Figure 7.6. Examples of dryland (top) and irrigated (bottom) agricultural practices occurring in the Rock and Lonerock creeks watershed, Oregon. Dryland agriculture occurs in the higher elevation areas further distant from water sources, such as on top of the plateaus of the middle and lower watershed, while irrigated agriculture occurs on the valley bottomlands, primarily in the middle and lower watershed.

Table 7.3. Cropland acreage within the Gilliam County portion of the Rock and Lonerock creeks watershed that is currently enrolled in the Conservation Reserve Program (CRP).

Subwatershed	Acres
Dry Creek-Rock Creek	2,142
French Charlie Canyon	1,545
Juniper Canyon	2,717
Lonerock Creek	1
Rood Canyon	15
Sixmile Canyon	1,662
South Fork Rock Creek	1,408
Grand Total	9,489

productivity, reduce soil erosion, improve water quality, and increase crop residue. Currently, approximately 62,000 acres are under direct-seeding/no-till practices in Gilliam County. Financial assistance is available to farmers using no-till seeding. The Gilliam SCWD recently completed two large OWEB grants that supported no-till production. The USDA Farm Bill Environmental Quality Incentives Program (EQIP) also provides support for no-till practices as does the Conservation Security Program (CSP). More information about EQIP can be found at http://www.nrcs.usda.gov/programs/eqip/ or by calling the Gilliam SWCD.

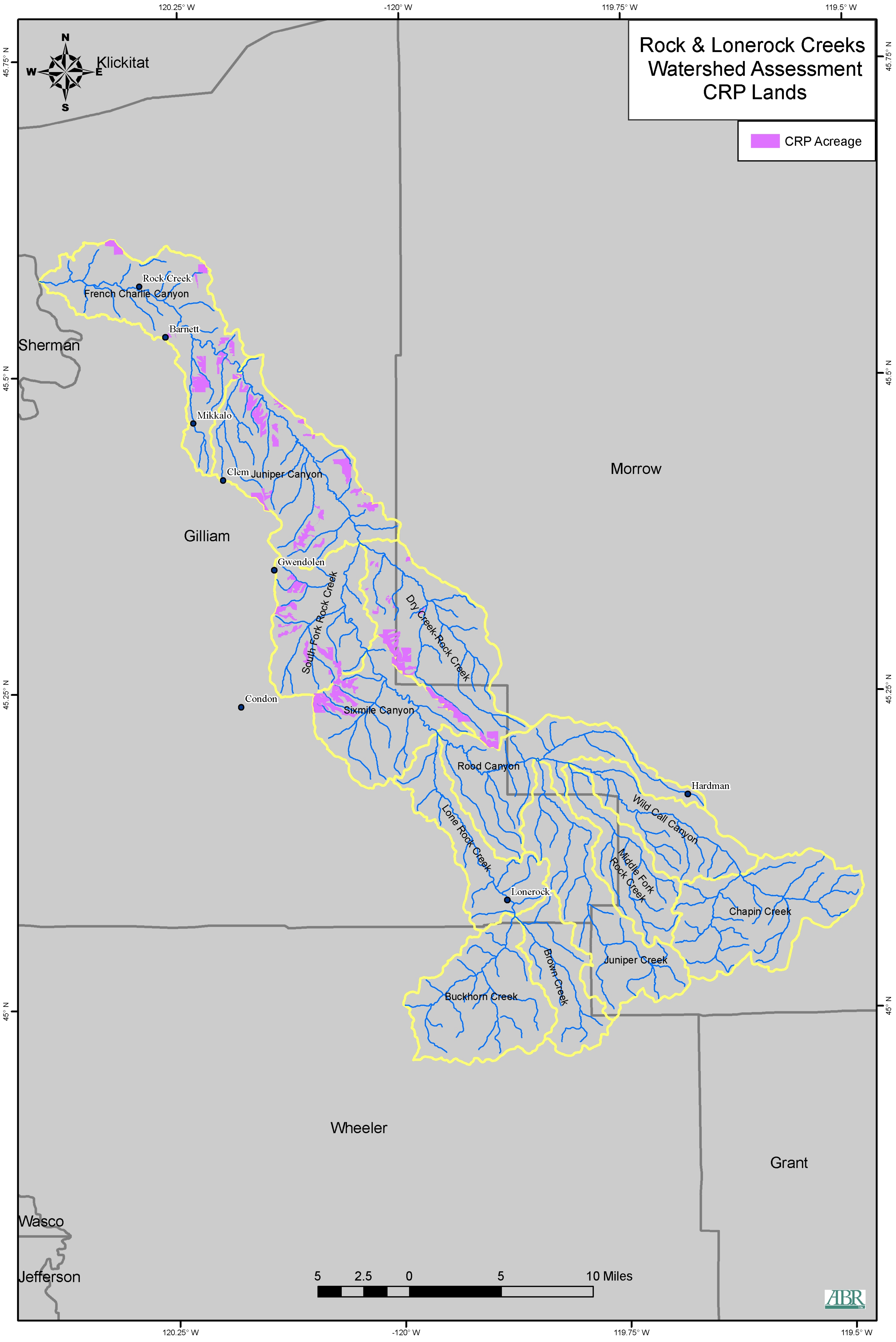

Figure 7.7. Cropland within the Gilliam County portion of the Rock and Lonerock creeks watershed that is currently enrolled in the USDA NRCS Conservation Reserve Program (CRP).

CHAPTER 8:
SEDIMENT SOURCES

INTRODUCTION

Hillslope erosion and the delivery of sediment into streams are natural processes, and sediment occurs naturally in rivers and streams. In a properly functioning watershed, rivers and streams convey sediment at the same rate that sediment is being delivered to the drainage network. As a result, no net accumulation or loss of sediment occurs and the system is said to be in equilibrium. Changes to land cover and streamflows by human activities can disrupt this equilibrium and increase delivery of sediment into streams with adverse effects on stream habitat and aquatic life. The primary sources of stream sediment include erosion of uplands (hillslope sources), lateral movement of channels into streambanks (bank erosion), and downcutting of streambeds (Waters 1995). Rivers and streams self regulate their ability to carry sediment by adjusting their shape and pattern to respond to changes in sediment load or streamflow. In natural river and stream systems, an approximate equilibrium is maintained in which there is no net loss or gain of sediment from the river. The river, in turn, maintains a stable pattern and profile. However, when sediment loads increase, the balance between sediment quantities and water volumes required to effectively convey sediment can be disrupted and alteration to stream habitat occurs.

Sediment is widely recognized as the single greatest pollutant of streams in the United States in terms of quantity involved (Waters 1995). Additionally, the EPA has identified sediment as the most important cause of river and stream pollution in the United States in terms of miles of rivers and streams polluted (EPA 1990). Still, separating excessive sediment loading resulting from human activities from that resulting from natural background levels and rates can be challenging, particularly with a lack of baseline information. Excessive sediment in streams has been well documented to negatively affect aquatic life and habitats. Fine sediment deposited on spawning gravels can reduce the survival of eggs and other early life stages of fish. Filling in of gravels and other coarse substrates also reduces habitat available to organisms living on the stream bottom and may lead to decreased richness and abundance of macroinvertebrates. Suspended sediment also can affect fish and macroinvertebrates by accumulating on gill and other respiratory surfaces and by disrupting or altering social and feeding behaviors. Sediment has been identified as one of the most important limiting factors to steelhead in the Rock and Lonerock creeks watershed (NWPCC 2004). As of March 2011, the TMDL for sediment has not yet been completed for the basin (Tom Straughan, Oregon Department of Agriculture, personal communication).

SEDIMENT SOURCES AND TRANSPORT PROCESSES

Stream sediment originates from two types of sources: colluvial and alluvial. Colluvial sources include erosion of uplands used for production of crops or as rangeland, land-slide events, and post-fire erosion of exposed soils. Alluvial sources include lateral movement of channels into streambanks (bank erosion) and downcutting of streambeds (Waters 1995). Colluvial (hillslope) sources of surface erosion related to human activity in the Rock and Lonerock creeks watershed include agricultural fields, rangelands, timberlands and roads. Surface erosion from cropland and rangeland occurs when rainfall intensity exceeds the absorption capacity of the soil, resulting in surface runoff which transports suspended sediment. Forestry and agricultural practices such as vegetation removal and soil compaction can reduce absorption capacities of soils and increase both surface runoff and erosion rates. Altered vegetative composition of landscape, such as from native bunchgrass communities to juniper and invasive-weed-dominated communities, will also increase overland flows that carry sediment to streams.

Alluvial erosional processes such as bank erosion and downcutting of the stream channel occur during peak flows when water velocities and hydraulic turbulence peak. Velocity, turbulence, and discharge increase proportionately with rising river stage; these components of stream power continue to increase until a threshold is reached at which point the force of water exceeds that of the cohesive forces of the stream bank materials. As flows and stream power increase, the force of water acting on the material's cohesive property also rises, resulting in shear stress on these materials. When shear stress reaches a given threshold, the cohesion of the material fails, turbulence entrains the material and the higher velocity maintains transport of the material into and through the drainage network. While both alluvial and colluvial erosional processes occur naturally, human modification of the landscape has altered the timing, frequency, and magnitude of sediment delivery to Rock Creek and its tributaries, resulting in increased sediment levels throughout much of the drainage network.

Most of the Rock and Lonerock creeks watershed is rangeland. Grazing at appropriate stocking densities, at appropriate times, and for appropriate durations can minimize damaging effects on rangeland vegetative cover (Johnson 1992). On well-managed rangelands, sediment is captured and sequestered by sufficient grass and stubble before it enters stream systems. Poor forestry practices can also increase sediment delivery rates to streams; clearcuts, skid trails, and access roads are all sources of sediment that can enter streams during high rainfall events. Intensive forestry is not currently practiced in the Rock and Lonerock creeks watershed and crown closures generally exceed 30% (crown closures less than 30% present an elevated risk of altering hydrology and therefore sediment delivery to streams). Therefore, forested portions of the upper watershed are not likely to be a significant source of elevated sediment to Rock Creek at present. It is worth noting that dense, overstocked forests resulting from a century or more of fire suppression are extremely vulnerable to stand-replacement fires, rather than the cooler ground fires of the past. These massive fires denude the landscape of vegetation, and for a few years after their occurrence, large quantities of sediment can enter stream systems with rain and snowmelt events (Waters 1995, WPN 1999). With this, and other forest health issues in mind, forest management in the upper watershed should be practiced to ensure long-term benefits to watershed conditions and functions.

While road densities in the watershed are generally sufficiently low to avoid significant impacts to hydrologic functioning of the watershed, roads and road construction can still locally add significant quantities of sediment to streams. Roads tend to concentrate sediment-laden runoff directly to streams through ditches and culverts. In the absence of roads, most sediment in runoff is filtered as it travels over the forest floor or infiltrates forest soils. Hillside road-grade construction on frequently cuts the uphill material and sidecasts the material on the downhill-slope side of the road to create a flat driving surface. The cohesion of sidecast material and the cutslope is weakened through this disturbance. Cutslope and sidecast road construction can often result in slumping and slope failure. These conditions can lead to failure of the entire road prism especially when practiced on steep slopes. As a result, roads can significantly increase the potential for large amounts of sediment to be delivered to streams, depending, in part, in their proximity to stream channels and the steepness of slopes on which they're built. If located near watercourses, forest roads constructed on flat surfaces can also increase sediment loading via improperly designed road drainage systems that ineffectively trap sediment and/or convey runoff directly into receiving surface waters. Careful planning of the siting and construction of roads and proper maintenance of roadways and their attendant drainage systems can significantly reduce the impacts of forest roads on increased sediment loads in streams. Recent work has identified forest/rural road construction and maintenance techniques that help reduce erosion of the road prism and transport of sediment to streams. The Oregon Department of Forestry (ODF) has engaged in research aimed at reducing sedimentation from forest road systems. Any new gravel-topped road construction should be sure to follow the most up-to-date road construction information available through ODF.

Sediment sources from stream channels include bank erosion, channel down-cutting and debris flows. Bank erosion, or bank sloughing, occurs by lateral cutting of a stream channel into its streambanks. Bank failure and sloughing, as previously discussed, occurs when hydraulic forces against the streambank exceed the cohesive strength of the bank material. Channel movement is a naturally occurring process that is evident in historic floodplain terraces associated with many

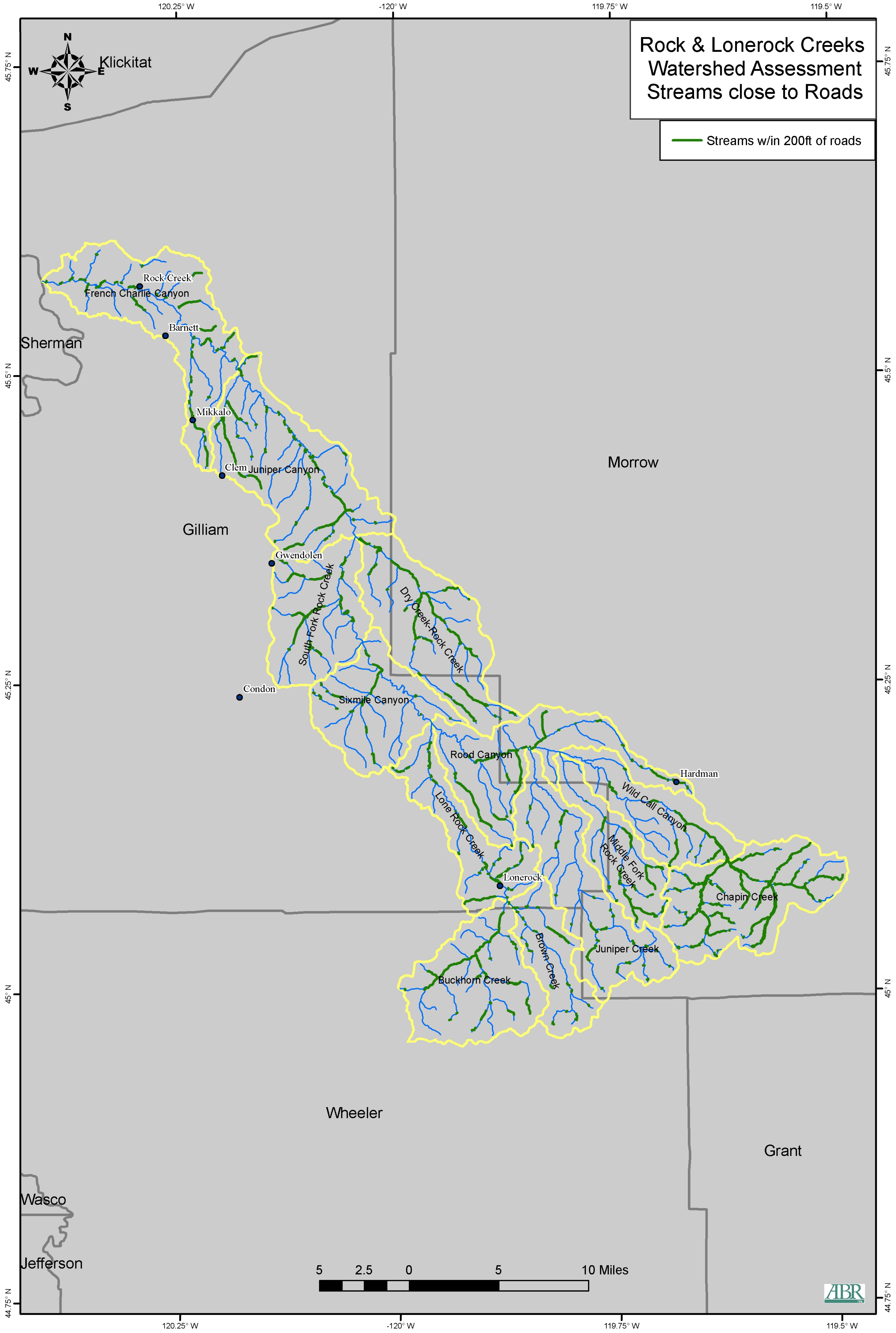

Figure 8.1. Stream reaches within 200 feet of roads in the Rock and Lonerock creeks watershed, Oregon. .

eastern Oregon rivers. Human activities such as timber harvest, removal or spraying of riparian vegetation, and over-grazing can result in accelerated lateral and vertical movement. These highly eroded streams often suffer from deeply incised channels that are disconnected from their floodplains.

In this section, each of these potential sediment sources to streams within the Rock and Lonerock creeks watershed is assessed and discussed. Focal issues in this assessment include rural and forest road runoff, road instability at road crossings, runoff from crop lands, slope instability (landslides), and recent burns. These five potentially significant sediment sources were identified for a quantitative or qualitative characterization, based on the perceived likelihood of contributing to the total sediment load within the Rock and Lonerock creeks watershed. The rural roads assessment was performed using GIS spatial analyses. Road instability at road crossings was also characterized through a coarse GIS assessment to spatially depict the number of road/stream crossings occurring in the watershed. The agricultural lands assessment included a GIS assessment of the proximity of crop lands to water courses and the land surface slope on which crop lands occur. A slope instability (due to landslides) characterization focused on a synthesis of existing information that describes historic landslide locations within the watershed. A description of the assessment process for each potential source and the results of these analyses is provided below.

RURAL AND FOREST ROAD RUNOFF

The potential for rural and forest roads to contribute sediment to streams in the watershed was assessed using stream and road data layers in ArcMap 9.3. This assessment focuses on the risk of increasing sediment loads to streams. In this basic assessment, the lengths of roads occurring within 200 feet of streams were identified and then summed for each subwatershed. In this screening-level assessment, a higher proportion of roads within 200 feet of streams (relative to total stream miles occurring in the subwatersheds) would indicate that roads are likely contributing higher sediment loads to streams. Further, roads occurring on steep hill slopes (greater than 50%) are more likely to contribute disproportionately high sediment loads to adjacent waterways. Therefore, we also calculated the length of roads that were both within 200 feet of streams and that occurred on slopes greater than 50%. These two variables, combined, were used to determine the relative risk of roads delivering sediment to streams within each subwatershed.

Watershed wide, 31.6% of rural and forest roads occur within 200 feet of streams and 31.0% of all streams within the watershed have roads occurring within 200 ft (Figures 8.1 and 8.2, Table 8.1). Longer road sections near streams only occurred on hillslopes with gradients less than 50%. The results of this basic assessment suggest that the Chapin Creek and Dry Creek-Rock Creek subwatersheds likely pose the greatest risk of elevated sediment delivery from road runoff with 81% and 40 % of their total stream lengths occurring within 200 feet of roads, respectively (Table 8.1). The Middle Fork Rock Creek and Buckhorn Creek subwatersheds also had higher-than-average stream lengths occurring in close proximity to roads (34% and 32% respectively). However, the risk of elevated sediment loading from road runoff in these areas is moderated because none of these road segments occur on hillslopes exceeding 50%. Nonetheless, many miles of dirt/gravel roads occur in close proximity to streams in the watershed. Such conditions are widely known to contribute significant quantities of sediment to streams. Therefore, reducing both the volume of runoff reaching streams and the amount of sediment in road runoff should be a focus of road building and maintenance activities in the watershed. To our knowledge, no comprehensive road conditions inventory has been performed on public roads within the watershed. Such an inventory, using protocols such as ODF's Forest Road Hazard Inventory Protocol (ODF 1997; http://www.oregon.gov/ODF/PRIVATE_FORESTS/docs/fp/RoadHazardProtocol.pdf), would aid in identifying and prioritizing road segments within the watershed most in need of drainage and sediment-control improvements.

Figure 8.2. Many miles of roads within the Rock and Lonerock creeks watershed occur in close proximity to streams, as shown in this photo, but because many of these occur off of steeper hillslopes, the risk of severe erosion is decreased.

Table 8.1. Lengths of road (miles) within 200 ft of streams and lengths of stream impacted by those roads within the Rock and Lonerock creeks watershed, Oregon.

Subwatershed	Total Stream Miles	Stream Miles with Roads within 200 ft	Percent of Total Stream Miles Affected
French Charlie Canyon	58.5	13.2	23
Juniper Canyon	71.2	19.5	27
South Fork Rock Creek	41.2	10.8	26
Dry Creek-Rock Creek	50.4	20.0	40
Sixmile Canyon	44.4	5.7	13
Lonerock Creek	34.3	9.1	26
Rood Canyon	56.8	16.1	28
Juniper Creek	50.4	6.0	12
Middle Fork Rock Creek	32.6	11.0	34
Wild Call Canyon	35.9	10.2	29
Buckhorn Creek	43.2	13.7	32
Brown Creek	23.8	4.5	19
Chapin Creek	56.4	46.0	81
Totals	599.1	185.8	31

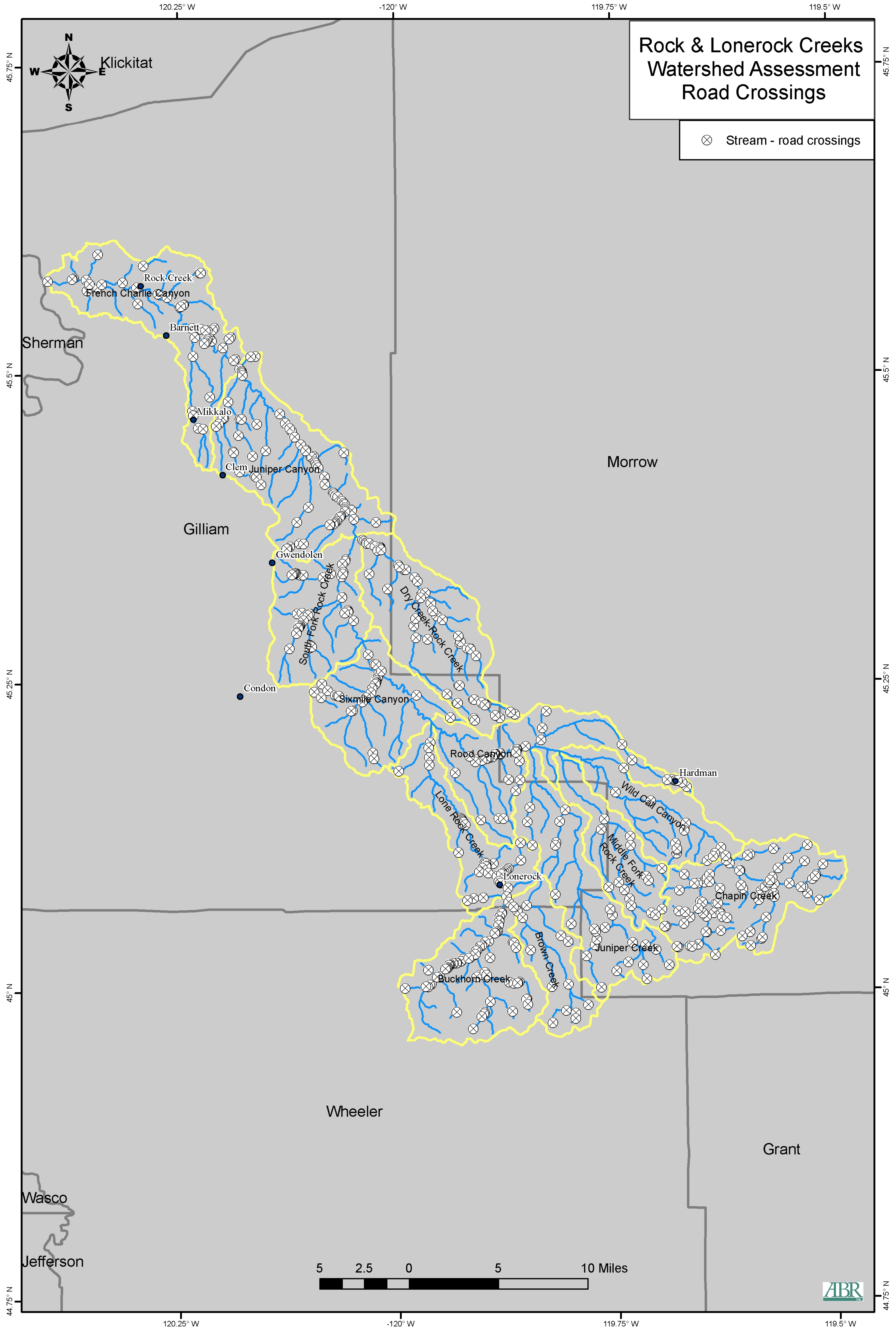

Figure 8.3. Locations of road/stream crossings (all types) occurring in the Rock and Lonerock creeks watershed, Oregon.

ROAD INSTABILITY AT ROAD/STREAM CROSSINGS

While road instability was not identified as a high-priority sediment source within the watershed, the number of road/stream crossings in the watershed necessitates some characterization. This section provides a qualitative evaluation of the potential for these crossings to increase sediment loads into the Rock Creek and Lonerock Creek drainage network. The term "road instability" refers to the risk a given road segment presents to adjacent waterways through road failure during a severe runoff event. Road stability depends, in large part, on how well a road was initially built. Road segments presenting the highest risk of failure, and therefore the greatest risk of delivering large quantities of sediment into streams, are those that are sidecast roads constructed on steeper slopes in close proximity to water courses. These types of roads are most prevalent in more mountainous areas with an abundance of hillsides with steep slopes, which are not common in the Rock and Lonerock creeks watershed. Therefore, this assessment focuses on summarizing the abundance of road/stream crossings that occur in the watershed and discusses the implications for increased risk of sediment loading from inadequate design and installation of culverts at road crossings. A GIS point layer was generated from the intersection of the watershed roads layer and the stream layer. The data were then compiled by subwatershed to depict and describe the occurrence of such crossings in the watershed. Road/stream crossing frequencies were then summarized by subwatershed. This information, combined with limited field surveys of road crossing conditions, was used to ascertain the relative risk of increased sediment loading from road crossings in various parts of the watershed.

A total of 591 road/stream crossings occur throughout the watershed (Table 8.2, Figure 8.3). This large number of crossings precluded an inventory to determine crossing types and conditions, but field reconnaissance surveys allowed visits to numerous road crossings to identify potential problems at crossings within the watershed. The Buckhorn Creek subwatershed supported the highest density of road crossings, averaging 1.7 crossings per stream mile (Table 8.2, Figure 8.3). The Chapin Creek subwatershed averaged 1.5 crossings per stream mile, while the Lonerock Creek subwatershed averaged 1.3 crossings per stream mile, with many occurring in close proximity to the town of Lonerock. While many of the crossings on the mainstem reaches of Rock Creek and Lonerock Creek were observed to

Table 8.2. Total number of road crossings and number of crossings per stream mile in subwatersheds within the Rock and Lonerock creeks watershed, Oregon.

Subwatershed	Total Stream Miles	Number of Road/Stream Crossings	Road/Stream Crossings per Stream Mile
French Charlie Canyon	58.5	51	0.9
Juniper Canyon	71.2	83	1.2
South Fork Rock Creek	41.2	45	1.1
Dry Creek-Rock Creek	50.4	61	1.2
Sixmile Canyon	44.4	32	0.7
Lonerock Creek	34.3	44	**1.3**
Rood Canyon	56.8	44	0.8
Juniper Creek	50.4	26	0.5
Middle Fork Rock Creek	32.6	15	0.5
Wild Call Canyon	35.9	17	0.5
Buckhorn Creek	43.2	73	**1.7**
Brown Creek	23.8	17	0.7
Chapin Creek	56.4	83	**1.5**
Totals	599.1	591	1.0

be bridges or larger culverts, road crossings on the tributaries were often undersized culverts that potentially present problems with flooding, sediment loading, and under severe high-flow conditions, potential for road crossing failures. Undersized, single round-pipe aluminum culverts, in various states of disrepair or clogged, were observed at some road crossings over smaller streams. Crossings over smaller perennial, ephemeral, or seasonal streams, while seemingly innocuous during dry conditions, can contribute significant sediment loads to receiving waterways during storm events (see example in Figure 8.4).

A complete inventory of road crossings on public roadways has not been performed for Gilliam County. We recommend that such an inventory be conducted in the Rock and Lonerock creeks watershed to identify and prioritize those road crossings contributing most to sediment loading problems and that present the greatest risk of failure. Undersized culverts are those that are too small to convey water from a flood event with a 50-year recurrence interval. These culverts should be identified and replaced with culverts that can accommodate such flows. The Oregon Department of Forestry provides guidance for both identifying these problem culverts and determining how to appropriately size a culvert for passing a 50-year flow (ODF 2002; http://oregon.gov/ODF/PRIVATE_FORESTS/docs/fp/Peakflow.pdf).

It is important to note that any further road construction within the watershed should consider

Figure 8.4. Example of a road crossing fitted with a small culvert that conveys water only during storm events. These smaller crossings, while seemingly innocuous, potentially contribute significant amounts of sediment to nearby perennial waterways.

the following general principles that will help minimize risk of sediment entering streams, changes to hillslope drainage patterns, and alterations to channel morphology (Furniss et al. 1991):

- Know what the erosional processes are, how roads can affect these processes and appropriate measures to present or control changes in erosional patterns.
- Avoid building roads in areas with high erosion hazards.
- It is always less expensive and more effective to design and build roads so that erosion is prevented or minimized than to control sediment once it is mobilized.

CROPLANDS

The standard OWEB sediment sources assessment for croplands determines the potential for croplands to deliver elevated sediment loads to streams in the watershed. This is accomplished by examining current crop conditions (fallow, stubble, etc.), farming practices (normal, conservation tillage, etc.), the hillslope on which these practices occur, and the erodibility of soils. Because some of this information was not available (farming practices on an individual field scale), this assessment focused on summarizing agricultural practices in the watershed by subwatershed, proximity to watercourses, and land surface slope. Conservation measures that can be employed by farmers to decrease the delivery of sediments to Rock Creek and Lonerock Creek and their tributaries, given the type and location of particular activities, are also discussed. Because agricultural activity is prevalent in the watershed, there is little question that soil loss occurs and that sediment enters streams through these activities. Because crop land in close proximity to streams offer the greatest potential for sediment loading, we used GIS to identify and measure the length of streams occurring within or adjacent to these areas within each subwatershed. We assumed that larger lengths of stream occurring adjacent to croplands would correlate with a greater risk of elevated sediment loading from croplands into streams within each subwatershed. Subwatersheds were then ranked by the total number of stream miles that occur adjacent to or within crop lands.

Approximately 24% of the Rock and Lonerock creeks watershed area is used for crop production with irrigated agriculture occurring throughout much of the mainstem Rock Creek valley bottom, and dryland agriculture occurring in uplands in the middle and lower portions of the watershed (Figure 8.5 provides an incomplete accounting of the locations of these activities). Farming practices along the Rock Creek and Lonerock Creek valley bottoms largely involve production of grass hay and alfalfa that don't require fallow or tillage on an annual basis, thereby significantly reducing the risk of delivering elevated sediment loads to nearby streams (see example in Figure 8.6). Some valley bottom production of beardless barley also occurs, which would necessitate annual seeding. Dryland wheat production also occurs in a few areas on the valley bottom. In these areas, annual tillage occurs primarily in the spring and summer, when the risk of soil loss and sediment loading into streams is can be high during storm events. During springtime field surveys, several such areas were observed having been tilled to very close to the stream bank (see example in Figure 8.7). Because of their close proximity to receiving waters, these areas present one of the more significant sedimentation threats to Rock Creek. These areas could benefit tremendously from establishment of wider riparian buffers to minimize the risk of heavy sediment loading into Rock and Lonerock creeks during storm events.

Farming of annual cereal crops and fallow/ winter wheat occurs in the mid and lower portion of the watershed, primarily in the Juniper Canyon and Dry Creek-Rock Creek subwatersheds. Conventional dry-land crop production activities include annual tilling, or semi-annual in the case of fallow cropping. Springtime tilling carries the risk of potentially severe soil loss during storm events, particularly on steep sloped land-surfaces (see example in Figure 8.8). Furthermore, depending on the proximity of the cropland to surface waters, much of this eroded material can end up in streams. When applied to these areas, conservation-minded agricultural practices such as conservation tillage, strip cropping, and direct seeding can significantly

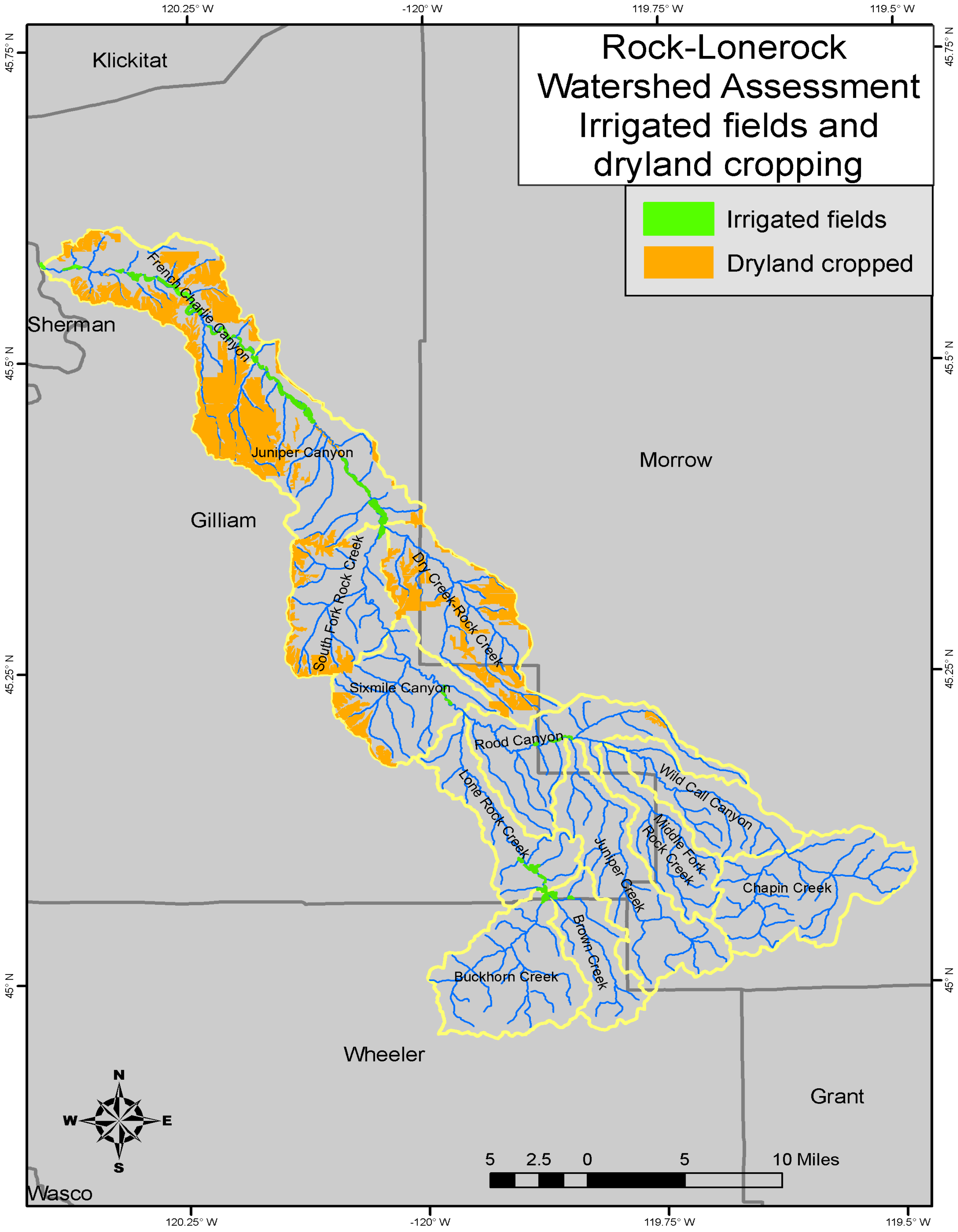

Figure 8.5. Locations of dryland and irrigated croplands occurring in the Rock and Lonerock creeks watershed (figure provide an incomplete accounting of these land uses). Source: ORGEO.

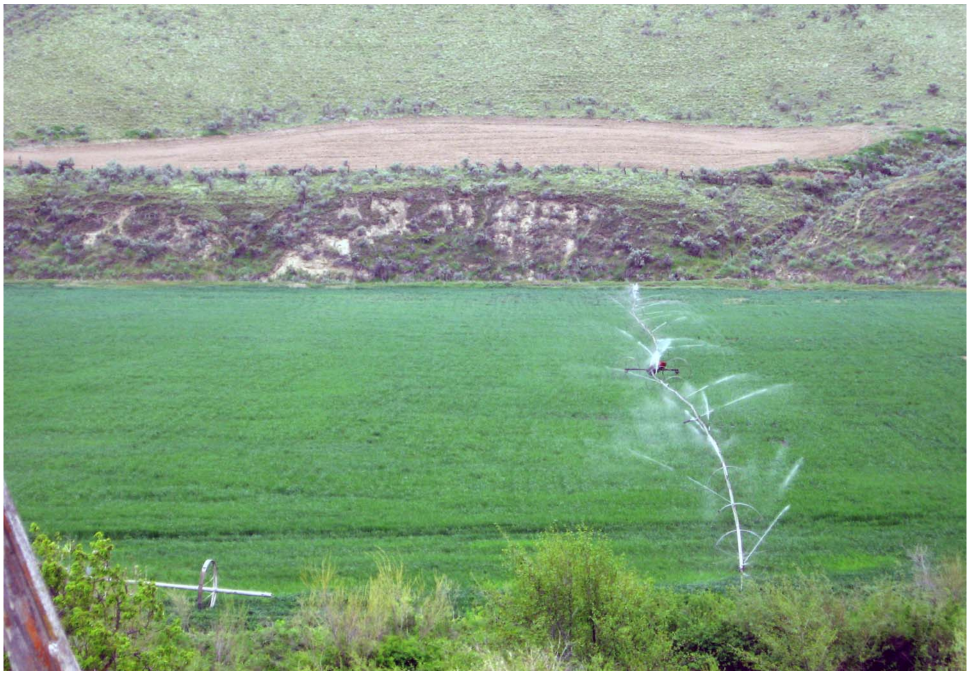

Figure 8.6. An example of an irrigated hay crop occurring on the valley bottom of Rock Creek, Gilliam County, Oregon. These irrigated croplands don't typically require annual tillage, thereby significantly reducing the risk of heavy soil loss and sediment loading into nearby streams.

Figure 8.7. Recently tilled cropland occurring on the Rock Creek floodplain, Gilliam County, Oregon. Note the lack of any riparian buffer, thereby increasing the risk of elevated sediment loads from the cropland during storm events. Also note the steep-side and eroding streambank, also being affected by the lack of sufficient riparian vegetative cover.

Figure 8.8. Spring-time tilling of wheat fields on lower Rock Creek, Gilliam County, Oregon. Note the close proximity of Rock Creek (indicated by the steep-sided eroding bank at the bottom of the hillslope).

reduce the severity of these problems. Very little strip cropping presently occurs in Gilliam County (Walter Powell, Gilliam SWCD, personal communication).

A number of producers are already using conservation tillage practices, some through participation in NRCS's Environmental Quality Incentives Program (EQIP), to reduce soil loss to erosion. Eight producers currently participate in the EQIP program in the watershed, including four or five in the Lonerock area, which has seen the biggest impact from EQIP because the area was selected as a geographic priority area for EQIP in the late 1990s. Most of the work in the Lonerock area is juniper removal, livestock water, timber thinning, and range planting (Josh Coiner, District Conservationist, USDA/NRCS Condon Field Office, personal communication, September 2009).

Environmental Quality Incentives Program supported practices have also been implemented in middle and lower Rock Creek, including irrigation efficiency measures, direct seeding on cropland, and various grazing land practices such as prescribed grazing, fencing, spring developments, and range planting (Josh Coiner, District Conservationist, USDA/NRCS Condon Field Office, personal communication, September 2009). Because many of these improvements have been implemented in a mosaic fashion, some would suggest that the impacts on the watershed as a whole have not been significant (Josh Coiner, District Conservationist, USDA/NRCS Condon Field Office, personal communication, September 2009). However, from a historic perspective, by 1939, 25% of the cropland in the county had lost 75% of their topsoil. Movement to minimum tillage has significantly aided efforts to hold soils (Walter Powell, Gilliam SWCD, personal communication, March 2011).

Producers using conventional agricultural practice activities rather than being managed with any soil conservation measures such as conservation tillage, direct seeding, strip cropping, or crop rotation should be encouraged to adopt such measures with assistance from the NRCS (http://www.or.nrcs.usda.gov/programs/eqip/index.html). The NRCS's Conservation Stewardship Program (http://www.or.nrcs.usda.gov/programs/csp/), also provides incentives for conservation practices and is having a significant impact on cropping (Walter Powell, Gilliam SWCD, personal communication, March 2011). As discussed in

Chapter 7, Uplands, farmers also have the Conservation Reserve Program (CRP) to assist with managing soil loss and protecting water quality. Table 8.3 lists potential sediment reduction strategies and potential financial-assistance sources for crop producers. These programs have already likely significantly benefitted the watershed, as nearly 60,000 acres of agricultural lands are under CRP contract in Gilliam County, approximately 9,500 of which occur in the Rock and Lonerock creeks watershed.

Of the 599 mapped stream miles occurring in the watershed, 185 miles, or nearly one third of those miles occur within or immediately adjacent to crop land. Furthermore, this is an under-estimate because the croplands data layer used in these analyses is known to be incomplete. Subwatersheds in the middle and lower watershed—namely the Juniper Canyon, French Charlie Canyon, and Dry Creek-Rock Creek subwatersheds—had the highest percentage of streams occurring adjacent to or within croplands, ranging from 39% to 42%. Most of the cropland (greater than 90%) occurring in these subwatersheds takes place on flat terrain with less than 10% hillslopes, thereby reducing the risk of elevated sediment loading. While the South Fork Rock Creek and Rood Canyon subwatersheds had fewer stream miles occurring adjacent to or within croplands, a larger proportion of croplands (>25%) occur on slopes exceeding 10% in these watersheds, thereby increasing the risk of soil loss and sediment loading into the creeks.

Based on this assessment of cropland activities, we recommend that areas along the valley bottom undergoing annual tillage and dryland crop fields occurring on steeper slopes receive priority attention for development of conservation measures to control soil loss and delivery of sediment to streams. Whenever possible, land managers should use soil conservation techniques that help retain soils during wet-weather events. Such measures include any conservation tilling practices, crop rotation, strip cropping, and any other techniques that reduce the area and length of exposure of bare ground. Restoration and maintenance of well vegetated riparian zones, as discussed in Chapter 5, also helps reduce delivery of sediment to streams from agricultural lands and should be encouraged whenever possible.

Table 8.3. Strategies and sources to reduce soil erosion and sediment delivery to streams from crop lands in the Rock and Lonerock creeks watershed, Oregon.

Category	Strategy	Potential financial assistance
Uplands - dryland	Conservation planning to include erosion control and buffers.	EQIP
	Convert highly erodible and environmentally sensitive areas to permanent vegetative cover	CRP
	Implement conservation tillage practices, range planting, direct seeding, water source development, and other soil conservation BMPs.	EQIP
Valley floor - irrigated	Establish riparian buffers between crops and waterways	CREP
	Conservation planning to include erosion control and buffers.	EQIP

SLOPE INSTABILITY (LANDSLIDES)

Landslides are a general term describing a wide range of ground movements and are a natural process in land and streambed formation. River systems with a history of landslide events can have a different sediment regime, depending on the material involved, than those occurring in more stable landscapes. Land-clearing activities can significantly increase landslide activity and therefore hasten sediment loading into streams. Therefore, identifying the extent to which landslides currently and historically occurred in a watershed can inform efforts to identify potential sediment sources. A combination of field surveys and GIS information was used to characterize the contribution of sediment from landslides to Rock Creek and its tributaries. The Oregon Department of Geology and Minerals Industries (DOGAMI) maintains a GIS dataset (SLIDO-1) compiled from over 250 published and unpublished studies. While it is not comprehensive, it does identify areas at risk of enhanced sedimentation activity. Information from this dataset was compiled in GIS by subwatershed to assess the relative risk of landslide contributions to elevated sediment loads in the watershed.

GIS data obtained from DOGAMI indicate that landslide activity has historically occurred in the Buckhorn Creek and upper portion of Lonerock Creek subwatersheds (Figure 8.9). These data show that historic landslide activity occurred in approximately 15,900 acres in these areas, suggesting that the southeast portion if the watershed, where topographic relief is most pronounced, potentially contributed significant quantities of sediment to Rock Creek and Lonerock Creek in the past. However, no recent landslide activity of any significance was documented during field reconnaissance surveys of much of the watershed for this assessment. Accordingly, landslide activity was deemed to be low, as was the risk of landslides increasing sediment loads to Rock Creek under current conditions.

RECENT FIRES

The forested regions of dry ecosystems, such as those that occur in the Rock Lonerock creeks watershed, have evolved with fire as a part of the maintenance of a healthy ecosystem. Regular, low-intensity fires would clear out dead and downed material and thin stands, thereby reducing competition for water . The arrival of settled agriculture and pastoral practices, however, led to the suppression of these fuel-clearing fires, while the arrival of exotic species, namely Cheatgrass (*Bromus tectorum*), brought the fires down into the ranges with greater frequency. The lack of fire thinning of stands created dense, disease-prone stands of trees. This combination of increased fuel buildup of downed trees and annual invasive grasses creates a higher risk of intense, stand-replacing fires. These intense events also increase sediment runoff during heavy precipitation events. The Oregon Department of Forestry maintains a GIS layer of wildfires, current up to 2005, which was used to create a recent fire history of the watershed, so fire events from 2004 and 2005 (more current data were unavailable) were compiled by subwatershed to ascertain the extent to which recent fires have contributed to sediment loading into Rock Creek, Lonerock Creek, and their tributaries.

Fire data obtained from ODF suggest that wild fires were ignited in the forested upper watershed in 2004 and 2005 (Figure 8.10). Eight of the 11 fires were started by lightning strikes and only one fire exceeded one acre in size (1.3 acres). While more recent data are unavailable, no larger fires are known by local resource managers to have occurred within the last several years. As such, recent fire activity in the watershed has been minimal and therefore presently presents no risk of delivering elevated sediment loads. It is important to note, however, that increasing fuel loads in the upper watershed through lack of attention to proper forest management will increase the risk of larger stand-replacing fires potentially resulting in dramatic increases in sediment loading to streams within the watershed. Please refer to the Uplands Conditions Chapter for a more detailed discussion of forest conditions in the watershed.

CONCLUSIONS

While the Rock and Lonerock creeks watershed has always received sediment from upland sources, human alteration of the landscape has increased these inputs with adverse effects to aquatic habitat and the life it supports. While

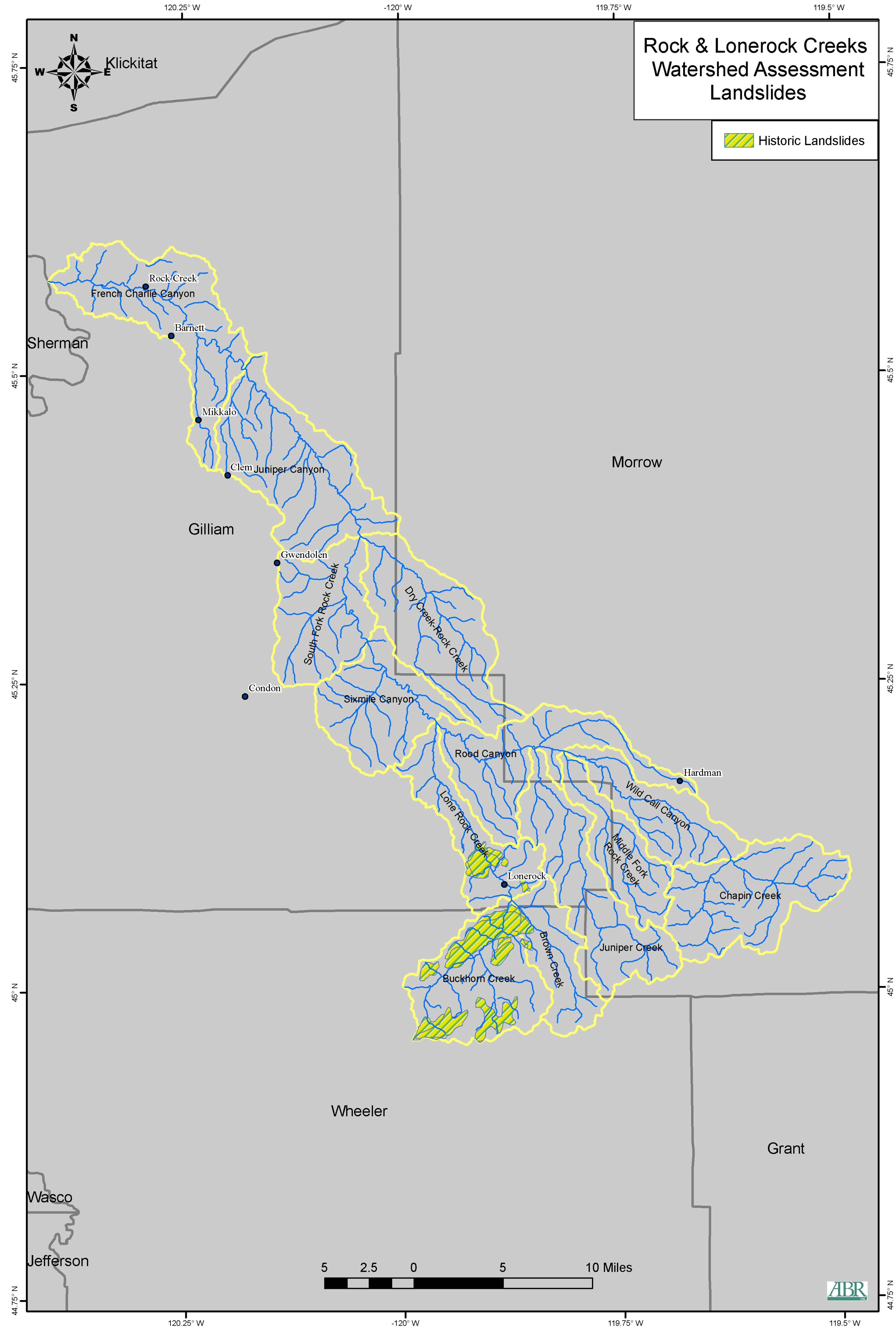

Figure 8.9. Locations of historic landslides in the Rock and Lonerock creeks watershed, Oregon. Data source: DOGAMI. .

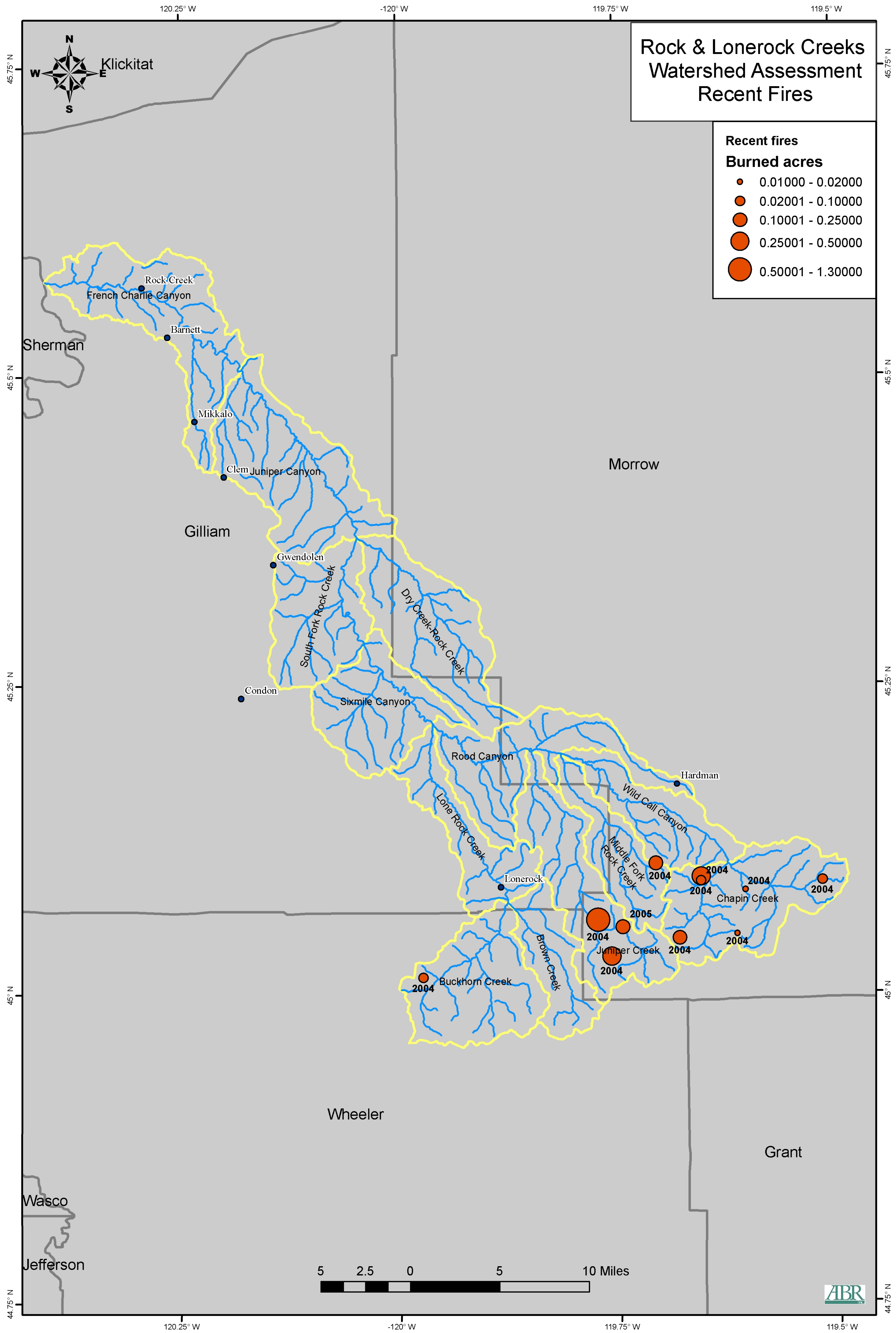

Figure 8.10. Location of recent (2004-2005) fires in the Rock and Lonerock creeks watershed, Oregon. Data source: ODF.

current sediment loading levels are almost surely not as high as they were in the late 19th and early 20th centuries when land-clearing and overgrazing were commonplace in eastern Oregon, some land-use activities still contribute high sediment loads to Rock Creek, Lonerock Creek, and their tributaries. Land use is dominated by cattle grazing, small grain farming, and hay production. When not properly managed for erosion control, each of these land uses result in increased sediment loads into stream systems. While Best Management Practices (BMPs) can minimize adverse effects to streams (Waters 1995 and Turner 1997), these practices are only partially implemented in the watershed (Cole, Lemke, & Blaha; personal observation; May 2008). As discussed earlier, cropland farmers should be made aware of the effects of their practices on water quality and aquatic habitat and presented with opportunities and financial-incentive-based programs to adopt conservation techniques and implement BMPs.

Much of the watershed area is used as rangeland for cattle. In some areas of the watershed, livestock allowed to overgraze riparian areas, leading to degradation of channels and aquatic habitats. Some bottomland pastures are heavily overgrazed, or even completely denuded of vegetation in late fall, leaving no cover on the land for the entire winter. Some incised channels are not vegetated, leading to further erosion, incision and sediment delivery. Addressing land-use practices, such as overstocking bottomland pastures and allowing livestock unlimited access to riparian zones and stream channels, would also reduce the sediment load to Rock Creek. Benefits from these practices go beyond the reduction of sediment. Fisheries, water quality and quantity all benefit as well, as discussed in other relevant chapters.

Rural road runoff is also contributing sediment to Rock Creek, Lonerock Creek, and their tributaries, both through the physical action of washing of sediment off of the road, as well as from the channelization and concentration of runoff through culverts (WPN 1999). The OWEB Watershed Assessment manual uses a standard of all roads within 200ft streams as potential sediment sources. Based on that criterion, 31% of the streams in the watershed are thus potentially affected by nearby roads. Those streams that are paralleled at a close distance by roads should be further assessed for the potential to improve run-off conditions with the use of sediment traps and water bars, and other runoff abatement and control measures.

DATA GAPS AND RECOMMENDATIONS

The lack of a complete description of agricultural practices within the watershed precluded a quantitative assessment of risks of elevated sediment loading from croplands. However, the small number of land owners occurring in the watershed and the knowledge that both these landowners and local resource managers already have of current conditions lend well to identifying land parcels most in need of soil erosion and other conservation measures. Specifically, focusing on croplands that occur on steeper slopes and those that are tilled adjacent to streams with no riparian buffer should receive priority attention for such activities.

Rural and forest roads appear to be the other significant “hillslope” source of sediment to streams in the Rock and Lonerock creeks watershed. Roads were constructed throughout the watershed long before much attention was given to controlling sediment-laden runoff to streams. A significant length of roads occurs adjacent to streams in the watershed and road/stream crossings are numerous. We therefore recommend a comprehensive inventory of road-stream crossings and other potential problem areas. A standard approach such as ODF’s Forest Road Hazard Inventory Protocol (1997) would identify specific areas that present the greatest risk of delivering sediment to streams. This information could be used to prioritize risks and develop mitigation strategies for areas identified as highest risk.

While not included in the assessment portion of this chapter, erosion from rangelands also occurs in the watershed, particularly in areas lacking ground cover from overgrazing or juniper encroachment. Use of rotational grazing strategies and continued control of juniper expansion within the watershed will significantly reduce the contribution of sediment to streams from rangelands in the watershed (please see the Uplands Chapter for more information on current conditions of range lands in the Rock Lone rock creeks watershed).

Finally, because stream bank conditions are discussed in detail in Chapter 11 (Fish and Fish Habitat) of this assessment, they were not treated in this section. It should be noted that while accelerated streambank erosion is occurring in sections of Rock Creek (see example in Figure 8.11), severe bank erosion and active channel downcutting does not appear to be pervasive in the watershed. Smaller channels were frequently observed to be connected to floodplains and supported gently sloping, well-vegetated banks (see example in Figure 8.12). Sections of Rock Creek that showed significant signs of erosion largely occurred in the lower and middle sections of the creek. Much of this erosion is likely occurring as a result of the river attempting to re-establish meander bends to re-distribute energy expenditure more uniformly along the length of the channel. While simple stop-gap measures such as armoring with riprap or woody debris can locally improve bank conditions, these "band aid" approaches often lead to problems elsewhere along the river. Ultimately, improvement in channel stability will result only from improvement in management of soil and water resources in the uplands to improve retention of sediment and infiltration of rain water into the ground. Only these improvements in watershed hydrology resulting from land-use-practice changes will restore Rock Creek and Lonerock Creek to a more stable state. Even then, resumption to a more stable condition will require many years as the channel continues to reconfigure and respond to its changing sediment loads and flow regime.

Figure 8.11. Example of a section of Rock Creek with severe bank erosion.

Figure 8.12. Example of a Rock Creek watershed tributary stream (Chapin Creek) with a stable channel, well vegetated and stable banks, and a well-connected floodplain.

CHAPTER 9: CHANNEL MODIFICATIONS

INTRODUCTION

Channel modifications are readily observed changes in channel conditions that result from direct manipulation of the channel (e.g., straightening) or encroachment of human activities that constrain or alter channel shape and pattern (e.g., roads, dams, bridges). This component of the assessment identifies existing channel modifications that are affecting channel morphology and hydrologic conditions in the Rock and Lonerock creeks watershed and assesses the likely effects of these modifications. In the Rock and Lonerock creeks watershed, known channel modifications include agricultural impoundments and stock watering ponds, channelization, roads constraining stream channels, dams, and water withdrawals or diversions. As road crossings have been addressed in Chapter 8 (Sediment Sources) and stream restoration projects will be addressed in Chapter 11 (Fish and Fish Habitat), neither will be addressed in this chapter.

Because the Rock and Lonerock creeks watershed occurs in a rural area, most channel modifications result from agricultural activity and road infrastructure. Straightening of river and stream channels, called channelization, was a common practice in the past to more efficiently transport water through a stream reach, which increased draining of floodplains and reduced flooding of these areas. Rivers and streams were often relocated to one side of a valley floor to increase the area available for crop production. To understand how channelization affects rivers and streams, it's useful to view rivers as conduits that transport water and materials (Leopold 1994). Rivers are dynamic systems that self regulate or adjust to changes in water or sediment inputs to maintain a constant transport of sediment. For example, river meanders develop to maintain a channel slope that allows the expenditure of energy at a rate that results in channel stability; that is, the channel neither degrades nor aggrades (Rosgen 1996). Floodplain rivers and streams develop meanders along which energy is expended over longer distances than would be expended in a straight stream channel with the same vertical drop (i.e., steeper gradient). Straightened channels result in steeper channel gradients and produce accelerated water velocities that increase streambank and bed erosion. Channel deepening (called incision) and widening can both result from these processes and can disconnect the river or stream from its floodplain. Once a river is disconnected from its floodplain, existing problems only degrade further because high flows remain confined inside the incised stream channel, rather than dispersing across a flood plain. As a result, all of the energy that would otherwise be dissipated across the floodplain is expended in the stream channel in the form of accelerated rates of bank and bed erosion. Channel incision and its attendant problems is one of the most pervasive disruptions to streams across the arid west; land-use changes often result in the physical and hydrologic modifications that lead to an incised channel. While this chapter focuses on some of the causes (modifications) of channel incision and widening, it does not identify areas of the watershed where these degraded conditions occur. Please refer Chapter 11 (Fish and Fish Habitat) for more information on current stream channel conditions.

Construction of dikes often accompanies channelization to further confine stream flows and prevent flooding of lands in agricultural production. Such activities further disconnect the stream channel from its floodplain, thereby exacerbating the effects of channelization described above.

Dams and irrigation ditches also alter the natural flow of streams. Some irrigation ditches divert water onto fields in late summer , when stream flows are at their lowest, consequently reducing water available for instream uses. Roads constructed in close proximity to stream channels may impede or prevent lateral channel migration and produce some of the same effects caused by channelization. In general, all of these activities have the potential to adversely affect stream conditions by increasing water velocity, decreasing flood plain function, decreasing water quality and quantity, and reducing fish habitat value (Leopold 1996).

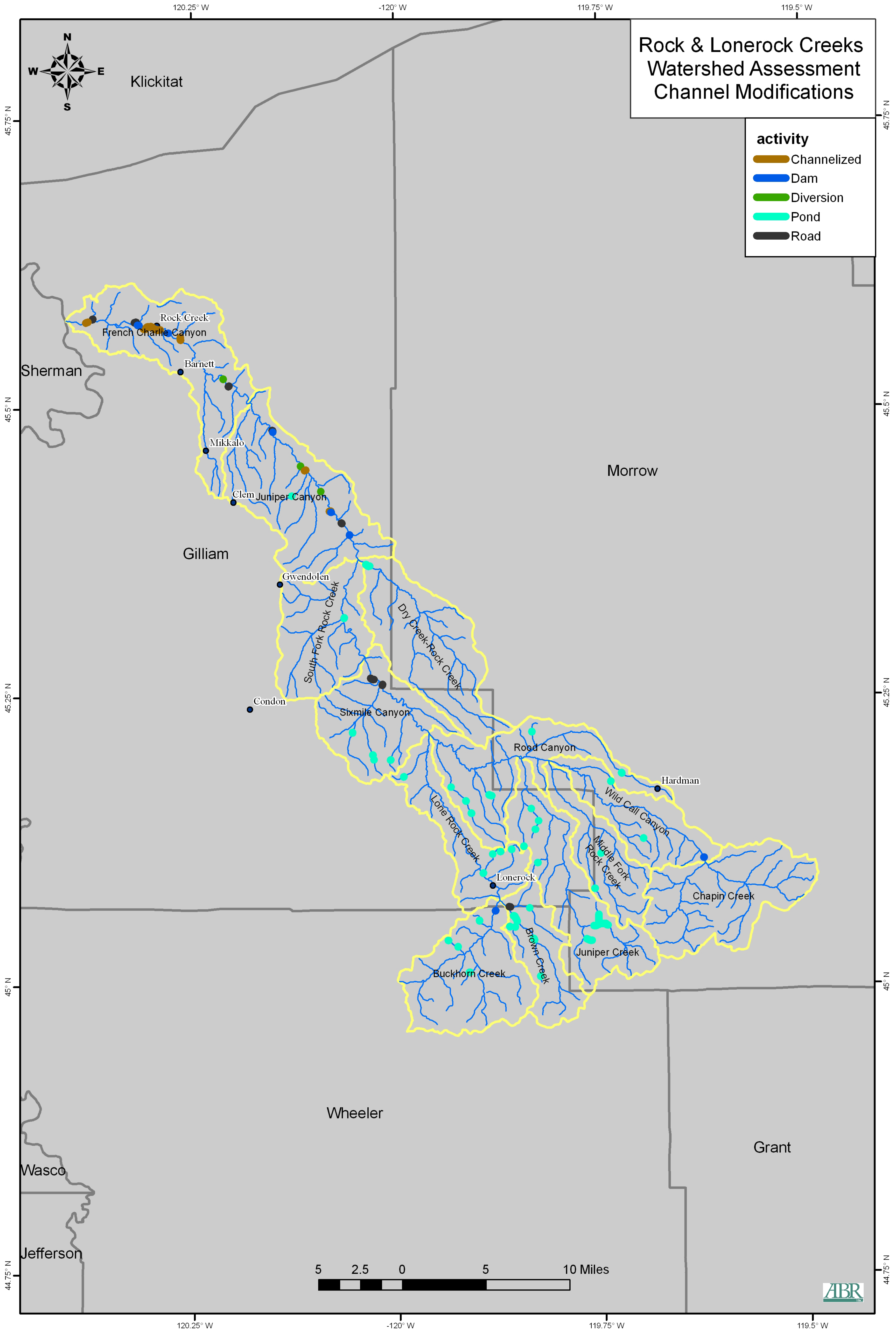

Figure 9.1 Locations of known channel modifications occurring within the Rock Creek and Lonerock Creek watershed, Oregon. .

METHODS

Channel modifications in the Rock and Lonerock creeks watershed were evaluated using county-provided digital aerial photographs from 2005, ground truthing from public access roads within the watershed, and information provided by the Gilliam SWCD. Aerial photography coverage of the watershed was nearly complete with the exception of peripheral areas outside of Gilliam County, including the south-western portion of the Buckhorn Creek subwatershed, the eastern portion of the Chapin Creek subwatershed, and small areas of the Rood Canyon and Wild Call Canyon subwatersheds. Modifications were mapped using ArcMap 9.2 (ESRI, Redlands, CA) and coded using the following fields:

Site Number—An individual code assigned to the noted channel modification.

Subwatershed—The subwatershed where the noted channel modification occurs.

Type—A brief description of the noted channel modification; categories include impoundment/ pond, channelization, road, dam, and diversion.

Data Source—The source of the information acquired (i.e., digital aerial photography, ground-truthing, etc.).

CHT—Channel Habitat Type (see Chapter 4) of the stream impacted by the channel modification.

Length—Length, in feet, of the noted channel modification.

Degree of Impact—Subjectively coded as High, Medium, or Low impact, depending upon the nature of the channel modification.

Type of Impacts—Potential impacts of modifications were coded as follows.

1. Migration barrier: Fish passage, both anadromous and for fish colonization / seasonal movement are compromised by the activity
2. Loss of spawning / rearing / escape habitat: Simplification of the channel reduces the amount of habitat available for the various life stages of fish species
3. Water quality: Agricultural impoundments can cause increased temperatures and higher nutrient loads in streams
4. Decreased flood plain function: Channelization disconnects the stream channel from its flood plain, increasing high water flows and negatively impacting ground water supplies.
5. Flow alteration: Impoundments and channelization change the hydrologic character of the stream, with ponds decreasing peak flows and channelization increasing flows.
6. Erosion potential: Areas with roads adjacent to streams can lead to increased runoff from culverts, runoff, and road failure.

RESULTS

A total of 72 channel modifications were observed from inspection of aerial photography and ground-truthing (Figure 9.1, Tables 9.1 and 9.2). Most channel modifications occurred in the French Charlie Canyon and Juniper Creek subwatersheds accounting for 29.0% and 35.7% of channel modifications within the Rock and Lonerock creeks watershed respectively. Approximately 3.4 miles of channel have been modified within these two subwatersheds alone. Channel modifications within the French Charlie Canyon subwatershed occur exclusively on the mainstem of Rock Creek and include channelization (identified by inspection of aerial photography and ground-truthing; Figure 9.2), portions of the channel that are constrained by road grades, dams and diversions. Channel modifications within the Juniper Creek subwatershed are limited to impoundments and ponds; the majority of these modifications occur within Morrow County on the mainstem of Juniper Creek and the West Fork of Juniper Creek. Approximately 1.8 miles of these two channels have been modified within a large freshwater emergent wetland complex (Figure 9.3).

The most common channel modifications in the Rock and Lonerock creeks watershed are agricultural impoundments and livestock water-source ponds accounting for 57.9% of the total

Table 9.1 Summary of channel modifications, measured by the number of stream-feet impacted, in the Rock and Lonerock creeks watershed, Oregon.

	Channel Modification					
Subwatershed	Impoundment/ Pond	Channelization	Road	Dam	Diversion	Total
French Charlie Canyon	0	6,553	1,029	480	50	8,032
Juniper Canyon	36	1,071	513	121	34	1,692
South Fork Rock Creek	149	0	0	0	0	149
Dry Creek-Rock Creek	1,217	0	0	0	0	1,217
Sixmile Canyon	595	0	1,520	0	0	2,115
Lonerock Creek	381	0	0	0	0	381
Rood Canyon	1,152	0	0	0	0	1,152
Juniper Creek	9,973	0	0	0	0	9,973
Middle Fork Rock Creek	128	0	0	0	0	128
Wild Call Canyon	206	0	0	30	0	236
Buckhorn Creek	458	0	0	47	0	504
Brown Creek	1,888	0	327	0	0	2,215
Chapin Creek	0	0	0	0	0	0
Total	16,182	7,624	3,389	408	34	27,957

length of stream channel modifications within the basin (Figure 9.4). Channelization (27.3%) and roads immediately adjacent to stream channels (12.1%) are also common modifications within the basin.

Dams and diversions are relatively uncommon in the basin, accounting for 2.7% of the channel modifications within the basin (Figure 9.5). However, five major concrete diversion dams currently occur on the mainstem of Rock Creek including the lower Ramsey diversion, the upper Ramsey diversion, the Bettencourt diversion (Olsen Dam), the lower Kayser diversion, and the upper Kayser diversion (Wolf Hollow Dam). At the time of this assessment only one of the five dams (at RM 20) had a dedicated, functional fish passage structure, in this case a fish ladder, to aid passage of juvenile and adult salmonids; however, the Gilliam SWCD has grants in place to address barrier issues at the four other dams beginning in 2011. For a detailed discussion of fish passage issues within the basin please refer to Chapter 11 (Fish and Fish Habitat). No fish passage structure occurs at the uppermost dam on mainstem Rock Creek, located at RM 30, but adult steelhead and redds have been observed above this dam as recently as 2007, suggesting that at least adult migratory fish can ascend this structure (Data obtained from Josh McCormick, ODFW, June 2009). A low concrete diversion dam also occurs on Buckhorn Creek; a fish ladder was installed on this dam during the summer of 2008. Finally, a series of two small rock and timber dams impound a small pond in Anson Wright Park. This structure is likely a seasonal barrier to resident fish.

DISCUSSION

Channel modifications that have occurred in the watershed have resulted primarily from agricultural activities and construction of road infrastructure. Small agricultural impoundments and cattle ponds commonly observed within the watershed can create migration barriers to resident and anadromous salmonids. These impoundments also result in the loss of spawning and rearing habitat for native fish species and impact water quality. Furthermore, such areas often provide suitable habitat for non-native fish species, and it is not uncommon for non-native fish to be introduced into ponds and other impoundments. Channelization, including the straightening and relocation of channels, is often a result of

Table 9.2 Summary of channel modifications, measured by the number of stream-feet impacted, in subwatersheds of the Rock and Lonerock creeks watershed, Oregon.

Subwatershed	Modification Type	Number of locations	Total length	Type of impact	Comments
French Charlie Canyon	Channelization	4	6,553	1, 4, 5	Mainstem Rock Creek
French Charlie Canyon	Road	3	1,029	2, 6	Mainstem Rock Creek
French Charlie Canyon	Dam	2	480	2, 3, 5	Mainstem Rock Creek
French Charlie Canyon	Diversion	1	50	2,5	Mainstem Rock Creek
Juniper Canyon	Channelization	2	1,071	1, 4, 5	Mainstem Rock Creek
Juniper Canyon	Road	2	513	2, 6	Mainstem Rock Creek
Juniper Canyon	Dam	3	121	2, 3, 5	Tributary to Rock Creek
Juniper Canyon	Pond	1	36	2, 3, 5	Mainstem Rock Creek
Juniper Canyon	Diversion	2	34	2, 5	Mainstem Rock Creek
South Fork Rock Creek	Pond	1	149	2, 3, 5	South Fork Rock Creek
Dry Creek-Rock Creek	Pond	2	1,217	2, 3, 5	Dry Creek
Sixmile Canyon	Road	2	1,520	2, 6	Mainstem Rock Creek
Sixmile Canyon	Pond	4	595	2, 3, 5	Sixmile Canyon (1), Monahan Canyon (2), Bruce Hollow (1)
Lonerock Creek	Pond	5	381	2, 3, 5	McPherson Canyon (1), Unnamed trib to Lonerock Creek (3), Robinette Creek (1)
Rood Canyon	Pond	8	1,152	2, 3, 5	Needle Fork (3), Lyons Canyon (3), Harshman Canyon (1), Rood Canyon (1)
Juniper Creek	Pond	8	9,973	2, 3, 5	Fichter Canyon (1), Hahn Canyon (3), Pullen Canyon (1), West Fork Juniper Creek (2), Juniper Creek (1)
Middle Fork Rock Creek	Pond	2	128	2, 3, 5	Long Hollow (1), Unnamed trib to Middle Fork Rock Creek (1)
Wild Call Canyon	Dam	1	30	1, 2, 3, 5	Mainstem Rock Creek (1)
Wild Call Canyon	Pond	2	206	2, 3, 5	Cannon Canyon (1), Unnamed trib to Rock Creek (1)
Buckhorn Creek	Pond	4	458	2, 3, 5	Four unnamed tribs to Buckhorn Creek (4)
Buckhorn Creek	Dam	1	47	2, 3, 5	Buckhorn Creek
Brown Creek	Pond	11	1,888	2, 3, 5	Brown Creek (7), Two unnamed tribs to Brown Creek (2), Dry Fork Brown Creek (1), Big Dutch Canyon (1)
Brown Creek	Road	1	327	2, 6	Big Dutch Canyon (1)

Figure 9.2 Dike along a channelized portion of lower Rock Creek in the Rock Creek and Lonerock Creek watershed, Oregon.

agricultural activities. Impacts caused by such activities may include the reduction of key habitat features and altered hydrologic regimes.

Roads commonly occur in close proximity to stream channels within the watershed, both in low-gradient areas along mainstem streams and higher-gradient, steeper areas along tributaries. We limited our delineation of channel modifications caused by roads to areas where the stream channel is significantly constrained by a road grade. However, it is likely that negative impacts caused by roads, including the loss of side channels, lateral pools, and riparian function, occur throughout the watershed (see Sediment Sources Section for a more thorough treatment on the effects of roads on stream habitat conditions).

Small dams and irrigation ditches provide water necessary to support agricultural production on the Rock Creek floodplain. Their effects on hydrology and fish populations cannot be overlooked and can be minimized. Fish screens on diversion intakes, installed on a number of irrigation ditches in the watershed, prevent fish from entering and stranding in irrigation ditches. Small dams used for irrigation diversions can be built to allow fish passage with the inclusion of fish ladders and other features used to aid fish passage. Such measures are already being implemented in places within the Rock and Lonerock creeks watershed owing largely to the cooperation between concerned land owners and the Gilliam SWCD (Figure 9.5). Please see Chapter 11 (Fish and Fish Habitat) for a more thorough treatment of these fish-friendly measures occurring in the watershed.

While a fairly extensive list of channel modifications was compiled from inspection of aerial photography and ground-truthing it should be noted that this list of modifications is by no means complete. Limited access to private lands, as well as difficulty in identifying smaller channel modifications on aerial photos, prevented a complete coverage of the watershed.

Historically, beaver had a large presence in the watershed. Their removal, by trapping for furs, or elimination to ‘free’ the river and streams has also likely changed the character of the watershed. The presence of beaver in the pre-European-settlement era would have moderated high-water flows, created fish rearing habitat, and raised the water table. Beaver are far less numerous in the watershed and yet are perceived as a nuisance

Figure 9.3 Aerial photograph showing a series of small earthen dams along Juniper Creek to provide flood irrigation in the Rock Creek and Lonerock Creek watershed, Oregon.

species because they remove woody riparian vegetation, which is now scarce throughout numerous reaches of Rock Creek and its tributaries. The reduction in riparian vegetation from clearing and riparian grazing management practices has resulted in inadequate riparian conditions for herbivores such as beaver. Other streamside functions such as bank stabilization and stream shade are also affected. Research has shown that ungulate grazing (both domestic and wild) reduces the re-growth of stream riparian plants, locking the system into a channelized, incised condition until management is changed (Baker et al. 2005, Leonard and Karl 1995). This condition will have to be addressed, and management of riparian zones adjusted accordingly, in order to ensure the success of restoration projects.

Figure 9.4 Impoundment for stock water in the Wild Call Canyon subwatershed, Morrow County, Oregon.

Figure 9.5. Fish ladder on a concrete irrigation dam located on the mainstem of Rock Creek, Gilliam County, Oregon.

CHAPTER 10: WATER QUALITY

INTRODUCTION

The Federal Clean Water Act was passed and signed into law in 1972 with the mandate "to protect and maintain the chemical, physical, and biological integrity of the nation's waters." The DEQ, under the authority of the United States Environmental Protection Agency (EPA), has the responsibility to set standards to protect water quality and to enforce these standards. The Clean Water Act (CWA) requires each state to designate beneficial uses, determine what parameters to measure to ascertain whether beneficial uses are being met, and to develop criteria for those parameters. Beneficial uses have been established by the OWRD for each major river basin in the state and are listed in the Oregon Administrative Rules, Chapter 340 Division 41. The OWRD has identified 11 beneficial uses in the John Day River basin (Table 10.1); the DEQ is responsible for ensuring that these beneficial uses are being met. Federal law requires protection of the most sensitive of these beneficial uses. The most sensitive beneficial use of most waters occurring in the lower John Day River basin are the spawning and rearing of cold-water fish species.

In Oregon, the DEQ is responsible for developing water quality standards that will protect designated beneficial uses of waters of the state. Section 303(d) of the Clean Water Act requires each state to develop a list of water quality limited streams that violate these water quality standards. This list of water quality limited streams is reviewed, updated, and submitted to the EPA every two years. To warrant a listing, water quality criteria must be evaluated using sufficient data that both verify the violation and meet minimum quality assurance requirements. Because water bodies may often not have sufficient data that would allow a listing determination to be made, the 303(d) list may under represent the number of impaired water bodies in a given region or watershed. Watersheds lacking sufficient water quality monitoring programs are likely to have streams that do not meet standards, yet do not occur on the state's impaired water bodies list. The Rock and Lonerock creeks watershed generally lacks sufficient data to assess whether waterbodies within the watershed are meeting water quality standards. Minimal water quality monitoring has occurred in the Rock and Lonerock creeks watershed prior to the activities performed under this watershed assessment. As such, one of the priorities of this assessment was to collect water quality information on selected parameters throughout the watershed to characterize these conditions and identify potential areas and parameters of concern.

Table 10.1. Designated beneficial uses of waterbodies in the John Day River Basin, Oregon.

Beneficial Use
Public Domestic Water Supply
Private Domestic Water Supply
Industrial Water Supply
Irrigation
Livestock Watering
Fish and Aquatic Life
Wildlife & Hunting
Fishing
Boating
Water Contact Recreation
Aesthetic Quality

WATER QUALITY MANAGEMENT PLANNING

Federal law requires that 303(d)-listed waterways be managed to meet state water quality standards. The DEQ uses total maximum daily loads (TMDL), which describe how much of a particular pollutant a water body can receive without violating water quality criteria (DEQ 2001), to reduce pollution of listed waters. TMDLs are calculated for each pollutant entering a body of water, and then these maximum allowable pollutant loads are allocated among pollution sources such as industry or run-off from farms and forests. TMDLs for 303(d) listed waters occurring in the Lower John Day River Subbasin were approved by the EPA on December 17, 2010 (DEQ 2010). The document "John Day River Basin Total Maximum Daily Load (TMDL) and Water Quality Management Plan (WQMP)" includes TMDLs to address the 303(d) listed impairment for temperature, bacteria, biological criterion and dissolved oxygen in the John Day basin. The WQMP describes what actions will be taken to achieve desirable pollutant loads. The Oregon Department of Forestry (ODF) and ODA, through Memoranda of Understanding with DEQ, serve as the Designated Management Agencies for forestry and agricultural activities on state and private lands. The BLM and USFS serve as the Designated Management Agencies on federally administered lands (DEQ 2000).

The temperature TMDL is particularly important in the lower John Day basin, including the Rock and Lonerock creeks watershed. The temperature standard is exceeded during the summer in much of the John Day basin. The causes of excess stream heating in this area were listed in the John Day Basin TMDL (DEQ 2010) and include:

- "Riparian vegetation disturbance that decreases stream shading through reduced vegetation height and abundance";
- "Channel widening (increased width to depth ratios) due to loss of riparian vegetation, stream straightening, reduction in larger woody debris, increased sediment loading and decreased floodplain availability";
- "Reduced warm season instream flow volumes (resultant primarily from irrigation withdrawals)";
- "High temperature discharges";
- "Ponds and reservoirs can cause stream heating."

The temperature TMDL allocates pollutant loads to point sources and non-point sources within the basin. No permitted point sources occur with the Rock and Lonerock creeks watershed, however.

Prior to the completion of the TMDL in 2010 the Lower John Day Local Advisory Committee (LJDLAC), the ODA, and the Gilliam and Sherman County SWCDs developed an agricultural Water Quality Management Plan. The purpose of the plan was to "identify strategies to reduce water pollution from agricultural lands through a combination of educational programs, monitoring, suggested land treatments, and management activities" (LJDLAC 2004). The plan is used by landowners to "enhance awareness and understanding of water quality issues and to provide guidance to solutions for water quality problems (LJDLAC 2004)." According to the plan, "compliance with Division 95 rules is expected to aid in the achievement of applicable water quality standards in the Lower John Day subbasin (LJDLAC 2004)."

303(D)-LISTED WATERS

Four waterbodies in the Rock and Lonerock creeks watershed are listed by the DEQ as water quality impaired (DEQ 2009). Of these four streams, three are listed for exceeding water temperature standards and one is listed for both exceeding water temperature standards and for violation of dissolved oxygen standards (Figure 10.1, Table 10.2). Beneficial uses that are affected by these water quality violations include salmon and trout rearing and migration, salmonid fish rearing, salmonid fish spawning, anadromous fish passage, and cool-water aquatic life.

WATER QUALITY PARAMETERS

A screening of 303(d)-listed waters within the lower John Day River subbasin suggested that temperature, dissolved oxygen, bacteria, and biological criteria are water quality parameters that should receive priority attention in the Rock and Lonerock creeks watershed, as other watersheds in the subbasin with similar land-use patterns were listed for these parameters. For this assessment, ABR and the Gilliam County SWCD collected temperature, dissolved oxygen, conductivity, and biological data at monitoring stations in the summer of 2008 to further characterize water quality conditions and determine where impairment may be occurring (Figure 10.2).

TEMPERATURE

Water temperature can significantly influence the distribution of aquatic organisms, as all aquatic organisms are adapted to live within a certain range of temperatures. When water temperatures shift outside of the optimal range of aquatic organisms, growth and reproduction rates can be adversely affected. Severe deviations outside of their

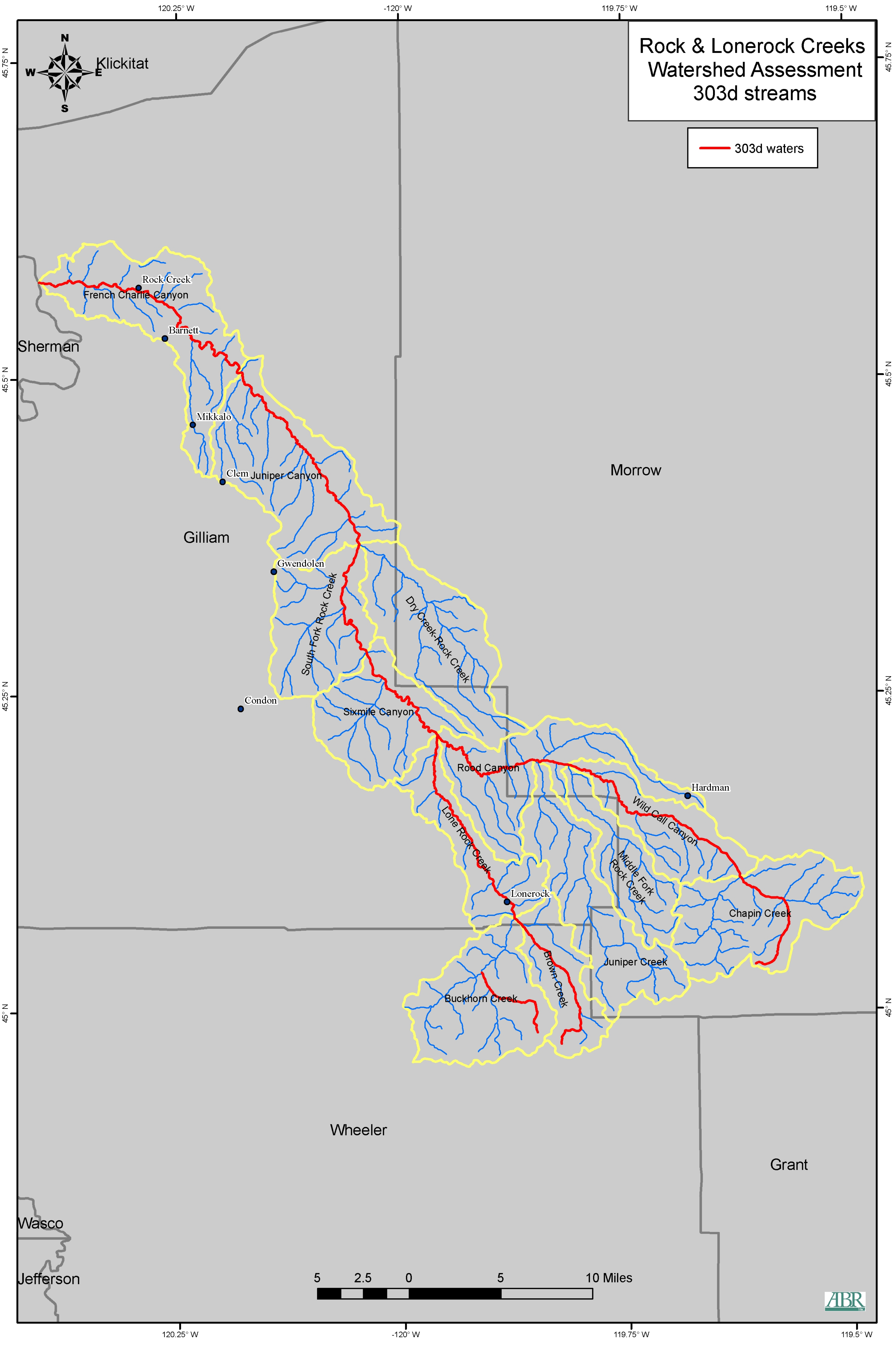

Figure 10.1. Streams that are 303(d)-listed in the Rock Creek and Lonerock Creek watershed, Oregon. .

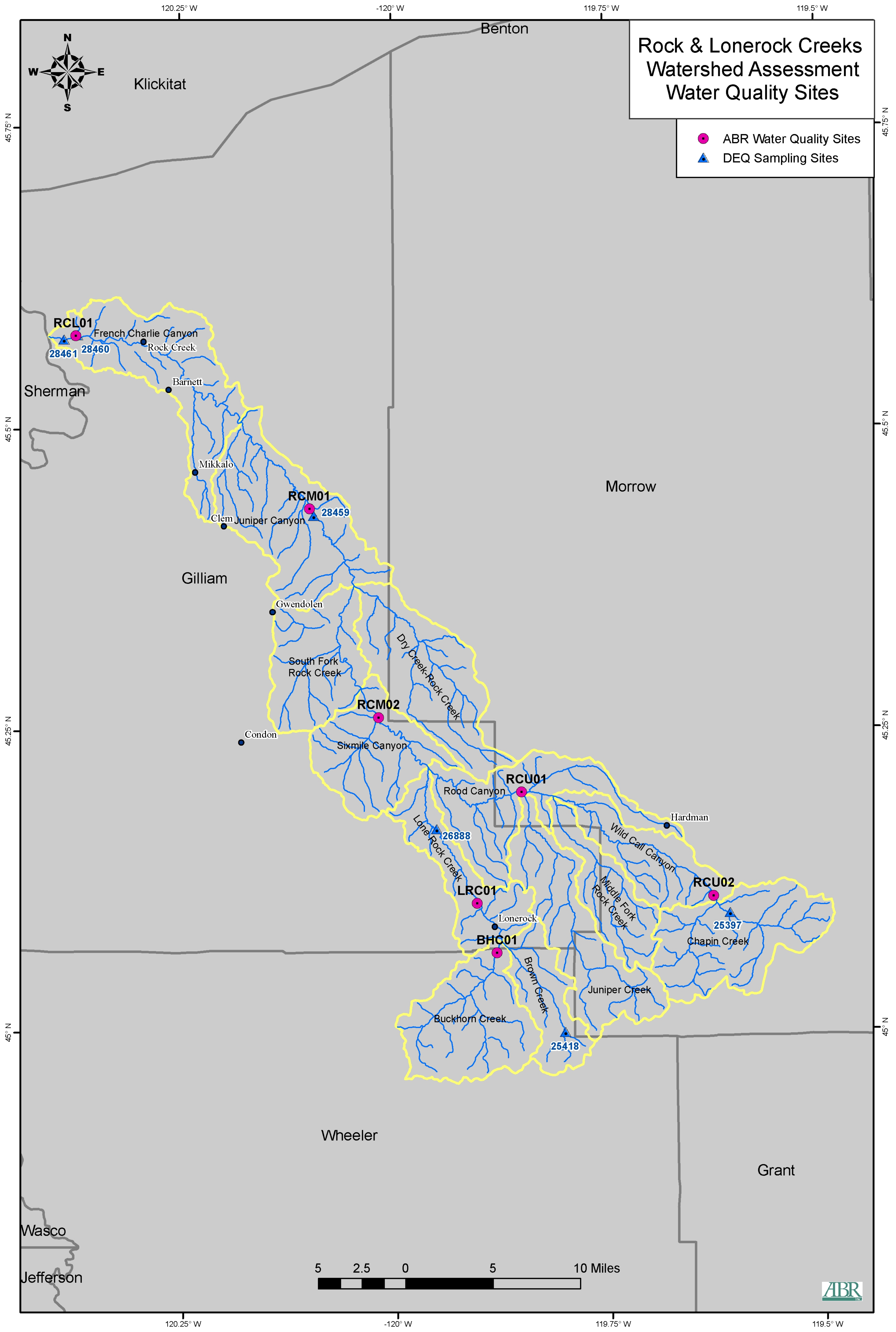

Figure 10.2. Water quality monitoring sites in the Rock Creek and Lonerock Creek watershed, Oregon.

Table 10.2. Streams that are 303(d)-listed in the Rock and Lonerock creeks watershed, Oregon.

Waterbody	Water Quality Parameter: Temperature	Water Quality Parameter: Dissolved Oxygen	Data Source	Collection Date	Listing Date
Rock Creek	✓		DEQ	2000, 2001	2004
Lonerock Creek	✓	✓	DEQ	1998 (T), 2002 (DO)	1998 (T), 2004 (DO)
Brown Creek	✓		DEQ	2001	2004
Stahl Canyon	✓		USFS	1993	1998

tolerance range can result in mortality. Salmonids, in particular, require cool water for optimal physiological functioning during various stages of their life cycle including spawning and rearing. Physical stress and increased susceptibility to fungal infection can occur when temperatures rise above a preferred range. Additionally, cold water can hold higher concentrations of dissolved oxygen than can warm water and can slow the growth of problem-causing bacteria and algae.

In the Rock and Lonerock creeks watershed, land uses such as livestock grazing, agricultural practices, and timber removal can lead to bank erosion, sedimentation, and the removal of riparian vegetation. Such conditions may impair water quality by elevating water temperatures. Bank erosion and sedimentation produce wider, shallower stream channels that absorb more solar radiation per unit volume of water than do narrower, deeper channels. A lack of riparian vegetation exacerbates the rate of warming by further increasing the amount of sunlight directly absorbed by the stream (DEQ 2000).

Eastern Oregon streams are currently considered impaired if the rolling seven-day average of the daily maximum temperature exceeds the 64 °F (17.8 °C) standard. If stream temperature data are not collected in such a manner that allows calculation of the rolling seven-day average, greater than 25% of the samples (and a minimum of at least two exceedences) must exceed the appropriate standard based on a multi-year monitoring program that collects representative samples during periods of concern. In the Rock and Lonerock creeks watershed, mid- to late-afternoon summer water temperatures are typically of concern. Further discussion of the appropriateness of this standard and these criteria for Blue Mountain Ecoregion streams follows in the "Collection and Analysis of Assessment Water Quality Data" section of this chapter.

Within the watershed, Rock Creek, Lonerock Creek, Brown Creek, and Stahl Canyon are listed for violating state water temperature standards (Figure 10.1). The mainstem of Rock Creek is listed from the mouth to the headwaters as determined by data collected during the summers of 2000 and 2001 at four stations along the creek (Station ID 28461, 28460, 28459, and 25397; Table 10.3). Lonerock Creek was added to the database in 1998 with insufficient data to determine whether the temperature standard is being met from river mile (RM) 0 to RM 13. Brown Creek is listed from RM 0 to RM 9.5 following the examination of data collected by the DEQ during the summer of 2001 (Station ID 25418). Stahl Canyon was listed for temperature in 1998 from RM 0 to RM 5.7 after analysis of USFS data collected in 1993.

DISSOLVED OXYGEN

Salmonids and other cold-water-adapted aquatic life typically require high concentrations of dissolved oxygen (DO). Dissolved oxygen concentrations in streams fluctuate predictably both seasonally and over a 24-hour period. Photosynthesis from aquatic plants, respiration from aquatic organisms, and temperature fluctuations all influence DO concentration changes. During the day, algal photosynthesis can produce high DO concentrations by late afternoon. Then at night, when no photosynthesis occurs, yet respiration by aquatic organisms continues and consumes dissolved oxygen, DO concentrations can significantly decrease by dawn. Decomposition of organic wastes by aquatic microorganisms also consumes oxygen; the

Table 10.3. DEQ water quality monitoring and assessment locations in the Rock and Lonerock creeks watershed, Oregon, with period of record noted (DEQ 2009).

DEQ Station Identifier	Station Description	Latitude	Longitude	Start	End
28461	Rock Creek at River Mile 0.8	45.5744	-120.3873	6/1/2000	10/19/2000
28460	Rock Creek at River Mile 1.8	45.5781	-120.3715	6/1/2000	10/19/2000
28459	Rock Creek at River Mile 25.7	45.4275	-120.0942	6/16/2000	10/19/2000
26888	Lonerock Creek at River Mile 4.3	45.1674	-119.9519	7/9/2002	10/3/2002
25397	Rock Creek at River Mile 72.4	45.0966	-119.6089	5/21/2001	7/23/2001
25418	Brown Creek at River Mile 6.4	44.9986	-119.8026	5/21/2001	9/25/2001

amount of oxygen consumed in this process is called the biochemical oxygen demand (BOD).

Dissolved oxygen standards for a particular water body differ depending on whether the water body is used by cold-water, cool-water, or warm-water aquatic life. For example, streams are designated as being used by cold-water aquatic life if salmon, trout, cold-water invertebrates, and other native cold-water species exist throughout all or most of the year. The dissolved oxygen criterion for such waters is a concentration of at least 8.0 mg/L (30-day mean minimum). During the salmonid spawning period (October through July), a more restrictive criterion of 11.0 mg/L (or 95% saturation) is specified. For the purpose of this screening level assessment, the criterion has been set at 8 mg/L, as recommended by the Oregon Watershed Assessment Manual (WPN 1999).

On 9 July 2002 a sample collected by the DEQ violated the dissolved oxygen standard of 6.5 mg/L required for cool-water aquatic life (Station ID 26 888; Table 10.3). Consequently, Lonerock Creek is currently listed for dissolved oxygen from RM 0 to RM 13.

BACTERIA

The coliform group of bacteria is used as an indicator to determine the sanitary quality of water for drinking water and swimming. These bacteria are relatively harmless microorganisms that can be found in the intestines of man and warm- and cold-blooded animals. Some coliform bacteria, however, can be of non-fecal origin. The presence of coliform bacteria suggests the possibility of the presence of more harmful pathogens found in human and animal waste, including viruses, other bacteria, and protozoa. In the past, fecal coliform data were most commonly collected and standards were based on such measurements, but because coliform bacteria can also be of a non-fecal origin, these tests did not conclusively demonstrate fecal contamination. As a result, the standards were changed in 1996 to measurements based on the number of *Escherichia coli* organisms per 100 mL as these bacteria are known to be almost exclusively of fecal origin. Coliform bacteria (MPN 100 mL) data were collected on five occasions between 1970 and 1972 at five sites within the basin (Gilliam County SWCD et al. 1975). No stream segments in the watershed are currently, or have been in the past, listed for violation of bacteria water quality standards.

BIOLOGICAL CRITERIA

The biological criteria parameter was established to ensure that the state's waters are of "sufficient quality to support the aquatic species without detrimental changes in the residential biological communities." Streams are listed under this criterion if the aquatic community scores are 60% or less of the reference community condition, as determined by multimetric scores or multivariate model scores (DEQ 1998). The DEQ performed an assessment of macroinvertebrate communities at one site each in Rock Creek and Lonerock Creek in 2001 and 2002, respectively (the results of the DEQ assessment are presented in the following section, "Analysis of Existing Data"). A more extensive assessment of macroinvertebrate communities was performed as part of this watershed assessment to determine the extent to which aquatic communities are impaired in the watershed, including a number of waterbodies that have not been assessed in the watershed.

NUTRIENTS

The two primary nutrients that limit plant growth in water are nitrogen and phosphorus. However, excess nitrogen and phosphorus concentrations may increase plant and algae growth which, in turn, can lead to low levels of dissolved oxygen. In addition, certain algae can produce chemicals that can be toxic to livestock and wildlife. Some grazing management practices, particularly those that confine animal feeding operations to areas adjacent to streams, can produce nutrient enrichment of receiving waters (EPA 1993).

Water quality criteria for total phosphorus and total nitrates have been established to help identify waterbodies that are receiving excess concentrations of these nutrients. Total phosphorus measures phosphates in the water column and phosphorus in suspended elements, while total nitrate (usually nitrite plus nitrate) measures most of the nitrogen in the water column. Evaluation criteria of 0.30 mg/L for total nitrate and 0.05 mg/L for total phosphorus have been established in areas where TMDLs have not been set up, such as in the Rock and Lonerock creeks watershed (WPN 1999).

Limited nutrient data are available for the Rock and Lonerock creeks watershed and none were collected during the course of this assessment. In the early 1970’s, sulfate, ammonia N, nitrate N, and phosphate testing was performed and discharge was measured to calculate these constituents in tons/day. Samples were collected on 3 December 1970, 25 and 26 March 1971, 25 May 1971, and 11 January 1972 at five sites within the basin (Gilliam County SWCD et al. 1975). The highest level of each constituent was measured on 26 March 1971 when stream discharge was highest.

TURBIDITY

Turbidity, a measure of water clarity, acts as a gauge of the amount of suspended particulate organic and inorganic materials in the water column. Turbidity varies naturally with soil type, as larger, heavier particles such as sand will more readily sink to the stream bottom, while smaller, lighter particles such as silts and clays will remain suspended for longer durations. While clear water is aesthetically pleasing, it is also functionally important for aquatic organisms such as salmonids that require clear water to sight-feed. Additionally, sensitive gill tissues of fish and other aquatic life can be damaged by sediment particles in the water column. No turbidity data are known to exist for the Rock and Lonerock creeks watershed and none were collected during this assessment.

CONTAMINANTS

Contaminants generally fall into two subgroups, metals and organics, both of which can cause toxicity in aquatic organisms. Criteria for metals contaminants are expressed as acute and chronic values. The presence of metals can cause sublethal effects such as physiological stress and reduced growth and reproduction rates (chronic levels) or death (sublethal levels). These regulatory criteria are generally expressed as formulas, as they are based on the hardness of the water. For organic contaminants, any detection recorded above minimum detection levels is an indicator of impaired water quality (WPN 1999). No contaminants data for the Rock and Lonerock creeks watershed are known to exist.

ANALYSIS OF EXISTING DATA

Water quality data, including those listed above as supporting data for 303(d) listings in the watershed, have been collected only sporadically. No single program has been implemented to monitor water quality throughout the watershed, and data collection efforts vary extensively among the subwatersheds. In the last 40 years a handful of qualitative and quantitative water quality data have been collected in conjunction with the production of investigation reports, watershed work plans, and watershed improvement plans (Gilliam County SWCD et al. 1969, Gilliam County SWCD et al. 1975, Gilliam County SWCD et al. 1985, Bureau of Reclamation [BOR] 1993). In 1962, local soil and water conservation districts in cooperation with the Rock Creek Water Control District submitted an application for assistance under the Watershed Protection and Flood Prevention Act (Public Law 566) to rectify the following watershed problems and needs: flood damage, erosion including sediment deposition, water management including irrigation and drainage, and fish management problems. The preliminary investigation report written in 1969 noted that low to non-existent summer flows were an issue in the watershed (Gilliam County SWCD et al. 1969).

From this application a watershed project was proposed to evaluate dam sites within the Rock Creek basin with the objectives of "land stabilization, flood prevention, irrigation water supply, increased forest resource productivity, fire protection, rural area development, and fish and wildlife benefits." The Rock Creek Watershed Work Plan published in 1975 noted that water quality is "generally good throughout all reaches of the stream when it is flowing," and "exceeds general water quality standards established by the Oregon Department of Environmental Quality (Gilliam County SWCD et al. 1975)." However, the Work Plan also noted that factors including "high water temperatures in the creek during the summer," and "intermittent flows," limited aquatic life. Water temperatures measured in conjunction with the study noted that water temperatures on 25 May 1971 ranged from 60.8 to 66.2 ºF (mean = 64.0 ºF) at five locations distributed throughout the watershed. Dissolved oxygen concentration measured the same day ranged from 9.2 to 10.8 mg/L (mean = 10.0 mg/L). Water quality was deemed to be of "high quality" for recreational and irrigation use, two of the basin's designated beneficial uses.

In 1993, the John Day Basin Council noted that "high stream temperatures in the summer, low summer flows, and high spring runoff" were "major problems" in the Rock Creek subbasin of the John Day River (BOR 1993). When the "Stream restoration program for the Rock Creek tributary of the John Day River" was drafted, the only water quality data that were known to be available were those collected by the USGS from 25 May 1980 to 20 October 1980 near Condon, Oregon. At the time, these limited data suggested that the water quality of Rock Creek was suitable for all designated beneficial uses near Condon and that the water temperature during this time period was below the 64 ºF standard (range: 53.6 ºF to 63.5 ºF). The restoration program noted that enhancement of riparian vegetation would have a "significant cooling effect on stream temperatures during the late summer."

Two surveys of macroinvertebrate communities are known to have occurred in the Rock and Lonerock creeks watershed prior to this assessment. Two sites in the Rock and Lonerock creeks watershed were sampled as part of the EPA's Wadeable Streams Assessment under their Environmental Monitoring and Assessment Program (EMAP); one in mainstem Rock Creek (WORP99-0685) on 23 July 2001 and one in the mainstem of Lonerock Creek (WORP99-0852) on 9 July 2002. These samples are also listed in the DEQ's database as part of their ambient water quality monitoring program (Station ID 25397 and 26888). The sample collected in Rock Creek in 2001 received the lowest score of 0.6782 corresponding with a "most disturbed" condition class and a greater than or equal to 22% loss in common taxa that would be expected to be observed at the site. The Lonerock Creek site sampled in 2002 received the best score of 1.0061 corresponding with a "least disturbed condition class" and a loss of between 0 and 7% of the expected common taxa (Table 10.4).

Table 10.4. PREDATOR O/E scores, condition class and taxa loss of macroinvertebrate communities sampled within Rock Creek (23 July 2001) and Lonerock Creek (9 July 2002), Oregon (DEQ 2009).

Waterbody	Site code	O/E score	Condition Class	Taxa loss
Rock Creek	25397	0.6782	Most disturbed	$\geq$22% loss of common taxa
Lonerock Creek	26888	1.0061	Least disturbed	0-7% loss of common taxa

COLLECTION AND ANALYSIS OF WATER QUALITY DATA

Water quality data were collected in the summer of 2008 to begin to characterize current water quality conditions and patterns in the watershed. The water quality field assessment comprised three parts: continuous water temperature monitoring, regular (approximately bi-weekly) monitoring of temperature, conductivity, and dissolved oxygen, and a survey of macroinvertebrate communities (Figure 10.2, Table 10.5).

TEMPERATURE

Onset Water Temp Pro temperature recorders (set to record water temperature at fifteen-minute intervals) were deployed within the Rock and Lonerock creeks watershed on 1 July, 10 July, and 1 August, 2008. Deployment dates correspond to dates that ABR and SWCD staff were available to deploy loggers. Recorders were placed in the stream with sufficient flow and depth to keep the recorder completely submerged during low-flow periods. Recorders were checked regularly by assessment staff to ensure they were submerged and not exposed to direct sunlight. Recorders were placed in one lower Rock Creek reach (RCL01) near the confluence with the John Day River; two middle Rock Creek reaches, including one near Spring Hollow (RCM01) and one downstream of the confluence with Sixmile Canyon (RCM02); two upper Rock Creek reaches, one near the confluence with Juniper Creek (RCU01) and one at Anson Wright Park (RCU02); one Lonerock Creek reach downstream of the town of Lonerock (LRC01); and in one Buckhorn Creek reach (BHC01). The recorders were retrieved on 10 October 2008, after approximately 3 months of continuous water temperature recording. Data were downloaded and summarized by calculating and graphing seven-day running mean daily maximum water temperatures.

Results suggest that water temperatures are highest in the upper reach of Rock Creek (RCU01) near the confluence with Juniper Creek, which was dry for much of the monitoring period (Figure 10.3). This section of Rock Creek experienced severe low flows during late summer 2008, which resulted in the high water temperatures measured at RCU01. These extreme low-flow conditions are likely a regular seasonal occurrence in parts of upper Rock Creek, as previous reports have also documented their occurrence (Gilliam County SWCD et al. 1975). These low flows are likely to produce water temperatures and other ambient environmental conditions that are unsuitable for salmonids and other more sensitive species of aquatic life.

Maximum water temperatures were consistently at least 5 °F cooler at downstream stations located in the middle (RCM01 and RCM02) and lower (RCL01) sections of Rock Creek through much of the summer. Maximum water temperatures in middle Rock Creek at RCM02, near the confluence with Sixmile Canyon, were considerably lower and fluctuated less than the other water quality monitoring stations within the watershed. While no stations other than RCU01 went dry or experienced cessation of flows, the middle Rock Creek station, RCM02, was the only location that eventually reached and remained below the state-wide 64 °F water temperature standard intended to protect salmonid rearing. This station was located in a well shaded reach (Figure 10.4), several meters downstream of the confluence with Sixmile Creek, a perennial tributary that contributed a steady flow of cool water (normally at least 5 °F cooler than Rock Creek) into Rock Creek.

Water temperatures at the remaining stations remained above the 64 °F standard until the beginning of September (Figure 10.3). However, the applicability of this standard to Rock Creek and Lonerock Creek and similar waters in the Blue Mountains Ecoregion is questionable. A recent study showed that the "thermal niche" (i.e., the range of temperatures that a species is observed occupying) and the upper limit of the thermal niche for rainbow trout occurring in this ecoregion were considerably higher than those of rainbow trout occurring in the Cascades Ecoregion (Huff et al. 2005). The upper limit of the realized thermal niche for rainbow trout of the Blue Mountains ecoregions was 72.3 °F, while that of rainbow trout in the Cascades Ecoregion was 62.3 °F. Furthermore, rainbow trout were the most temperature-sensitive fish species occurring in the Blue Mountains Ecoregion, and yet the calculated

Table 10.5. Water quality monitoring and assessment locations in the Rock and Lonerock creeks watershed and associated parameters measured at each location.

		Parameters Measured				
Site Code	Waterbody	Temp (cont)	Temp (grab)	DO (grab)	Conductivity (grab)	Biological (macroinvertebrates)
RCL01	Rock Creek, lower	✓	✓	✓	✓	✓
RCM01	Rock Creek, middle	✓	✓	✓	✓	✓
RCM02	Rock Creek, middle	✓	✓	✓	✓	✓
RCU01	Rock Creek, upper	✓	✓	✓	✓	
RCU02	Rock Creek, upper	✓	✓	✓	✓	✓
LRC01	Lonerock Creek	✓	✓	✓	✓	✓
BHC01	Buckhorn Creek	✓	✓	✓	✓	✓

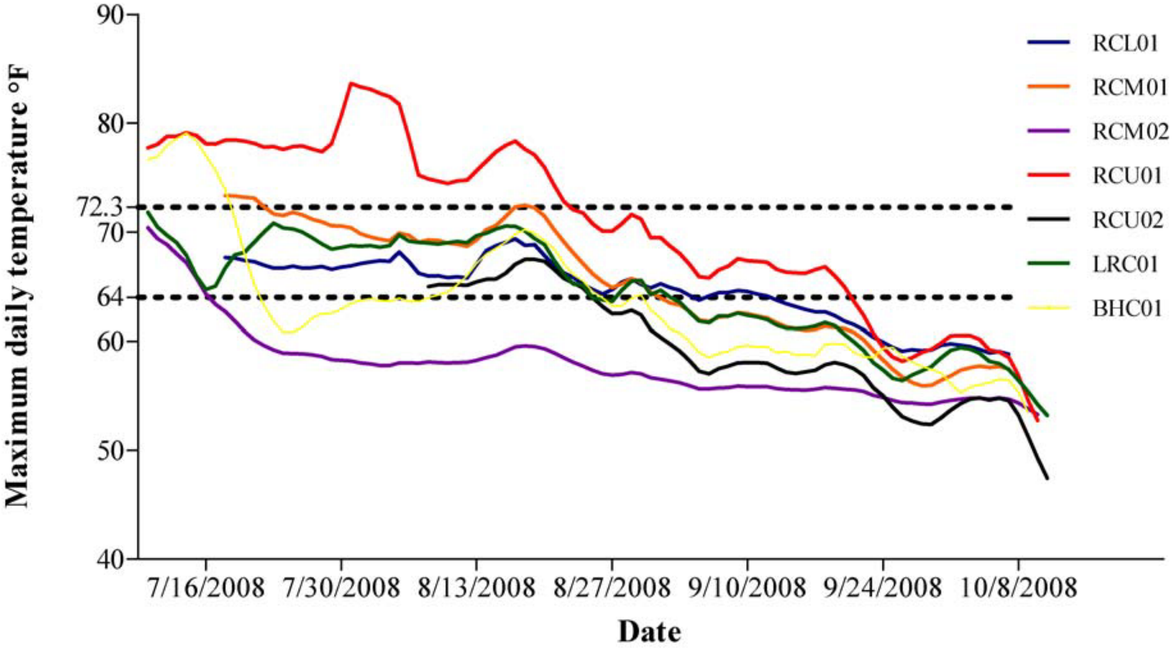

Figure 10.3. Seven-day running mean daily maximum water temperatures at seven water quality monitoring sites within the Rock Creek and Lonerock Creek watershed, Oregon.

Figure 10.4. A well-shaded reach of Rock Creek near the middle Rock Creek station (RCM02) located several meters downstream of the confluence with Sixmile Creek.

upper limit of their thermal niche was almost 9°F higher than the current state standard for salmonid rearing of 64 °F. The study that elucidated these regional differences and that was authored by DEQ biologists suggests that resource policies should be region specific and based on analysis of detailed local information (Huff et al. 2005). As such, we feel that an examination of these water temperature data in relation to the realized thermal niche for rainbow trout was more relevant than in relation to the current state-wide standard.

With the exception of the upper Rock Creek reach near the confluence with Juniper Creek (RCU01), water temperatures within the watershed remained below the 72.3 °F upper limit for rainbow trout for much of the monitoring period. This reach (RCU01) exceeded the limit on nearly half of the days of summertime temperature monitoring. The data suggest that much of the total length of perennial streams within the Rock and Lonerock creeks watershed is able to maintain water temperatures required for the maintenance of rainbow trout populations during years with weather and hydrologic conditions similar to those that occurred in summer 2008. This is not to discourage or minimize efforts to reduce water temperatures, particularly in the upper reaches of Rock Creek (RCU01). The lack of riparian vegetation throughout the watershed exposes Rock Creek to higher amounts of sunlight than it would have received historically, when a well-developed canopy of willows and other trees shaded the channel. Efforts to re-establish these conditions and otherwise reduce the extent of anthropogenic warming of Rock Creek and its tributaries should be encouraged and undertaken.

DISSOLVED OXYGEN

Dissolved oxygen (DO) was measured twice during late summer/early fall 2008 at each of the seven water-quality monitoring stations. Dissolved oxygen concentrations were generally greater than the 8 mg/L coldwater standard. Only one site, upper Rock Creek RCU01, had dissolved oxygen concentrations lower than the standard. This screening-level monitoring suggests that dissolved oxygen concentrations in the Rock and Lonerock creeks watershed are not likely a limiting factor to aquatic communities under flow and temperature conditions similar to those occurring in summer 2008, with the exception of reaches that experience severe low flows. While our limited data suggest that low DO is not expected to be a widespread problem in the watershed, further efforts should focus on monitoring of early-morning (before 9 AM) dissolved oxygen concentrations to help characterize these conditions when they would be expected to be most limiting to aquatic life, as almost all monitoring for this assessment occurred in the afternoon when DO concentrations would normally be higher. Additionally, no water quality sampling occurred during the period when rainbow trout and steelhead would be expected to spawn in the Rock and Lonerock creeks watershed, which likely occurs in May. At this time and into the early summer, a more restrictive DO standard of 11 mg/L must be met.

BIOLOGICAL INTEGRITY

While macroinvertebrates have been sampled by DEQ at two locations in Rock Creek (once in 2001 and once in 2002), the macroinvertebrate assessment performed for this project represents the most extensive biological assessment effort in the watershed to date. Biological monitoring of macroinvertebrate communities provides valuable information because biological communities integrate the effects of multiple stressors—excess nutrients, toxic chemicals, increased temperature, excessive sediment loading, and others and thereby provide a reliable measure of the overall ability of a water body to support aquatic life.
Macroinvertebrate communities were sampled from six of the seven water quality monitoring stations in Rock Creek (four sites), Lonerock Creek (one site), and Buckhorn Creek (one site) in early September, 2008. Macroinvertebrates were collected using DEQ's Benthic Macroinvertebrate Protocol for Wadeable Rivers and Streams (DEQ 2003). An 8-kick composite sample was collected from the best available habitat occurring in each reach (riffles, in all cases). Instream sampling points were selected to apportion the eight kick samples among as many as four habitat units. Macroinvertebrates were collected with a D-frame kick net (12-in wide, 500-µm mesh opening) from a 30 x 30 cm (1 x 1 ft) area at each sampling point. Larger pieces of substrate were first hand-washed inside the net and then placed outside of the sampled area. The area was then thoroughly disturbed by hand (or by foot in deeper water) to a depth of ~10 cm. The eight samples from a reach were placed together into a 500-µm sieve and carefully washed to remove larger substrate and leaves after inspection for clinging macroinvertebrates. The composite sample then was placed into one or more 1-L polyethylene wide-mouth jars, labeled, and preserved with 80% ethyl alcohol for later sorting and identification at the laboratory.

Samples were sorted to remove a 500-organism subsample from each preserved sample following the procedures described in DEQ's Level 3 protocols (Water Quality Interagency Workgroup [WQIW] 1999) and using a Caton gridded tray, as described by Caton (1991). Contents of the sample were first emptied onto the gridded tray and then floated with water to evenly distribute the sample material across the tray. Squares of material from the 30-square gridded tray were placed into a Petri dish which was then examined under a dissecting microscope at 7X magnification to sort aquatic macroinvertebrates from the sample matrix. Macroinvertebrates were removed from each sample until at least 500 organisms were counted or until the entire sample had been sorted.

Following sorting and identification, macroinvertebrate taxonomic data were analyzed using the PREDATOR (PREDictive Assessment Tool for ORegon) model, developed by DEQ staff (Hubler 2008) and researchers at Utah State University (Hawkins et al. 2000). PREDATOR is a predictive model that evaluates macroinvertebrate community conditions based on a comparison of observed (O) to expected (E) taxa. The observed taxa are those that occurred at the site, whereas the expected taxa are those predicted to occur at the site in the absence of disturbance. PREDATOR is now widely used for determining biological conditions of Oregon's rivers and streams. Three regional PREDATOR models are currently in use in Oregon; one of these three models—the Western Cordillera + Columbia Plateau (WCCP) Predictive Model—encompasses streams in the Klamath Mountains, Cascades, East Cascades, Blue Mountain, and Columbia Plateau Ecoregions (Hubler 2008).

Using PREDATOR O/E scores, the lower Rock Creek site (RCL01) sampled received a score of 0.7327 corresponding with a "most disturbed" condition class and a greater than or equal to 22% loss in common taxa that would be expected to be observed at the site (Table 10.6). The remaining five sites scored between 0.79 and 0.92, corresponding to a "moderately disturbed" condition class and an 8–21% loss in common taxa that would be expected to be observed at the sites (Table 10.6). In 2008, biological integrity decreased in a downriver direction from the uppermost middle reach of Rock Creek (RCM02) to the confluence with the John Day River (RCL01). This pattern suggests that macroinvertebrate communities are most impaired in the lower reaches of Rock Creek. However, the reach sampled furthest upstream on Rock Creek (RCU02) scored lower than the two middle reaches (RCM01 and RCM02).

Physical habitat data collected during these biological assessments show that habitat variables to which macroinvertebrates are most responsive, such as substrate type, substrate embeddedness, available habitat types, and water temperatures, were most favorable in the middle reach of Rock Creek (RCM02; an analysis of physical habitat conditions is presented in the following chapter), and worsened in the lower reaches. The biological data suggest that if improvements in these physical conditions can be made in the lower reaches of Rock Creek, biological recovery to levels observed in less degraded portions of Rock Creek would be expected to follow.

CONCLUSIONS AND RECOMMENDATIONS

- Water quality data for the Rock and Lonerock creeks watershed are scant. No regular monitoring, aside from that performed in summer 2008 for this assessment, has occurred in the watershed.
- Data collected during this assessment suggest that the water quality parameters of temperature and biological integrity are most impaired in the middle reaches of Rock Creek. As efforts to improve upland, instream, and riparian conditions are undertaken, monitoring of chemical and biological endpoints that are responsive to these efforts is recommended to document improvement.
- To better characterize the water quality of the Rock and Lonerock creeks watershed, monitoring efforts should be initiated. We suggest developing a water quality monitoring plan for the watershed that would include establishment of permanent monitoring sites and regular monitoring of selected parameters, including water temperature, dissolved oxygen, and biological communities. Monitoring sites should be established that would allow determination of both overall trends in water quality as well as the effects of any restoration efforts. The Gilliam County SWCD and the Gilliam-East John Day Watershed Council are in the planning stages of initiating a long-term water quality monitoring program that will focus on deploying temperature loggers in four larger watersheds in the county (Hay Creek, Thirtymile Creek, Rock Creek, and Ferry Canyon Creek). We recommend that monitoring sites overlap with those used in previous assessments (DEQ and/or ABR) to the extent possible.

Table 10.6. PREDATOR O/E scores of macroinvertebrate communities sampled in September 2008 from six reaches within the Rock and Lonerock creeks watershed, Oregon.

Waterbody	Site code	O/E score	Condition Class	Taxa loss
Rock Creek, lower	RCL01	0.7327	Most disturbed	≥22% loss of common taxa
Rock Creek, middle	RCM01	0.8424	Moderately disturbed	8-21% loss of common taxa
Rock Creek, middle	RCM02	0.8716	Moderately disturbed	8-21% loss of common taxa
Rock Creek, upper	RCU02	0.8162	Moderately disturbed	8-21% loss of common taxa
Lonerock Creek	LRC01	0.8287	Moderately disturbed	8-21% loss of common taxa
Buckhorn Creek	BHC01	0.8639	Moderately disturbed	8-21% loss of common taxa

CHAPTER 11:
FISH AND FISH HABITAT

INTRODUCTION

Salmonids are regarded as among the most sensitive aquatic species occurring in Oregon's watersheds. As such, information related to their abundance and distribution can help identify portions of the watershed that are most degraded with respect to habitat and water quality. This information also provides valuable insight into the relative condition of different areas within a watershed. Information describing patterns in salmonid abundance and distribution, used in conjunction with information describing the quality of fish habitat, can help identify what factors are most limiting to fish populations in the watershed and can assist in identifying restoration priority areas and project types. In this chapter, we examine data describing fish populations and communities in Rock Creek and Lonerock Creek to determine the present status of these fish populations in the watershed. Physical habitat data are also discussed and summarized to make inferences about the relative condition of different areas within the watershed and what factors may be limiting to salmonid populations and fish communities.

Fish habitat quality in Rock Creek, Lonerock Creek, and perennial tributaries has been degraded by certain land management practices and associated infrastructure such as clearing of riparian vegetation, roads and road crossings, and water diversions. Fish production in the watershed is potentially limited by the combined effects of water quality and quantity, including reduction or cessation of stream flows, elevated water temperatures, and increased sediment loading. Habitat loss and fragmentation caused by impassable diversions is also likely affecting steelhead and trout populations in the watershed. In this chapter, fish and fish habitat data from the watershed are examined to determine the current condition of the watershed in relation to supporting native steelhead and trout.

STEELHEAD

Steelhead are native to the John Day River subbasin. The John Day basin population of steelhead belongs to the Columbia Basin redband/steelhead trout *Oncorhynchus mykiss gairdneri* subspecies that occupies the Columbia basin east of the Cascade Mountains starting at Fifteen Mile Creek (Kostow 1995). Steelhead and redband are the same subspecies—they differ only in their life histories—the former is anadromous, while the latter remains in fresh water for its lifespan and is referred to as a "resident" form. Streams within the Rock and Lonerock creeks watershed are inhabited by sympatric populations of both life-history types (occupying the same range without loss of identity from interbreeding). As the same subspecies, the two life-history types cannot be differentiated in the field when they co-occur as juveniles. Inventories of steelhead populations must therefore focus on surveys of returning adults, redds, or out-migrating smolts.

POPULATION STATUS AND MANAGEMENT

Oregon's Middle Columbia River steelhead populations were listed as threatened on 25 March 1999 under the Endangered Species Act (ESA) as part of the Middle Columbia River Evolutionarily Significant Unit (ESU). This ESU includes all naturally spawned populations of steelhead in Oregon and Washington tributaries to the Columbia River upstream from the Hood and Wind River systems, upstream to, and including, the Yakima River in Washington. At the time of the original listing, this ESU included both anadromous and resident biological forms of *Oncorhynchus mykiss*. Species determinations were revised by the National Marine Fisheries Service (NMFS) to delineate anadromous, steelhead-only "distinct population segments (DPS)." The Middle Columbia River Steelhead DPS was listed as threatened on 5 January 2006.

The Middle Columbia River Steelhead DPS has four major population groupings (MPGs) including the John Day River, the Cascades Eastern Slope Tributaries, the Umatilla/Walla Walla Rivers, and the Yakima River Group. Populations within the John Day River MPG include the Lower Mainstem John Day River, North Fork John Day River, Middle Fork John Day River, South Fork John Day River and the Upper Mainstem John Day River Summer Steelhead

Populations. Summer steelhead within the Rock and Lonerock creeks watershed are part of the Lower Mainstem John Day River population which includes the Lower John Day watershed downstream of the confluence with the South Fork of the John Day River. Steelhead from this population spawn in major tributaries including Bridge, Butte, Thirtymile, Hay, and Rock Creeks. There are 11 Major Spawning Areas (MaSAs) and 19 Minor Spawning Areas (MiSAs) contained within this population. Three of the 11 MaSAs occur in the Rock and Lonerock creeks watershed including Middle Rock Creek, Upper Rock Creek, and Lonerock Creek. The population is considered "very large" with a mean minimum abundance threshold of 2,250 spawners (ODFW 2008a).

The key threats to the viability of the Lower Mainstem John Day River steelhead population include current hatchery practices and current land-use practices which affect a number of steelhead life stages including fry, summer parr, winter parr, and adult spawners (ODFW 2008a). While no hatchery production exists within the John Day River basin, hatchery programs designed to produce returns of summer steelhead to Columbia River tributaries upstream of the John Day River have resulted in a significant number of stray hatchery steelhead spawning within the basin. Spawning by stray hatchery steelhead can pose risks to the genetic traits and the productivity of naturally spawned steelhead. Current land-use practices such as agriculture, grazing, and forestry within the basin have resulted in impaired physical habitat quality and elevated water temperatures.

DISTRIBUTION WITHIN THE WATERSHED

In recent years the ODFW has conducted a number of formal surveys in the Rock and Lonerock creeks watershed including steelhead redd surveys and snorkel surveys of juvenile *O. mykiss* populations (Table 11.1). In conjunction with redd surveys, surveyors also note the presence of live spawners within survey reaches. Steelhead adult live spawner and redd surveys were performed most recently in the spring of 2008 and 2009 in the mainstem of Rock Creek to document the use of the watershed by adult steelhead. Surveys were conducted by ODFW within two individual 2-km reaches (OJD03458-006 and OJD03458-009; Figure 11.1). Each site was sampled six times between 4 March and 21 May 2008 and four times between 7 April and 28 May 2009. Surveys have been conducted annually at these two sites since 2004 as part of the Regional Environmental Monitoring and Assessment Project (REMAP). Additionally, redd surveys have been conducted within five other reaches in the basin since 1994 including two additional reaches on Rock Creek (OJD03458-557, 2007 and OJD03458-539, 2006), two reaches on Lonerock Creek (OJD03458-045, 2005, 2009 and OJD03458-170, 2009), and two reaches on Buckhorn Creek (OJD03458-091, 2004 and OJD03458-145, 2007; Figure 11.1, Table 11.1).

At the furthest downstream site on Rock Creek (Site 009), redd density ranged from 0.0 to 8.0 redds/km (mean = 3.0, SD = 2.8) between 2004 and 2009, while redd density ranged from 0.5 to

Table 11.1. Formal redd surveys (R) and juvenile snorkel surveys (J) for *Oncorhynchus mykiss* conducted by ODFW in the Rock and Lonerock creeks watershed, Oregon.

Waterbody	Site ID	2004	2005	2006	2007	2008	2009
Rock Creek	OJD03458-557				R		
Rock Creek	OJD03458-009	R/J	R/J	R/J	R/J	R	R
Rock Creek	OJD03458-006	R/J	R/J	R/J	R/J	R	R
Rock Creek	OJD03458-539			R			
Lonerock Creek	OJD03458-170						R
Lonerock Creek	OJD03458-045		R				R
Buckhorn Creek	OJD03458-091	R					
Buckhorn Creek	OJD03458-145				R		

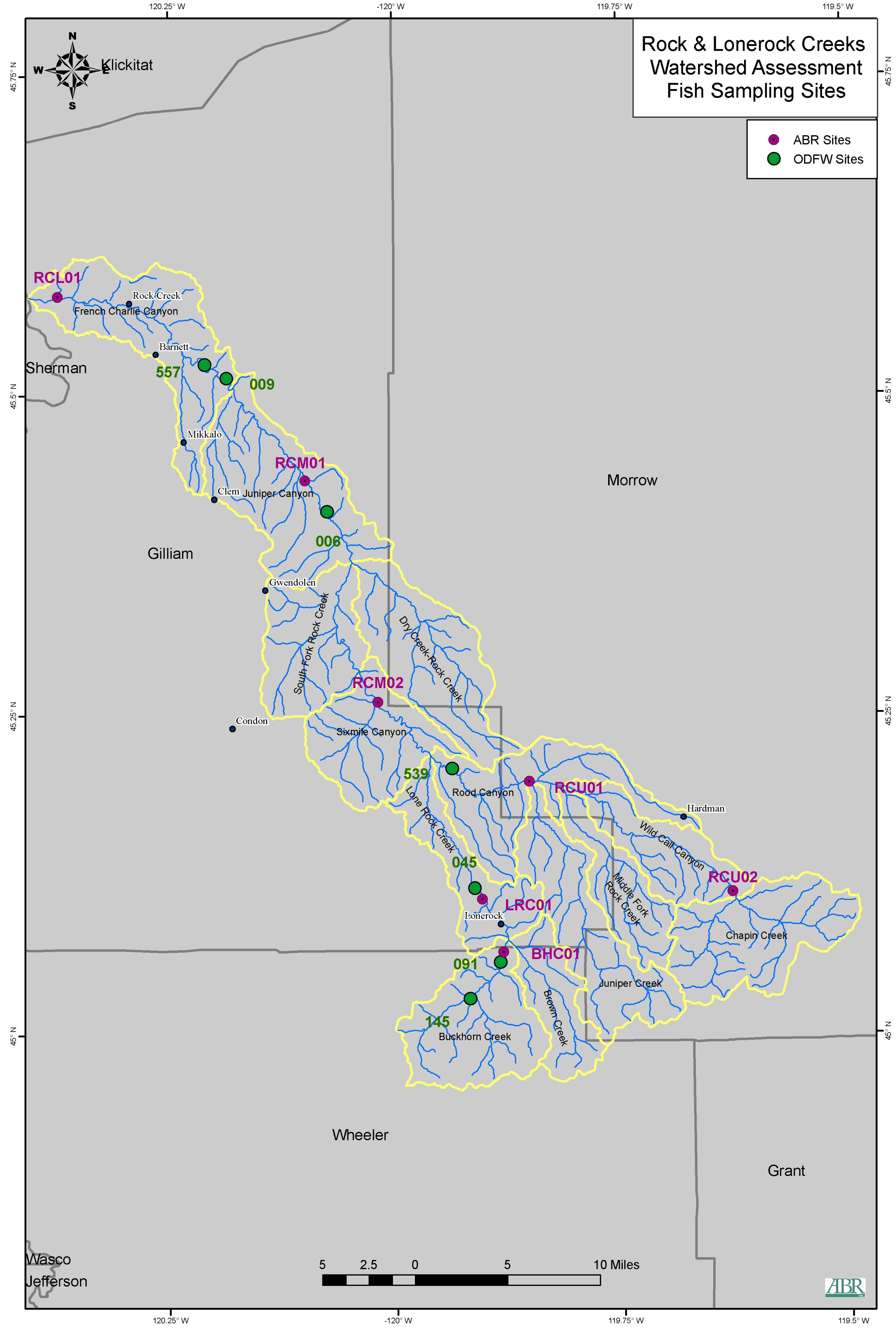

Figure 11.1. Map of locations within the Rock and Lonerock creeks watershed sampled in 2008 by ABR for fish community structure and/or physical habitat conditions and locations sampled in 2004–2009 by the Oregon Department of Fish and Wildlife for steelhead abundance.

3.5 redds/km (mean = 2.25, SD = 1.1) during the same time period at the upstream site (Site 006; Figure 11.2). Surveyors recorded the number of live spawners that were observed during the surveys; number of live steelhead ranged from 0 to 9 (mean = 2.7, SD = 3.7) at site 009, and from 0 to 2 (mean = 0.8, SD = 0.8) at site 006 (Figure 11.3). Notably, one of the two live steelhead observed in 2009 was a hatchery steelhead located off the redd. The number of juvenile *O. mykiss* observed during snorkel surveys between 2004 and 2007 varied widely and ranged from 0 to 1,663 juveniles (mean = 527, SD = 767) at site 009, and from 0 to 2,221 juveniles (mean = 722, SD = 1,012) at site 006 (Figure 11.4).

Collectively these data show that 2005 was a poor year for steelhead in Rock Creek with the lowest density of redds observed during the six-year period; no live spawners or juvenile *O. mykiss* were observed. Conversely, 2007 had the highest densities of redds, the highest number of live steelhead observed, and the highest number of juvenile *O. mykiss* observed at both sites. Since 2007, the overall redd density for Rock Creek has declined with 10 redds observed in 2008 and 5 redds observed in 2009. In 2009, one redd was observed at each of the redd survey reaches on Lonerock Creek (OJD03458-045 and OJD03458-170), while one live, wild steelhead was observed off a redd (Site 170).

REDBAND TROUT

Redband trout, the resident life-history type of Oncorhynchus mykiss gairdneri, co-occur with steelhead in the Rock and Lonerock creeks watershed. Redband trout typically inhabit smaller streams in eastern Oregon that exhibit extreme variation in seasonal flow, temperature, and dissolved oxygen (Bhenke 1992, Northwest Power and Conservation Council [NWPCC] 2004). Despite their apparent adaptability to these variable environments, all species groups of inland redband trout are currently classified as “vulnerable” by ODFW (ODFW 2008b), largely owing to the recent decline and disappearance of several populations and a lack of understanding of the myriad physical and biological factors that govern their physiological functioning, survival, and consequent population sizes.

ABUNDANCE AND DISTRIBUTION WITHIN THE WATERSHED

ABR conducted electrofishing surveys of select reaches of Rock Creek and its tributaries on 17 and 18 July 2008 to determine the relative abundance and distribution of *O. mykiss* within the watershed. Single-pass electrofishing surveys were conducted at four sites including two on the mainstem of Rock Creek within the Sixmile Canyon (RCM02) and Rood Canyon (RCU01) subwatersheds, on the mainstem of Lone rock Creek (LRC01), and on the mainstem of Buckhorn Creek (BHC01; Figure 11.1).

O. mykiss were observed at all sites with the exception of the upper Rock Creek site (RCU01; Table 11.2). The majority of this reach was dry with isolated pools of nearly standing water with very low or no flow between them. Of the three reaches where *O. mykiss* were present, both juvenile and adult *O. mykiss* (>152 mm by ODFW definition) were either captured or visually observed. Adults were captured within Lonerock Creek (LRC01) and its tributary, Buckhorn Creek (BHC01), while a number of large, likely adult-by-definition, *O. mykiss* were visually observed in large, deep pools immediately downstream of the confluence of Rock and Sixmile creeks (RCM02).

Results of the electrofishing surveys suggest that *O. mykiss* are distributed throughout the watershed and that relative abundance is highest in the mainstem of Lonerock Creek. Although sampling efficiency was low because an abundance of boulder and cobble habitat provided ample cover under low-flow conditions, the highest number of *O. mykiss* was observed at this site. Most of the *O. mykiss* sampled from this reach were between 40 and 60 mm long, comprising 14 of the 23 individuals sampled (Figure 11.5). The absence of a smaller size class indicated that these were likely Age-0 *O. mykiss*. By ODFW definition (> 152 mm), 22% of the *O. mykiss* sampled at this site were adults (Table 11.2).

It should also be noted that a large number of *O. mykiss* were either captured or visually observed at the confluence of Rock Creek with Sixmile creek (RCM02). When surveyed, the water temperature of mainstem Rock Creek was 3°C cooler downstream of the confluence with Sixmile

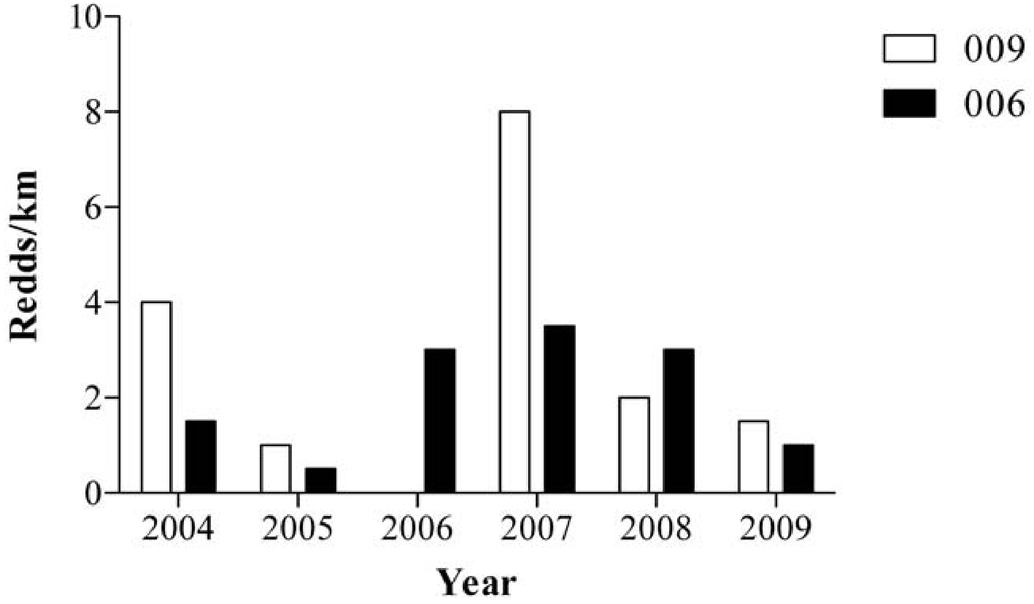

Figure 11.2. Density of steelhead (*Oncorhynchus mykiss*) redds observed at annual spawning survey sites in Rock Creek (OJD03458-009 and OJD03458-006) conducted from March to May, 2004–2009 (ODFW).

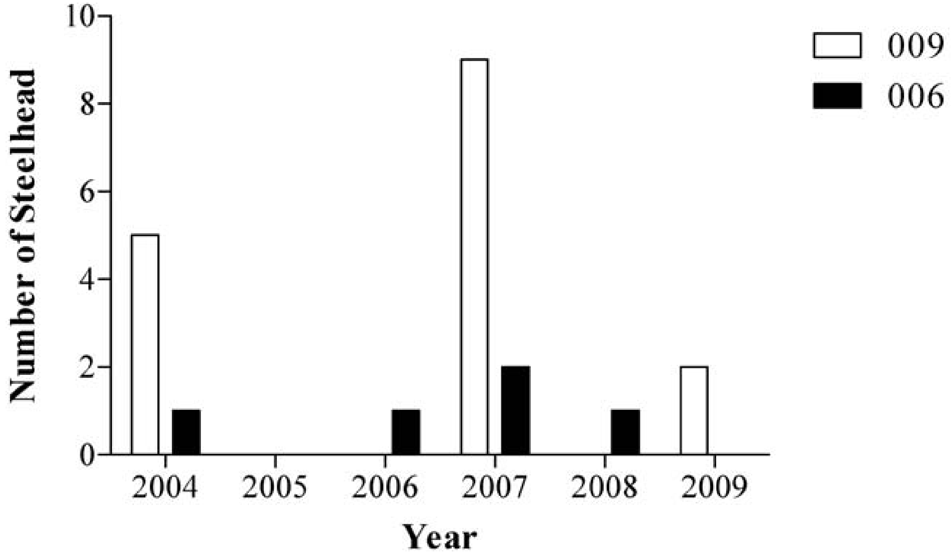

Figure 11.3. Number of live steelhead (*Oncorhynchus mykiss*) spawners observed at annual spawning survey sites in Rock Creek (OJD03458-009 and OJD03458-006) conducted from March to May, 2004–2009 (ODFW).

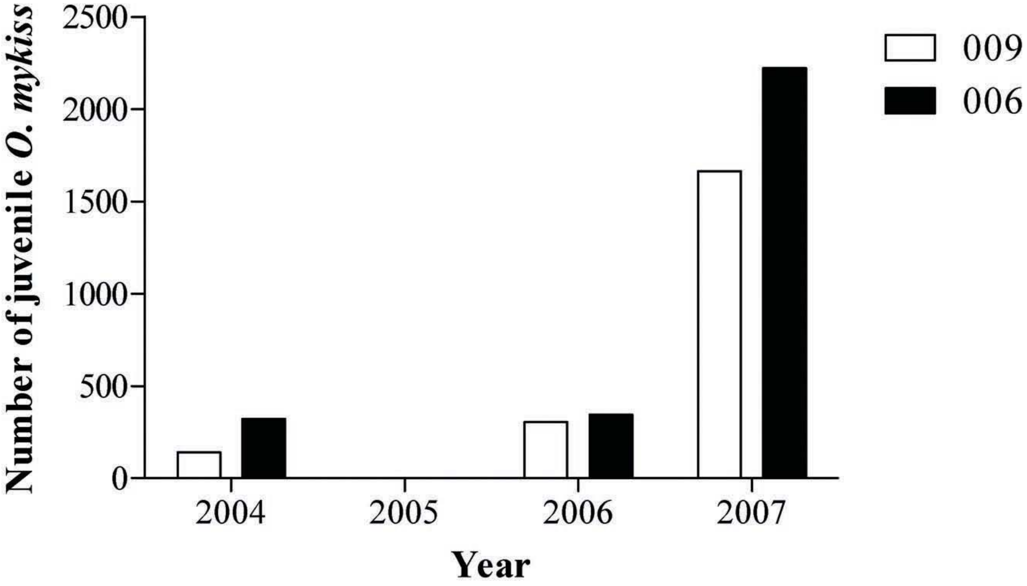

Figure 11.4. Number of juvenile steelhead (*Oncorhynchus mykiss*) observed at annual survey sites in Rock Creek (OJD03458-009 and OJD03458-006) conducted from March to May, 2004–2007 (ODFW).

Table 11.2. Number of juvenile (<152 mm) and adult (>152 mm) *Oncorhynchus mykiss*, by size class, captured by single-pass backpack electrofishing surveys of 100-m reaches within the Rock and Lonerock creeks watershed, Oregon, in July 2008.

		Size class		
Waterbody	Site Code	<152 mm	>152 mm	Total
Rock Creek, middle	RCM02	4	0	4
Rock Creek, upper	RCU01	0	0	0
Lonerock Creek	LRC01	18	5	23
Buckhorn Creek	BHC01	3	4	7

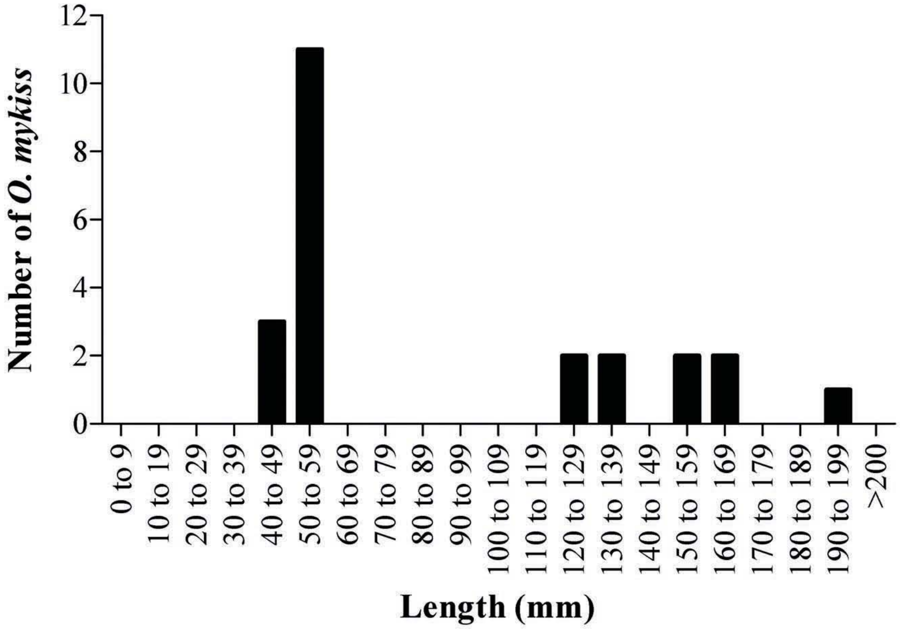

Figure 11.5. Length of frequency distribution of steelhead (*Oncorhynchus mykiss)* observed at Lonerock Creek survey reach (LRC01) conducted on 17 July 2008 (ABR).

Creek in comparison to the upstream water temperature. The cooler water input from Sixmile Creek seems to be providing a cool-water thermal refugium for *O. mykiss* in Rock Creek.

FISH COMMUNITIES

Little information describing fish communities exists for the Rock and Lonerock creeks watershed. While performing snorkel surveys for juvenile O. mykiss in 2006, ODFW observed incidental species including a mixed community of more tolerant minnows such as northern pikeminnow (Ptychocheilus oregonensis), redside shiners (Richardsonius balteatus), dace (Rhinichthys spp.), and suckers (Catostomus spp.) along with O. mykiss in the mainstem of Rock Creek (Table 11.3).

A similar community composition was observed during the electrofishing surveys of fish communities in the summer of 2008 conducted in conjunction with this assessment. Species observed during fish community surveys include redside shiners (*Richardsonius balteatus*), speckled dace (*Rhinichthys osculus*) bridgelip suckers (*Catostomus columbianus*) and sculpin (*Cottus* spp.; Figure 11.6). Northern pikeminnow were not observed during the 2008 surveys. Reaches were dominated or co-dominated by speckled dace (*Rhinichthys osculus*), which were the most numerically abundant species captured, while redside shiners (*Richardsonius balteatus*) were also commonly observed. Notably, sculpin were only observed at the most downstream site within the watershed (mainstem Rock Creek; RCM02); and were sampled from shallow areas both downstream and upstream of the confluence with Sixmile Creek.

FISH HABITAT

Understanding the current condition of fish habitat in the Rock and Lonerock creeks watershed is critical to understanding what changes to land management and watershed enhancement activities should be recommended. The current condition of fish habitat in the watershed should be compared to its potential to support healthy fish and macroinvertebrate communities. Identifying factors that are limiting the watershed's capacity to support productive resident redband trout and anadromous steelhead populations can result in

Table 11.3. Stream, site identification number, and presence (X) of incidental species collected during juvenile fish snorkel surveys in Rock Creek, Oregon, during 5–7 July 2006 (ODFW).

Waterbody	Site ID	Northern pikeminnow	Redside shiner	*Rhinichthys* spp.	*Catostomus* spp.	*Cottus* spp.
Rock Creek	OJD03458-009	X	X	X	X	
Rock Creek	OJD03458-006		X	X	X	
Rock Creek	OJD03458-539	X	X	X	X	X

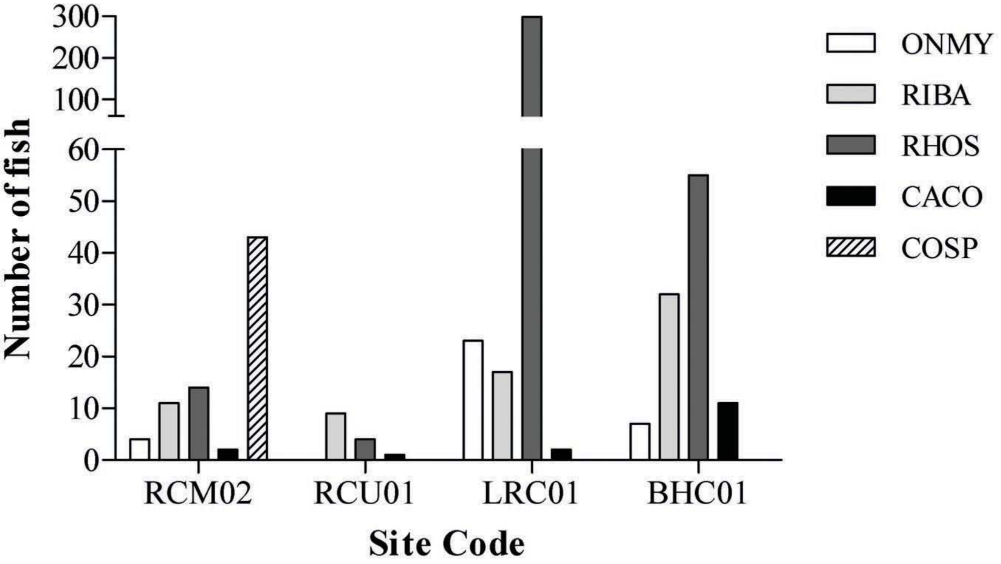

Figure 11.6. Number of individuals of redband trout/steelhead, *Oncorhynchus mykiss* (ONMY); redside shiners, *Richardsonius balteatus* (RIBA); speckled dace, *Rhinichthys osculus* (RHOS); bridgelip suckers, *Catostomus columbianus* (CACO), and sculpin, *Cottus spp.* (COSP); sampled during summer 2008 electrofishing inventories of four 100-m stream reaches in the Rock and Lonerock creeks watershed, Oregon.

prescribing restoration activities and best management practices that can improve conditions with respect to these impaired factors.

The John Day Subbasin Draft Plan (NWPPC 2004) lists habitat diversity, key habitat quantity, temperature, flow, sediment loading, and channel stability as factors limiting steelhead production in mainstem Rock Creek, based on output from the Ecosystem Diagnosis and Treatment (EDT) model. Among these, sediment loading received "high" priority in all three noted Rock Creek reaches (Lower Rock Creek, Rock Creek, and Upper Rock Creek); while key habitat quantity received "high" priority in the Upper Rock Creek reach. According to the model, those receiving the highest priority rating are factors that will result in the greatest benefit to steelhead populations if improved through restoration efforts and best management practices (NWPPC 2004). These efforts to identify limiting factors in Rock Creek were included in a larger effort to do so for every fifth-field watershed within the John Day subbasin (NWPPC 2004).

Very little information documenting the condition of fish habitat with the Rock and Lonerock creeks watershed was known to exist prior to this assessment. During 2008 field assessments of watershed conditions, instream and riparian habitat conditions were assessed in each of the six reaches within which macroinvertebrate surveys were performed and corresponded with three of the four fish sites (RCM02, LRC01, and BHC01; Figure 11.1). Physical habitat surveys generally followed those of the EPA EMAP protocols for assessing the ecological condition of wadeable streams (EPA 2000).

The quality of fish habitat varied substantially across the watershed and among reaches within the Rock and Lonerock creeks watershed. Most measured factors that govern fish habitat quality, including substrate composition, substrate embeddedness, stream shading, size and diversity of habitat types (pools, glides, and riffles), bank conditions, and woody debris abundance varied among reaches as described below

STREAM SUBSTRATE

Stream substrate embeddedness, the degree to which fine sediments surround coarse substrates, varied markedly among sites (range: 38.9% to 76.4%) and was generally high across the watershed, averaging 58.8% across all sampled reaches (Table 11.4). The middle Rock Creek reach at the confluence with Sixmile Creek (RCM02) had the lowest embeddedness, averaging 38.9% across all habitat types. Embeddedness was highest in the Rock Creek reaches that were the furthest upstream (RCU02) and the furthest downstream (RCL01), averaging 76.4% and 71.6%, respectively, across all habitat types. The remaining reaches including middle Rock Creek (RCM01), Lonerock Creek (LRC01), and Buckhorn Creek (BHC01) all had intermediate levels of embeddedness. Generally, reaches with lower percent substrate embeddedness supported larger numbers of *O. mykiss*. These embeddedness data generally suggest that an elevated load of fine sediment continues to enter Rock Creek and its tributaries, and is likely one of the most significant factors limiting steelhead and trout production in the watershed.

The proportion of coarse substrates (e.g., gravel, cobbles, and boulders) was inversely related to stream substrate embeddedness values and varied among the surveyed reaches. Coarse gravel that is free of significant accumulations of sediment provides ideal spawning substrate for steelhead. Coarse gravel and cobble was the predominant substrate type in the middle Rock Creek reach at the confluence with Sixmile Creek (RCM02) and the Lonerock Creek reaches (LRC01), where the highest number of *O. mykiss* was also observed (Table 11.4). The furthest downstream reach and furthest upstream reach of Rock Creek, where sediment problems appear to be most pronounced, are lacking adequate amounts of gravel and cobble necessary for steelhead and redband trout spawning and egg incubation (Table 11.4).

RIPARIAN CANOPY COVER AND BUFFER WIDTHS

Riparian zone conditions, and consequently, overhead canopy cover and attendant stream shading, varied widely among reaches. Riparian canopy cover was generally moderate among the survey reaches. However, these reaches were not randomly selected and therefore do not represent an average condition occurring in the watershed.

Table 11.4. Instream habitat and riparian conditions measured or observed in six 100-m reaches in the Rock and Lonerock creeks watershed, Oregon.

	Site Code					
	RCL01	RCM01	RCM02	RCU02	LRC01	BHC01
Wetted width	5.1	7.0	5.1	2.7	2.6	2.3
Bankfull width	6.1	10.7	8.0	5.0	5.2	4.7
Bankfull height	0.4	0.4	0.6	0.4	0.4	0.4
Incised height	0.0	0.0	0.1	0.0	0.0	0.3
Water depth	0.3	0.2	0.2	0.1	0.1	0.1
W:D ratio	18.5	38.7	32.0	31.8	45.5	29.2
Bankfull W:D ratio	16.2	26.5	14.5	13.5	11.8	10.5
Percent pool habitat	32.0	41.2	32.3	41.7	12.2	14.7
Percent glide habitat	49.3	50.7	52.5	43.3	76.4	57.3
Percent riffle habitat	18.7	8.1	15.2	15.0	11.5	28.0
Percent cascade habitat	0.0	0.0	0.0	0.0	0.0	0.0
Percent sand and fines	58.2	36.4	16.7	63.0	24.1	45.5
Percent coarse substrate	30.9	56.4	73.3	35.2	63.0	52.7
Percent embeddedness	71.6	49.5	38.9	76.4	51.1	65.3
Percent canopy cover	24.9	75.0	92.6	78.3	52.0	45.5
Fish cover	1.1	1.2	0.8	1.3	1.3	1.0
Rapid habitat assessment score	13.3	11.2	9.9	11.9	12.7	12.8

Canopy cover ranged from 24.9% to 92.6% among the six survey reaches (Table 11.4). Riparian conditions along Rock Creek, Lonerock Creek, and the tributaries to both, are highly variable and are often completely devoid of woody riparian vegetation.

The importance of reestablishing and maintaining well-vegetated riparian conditions in the Rock and Lonerock creeks watershed cannot be overstated. The vegetation provides bank and channel stability, stream shading (and therefore moderation of water temperatures), and inputs of wood and leaf material and sources of food and cover for aquatic life. Such functions have been impaired in the watershed as a result of removal and loss of streamside vegetation. Robert Behnke, a highly regarded trout and salmon biologist, believed that the best opportunity for increasing populations of resident fish in western North America is to improve riparian habitat conditions that have been adversely affected by livestock (Behnke 1977).

WOODY DEBRIS

Numbers and size of instream LWD would be expected to vary among vegetative community types within a watershed. Therefore, this analysis focused on examining the number of pieces of LWD occurring in each reach relative to that in other reaches within the same ecoregion. Across all ecoregions and expected riparian vegetative classes, counts ranged from 0 to 38 pieces of LWD, of which all but one piece were in the 1.5–5.0 m length class. Numbers were highest within the middle Rock Creek reach (RCM01) and the uppermost Rock Creek reach (RCM02), with 38 and 23 pieces respectively, each of which would have been expected to support forested riparian zones. Areas such as these, with higher concentrations of LWD, corresponded with the widest riparian zones among the surveyed reaches. Conversely, no pieces of large woody debris were present in the furthest downstream reach of Rock Creek (RCL01) where the riparian zone tends to be devoid of trees (Figure 11.7). Because the natural riparian vegetative community in the lower reaches of Rock Creek is expected to have been dominated by grasses and shrubs, woody debris counts would be expected to be considerably lower than in upper sections of the watershed.

Instream woody debris helps to create and maintain fish habitat by adding structure to the stream channel that creates refuge for the fish and increases hydraulic turbulence, thereby producing local scour and deposition areas, which increase habitat complexity. Maintenance of intact riparian zones stocked with mature trees ensures a supply of these materials to the stream channel. The lack of older, mature shrubs and trees in sections of the middle and even upper watershed has resulted in less input of woody materials and an attendant decrease in habitat quality, complexity, and cover for aquatic life. While these limited surveys suggest that some recruitment is presently occurring in the middle and upper portions of the watershed, increased woody debris and the attendant improvements to aquatic habitat conditions is just one of many benefits derived from restoration of riparian zones.

BANK STABILITY

Bank stability ratings were similar among reaches, suggesting that the surveyed reaches are experiencing similar levels of bank erosion. Scores ranged from a 12 to 14, indicating moderately stable banks with infrequent, small areas of bank erosion. Such conditions fall within the "sub-optimal" category for this type of habitat assessment. However, a number of reaches on the mainstem of Rock Creek have been incised (down cut into the floodplain) and it is likely that bank erosion and bank failure are an issue within these reaches. Unstable banks contribute to elevated sediment loads, and their instability leads to lateral erosion and potential widening of stream channels, which in turn, can increase width-to-depth ratios, decrease habitat quality (pool depths, for example), and increase stream temperatures.

POTENTIAL FISH PASSAGE BARRIERS

DIVERSION DAMS

Five significant concrete diversion dams are present on the mainstem of Rock Creek including two in the French Charlie subwatershed: the Lower Ramsey Diversion and the Upper Ramsey Diversion, and three in the Juniper Canyon subwatershed: the Bettencourt Diversion, the Lower Kayser Diversion, and the Upper Kayser Diversion (Table 11.5). At the time of this assessment, only the Bettencourt Diversion had a dedicated fish passage structure which was passing both juvenile and adult salmonids. A fish ladder was installed by the ODFW in 2005 (Figure 11.8). While a fish passage structure exists on the Upper Ramsey Diversion, it currently does not meet the standards established by ODFW for juvenile fish passage. The Gilliam SWCD, in conjunction with the Gilliam-East John Day Watershed Council, submitted grant applications to OWEB in the fall of 2009 to install fish passage structures on the Lower Ramsey and Upper Kayser Diversions with matches from ODFW and the Bonneville Power Administration (BPA). Grant applications for fish passage structures on the remaining two diversions (Upper Ramsey and Lower Kayser) were submitted in the fall of 2010. Funding was awarded for each of the four projects which are currently in the design phase. The designs differ for each diversion: the Lower Ramsay Diversion will be re-graded downstream of the diversion, the concrete fish ladder at the Upper Ramsay diversion will be redesigned to facilitate fish passage, the Lower Kayser diversion will be re-stepped and re-graded, and the Upper Kayser diversion will be re-graded. All four of the designs will incorporate elements that facilitate the passage of both juvenile and adult life stages.

The only other significant diversion dam within the watershed occurs on the mainstem of Buckhorn Creek in the Buckhorn Creek subwatershed. A fish ladder was installed on this structure during the summer of 2008 to provide fish passage for both juvenile and adult salmonids (Figure 11.9).

Figure 11.7. Degraded riparian zone conditions along the middle mainstem of Rock Creek, Gilliam County, Oregon.

Table 11.5 Diversion dams within the Rock and Lonerock creeks watershed, Oregon.

			Fish passage		
Name	Subwatershed	Waterbody	Structure	By juveniles	By Adults
Lower Ramsey Diversion	French Charlie	Rock Creek	No	No	Possible
Upper Ramsey Diversion	French Charlie	Rock Creek	Fish ladder	No	Yes
Bettencourt Diversion	Juniper Canyon	Rock Creek	Fish ladder	Yes	Yes
Lower Kayser Diversion	Juniper Canyon	Rock Creek	No	No	Possible
Upper Kayser Diversion	Juniper Canyon	Rock Creek	No	No	No
Unnamed	Buckhorn Creek	Buckhorn Creek	Fish ladder	Yes	Yes

Figure 11.8. Bettencourt Diversion on mainstem Rock Creek with fish ladder installed by ODFW in 2005, Juniper Canyon subwatershed, Oregon.

Figure 11.9. Diversion dam on mainstem Buckhorn Creek with recently installed fish ladder, Buckhorn Creek subwatershed, Oregon.

ROAD CROSSINGS

A number of road crossings of creeks occur within the Rock and Lonerock creeks watershed. Most of the major road crossings along mainstem creeks within the watershed are bridges which have very minimal, if any, effect on fish passage. Based on surveys of accessible roads along the mainstem of Rock Creek, the first road crossing which is not a bridge occurs where Highway 207 crosses Rock Creek on the border of the Wild Call Canyon and Chapin Creek subwatersheds (Figure 11.10). However, it should be noted that the Rock Creek reach between the Buttermilk Canyon Road crossing upstream to the Highway 207 road crossing was inaccessible due to private ownership. A high density of private crossings of Rock Creek which provide access to National Forest Development Road 022 occur upstream of the Highway 207 road crossing. This approximately 1.2-mile stream reach between the confluence with John Z Canyon and the confluence with Harris Canyon has six road crossings, four of which have culverts and two with free-standing bridges.

Culverts at road crossing are more common in the headwaters of the Rock and Lonerock creeks watershed. According to the Oregon Mid-Columbia Steelhead Recovery Plan (http://www.nwr.noaa.gov/MidColStlhdV1/draft-recovery-plan.html), there are three high-priority culverts that need to be improved or replaced within the Rock and Lonerock creeks watershed. These culverts occur within the Buckhorn Creek subwatershed: two within Stahl Canyon and one on Wineland Creek. All three are located within the Umatilla National Forest in Wheeler County. In May 2009, a qualitative culvert survey was performed at accessible road crossings in the upper watershed. Culverts that are likely limiting or blocking fish passage were observed at Stahl Canyon and Wineland Creek road crossings (Figures 11.11 and 11.12). These culverts may be the high priority culverts noted in the recovery plan, but no specific information was given.

Figure 11.10.Highway 207 road crossing of mainstem Rock Creek on the border of the Wild Call Canyon and Chapin Creek subwatersheds, Oregon.

Figure 11.11. Culvert outlet drop at the Stahl Canyon road crossing within the Umatilla National Forest (Wheeler County), Buckhorn Creek subwatershed, Oregon.

Figure 11.12. Culvert outlet drop at the Wineland Creek road crossing within the Umatilla National Forest (Wheeler County), Buckhorn Creek subwatershed, Oregon.

DATA GAPS

- While this assessment included field surveys aimed at beginning to characterize aquatic habitat conditions in the watershed, a more thorough inventory of aquatic habitat conditions would help better quantify factors limiting steelhead and resident trout production and would assist with identifying specific restoration opportunities.
- Information describing fish community composition is limited for the Rock and Lonerock creeks watershed. Data is limited to incidental data collected by ODFW and surveys conducted in conjunction with this assessment.
- Relative abundance, distribution, and extent of *O. mykiss* within the watershed.
- The extent to which stray hatchery fish are present in natural spawning areas.
- Quantitative and current data describing physical habitat conditions for native fish in the watershed.

SUMMARY AND RECOMMENDATIONS

Steelhead in the Rock and Lonerock creeks watershed belong to the Lower John Day River population within the John Day River Major Population Group of the Middle Columbia River Steelhead Distinct Population Segment. The population is considered “very large” with a mean minimum abundance threshold of 2,250 spawners. Three of 11 Major Spawning Areas for this population occur with the Rock and Lonerock creeks watershed, emphasizing the importance of the watershed to contributing to the maintenance of the lower John Day steelhead population. Data collected over the past six years suggest variability in the population size among years, but no significant overall upward or downward trends in abundance have occurred over this period.

Past land-management practices, extensive poorly-managed grazing, fire suppression, and logging, in particular, resulted in changes in Rock Creek and Lonerock Creeks’ physical characteristics that persist to this day. These changes include increased sediment loads, increased water temperatures, lower summer flows, eroding streambanks, less riparian vegetation, channel incision and other changes to the size and shape of stream channels within the watershed. Although these deleterious effects are evident in places throughout the watershed, little information currently exists that characterizes these conditions in the watershed or identifies areas where conditions are particularly good or poor. This assessment included field surveys of habitat conditions aimed at beginning to characterize the physical and biological conditions of Rock Creek and Lonerock Creek.

According to ODFW (2008a), primary limiting factors to steelhead in Rock Creek include degraded channel structure and complexity (habitat quantity and diversity), increased sediment loading, elevated water temperatures, and altered hydrology. Fish passage is also listed as a high-priority limiting factor in a number of creeks by ODFW, including Rock Creek, and the Gilliam SWCD is working with ODFW to provide fish passage at all five diversion structures on the creek. Habitat strategies specific to areas within the Rock and Lonerock creeks watershed as defined by ODFW (2008a) include the following:

- Restore passage and connectivity (Rock, Upper Rock, Middle Rock, and Lonerock)
- Restore degraded and maintain properly functioning channel structure and complexity (Rock, Middle Rock)
- Restore natural hydrograph to provide sufficient flow during critical periods (Rock)
- Restore riparian condition and LWD recruitment (Lonerock)

The primary threats to steelhead in the Lower John Day River include hatchery management that results in high rates of straying hatchery fish in natural spawning areas, current land use practices, water withdrawals, wetland draining and conversion, stream channelization and diking, and the Columbia River mainstem hydropower system (ODFW 2008a). Land-use practices include agricultural and grazing practices which result in the removal of canopy cover and bank vegetation from the riparian corridor.

The Gilliam SWCD is currently engaging in a number of projects in Rock Creek aimed at addressing a number of these issues. In addition to the fish passage improvements being made at diversions on Rock Creek, the SWCD is seeking financial assistance to remove juniper from thousands of acres in the watershed, which should result in improved summertime hydrologic conditions in and downstream of Lonerock Creek. The first phase of this project totaled 3,500 acres while the second phase is expected to address another 1,500 acres. Continued use of the CREP program will also benefit Rock and Lonerock creeks by improving riparian zone conditions, which will result in improved channel stability, decreased rates of bank erosion and lower summer water temperatures.

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APPENDIX A. ECOREGION DESCRIPTIONS

The following information has been excerpted from the OWEB Watershed Assessment Manual (Source WPN 1999, Appendix A). Ecoregion descriptions for the Umatilla Plateau (10c), the Pleistocene Lake Basin (10e), the Deschutes/John Day Canyons (10k), the John Day/Clarno Highlands (11b), and the Maritime-Influenced Zone (11c) ecoregions have been included as a portion of each of these five ecoregions occurs in the Rock and Lonerock creeks watershed. All other ecoregion descriptions included in the OWEB Watershed Assessment Manual have been excluded from this document. However, the introductory information, background information, acknowledgments, and references have been retained as a reference.

INTRODUCTION

The ecological geography of Oregon has a significant influence on the response of streams and stream ecosystems. There is a rich literature on the use of watersheds, basins, or ecoregions as a framework for water quality planning (Griffith, Omernik and Woods, 1999; Omernik and Griffith, 1991, Omernik, 1995, Hughes, Heiskary, Matthews, and Yoder, 1990). Ecoregions are relatively uniform geographic areas that respond in a similar manner to physical activities (rainfall, fire, human land use activities, etc.). The identification of ecoregions within a watershed context is a very important exercise in determining how the different portions of the watershed will respond to physical alterations.

The ecoregions of Oregon have been mapped (Clarke, White and Schaedel, 1991; Omernik and Gallant, 1986; Thiele, Pater, Thorson, Kagan, Chappel and Omernik, 1996) and the Level IV mapping is being reviewed for the High Desert ecoregion (Omernik, personal communication, 2001). In a separate effort Anderson, Borman and Krueger (1998) have identified ecological provinces using different criteria and focusing on the use of soils mapping to differentiate ecological areas of Oregon. A similar approach has been used by the Oregon Natural Heritage Council in their efforts to maintain a list of threatened and endangered species for the state (Oregon Natural Heritage Program, 2001; Defenders of Wildlife, 1998). Ecoregion mapping used for this document is the mapping of the Natural Heritage Program and EPA (Thiele, et.al.).

It is intended that the ecoregion descriptions (Chapter 2) will be used to identify expected characteristics that affect watershed processes.

BACKGROUND ON ECOREGION DESCRIPTIONS

The State of Oregon is divided into ecoregions that have been identified based on climate, geology, physiography, vegetation, soils, land use, wildlife, and hydrology. Each ecoregion has characteristic disturbance regimes that shape the form and function of watersheds in the region. This assessment manual recognizes that watersheds within an ecoregion will have characteristic patterns. Both the Environmental Protection Agency (EPA) and the Oregon Natural Heritage Program (ONHP) have developed ecoregion boundaries for the state of Oregon. Both agencies are also in the process of updating their ecoregion boundaries. The most significant changes are going to occur in southeast Oregon where 13 new level IV ecoregions are being defined. However since the boundaries of these ecoregions have not been finalized at the time of this documents publication. This Appendix uses EPA Level III and Level IV ecoregion descriptions to characterize patterns within a watershed. More information about ecoregions is available from Omernik and Gallant (1986), Omernik (1994), Clarke and Bryce (1997), and Pater et al. (1998).

The purpose of this appendix is to organize information that can be helpful to Watershed Councils in interpreting watershed conditions. The Riparian and Hydrology sections of the manual utilize this information to simplify their assessment process. Addendum 1 at the end of this document gives the percentage of watershed area for each fifth-field watershed in Oregon by Ecoregion type. The general format of each Ecoregion Description in this draft is as follows:

Title: Title of the ecoregion; corresponds to ecoregion map of Oregon. To obtain GIS coverage of the ecoregion map contact the State Service Center for GIS at 503-378-2166.

Location: General description of the ecoregion location and extent, and elevation ranges for the ecoregion where appropriate. Also included is a small map showing the ecoregion area (in black) and county boundaries (in light gray).

Drainage Basins: A list of the primary drainage basins that occur in the ecoregion is listed. Drainage basins are those identified by the Oregon Water Resources Department. Addendum 1 identifies the percentage of watershed area by ecoregion.

Geology: General geology; type of rock and structure. Information obtained from geology maps, Environmental Protection Agency (EPA) ecoregion descriptions, and expert judgment.

Topography: General description of stream system; channel density and gradient by size class (small, medium, and large streams as indicated on Department of Forestry maps). Information obtained from EPA ecoregion descriptions and expert judgment.

Soil: General soil types by slope steepness. Information obtained from EPA ecoregion descriptions and expert judgment.

Erosion: Relative erosion rates and dominant erosional processes. Information obtained through expert judgment.

Climate Characterization: General descriptions of climatic conditions in each ecoregion.

Mean Annual Precipitation: Mean annual precipitation for each ecoregion as developed by Daly and Taylor, 1998 and from Pater et al. 1998.

Precipitation Pattern: Seasonal distribution of precipitation within each ecoregion and exemplified graphically for one station within each ecoregion. For ecoregions where no data were available, values were extrapolated from nearby stations.

2-Year 24-Hour Precipitation: Range of 2-year 24-hour precipitation values within each eco-region from NOAA, 1973.

Temperature: Mean, maximum, and minimum air temperatures within each ecoregion for July and January per Oregon Climate Service and Pater et al. 1998. For ecoregions where no data were available, values were extrapolated from nearby stations.

Snowpack Development: Characterization of winter snowpack for the ecoregion.

Hydrologic Basin Characteristics: General descriptions of basin characteristics affecting runoff.

Runoff Patterns: General description of runoff exemplified graphically through an annual hydrograph from one stream in each ecoregion. Data were extrapolated from nearby stations for each ecoregion where no data were available.

Peak Flow Generating Processes: Description of dominant peak flow generating process (e.g. rainfall, snowmelt, rain-on-snow).

Peak flow magnitude: Peak flow associated with the 2-year recurrence interval for streams within the ecoregion. Units are cubic feet per second per square mile of drainage area.

Stream Channels: General stream **substrate** descriptions by stream size class (Department of Forestry maps) and relative channel gradient class (lower gradient, higher gradient). Dominant substrate followed by sub-dominant substrate. Information obtained through expert judgment. Relative current abundance of **beaver dams** (many, some, few, none) and seasonal presence (summer only, year-round). Information obtained through expert judgment.

Natural disturbances: Significant landscape-level natural disturbances that can influence vegetation and/or erosion rates (wildfire, large earthquakes, wind storms, disease, insects).

Potential Streamside vegetation: Potential streamside vegetation can be viewed as the vegetation after 120 years of growth with no major natural disturbances and no human-caused disturbances (tree removal, animal grazing, and encroachment of buildings or roads). Does not include description of streamside vegetation following infrequent (average intervals of one to many centuries) and major disturbances such as floods, windstorms, wildfire, or earthquakes. Descriptions are according to valley type (constrained, semi-constrained, and unconstrained). Average widths of the stream-adjacent riparian area (RA1), and (if applicable) upland-adjacent riparian area (RA2) are provided. Dominant species or types (e.g., conifers, hardwoods) of vegetation are described for each zone. Focus is on general pattern with some exceptions noted, such as unstable slopes, wet soils, low terraces, and beaver disturbance.

Streamside vegetation is highly variable and dynamic. Potential streamside vegetation descriptions provide a minimum set of guidelines against which current conditions can be evaluated. Species lists do not comprise a plant community. All of the species listed may not be present together on a site.

Information has been obtained through expert judgment, published literature, and un-published reports.

Current streamside conifer regeneration: Relative abundance of conifers that occupy streamside areas under current conditions, along with factors that influence their abundance or lack of abundance.

Upland vegetation: Common types of upslope overstory and understory vegetation, starting about 200 feet from streams.

Historic Crown Closure: Generalized historic crown closure estimates for upland stands in the ecoregion. This attribute is important for determining hydrologic regimes. All information obtained through expert judgment, primarily from USDA Forest Service forestry professionals

Land Use: Dominant land uses present in the ecoregion.

Other: Includes comments on other factors that influence streams.

This information was compiled from a number of different sources. Table 1 lists the primary sources for the information included in this document. For land use and land cover, descriptions from Pater and others (1998) were used for ecoregions 4-9, and 78. "Potential natural vegetation" was described only where it differed markedly from current land cover types. Comments on that map, generally about land ownership or importance as a water source, were noted in "Additional Comments" section. For ecoregions 10 and 11, native vegetation descriptions were taken from Clarke and Bryce (1997). Land use and land cover are obtained through expert judgment (refer to Clark and Bryce (1997), especially for the Blue Mountains, for their explanation of the complexity of the region). For ecoregion 12 (Snake River Basin/High Desert), descriptions were taken from Omernik and Gallant (1986). Fire history comments for all regions were summarized from Agee (1993). Potential streamside vegetation information was obtained through expert judgment, and from Crowe and Clausnitzer (1997), Diaz and Mellen (1996), Kovalchik (1987), Manning and Padgett (1995), McCain (1998), Atzet (pers. Comm., 2000), Frenkel and Heintz (1987), Hall (pers. Comm. 2000), Hemstrom and Logan (1986), Kovalchik (1987), Kovalchik et. al. (1988), Crowe and others (2000) and Wickramarantne (1983).

Table 1: Sources of Information for Ecoregion Descriptions.

Topic	Pater et al. (1998)	Clarke and Bryce (1997)	Franklin and Dyrness (1988)	Experience of compilers	Experience of riparian vegetation reviewers	Other
Precipitation	X					Oregon Climate Service, Oregon State University, Website 2000 Daly and Taylor, 1998, NOAA, 1973
Runoff	X	X		X		Greenberg & Welch, 1998 WPN, 2000, USGS Report, 1983 EarthInfo, 1996
Peak flows						Greenberg & Welch, 1998 , WPN, 2001, USGS Report, 1983 EarthInfo, 1996
Geology	X	X		X		
Topography	X	X		X		
Soil type	X	X		X		
Erosion	X	X		X		
Channel substrate	X	X		X		
Beaver dams				X	X	
Natural disturbances	X	X		X		Agee 1993
Potential streamside vegetation				X	X	Crowe and Clausnitzer (1997), Diaz and Mellen (1996), Kovalchik (1987), Manning and Padgett (1995), McCain (1998), Frenkel and Heintz (1987), Hemstrom and Logan (1986), Kovalchik and others (1988), Crowe and others (2000), Wickramarantne (1983).
Current streamside conifer regeneration				X	X	
Upslope vegetation	X	X	X	X	X	

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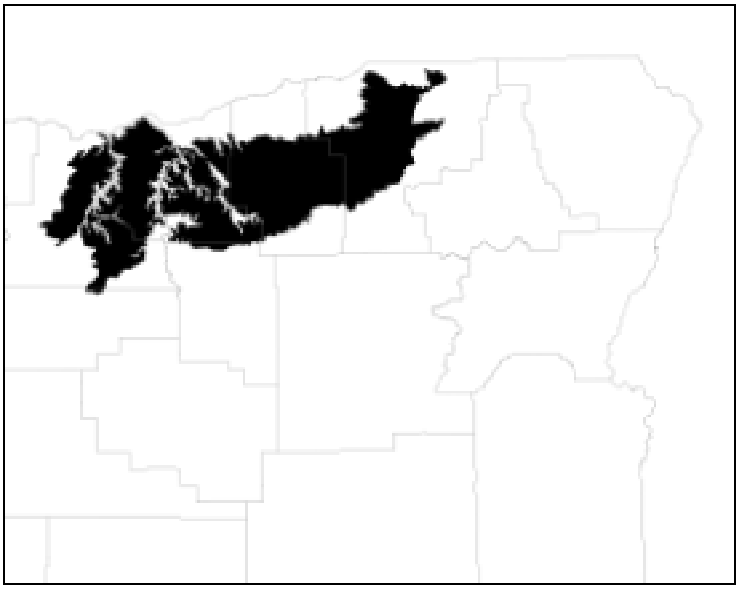
Umatilla Plateau (10c)



Location: High plateau south of the Columbia River and north of the Blue Mountains

Drainage Basins: Umatilla, John Day, Deschutes and Hood River Basins

Geology: Geology is wind-deposited soil underlain by basalt flows.

Topography: Consists of undulating hills and plateaus dissected by steep-sided canyons, in which, the major rivers flow. Streams have a moderate gradient. Stream density is low within watersheds.

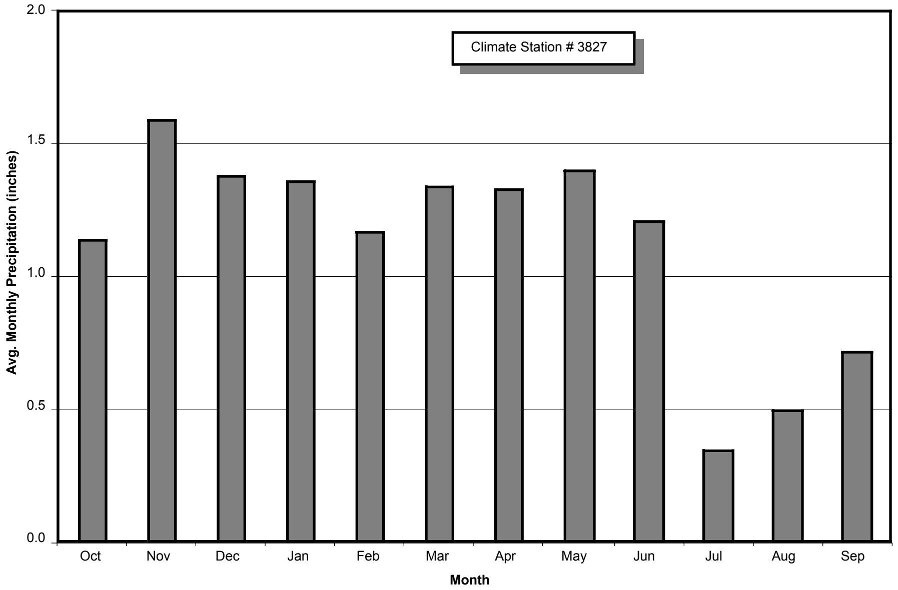
Soil: Wind-deposited silt soils, thick in north and thin in south.

Erosion: Erosion rate is moderate; precipitation is usually low, yet high-intensity thunderstorms can occur during summer, causing rill and gully erosion.

Climate characterization: Climate is continental with a marine influence. The relatively dry climate is due to the rain shadow effect from the Cascade Mountain range. Winters are cold and summers hot with an occasional thunderstorm. Majority of the precipitation falls in winter, mainly as snow in the higher elevations.

Mean annual precipitation: 10 to 20 inches.

Precipitation Pattern: The majority of the precipitation is spread out during late fall, winter, and early summer from October to June.



2-year 24 hour precipitation: From less than 1.0 to 1.6 inches.

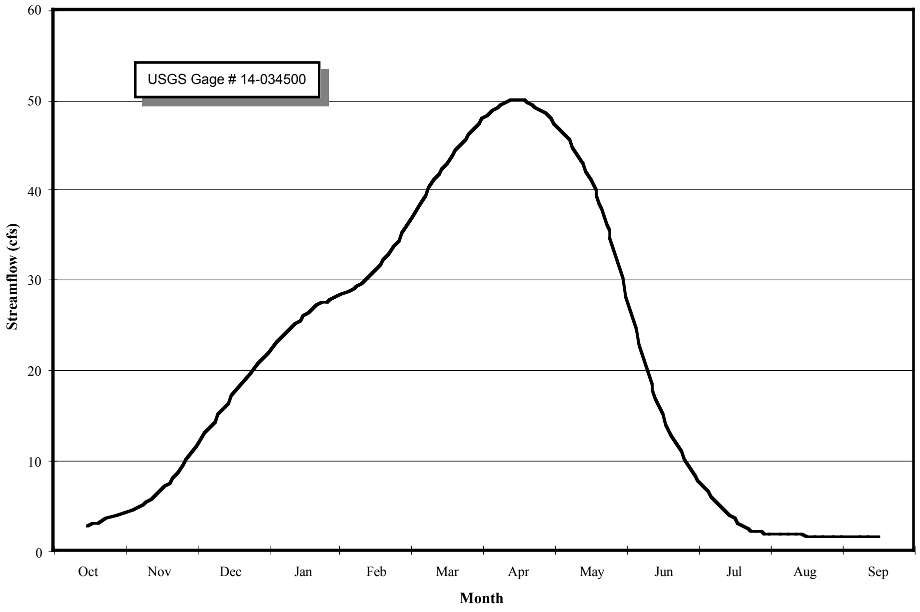
Temperature

	January			*July*		
°F	**41**	**27**	**33**	**85**	**56**	**70**
	Maximum	Minimum	Mean	Maximum	Minimum	Mean

Snowpack development: Most precipitation during winter months falls as snow and snowmelt can minimally contribute to runoff. Deep snowpacks rarely develop below 3,000 feet.

Hydrologic basin characteristics: Basins are oriented to the north, draining into the Columbia River. Streams generally have a moderate gradient.

Runoff patterns: Average monthly streamflows are highest in the spring months.



Peak flow generating process: Rainfall

Peak flow magnitude (2-year recurrence interval): less than 10 cfs/mi^2, with a few 10 cfs/mi^2 to 20 cfs/mi^2.

Stream channels:

		Small	*Medium*	*Large*
Substrate	lower gradient	fines / gravel	gravel	gravel / cobble
	higher gradient	gravel	gravel / cobble	cobble
Beaver dams	lower gradient	Some year-round	some year-round	some in summer
	higher gradient	Few year-round	none	none

Natural Disturbances:

Potential streamside vegetation:

CHT group	RA1 zone	RA1 description	RA2 width	RA2 description	Other considerations
Constrained	0-25’	**Type**: Shrubs such as Douglas spirea, red osier dogwood, willows, water birch, and mountain alder. **Size**: N/A **Density**: N/A	N/A	**Type**: N/A **Size**: N/A **Density**: N/A	
Semi-constrained	0-50’	**Type**: Shrubs such as Douglas spirea, red osier dogwood, willows, water birch, and mountain alder. **Size**: N/A **Density**: N/A	N/A	**Type**: N/A **Size**: N/A **Density**: N/A	
Un-constrained	0-75’	**Type**: Shrubs such as Douglas spirea, red osier dogwood, willows, water birch, and mountain alder. **Size**: N/A **Density**: N/A	N/A	**Type**: N/A **Size**: N/A **Density**: N/A	

Current Streamside Conifer Regeneration: Naturally not present.

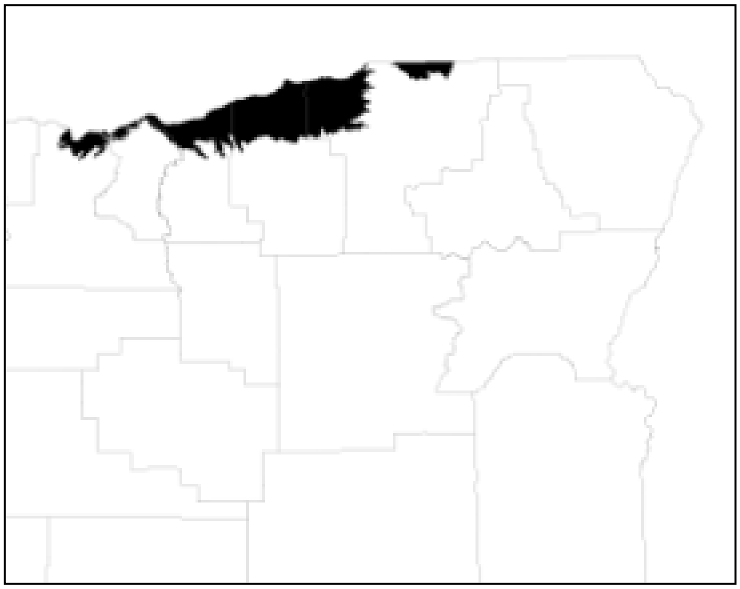
Upland vegetation: Agricultural crops (primarily wheat). Native vegetation includes bluebunch wheatgrass, Idaho fescue, rose, hawthorn, and snowberry.

Historic Crown Closure: Less than 30%.

Land Use: Wheat farming, grazing.

Other:

Pleistocene Lake Basin (10e)



Location: Lowlands immediately south of the Columbia River in north-central Oregon.

Drainage Basins: Umatilla, John Day and Hood River, and Deschutes Basins

Geology: Geology is lake deposits caused by temporary ponding during the Missoula floods.

Topography: Consists of low-gradient slopes. Streams have a moderate to low gradient. Stream density is very low within watersheds. Perennial streams originate in the Blue Mountains. Many streams are intermittent.

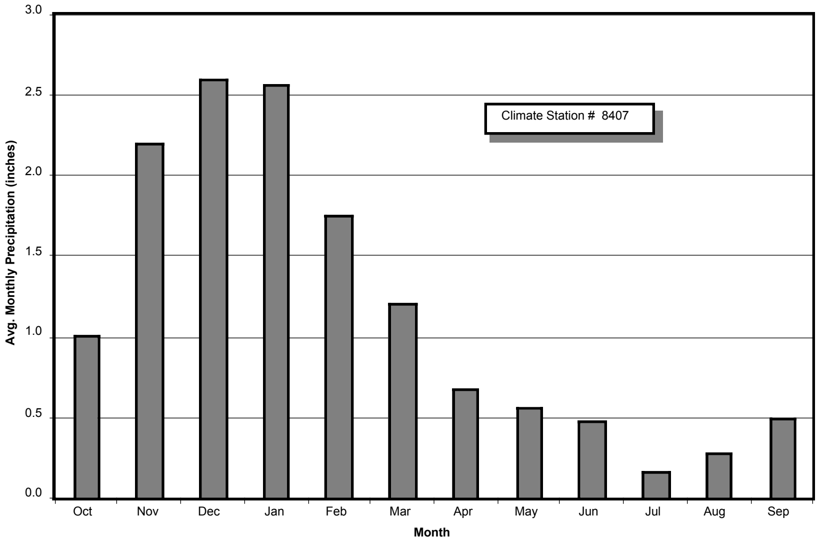
Soil: Flood-deposited silty loams.

Erosion: Erosion rate is low due to low precipitation and gentle slopes.

Climate characterization: Climate is continental with a marine influence. The relatively dry climate is due to the rain shadow effect from the Cascade Mountain range. Winters are cold and summers hot with an occasional thunderstorm. Majority of the precipitation falls in winter, mainly as snow in the higher elevations. Vigorous winds are common in and around the Columbia Gorge during winter and summer months. Moderation of air temperatures can occur as west flowing maritime air reaches the region through the Columbia River corridor. By contrast, large-scale easterly airflows can bring very cold continental air into the region.

Mean annual precipitation: 5 to 10 inches.

Precipitation Pattern: Majority of the precipitation occurs during the winter months of November, December, and January.



2-year 24 hour precipitation: From less than 1.0 to 1.2 inches

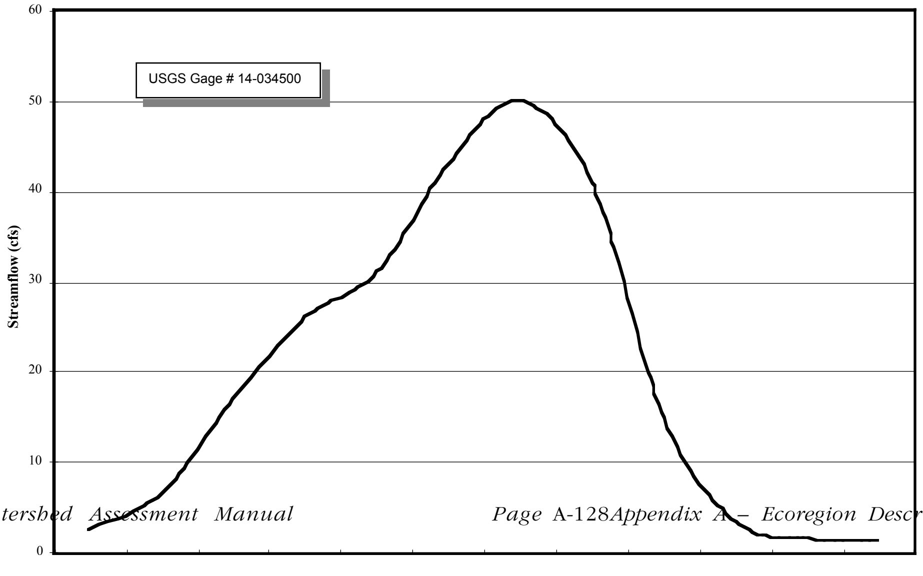
Temperature

	January			*July*		
°F	**43**	**30**	**37**	**88**	**60**	**74**
	Maximum	Minimum	Mean	Maximum	Minimum	Mean

Snowpack development: Winter precipitation falls primarily as rain in lower elevation and snow on ridges. Snowpack development can occur at the higher elevations, however they likely do not persist for long.

Hydrologic basin characteristics: Basins are oriented to the north, draining into the Columbia River. Streams have a medium to low gradient.

Runoff patterns: Average monthly streamflows are highest in the spring months.*



*as represented by a stream gage from ecoregion 10c because no daily values were available for this ecoregion.

Peak flow generating process: Rainfall

Peak flow magnitude (2-year recurrence interval): Less than 10cfs/mi^2

Stream channels:

		Small	*Medium*	*Large*
Substrate	lower gradient	fines / gravel	gravel	gravel / cobble
	higher gradient	gravel	gravel / cobble	cobble
Beaver dams	lower gradient	few year-round	few year-round	few in summer
	higher gradient	few year-round	none	none

Natural Disturbances:

Potential streamside vegetation:

CHT group	RA1 zone	RA1 description	RA2 width	RA2 description	Other considerations
Constrained	0-25'	**Type**: Shrubs such as mountain alder, red osier dogwood and willows. **Size**: N/A **Density**: N/A	N/A	**Type**: N/A **Size**: N/A **Density**: N/A	
Semi-constrained	0-50'	**Type**: Shrubs such as mountain alder, red osier dogwood & willows. Galleries of black cottonwood occurred in areas of perennial streamflow. **Size**: N/A **Density**: N/A	N/A	**Type**: N/A **Size**: N/A **Density**: N/A	
Un-constrained	0-75'	**Type**: Shrubs such as mountain alder, red osier dogwood and willows. Galleries of black cottonwood occurred in areas of perennial streamflow **Size**: N/A **Density**: N/A	N/A	**Type**: N/A **Size**: N/A **Density**: N/A	

Current Streamside Conifer Regeneration: Naturally not present.

Upland vegetation: Big sagebrush, bluebunch wheatgrass.

Historic Crown Closure: Less than 30%.

Land use:

Other:

Deschutes / John Day Canyons (10k)

Location: Deep canyons of the Deschutes River and John Day River.

Drainage Basin: John Day Basin

Geology: Geology is basalt lava flows

Topography: Consists of very steep-sided canyons cutting through plateaus. Streams have a moderate to steep gradient. Main rivers originate within ecoregions to the south that have more rain and snow. Perennial tributary streams often originate at springs at the base of canyon walls.

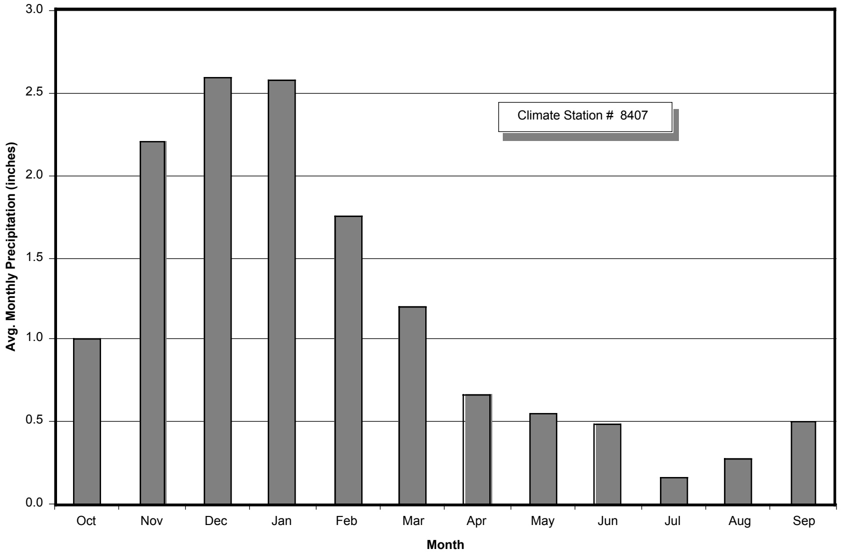
Soil: Clay loam to gravelly loam.

Erosion: Erosion rate is moderate. Most erosion occurs during high intensity runoff events during snow melt periods or during thunderstorms. Shallow landslides usually occur in steep depressions along canyon walls and often trigger debris torrents that travel to the main river or stream.

Climate characterization: Climate is continental with a marine influence. The relatively dry climate is due to the rain shadow effect from the Cascade Mountain range. Winters are cold and summers hot with an occasional thunderstorm. Majority of the precipitation falls in winter, mainly as snow in the higher elevations.

Mean annual precipitation: 10 to 15 inches.

Precipitation Pattern: Majority of the precipitation occurs during the winter months of November, December and January.*



* as represented by climate data from ecoregion 10e because no climate data were available for this ecoregion.

2-year 24 hour precipitation: 1.2 to 1.6 inches

Temperature

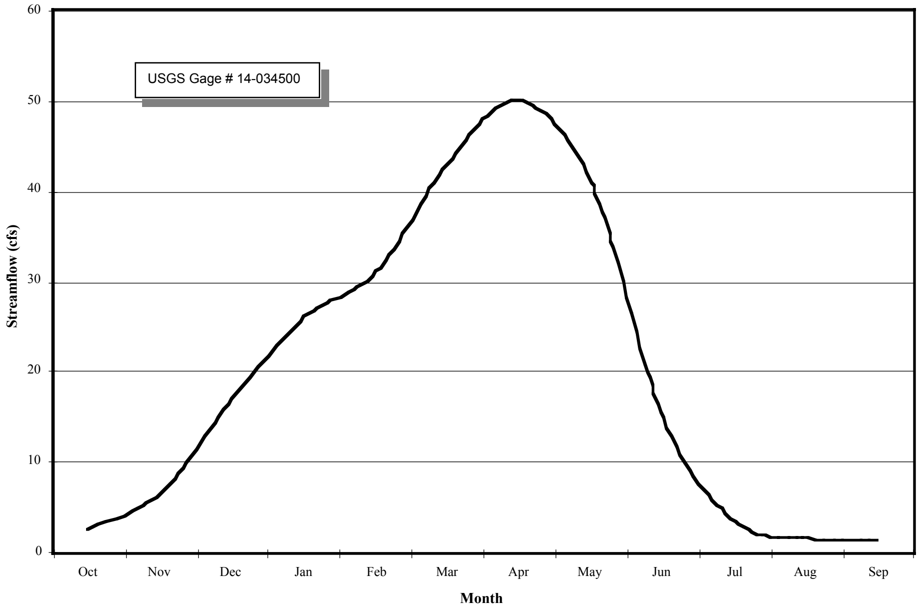
	January			*July*		
°F	**38**	**24**	**31**	**82**	**54**	**68**
	Maximum	Minimum	Mean	Maximum	Minimum	Mean

Snowpack development: Winter precipitation falls primarily as rain in lower elevation and snow on ridges. Snowpack development can occur at the higher elevations, however they likely do not persist for long.

Hydrologic basin characteristics: Basins oriented to the north, draining to the Columbia River.

Runoff patterns: Average monthly streamflows are highest in the spring months.*

* as represented by a stream gage from ecoregion 10c because no daily values were available for this ecoregion.



Peak flow generating process: Primarily rainfall; some peaks are generated by rain-on-snow events although the volumetric contribution of the snowmelt to runoff is limited.

Peak flow magnitude (2-year recurrence interval): 6 cfs/mi^2 to 20 cfs/mi^2, with few greater than 20 cfs/mi^2

Stream channels:

		Small	*Medium*	*Large*
Substrate	lower gradient	gravel	gravel / cobble	cobble
	higher gradient	cobble	cobble / boulder	cobble/ boulder
Beaver dams	lower gradient	few year-round	none	none
	higher gradient	few in summer	none	none

Natural Disturbances: The dominant grasses are not affected fire. Grazing tends to eliminate the larger perennial grasses and favors annual grasses like cheatgrass (Franklin and Dyrness 1988).

Potential streamside vegetation:

CHT group	RA1 zone	RA1 description	RA2 width	RA2 description	Other considerations
Constrained	0-25'	**Type**: Hardwoods (white alder, willow) and shrubs such as willow and red-osier dogwood. Infrequent ponderosa pine. **Size**: Medium **Density**: Sparse	N/A	**Type**: N/A **Size**: N/A **Density**: N/A	
Semi-constrained	0-50'	**Type**: Hardwoods (cottonwood galleries, willow, white alder) and shrubs such as willow and red-osier dogwood. Infrequent ponderosa pine. **Size**: Medium **Density**: Sparse	N/A	**Type**: N/A **Size**: N/A **Density**: N/A	
Un-constrained	0-75'	**Type**: Hardwoods (cottonwood galleries, willow, white alder) and shrubs such as willow and red-osier dogwood. Infrequent ponderosa pine. **Size**: Medium **Density**: Sparse	N/A	**Type**: N/A **Size**: N/A **Density**: N/A	

Current Streamside Conifer Regeneration: Few occur naturally.

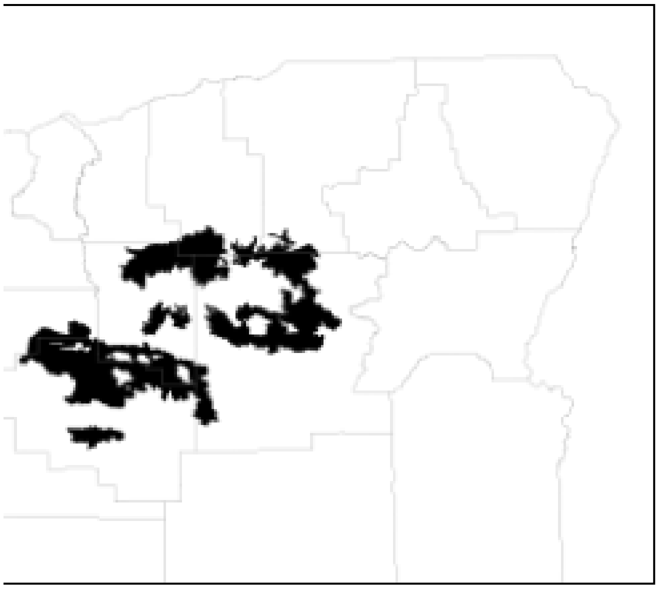
Upland vegetation: Agricultural crops (primarily wheat). Native vegetation includes juniper, bluebunch wheatgrass, and Idaho fescue.

Historic Crown Closure: Less than 30% historic crown closure.

Land Use: Wheat farming, grazing, recreation.

Other:

John Day/Clarno Highlands (11b)



Location: High elevation slopes that surround the western perimeter of the Blue Mountains and separates the north-central Blue Mountains from the southern Blue Mountains and Ochoco Mountains.

Drainage Basins: John Day and Deschutes Basins

Geology: Geology is varied; includes basalt flows and eroded remnants of a mountain chain.

Topography: Consists of dissected hills with some steep-sided. Streams have a low to moderate gradient. Main rivers originate within surrounding ecoregions that have more rain and snow.

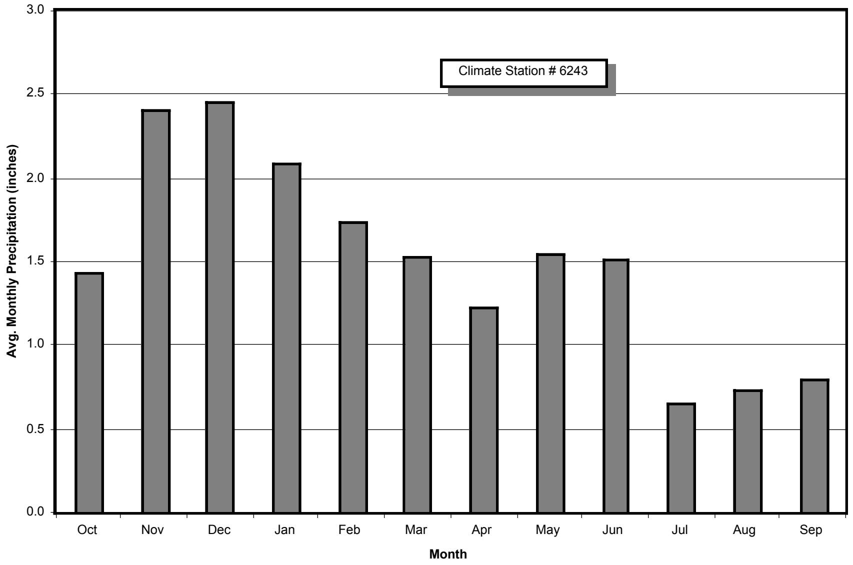
Soil: Subsoils are variable across ecoregion; surface soil often can be dominated by Mount Mazama ash, especially on north facing slopes.

Erosion: Erosion rate is moderate. Most erosion occurs during high intensity runoff events during snow melt periods or during thunderstorms.

Climate characterization: Continental climate with low precipitation and wide temperature extremes is moderated by a marine influence spreading southward from Columbia Gorge and eastward through the low passes of the Cascade Mountain range. Marine influence brings in more moisture and less extreme temperature fluctuations than other parts of the Blue Mountains.

Mean annual precipitation: 15 to 30 inches.

Precipitation Pattern: Majority of precipitation occurs in the winter months of November, December, and January.



2-year 24 hour precipitation: 1.2 to 1.6 inches.

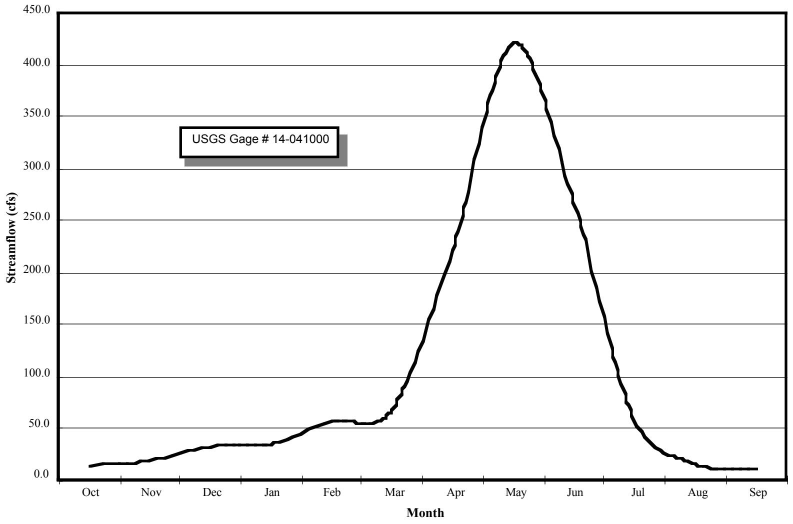
Temperature

	January			*July*		
°F	**40**	**22**	**31**	**82**	**42**	**62**
	Maximum	Minimum	Mean	Maximum	Minimum	Mean

Snowpack development: Much of the winter precipitation falls as snow that accumulates into moderately deep snowpacks. The deepest snowpacks are found at higher elevations (e.g. Ochoco Mountains).

Hydrologic basin characteristics: Basins oriented to the north and south draining to the John Day and the Columbia Rivers, and into the Crooked River to the Deschutes River.

Runoff patterns: Average monthly streamflows are highest in the late spring and summer months.



Peak flow generating process: Primarily spring rain, spring rain-on-snow, and snowmelt events.

Peak flow magnitude (2-year recurrence interval): Mainly less than 20 cfs/mi^2, and a few greater than 20 cfs/mi^2

Stream channels:

		Small	*Medium*	*Large*
Substrate	Lower gradient	Fines / gravel	Gravel	Gravel /cobble
	Higher gradient	Gravel	Gravel / cobble	Gravel / cobble
Beaver dams	Lower gradient	Some year-round	Few year-round	None
	Higher gradient	Few in summer	None	None

Natural Disturbances: Frequent fire except where suppressed.

Potential streamside vegetation:

CHT group	RA1 zone	RA1 description	RA2 width	RA2 description	Other considerations
Constrained	0-25’	**Type**: Hardwoods (alder & cottonwood) and shrubs (willows, Sitka alder, mountain alder) **Size**: Small **Density**: Dense	25-100'	**Type**: Conifers (infrequent true fir and ponderosa pine) **Size**: Medium **Density**: Sparse	Fire suppression in recent decades has caused an increase in true fir dominance. See Kovalchik (1987) for more details about specific plant communities and where they occur.
Semi-constrained	0-50'	**Type**: Hardwoods (alder & cottonwood) and shrubs (willows, Sitka alder, mountain alder and common snowberry) **Size**: Small **Density**: Dense	50-100’	**Type**: Conifers (infrequent true fir and ponderosa pine) **Size**: Medium **Density**: Sparse	Fire suppression in recent decades has caused an increase in true fir dominance. See Kovalchik (1987) for more details about specific plant communities and where they occur.
Un-constrained	0-75'	**Type**: Hardwoods (alder, willow, cottonwood & aspen) and shrubs (willows, Sitka alder, mountain alder and common snowberry, shrubby cinquefoil) **Size**: Small **Density**: Dense	75-100’	**Type**: Conifers (infrequent true fir and ponderosa pine) **Size**: Medium **Density**: Sparse	Fire suppression in recent decades has caused an increase in true fir dominance. Under certain circumstances, there are a few potential plant communities which have no woody vegetation in RA1, and are characterized by herbaceous plants such beaked sedge or aquatic sedge at higher elevations. See Kovalchik (1987) for more details about specific plant communities and where they occur.

Current Streamside Conifer Regeneration: Some true fir, ponderosa pine.

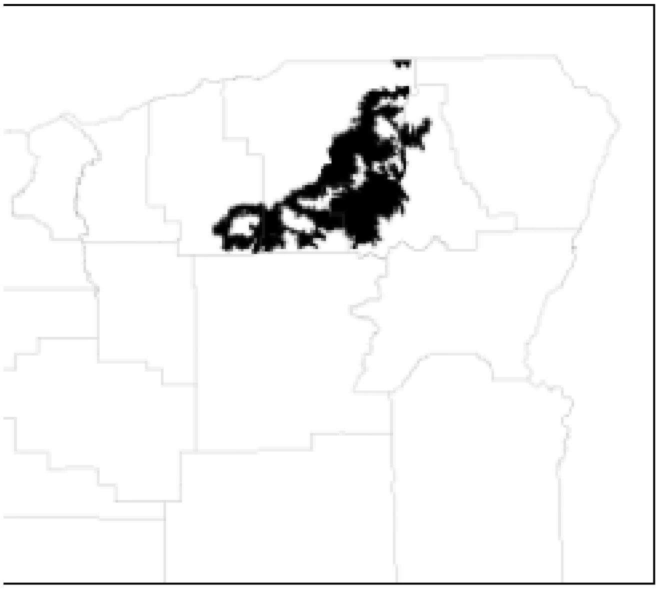
Upland vegetation: Native vegetation includes grasses, ponderosa pine, true fir

Historic Crown Closure: Historically and currently, the forests in this ecoregion were highly variable. Historic canopy closure was <30% in the areas dominated by ponderosa pine savannas. Some park-like ponderosa pine stands had canopy closures of 40-60%. Some pole sized stands that originated after fire had densities of greater than 70%. Other forest types in this region also had canopy closures of greater than 30%.

Land Use: Grazing, timber harvest

Other:

Maritime-Influenced Zone (11c)



Location: Western slopes of the northern Blue Mountains that are influenced by marine weather systems that move east through the break in the Cascade Range at the Columbia River gorge.

Drainage Basins: John Day, Grande Ronde, and Umatilla Basins

Geology: Geology is mostly Columbia River basalts.

Topography: Consists of rolling hills with some steep-sided canyons. Streams have a moderate gradient. Main rivers originate within surrounding ecoregions that have more rain and snow.

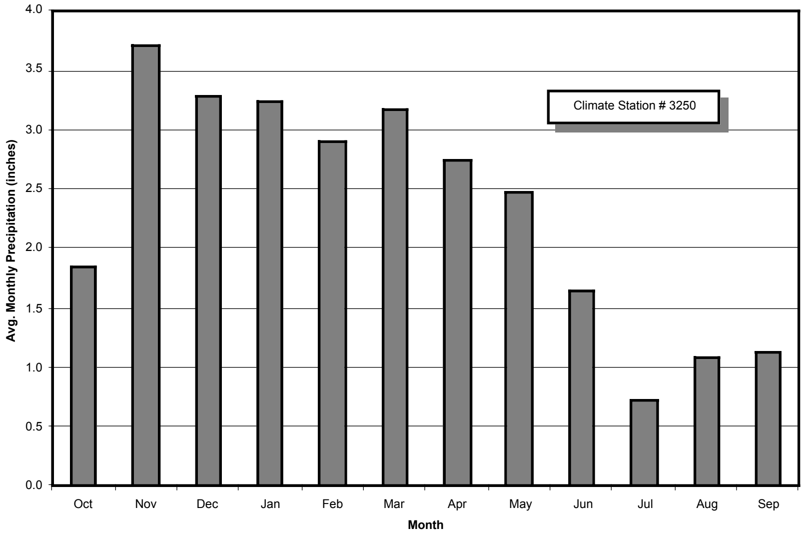
Soil: Subsoils are derived from basalt but surface layers (up to 3 feet deep) consist of weathered ash and loess.

Erosion: Erosion rate is low. Most erosion occurs during high intensity runoff events during snow melt periods or during thunderstorms.

Climate characterization: Continental climate with low precipitation and wide temperature extremes is moderated by a marine influence spreading southward from Columbia Gorge and eastward through the low passes of the Cascade Mountain range. Marine influence brings in more moisture and less extreme temperature fluctuations than other parts of the Blue Mountains.

Mean annual precipitation: 20 to 35 inches; up to 45 inches in higher elevations.

Precipitation Pattern: Majority of the precipitation occurs in the winter months, November, December and January, and early spring during February and March.



2-year 24 hour precipitation: 1.4 to 2.0 inches.

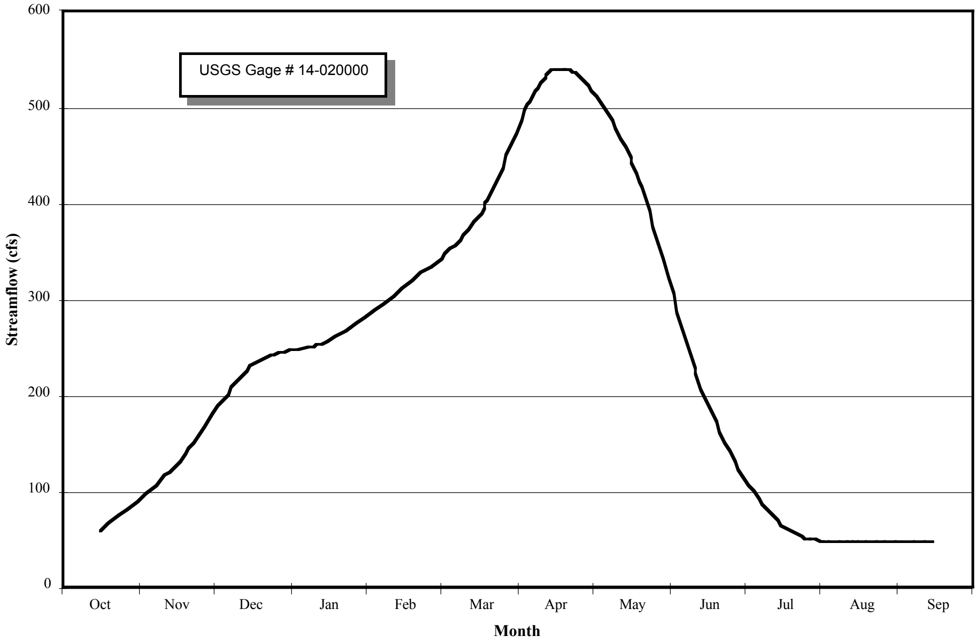
Temperature

	January			*July*		
°F	**38**	**24**	**31**	**86**	**53**	**69**
	Maximum	Minimum	Mean	Maximum	Minimum	Mean

Snowpack development: Maritime influence brings in precipitation, some in the form of snow. Shallow snowpacks can develop, particularly in the higher elevations where the most snow falls.

Hydrologic basin characteristics: Basins are oriented to the north and east. Northern basins contain tributary streams to the Columbia River. Eastern basins tend to drain into tributaries of the Snake River.

Runoff patterns: Average monthly streamflows are highest in the spring months.



Peak flow generating process: Primarily spring rain, spring rain-on-snow, and snowmelt.

Peak flow magnitude (2-year recurrence interval): 6 cfs/mi^2 to 20 cfs/mi^2, with a few greater than 20 cfs/mi^2.

Stream channels:

		Small	*Medium*	*Large*
Substrate	Lower gradient	Fines / gravel	Gravel	Gravel /cobble
	Higher gradient	Gravel	Gravel / cobble	Gravel / cobble
Beaver dams	Lower gradient	Some year-round	Few year-round	None
	Higher gradient	Few in summer	None	None

Natural Disturbances: Frequent fire except where suppressed.

Potential streamside vegetation:

CHT group	RA1 zone	RA1 description	RA2 width	RA2 description	Other considerations
Constrained	0-25’	**Type**: Hardwoods (cottonwood) and shrubs (willows & mountain alder). **Size**: Small **Density**: Dense	25-100'	**Type**: Conifers (Douglas-fir with ponderosa pine at lower elevation). **Size**: Large **Density**: Dense	See Crowe (1997) for more details about specific plant communities and where they occur.
Semi-constrained	0-50’	**Type**: Hardwoods (cottonwood, willow, alder) and shrubs (willows, mountain alder & common snowberry). **Size**: Small **Density**: Dense	50-100’	**Type**: Conifers (Douglas-fir with ponderosa pine at lower elevation). **Size**: Large **Density**: Dense	See Crowe (1997) for more details about specific plant communities and where they occur.
Un-constrained	0-75’	**Type**: Hardwoods (cottonwood, willow, alder & aspen) and shrubs (willows, mountain alder & common snowberry, shrubby cinquefoil). **Size**: Small **Density**: Dense	75-100’	**Type**: Conifers (Douglas-fir with ponderosa pine at lower elevation). **Size**: Large **Density**: Dense	See Crowe (1997) for more details about specific plant communities and where they occur.

Current Streamside Conifer Regeneration: Douglas-fir and ponderosa pine.

Upland vegetation: Native vegetation includes shrubs, Douglas-fir, and ponderosa pine.

Historic Crown Closure: At lower elevations, less than 30% historic crown closure. In the past, the lower elevations of this ecoregion were dominated by ponderosa pine savannas. Ponderosa pine savannas have all but disappeared due to fire suppression. At higher elevations, the forest is dominated by Douglas-fir and historic crown closure was greater than 30%.

Land Use: Grazing, timber harvest

Other:

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Appendix B. Descriptions of Channel Habitat Types (Source: WPN 1999, Appendix III-A)

LOW GRADIENT MEDIUM FLOODPLAIN CHANNEL—FP2

FP2 channels are main-stem streams in broad valley bottoms with well-established floodplains. Alluvial fans, dissected foot slopes, and hill slope and lowland landforms may directly abut FP2 floodplains. Channels are often sinuous, with extensive gravel bars, multiple channels, and terraces. These channels are generally associated with extensive and complex riparian areas that may include such features as sloughs, side-channels, wetlands, beaver pond complexes, and small groundwater-fed tributary channels.

Sediment deposition is prevalent, with fine-sediment storage evident in pools and point bars, and on floodplains. Bank erosion and bank-building processes are continuous, resulting in a dynamic and diverse channel morphology. Stream banks are composed of fine alluvium and are susceptible to accelerated bank erosion with the removal or disturbance of stream-bank vegetation and root mats. Channel gradient is low, and high stream flows are not commonly contained within the active channel banks, resulting in relatively low stream power.

CHANNEL ATTRIBUTES

Stream gradient: =2%

Valley shape: Broad, flat, or gentle landforms

Channel pattern: Single to multiple channels, sinuous

Channel confinement: Unconfined

Oregon stream size: Large to medium

Position in drainage: Middle to lower end of drainage basin

Dominant substrate: Sand to cobble

CHANNEL RESPONSIVENESS

Floodplain channels can be among the most responsive in the basin. The limited influence of confining terrain features and fine substrate allows the stream to move both laterally and vertically. Although often considered low -energy systems, these channels can mobilize large amounts of sediment during high flows. This often results in channel migration and new channel formation.

LARGE WOODY DEBRIS: HIGH

Because of the high sedimentation rates, only large pieces or accumulations of smaller pieces are likely to impact overall channel conditions. The role of wood, as well as the amount and distribution of pieces, is variable over time, as high flows and stream power regularly change conditions. Single pieces are likely to be associated with pools in side-channels and localized sediment depositions. Accumulations of wood are often responsible for the creation of midchannel bars and side-channel development.

FINE SEDIMENT: MODERATE

Increases in the supply of fines may cause temporary storage and pool filling, but moderate to high flows will mobilize the majority of the sediment. Deposition may be more permanent in smaller side-channels, and pool filling and minor shifts in side-channel location could occur.

COARSE SEDIMENT: HIGH

Floodplain channels are generally depositional areas for coarse sediment. When the supply of coarse sediment surpasses the transport capabilities of the stream, the channel is particularly vulnerable to widening, lateral movement, side channel development, and braiding. Overall aquatic habitat complexity is reduced, as pools are filled and obstructions such as large boulders or bedrock outcrops are buried.

PEAK FLOWS: LOW TO MODERATE

These floodplain channels are usually capable of transporting high flows with a minimum of alteration to the primary physical characteristics of the channel. Flows tend to spread out across the valley rather than cause streambed scour. Localized bank erosion is expected as new channels are developed, especially if the sediment supply has been increased.

RIPARIAN ENHANCEMENT OPPORTUNITIES

Due to the unstable nature of these channels, the success of many enhancement efforts is questionable. Opportunities for enhancement do occur, however, especially in channels where lateral movement is slow. Lateral channel migration is common, and efforts to restrict this natural pattern will often result in undesirable alteration of channel conditions downstream. Side-channels may be candidates for efforts that improve shade and bank stability.

LOW GRADIENT SMALL FLOODPLAIN CHANNEL - FP3

FP3 streams are located in valley bottoms and flat lowlands. They frequently lie adjacent to the toe of foot slopes or hill slopes within the valley bottom of larger channels, where they are typically fed by high-gradient streams. They may be directly downstream of a small alluvial fan and contain wetlands. FP3 channels may dissect the larger floodplain. These channels are often the most likely CHT to support beavers, if they are in the basin. Beavers can dramatically alter channel characteristics such as width, depth, form, and most aquatic habitat features. These channels can be associated with a large floodplain complex and may be influenced by flooding of adjacent main-stem streams. Sediment routed from upstream high- and moderate-gradient channels is temporarily stored in these channels and on the adjacent floodplain.

CHANNEL ATTRIBUTES

Stream gradient: = 2%

Valley shape: Broad

Channel pattern: Single to multiple channels

Channel confinement: Moderate to unconfined

Oregon stream size: Small to medium

Position in drainage: Variable

Dominant substrate: Sand to small cobble

CHANNEL RESPONSIVENESS

Floodplain channels can be among the most responsive in the basin. The limited influence of confining terrain features and fine substrate allows the stream to move both laterally and vertically. Although often considered low-energy systems, these channels can mobilize large amounts of sediment during high flows. This often results in channel migration and new channel formation.

LARGE WOODY DEBRIS: HIGH

In forested basins, these channels are likely to have relatively high wood counts. Those located at the foot of high-gradient channels or along the margin of a large floodplain channel are especially subject to wood availability. Wood can readily affect channel pattern, location, and dimension. Wood is likely to be a major channel roughness element, often associated with pools or spawning gravel distribution.

FINE SEDIMENT: MODERATE TO HIGH

The location of these channels often dictates a high sediment input to the stream. These channels are sediment deposition zones, with side-channels particularly vulnerable to **aggradation** and shifting. If a large and persistent source of sediment is available, pool filling and channel migration could result.

COARSE SEDIMENT: HIGH

Floodplain channels are generally depositional areas for coarse sediment. When the supply of coarse sediment surpasses the transport capabilities of the stream, the channel is particularly vulnerable to widening, lateral movement, side-channel development, and braiding. Overall aquatic habitat complexity is reduced as pools are filled and obstructions such as large boulders or bedrock outcrops are buried.

PEAK FLOWS: LOW

Floodplain channels are usually capable of transporting high flows with a minimum of alteration to the primary physical characteristics of the channel. Flows tend to spread out across the valley rather than cause streambed scour. Localized bank erosion is expected as new channels are developed.

RIPARIAN ENHANCEMENT OPPORTUNITIES

Floodplain channels are, by their nature, prone to lateral migration, channel shifting, and braiding. While they are often the site of projects aimed at channel containment (diking, filling, etc.), it should be remembered that floodplain channels can exist in a dynamic equilibrium between stream energy and sediment supply. As such, the active nature of the channel should be respected, with restoration efforts carefully planned. The limited power of these streams offers a better chance for success of channel enhancement activities than the larger floodplain channels. While the lateral movement of the channel will limit the success of many efforts, localized activities to provide bank stability or habitat development can be successful.

LOW GRADIENT MODERATELY CONFINED CHANNEL—LM

These channels consist of low-gradient reaches that display variable confinement by low terraces or hill slopes. A narrow floodplain approximately two to four times the width of the active channel is common, although it may not run continuously along the channel. Often low terraces accessible by flood flows occupy one or both sides of the channel. The channels tend to be of medium to large size, with substrate varying from bedrock to gravel and sand. They tend to be slightly to moderately sinuous, and will occasionally possess islands and side-channels. Because of the difficulty in assessing the degree of confinement and the height of stream-bank terraces from maps or air photos, these channels are often misidentified as LC channels unless field-checked.

CHANNEL ATTRIBUTES

Stream gradient: <2%

Valley shape: Broad, generally much wider than channel

Channel pattern: Single with occasional multiple channels

Channel confinement: Variable

Oregon stream size: Variable, usually medium to large

Position in drainage: Variable, often main-stem and lower end of main tributaries

Dominant substrate: Fine gravel to bedrock

CHANNEL RESPONSIVENESS

The unique combination of an active floodplain and hillslope or terrace controls acts to produce channels that can be among the most responsive in the basin. Multiple roughness elements are common, with bedrock, large boulders, or wood generating a variety of aquatic habitat within the stream network.

LARGE WOODY DEBRIS: MODERATE TO HIGH

In forested basins, wood alone or in combination with other elements is associated with pool formation and maintenance, bar formation, and, occasionally, side-channel development. Thes channels may have relatively low wood numbers due to past management activities.

FINE SEDIMENT: MODERATE TO HIGH

The location of these channels often dictates a high sediment input to the stream. These channels can be sediment deposition zones for larger particles, although a significant portion of the fine sediment may be transported, particularly in bedrock channels. Increases in fine-sediment supply will likely result in filling of margin pool and bed-fining of side-channels and low-velocity areas. Decreases in sediment supply may induce scour in non-bedrock channels or localized bank erosion.

COARSE SEDIMENT: MODERATE TO HIGH

These channels are depositional areas for coarse sediment. When the supply of coarse sediment surpasses the transport capabilities of the stream, pools are filled, and the influence of large boulders, wood, and bedrock control structures is lessened. If significant amounts of large sediment are added, the channel is particularly vulnerable to widening, lateral movement, side-channel development, and localized scour.

PEAK FLOWS: MODERATE

These channels are capable of passing most high flows without adjustments to the overall dimensions of the channel. Development of point or **medial bars** is likely in basins with high sediment loads, as is side-channel development. Localized bed or bank scour is possible on bends in the main channel.

RIPARIAN ENHANCEMENT OPPORTUNITIES

Like floodplain channels, these channels can be among the most responsive of channel types. Unlike floodplain channels, however, the presence of confining landform features often improves the accuracy of predicting channel response to activities that may affect channel form. Additionally, these controls help limit the destruction of enhancement efforts common to floodplain channels. Because of this, LM channels are often good candidates for enhancement efforts. In forested basins, habitat diversity can often be enhanced by the addition of roughness elements such as wood or boulders. Pool frequency and depth may increase, and side-channel development may result from these efforts. Channels of this type in nonforested basins are often responsive to bank stabilization efforts such as riparian planting and fencing. Beavers are often present in the smaller streams of this channel type, and fish habitat in some channels may benefit from beaver introduction through side-channel and scour pool development. Introduction of beavers, however, may have significant implications for overall channel form and function, and should be thoroughly evaluated by land managers as well as biologists as a possible enhancement activity.

LOW GRADIENT CONFINED CHANNEL —LC

LC channels are incised or contained within adjacent, gentle landforms or incised in volcanic flows or uplifted coastal landforms. Lateral channel migration is controlled by frequent bedrock outcrops, high terraces, or hill slopes along stream banks. They may be bound on one bank by hill slopes and lowlands on the other, and may have a narrow floodplain in places, particularly on the inside of meander bends. Stream-bank terraces are often present, but they are generally above the current floodplain. The channels are often stable, with those confined by hill slopes or bedrock less likely to display bank erosion or scour than those confined by alluvial terraces. High-flow events are well-contained by the upper banks. High flows in these well-contained channels tend to move all but the most stable wood accumulations downstream or push debris to the channel margins. Stream banks can be susceptible to landslides in areas where steep hill slopes of weathered bedrock, glacial till, or volcanic-ash parent materials abut the channel.

CAUTION: Some degree of caution should be exercised in evaluating channels that have downcut into alluvial material set in a wide flat valley. If the stream banks are high enough to allow a floodplain width less than two times the **bankfull width**, then the stream meets the definition of confined. However, some streams meeting this definition may have recently downcut, effectively reducing floodplain width as the channel deepens. It is beyond the scope of this manual to deal with technical issues such as rate of channel incision. The analyst, however, should note channels that display evidence of recent downcutting, low channel banks, and evidence of abandoned floodplain. For whatever reason, these channels may be transitioning from LM to LC channels, and should receive additional scrutiny before assigning the proper CHT.

CHANNEL ATTRIBUTES

Stream gradient: <2%

Valley shape: Low- to moderate-gradient hill slopes with limited floodplain

Channel pattern: Single channel, variable sinuosity

Channel confinement: Confined by hill slopes or high terraces

Oregon stream size: Variable, usually medium to large

Position in drainage: Variable, generally mid to lower in the larger drainage basin

Dominant substrate: Boulder, cobble, bedrock with pockets of sand/gravel/cobble

CHANNEL RESPONSIVENESS

The presence of confining terraces or hill slopes and control elements such as bedrock limit the type and magnitude of channel response to changes in input factors. Adjustment of channel features is usually localized and of a modest magnitude.

LARGE WOODY DEBRIS: LOW TO MODERATE

In larger forested basins, wood numbers are often low in this channel type. This may be in part due to land management activities, but these channels usually display sufficient energy to route wood downstream. Also, limited lateral movement of the channel reduces the recruitment of wood from bank erosion. Wood is often present in jams or as large single pieces capable of withstanding high energy flows. Even in streams of this channel type that are smaller and display less energy, wood may be routed or retained above the elevation of the bankfull channel, where it has limited impact on aquatic habitat.

FINE SEDIMENT: LOW

The confining nature of the landforms that define this channel type tends to focus enough stream energy to route most introduced fine sediment downstream. In basins with high background sediment levels, such as sand and siltstone-bedded channels in the Coast Range, supply may approach or surpass transport capacity, resulting in pool filling and **bed fining**.

COARSE SEDIMENT: MODERATE

These channels can be depositional areas for coarse sediment. When the supply of coarse sediment surpasses the transport capabilities of the stream, pools are filled, and the influence of large boulders, wood, and bedrock control structures is lessened. If significant amounts of large sediment are added, the channel is particularly vulnerable to widening, lateral movement, side channel development, or scour.

PEAK FLOWS: LOW TO MODERATE

These channels have limited floodplain, and are capable of passing most high flows without adjustments to the overall dimensions of the channel. Development of point or medial bars is likely in basins with high sediment loads. Localized bed or bank scour is possible on bends in the main channel.

RIPARIAN ENHANCEMENT OPPORTUNITIES

These channels are not highly responsive, and in channel enhancements may not yield intended results. In basins where water-temperature problems exist, the confined nature of these channels lends itself to establishment of riparian vegetation. In non-forested land, these channels may be deeply incised and prone to bank erosion from livestock. As such, these channels may benefit from livestock access control measures.

MODERATE GRADIENT MODERATELY CONFINED CHANNEL—MM

This group includes channels with variable controls on channel confinement. Alternating valley terraces and/or adjacent mountain-slope, foot-slope, and hill-slope landforms limit channel migration and floodplain development. Similar to the LM channels, a narrow floodplain is usually present, and may alternate from bank to bank. Bedrock steps with cascades may be present.

CHANNEL ATTRIBUTES

Stream gradient: Generally 2-4%

Valley shape: Narrow valley with floodplain or narrow terrace development

Channel pattern: Usually single channel, low to moderate sinuosity

Channel confinement: Variable

Oregon stream size: Variable, usually medium to large

Position in drainage: Mid to lower portion of drainage basins

Dominant substrate: Gravel to small boulder

CHANNEL RESPONSIVENESS

The unique combination of a narrow floodplain and hill-slope or terrace controls acts to produce channels that are often the most responsive in the basin. The combination of higher gradients and the presence of a floodplain set the stage for a dynamic channel system. Multiple roughness elements such as bedrock, large boulders, or wood may be common, resulting in a variety of aquatic habitats within the stream network.

LARGE WOODY DEBRIS: HIGH

In forested basins, wood alone or in combination with other elements is associated with pool formation and maintenance, bar formation and gravel sorting, and, occasionally, side-channel development. LWD may be the primary factor responsible for forming pools in forested systems. Due to the moderate gradient, smaller pieces are transported downstream or form jams. A change in the wood supply would likely have significant impact on pool condition, sediment movement, bar development, and, possibly, side-channel condition.

FINE SEDIMENT: MODERATE

The location of these channels often dictates a high sediment input to the stream. These channels can be sediment deposition zones for larger particles, although the moderate gradient produces enough energy to route most of the fine sediment downstream. Increases in fine-sediment supply will likely result in filling of margin pool and bed fining of side-channels and low-velocity areas. Decreases in sediment supply may induce scour in non-bedrock channels or localized bank erosion.

COARSE SEDIMENT: MODERATE TO HIGH

Unless the channel is quite large, these channels may be temporary storage areas for coarse sediment. When the supply of coarse sediment surpasses the transport capabilities of the stream, pools are filled, and the influence of large boulders, wood, and bedrock control structures is reduced. If significant amounts of large sediment are added, the channel is particularly vulnerable to widening, lateral movement, side-channel development, or scour. Steeper channels within this CHT would likely transport a greater portion of the load and not be as responsive as lower-gradient reaches.

PEAK FLOWS: MODERATE

These channels have limited floodplain, and are capable of passing most high flows without adjustments to the overall dimensions of the channel. The higher energy induced by steeper gradients can result in development of point or medial bars in basins with high sediment loads, as well as side channel development. Localized bed or bank scour is possible on bends in the main channel.

RIPARIAN ENHANCEMENT OPPORTUNITIES

Like floodplain channels, these channels are among the most responsive of channel types. Unlike floodplain channels, however, the presence of confining landform features improves the accuracy of predicting channel response to activities that may affect channel form. Additionally, these controls help limit the destruction of enhancement efforts, a common problem in floodplain channels. The slightly higher gradients impart a bit more uncertainty as to the outcome of enhancement efforts when compared to LM channels. MM channels, however, are often good candidates for enhancement efforts. In forested basins, habitat diversity can often be enhanced by the addition of roughness elements such as wood or boulders. Pool frequency and depth may increase as well as side-channel development as the result of these efforts. Channels of this type in non-forested basins are often responsive to bank stabilization efforts such as riparian planting and fencing. Beavers are often present in the smaller streams of this channel type, and fish habitat in some channels may benefit from beaver introduction through side-channel and scour pool development. Introduction of beavers, however, may have significant implications for overall channel form and function, and should be thoroughly evaluated by land managers as well as biologists as a possible enhancement activity.

MODERATE GRADIENT CONFINED CHANNEL—MC

MC streams flow through narrow valleys with little river terrace development, or are deeply incised into valley floors. Hill slopes and mountain slopes composing the valley walls may lie directly adjacent to the channel. Bedrock steps, short falls, cascades, and boulder runs may be present; these are usually sediment transport systems. Moderate gradients, well-contained flows, and large particle substrate indicate high stream energy. Landslides along channel side slopes may be a major sediment contributor in unstable basins.

CHANNEL ATTRIBUTES

Stream gradient: 2-4%, may vary between 2 to 6%

Valley shape: Gentle to narrow V-shaped valley, little to no floodplain development

Channel pattern: Single, relatively straight or conforms to hill-slope control

Channel confinement: Confined

Oregon stream size: Variable

Position in drainage: Middle to lower

Dominant substrate: Coarse gravel to bedrock

CHANNEL RESPONSIVENESS

The presence of confining terraces or hill slopes and control elements such as bedrock substrates limits the type and magnitude of channel response to changes in input factors. Adjustment of channel features is usually localized and of a modest magnitude.

LARGE WOODY DEBRIS: LOW

In larger forested basins, wood numbers are often low in this channel type. This may be, in part, due to past land management activities, but these channels usually display sufficient energy to route wood downstream. Also, limited lateral movement of the channel reduces the recruitment of wood from bank erosion. Wood is often present in jams or as large single pieces capable of withstanding high-energy flows. Even in streams of this channel type that are smaller and display less energy, wood may be routed or retained above the elevation of the bankfull channel, where it has limited impact on aquatic habitat.

FINE SEDIMENT: LOW

The confining nature of the landforms and the moderate gradient combine to produce enough stream energy to route most introduced fine sediment downstream. Localized pool filling and bed fining may occur if a large and persistent source exists.

COARSE SEDIMENT: MODERATE

These channels can be both a transport or deposition area for coarse sediment. When the supply of coarse sediment surpasses the transport capabilities of the stream, pools are filled, and the influence of large boulders, wood, and bedrock control structures is lessened. If significant amounts of large sediment are added, the channel is particularly vulnerable to widening, limited lateral movement, or scour.

PEAK FLOWS: MODERATE

These channels have limited floodplain, and are capable of passing most high flows without adjustments to the overall dimensions of the channel. Development of point or medial bars is likely in basins with high sediment loads. Localized bed or bank scour is possible on bends in the main channel.

RIPARIAN ENHANCEMENT OPPORTUNITIES

These channels are not highly responsive, and in-channel enhancements may not yield intended results. Although channels are subject to relatively high energy, they are often stable. In basins where water-temperature problems exist, the stable banks generally found in these channels lend themselves to establishment of riparian vegetation. In non-forested land, these channels may be deeply incised and prone to bank erosion from livestock. As such, these channels may benefit from livestock access control measures.

MODERATE GRADIENT HEADWATER CHANNEL—MH

These moderate-gradient headwater channels are common to plateaus in Columbia River basalts, young volcanic surfaces, or broad drainage divides. They may be sites of headwater beaver ponds. These channels are similar to LC channels, but occur exclusively in headwater regions. They are potentially above the **anadromous fish** zone. These gentle to moderate headwater streams generally have low streamflow volumes and, therefore, low stream power. The confined channels provide limited sediment storage in low-gradient reaches. Channels have a small upslope drainage area and limited sediment supply. Sediment sources are limited to upland surface erosion.

CHANNEL ATTRIBUTES

Stream gradient: 1-6%

Valley shape: Open, gentle V-shape valley

Channel pattern: Low sinuosity to straight

Channel confinement: Confined

Oregon stream size: Small

Position in drainage: Upper, headwater

Dominant substrate: Sand to cobble, bedrock; boulders may be present from erosion of surrounding slopes and soils

CHANNEL RESPONSIVENESS

The low stream power and presence of confining terraces or hill slopes and control elements such as bedrock substrates limit the type and magnitude of channel response to changes in input factors. Adjustment of channel features is usually localized and of a moderate magnitude.

LARGE WOODY DEBRIS: MODERATE

Wood numbers and influence is quite variable in these channels. While the low stream energy may limit the magnitude of response associated with wood, wood numbers can be high and wood may be the dominant roughness element. In these cases, wood is critical for pool and cover habitat formation and maintenance.

FINE SEDIMENT: MODERATE

The confining nature of the landforms that define this channel type tends to focus enough stream energy to route much of the introduced fine sediment downstream. Localized pool filling and bed fining can occur in lower-gradient reaches.

COARSE SEDIMENT: MODERATE TO HIGH

The low energy in these small channels is incapable of transporting larger sediment. Increases in the sediment load can easily overwhelm the channel and result in widening, lateral movement, or scour. In some basins, the location of these channels makes them vulnerable to inputs of sediment and wood from slides.

PEAK FLOWS: MODERATE

These channels have limited floodplain, and are capable of passing most high flows without adjustments to the overall dimensions of the channel. Localized bed or bank scour is possible on bends in the main channel.

RIPARIAN ENHANCEMENT OPPORTUNITIES

These channels are moderately responsive. In basins where water-temperature problems exist, the stable banks generally found in these channels lend themselves to establishment of riparian vegetation. In non-forested land, these channels may be deeply incised and prone to bank erosion from livestock. As such, these channels may benefit from livestock access control measures.

MODERATELY STEEP NARROW VALLEY CHANNEL—MV

MV channels are moderately steep and confined by adjacent moderate to steep hill slopes. High flows are generally contained within the channel banks. A narrow floodplain, one channel width or narrower, may develop locally. MV channels efficiently transport both coarse bed load and fine sediment. Bedrock steps, boulder cascades, and chutes may be common features. The large amount of bedrock and boulders create stable streambanks; however, steep side slopes may be unstable. Large woody debris is found commonly in jams that trap sediment in locally low-gradient steps.

CHANNEL ATTRIBUTES

Stream gradient: 4-8%, may vary between 3 to 10%

Valley shape: Narrow, V-shaped valley

Channel pattern: Single channel, relatively straight similar to valley

Channel confinement: Confined

Oregon stream size: Small to medium

Position in drainage: Mid to upper

Dominant substrate: Small cobble to bedrock

CHANNEL RESPONSIVENESS

The gradient and presence of confining terraces or hill slopes and control elements such as bedrock substrates limit the type and magnitude of channel response to changes in input factors. Adjustment of channel features is localized and of a minor magnitude.

LARGE WOODY DEBRIS: MODERATE

In larger forested basins, wood numbers are often high in this channel type. Wood is present in jams or as single pieces capable of withstanding high-energy flows. Large woody debris may be the primary element responsible for pool formation and development. In bedrock systems, wood has less influence, and is often transported downstream.

FINE SEDIMENT: LOW

The confining nature of the landforms and the higher gradients combine to produce enough stream energy to route most introduced fine sediment downstream. Filling of lateral pools and lower energy areas may result from increases in the sediment supply.

COARSE SEDIMENT: MODERATE

These channels are usually transport reaches for coarse sediment, although lower-energy sections can retain sediment and adjust channel dimensions. When the supply of coarse sediment surpasses the transport capabilities of the stream, pools are filled, and the influence of large boulders, wood, and bedrock control structures is lessened.

PEAK FLOWS: MODERATE

These channels have limited floodplain, and are capable of passing most high flows without adjustments to the overall dimensions of the channel. Development of point or medial bars is likely in basins with high sediment loads. Localized bed or bank scour is possible on bends in the main channel.

RIPARIAN ENHANCEMENT OPPORTUNITIES

These channels are not highly responsive, and in channel enhancements may not yield intended results. Although channels are subject to relatively high energy, they are often stable. In basins where water-temperature problems exist, the stable banks generally found in these channels lend themselves to establishment of riparian vegetation. In non-forested land, these channels may be deeply incised and prone to bank erosion from livestock. As such, these channels may benefit from livestock access control measures.

STEEP NARROW VALLEY CHANNEL—SV

VERY STEEP HEADWATER—VH

These two channel types are very similar, except that VH channels are steeper. Because of this similarity, they are presented together. SV channels are situated in a constricted valley bottom bounded by steep mountain or hill slopes. Vertical steps of boulder and wood with scour pools, cascades, and falls are common. VH channels are found in the headwaters of most drainages or side slopes to larger streams, and commonly extend to ridge-tops and summits. These steep channels may be shallowly or deeply incised into the steep mountain or hill slope. Channel gradient may be variable due to falls and cascades.

CHANNEL ATTRIBUTES

Stream gradient: SV 8-16%, VH >16%

Valley shape: Steep, narrow V-shaped valley

Channel pattern: Single, straight

Channel confinement: Tightly confined

Oregon stream size: Small, small-medium transition

Position in drainage: Middle upper to upper

Dominant substrate: Large cobble to bedrock

CHANNEL RESPONSIVENESS

The gradient and presence of confining terraces or hill slopes and control elements such as bedrock substrates limit the type and magnitude of channel response to changes in input factors. Adjustment of channel features is localized and of a minor magnitude. These channels are also considered source channels supplying sediment and wood to downstream reaches, sometimes via landslides.

LARGE WOODY DEBRIS: MODERATE

In larger forested basins, wood numbers are often high in these channel types. Large woody debris may be the primary element responsible for pool formation and development. In bedrock systems, wood has less influence, and is often transported downstream.

FINE SEDIMENT: LOW

The confining nature of the landforms and the higher gradients combine to produce enough stream energy to route most introduced fine sediment downstream. Filling of lateral pools and lower energy areas may result from increases in the sediment supply.

COARSE SEDIMENT: LOW TO MODERATE

These channels are usually transport reaches for coarse sediment, although lower-energy sections can retain sediment and adjust channel dimensions. When the supply of coarse sediment surpasses the transport capabilities of the stream, pools are filled, and the influence of large boulders, wood, and bedrock control structures is lessened. Minor channel widening or scour can occur.

PEAK FLOWS: LOW

These channels have limited floodplain, and are capable of passing most high flows without adjustments to the overall dimensions of the channel. Localized bed or bank scour is possible.

RIPARIAN ENHANCEMENT OPPORTUNITIES

These channels are not highly responsive, and in channel enhancements may not yield intended results. Although channels are subject to relatively high energy, they are often stable. In basins where water-temperature problems exist, the stable banks generally found in these channels lend themselves to establishment of riparian vegetation. This may also serve as a recruitment effort for LWD in the basin.