerate succession in the short-run, and in the long-run create fuel conditions and stand structures that may increase the risk of stand-replacing wildfires.

Native insects and pathogens are also now responsible for a relatively much larger proportion of forest disturbance than they were historically. The impact of all these insects and pathogens in the short-run is to strongly accelerate succession towards late seral, shade-tolerant tree species. A recent analysis of pathogen and insect impacts in ecoregion section M333d (Bitterroot Mountains Section) (Hagle et al. 2000) examined successional changes for the period 1935 to 1975. This analysis shows that in 40 years, pathogens and insects changed forest cover types to more late-successional, shade-tolerant tree species on over 80% of the area dominated by moist forest habitat types (Byler and Hagle 2000). The same analysis of insect and pathogen impacts also showed that almost 40% of the moist habitat type area analyzed was either stalled in small tree structures or was actually moving back towards the small tree structures as a result of the removal of the largest trees.

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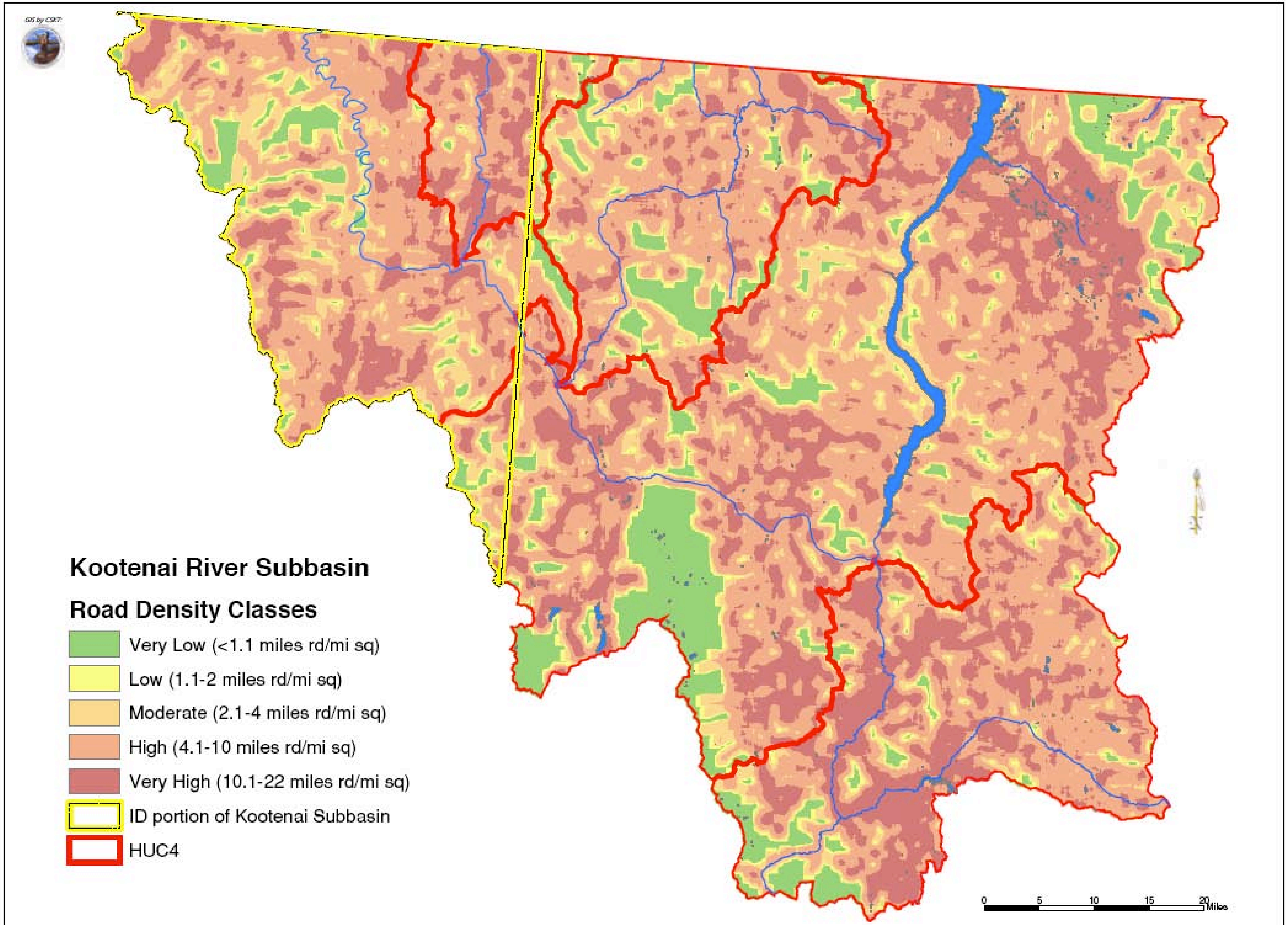

Figure 2.16. Road density in the U.S. portion of the Kootenai River Subbasin.

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Figure 2.17. Road density in the Canadian portion of the Kootenai River Subbasin.

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Vegetative Response Unit (VRU) Groups[27]

Warm/Dry VRU Group

A comparison of historic and existing forest cover types shows some changes and trends. In general, there is a decrease in seral species such as ponderosa pine and larch and an increase in Douglas-fir. This is most likely due to a combination of historic logging of seral ponderosa pine and larch and fire suppression, which allowed understory Douglas-fir to develop.

A comparison of historic and existing age-classes shows some changes and trends. In general, there is currently a higher proportion in the mid-successional stages and a lower proportion in the late-successional stages in comparison to historic conditions. This may be due to historic timber harvest of large overstory ponderosa pine and larch since many areas in this group were easily accessible for timber harvest in the early part of the 20th century. Many stands that were harvested then would now be in mid-successional stage.

Moist VRU Group

A comparison of historic and current cover types shows some changes and trends. Major changes are decreases in seral larch and white pine and increases in Douglas-fir and grand fir. The large decrease in white pine is most likely a result of white pine blister rust. The loss of larch may be due to historic logging of overstory larch. Douglas-fir and grand fir now dominate many stands in this group due to the removal of white pine and larch combined with effects of fire suppression.

A comparison of historic and existing age-classes shows some changes and trends. In general, there is an increase in mid-successional stages and a decrease in late-successional stages in comparison to historic conditions. As the most productive areas on the Forests, timber harvest activities have occurred throughout this group. In particular, older or decadent stands as well as disease-ridden white pine stands have been regenerated, which may be the reason for the decrease in the late-successional stage. In addition, portions of this group experienced stand-replacing fires in the late 1800s and early 1900s, which may contribute to the increase in the mid-successional stages.

Cool/Moist VRU Group

A comparison of historic and existing cover types shows some changes and general trends. Major changes are decreases in seral white pine, larch and to a lesser extent, lodgepole pine, and increases in Douglas-fir and spruce-subalpine fir.

[27] *Excerpted from USFS KIPNF (2003)*

The large decrease in white pine is most likely a result of white pine blister rust. Logging of overstory larch may contribute to the decrease in larch. The loss of lodgepole pine may be due to mountain pine beetle and subsequent salvage harvesting of dead and dying lodgepole pine stands. Spruce-subalpine fir and Douglas-fir now dominate many stands in this group with declines in seral white pine, larch, and lodgepole pine.

There are slight differences between the KNF and the IPNFs. On the IPNF, there are increases in the medium and large size classes and a decrease in the small size class. Areas in this group are highly productive and timber harvest activities have occurred here. In particular, older or decadent stands as well as insect and disease prone lodgepole pine and white pine stands have been regenerated, which may be the reason for the low proportion in the large/very large class. In addition, portions of this group experienced stand-replacing fires in the late 1800s and early 1900s, which may contribute to the high proportion in the medium successional stage.

LINKS

The TBA assessment estimates coniferous forest (xeric and mesic forest) biome acres and assesses various impacts by subunit. Go to Appendix 80.

Click Here

Cool/Cold VRU Group

Whitebark pine occurs in this group. Major changes here are decreases in whitebark pine and lodgepole pine and an increase in spruce-subalpine fir. Whitebark pine has declined dramatically due to white pine blister rust and fire suppression. The loss of lodgepole pine may be due to mountain pine beetle and fire suppression, as lodgepole pine tends to regenerate following stand-replacing fires. The proportions of spruce-subalpine fir and Douglas-fir may have increased due to fire suppression and natural succession from lodgepole pine stands.

There is an increase in medium size class and decreases in old growth and small size classes. These shifts may be due to the suppression of potentially stand-replacing fires.

2.4.5 Potential Coniferous Forest Condition

Under this scenario, unnatural fuel accumulations will have first been removed using mechanical treatments in coordination with prescribed fire, making it possible for fire to play a more natural role on a larger scale than today. Wherever possible, prescribed fire (broadcast burning, under burning, prescribed natural fire, and stand-replacement fire) will have been used for a period of decades on a large scale—landscape-sized prescriptions—to bring forest communities to a more natural condition. Fire will have been prescribed such that some forest floor duff and large woody material remain.

Natural fire frequencies will have been returned to encroached grassland areas that border forests to reduce or eliminate woody species. In the nonlethal fire regime, understory fires will have been repeated about every 7 to 25 years to control fir regeneration and to prevent accumulations of fuel that could support intense wildfires. In this fire regime, the long-term goal will be to maintain a continuous, open overstory of healthy seral pine and larch through innovative forestry systems involving retention shelterwood, single tree selection, and group selection systems in conjunction with periodic under-burning. Planting of seedling ponderosa pine and larch will be done in many areas to obtain adequate regeneration.

Where it is not possible to use prescribed fire, managers will apply mechanical management techniques to encourage a fire-adapted ecosystem. Some tree crowns and large downed woody material will be left on site to reduce the loss of nutrients and to improve productivity. On these sites, pine and larch will have been reestablished through a series of stand entries for selective harvesting followed by natural regeneration or planting. Fuel buildup will have been reduced by mechanical treatments, and ponderosa pine forests will be managed for lower tree densities and fewer conifers in the understory than we see today.

As a result of these practices, biological diversity will have improved, as will have the vigor and vitality of plant communities, the availability of species palatable to ungulates, and the production of cone crops from seral tree species. The fire hazard will have declined, as will have the invasion rate of non-native species, and a more natural species composition will have been established. Forests will be more fire tolerant and pest and disease resistant. The effects that fire has on a site—thermal, chemical, nutrient cycling, structural, as well as the unknown roles that fire plays in ecosystems—will also be substantially restored.

Road management policies will have reduced open and closed road densities, and local land use will have reduced the rate of development in the wildland urban interface.

2.4.6 Future/No New Action Coniferous Forest Condition

Under this scenario—a continued policy of strict or modified fire suppression, timber harvesting that poorly mimics natural disturbance events, the use of prescribed fire only in isolated situations, continued road building and residential development—the health of the forest biome will have continued to decline. Insect and disease infestations will have spread; lethal wildfires will now occur in areas that during presettlement times supported nonlethal fire regimes; natural reproduction of larch and pine will continue to be poor; Douglas-fir and the true firs will continue to replace shade-intolerant conifers in many areas; and the natural distribution of shrubs, forbs, and wildlife will be adversely affected by the shifts in vegetative makeup and invasion by non-native species (Mutch et al. 1993).

Other trends will have continued as well: trees and other woody species will have encroached onto grasslands at the forest edge; overall biological diversity will have declined; stand density will have continued to increase; the amount of patch-size and edge will have declined; there will have been shifts in the ages and sizes of trees; and roads and other human developments will have increased. In fifty years, the result will be a seriously degraded biome that offers substantially fewer benefits and significantly greater risks and costs to society.

2.5 Subbasin Biomes in a Regional Context

It is valuable to view the current condition of the Kootenai Subbasin in the context of the region and subregion in which it is located, that of the Interior Columbia River Basin ecosystem and the Northern Glaciated Mountains Ecological Reporting Unit. The Interior Columbia River Basin (CRB) assessment showed the following changes have occurred across these larger landscapes (Quigley and Arbelbide 1997; Quigley et al. 1996).

2.5.1 Interior Columbia River Basin Ecosystem:

- There has been a 27 percent decline in multilayer and 60 percent decline in single-layer old forest structure, predominantly in forest types used commercially.

- Aquatic biodiversity has declined through local extirpations, extinctions, and introduction of non-native species, and the threat to riparian associated species has increased.

- Watershed disturbances, both natural and human induced, have caused and continue to cause risks to ecological integrity, especially owing to isolation and fragmentation of habitat.

- The threat of severe fire has increased; 18 percent more of the fires that burn are in the lethal fire severity class now than historically. In the forest, Potential Vegetation Groups lethal fires have increased by 30 percent.

- Rangeland health and diversity have declined owing to non-native species introductions, changing fire regimes, and increasing woody vegetation.

- Rapid change is taking place in the communities and economies of the Basin although the rates of change are not uniform.

2.5.2 Northern Glaciated Mountains Ecological Reporting Unit:

- Large western larch and ponderosa pine emergent structures are currently much less abundant in areas where historically mixed- and high-severity fire regimes would have encouraged their development.

- Forest landscapes have been substantially fragmented (the break up of contiguous areas into progressively smaller patches of increasing degrees of isolation). The frequency distribution of patch sizes did not coincide with the size ranges typical of the dominant fire regimes within the biophysical template.

- The areal extent of middle-aged multistory structures that have grand fir, western hemlock/western redcedar, and subalpine fir understories increased well above historic levels.

- As a result of fire exclusion, the areal extent of grand fir, Engelmann spruce/subalpine fir, and western hemlock cover types increased. This change was exacerbated by timber harvests that extracted seral Douglas fir, western larch, and white pine. The white pine cover type also declined substantially as a result of epidemic white pine blister rust and mountain pine beetle infestations.

These overall findings were based on large-scale analyses of the entire Basin. This large area was then subdivided into Forest and Rangeland Clusters corresponding to 4th Code HUCs to determine ecological integrity ratings. The Kootenai Subbasin is composed of Forest Cluster 4. No data was available for rating range clusters in the subbasin. The forest cluster ratings are summarized in table 2.16.

Table 2.16. Summary of ICEBMP ratings for Forest Cluster 4.

Forest Clusters	Primary Characteristics	Primary Risks to Ecological Integrity	Primary Opportunities to Address Risks to Integrity
Forest 4	1. Moist forest types	1. Hydrologic and aquatic systems from fire potentials	1. Restoration of late and old forest structure in managed areas
	2. Highly roaded	2. Late and old forest structures in managed areas	2. Connection of aquatic strongholds through restoration
	3. Low forest, aquatic, and composite integrity	3. Forest compositions - susceptibility to insect, disease, and fire	3. Treatment of forested areas to reduce fire, insect, and disease susceptibility
	4. Moderate to high hydrologic integrity		