ELK LOCAL FRAMEWORK (version 3.4)
High Ranked KEAs and Stresses ONLY

The following table indicates the “key ecological attributes” by component (habitat type) that the Elk River Coho Team identified as highest priority to meet the two (draft) goals identified for the Elk River Coho Strategic Action Plan (SAP). These goals include:

1. Protect and restore winter rearing habitats in selected sub-watersheds sufficient to sustain viable coast coho populations in the Elk watershed.
2. Protect and restore the watershed processes that support sufficient habitat diversity to promote a broad expression of life history diversity in the Elk coho population.
3. Demonstrate how working lands can produce self-sustaining coho populations

The third column identifies potential indicators of these high priority KEAs. Indicators in bold reflect those which can be (or are) assessed with existing data, and data is expected to be available in the future. Indicators in italics reflect those that would effectively assess the health of a KEA, but either data does not exist, is unlikely to exist in the future; or the analysis of available data is not likely to be repeated in the future. Note: indicators with “(CAP)” next to them were included in the Nehalem Conservation Action Plan.

COMPONENT	KEY ECOLOGICAL ATTRIBUTES (KEAs)	INDICATOR OF KEA HEALTH **Bold = Sufficient data exists to evaluate the indicator with a reasonable/replicable amount of analysis.** *Italics = Aspirational indicator. Data is not readily available (i.e no monitoring program exists or is planned) and/or available data requires extensive (not easily replicated) analysis to assess.*
<u>Mainstem River:</u> Portions of rivers above head of tide (Coastal and Marine Ecological Classification Standard (CMECS) definition); typically 4th order,	Water Quality	• **Temperature** • **Cold water refugia**
	Habitat complexity	• ***# log jams (per NOAA definition)*** • ***Number of large pieces of wood*** • ***Reaches with connected off-channel alcoves, flood plains***

downstream of coho spawning distribution, non-wadeable. This includes riparian and floodplain.		***and wetlands*** • ***% pool habitat***
	Riparian Function	• ***Number of conifers >50cm dbh*** • ***Number of conifers >90cm dbh*** • **Width of riparian** • **Height of riparian** • ***Dominant over story*** • ***Plant community diversity*** • *% channel shade* • *Conversion potential (threats indicator)*
	Lateral connectivity	• *% of the potential fish use stream length with entrenchment ratio > 2.2**
COMPONENT	**KEY ECOLOGICAL ATTRIBUTES (KEAs)**	**INDICATOR OF KEA HEALTH** **Bold = Sufficient data exists to evaluate the indicator with a reasonable/replicable amount of analysis.** *Italics = Aspirational indicator. Data is not readily available (i.e no monitoring program exists or is planned) and/or available data requires extensive (not easily replicated) analysis to assess.*
<u>Tributaries:</u> All 1st – 3rd order streams with drainage areas > 0.6 km2. This includes fish-bearing and non-fish-bearing, intermittent streams, and the full aquatic network including headwater areas. This includes riparian and floodplain.	Water quality	• **Temperature** • *Biological indicators*
	Habitat complexity	• ***Miles of high quality habitat*** • **# of wood pieces per 100m of stream** • **# of key wood pieces (>12m long, 0.60 m dbh)** • **Volume of LWD per 100 m** • **# alcoves and side channels per reach**
	Riparian Function	• **Width of riparian** • **Height of riparian**

		• **Dominant over story** • **Plant community diversity** • **# of conifers >50cm dbh** • **# of conifers >90cm dbh**
	Geomorphic processes	• ***% gravel within a reach*** • ***Ratio of side channel to tributary length*** • **Slow-water habitats** • **% fine sediment in pool tailout areas** • **% bedrock in stream reach**
	Lateral connectivity	• *% of the potential fish use stream length with entrenchment ratio > 2.2**
COMPONENT	**KEY ECOLOGICAL ATTRIBUTES (KEAs)**	**INDICATOR OF KEA HEALTH** **Bold = Sufficient data exists to evaluate the indicator with a reasonable/replicable amount of analysis.** *Italics = Aspirational indicator. Data is not readily available (i.e no monitoring program exists or is planned) and/or available data requires extensive (not easily replicated) analysis to assess.*
<u>Freshwater Non-Tidal Wetlands:</u> Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Habitats include depressions, flat depositional areas that are subject to flooding, broad flat areas that lack	Landscape Array of Habitats	• **Distribution of different wetland types compared to historic (NWI)**
	Riparian Function relevant to wetland type	• *Width* • *Dominant over story* • *Plant community diversity*

drainage outlets, sloping terrain associated with seeps, springs and drainage areas, areas associated with bogs, and open water bodies (with floating vegetation mats or submerged beds). This component is restricted to those wetlands that are hydrologically connected to coho streams. Estuarine associated wetlands are addressed in the estuarine section. These are areas that are not accessible to fish except under largest flood events. Areas that are accessible are included under “off-channel’ below.	Beaver ponds	• # and area of beaver ponds
	Hydraulic Connectivity	• ***Frequency and duration of floodplain wetland inundation*** • ***Accessible to fish*** • *Subsurface connectivity*
COMPONENT	**KEY ECOLOGICAL ATTRIBUTES (KEAs)**	**INDICATOR OF KEA HEALTH** **Bold = Sufficient data exists to evaluate the indicator with a reasonable/replicable amount of analysis.** *Italics = Aspirational indicator. Data is not readily available (i.e no monitoring program exists or is planned) and/or available data requires extensive (not easily replicated) analysis to assess.*
<u>**Off-channel:**</u> Any area other than the main or primary channel of mainstem or tributary habitats that provides a velocity refuge for coho. This includes off-channel habitats such as alcoves, side channels, and oxbows. This includes riparian and floodplain.	Habitat complexity	• **% of stream reach that is slackwater pool habitat** • **% pools greater than 1 meter in depth** • **Volume of LWD per 100 m** • **# alcoves and side channels per stream reach** • **# of wood pieces per 100m of stream** • **# Key wood pieces (>12m long, 0.60m dbh)**
	Riparian Function	• **Width** • **Dominant overstory** • **Plant community diversity**
	Lateral connectivity	• **Miles/acres of off-channel area connected to mainstem**

		or tributary
COMPONENT	**KEY ECOLOGICAL ATTRIBUTES (KEAs)**	**INDICATOR OF KEA HEALTH** **Bold = Sufficient data exists to evaluate the indicator with a reasonable/replicable amount of analysis.** *Italics = Aspirational indicator. Data is not readily available (i.e no monitoring program exists or is planned) and/or available data requires extensive (not easily replicated) analysis to assess.*
<u>Estuaries:</u> The areas historically available for feeding, rearing, and smolting in tidally influenced lower reaches of rivers that extend upstream to the head of tide and seaward to the mouth of the estuary. Head of tide is the inland or upstream limit of water affected by a tide of at least 0.2 foot (0.06 meter) amplitude (CMECS). This includes tidally influence portions of rivers that are considered to be freshwater (salinity <0.5 ppt). We are extending the definition laterally to the uppermost extent of wetland vegetation (mapped by CMECS). Habitats include saltmarsh, emergent marsh, open water, subtidal, intertidal, backwater areas, tidal swamps, and deep channels. This includes the ecotone between saltwater and freshwater and the riparian zone.:	Water Quality	• **Temperature** • ***DO*** • **Nuutrient** • *Cold water refugia* • ***Nutrients***
	Landscape Array of Habitats	• **Acres of connected tidal wetland** • **Distribution of habitat types relative to historic condition (CMECS/C-CAP data)** • **Riparian condition** • Acres of wetland relative to historic condition (use Coastal and Marine Ecological Classification (CMECS) and Coastal Change Analysis Program (C-CAP) data) • *Acres of beaver ponds*
	Connectivity (lateral and longitudinal	• **Barrier inventory (indicator of extent of fish passage)**

COMPONENT	KEY ECOLOGICAL ATTRIBUTES (KEAs)	INDICATOR OF KEA HEALTH **Bold = Sufficient data exists to evaluate the indicator with a reasonable/replicable amount of analysis.** *Italics = Aspirational indicator. Data is not readily available (i.e no monitoring program exists or is planned) and/or available data requires extensive (not easily replicated) analysis to assess.*
Uplands: All lands that are at a higher elevation than adjacent water bodies and alluvial plains. They include all lands from where the floodplain/riparian zones terminate and the terrain begins to slope upward forming a hillside, mountain-side, cliff face, or other non-floodplain surface.	Connectivity	• *% high debris flow areas intersected by roads* • *% riparian corridors intersected by roads* • *Sediment delivery (fine, coarse)* • *Road density (threats indicator)*
	Landscape Array of Structural Diversity	• *% of forest classified as: regeneration, closed single canopy; understory; layered; older forest.* • *% high risk landslide areas with forest stands in layered or older forest structure.* • *% land use conducive to watershed processes* • *% of watershed in T&FG or EFU (threats indicator)* • *Acres of new development in FEMA floodplains*

* Entrenchment indicator references:

- Aquatic and Riparian Effectiveness Monitoring Program (AREMP) Staff. 2005. Watershed Monitoring for the Northwest Forest Plan, Data Summary Interpretation 2005, Oregon/Washington Coast Province. USDA Forest Service, Pacific Northwest Regional Office; Bureau of Land Management, Oregon State Office; 4077 S.W. Research Way, Corvallis, OR 97333. http://www.reo.gov/monitoring/watershed

- EPA Watershed Academy. 2005. Fundamentals of the Rosgen Stream Classification System; Excerpts of copyrighted material used with permission from Rosgen, D.L. and H.L. Silvey. 1996. Applied River Morphology. Wildland Hydrology Books, Fort Collins, CO. http://www.epa.gov/watertrain/stream_class/index.htm

High Ranked Stresses
Lower Elk River
July 23 Meeting

Component	**Associated Stresses**	**Related threats**
Mainstem	**1) Altered riparian function (species of complexity, age complexity, width of buffer, extent) (gorse invasion)**	Incompat. Timber practices, ag practices, conversion, roads, conversion
	2) Reduced extent of instream habitat	Incompat. Ag, timber, roads, conversion, dredging, beaver removal, invasives, loss POC, fish passage impairments, water withdrawals, water storage
	3) Decreased lateral connectivity (incised channel)	Incompat. Timber, ag practices, armoring, roads, conversion
	Reduced riparian wood inputs (frequency and size/composition of wood in streams, recruitable wood)	Conversion, conversion, ag practices, timber management, road management, invasives (gorse), bank armoring, loss of POC, removal of wood (navigation, firewood, perceived "good practice".)
	Lack of pools (infill with excess coarse sediment)	Incompat. Timber practices (legacy, high bed-load system), roads, armoring,
	Forest disease	Disease transport (SOD, POC)
	Increased water temperature	Conversion, water withdrawals, incompatible and poorly managed grazing and other agricultural practices, incompatible and poorly managed timber, incompatible and poorly managed roads, invasive species, climate change, bank armoring, hatchery discharge
	Reduced DO (listed, but treated with temperature)	See temperature
Tributary	**1) Altered riparian function (species of complexity, age complexity, width of buffer)**	Incompat. Ag, timber, roads, conversion, loss POC, invasives,
	2) Decreased lateral connectivity (overwintering habitat)	Armoring (Bagley), Incompat. Timber, roads, conversion, agriculture, dredging, ~~gravel/placer and suction dredge~~ mining
	3) Reduced extent of habitat	Incompat. Ag, timber, roads, conversion, dredging, beaver removal, invasives, loss POC, fish passage impairments, water withdrawals, water storage
	4) Increased water temperature	See mainstem except hatchery discharge, removal of beavers and

		beaver ponds, dams and off-channel water storage,
	Decreased longitudinal connectivity (fish Passage)	Culverts, dams
	Lack of pools	Removal of beavers and beaver ponds, incompat. Roads, timber, ag, conversion, ag dredging
	Decreased beaver ponds	Removal of beavers and beaver ponds, incompat. Ag, timber, roads, conversion (loss of suitable beaver riparian habitat)
	Reduced riparian wood inputs (frequency and size/composition of wood in streams, recruitable wood)	13, 14, stream cleaning (make recreation threat), 11, 6, loss of POC, armoring (Bagley),
	Increased coarse sediment loading	
Freshwater Nontidal Wetlands	**1) Reduced extent of habitat (area)**	Incompat. Ag, timber, roads, conversion, dredging, levees dikes, removal of beaver, invasives (gorse, Himalayan blackberry)
	2) Decreased connectivity	Incompat. Roads, timber, ag, conversion,
	3) Lack of natural storage	Incompat. Ag, timber, roads, conversion, dredging, levees dikes, removal of beaver, invasives (gorse, Himalayan blackberry),
	Reduced frequency and size of wood	Incompat. Ag, timber, roads, conversion, dredging, levees and dikes, firewood gathering,
	Decreased beaver ponds	Beaver removal, lack of beaver habitat in riparian,
Off-channel	**1) Altered riparian function (species of complexity, age complexity, width of buffer)**	Invasives (gorse, H. blackberry), incompat. Ag, timber, conversion , roads, dredging
	2) Decreased lateral connectivity	Invasives (gorse, H. blackberry), incompat. Ag, timber, conversion , roads, dredging
	3) Reduced extent of habitat Restoring a largely missing component (function) on mainstem and tributaries	Invasives (gorse, H. blackberry), incompat. Ag, timber, conversion , roads, dredging,
	Reduced riparian wood inputs (frequency and size/composition of wood in streams, recruitable wood)	Invasives (gorse, H. blackberry), incompat. Ag, timber, conversion , roads, dredging,
	Decreased beaver ponds	Beaver removal, lack of riparian habitat
Estuary	**1a) Increased water temperature (summer)**	(upstream) incompat. Ag, timber, roads, conversion, dredging of tribs
	1b) Increased nutrients	(upstream and adjacent to estuary) incompat. Ag, timber, roads, conversion, dredging of tribs
	1c) Reduced DO	(upstream and adjacent to estuary) incompat. Ag, timber, roads, conversion, dredging Due to nutrients

	2 Reduced habitat diversity (flow, depth, wood) (winter)	upstream and adjacent to estuary) incompat. Ag, timber, roads, conversion, dredging of tribs
	3 Reduced extent of margin, channel, and size of habitat	upstream and adjacent to estuary) incompat. Ag, timber, roads, upstream conversion, wood removal upstream, invasives
	Reduced frequency of wood in estuary	upstream and adjacent to estuary) incompat. Ag, timber, roads, upstream conversion, wood removal upstream
	Reduced size of wood in estuary (combine with frequency)	upstream and adjacent to estuary) incompat. Ag, timber, roads, upstream conversion, wood removal upstream
	Reduced riparian width (buffer size)	Incompatible ag. Practices, (ranch) roads,
	Reduced riparian species complexity (+ gorse)	Incompatible ag. Practices, (ranch) roads, invasives (gorse, broms, blackberry)
	Altered marine mixing	Invasive species (European dune grass—dune stabilization)
	Reduced tidal wetland connectivity	Incompatible ag, (ranch) roads, Invasive species (European dune grass—dune stabilization)
	Altered freshwater hydrology	Water withdrawal, loss of wetland storage
Uplands	**1) Fragmentation**	Incompatible timber and agricultural practices, conversion (recreation, subdivision, irreversible land use changes on a large scale)
	2) Increased sediment delivery and hydrologic peaks	Incompatible ag, timber, roads, conversion
	3) Altered forest composition	Incompatible timber practices, fragmentation, agricultural practices; POC, SOD, invasives (gorse)
	Altered connectivity to stream networks	Land conversion and roads

PC Trask and Associates

Elk River Synthesis

Coho Business Plan

Historically, the Elk River was a stronghold for Coho salmon along the southern Oregon coast. The Elk provided complex habitat structure in channels and access to its floodplain, wetlands, and tributaries for spawning adult and rearing juvenile Coho. Today, agricultural development and timber harvest have lasting effects on the quality and accessibility of habitat for Coho salmon. There are several habitat components that contribute to Coho salmon habitat in the Elk River watershed. The following section will synthesize the current literature, highlighting key ecological attributes identified by the local core team for the mainstem, tributary, freshwater non-tidal wetland, off channel, estuary, and upland habitat components. Each component section will discuss key ecological attributes for each subwatershed (also known as 6^{th} Level, Watershed 6^{th} Level, or HUC-12) and identify data gaps and uncertainty.

Overall, there seemed to be clear levels of confidence in the limiting factors impacting the subwatersheds and the watershed as a whole. At the assessment and synthesis level, the information was well documented. However, it was unclear at times what specific raw data sets these conclusions were drawn upon, the period of record for those data sets, and the replicability of their methods. In addition, most of the reviewed literature is over ten years old (if not more) so considering the conditions reported in these documents as current conditions could be misleading or inaccurate.

Mainstem Component

The lower Elk River limiting factors for Coho salmon habitat and production for the mainstem appear to be high water temperatures, channel modification, disconnected floodplains and wetlands, reduced riparian cover, exotic weed infestation, and increased fine sediment sources (present and potential). The mainstem Elk River is listed as water quality limited for temperature and habitat modifications by the Oregon Department of Environmental Quality (ODEQ). Temperatures in the lower Elk River mainstem are above the ODEQ standard during summer months. Water in the Lower Elk Mainstem warms 3-4 degrees Fahrenheit between the National Forest Boundary above the hatchery and Bagley Creek (Massingill & Hoogesteger, 2002).

Agricultural development in the lower watershed has resulted in removal of large log drifts and snags from channel habitats and disconnection of off-channel, floodplain, and wetland habitats. Levees, culverts, and other impoundments limit wetland connectivity, cutting off access points to the wetlands and tidal slough channels for Coho and interrupting natural hydrology. Agriculture infrastructure like ditches simplify hydrology and drain wetlands while decreasing channel edge habitat complexity.

Conversion of the floodplain to agriculture and grazing has resulted in the loss of wetlands, contributes to reduced habitat diversity, invasive plant species infestations, and degrades overall riparian habitat function. Lower Elk River riparian zones were once dominated by large conifers. Today, riparian vegetation in the lower watershed is primarily shrubs and lower growing hardwoods heavily impacted with gorse and Himalayan blackberry (USFS 1998, Maguire 2001). Two-thirds of the lower mainstem is in immature pioneer and brush communities with little to offer for stream shade and large wood.

The upper Elk River mainstem is water quality limited for summer water temperatures and modification. Riparian areas in the Upper Elk River mainstem and its tributaries were heavily impacted in the 1950s and 1960s by road building and timber harvest. The loss of shade trees and channel alterations has contributed to increasing summer stream temperatures by several degrees on the mainstem. The desired trend for large wood and riparian vegetation is to accelerate reestablishment of large conifers through vegetative treatment. The mainstem of Elk River is a high priority area for vegetative treatment (USFS 1998). While riparian shading is an issue in the upper Elk River mainstem, large wood recruitment potential does not seem to be an issue within the Nation Forest boundary.

In reviewing the literature, there was a good deal of information about flow, both about lack of flow during summer months and peak flow enhancement during storm events. The topic of flow and water withdrawal includes uncertainty. It should be mentioned that the literature (Maguire 2001) states that instream water rights are usually met. However, these flow measurements were taken near the Elk River Hatchery, not taken in the lower Elk River where almost all of the water diversion occurs for agriculture. Based on this information, there is no way to establish if the instream flow is in compliance with the water right downstream of the hatchery.

Tributary Component

The lower Elk River tributaries suffer from many of the same issues as the mainstem. Most of the lower Elk River tributaries have high summer stream temperatures, poor habitat complexity, lack of riparian function, and high fine sediment yield. Bagley Creek, Bald Mountain Creek, Cedar Creek, and Swamp Creek all exceed the 64 degree ODEQ standard (Massingill 2001). Bald Mountain Creek is also limited by habitat modification while many lower Elk River tributaries lack large wood. Sediment concerns include high sediment yield in Bald Mountain Creek as well as numerous steep roads located in unstable soils in Purple Mountain Creek (Maguire 2001). Purple Mountain Creek in the upper end of the subwatershed is producing a high amount of sediment with some long-lasting effects on habitat and channel characteristics downstream (Massingill 2001). There is decreased connectivity to off-channel habitats and tributaries because of a culvert on Bagley Creek (Cotton & Maiyo 2012). Twelve barriers to fish migration are identified on tributaries in the Lower Mainstem and Coastal Area. Five culverts are identified as adult barriers, six as juvenile barriers, and one as an uncertain juvenile barrier (Massingill 2001).

The upper Elk River tributaries were heavily impacted in the 1950s and 1960s by road building and timber harvest. The loss of shade trees and channel alterations has contributed to increasing summer stream temperatures by several degrees on the mainstem (USFS 1998, Cotton & Maiyo 2012). Butler Creek is on the 303(d) list as water temperature limited, and also has a high sediment yield (Massingill 2001). Panther Creek exceeds the 64 degree EPA standard as well. Butler Creek has poor riparian condition, leading to a lack of shade, large wood, and pool habitat complexity. The desired trend for large wood and riparian vegetation is to accelerate reestablishment of large conifers through vegetative treatment. East fork of Butler Creek is a high priority area (USFS 1998). A culvert on Blackberry Creek reduces connectivity and access for Coho.

Freshwater Non-Tidal Wetlands Component

The lower Elk River freshwater wetlands are heavily impacted by agricultural practices. Agriculture associated infrastructure like ditches simplify hydrology and decrease edge habitat and habitat complexity. Levees, culverts, and other impoundments limit wetland connectivity, reducing access points to the wetlands for Coho and interrupting natural hydrology which can encourage invasive species colonization. Wetland degradation in the Lower Elk is a product of agriculture associated infrastructure and practices like grazing. Lower Elk wetlands are overgrazed, lack native vegetation diversity, and have poor riparian conditions, making way for opportunistic invasive species colonization. According to Brophy 2003, some restoration has taken place in freshwater non-tidal wetlands in the form of riparian fencing, gorse treatments, and native plantings. Filling of ditches and restoring meanders as well as eliminating grazing practices are suggested restoration techniques for future efforts (Brophy 2003).

Off-Channel Component

Off-channel habitats not associated with mainstem, tributary, or estuary habitat was not a prominent topic of the reviewed literature. Off-channel habitat associated with mainstem, tributary, and estuary habitat is discussed in those sections. Off-channel habitats were explicitly mentioned in Vander Schaaf et al 2008 and Cotton & Maiyo 2012, with somewhat conflicting observations. Vander Schaaf et al 2008 report that off-channel freshwater system connectivity was rated good while estuary system connectivity was rated fair. Cotton & Maiyo 2012 state that the lower Elk River side channel habitat has been significantly reduced. The status of these habitats is unclear, but based on observations of habitats associated with the mainstem, tributaries, and estuary, it could be speculated that these habitats lack complexity, riparian function, and lateral connectivity (especially in the lower Elk River).

Estuary Component

The Elk River estuary is an important transition zone for migrating Coho salmon. Historically, the Elk River estuary provided important foraging and rearing habitat with accessible floodplains and wetlands. Today, more than two-thirds of the lower Elk River tidally influenced wetlands have high levels of alteration (Massingill 2001). These alterations are largely agricultural based activities. Channelization, ditching, land clearing, and levee construction reduce the expression of tidal hydrologic influence and normative estuarine drainage patterns. This introduced infrastructure limits wetland connectivity, reducing access points to the wetlands and tidal slough channels. Agriculture infrastructure interrupts natural hydrology which can encourage invasive plant species colonization. Land clearing and introduced vegetation for grazing needs also reduces the extent of estuarine habitat diversity including important tidal swamps and other unique coastal wetland types (Brophy 2003).

Agricultural activities contribute to increased nutrients from agricultural inputs, but it is unclear to what level. It can also be assumed that other contaminants from agriculture may be in the system, but no pesticide, herbicide, or other contaminant monitoring has been documented. While several reports acknowledged the past existence and importance of beaver dams and ponds in the estuary, no quantifiable data was presented in the literature.

Uplands Component

Both the lower and upper Elk have issues with sediment originating from uplands. In the lower Elk River, sediment concerns include high sediment yield in Bald Mountain Creek as well as numerous steep roads in unstable soils in Purple Mountain Creek (Maguire 2001). Purple Mountain Creek in the upper end of the lower Elk River subwatershed is producing a high amount of sediment with long-lasting effects on habitat and channel characteristics downstream (Massingill 2001). The Upper Elk River has issues with upland connectivity and sediment delivery with roads and timber harvest contributing fine sediments during storms. These forestry activities can accelerate mass-movement events by increasing overland and surface flow patterns that can further destabilize upland slopes. Road 5201 near Butler Creek and Road 5325-180 near Panther Creek are concerns for fine sediment delivery (USFS 1998, DEQ 2003).

Fish Survey Data

Fish sampling surveys have been conducted in the Elk River system by multiple entities employing a variety of sampling techniques providing mixed results. Oregon Department of Fish and Wildlife conducted adult carcass and redd counts as well as snorkel surveys. The South Coast Watershed Council conducted smolt traps surveys in Swamp Creek and Cedar Creek. There are far more surveys with no sightings than those where Coho salmon were found. Adult Coho salmon were found in Anvil, Indian, Butler, and Red Cedar creeks as well as the mainstem Elk River between Sunshine Creek and Red Cedar Creek. Juvenile Coho salmon were found in Panther, Red Cedar, Swamp, Cedar, and Blackberry creeks as well as the middle mainstem Elk River (NOAA Fisheries 2014). The 1985 surveys conducted by USFS Pacific Northwest Research State estimated that Coho densities were as high as 0.61 fish/m^2 in the North Fork (Reeves 1987 via USFS 1998).

Tributaries important for coho production are Red Cedar, the North Fork, Panther and Anvil creeks (Reeves et al. Unpublished data via USFS 1998). These tributaries appear to account for most of the present coho production in the entire watershed (USFS 1998). Productive flats reaches include the Elk River mainstem, North Fork Elk River, Red Cedar Creek, and Panther

Creek (Vander Schaaf 2008). In 1997, adult coho salmon populations for the entire Elk River population area ranged between 100 and 200 (USFS 1998). Estimated returns were zero in many years between 1998 and 2007, and at most 501 in 1998. Large differences in effort between years and incomplete survey coverage could account for observed differences in estimates. In addition, high flows may have occurred in some years, which could affect the ability to carry out sampling consistently or effectively (NOAA Fisheries 2014). The fish data and productive reaches referenced above lack long term fish monitoring data, at least how they are presented in the reviewed literature. An understanding of fish productivity and productive areas is fairly general based on limited observations.

Seminal Document Bibliography – Elk River

- Brophy, L. (2003). Wetland Site Prioritization Lower Elk and Sixes Rivers , Curry County , OR.
- Cottom, K., & Maiyo, S. (2012). Elk River Watershed Restoration Aquatic Action Plan. USFS.
- Maguire, M. (2001). Elk River Watershed Assessment.
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- Massingill, C., & Hoogesteger, H. (2002). Curry Action Plan. South Coast Watershed Council.
- National Marine Fisheries Service. (2014). Elk River Population Profile. In *Final Recovery Plan for the Southern Oregon/Northern California Coast Evolutionary Significant Unit of Coho Salmon* (pp. 1–24). Arcata, CA: National Marine Fisheries Service.
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- USDA Forest Service Northwest Region. (1998). Elk River Watershed Analysis.
- Vander Schaaf, D., Pickering, D., Bach, L., & Becker, J. (2008). *Cape Blanco Site Conservation Action Plan*.

Brophy, L. (2003). Wetland Site Prioritization Lower Elk and Sixes Rivers, Curry County , OR.

<u>Lower Elk River Summary</u>

In general, the Lower Elk River tidal and freshwater wetlands are heavily impacted by agricultural practices. Agriculture associated infrastructure like ditches simplify hydrology and decrease edge habitat and habitat complexity. Levees, culverts, and other impoundments limit wetland connectivity, cutting off access points to the wetlands for Coho and interrupting natural hydrology which can encourage invasive species colonization. Wetland degradation in the Lower Elk is a product of agriculture associated infrastructure and agricultural practices like grazing. Lower Elk wetlands are overgrazed, lack native vegetation, and have poor riparian conditions, making way for invasive species colonization.

Cottom, K., & Maiyo, S. (2012). Elk River Watershed Restoration Aquatic Action Plan. USFS.

<u>Lower Elk Summary</u>

The Lower Elk River estuary, mainstem, and tributaries suffer from poor water quality, mostly during the summer months. The estuary has increased nutrient levels from agriculture. The mainstem and Bald Mountain Creek are water quality limited for summer water temperatures and modification. The mainstem has poor riparian function which contributes to the high summer water temperatures. The vegetation along the lower river valley today consists primarily of shrubs and lower growing hardwoods providing little riparian shade. Lower Elk River riparian zones were once dominated by large conifers, but today are dominated by hardwoods and invasive non-native species, especially gorse and Himalayan blackberry. There is decreased connectivity to off-channel habitats and tributaries because of culverts (Specifically on Bagley Creek) and reduced tidal wetland connectivity in the estuary. The Lower Elk River has some issues with upland connectivity and sediment delivery with roads and timber harvest contributing fine sediments during storms. The mainstem and tributaries lack habitat complexity in the form of large wood and pools. Removal of in-channel wood due to log rafting operations and periodic clearing of wood to maintain drift boat fishing access are main causes of less large wood in the channel.

<u>Upper Elk Summary</u>

The Upper Elk River mainstem is water quality limited for summer water temperatures and modification. Riparian areas in the Upper Elk River mainstem and its tributaries were heavily impacted in the 1950s and 1960s by road building and timber harvest. The loss of shade trees and channel changes has contributed to increasing summer stream temperatures by several degrees on the mainstem. Butler Creek has poor riparian condition, leading to a lack of shade and large wood and pool habitat complexity. A culvert on Blackberry Creek reduces connectivity and access for Coho. The Upper Elk River has some issues with upland connectivity and sediment delivery with roads and timber harvest contributing fine sediments during storms.

Maguire, M. (2001). Elk River Watershed Assessment.

<u>Lower Elk River Summary</u>

Limiting factors to fish production and water quality in the Elk River appear to be weak riparian cover, sediment sources (present and potential), high water temperatures, and noxious weed invasions. Agricultural development in the lower watershed resulted in removal of large log "drifts", loss of wetlands and reduction of riparian vegetation. Riparian vegetation in the lower watershed is heavily impacted with gorse and Himalayan blackberry. Two-thirds of the lower mainstem is in pioneer and brush communities with little to offer for stream shade and large wood. Water use issues in the watershed are minor, and the in-stream water right – though younger than most - is usually met. The largest user of water in the watershed is the Elk River Fish Hatchery. Water quality is limited for temperature and habitat modifications in the Mainstem as well as Bald Mountain Creek. Butler Creek is listed for temperature. Temperatures in the mainstem are warm to very warm and tributaries are generally cool. Water in the Lower Elk Mainstem warms 3-4 degrees between the National Forest Boundary above the hatchery and Bagley Creek. Wetlands are all located in the Lower Elk Mainstem and Coastal Area and more than two thirds have high levels of alteration. Sediment concerns include high sediment yield in Bald Mountain Creek as well as numerous steep roads in unstable soils in Purple Mountain Creek.

<u>Upper Elk River Summary</u>

Bagley Creek is reported as possible coho habitat with restoration potential.

Massingill, C. (2001). Elk River Watershed Action Plan.

<u>Lower Elk Summary</u>

The Elk River Watershed Council identified noxious weed invasion and channel modification as their primary concerns for the watershed, related to land uses. Twelve barriers to fish migration are identified in the watershed, and all are located in the Lower Mainstem and Coastal Area. Five culverts are identified as adult barriers, six as juvenile barriers, and one as an uncertain juvenile barrier. Elk River water quality is moderately impaired for fecal coliform bacteria, as measured at the Highway 101 Bridge. Elk River and Bald Mountain Creek are 303(d) listed for temperature and under investigation for habitat modification. All tributaries in the Lower Elk watershed have low flows compared to the mainstem. Bagley Creek, Cedar Creek, and Swamp Creek all exceed the 64 degree standard. Mainstem temperatures are in the mid 60's to low 70's (7-day maximum). Two-thirds of the identified wetlands have a high degree of alteration, and most are in the Coastal Area (87%) and Lower Mainstem (13%). During recent history (150 years) the lower Elk channel has been straightened, vegetation has been altered both by removal and introduced species, and the channel is now confined to one portion of the floodplain. Purple Mountain Creek in the upper end of the subwatershed is producing a high amount of sediment with some long-lasting effects on habitat and channel characteristics downstream.

<u>Upper Elk Summary</u>

Butler Creek is on the 303(d) list as water temperature limited, and also has a high sediment yield. Bagley Creek exceeds the 64 degree EPA standard as well.

Massingill, C., & Hoogesteger, H. (2002). Curry Action Plan. South Coast Watershed Council.

Massingill & Hoogesteger (2002) contains identical watershed assessment and synthesis language to Maguire (2001) and Massingill (2001). See above for major discussion points.

National Marine Fisheries Service. (2014). Elk River Population Profile. In Final Recovery Plan for the Southern Oregon/Northern California Coast Evolutionary Significant Unit of Coho Salmon (pp. 1–24). Arcata, CA: National Marine Fisheries Service.

<u>Lower Elk River Summary</u>

Agricultural practices are the top threat for coho salmon because their impacts are concentrated in the lower basin, where the highest IP habitat exists and where all fish from the upper basin must pass. Agricultural impacts include the loss and filling of wetlands, water diversion, riparian alteration, polluted stormwater runoff, and blocked access to formerly productive tributaries. Lack of floodplain and channel structure is the greatest constraint to coho salmon production in the Elk River. Habitat simplification, resulting from straightening, channelizing, revetting, filling, and/or stream channel dredging, was the most limiting stress upon coho salmon in the Elk River. The lower Elk River channel is disconnected from its floodplain, wetlands, and tributaries. This has significantly reduced what was once optimal habitat for coho salmon spawning, egg incubation, and rearing. Large woody debris was historically important and available in the lower Elk River but today there is little large wood. Water temperature in the mainstem Elk River and Bald Mountain Creek do not meet the Oregon Department of Environmental Quality (ODEQ) maximum average weekly temperature standard of 64 ºF. Water temperatures are suitable during the time of adult returns and when eggs are in the gravel. The water temperature at Bagley Creek is 3 to 4 °F warmer than that observed upstream at the National Forest boundary (Maguire 2001). Swamp Creek, a tributary to the estuary, also had impaired water temperature conditions of 69.7 °F.

These high temperatures can be partially attributed to riparian shade loss and competition from non-native shrubs. Elk River riparian zones were once dominated by large conifers, but today are dominated by hardwoods and invasive non-native species including gorse and Himalayan blackberry (USFS 1998a, Maguire 2001a). Sediment contribution from landslides and erosion occurs naturally in the Elk River basin; however, roads, timber harvest, and bank erosion following removal of riparian vegetation have elevated fine sediment input. High sediment yield is of particular concern in those areas of the basin with decomposing diorite-type soil, such as at Bald Mountain Creek and Purple Mountain Creek (Maguire 2001a). Excess fine sediment directly impacts coho salmon egg viability and can reduce food for fry, juveniles and smolts. Poor pool frequency and depth throughout the Elk River basin (Maguire 2001a) are likely due to elevated levels of fine sediment partially filling pools, a lack of scour-forcing obstructions such as large wood, and, in some reaches, diminished scour due to channel widening.

Upper Elk River Summary

Water temperature in the mainstem Elk River, Panther, and Butler creeks does not meet the Oregon Department of Environmental Quality (ODEQ) maximum average weekly temperature standard of 64 ºF. Water temperatures are suitable during the time of adult returns and when eggs are in the gravel. In steeper channels of headwater streams, riparian trees may be removed by rapidly moving landslides known as debris torrents that move down channels (USFS 1998a). Sediment contribution from landslides and erosion occurs naturally in the Elk River basin; however, roads, timber harvest, and bank erosion following removal of riparian vegetation have elevated fine sediment input.

Siskiyou National Forest Oregon Department of Environmental Quality Coos Bay Office. (2003). Elk River above National Forest Boundary Water Quality Restoration Plan.

Lower Elk River Summary

The Lower Elk River mainstem is listed as water quality limited for summer stream temperatures and habitat modification. This is in large part due to reduced tree heights that result when riparian vegetation changes from conifers (able to grow to a target height of 160 to 200 feet) to alders and big leaf maples that attain a maximum height of 90 feet. Road 5502 near Bald Mountain Creek is a concern for fine sediment delivery.

Upper Elk River Summary

In general, the upper reaches of the Elk River and most of its major tributaries within National Forest land have good to excellent fisheries resources and channel conditions, and are adequately supplied with large woody material. The Elk River above National Forest Boundary and its major tributaries appear to have sufficient quantities of potential (standing) large woody material in the riparian zones. The exceptions to varying degrees are Butler Creek and Bald Mountain Creek, primarily due to logging within the Riparian Reserves. The Upper Elk River mainstem is listed as water quality limited for summer stream temperatures. Excess solar loading from the Upper Elk sub-watershed and its tributaries is approximately 60% of the total excess loading coming off National Forest lands within the entire Elk River Watershed. Road 5201 near Butler Creek and road 5325-180 near Panther Creek are concerns for fine sediment delivery.

USDA Forest Service Northwest Region. (1998). Elk River Watershed Analysis.

Lower Elk River Summary

The key habitat elements which are important for coho salmon no longer exist in the lower Elk. Along the lower Elk River valley, land adjacent to the river has been cleared for pasture, and much of the riparian vegetation removed. Log drives altered or destroyed riparian vegetation, and removed large wood and jams. The majority of the heating of the Elk River appears to be 4 to 5 miles below the Fish Hatchery. These high temperatures are presumably due to the wide channel and lack of shading vegetation (McSwain 1988). Bald Mountain Creek is warm with peak temperatures ranging from 66oF to 68oF. The higher stream temperature in this tributary is the result of timber harvest and road construction. Open riparian canopies along first and second-order stream channels (class IV and III) increased 30-fold between 1956 and 1979, and were generally located along or near roaded or harvested sites. In areas where temperatures have increased as a result of management activities, reestablishing conifers will provide long-term shade and cooling. This is particularly important in Bald Mountain Creek and along the mainstem of Elk River. The most notable evidence of channel widening and an increase in the number and size of gravel bars occurred below the confluence with Purple Mountain Creek. This change can be attributed to sediment coming from Purple Mountain Creek following a period of poor timber harvest and road construction practices in the late 1950’s-early 1960's. Below the Forest boundary, continual water withdrawal by private landholders for agricultural purposes may affect summer survival of salmonids rearing in this portion of the watershed. This particularly impacts rearing conditions for coho salmon and limits the acclimation zone for all downstream migrants to the ocean.

Upper Elk River Summary

The majority of the heating of the Elk River appears to be occurring in the upper reaches of the mainstem. Butler and Panther Creeks are warm with peak temperatures ranging from 66oF to 68oF. They have little or no effect on buffering mainstem temperatures. The higher stream temperature in these tributaries is the result of timber harvest and road construction. The desired trend for large wood and riparian vegetation is to accelerate reestablishment of large conifers through vegetative treatment. High priority areas include east fork of Butler Creek and the mainstem of Elk River.

The 1985 surveys conducted by PNW estimated that coho densities were as high as 0.61 fish/m2 in the North Fork (Reeves 1987).Tributaries important for coho production are Red Cedar, the North Fork, Panther and Anvil creeks (Reeves et al. Unpublished data).These tributaries appear to account for most of the present coho production in the entire watershed.

Vander Schaaf, D., Pickering, D., Bach, L., & Becker, J. (2008). Cape Blanco Site Conservation Action Plan.

Vander Schaaf et al. (2008) provides strategic actions and potential implementation sites in support of the larger Conservation Action Plan (CAP) mission to “Support conservation and restoration-based working landscapes and seascapes.” The CAP employs a “Sea to Summit” approach, encompassing aquatic ecosystems to uplands. The CAP offers the following suggestions for coho habitats:

- Address altered hydrology by identifying water withdrawals that have a significant impact on late-season streamflow and water delivery to wetlands/estuary. Elk River priority streams: Bald Mountain, Butler, Panther Creeks and lower and upper mainstem Elk River.
- Work with producers to reduce adverse habitat and water quality impacts from grazing. All ranches in lower river reaches.
- Address altered hydrology by removing dikes and levees, filling ditches, and reconnecting channels. Emphasis on Brophy (2003) priority wetlands for Elk, Bagley Creek, and Swamp Creek. Productive flats reaches: Elk River mainstem, North Fork Elk River, Red Cedar Creek, and Panther Creek.
- Ensure passage to habitats through culvert replacement on Blackberry Creek.
- Increase average width of native vegetated riparian corridors along key stream reaches: Elk River Priority Reaches (Temp. management): Bald Mountain, Panther, and Butler Creeks. Bald Mountain on non FS lands. Focus on productive flats for Elk.
- Restore and maintain instream habitat and reconnect stream and riparian areas. Channel morphology problems are severe below FS land due to losses of riparian veg and large conifer removal, particularly in Bagley Creek and lower watershed Elk River. Productive flats: Elk River-mainstem, Red Cedar Creek, Panther Creek, North Fork tributaries.
- Modify or eliminate impediments, such as roads, to stream/riparian function. Sediment loading problems in Butler and Bald Mountain Creeks due to depleted large wood supply and continued harvest on private lands in Bald Mountain Creek.

Elk River SAP

Project Prioritization Criteria (updated for 7/1 meeting and again for IP on 8/2)

Criteria / Score ->	**0**	**1**	**2**	**3**	**4**	**5**
Importance of Tributary or Reach						
• Life Stages: Which stage(s) of the life cycle does the trib support? (spawning, over-wintering, summer rearing, all)	none	spawning	Summer rearing	Over-wintering	Two stages	All three stages
• Habitat Potential: Is it high IP for coho?	No	1 to 49% of trib high IP	50% or more of trib is high IP			
• Bonus: Does the tributary support a unique life history or habitat type? (estuary, nomadic)	No		yes			
• Bonus: Is the trib a cold water source?	No		yes			
Total Score for tributary or reach:						
Importance of Project						
• Limiting factors: Which stresses and/or limiting factors does this project address?	None	Addresses a stress but not a limiting factor (e.g. bedload transport)	Addresses Temperature	Improves complexity of winter habitat	Prevents loss of complexity (e.g. prevent mass wasting)	Significantly addresses temp and complexity of winter habitat
• Processes: How many high priority, altered processes does it target? (Bedload transport, flow, lwd delivery, channel migration, floodplain interaction, riparian function)	None	1 – 6 based on number of processes enhanced				
• Longevity: How long will impact last?	Less than a year	1 - 3years	3 – 27 years	> 27 years		
• Assurance of success:	No	Yes				

• <u>Working lands</u> – Does the project protect or enhance habitat conditions while benefitting the landowner?	No		Yes (points based on scale of impact)	Yes (points based on scale of impact)		
• <u>Bonus:</u> Does the project advance an innovative practice of a proven technique not yet used in that basin, or does it apply an entirely new practice?	No	yes				
• <u>Bonus</u>: Does this project complete the work in the sub-watershed for the period of the plan?	No	yes				
Total Score: (Total of LF, Process, long, Assurance)/4 + Bonuses = **<u>TOTAL (Trib + Project) =</u>**						

Social Criteria

Criteria / Score ->	0	1	2	3	4	5
Social Support for the Project						
• Implementation Feasibility: Will there be political or social resistance?	Yes, high	Yes, moderate	Unknown	Yes, but not much	None expected	No, local champion(s)
• Assurance of success: has approach worked before? Is location suitable?	No / unknown	No / yes	Yes / yes			
• Cost	>1 million	400k – 1 mil	250-400k	50-250k	0-50k	
• Bonus: Does the project present an opportunity to educate the public and/or demonstrate an innovative restoration approach?	No		Yes			
• Bonus: Does this project complete the work in the watershed?	No		Yes			
• Bonus: Is there an opportunity to demonstrate working lands approach?	No		Yes (points based on scale)	Yes (points based on scale)		
• Bonus: Research, demonstration, or innovation, all with monitoring	No	yes				
Total Score: (Total of LF, Process, long, Assurance)/4 + Bonuses = **TOTAL (Trib + Project) =**						

Elk River SAP - Scoring Processes

Updated August 2, 2016

The following is an attempt to standardize how the team scores the extent to which a type of project restores a watershed process. This is intended to ensure consistency, while also speeding up this step in the scoring process.

Priority Processes that need to be restored in the Elk (identified by team)

1. Bedload transport
2. Flows
3. LWD delivery and recruitment
4. Channel migration
5. Floodplain interaction
6. Riparian function

Project Type Ranked	Notes	Score	Priority Processes addressed
1. Floodplain reconnection		6	Bedload transport Flows LWD delivery Channel migration Floodplain interaction (inc estuaries) Riparian function
2. LWD Installation		4	Bedload transport Channel migration Floodplain interaction (inc estuaries) Riparian function
3. Riparian enhancement		4	Riparian function LWD delivery Floodplain interaction (inc estuaries) Channel migration
4. Channel meander	Just adds length and habitat,	3	Bedload transport

	e.g. re-meandering a ditch. Does not substantially increase floodplain interaction. Assumes planting.		Channel migration Riparian function
5. Off channel wetlands restoration / creation		2	Flows Riparian function
6. Fish passage (culverts)	Assumes design to a standard that will move large wood.	2	LWD delivery Bedload transport
7. Roads - Storm proofing		2	Flows

ID	Stream or Reach	HUC
26	Indian Creek	Lower
53	Swamp Creek	Lower
33	Off-channel areas downstream of Highway (river left)	Lower
38	Camp Creek	Lower
44	Knapp Creek	Lower
49	Cedar Creek	Lower
42	Mainstem - Lower (heading west)	Lower
34	Mainstem - Kermit to Camp	Lower
28	Kermit Creek	Lower
30	Kermit Creek	Lower
63	Panther Creek	Upper
35	Ram Creek (or un-named trib)	Lower
4	Mainstem - Anvil Creek to Indian	Lower
27	Indian Creek	Lower
47	Cedar Creek	Lower
39	Mainstem - Camp to Lower (Just above two small tribs)	Lower
45	Knapp Creek	Lower
48	Cedar Creek	Lower
17	Henry Creek	Lower
29	Kermit Creek	Lower

50	Swamp Creek	Lower
6	Bear Creek	Lower
40	Mainstem - Just above two small tribs	Lower
8	Bald Mountain Creek	Upper
31	Kermit Creek	Lower
9	Bald Mountain Creek	Upper
1	Mainstem - Anvil Crek to Rock Creek	Lower
22	Bagley Creek	Lower
23	Bagley Creek	Lower
60	Mainstem - Butler to Red Cedar	Upper
57	Blackberry Creek	Upper
61	Butler Creek	Upper
56	Blackberry Creek	Upper
55	Mainstem - Blackberry to Butler	Upper
58	Blackberry Creek	Upper
62	Butler Creek	Upper
64	Panther Creek	Upper
3	Mainstem - Rock Creek to estuary	Lower
15	Hatchery Creek	Lower
16	Champman Creek	Lower
36	Ram Creek (or un-named trib)	Lower
37	Camp Creek	Lower

51	Swamp Creek	Lower
52	Swamp Creek	Lower
71	Indian Creek (and all tribs below)	Lower
59	Bungalow Creek	Upper
66	Sunshine Creek	Upper
67	Red Cedar Creek	Upper
70	Purple Mountain Creek	Upper
11	Mainstem - Bald to Anvil Creek	Lower
13	Anvil Creek	Lower
20	Mill Creek	Lower
21	Unamed Creek	Lower
25	Indian Creek (and all tribs below)	Lower
41	Two un-named tribs from SE	Lower
54	Elk River Estuary	Lower
69	Mainstem - Anvil to Indian Creek	Upper
5	Mainstem - Anvil Creek to Indian Creek	Lower
43	Mainstem - Lower (heading west)	Lower
46	Mainstem - Lower (where it turns north)	Lower
2	Mainstem - Rock Creek to Anvil Creek	Lower
68	Bald Mountain Creek	Upper
7	Bear Creek	Lower
10	Bald Mountain Creek	Lower
12	Anvil Creek	Lower
14	China Creek (un-named)	Lower
18	Henry Creek	Lower
19	Dan Creek	Lower
24	Bagley Creek	Lower
65	Panther Creek	Upper
110	Rock Creek	Upper
100	South Fork and North Fork Elk River	Upper
101	Indian	Lower
102	Kermit Creek	Lower

103	Cedar Creek	Lower
104	Camp Creek	Lower
105	Cedar Creek	Lower
106	Knapp Creek	Lower
107	Kermit Creek	Lower
108	Swamp Creek	Lower
109	Swamp Creek	Lower
98	Mainstem - Kermit to Indian	Lower
99	Mainstem - Kermit to Indian	Lower

Project	Project Type
Reconnect lower 1/4 mile of Indian Creek floodplain	Floodplain reconnection / off-channel restoration
Reconnect floodplains in lower Swamp Creek (includes LWD and riparian)	Floodplain reconnection / off-channel restoration
Convert ag ditch channels to off-channel rearing habitat downstream of highway 101 on river left (project 1 of 2)	Floodplain reconnection / off-channel restoration
Protect and enhance riparian habitat on Camp Creek (see related project on mainstem and Kermit)	Protection (easement)
Re-meander Knapp Creek (1 of 2)	Instream Complexity
Create wetlands (fish hotels) along Cedar Creek	Floodplain reconnection / off-channel restoration
Install LWD in lower mainstem (heading west)	Instream Complexity
Enhance riparian habitat on the mainstem between Kermit and Camp Creeks (project 2 of 2)	Riparian restoration
Enhance riparian habitats on Kermit Creek (see associated project on Camp Creek and mainstem)	Riparian restoration
Reconnect the Kermit Creek floodplain from the BPA/ranch access road down to the mouth	Floodplain reconnection / off-channel restoration
Add LWD to Panther Creek (West Fork and ½ mile in lower mainstem)	Instream Complexity
Protect riparian condition along Ram Creek	Protection (easement)
Enhance riparian habitats on mainstem from Anvil to Indian Creeks	Riparian restoration
Add LWD to Indian Creek	Instream Complexity
Add LWD to Cedar Creek	Instream Complexity
Plant cottonwood on two vegetated bars in lower mainstem property below Camp Creek	Riparian restoration
Enhance riparian habitats on Knapp Creek (2 of 2)	Riparian restoration
Enhance riparian vegetation on Cedar Creek	Riparian restoration
Add LWD to Henry Creek	Instream Complexity
Re-meneader and add LWD to Kermit Creek (above the road)	Instream Complexity

Install by-pass channel(s) on Swamp Creek	Longtitudinal re-connection
Add LWD to lower mile of Bear Creek	Instream Complexity
Add LWD to mainstem (below Camp andjust above two small tribs)	Instream Complexity
Enhance riparian habitats on Bald Mountain Creek and selected tribs	Riparian restoration
Replace culvert on Kermit Creek	Longtitudinal re-connection
Stormproof Road 5502 from Elk River Road for four miles, and Spur 20 off of 5400 in Bald Mountain Creek	Roads - Stormproofing
Reconnect off-channel habitats on mainstem, just below Rock Creek	Floodplain reconnection / off-channel restoration
Re-meander Bagley Creek and add LWD (step 2 of 3)	Instream Complexity
Replace two culverts on Bagley Creek (step 3 of 3)	Longtitudinal re-connection
Stormproof Road 5325 in the upper mainstem (Butler to Red Cedar).	Roads - Stormproofing
Add LWD to Blackberry Creek (with culvert replacement, project 56)	Instream Complexity
Add LWD to Butler Creek	Instream Complexity
Replace Blackberry Creek culvert and add LWD (project 57)	Longtitudinal re-connection
Inter-plant Port-Orford-cedar in upper mainstem (Blackberry to Butler)	Forest rehab
Stormproof the last three miles of Road 5502, Spur 295, Spur 240 in Upper Blackberry watershed	Roads - Stormproofing
Stormproof Road 5201 in Butler Creek	Roads - Stormproofing
Stormproof Roads 5502 and 5544 (including Spur 110) in Panther Creek watershed 5544 - Add the 110 spur. 5502 - Panther Creek section is the priority	Roads - Stormproofing
Use Netmap to assess and prioritize off-channel restoration opportunities at trib/mainstem connections downstream of Rock Creek	Assessment / Monitoring
Assess impact of ODFW hathcery on temperature in Hatchery Creek	Assessment / Monitoring
Monitor presence/absence of fish in Chapman Creek	Assessment / Monitoring
Assess temperature and flow on Ram Creek	Assessment / Monitoring
Assess drainage patterns (from cranberry bogs) and culvert condition on Camp Creek	Assessment / Monitoring

Evaluate potential for headwall failure in upper Swamp Creek and prioritize areas for protection	Assessment / Monitoring
Evaluate temperature regimes in Swamp Creek (above and below the reservoirs). Document extent of tidal reach.	Assessment / Monitoring
Assess sediment production from cranberry bogs, rock pits; and resource roads downstream of Inidan Creek. Prioritize abatement projects.	Assessment / Monitoring
None	None
None	None
None	None
None	None
None	None
None	None
None	None
None	None
None	None
None	None
None	None
Initiate outreach to County to prevent sub-division of lands and loss of hobby farms between Anvil and Rock Creek.	Outreach and Education
Initiate outreach to landowners between Anvil and Indian Creeks to recruit riparian projects (Repeated as project 69 for upper)	Outreach and Education
Conduct outreach to landowners on the lower mainstem regarding alternatives to conversion	Outreach and Education
Educate community on erosion potential in lower mainstem (where it turns north)	Outreach and Education
Acquire ranch on mainstem, just below Rock Creek, as working lands demonstration project	Proection (Acquisition or Easement)
Convey Purple Mountain tract to USFS	Proection (Acquisition)
Acquire tract on Bear Creek (outside of USFS boundary)	Proection (Acquisition)
Acquire three properties on Bald Mountain Creek	Proection (Acquisition)
Acquire property on Anvil Creek	Proection (Acquisition)
Acquire inholding on China Creek	Proection (Acquisition)
Acquire 15 acre parcel on Henry Creek	Proection (Acquisition)
Acquire property on Dan Creek	Proection (Acquisition)
Acquire mill site on Bagley Creek (step 1 of 3)	Proection (Acquisition)
Acquire Upper Panther Creek tract	Protection (Acquisition)
None	None
Stormproof Road 3353	Roads - Stormproofing
Protect existing high quality habitat on Indian Creek	Protection (easement)
Protect headwall on Kermit Creek	Protection (easement)

Protect headwall on Cedar Creek	Protection (easement)
Evaluate potential for headwall failure in upper Camp Creek and prioritize areas for protection	Assessment / Monitoring
Evaluate potential for headwall failure in upper Cedar Creek and prioritize areas for protection	Assessment / Monitoring
Evaluate potential for headwall failure in upper Knapp Creek and prioritize areas for protection	Assessment / Monitoring
Evaluate potential for headwall failure in upper Kermit Creek and prioritize areas for protection	Assessment / Monitoring
Evaluate potential for headwall failure in upper Bagley Creek and prioritize areas for protection	Assessment / Monitoring
Evaluate potential for headwall failure in upper Bear Creek and prioritize areas for protection	Assessment / Monitoring
Enhance riparian zones from Kermit to Indian	Riparian restoration
Add LWD to channel margins and floodplain from Kermit to Indian	Instream Complexity

Restoration or Other	Habitat Component
Restoration	Wetlands / Off-channel
Restoration	Wetlands / Off-channel
Restoration	Wetlands / Off-channel
Other	Tributary
Restoration	Tributary
Restoration	Wetlands / Off-channel
Restoration	Wetlands / Off-channel
Restoration	Mainstem
Restoration	Tributary
Restoration	Wetlands / Off-channel
Restoration	Tributary
Other	Tributary
Restoration	Mainstem
Restoration	Tributary
Restoration	Tributary
Restoration	Mainstem
Restoration	Tributary
Restoration	Tributary
Restoration	Tributary
Restoration	Tributary

Restoration	Tributary
Restoration	Tributary
Restoration	Mainstem
Restoration	Tributary
Restoration	Tributary
Restoration	Tributary
Restoration	Wetlands / Off-channel
Restoration	Tributary
Restoration	Tributary
Restoration	Mainstem
Restoration	Tributary
Restoration	Tributary
Restoration	Tributary
Restoration	Uplands
Restoration	Uplands
Restoration	Uplands
Restoration	Uplands
Other	Wetlands / Off-channel
Other	Mainstem
Other	Tributary
Other	Tributary
Other	Tributary

Other	Uplands
Other	Tributary
Other	Tributary
None	Tributary
None	Tributary
None	Tributary
None	Tributary
None	None
None	Tributary
None	Tributary
None	Uplands
None	Tributary
None	Tributary
None	Estuary
Other	Uplands
Other	Mainstem
Other	Uplands
Other	Uplands
Other	Riparian
Other	Uplands
Other	Uplands
Other	Uplands
Other	Uplands
Other	Uplands
Other	Uplands
Other	Uplands
Other	Uplands
Protection	Uplands
None	Tributary
Restoration	Tributary
Other	Tributary
Other	Tributary

Other	Tributary
Other	Uplands
Other	Uplands
Other	Uplands
Other	Uplands
Other	Uplands
Other	Uplands
Restoration	Mainstem
Restoration	Mainstem

Comments
Reconstruct lower 1/4 mile of channel to restore floodplain/wetlands habitats Good source of cold water. *Note: Sediment is a major concern from tribs from Indian Creek and below.*
Downstream of reservoirs: reconstruct channel to increase sinuosity and connect to floodplain. Add LWD. Remove gorse and improve riparian.
There is a ditch line just above the two little tribs at the bottom of the terrace. (First trib is on south bank immediately downstream of the highway bridge. Second trib is the dairy barn ditch also on south bank.) Groundwater is collected at the bottom of the slope and collected in the ditch. Floods in winter, so high rearing potential Jan-April. Primary project goals are to generate more groundwater during low flows and create a larger inundation footprint at high flows. Project would take floodplain down in elevation and enhance contours to create backwater habitats. This type of habitat is priority for NOAA.
Good spruce forest below bogs. Landowner open to an easement. When land is logged, gorse moves in, so there is an incentive to landowner to keep it in timber. ($2,300/acre to eliminate gorse, and $50/year to keep it back.) However, pressure to log Camp Creek bc of poor return from cranberries currently. This should be a priority
Rearing habitat downstream of road. High potential for restoration. Half the floodplain wet year round. Lots of nutrients. No riparian though. Project priority is to re-meander stream channel and enhance riparian. Reservoir
Three landowners. Opportunities for additional fish hotels with channel improvement and LWD installation.
Below head of tide. Install LWD in mainstem to increase complexity. Project opportunity is limited to work instream (not floodplain reconnection). Our plan should highlight the value/opportunity of habitat restoration
Strong consensus among the group that this reach is a high priority ecologically and socially. Getting this landowner (P.) could leverage other landowners. May be interested in long term easement but WRP not a good fit bc too restrictive. Need a third a third party to manage the property. Opportunity for working landscape model: improve ag operations: cross-fencing, gorse control (third party), off-channel watering. This project will
Tribs may provide some cool water but almost dry in summer so not a significant source. Little else for habitat. Riparian enhancement needed (including major gorse control).
Panther is highly productive and under-protected. It is focus of Elk River Salmon Emphasis Area. Not in bad shape but not enough complexity in there for coho. It offers the best opportunity for LWD because it's not
Priority for an easement on forestland. No FPA protections bc not fish-bearing but provides cold water refugia area in mainstem. Plan needs to emphasize that we will seek to protect areas that may provide temp refugia
Lack of riparian, significant down-cutting, high need for landowner education. Major priority for riparian
Area was treated in late 90s by ODFW. Addiitonal wood recommended up to 1/4 mile (the area covered in
Runs along toe of terrace at elevation of floodplain. Probably getting a lot of groundwater. Good stream temps. Likely refugia. Downstream of Mckenizie road, cuts into floodplain and creates a valley with decent habitats.
Two vegetated point bars (one is ~5 acres and one is ~10). Primarily gorse, and conversion is a priority. Opportunity to rehab this ground. Series of beaver dams and an over-flow channel. Cottonwood planting receomended on bars and riparian zones. Easement is needed to ensure long term project benefits.
Enhance riparian following re-meander.
Downstream of Mckenizie road, cuts into floodplain and creates a valley with decent habitats.   Opportunities to add LWD and improve riparian.
Great opportunity for LWD. High refugia potential (8 degrees cooler than mainstem in August). LWD was placed

Low gradient. Extensive fish use (all species). Very little spawning habitat (lots of fine sediment; no gravel substrate), but good rearing habitat throughout for smolts. Fish probably moving in in the fall on first freshet. Probably provides the most over-wintering habitat for coho in the lower system. Migrate out in the spring.
May be very simplified due to high sediment/substrate loads. Lots of LWD opportunity. Add LWD (½ mile of anadromy in Bear Creek but this could be improved with LWD). In 2014, 50 logs installed and and coho returned
High potential for LWD placement. Pilot could combine planting and experiment with bank stabilization through LWD. NOAA interest. Low risk site for wood: low energy; just a few landowners.Project would enhance lateral
Priority is getting POC in the drainage and doing riparian enhancement up about 3 miles of Bald Mountain, lower Bear Creek, and lower SF Bald Mountain. The lower two miles are 303d listed due to stream temp and habitat
Road crossing needs to be addressed (BPA has easement). Culvert is potential fish passage barrier and needs to pass bedload. Bridge most likely.
#3 stormproofing priority. Sediment abatement from roads is a high priority in Bald Mountain Creek watershed. #2 road stormproofing priority on WRLT list. Most of the private road system was upgaded (Moore Mill). Focus
Reconnect oxbow. Potential floodplain reconnection on pasture just below Rock Creek. Lightly used ag parcel. L's Ranch and other small holdings. A couple of terraces. Lower one is 10-15 acres. Likely some historic oxbows.
Potential to address a barrier and add LWD, but ownership is a can of worms and would require a lot of prep work besides the actual restoration. LWD and re-meander would happend below Elk River road. Could be an
See other notes on Bagley. Reconnect 1.5 miles of salmon habitat through removal of a fish passage barrier. Two barriers: one at upstream end of fire pond and one downstream end. Re-meander to make up for drop in gradient out of culvert and down to river (6-8 feet). County road to mill pond.
#2 priority for stormproofing/road maintenance. Failure will deliver heavy sediment load. Make sure this is captured as a sediment priority. Not a priority for LWD. LWD will not stay in mainstem below Panther.
Only one opening in canopy to get wood in through helicopter. Could get wood in there when they replace the
Extreme environment: steep, rocky. Creek is Grassy Knob Wilderness Area boundary, road is just outside of boundary. Lower reaches are Alder dominated and ripe for LWD
Road 5325. Culvert replacement already designed, but this project is not a priority for coho (Channel constrained above it; lot of bedrock; no floodplain; not likely a depositional reach; not much old growth to contribute.)
Diversify forest stands is goal. Plant underneath Alder. From road on the south side to the river.
Upper Blackberry watershed is WRLT #4 priority for sediment abatement from roads.
Butler Creek watershed is #5 priority for sediment abatement from roads. Road 5201 is a major sediment producer.
Panther Creek watershed is #1 road stormproofing priority. Heavily roaded, high priority for road maintenance. Roads 5325, 5002, 5544 are priorities. Road 5544 suffered several mass failures that degraded habitat and water quality. Sub-watershed has extensive areas of matrix land allocation. Matrix areas are designated for active logging.
From Rock Creek down all of the tribs coming in across the floodplain present opportunities for restoration at connection with the mainstem. More project opportunities exist from Rock Creek downstream. If available, Use
The Hatchery: Temperature may be an issue as fish are raised in un-shaded ponds. Facility in compliance but this
Small (just a half mile of habitat) but great temperatures. Haven't seen coho but potential for use. Add fish use
Not a ton of potential. Could provide some over-wintering with habitat enhancement, but moderately steep, so it would take a high water event for fish to move up into it. Between Elk River and Highway 101, about 100 feet of drop with a natural boulder cascade. No anadromous habitat above 101, so fish passage blocked close to the
Extensive cranberry bogs in upper watershed. Sit on terraces. Recirculate water through bogs all season long. In rain events, they drain to center bog. Accumulation of chemicals after extensive recirculation likely. Overtopping in heavy rain events a potential problem; could trigger slides and debris flows. Project: evaluation of drainage

See other notes on Swamp Creek. Need to protect upstream network, including headwalls. Potential for headwall failure. Lots of gorse. Assessment needed to determie priorities.
Reservoirs: water quality (temp) is an issue. Group not sure whether dam removal is an option. Lots of standing water downstream, so reservoir may not be the only warm water source. Temperature monitoring is needed
Tributaries from Indian Creek downstream may be higher priority in the lower watershed than those upstream, but sediment is a major concern. Swamp, Cedar, Camp, Kermit, and Indian Creeks have the most potential if we take a whole-watershed approach in each to ensure that the sediment sources in the headwaters don't destroy
Small. Not a priority
No work recommended. In Wilderness.
Good Chinook producer. Great summer temps. Protected by Wilderness designation. Nothing to do.
Natural barrier at a quarter mile. Coho use in very bottom end. They put lwd in and in there and it blew out.
Gorge. No projects.
Anadromous barrier just above North Fork. Falls in Grassy Knob Wilderness. No project.
Not much opportunity.
Recent clearcut. Buffered as small fish bearing. Gorse magnet. Will apply heavy herbicide.
No discussion
No estuary restoration discussed
Lack of riparian cover, significant down-cutting. Hobby farms and high threat of subdivision. Extensive riparian degradation. High need for outreach and education.
Lack of riparian, significant down-cutting, high need for landowner education.
All of these lower properties are threatened by conversion. The priority is to give local landowners an alterantive to conversion. If conversion happens, need to call for low-impact.
To Swamp Creek: little complexity. Above Swamp: sand, no complexity. Not much to do. Plan should describe how mouth will move based on winds, and that the area is highly erodible.
Small ranch may come up for sale within 20 years. Good candidate for an easement and working lands demo though not much river frontage.
Purple Mountain Tract, 160 acres, sect 22. Purchased by WRLT 5/20/16 to convey to Forest Service using 2017
Two tracts on WRLT hotlist. Tract 1, an inholding near confluence of Bear Creek/Bald Mountain Creek, is currently owned by WRLT and in the process of being sold to Forest Service. Tract 2 is located outside of USFS
Three properties on Land Trust acquisition hotlist. Seller not currently willing.
Valley opens up and material starts dropping out. Creek moves a lot. Critical spawning area. Anvil Creek runs
Acquisition list: one priority inholding.
15 acre parcel is a high priority for acquisition. Two other owners along Henry. (Need #)
Tributary with timberland that is for sale – acquisition priority (Need #). May be a warm water source.
Acquisition: one piece available for $125k. Low on priority list because of amount of restoration needed.
WRLT purchases and reconveys to USFS (matrix). Upper Panther Creek Tract is a 240 acre two-part inholding in section 36 at source of West Fork. Timber industry owner wishes are unknown. (6 of 6 on WRLT acquisition list.) Major benefit of acquisition is improvement to water quality. Sediment and chemical contaminants are primary
Almost all USFS ownership and in good shape. Have put in a lot of lwd. Road 5105 is a priority for
#4 stormproofing priority.
good habitat already. Protective measure concern about headwall failure
concern about headwall failure swamping future work

concern about headwall failure. If we can't manage bedload, then benefits of future restoration will be short-

Mainstem (Kermit to Indian) – Riparian and LWD. Opportunity to do some bank stabilization and add to channel

Stream or Reach	Life Stage (1-5)	Unique (0 / 2)	Cold water (0 / 2)	IP (0/1/2)	Site Score	LFs (0-5)
Indian Creek	5	0	2	**1**	8	5
Swamp Creek	4	2	0	**2**	8	5
Mainstem - Kermit to Camp	4	0	2	**1**	7	3
Camp Creek	5	2	2	**0**	**9**	3
Knapp Creek	4	2	0	**2**	8	5
Cedar Creek	5	0	0	**1**	6	5
Mainstem - Lower (heading west)	4	2	0	**1**	7	3
Mainstem - Kermit to Camp	4	0	2	**1**	**7**	3
Kermit Creek	5	0	0	**2**	7	3
Kermit Creek	5	0	0	**2**	7	3
Panther Creek	5	0	2	**0**	**7**	5
Ram Creek (or un-named trib)	4	0	2	**0**	**6**	3
Mainstem - Rock Creek to Bagley	5	0	0	**1**	6	5
Indian Creek	5	0	2	**1**	8	3
Cedar Creek	5	2	0	**1**	8	3
Mainstem - Camp to Lower (Just above two small tribs)	4	0	0	**2**	6	3
Knapp Creek	4	2	0	**2**	8	3
Cedar Creek	5	2	0	**1**	8	3
Henry Creek	5	0	2	**0**	7	3
Kermit Creek	5	0	0	**2**	7	3

Swamp Creek	4	2	0	**2**	**8**	3
Bear Creek	5	0	0	**1**	**6**	3
Mainstem - Just above two small tribs	4	0	0	**2**	**6**	3
Bald Mountain Creek	5	0	0	**1**	**6**	3
Kermit Creek	5	0	0	**2**	**7**	3
Bald Mountain Creek	5	0	0	**1**	**6**	4
Mainstem - just below Rock Creek	5	0	0	**0**	**5**	3
Bagley Creek	4	0	0	**1**	**5**	3
Bagley Creek	4	0	0	**1**	**5**	3
Mainstem - Butler to Red Cedar	5	0	2	**2**	**9**	1
Blackberry Creek	5	0	2	**0**	**7**	3
Butler Creek	5	0	2	**0**	**7**	3
Blackberry Creek	5	0	2	**0**	**7**	1
Mainstem - Blackberry to Butler	5	0	2	**0**	**7**	1
Blackberry Creek	5	0	2	**0**	**7**	1
Butler Creek	5	0	2	**0**	**7**	1
Panther Creek	5	0	2	**0**	**7**	1
Mainstem - Rock Creek to estuary					**0**	
Hatchery Creek					**0**	
Champman Creek					**0**	
Ram Creek (or un-named trib)					**0**	
Camp Creek					**0**	

Swamp Creek					0	
Swamp Creek					0	
Bungalow Creek					0	
Sunshine Creek					0	
Red Cedar Creek					0	
					0	
Mainstem - Bald to Anvil Creek					0	
Anvil Creek					0	
Mill Creek					0	
Unamed Creek					0	
Indian Creek (and all tribs below)					0	
Two un-named tribs from SE					0	
Elk River Estuary					0	
Mainstem - Anvil to Rock Creek					0	
Mainstem (Bagley to Indian Creek)					0	
Mainstem - Lower (heading west)					0	
Mainstem - Lower (where it turns north)					0	
Mainstem - just below Rock Creek					0	
Bald Mountain Creek					0	
Bear Creek					0	
Bald Mountain Creek					0	
Anvil Creek					0	
China Creek (un-named)					0	
Henry Creek					0	
Rock Creek					0	
Bagley Creek					0	
Panther Creek					0	

Processes (0-6)	Longevity (0-3)	Assurance (0-1)	Working Lands (0/2/3)	Demonstration (0 / 1)	Button Up (0 / 1)	Scoring notes	Project Score
6	3	1	3	1	0		19
6	3	1	2	0	0		17
6	3	1	3	1	0		17
4	3	1	3	1	0		**15**
4	3	1	2	0	0		15
4	3	1	2	1	0		16
6	3	1	2	0	0		15
4	3	1	3	1	0		**15**
4	3	1	2	1	0		14
6	3	1	0	0	0		13
4	3	1	0	0	0		**13**
4	3	1	2	1	0		**14**
3	3	1	2	0	0		14
4	3	1	0	0	0		11
4	3	1	0	0	0		11
4	3	1	2	0	0		13
4	3	1	0	0	0		11
4	3	1	0	0	0		11
4	3	1	0	0	0		11
4	3	1	0	0	0		11

0	3	1	2	1	0		10
4	3	1	0	0	0		11
4	3	1	0	0	0		11
3	3	1	0	0	0		10
2	2	1	0	0	0		8
2	2	1	0	0	0		9
2	3	1	0	0	0		9
2	3	1	0	0	0		9
2	3	1	0	0	0		9
1	2	1	0	0	0		5
0	2	1	0	0	0		6
0	2	1	0	0	0		6
1	3	1	0	0	0		6
0	3	1	0	0	0		5
1	2	1	0	0	0		5
1	2	1	0	0	0		5
1	2	1	0	0	0		5
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Total Score	Primary Stress Addressed		Land ownership	Cost
27	Complexity			
25	Complexity			
24	Complexity			
24	Complexity			
23	Complexity			
22	Complexity			
22	Complexity			
22	Temperature			
21	Temperature			
20	Complexity			
20	Complexity			
20	Temperature			
20	Temperature			
19	Complexity			
19	Complexity			
19	Temperature			
19	Temperature			
19	Temperature			
18	Complexity			
18	Complexity			

18	Distribution			
17	Complexity			
17	Complexity			
16	Temperature			
15	Distribution			
15	Sediment			
14	Complexity			
14	Complexity			
14	Distribution			
14	Sediment			
13	Complexity			
13	Complexity			
13	Sediment			
12	Altered forest composition			
12	Sediment			
12	Sediment			
12	Sediment			
0	Complexity			
0	Temperature			
0	None			
0	Temperature			
0	Sediment			

0	Sediment			
0	Temperature			
0				
0	None			
0	None			
0	None			
0				
0	None			
0	Fish passage			
0	None			
0	None			
0	Sediment			
0	None			
0	None			
0	Conversion (Threat)			
0	Temperature			
0	Conversion (Threat)			
0	None			
0	Sediment			
0	Sediment			
0	Sediment			
0	Sediment			
0	Sediment			
0	Sediment			
0	Sediment			
0	Temperature			
0	Sediment			
0	Sediment			

Other Plans	% Med IP	% High IP
o GAG partnership to ID priority areas for gorse conversion	3	3
	3	1
	0	0
	5	0
	7	0
· Remove (and replant) 3,840 acres of invasive plants (WRAP)	3	3
	7	0
§ WRAP (lower): 6 miles of stream restoration with large woody material for tributaries and associated side channels.	3	3
§ WRAP (lower): 1.5 miles of salmon habitat improved through removal of a fish passage barrier.	98	7
	16	16
	7	3
	0	0
WRAP: Reconnect 1.5 miles of aquatic habitat through removal of a fish passage barrier; $1 million.	0	0
By 2021, add LWD to key overwintering areas on 2 miles of stream (WRAP) ½ mile in the lower mainstem	7	0
	0	0
WRAP: By 2021, add LWD to key overwintering areas on 2 miles of stream (WRAP). Focus on the East Fork.	5	0
	25	0
	100	20

	89	57
· Enhance 400 acres of riparian vegetation to increase stream shading, incorporating POC	98	7
	51	29
	100	100
	96	72
	0	0
	100	0
· Enhance or restore hydrology and vegetation to 100 acres of altered historic tidal wetland area	5	2
· Restore composition of 75 acres of historic Spruce bog inclusions associated with tidally influenced freshwater wetlands	3	3
	54	8
	85	0
1. Mainstem Enhance riparian zones by planting riparian trees and vegetation (PG&O)	0	0
	0	0
	0	0
	0	0
· Enhance 1,000 acres of riparian zones to increase stream shading (WRAP-DEQ) on Ag lands and understocked forest	98	7
	100	22
	95	0
Enhance riparian zones by planting	100	62
	36	3
	67	0
2. Mainstem Reconnect 15% (2 miles)	0	0

	16	0
	?	?
	?	?
	82	58
	89	57
	54	8
	100	100
	100	22
	51	29
	36	3
Enhance or restore hydrology and vegetation to 100 acres of altered historic tidal wetland area, including 37 acres of foredune overwash area with invasive vegetation removal	0	0
	89	57
· Enhance or restore hydrology and vegetation to 50 acres of altered historic wetland area	5	2
	96	72
	54	8
	36	3
	82	58
	100	20
	51	29
	89	57
§ WRAP (lower): 100 acres of riparian planting and/or silviculture to increase stream shading	85	0
	38	0
	82	58
	82	58
	?	?
	32	0
	100	0
	0	0
·	0	0
	36	3

Matt and Jerry comments
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Please extend the line a little further past Rock Creek (to where the Elk turns due north)
good
check with Karla if we have lower 1/2 mile mapped correctly). Emailed her 12/1/17.
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The 31 project is mapped but the number "31" is not there. Please add it near the pink culvert icon (next to 28, 29)
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This is an education and outreach project. Please remove #69 from map
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Add project to map
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Elk River SAP Conceptual Models
Instructions for Next Steps and Narratives

Dear Elk River SAP Participants,

Thanks again for participating in the workshop last week. We made great progress. The workshop products have now been put into a PowerPoint file that can be easily edited. At the end of the workshop, we agreed to complete the following before our next meeting (Nov 20).

1) Review the conceptual models. A narrative has been drafted to use as a communications tool for people who were not in the room and as a reminder to participants of major points discussed. Please review the text in the narratives (below) and in the models (see accompanying PowerPoint slides).

2) The results chains should be reviewed by the leads listed below. You'll recall that the results chains will be used to create objectives and monitoring metrics to track whether or not a strategy is on track. Leads:

- Technical assistance: SWCD (Barbara and Matt)
- High Risk Forested Parcel Acquisition: Jerry
- State Fund for Acquisition Match: Mary and Mark
- Restoration: Watershed Council (Matt) with support from Dan and Todd

Results Chains from the workshop are presented in the attached PowerPoint (along with the conceptual models). Note that the ppt starts with an example of a completed results chain for reference. Each of the elements below have been completed.

For each results chain, the following needs to be reviewed/added.

- Review Logic and wording - Each result box (the blue ones) should show the expected outcome of a successful strategy.

- Add actions where obvious - Actions are the specific activities necessary to support the desired result. Often actions are the basis for an implementation plan.

- Add Indicators to the most important outcomes - Indicators should be precise, sensitive, and feasible to measure

- Add objectives - Objectives are time-bound and specific conditions on the results. "How much and by when?"

- Add relevant status and trends indicators for each relevant component - Dan Avery and Mark Trenholm will work to populate the habitat status and trends measures.

Conceptual Model Narratives

The Elk Watershed partners have a long history of working to directly restore coho habitats. Among other restorative approaches, their past and current work focuses on improving instream complexity, controlling invasive species, improving riparian areas, and repairing roads that contribute sediment to streams. This restoration directly improves the health of habitat components in the Elk, including estuaries, mainstem rivers, tributaries, off channel areas, and upland forests.

Even with the continued effort to directly improve habitat, the current watershed condition is not likely to advance coho recovery. In order to slow the practices that continue to degrade habitats, the watershed partners will work to abate the human activities known to stress coho habitat. The workshop held on October 14th and 15th, 2015 explored the first three threats, listed below.

As a reminder, the graphics of conceptual models are not intended to be communication tools. They are diagrams that support a workshop conversation. The narratives below are intended to describe the context around each of the threats to better explain how each strategy (described by the results chain) will address factors that need to change for recovery efforts to succeed.

Threat #1 - Incompatible Agricultural Practices

Agriculture in the Elk Watershed primarily refers to ranching. The harmful practices associated with some ranching affects the estuary, mainstem and side channels. The incompatible practices associated with extensive grazing include maintenance of drainage structures, ongoing bank hardening, road maintenance, overuse of riparian areas, and insufficient invasive species control.

The current incompatible practices are due to both an attachment to outdated practices and a response to drought.

There is some reluctance to adapting new techniques, which may be due in part to ranchers being more comfortable with what they already know. Due to low margins in their business, ranchers may be unwilling to take risks, particularly if they have been using the same practices for many years.

Farmers may also be using outdated techniques because it is expensive to change practices. This is both for existing ranchers and anyone else who might be thinking about entering the business.

Although there are both technical assistance and cost share opportunities available, neither is currently sufficient to motivate landowners to change practices. The incentives restrict use and do not offer enough money. This is particularly true when compared to the prices that ranchers can receive for selling to developers.

There is also no regulatory certainty available for short-term incentives. In general, the available programs are small and have complex application processes, which usually pose a barrier to ranchers.

Organizations such as conservation districts have staff with technical expertise that could assist ranchers, but the capacity of these organizations is limited.

There are opportunities to showcase how local ranchers have changed practices resulting in increased productivity and better environmental outcomes. The demonstration of the processes could help ranchers think about longer term planning in the face of changing climate conditions and increased development pressure.

Threat #2 - Incompatible Forestry Practices

The issues underlying incompatible forestry were split into those on privately managed land and those on publicly owned land. Much of the public forested land in the Elk Watershed is in federal ownership and management. There are two Wilderness areas and the US Forest Service manages the rest. There is little logging currently taking place on US Forest Service land.

Current management issues on federally managed lands center on the fact that there is little active management. In addition to the lack of active management (such as thinning), there are no changes proposed for designations such as late successional reserves – a status that would provide a high level of protection.

For both public and private land, there are a number of legacy issues that continue to degrade habitat. Due to legacy roads and stand management practices, there are a number of areas where stands are overstocked, legacy slides still affect the river system, legacy roads and culverts are in danger of failing, and old roads are in riparian corridors. These legacy issues affect sedimentation in the river and the functionality of riparian zones, leading to decreased in channel complexity.

There is little funding on public lands to deal with the legacy issues. The lack of funding is due to the lack of revenue generated by harvest. Also, federal money that would ordinarily go to the restoration of legacy conditions is often re-appropriated during the fire season to emergency burn control.

Private lands that are currently actively managed for timber are at risk to mass wasting events as the current state forest practice rules don't always provide adequate protection on the Elk Watershed due to unique geology and steep slopes. Additional degradation comes from the application of pesticides and short rotation cycles due to market demand.

The Forest Practice Rules do have an adaptive management program in place, but the adjustment of rules is slow and leaves areas currently managed under those rules vulnerable.

It is possible to protect these private lands, particularly those inholdings upstream of valuable wilderness areas, through acquisition. However, that acquisition is happening too slowly. There is currently limited funding for acquisition and no state fund to match federal and private acquisition dollars. Funders sometimes are not attracted to acquiring degraded parcels. The lack of nimbleness in the system makes it more difficult to take advantage of opportunities when landowners are willing to sell.

Threat #3 - Conversion

The threat of conversion was split into two categories. First, the conversion of working lands (agriculture and forestry) into commercial/residential. An underlying driver of why this is happening in the Elk Watershed is because the southern OR coast is increasingly popular for recreation, tourism, retirement, and second homes.

One of the main reasons working landowners are selling to developers is because it is more profitable than continuing operations. The technical assistance to improve profitability is lacking, margins are narrow, and markets are uncertain from year to year. Landowners might be offered conservation easements, but the appraisals for these easements only consider the use of farming or forestry. The potential residential conversion would command a higher price but is not considered in setting a conservation easement offer. There are also tax deferral programs available, but again, they do not compare to the price offered by developers. Finally, in an increasingly fragmented landscape, it is more difficult to maintain operations as the local support (e.g., supply stores) and infrastructure are not available.

Another reason working lands are being converted is because there is not a public priority to protect them. The value of intact large tracts of lands is not known or considered by public officials. As a result the laws, policies, and permitting processes do not support the protection of these lands. This is particularly true since new development adds to the tax base.

The second category of conversion is more general and describes the subdivision of existing lands, including large residential lots. One of the reasons this continues to happen is both permits and utilities are easy to obtain.

Generally, even though the comprehensive plan of Curry County describes certain character and protections that should be in place and low impact development requirements, it is not followed. The County is extremely underfunded and has limited capacity in the permitting department. Combined with a lack of technical information and poor understanding of the impact from development, permits are given through a rushed non-informed conditional use path to those who can pay for them. Developers have little incentive to develop using low impact development techniques and often, private landowners do not know what they can do to be most environmentally friendly.

New residents often undertake harmful practices (e.g., clearing the riparian zone for a view) without understanding that there are restrictions in place. Enforcement capacity and the desire to enforce are limited. Even if mitigation is required through some enforcement action, the benefit does not replace the value of the resource lost.

TerrainWorks

Elk River-NetMap Watershed Restoration Analysis

Lee Benda and Kevin Andras
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Abstract

A major challenge in river restoration is to characterize the fluvial system and its influences on aquatic habitats through riparian processes, erosion processes and current and historical land use activities. Intensive land use on valley floors often predates the earliest remote sensing: levees, dikes, dams, and other structures alter valley-floor morphology, river channels and flow regimes. Consequently, morphological patterns indicative of the fluvial landscape, including multiple channels, extensive floodplains, wetlands, and fluvial-riparian and tributary-confluence dynamics, can be obscured, and information to develop appropriate and cost effective river restoration strategies can be unavailable. To address this issue in the Elk River in southwest Oregon, we coupled general principles of hydro-geomorphic processes with computer tools (NetMap) to characterize the fluvial landscape. Using 1m LiDAR merged with 10m digital elevation models, we applied the NetMap system of virtual watersheds, smart river networks and computer tools to characterize numerous watershed attributes, including the channel network, anadromous and resident fish habitats, floodplains and valley floor morphology, current shade – thermal energy, current in-stream wood recruitment, slope stability, and forest roads. This information can be used to help prioritize where instream, riparian and road related restoration projects would be most ecologically and cost effective.

1.0 Introduction

A watershed scale perspective that encompasses the complete fluvial landscape is critical for successful river restoration (Logan and Furze, 2002, Bannister et al., 2005, Kondolf et al., 2006, Nilsson et al., 2007). The fluvial landscape includes the physical and biological features created by interacting fluvial, terrestrial, and ecological processes. It includes all the surface landforms and biologic communities that affect and are affected by the flow of water, sediment and organic materials through the network of river corridors including active and former river channels, off-channel water bodies including wetlands, floodplains, terraces, and riparian vegetation (Fausch et al., 2002, Ward et al., 2002, Nakamura, 2006) and subsurface patterns of hyporheic flow and associated organisms (Poole et al., 2006).

River restoration planning, design and implementation (levee removal, channel engineering, placement of in stream structures, planting riparian vegetation, etc.) necessarily and typically occur at the scale of individual channel reaches (100 – 1000 m) (Rosgen, 1996, Wohl et al., 2005). However, local restoration projects can be more effective if they are designed using a watershed (fluvial landscape) context to strategically place them for the greatest ecological benefit (Gilvear and Casas, 2005). A watershed scale context also provides a larger frame of reference for smaller scale projects, such as how valley topography, river network structure and sediment supply influence the distribution of habitats and how those landscape factors can affect restoration projects positively or negatively. Restoration activities within the framework of a watershed perspective can target meso-scale habitats such as large floodplains and islands (Jahnig et al., 2010) and can include measures such as levee pullback, re-meandering, flood embankment removal, buffer strip creation, reconnection of side channels, and wetland development (Gilvear and Casas, 2008).

Recognizing and characterizing the features and processes that form the fluvial landscape is a critical step in creating a watershed scale perspective and in forming a guiding ecological image of a river system. Design of a river-restoration strategy requires two important steps: 1) recognizing the spatial and temporal characteristics of the fluvial landscape, unique to some degree for every river system, that govern geomorphic and ecosystem interactions, and 2) recognizing human alterations to the fluvial system and the consequences for geomorphic and ecological processes.

Our goal is to apply hydro-geomorphic and ecological principles coupled with available computer analysis to characterize the fluvial landscapes in the Elk River watershed, located in southwestern Oregon. For our analysis we used available topographic data (1 m LiDAR and 10 m DEMs) with the analysis toolset 'NetMap' (www.terrainworks.com) (Benda et al. 2007, 2009) to examine relationships among valley geometry, river-network structure, landforms, and the potential for channel-floodplain and confluence interactions. Objectives include: 1) building a geo-spatial data structure in support of a watershed restoration analysis using a 'virtual watershed', 2) evaluating a range of key watershed processes including fish habitats, floodplains and associated valley floors, riparian zones and processes, slope stability and roads and 3) applying that information for prioritizing restoration site selection.

2.0 Study Area

The Elk River watershed (240 km^2) is located in the southwest portion of Oregon, in the southern Oregon Coast Range (**Figure 1**). The upper two-thirds of the watershed is located within the Rogue River-Siskiyou National Forest. The Elk River and its tributaries support native Chinook salmon (Oncorhynchus tshawytscha), coho salmon (O. kisutch), winter steelhead (O. mykiss) and coastal cutthroat trout (O. clarkii clarkii).

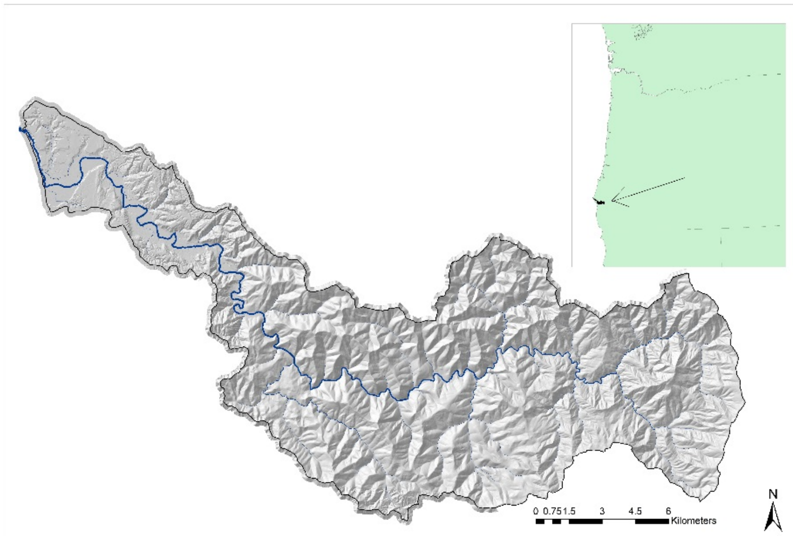

Figure 1. Location study area place holder.

3.0 Methods

3.1 NetMap's Virtual Watersheds and Smart, Synthetic River Networks

A 'virtual watershed' is a computer-based geospatial simulation of riverine landscapes used to enumerate numerous aspects of watershed landforms and processes, and human interactions within them over a range of scales (Benda et al. 2015, Barquin et al. 2015). A LiDAR DEM, covering the lower one fourth of the watershed, was merged with a 10 m DEM to create a seamless DEM across the study watershed. NetMap's virtual watershed contains six analytical capabilities that are required for Restoration Watershed Analysis in the Elk River basin: 1) delineating watershed scale synthetic river networks using the merged LiDAR and 10m DEMs (**Figure 2**), 2) connecting between river networks and terrestrial environments, and with other parts of the landscape, 3) routing of watershed information downstream (such as sediment) and upstream (such as fish), 4) discretizing landscapes and land uses into facets of appropriate scales to identify interactions and effects, 5) characterizing landforms and 6) attributing river segments with key stream and watershed information (Figure 2). A synthetic river network, derived from flow direction and accumulation, is comprised of a node based data structure, delineated at the scale of the composite 2 m DEM (Figure 2). From the nodes, individual channel reaches are created at a length scale that ranges between about 100 to 150 m (adjustable to any length scale during creation of the synthetic stream layer). To learn more about how NetMap's virtual watershed and synthetic river networks are created, see **NetMap's online Technical Help**.

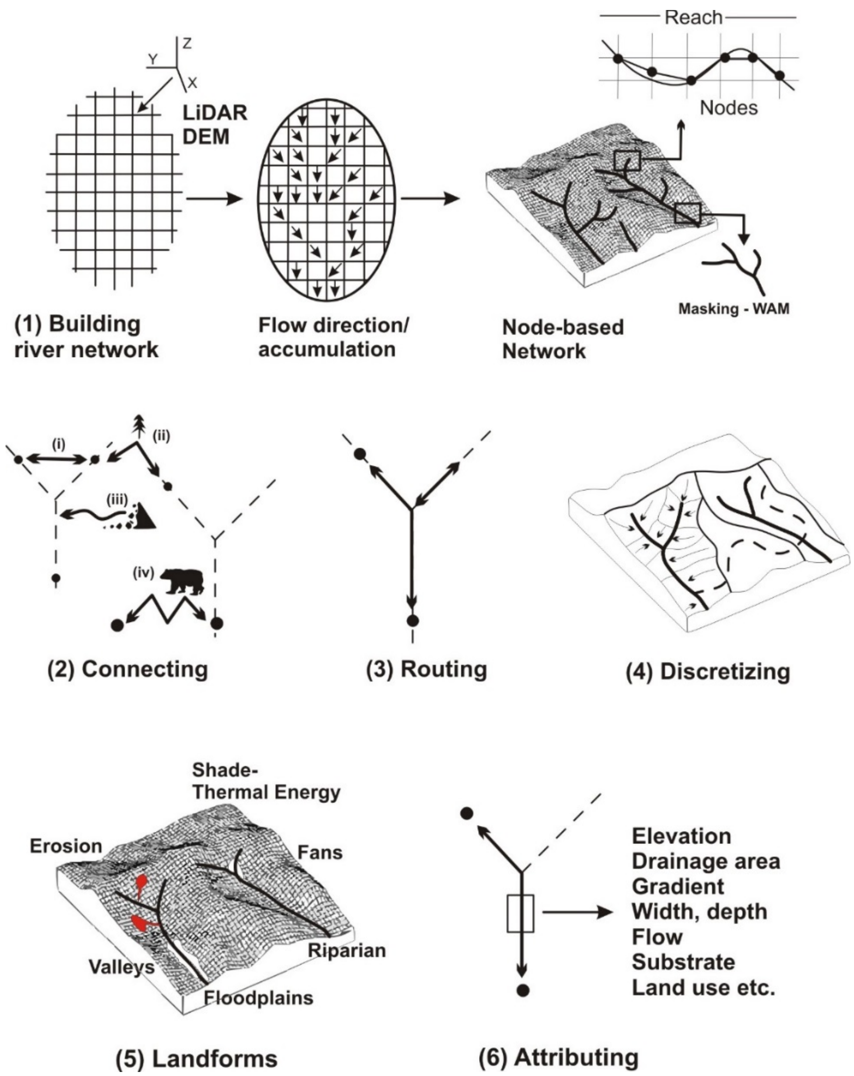

Figure 2. Analytical capabilities in the Elk River virtual watershed.

Modeling various forms of connectivity in a virtual watershed enables understanding of how landforms and processes interact with land uses. For example, each river node is linked to specific floodplain areas, thereby linking activities in floodplains to the reaches most affected. Predictions of heighted hillside erosion due to land use can be related directly to the channel reaches that would receive additional sediment. Using the Elk River virtual watershed, spatial patterns of processes and landforms, (e.g., aquatic habitats, slope stability, erosion-sediment supply, shade-thermal energy, floodplain extent etc.) and land uses (e.g., roads, timber harvest, agriculture etc.) are aggregated downstream (or upstream) through the synthetic network, revealing cumulative (effects) patterns at any spatial scale defined by river networks (e.g., from the bottom of a first-order channel to the bottom of a seventh-order river).

A key element in a Restoration Watershed Analysis when evaluating interactions among watershed processes, landforms and land uses is the "drainage wing", defined as the local contributing area to each channel segment. Drainage wings are used to transfer terrestrial information, such as upland and riparian vegetation, roads, and erosion potential, to stream reaches (**Figure 3**). Drainage wings are used to identify critical overlaps among reach scale attributes (~100 m length scale, or down to the 2-m resolution of LiDAR DEMs), such as fish-habitat potential, and watershed landforms (e.g., floodplains, erosion source areas), processes (e.g., road sediment delivery, pollutant spills), and land uses (e.g., roads, pipelines, timber harvest blocks, beetle-related tree mortality, engineered structures).

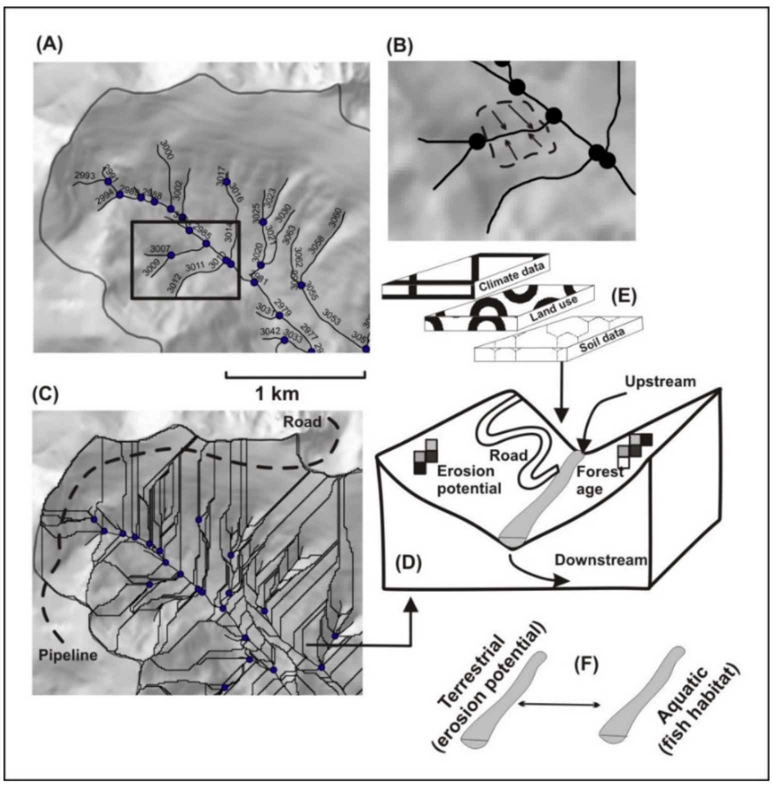

Figure 3. Drainage wings in a virtual watershed support numerous types of spatial analyses.

3.2 Attributes and Landforms in NetMap's *Elk River virtual watershed*

NetMap's *Elk River virtual watershed* contains more than 100 parameters derived from multiple analysis tools. **Table 1** provides a sample listing of channel attributes and landform and process characterizations. For a full listing and discussion of all tools and parameters within NetMap, go to the online Technical Help.

Table 1. A partial list of channel attributes and landform and process characterization in the Elk River virtual watershed.

Channel Attributes	**Landform and Process Characterization**
Gradient	Floodplains
Elevation	Terraces
Distance to outlet	Alluvial fans
Drainage area	Hillslope-gradient and convergence (mass wasting)
Mean annual flow	Tributary confluences
Stream order	Erosion potential
Channel width and depth	Hillslope–slope profile
Bed substrate	Surface erosion
Channel sinuosity	Valley width and transitions
Channel classification	Debris flows
Fish habitats	Earthflows
Radiation loading	Floodplains
Mean annual precipitation	Terraces
Gradient	Riparian Processes

3.3 Analysis Tools Included in the Elk River-NetMap System

There are approximately 70 analysis tools that can be incorporated and used within Elk River Restoration Watershed Analysis (**Table 2**). There are 700 pages of online technical help that covers all current tools, their functions and example applications (see here).

Table 2. A listing of analysis tools available in NetMap's system of virtual watershed and smart (synthetic) river networks. New tools will built and incorporated in the future.

***NetMap* Analysis Tools**	37) Westslope cutthroat habitat
Module: Analysis Tools	38) Coastal cutthroat habitat
1) Define fish distribution	39) Habitat diversity
2) Calculate channel gradients (multiple length scales)	40) Cumulative habitat length and quality
3) Query watershed databases (n=5)	41) Beaver habitat

4) Profile graphing (longitudinal and x-sectional)	42) Channel disturbance index
5) Attribute aggregation, downstream – upstream, routing of buffer and hillslope attributes	43) Piscidide tool
6) Google Earth zoom and map data transfer	
7) Data management (n = 5)	**Module: Riparian**
8) Risk analysis (n = 2)	44) Delineate variable width riparian zones
9) Sub-basin classification (n=2)	45) In-stream wood recruitment, project scale
10) Watershed delineation	46) In-stream wood recruitment, watershed scale
11) Construct drainage wings	47) Upslope wood recruitment
	48) Thermal energy sensitivity
Module: Fluvial Processes	49) Shade-thermal energy
12) Flow calculation	50) Thermal refugia (4 types)
13) Mean annual flow	
14) Stream power	**Module: Erosion**
15) Bankfull flow	51) Hillslope gradient
16) Channel width	52) Shallow landsliding
17) Channel depth	53) Debris flows
18) Flow velocity	54) Flash floods
19) Bed shear stress/D50	55) Gully erosion
20) Channel sinuosity	56) Earthflow/deep seated
21) Reach gradient adjustment	57) Convert to sediment yields
22) Maximum downstream gradient	58) Sediment delivery adjustment
23) Drainage area	59) Hillslope gradient
24) Stream order	
25) Stream power	**Module: Roads**
26) Tributary confluence effects	60) Import road layer
27) Valley width	61) Road density – basin scale
28) Azimuth	62) Road density – channel segment scale
29) Channel classification (4 types)	63) Road hydrologic connectivity
30) Drainage and tributary junction density	64) Road erosion and sediment delivery (n = 3)
31) Valley floor elevation mapping	65) Optimized drain locations
32) Floodplain mapping	66) Optimized road surface erosion remediation
33) Landslide – channel interactions	67) Road stability
34) In-stream wood accumulation types	68) Roads in floodplains
	69) Habitat upstream of crossings
Module: Aquatic Habitats	
35) Create aquatic habitats (HIP model builder)	**Module: Wildfire/Climate change**
36) Bull Trout habitat	70) Wildfire Cascade
	71) Climate change vulnerability

3.4 Multiple Scales of Analysis in Support of Restoration Watershed Analysis

A key element in the NetMap's Restoration Watershed Analysis is the ability to examine land-use, landform, and process interactions over multiple spatial scales that include: 1) DEM pixel scale (e.g., such as erosion potential), 2) stream segment scale, nominally 100 m length scale, but can be adjusted ranging from the grain of the LiDAR DEM (1 m) and upwards during creation of the synthetic stream layer, 3) buffer scale, such as vegetation patches and riparian zones, 4) hillside drainage wings (stream reach local contributing area, approximately 0.1 km^2 associated with 100 m stream segments), 5) terrestrial and channel reach information aggregated downstream (or upstream) at any spatial scale defined by the channel network (e.g., bottom of a first-order stream to the bottom of a seventh-order river), 6) linear features, such as road or pipeline networks, broken at pixel-cell boundaries (1 m) and then re-aggregated to any length scale to support various analyses, such as road hydrologic connectivity, road surface erosion, and pipeline infrastructure, and 7) watershed and land use data can be summarized at the scale of sub-watersheds of various scales (Figure 5).

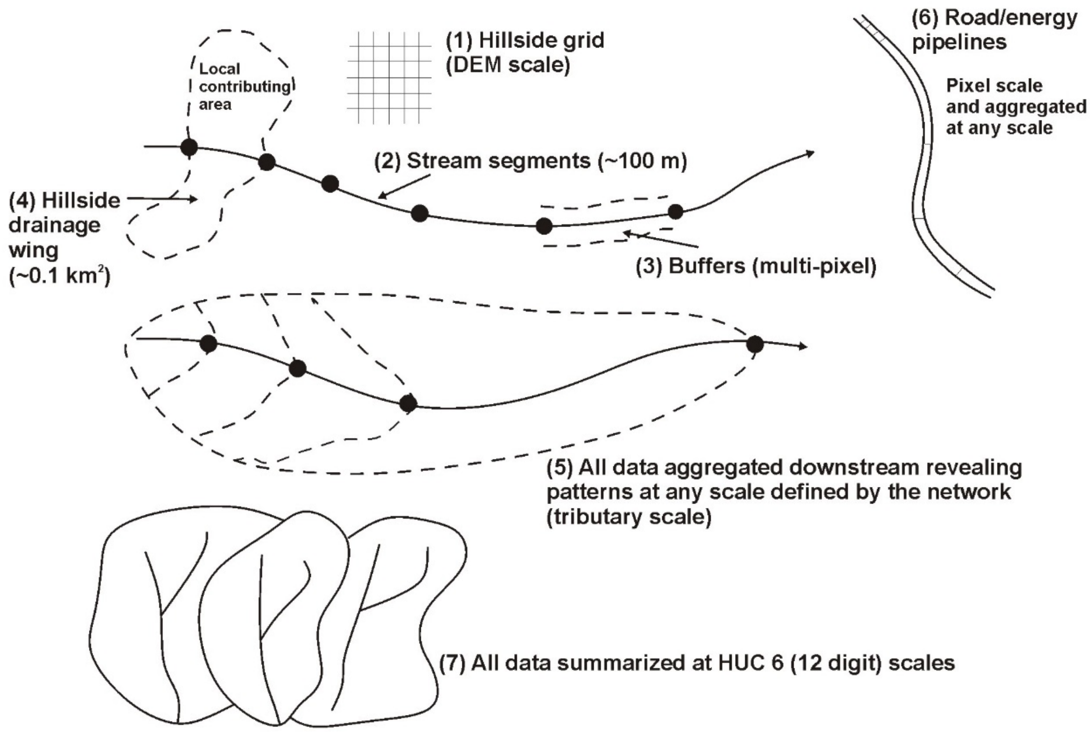

Figure 4. Multiple scale of analysis within the Elk River-NetMap Restoration Watershed Analysis.

4.0 Analysis Results

4.1 Valley Floor and Floodplain Ecosystems

NetMap's valley floor mapping tools were used to map the elevations and diversity of the floodplain ecosystem, including of Elk River mainstem and lower portions of tributaries. Estimates of bankfull channel depth are required to map floodplains and terraces in measures of multiples of bankfull depths.

We applied the bankfull width and depth regressions used in Clarke et al., 2008), where bankfull channel depth = 0.328 * (drainage area in km^2)$^{0.252}$ and where bankfull channel width = 10.7 * (mean annual flow, in CMS)$^{0.4}$. The predicted generalized (e.g., statistically smoothed) channel widths ranged from 32 m to 36 m in the lower mainstem (Figure 5). Predicted widths approximately matched actual channel widths as measured on Google Earth in the lower, unconfined (visible) portion of the Elk River mainstem. There is large variability in channel widths observed on Google Earth, and this variability is not captured in statistical regressions. Bank full channel depths in the lower mainstem are predicted to be 1.2 m to 1.3 m. Field measurements of bankfull channel depth (averaged over many locations in the thalweg) would be required to validate them.

If local data were available on bankfull depths and widths, more accurate statistical regressions could be developed and applied; however, this would require measurements that span the full range of basin drainage areas (headwaters to mainstem). In addition, if local measurements were available in select areas, they could be used to adjust reach scale values in the reach attribute table in ArcMap-NetMap. Then, the floodplain mapping tool could be rerun.

One task is to determine, particularly for the lower mainstem river, the absolute surface elevations and surface levels classified by multiples of bankfull depths that are associated with floodplains. Floodplains classified by multiples of bankfull depth accounts for the effects of channel size (width, depth) on floodplain elevations and extents (Dunne and Leopold 1978, Rosgen 1996). The analysis is challenging because many floodplains in the lower river have likely been converted to agricultural land. Nevertheless, we used a combination of NetMap's floodplain elevation and classified surface levels (e.g., multiples of bankfull depths), cross sectional profiles (across the valley floor) and Google Earth images to identify provisional floodplain surfaces along the lower mainstem river; our findings would also apply to floodplains located anywhere in the watershed.

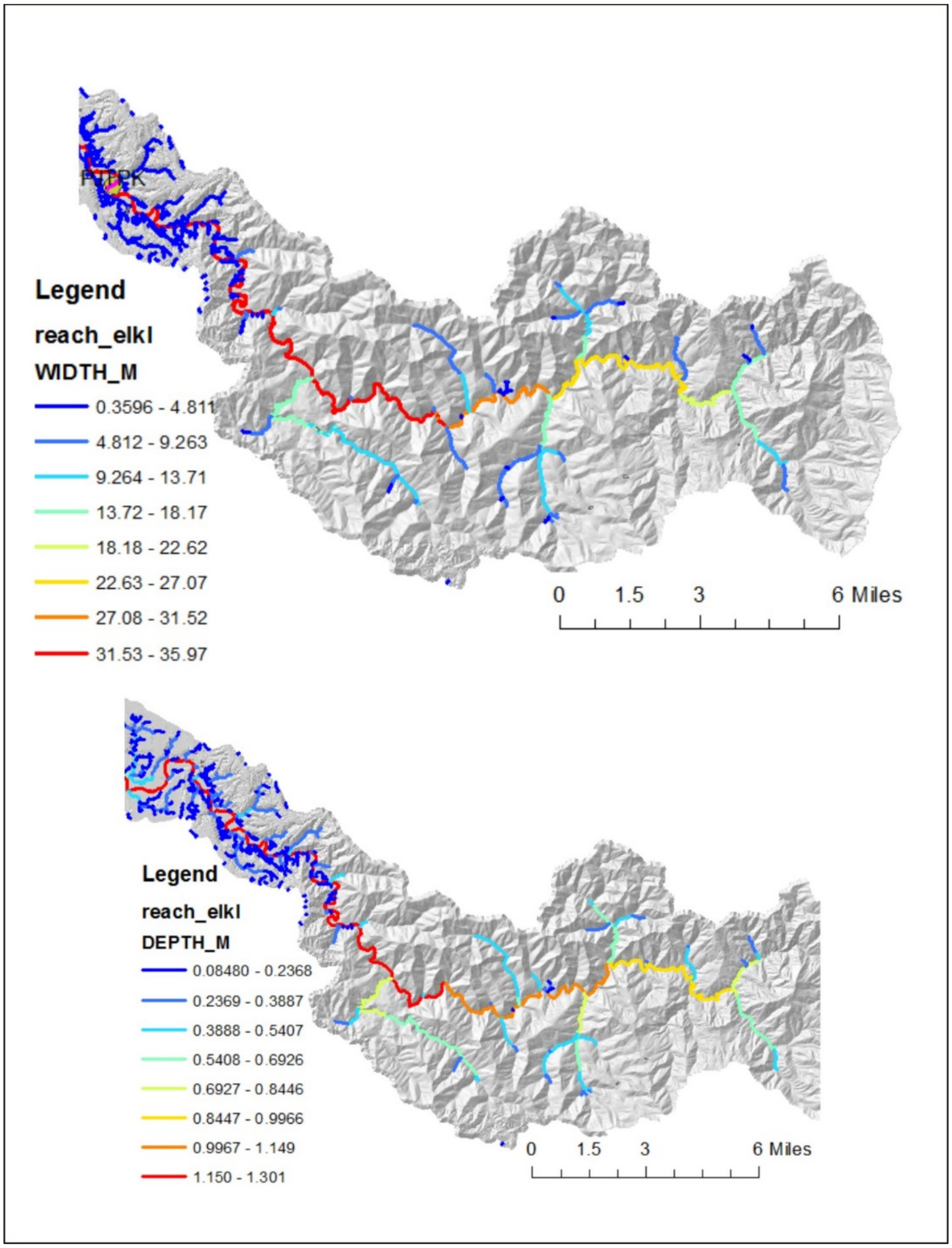

Figure 5. Statistical regressions from Clarke et al. (2008) were used to predict bankfull channel widths and depths.

Our analysis was conducted at three locations (**Figures 6 to 9**). Although the historically active floodplain is obscured in most locations by land use activities (primarily agriculture), the cross-section data that reveals floodplain features (side channels, oxbows, splay deposits and levees) are used to identify the elevations of naturally occurring floodplains. The locally higher elevation areas immediately adjacent to the channel, called levees, may either be natural features or engineered; Figure 6 shows a levee that might be engineered and Figure 8 shows one that might have natural origins. Apparent remnants of a side channel (B on floodplain map) corresponds to a depression in the cross-sectional profile.

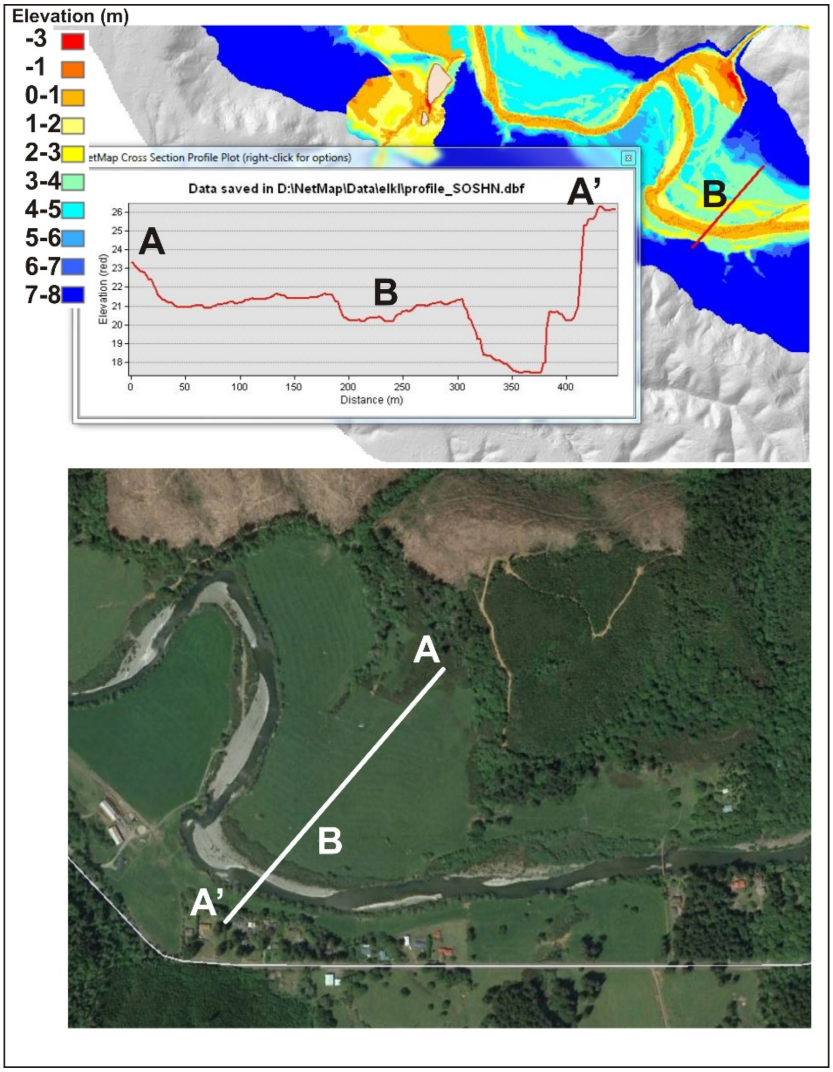

Figure 6. (upper) Valley floor surface elevations and a cross sectional profile (A-A'), along with a Google Earth image of the same area. Apparent remnants of a side channel (B on upper floodplain map) corresponds to a depression in the cross-sectional profile.

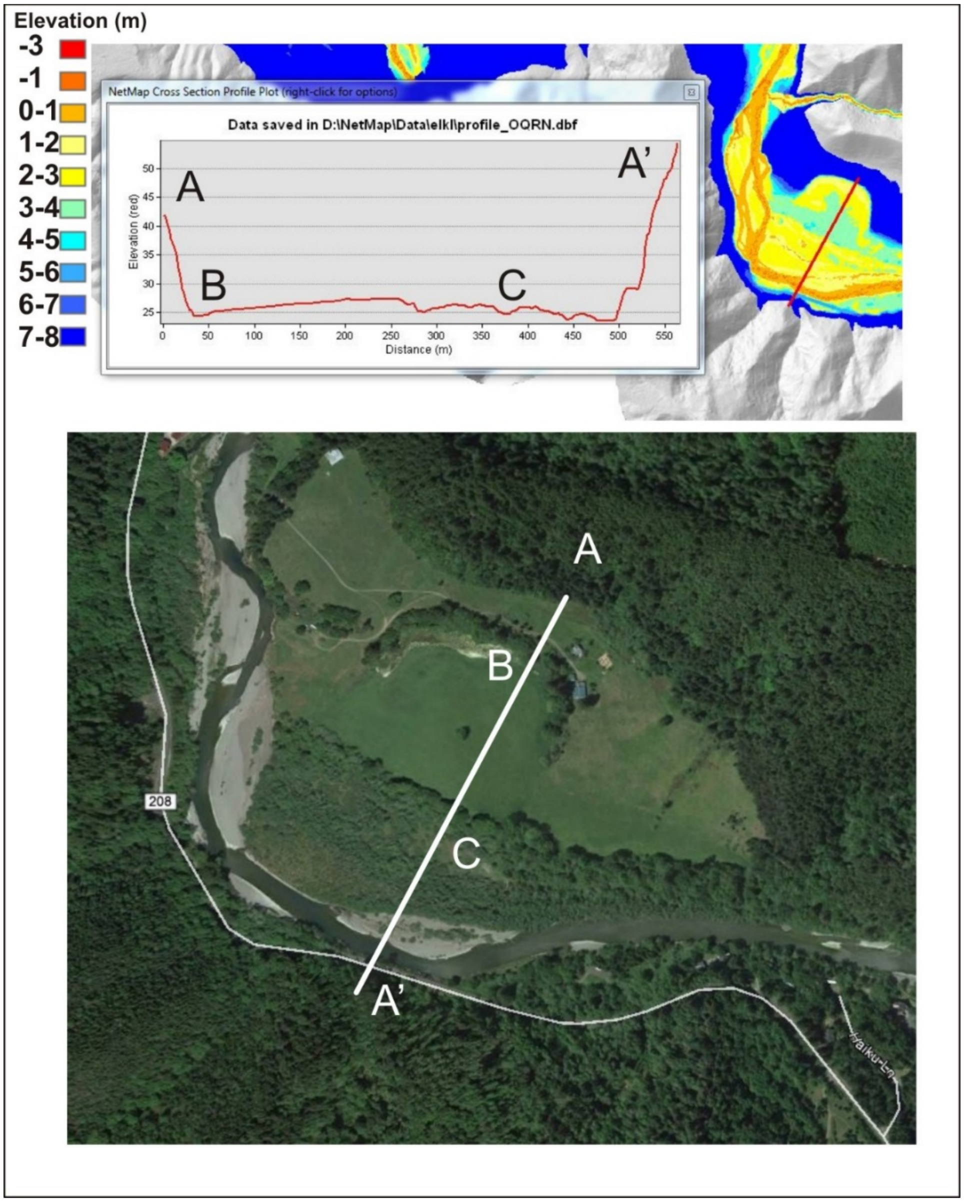

Figure 7. (upper) Valley floor surface elevations and a cross sectional profile (A-A'), along with a Google Earth image of the same area. "B" appears to represent an abandoned oxbow lake and "C" appears to represent active floodplain (flooding area). The active floodplain area is 2 to 3 meters above the channel.

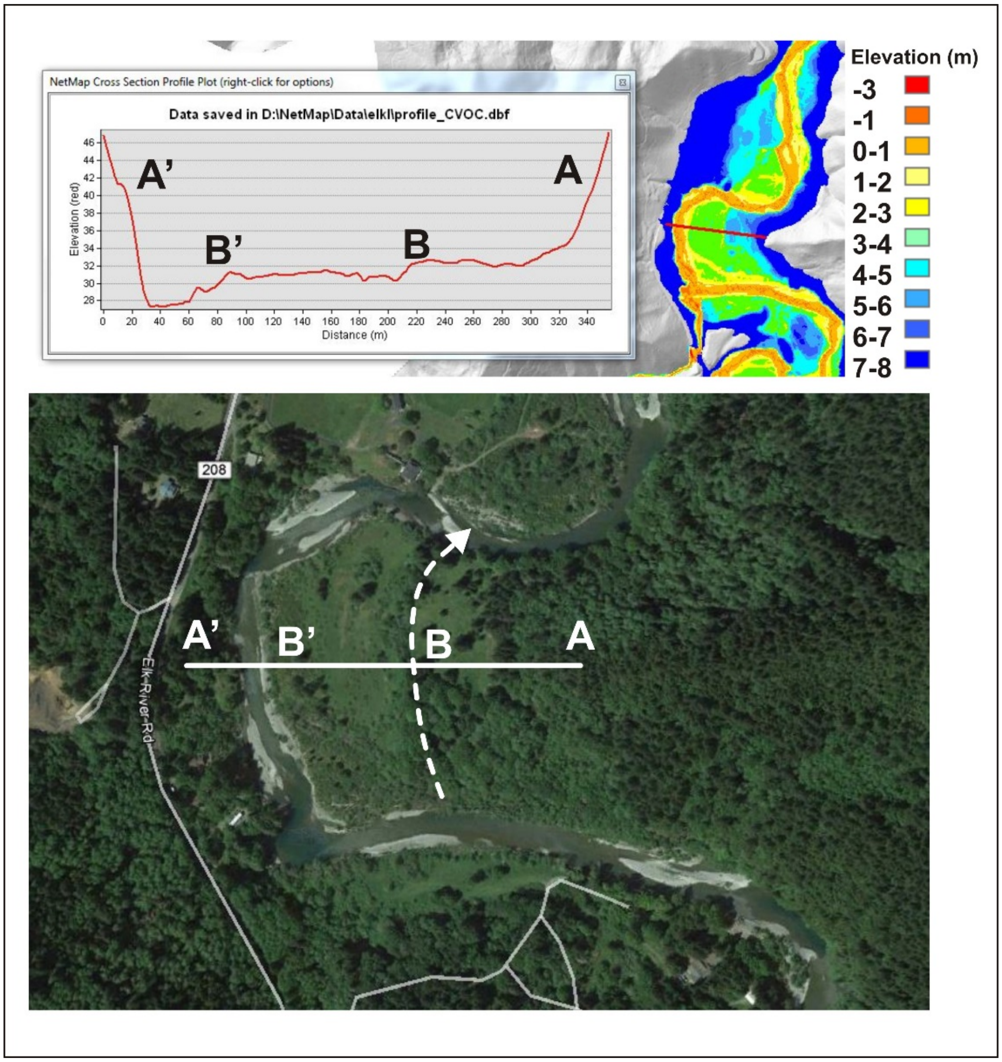

Figure 8. (upper) Valley floor surface elevations and a cross sectional profile (A-A'), along with a Google Earth image of the same area. "B" appears to represent a side channel, with the area between B and B' representing an active floodplain.

Our analysis indicates that natural floodplains along the lower mainstem of the Elk River may occur at three to four meters above the channel elevation (in the LiDAR DEM), with areas 3 meters being more frequently flooded and areas 4 meters being less frequently flooded (Figures 6 to 8). However, land use conversion of floodplains has likely reduced flooding potential. These elevations correspond to one through three multiples of bankfull depth floodplain elevation classes (**Figure 9**), with 2x bankfull depth surfaces being more frequently flooded and 3x bankfull depth being less frequently flooded. Most of the largest areas of predicted floodplains appear to have been converted to agricultural areas (**Figure 10**). The floodplain analysis will be coupled to predictions of habitat intrinsic potential to identify areas of potential channel/floodplain restoration.

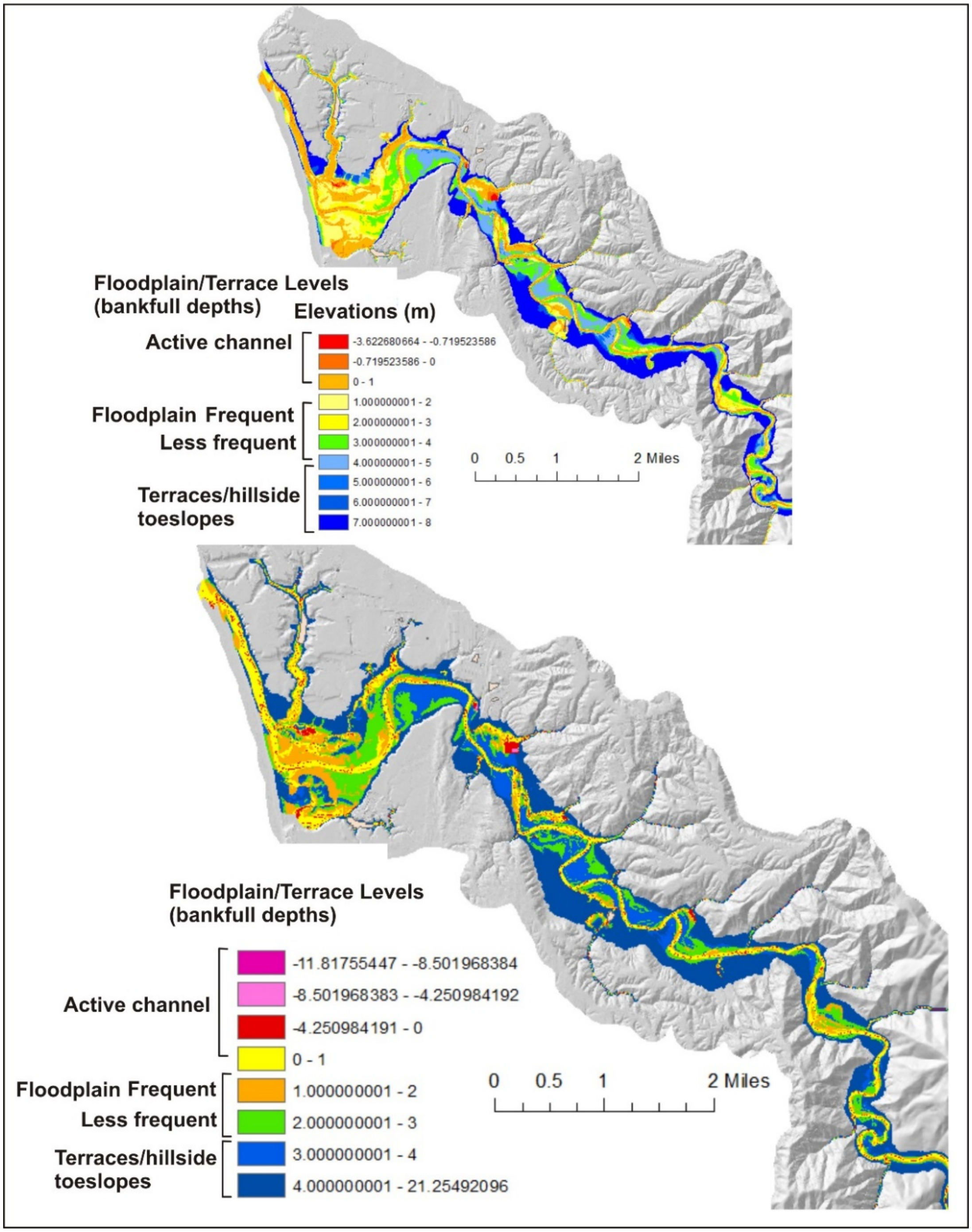

Figure 9. Classification of floodplains. Valley floor elevations (upper) and in multiples of bankfull depth (lower) along the lower mainstem of the Elk River watershed.

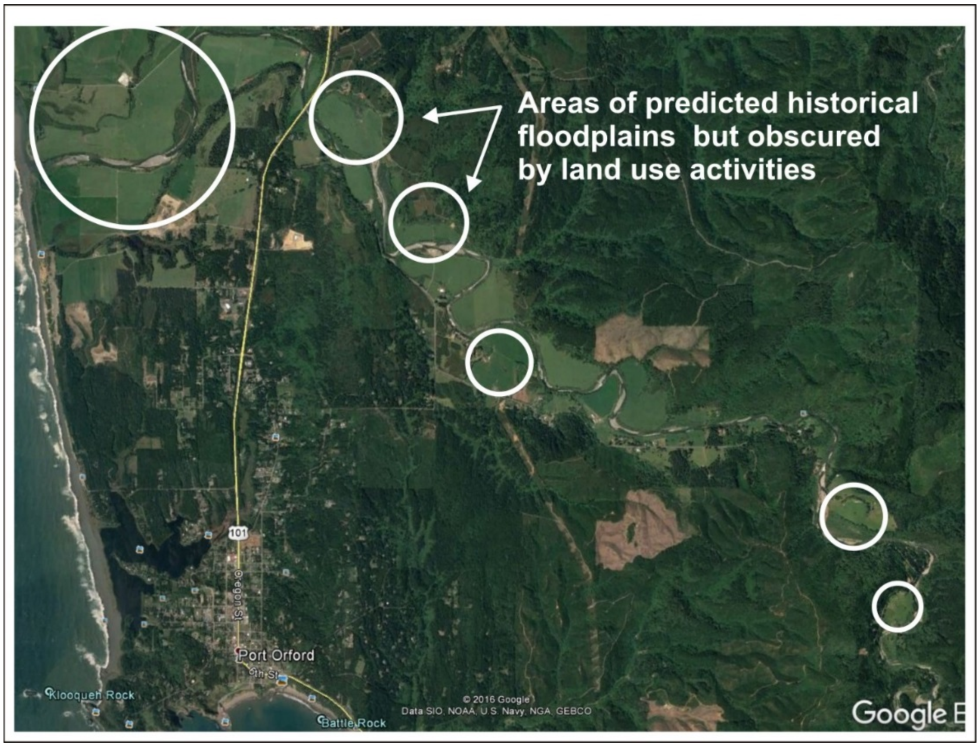

Figure 10. Likely areas of floodplain conversion (and abandonment) based on NetMap's floodplain analysis (Figures 6 to 9).

4.2 Fish and Beaver Habitats

The habitat intrinsic potential (HIP) model of Burnett et al. (2007) was applied in the Elk River to identify preferred habitats of coho and Chinook salmon, and steelhead. The HIP model uses channel gradient, channel confinement (valley width divided by channel width) and mean annual flow; values range from zero to one, with higher scores equaling better intrinsic habitats.

The best predicted coho salmon habitat in the Elk River (IP scores > 0.75) is located in the lower part of the watershed, in the area with the widest floodplains and unconstrained valley floors (**Figure 11**). Moderate habitat suitability for coho (IP 0.5 to 0.75) extend throughout the upper mainstem and into the lower portions of the largest tributaries (Figure 11). However, some of the highest potential coho habitat quality overlap areas in the lower watershed with diminished floodplains (Figures 9 and 10).

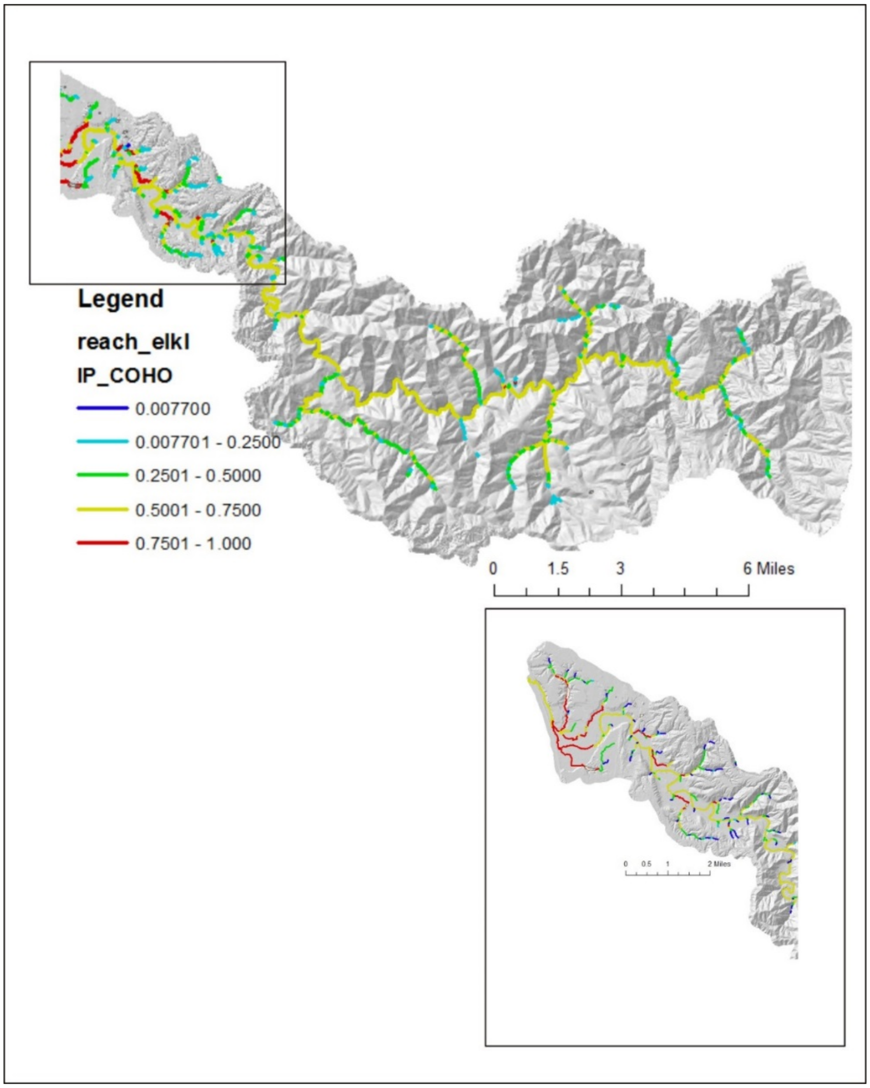

Figure 11. Habitat intrinsic potential for coho rearing habitat.

The best predicted steelhead habitat is located throughout the upper watershed and into the lowest portions of the largest tributaries (**Figure 12**). To some extent, the maps of coho and steelhead IP values are reversed, because steelhead prefer somewhat steeper and more confined channels compared to coho. Chinook habitat is predicted to have moderate quality throughout the mainstem and into the largest tributaries of the Elk River watershed (**Figure 13**).

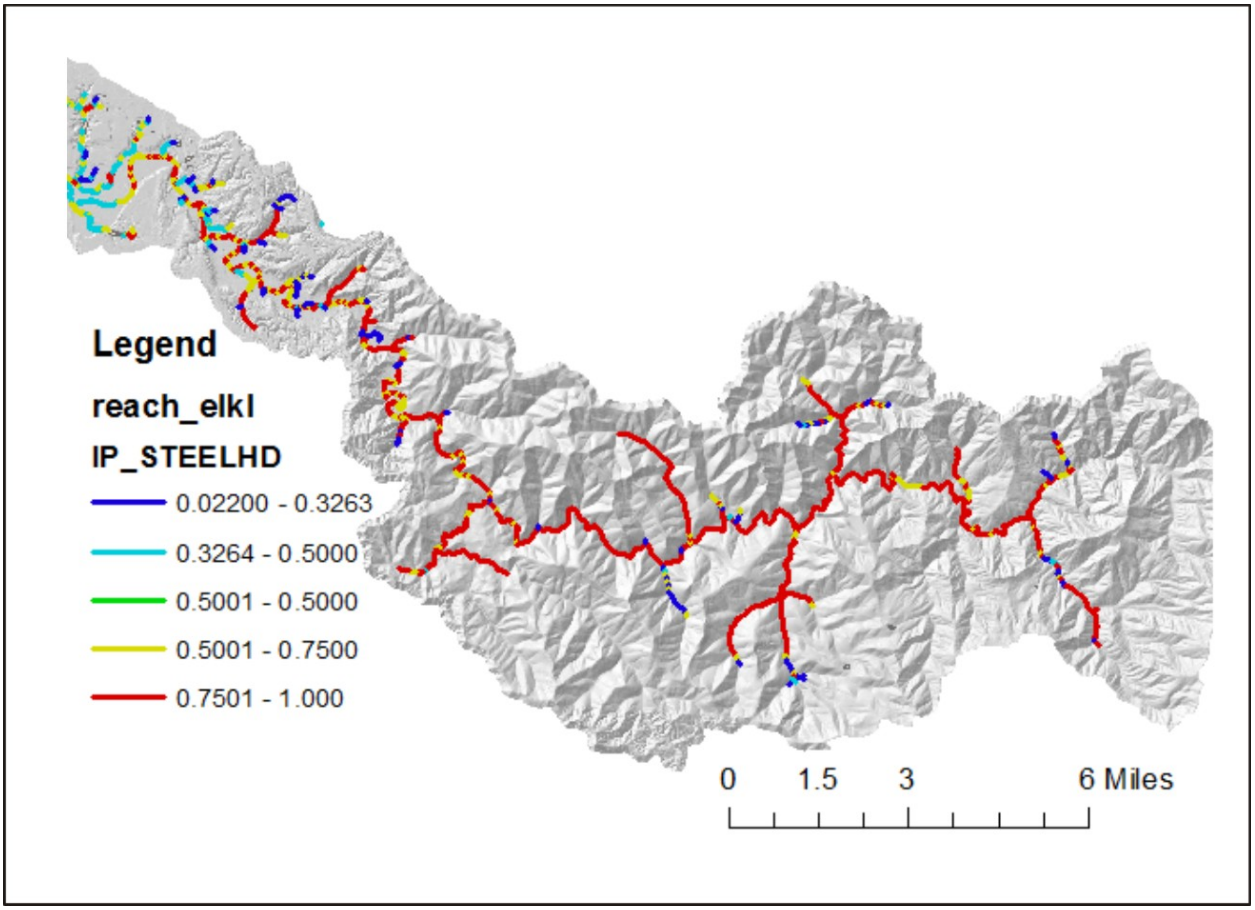

Figure 12. Habitat intrinsic potential for steelhead rearing habitat.

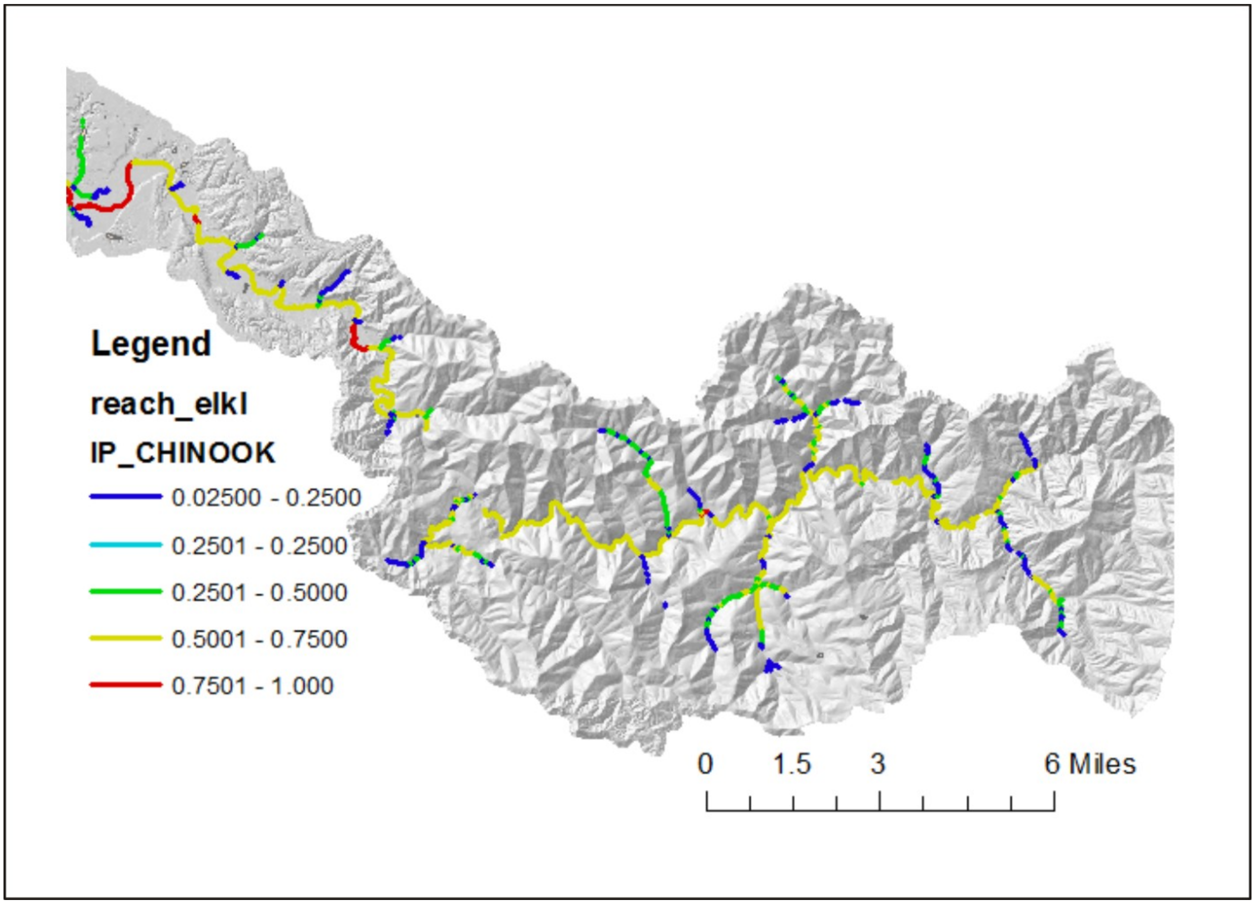

Figure 13. Habitat intrinsic potential for chinook rearing habitat.

The habitat intrinsic potential model predictions are only approximations of the spatial extent and quality of fish habitats. Field validation of salmon and steelhead spawning extent would provide a more accurate picture of the spatial distribution of the different species. Estimates of salmon and steelhead distributions (Oregon Department of Fish and Wildlife, draft in 2001, from the Elk River Watershed Assessment [2001]) is shown in **Figure 14**. The HIP models over-predict fish distribution in some areas, and under-predict it in other areas. However, the ODFW distribution may not be comprehensive in the smaller tributaries (ERWA 2001).

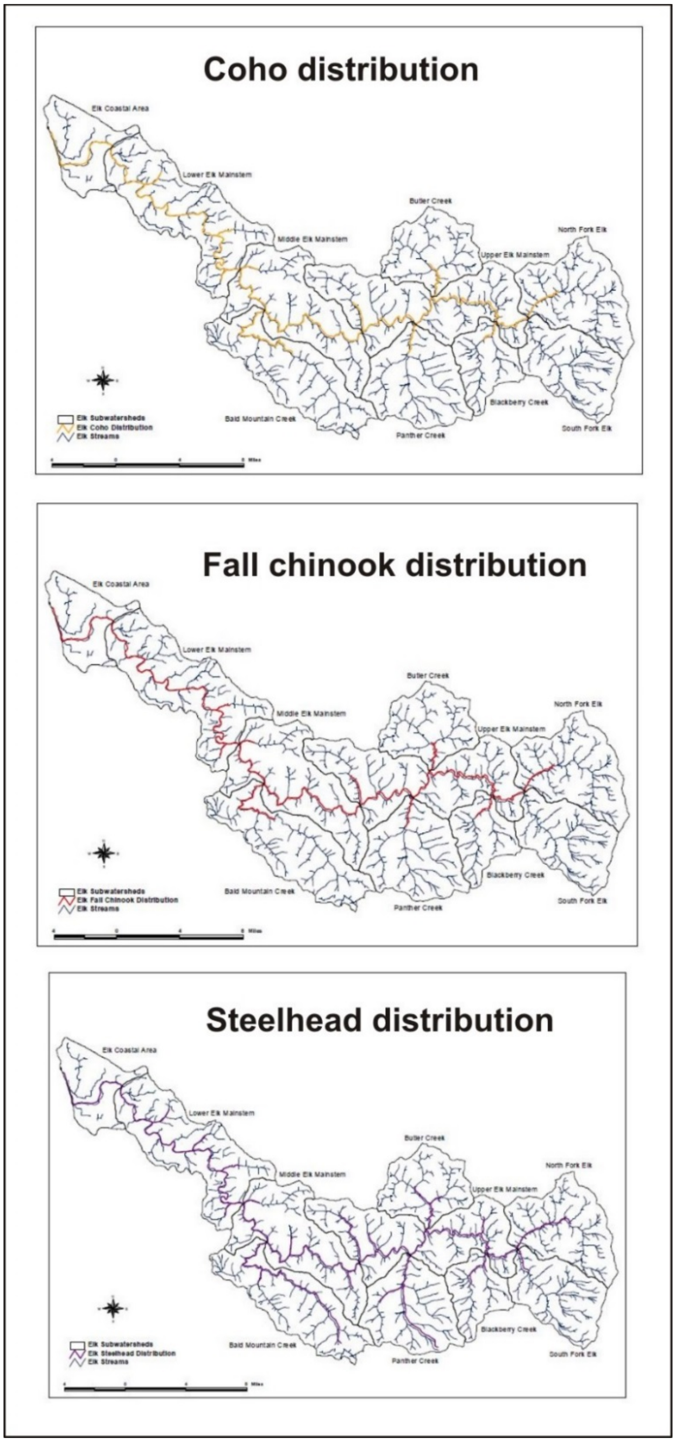

Figure 14. Estimates of fish distribution from Oregon Department of Fish and Wildlife (obtained from Elk River Watershed Assessment [2001]).

Beaver habitat was predicted using NetMap based on the model of Pollock et al. 2004. The model applies channel gradient, drainage area and stream power thresholds. The model predicts that the lower mainstem and tributaries were prime beaver habitat, although the mainstem river is probably too large and swift to support dam building (**Figure 15**). But the lower tributaries that extend onto the floodplains (historically) likely provided extensive beaver habitat.

Habitat predictions for westslope cutthroat and coastal cutthroat trout are not included in this report. Analysts are referred to the complete Elk River – NetMap datasets and tools to examine model predictions for resident species.

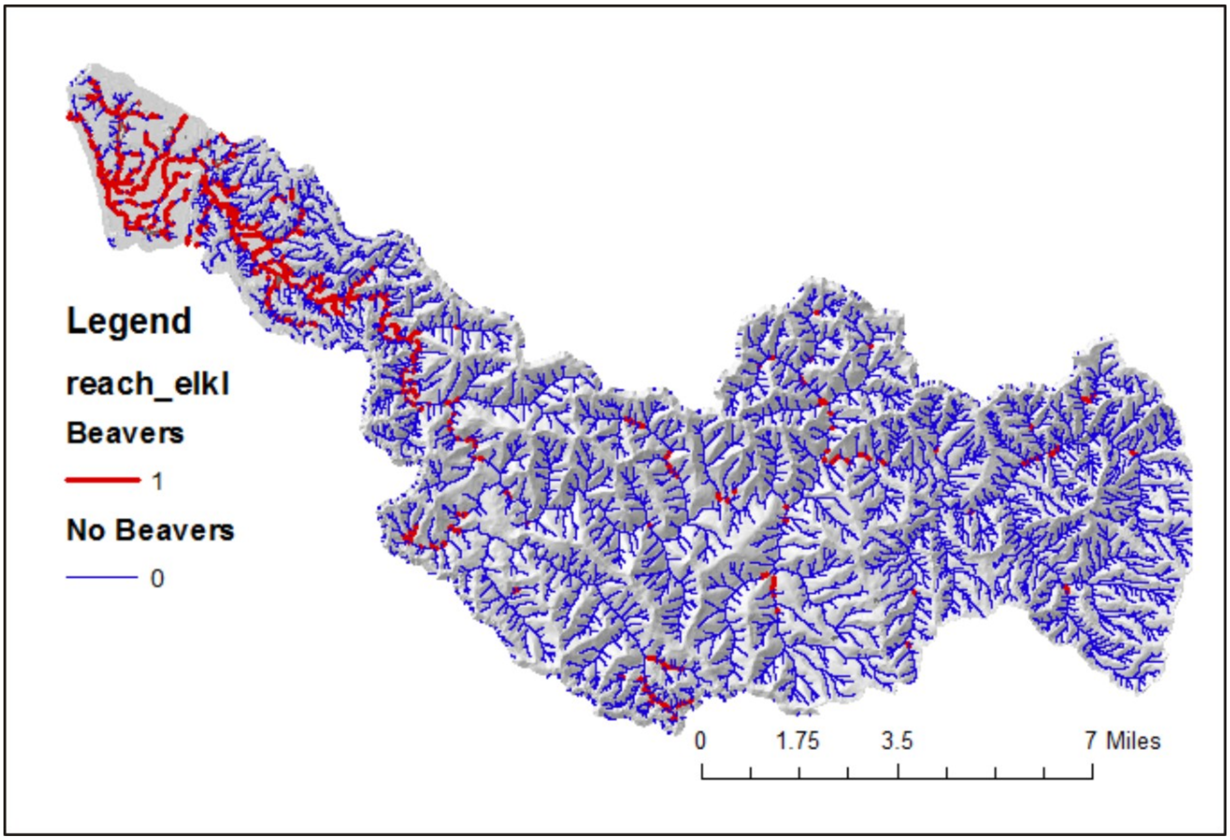

Figure 15. Predicted beaver suitable habitat in the Elk River watershed.

4.3 Riparian Analysis

Thermal Energy to Streams/ Stream Shading

NetMap tools were used to estimate the thermal energy load to the channel network in the Elk River basin, in the absence of vegetation (but taking account of latitude, solar angle, channel orientation, channel width and topographic shading); NetMap's "Bare Earth" thermal prediction is equivalent to "Solar Potential" in Oregon's DEQ Heat Source Model. NetMap tools were also used to predict thermal load given full forest vegetation canopy (assumed 200 foot tree height, vegetation density of 0.7 [dense] and an unlimited width of riparian forests, in watt-hours m^{-2}); NetMap's predicted "Vegetated Solar Radiation" is equivalent to "Solar Received" in Oregon's DEQ Heat Source Model. Solar received minus bare earth radiation provides one measure of the sensitivity of removal of vegetation on thermal load to the stream and consequently on potential stream heating (**Figure 16**). For additional technical background on NetMap's thermal tool, go here.

There are concentrated zones where removal of streamside vegetation, either by logging or fire, would lead to significant increases in thermal load. Many of these areas are in headwaters with western or southern exposure (**Figure 16**). For anadromous fish bearing streams only, channels with the highest potential for increases in thermal loading are located in the small tributaries in the lower river (Figure 16).

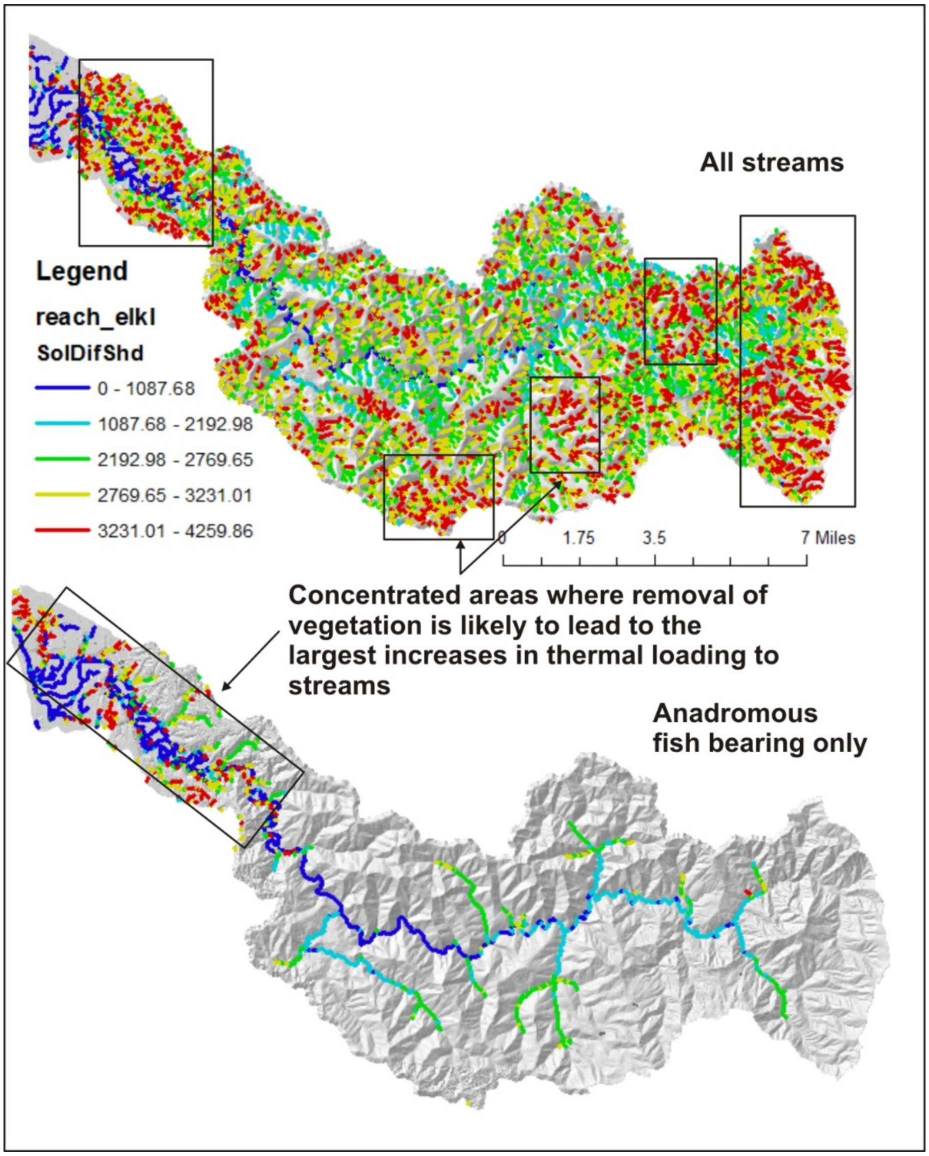

Figure 16. Thermal loading sensitivity analysis identifies areas where removal of streamside vegetation will lead to higher thermal loading.

NetMap also contains another tool for predicting shade-thermal loading conditions to streams based on existing riparian vegetation conditions. A shade model is applied that requires tree height and basal area (Groom et al. 2011); for additional information, go here. Existing vegetation conditions in the Elk River watershed is obtained from LEMMA. Maps of stand height (computed as an average of all dominant and co-dominant trees, in meters) and basal area (basal area of all live trees greater than 2.5 cm in diameter, in terms of m^2/ha) are shown in **Figure 17**. LEMMA data indicate that there is a large diversity of basal area and stand heights, including many areas of larger values, in the upper watershed, an area dominated by larger conifer trees and little logging history (including a wilderness area). The smallest tree heights and lowest basal area (including lack of forest vegetation) are concentrated in the lower river mainstem and adjoining tributaries, the area of concentrated agricultural activities (Figure 17).

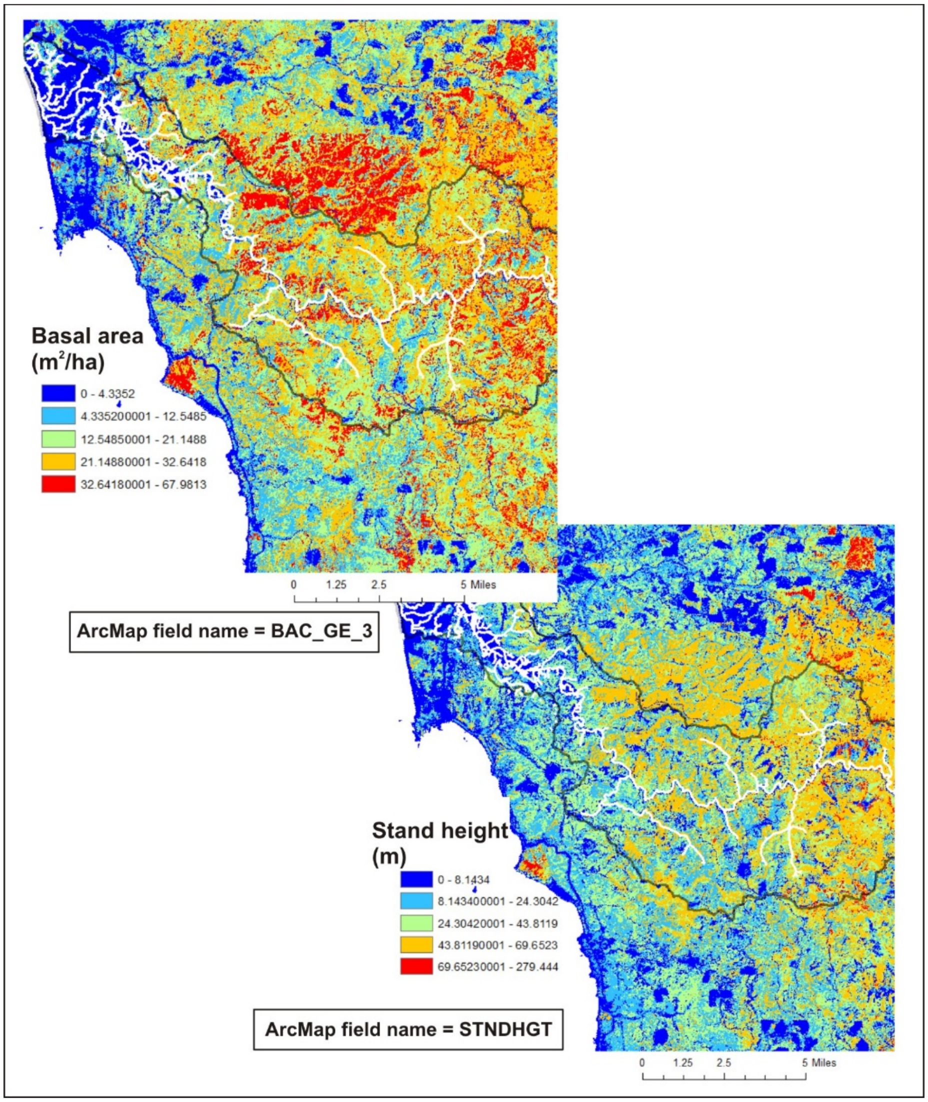

Figure 17. Vegetation characteristics from LEMMA used in NetMap's shade-thermal energy model.

Predicted current shade effects on thermal loading closely follow LEMMA maps of tree height and basal area. Thus, the channel segments with the lowest shade and highest predicted thermal loading are concentrated in the lower mainstem river (**Figure 18**). NetMap's tools allow an analyst to simulate ideal shade conditions in a watershed and to recalculate thermal loading to streams. By subtracting existing shade-thermal loading from idealized shade-thermal loading, one can identify where, in a watershed, additional streamside shade would be most effective. This was done in the Elk River watershed using a maximum tree height and basal area (approximately the 90th percentile of tree heights and basal area in the LEMMA data within the Elk River watershed). Results are shown in **Figure 19**.

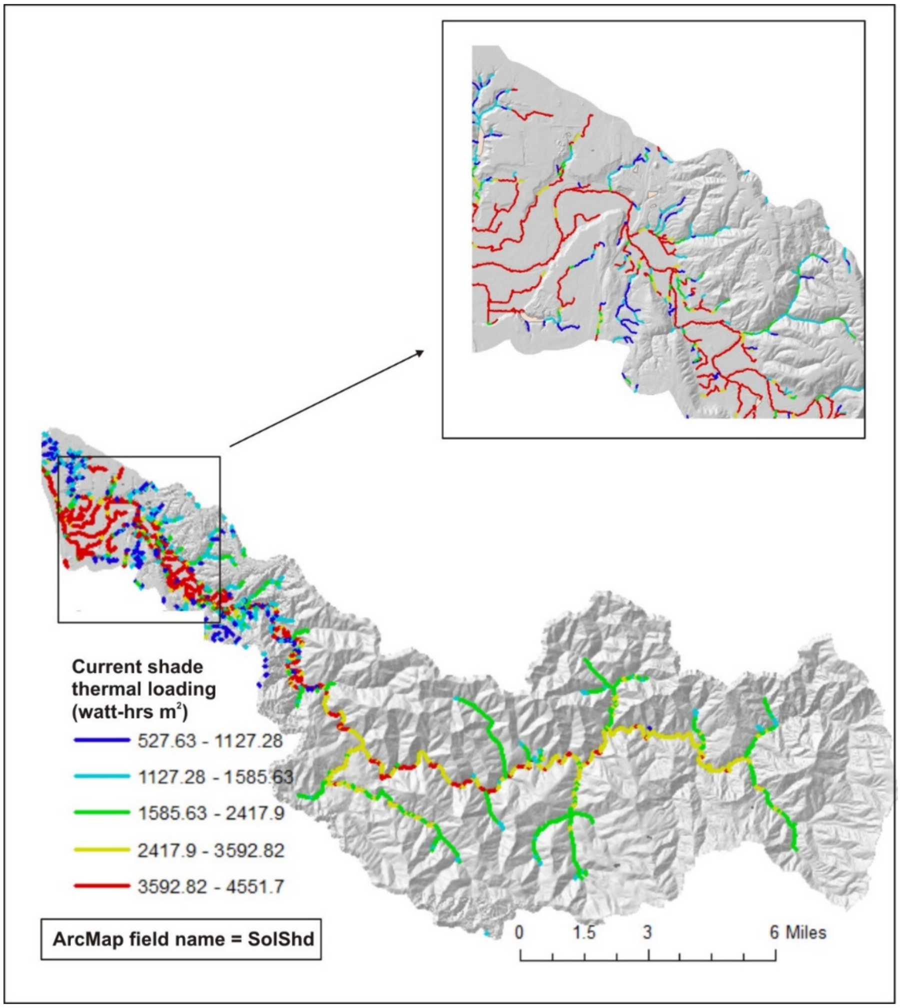

Figure 18. Current shade and thermal loading using vegetation data from LEMMA, showing fish bearing (anadromous) streams only.

The channel segments with the greatest positive effect from adding shade (e.g., reducing thermal loading) are concentrated in the lower mainstem river floodplains (including those that have been abandoned, see earlier) (Figure 19). Note that the largest and widest channels, specifically the Elk River mainstem, are not identified as having a significant positive effect from adding shade. This is because the wide channels receive the majority of their thermal energy from the sky view above the channel, and streamside shade does not contribute significantly to net thermal loading. The channels identified to gain the most from additional shade are the small tributaries located on the wide valley floors (including converted floodplains) (Figure 19).

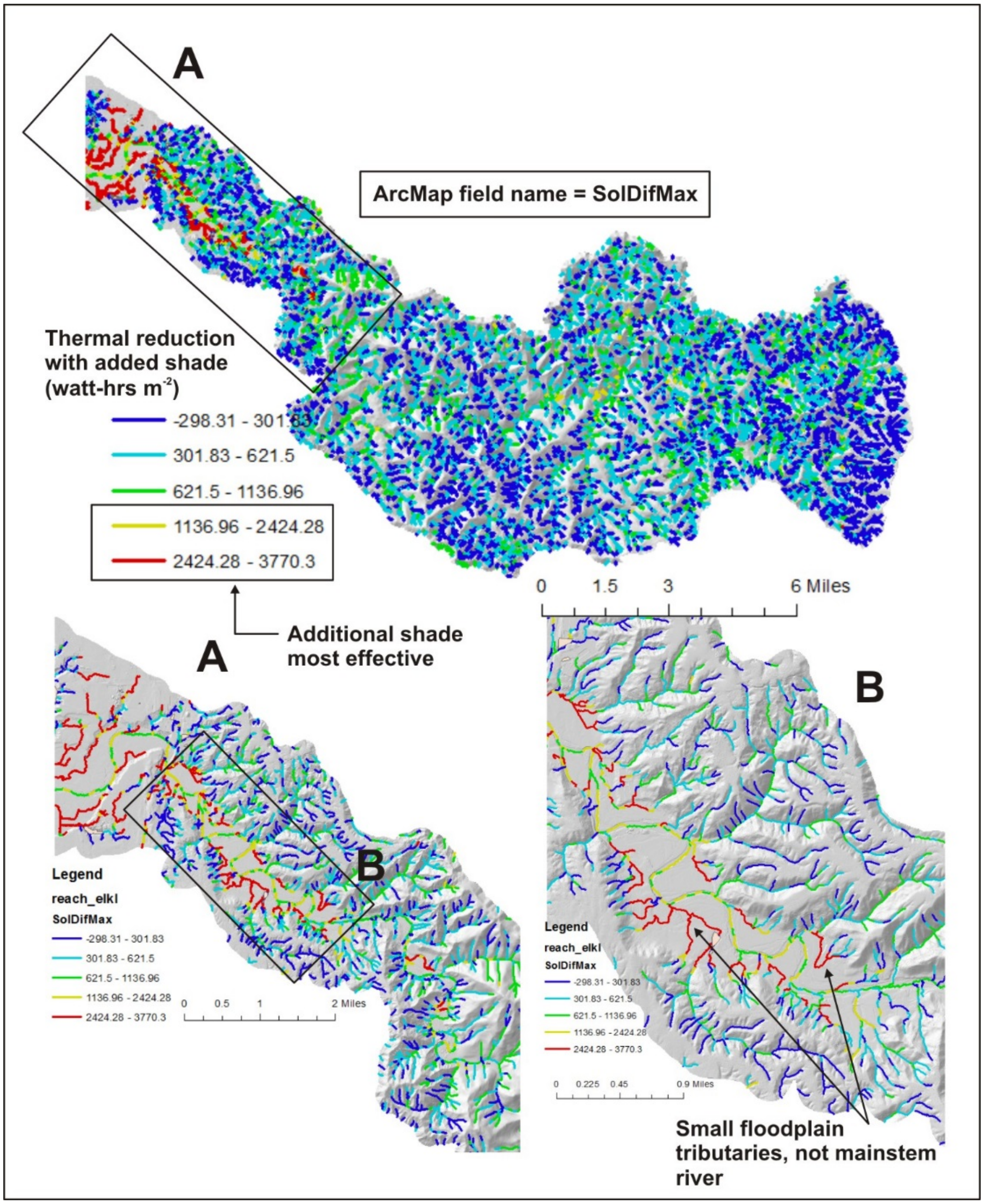

Figure 19. Where additional shade would be most effective.

In-stream wood

NetMap contains a tool for predicting a single year (current year) in-stream wood loading based on existing riparian forest conditions (using LEMMA vegetation data). The model applies a wood budgeting approach and considers forest stand density (of different diameter classes), width of the riparian forests, random or non-random tree fall trajectories, distance of trees from the stream edge, tree taper and channel width (Benda and Sias 2003). For additional information about the wood recruitment tool in NetMap, see here.

One of the main drivers of in-stream wood is the riparian tree sizes. This can be represented by the average quadratic mean diameter of stands, data available from LEMMA (**Figure 20**). There are numerous areas of larger trees located in the upper one half of the watershed, particularly located north of the mainstem. Most of the large tree areas are located within the national forest boundary and in the wilderness area (Figure 20). Areas of the smallest forest vegetation are concentrated in the lower one-third of the watershed, in areas of private forest land. Notably, there are extensive areas of no trees (zero quadratic mean diameter in Figure 20) located all along the wide valley floors and floodplains (including floodplains converted to agricultural lands) in the lower valley.

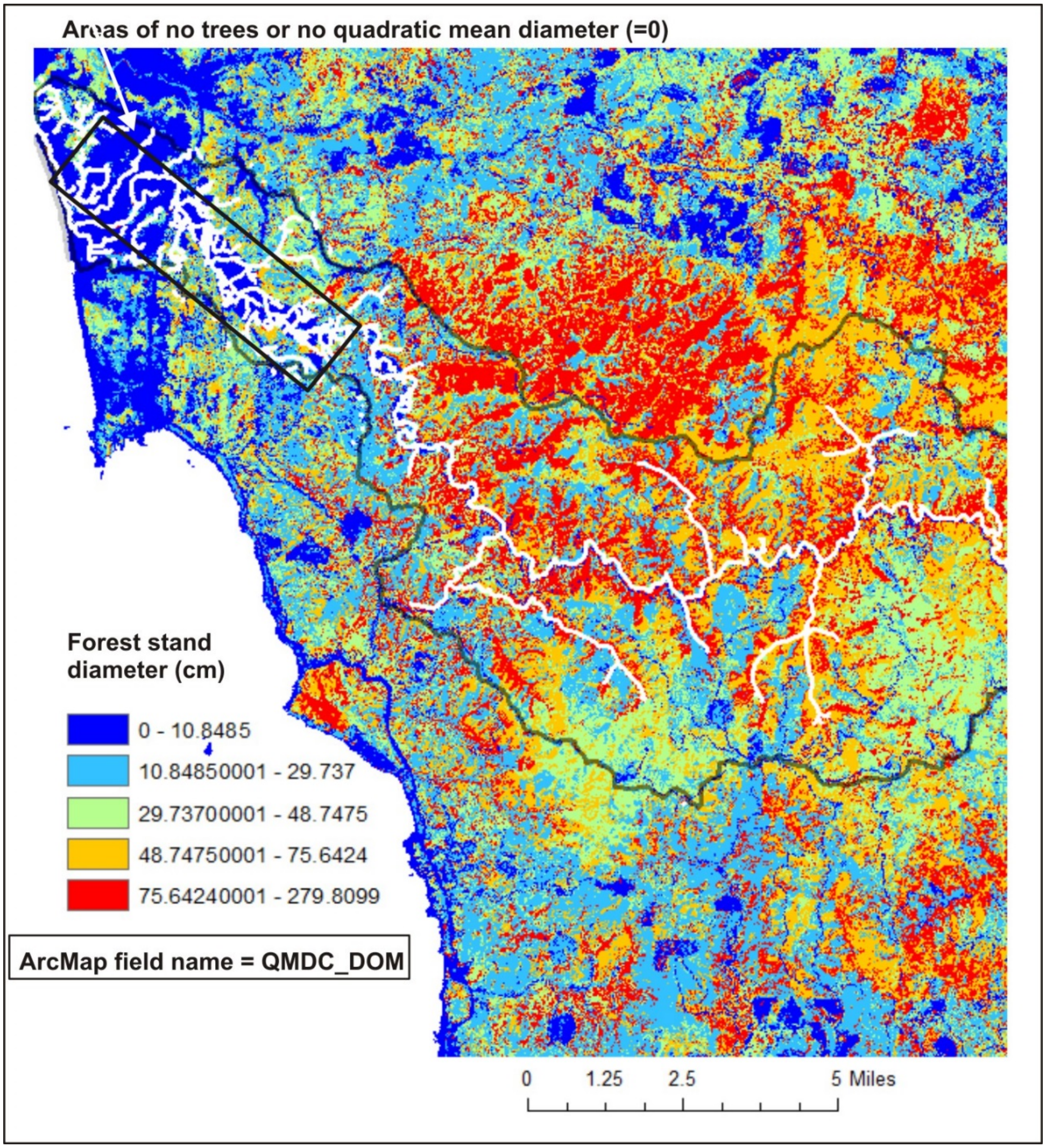

Figure 20. Vegetation information from LEMMA, used to characterize the current (single) year in-stream wood recruitment potential.

Consequently, there are numerous stream channels located in the upper two thirds of the watershed, including the mainstem and larger tributaries, that are predicted to have high levels of large (> 50 – 100 cm) in-stream wood (**Figure 21**). This is due to extensive national forest land with minimal history of intensive logging. The lower mainstem river and adjoining tributaries located along the wide valley floor, including historical floodplains, have the lowest in-stream wood, including no instream wood.

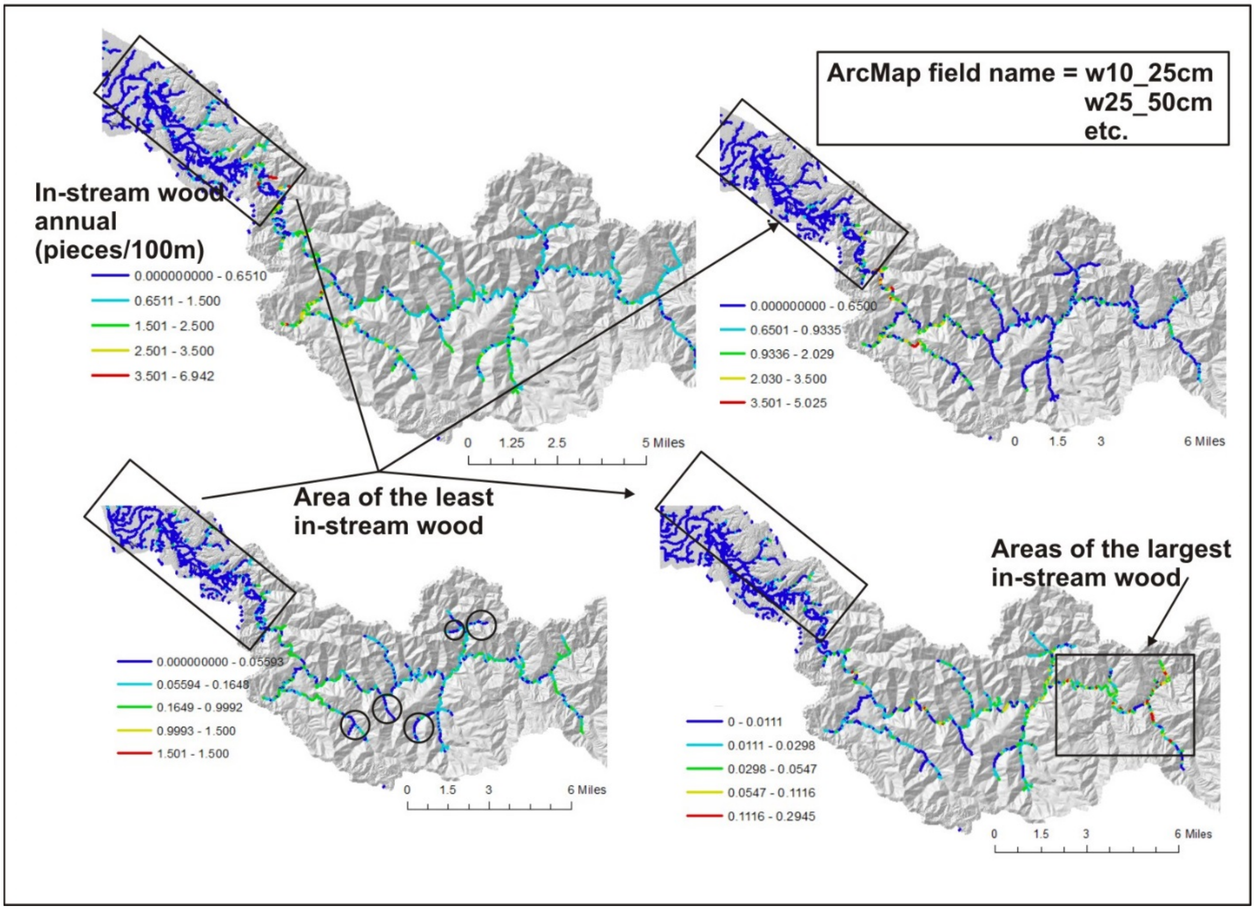

Figure 21. NetMap was used to predict the current (single) year in-stream wood recruitment potential across four-piece diameter classes.

Thermal Refugia

Thermal Refugia within streams is important for certain aquatic life, including endangered fish species such as salmon and trout. Thermal refugia is particularly important in watersheds that have less than optimum shade conditions because of historical and current land use including forestry, agriculture and urbanization. In addition, climate change that decreases summer stream flow or increases stream temperatures can exacerbate warm water conditions, making thermal refugia even more important.

Thermal refugia is best determined by field surveys of stream temperatures in the summer, but obtaining temperatures at the watershed scale can be expensive and time consuming. Another method is airborne thermal remote sensing which requires aircraft (fixed wings or helicopters) to fly over sections of rivers and document water temperature (Torgersen et al. 2001). Airborne thermal remote sensing holds great promise to obtain actual water temperature conditions, including identifying thermal refugia, however, it continues to be difficult (and expensive) to apply at the scale of large watersheds, landscapes and states. Another approach is to use intrinsic landscape conditions on thermal loading to streams, combined with current shade conditions, to map potential thermal refugia. NetMap contains a tool to map four types of provisional thermal refugia: 1) along channel (reach scale), 2) cumulative channel (tributary scale), 3) confluence intersections with mainstems, and 4) floodplain upwelling.

Reach scale (100 m +/-), tributary scale and confluence scale provisional thermal refugia (cooler water conditions) are shown in **Figures 22 through 24**. For additional information on NetMap's thermal refugia tools, see here.

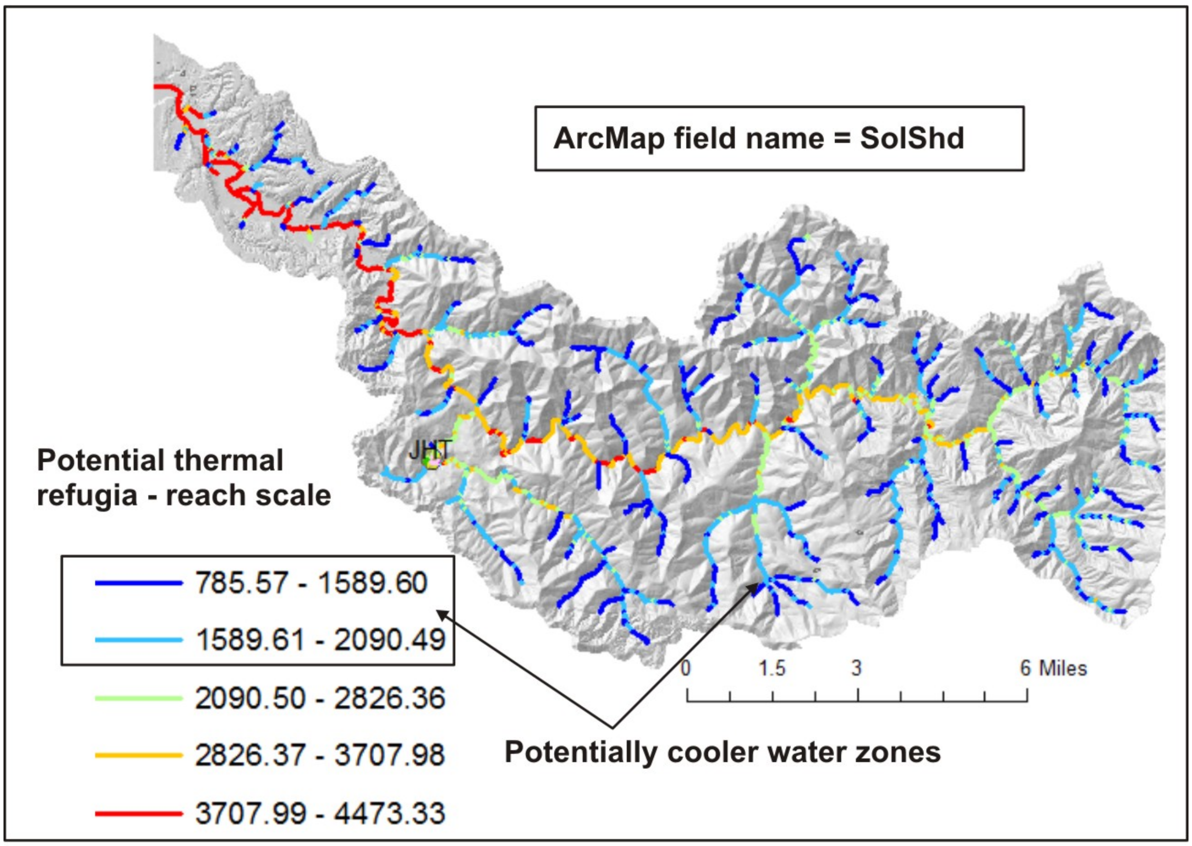

Figure 22. NetMap was used to predict potential reach scale cooler water conditions.

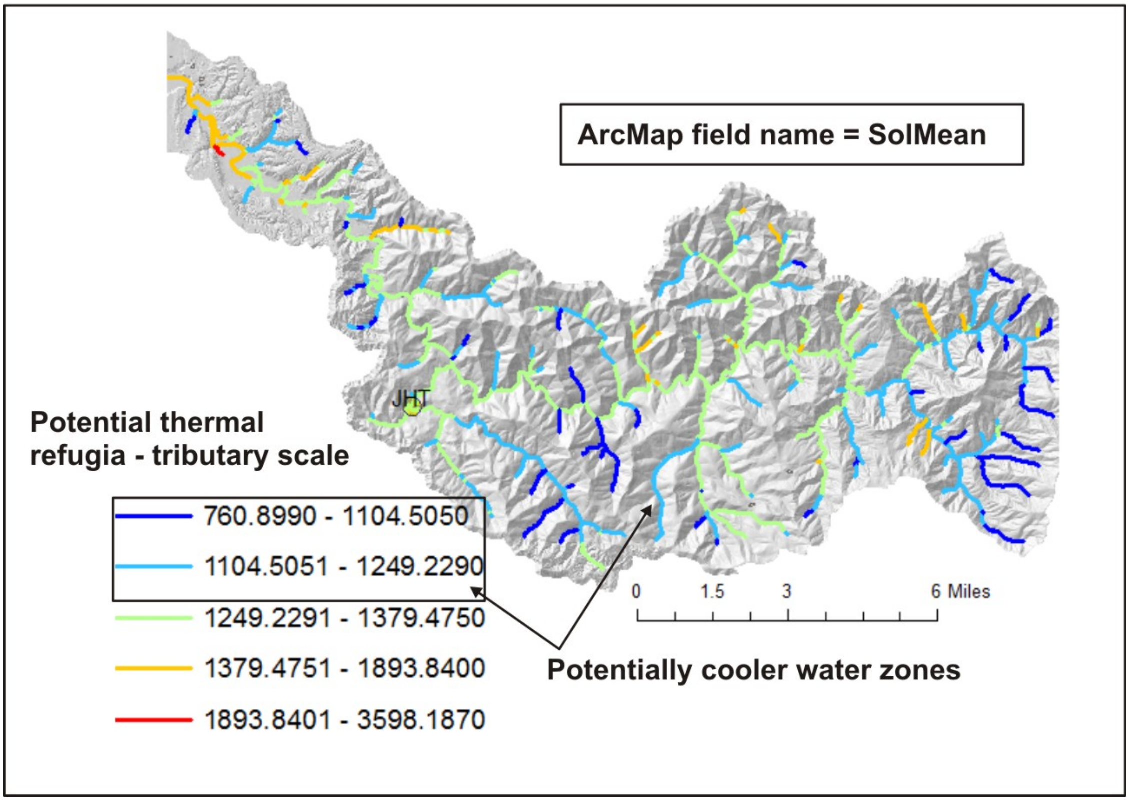

Figure 23. NetMap was used to predict potential tributary scale cooler water conditions.

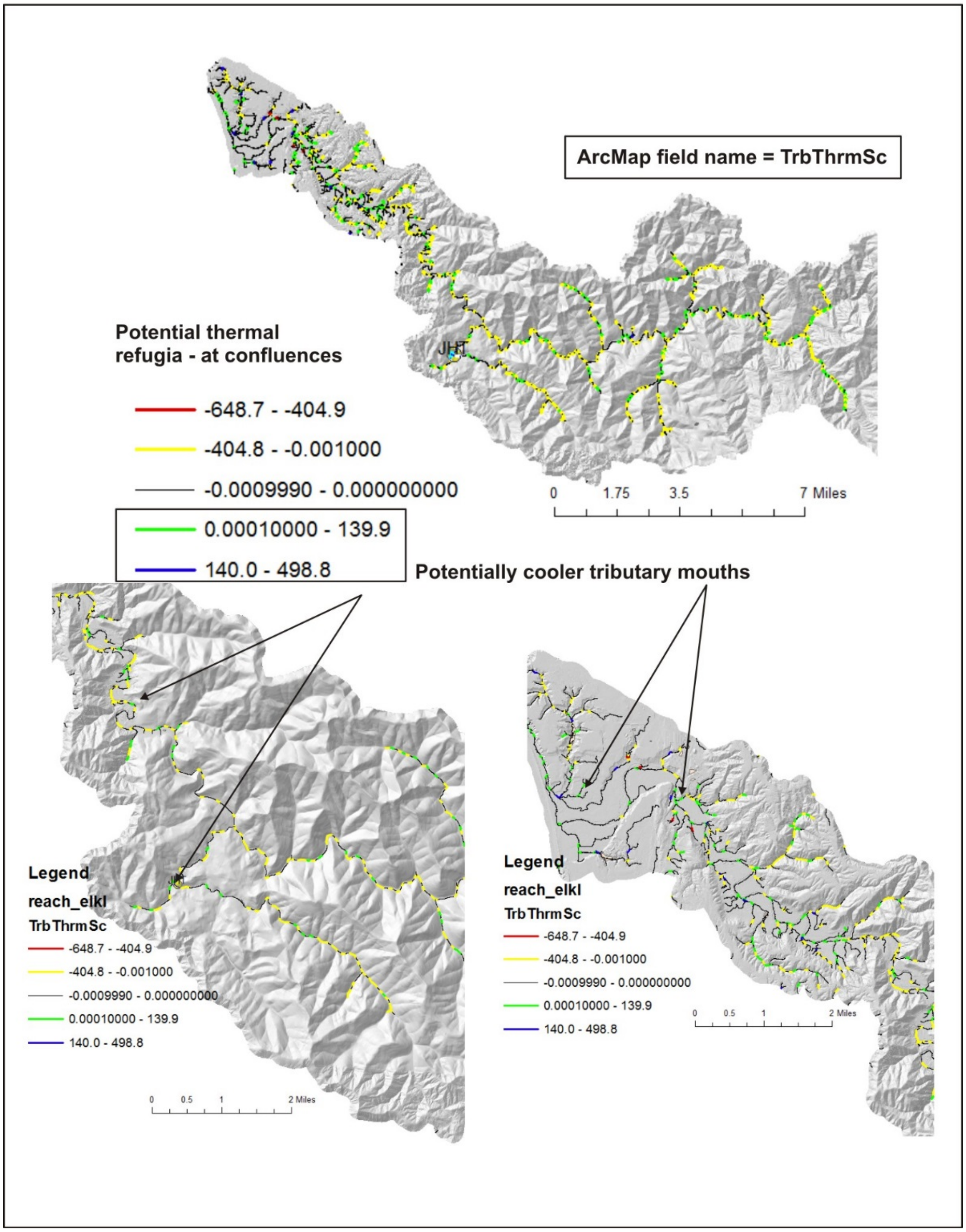

Figure 24. Potential confluence scale cooler water conditions are predicted across the watershed.

4.4 Erosion (Slope Stability) Analysis

NetMap's slope stability analysis is applied to the Elk River watershed to identify hillslope areas prone to shallow failure and to predict headwater channels susceptible to debris flows. Shallow landsliding is driven by hillslope (or swale) gradient, degree of topographic convergence, and contributing drainage area (Montgomery and Dietrich 1994, Miller and Burnett 2007). To analyze these processes NetMap's 'Generic Erosion Potential' (GEP) attribute is applied. GEP provides a relative measure of potential erosion based on slope steepness and convergence, recognized topographic indicators of shallow landsliding and gully erosion. GEP is based on topographic attributes of slope gradient, local contributing area, and topographic convergence derived from the DEM:

GEP = S*aL/b

where S is slope gradient (m/m), aL is a measure of local contributing area to a DEM pixel equal to the number of adjacent pixels that drain into it (varies between 0 and 8), and b is a measure of topographic convergence equal to the projection of flow direction out of a pixel onto the pixel edges. Values of b are 1 on planar slopes, less than 1 on convergent topography, and greater than 1 on divergent topography. Higher values of GEP are calculated in areas of steeper, more convergent topography. Higher values of GEP correspond to higher landslide densities and to higher gully-initiation-point densities (Miller and Burnett 2007).

For increased accuracy, GEP is calibrated using occurrences of landslides mapped from aerial photography (**Figure 25**). Seventeen landslides were inventoried on the 1997 aerial photographs. Values of hillslope gradient and landform curvature are extracted from NetMap's virtual watershed and they are used to calibrate GEP in terms of landslide density (# of slides per km^2). Predicted values ranged from a low of zero to 4.9 slides km^{-2} (**Figure 26**). Areas mapped as high potential on planar slopes generally have gradients of greater than 90% (as estimated from the DEM). Areas mapped as high potential on convergent slopes generally have gradients of greater than 70%.

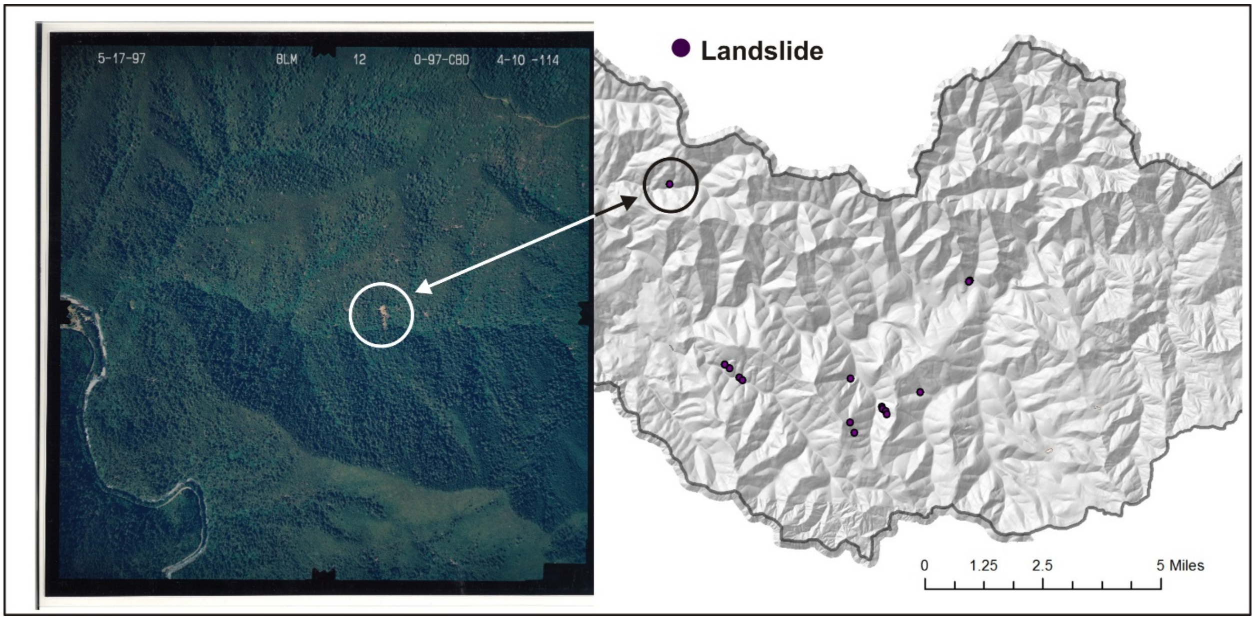

Figure 25. Landslide inventory in the Elk River basin.

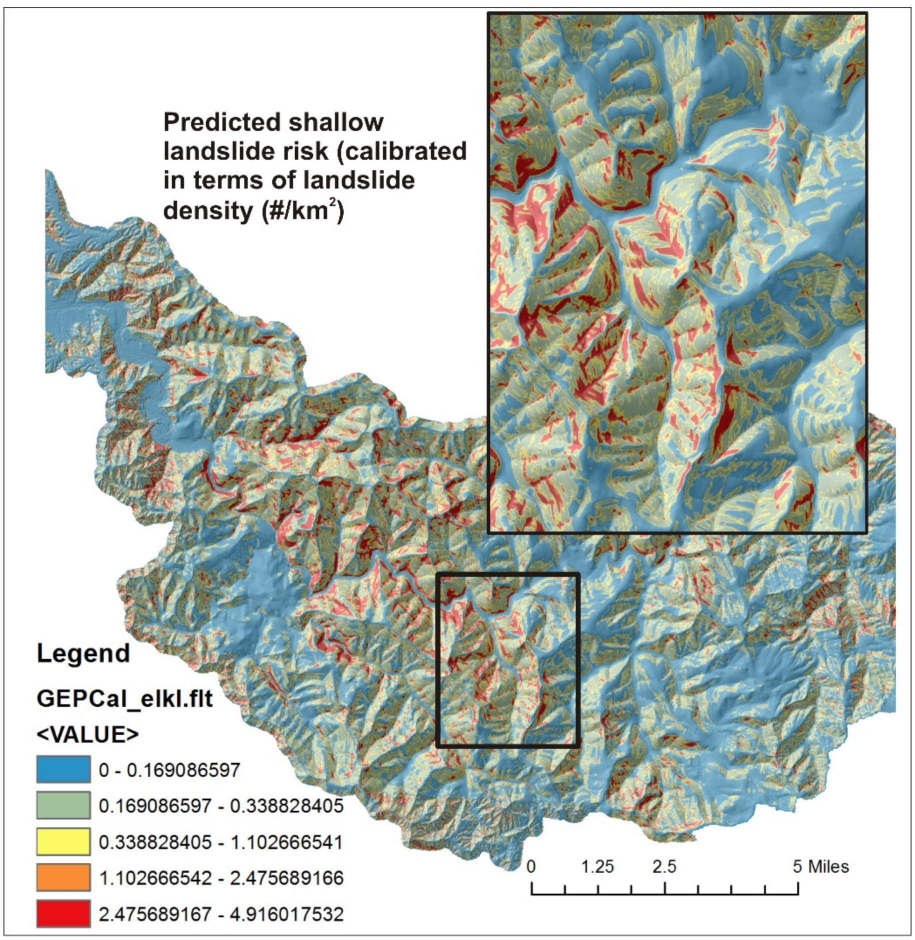

Figure 26. Calibrated shallow landslide model predictions.

The susceptibility of headwater channels to debris flow scour and deposition (based on Miller and Burnett 2008) was predicted in the Elk River basin (**Figure 27**). Overall, basin-wide, the Elk River basin has low to moderate susceptibility to debris flows compared to other watersheds in the central coast range. Nevertheless, there are groups of headwater channels that are prone to debris flows, and maps can be overlaid onto Google Earth to enhance visualization of this potential hazard (**Figure 28**).

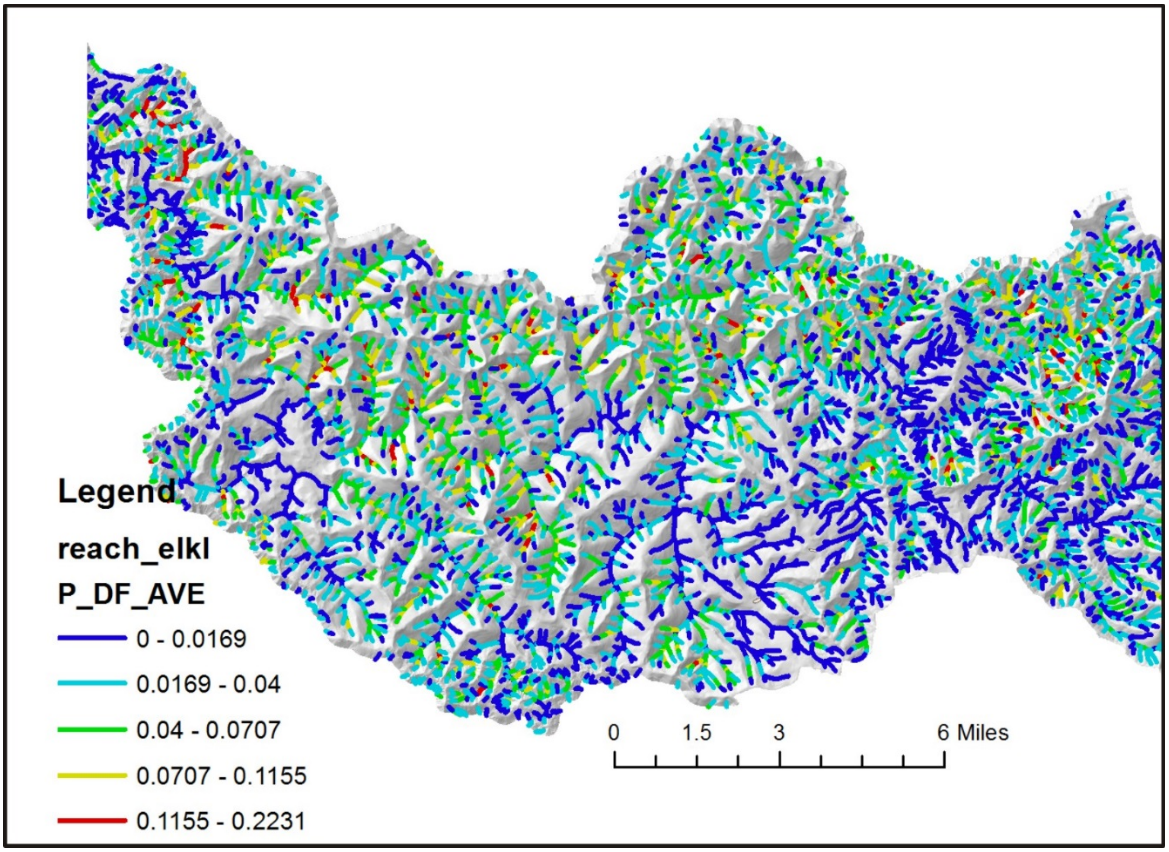

Figure 27. Predicted debris flow potential in the Elk River watershed.

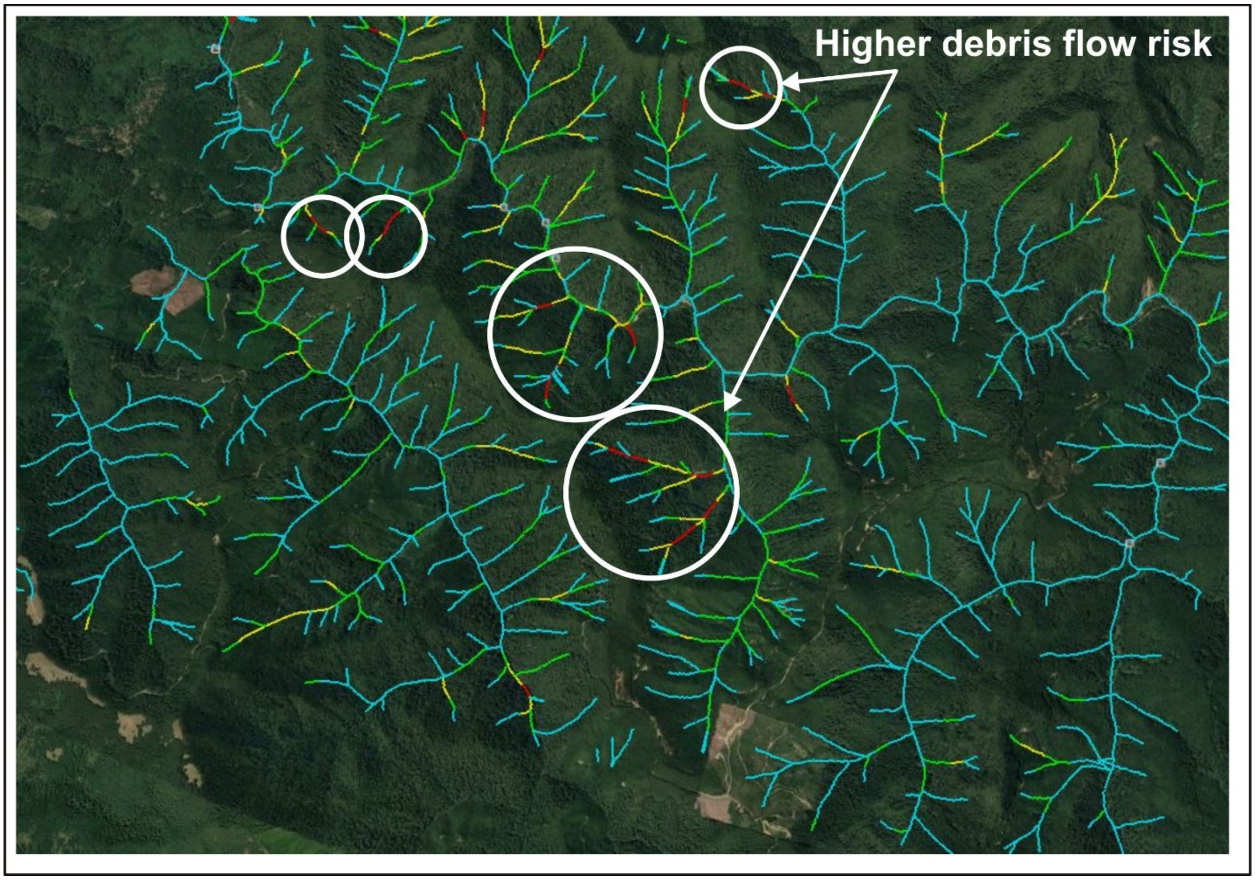

Figure 28. NetMap's predicted debris flow susceptibility in headwater channels overlaid onto Google Earth.

4.5 Forest Road Analysis

A model of unpaved road erosion and sediment delivery to streams (READI) is used to assess effectiveness of existing road engineering and maintenance at reducing sediment delivery to streams and to optimize future reductions in the Elk River watershed. Sediment production is driven by road surface area and slope and can be modified by rainfall intensity, surfacing and traffic; in the absence of reliable data on erosion rates, sediment production is dimensionless (as applied here). Road runoff hydrographs at drains and streams are generated using storm intensities and durations that deliver flow, with sediment, directly to streams at road-stream intersections or into the forest floor where runoff is either attenuated by soil infiltration or delivered to streams.

Vector road layers are draped onto the DEM and disaggregated at pixel borders. Road vector pixels are re-aggregated per topographic high and low points to determine road segments that drain directly to streams or to the forest floor. Road segments were further divided into smaller segments using georeferenced locations of engineered drainage structures on the National Forest (data supplied by the US Forest Service) (**Figure 29**). Junctions between two or more roads are treated as a drain point. A synthetic river network in NetMap, derived directly from surface flow routing and accumulation using DEMs, is used to identify all road-stream intersections. Each discreet road segment not directly connected to streams is hydrologically connected to individual channel segments via modeled overland flow paths within the virtual watershed, allowing precise connectivity between roads and streams for analysis of sediment delivery.

READI in the Elk River watershed was run as a dimensionless index (Erosivity parameter set to one). All roads are assumed to have the same surfacing (because of the large number of road segments in the road shapefile that had unknown surfacing). If forest roads are a mixture of gravel, native and paved, READI can be rerun but individual road segment surfacing will need to be identified. Ditches are assumed to occur along all segments (1 m wide). Soil infiltration rate was set to 0.12 m hr^{-1} and the one-hour duration design storm had an intensity of 0.02 m hr^{-1}. The forest floor runoff plume width was set to 1.5 m. The outslope proportion was set to 0.25 (25% of the road width outsloped); road width was set to 5 m. The objective of the analysis is to provide a relative ranking of road segments that are most likely to deliver sediment to streams either at road – stream crossings or via the forest floor. READI has been submitted for publication and additional information on the model can be found here.

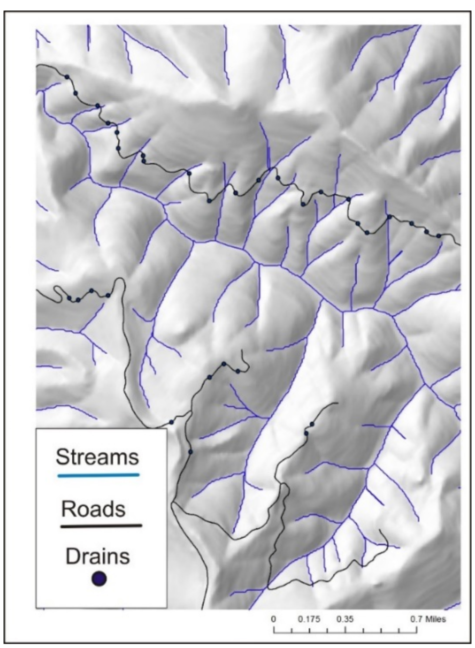

Figure 29. Road drain data used in the READI model.

READI predicts that all forest roads produce sediment but a smaller proportion of total sediment production is to delivery sediment to streams (21%) (**Figure 30**). Twenty-two percent of the total road length is predicted to be hydrologically connected to streams. The mean predicted runoff sediment plume length is 17 m.

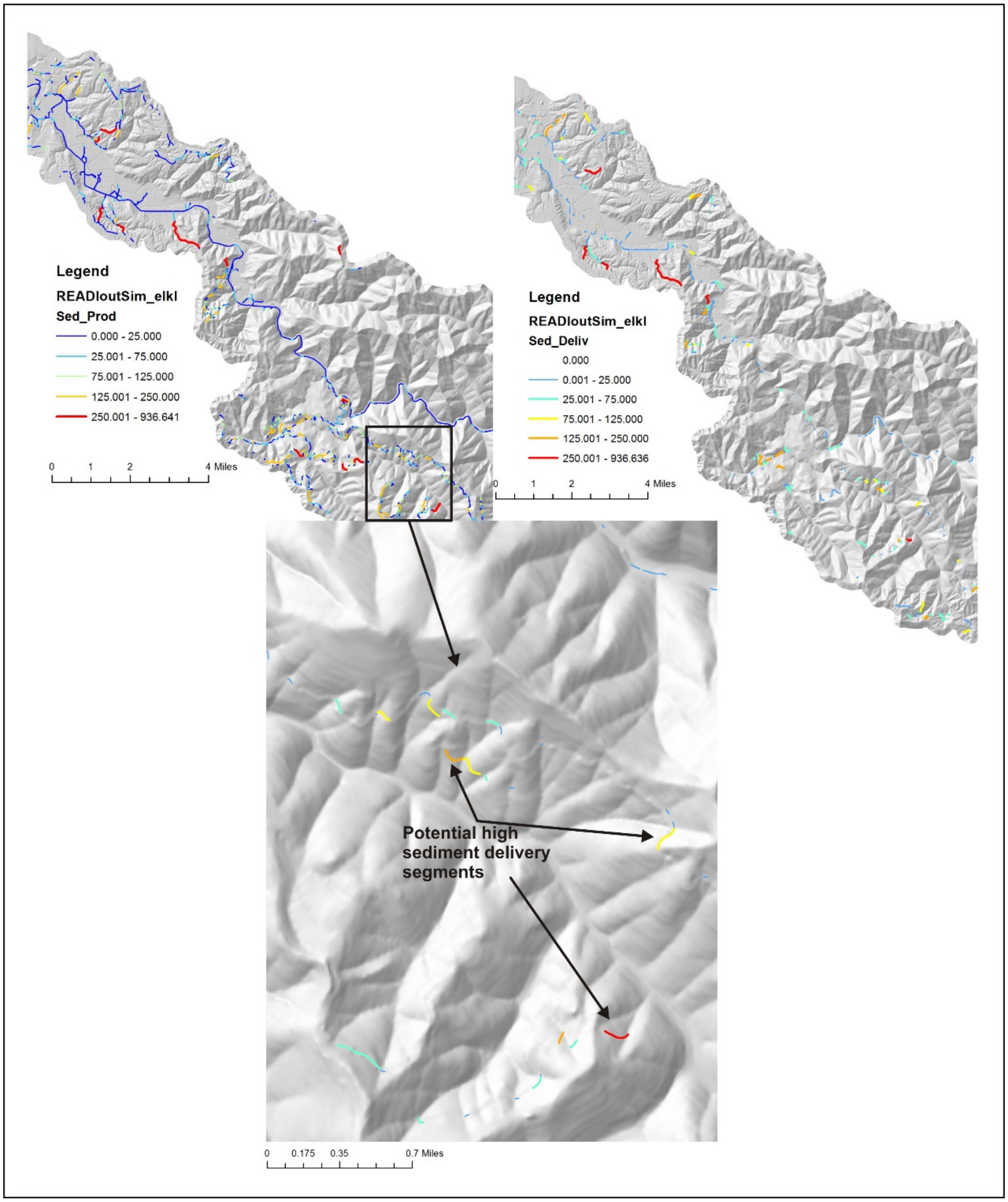

Figure 30. Predicted road sediment production and delivery. This type of road map could be used to prioritize future road maintenance and remediation efforts, including upgrading surfacing.

READI includes the ability to identify locations where additional engineered drains will be most effective at reducing delivery of water and sediment to the stream system. To locate optimal drain locations across a road network, READI analyzes each road drain in the network individually, starting with the drain with the largest sediment delivery, and searches for locations along the associated road segment(s) where a new drain would minimize sediment or water delivery. The model assesses each road segment, meter-by-meter, placing a new drain and calculating the combined delivery from the new and original drains to find the lowest minimum along the segment. A minimum drain spacing can be specified to reflect engineering or vehicle constraints to drain placement.

This procedure is done for all drain points as the model moves through a priority queue, examining all drains in order from highest to lowest delivery. This ensures that the optimal location is always at the top of the queue, even if it happens to fall within one of the newly created segments. This procedure is repeated until the specified number of new drains are added. Any number can be specified, from one to a maximum where the cumulative reduction of runoff and sediment delivery across all road segments attains a minimum, that is, until continued addition of new drains no longer reduces the total amount of water or sediment delivered to streams. READI provides a list of new drain points, each with an associated reduction in total delivery of water or sediment, ranked in order from the largest reduction to the least.

We applied the maximized the number of drains in the Elk River analysis (**Figure 31**). Predicted (dimensionless) sediment delivery was reduced from a total of 27,134 to 3,912, a reduction of 86%. Following placement of all drains (3,455, thus probably unrealistic) only 3% of total sediment production was delivered to streams and only 3% of the road is hydrologically connected to streams. However, the optimized drains are ranked in terms of effectiveness (amount of sediment reduced) and these can be used to prioritize drain placement for the most effectiveness (**Figure 32**). READI also contains the ability to predict where upgrading road surfacing (native to gravel or paved) would be the most effective in reducing sediment delivery (not included here because of uncertainty in existing road surfacing).

Sediment from roads (pre-optimized) is routed to streams and accumulated downstream and normalized by drainage area (**Figure 33**). Such information could be overlaid onto sensitive fish habitats to further prioritize where additional sediment delivery abatement measures might be applied.

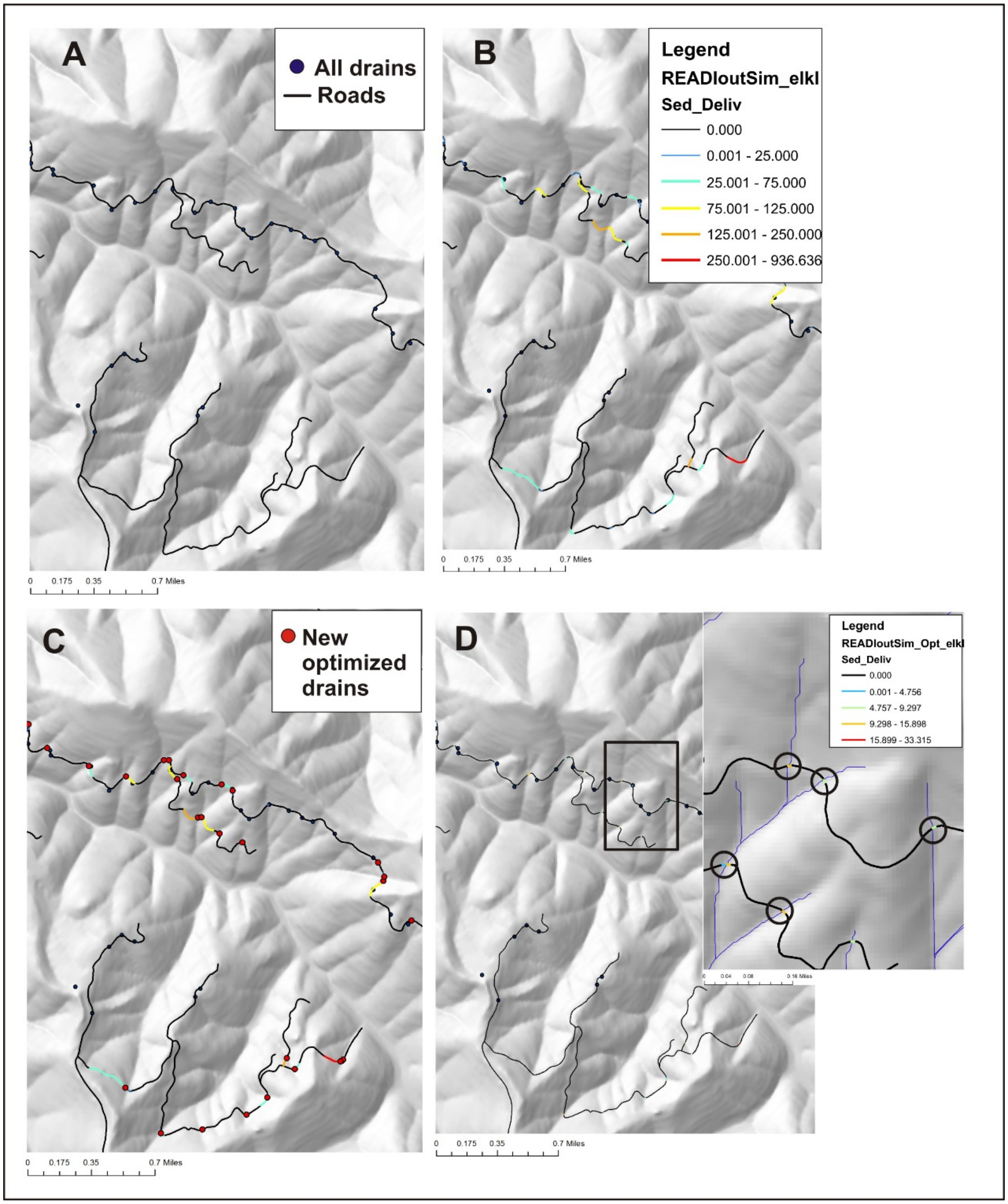

Figure 31. (A) Existing road drains, includes road-stream crossings, natural topographic low points and road segment junctions. (B) Predicted sediment delivery to streams. (C) Location of optimized drains also showing predicted sediment delivery prior to those drains. (D) Predicted sediment delivery following optimized drains. Inset in (D) shows the remaining short road segments that continue to supply sediment to streams.

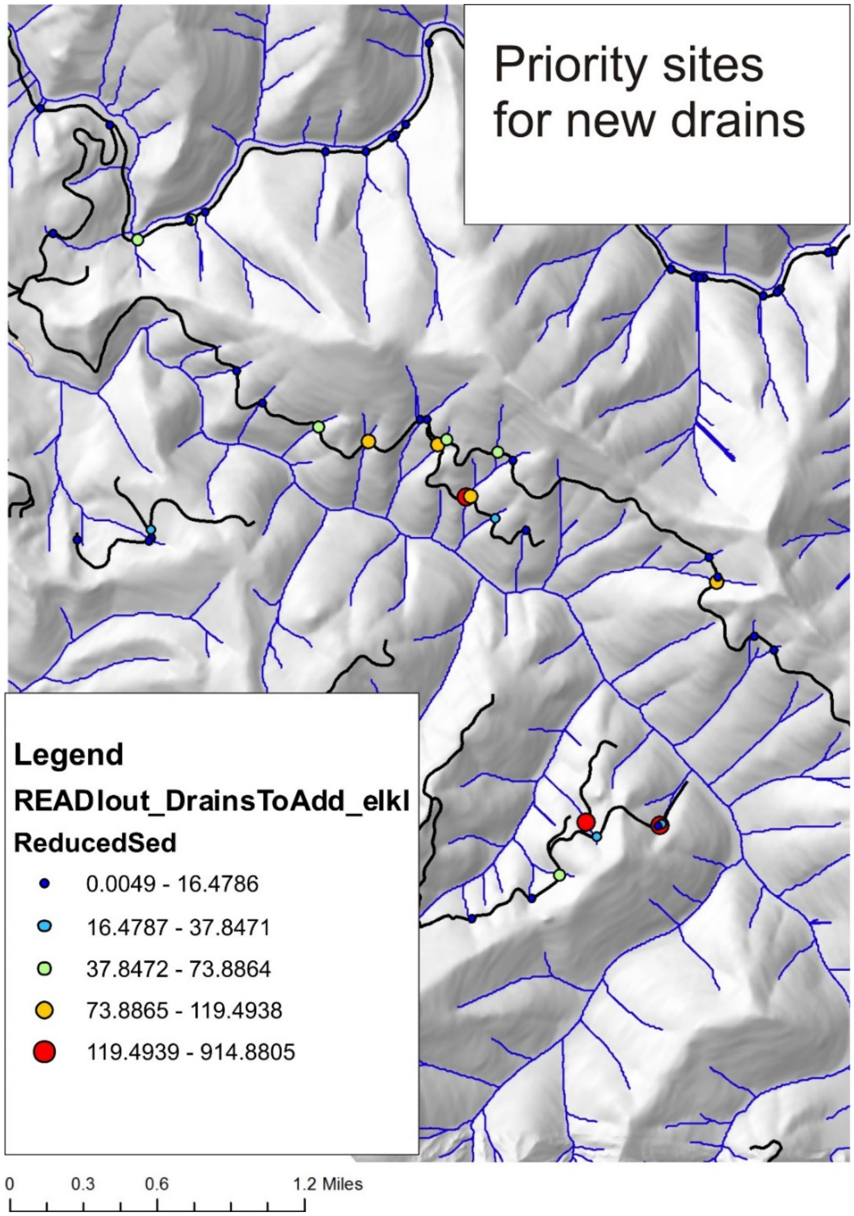

Figure 32. Optimized drains can be mapped according to their relative effectiveness at reducing sediment.

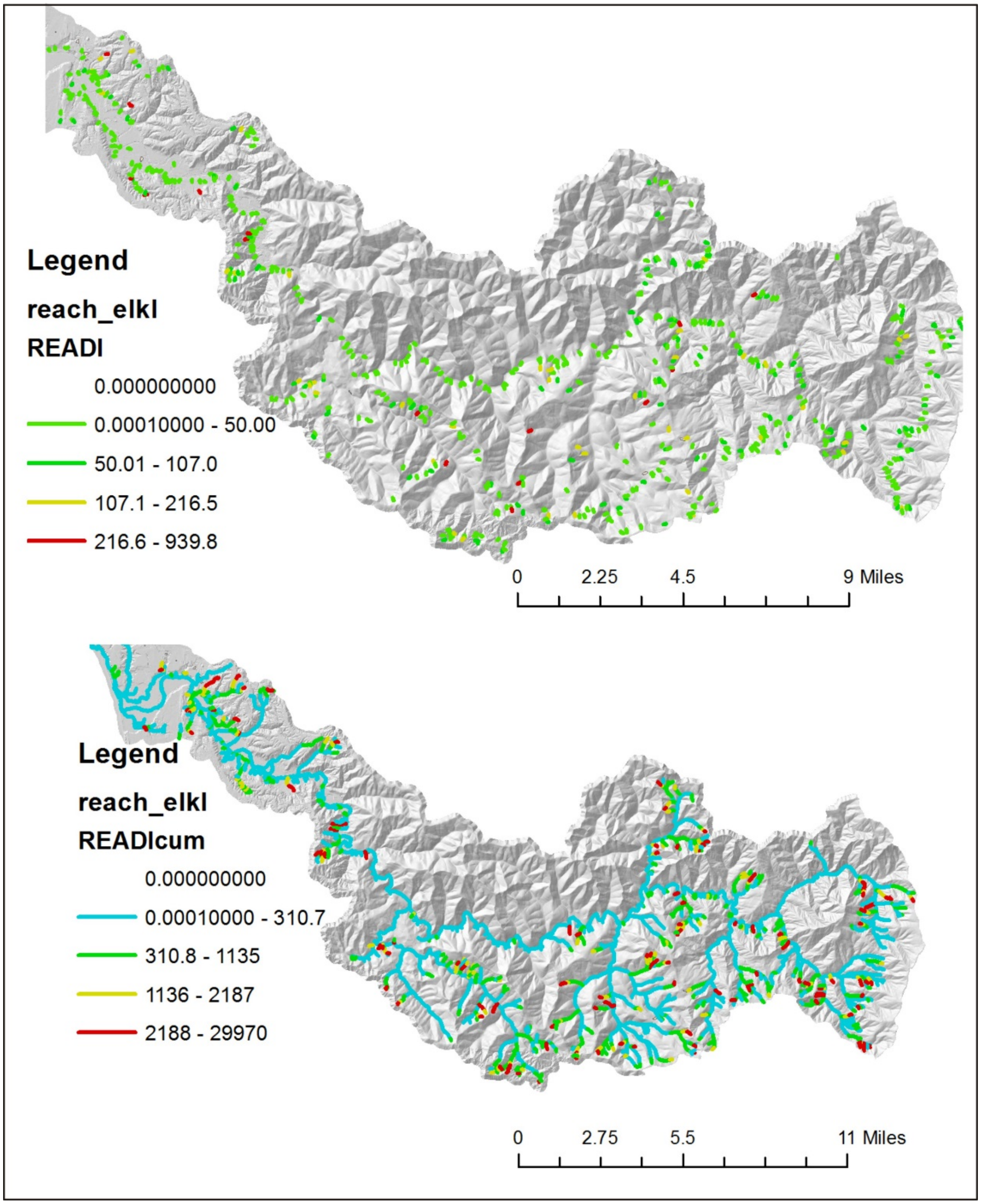

Figure 33. (Upper) Predicted forest road sediment is routed to individual stream segments. (Lower) Sediment delivery is then aggregated downstream and normalized by drainage area, providing a tributary scale perspective of sediment delivery.

NetMap's other road tools include road stability that can be used to help prioritize where additional remediation efforts can be applied to lessen the risk of road failures and the triggering of shallow landslides and debris flows (**Figure 34**). To learn more, see NetMap's Tech Help.

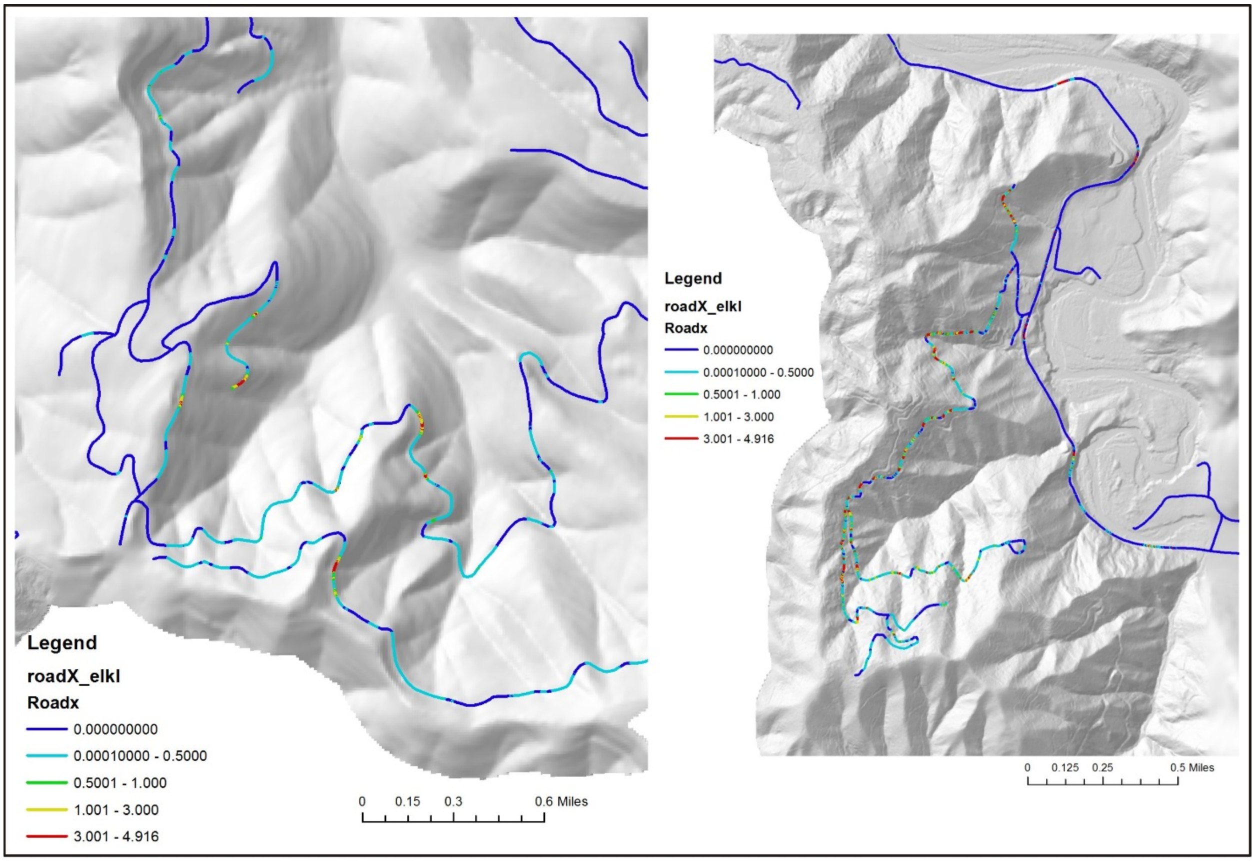

Figure 34. Predicted potential road stability, based on the calibrated shallow landslide model in Figure 26.

NetMap's debris flow predictions in headwater channels can be overlaid with the road layer to identify road crossings that might be at risk from debris flow damage, or from road failures that trigger debris flows (**Figure 35**).

Another road analysis is the cumulative length of predicted fish habitat upstream of all road crossings. This was done for coho habitat (**Figure 36**).

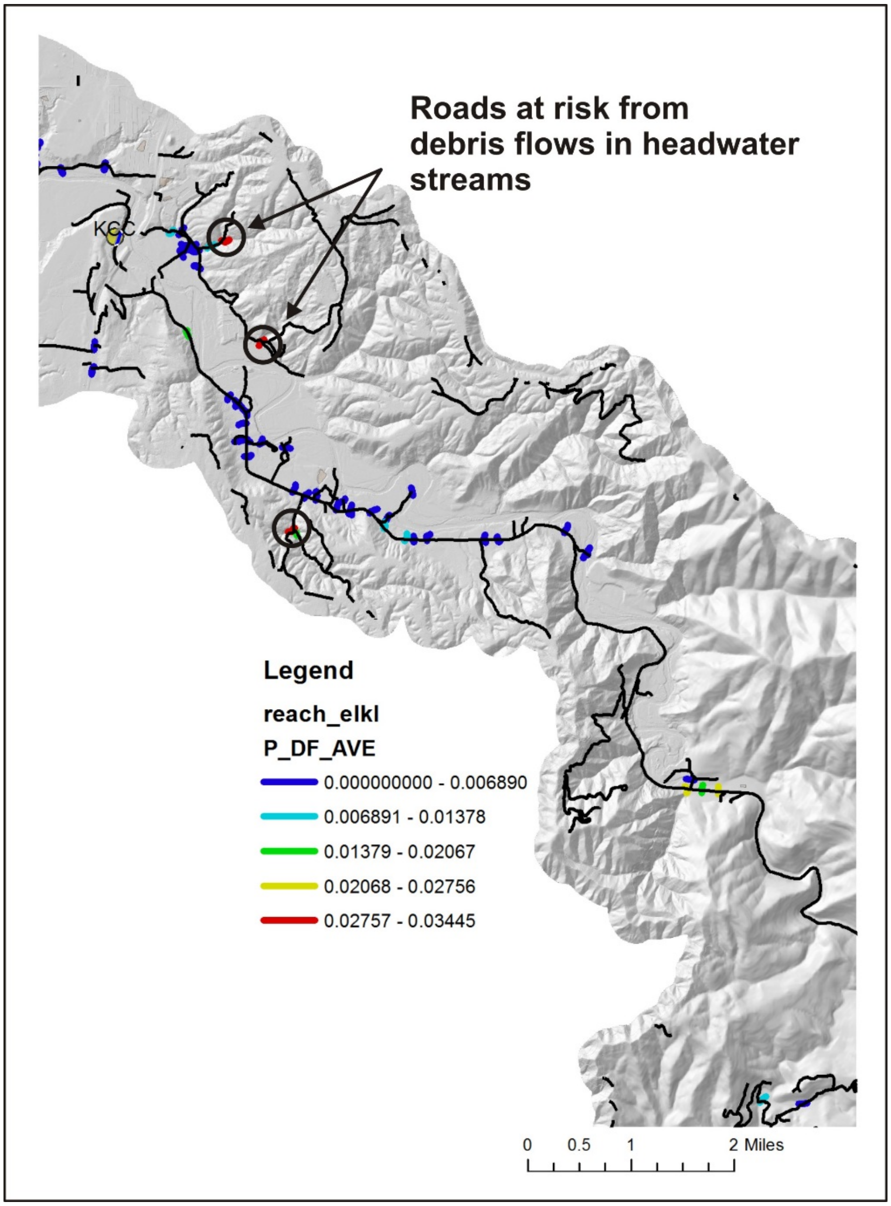

Figure 35. Predicted forest road – debris flow risk in headwater channels.

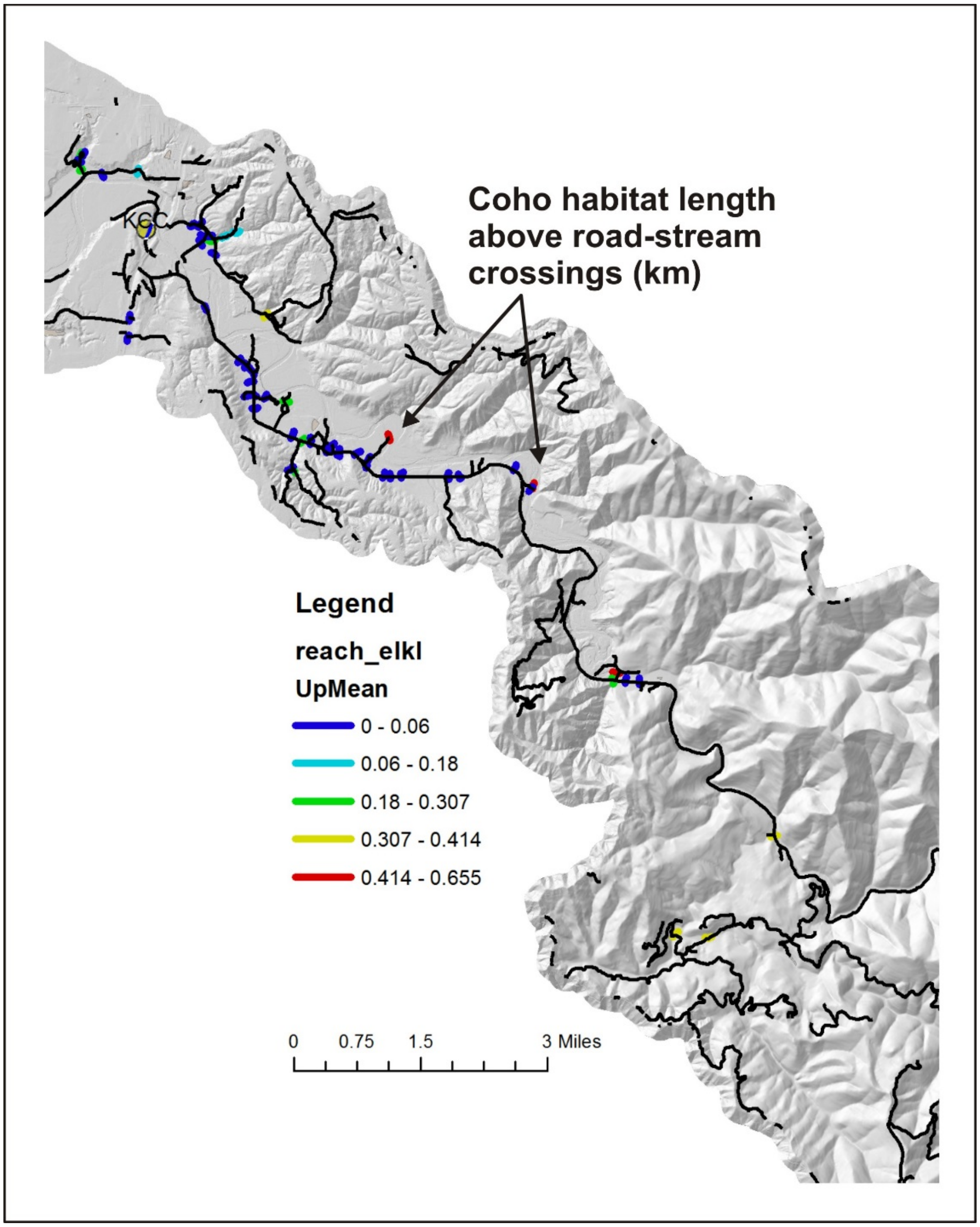

Figure 36. Cumulative coho habitat length (km) upstream of every road-stream crossing.

4.6 Upslope Sources of Large Wood

Landslides and debris flows can be large sources of wood to streams in the Oregon Coast Range. NetMap can be used to map the major sources of large wood to streams from shallow landslides and along debris flow scour paths. The predictions are based, in part, on the slope stability analysis described above (Section 4.4). Additional information on predicting upslope sources of large wood can be obtained at NetMap's online technical help.

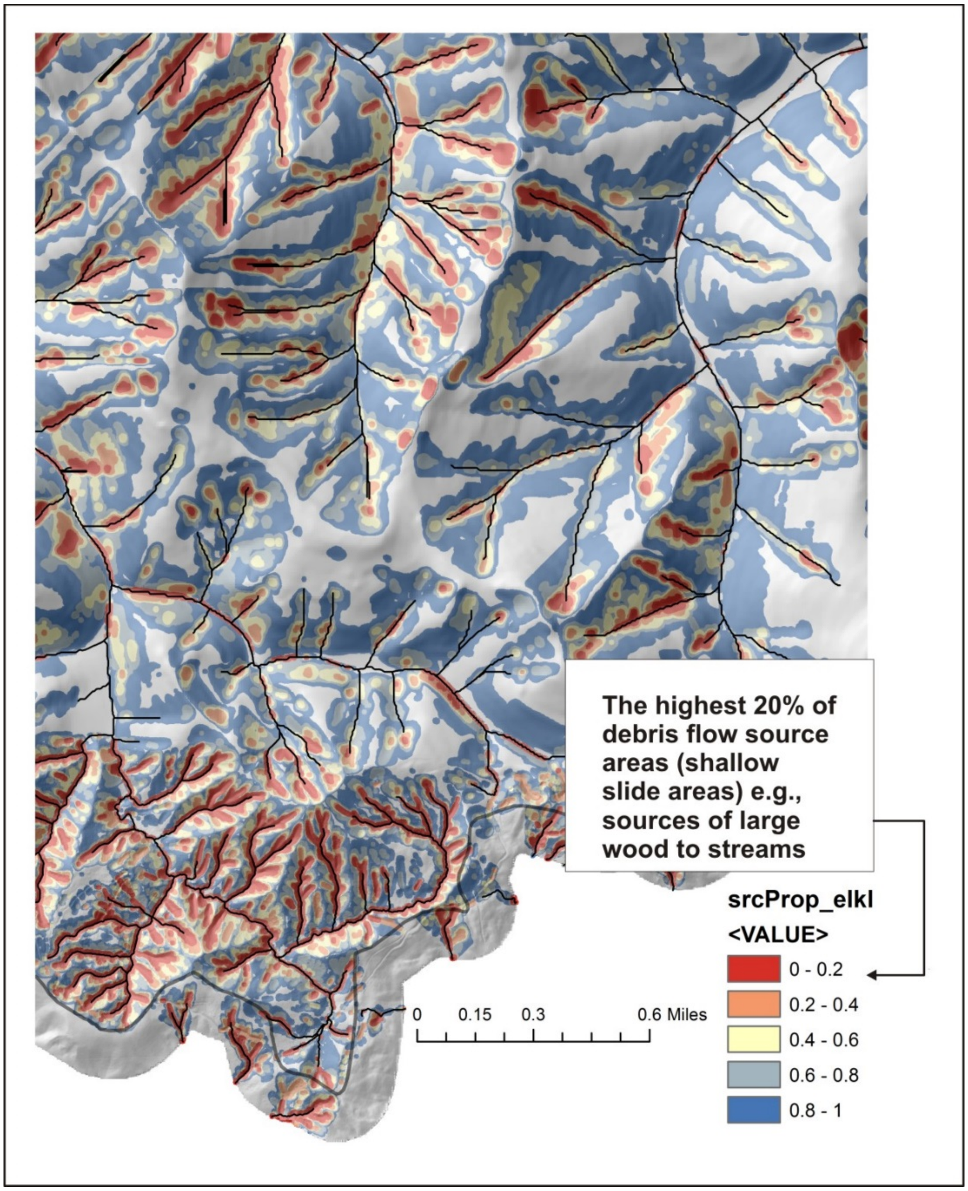

Figure 37. The NetMap attribute SrcProp that can be used to identify upslope areas that can contribute large wood to streams. Defined as the proportion of area that encompasses landslide initiation points (GEP based shallow landslide grid cells), 0 – 0.2 = the highest 20% of landslide initiation points starting with the most unstable, 20-40%, the next quartile etc. all four quartiles = 100% of all the landslide risk.

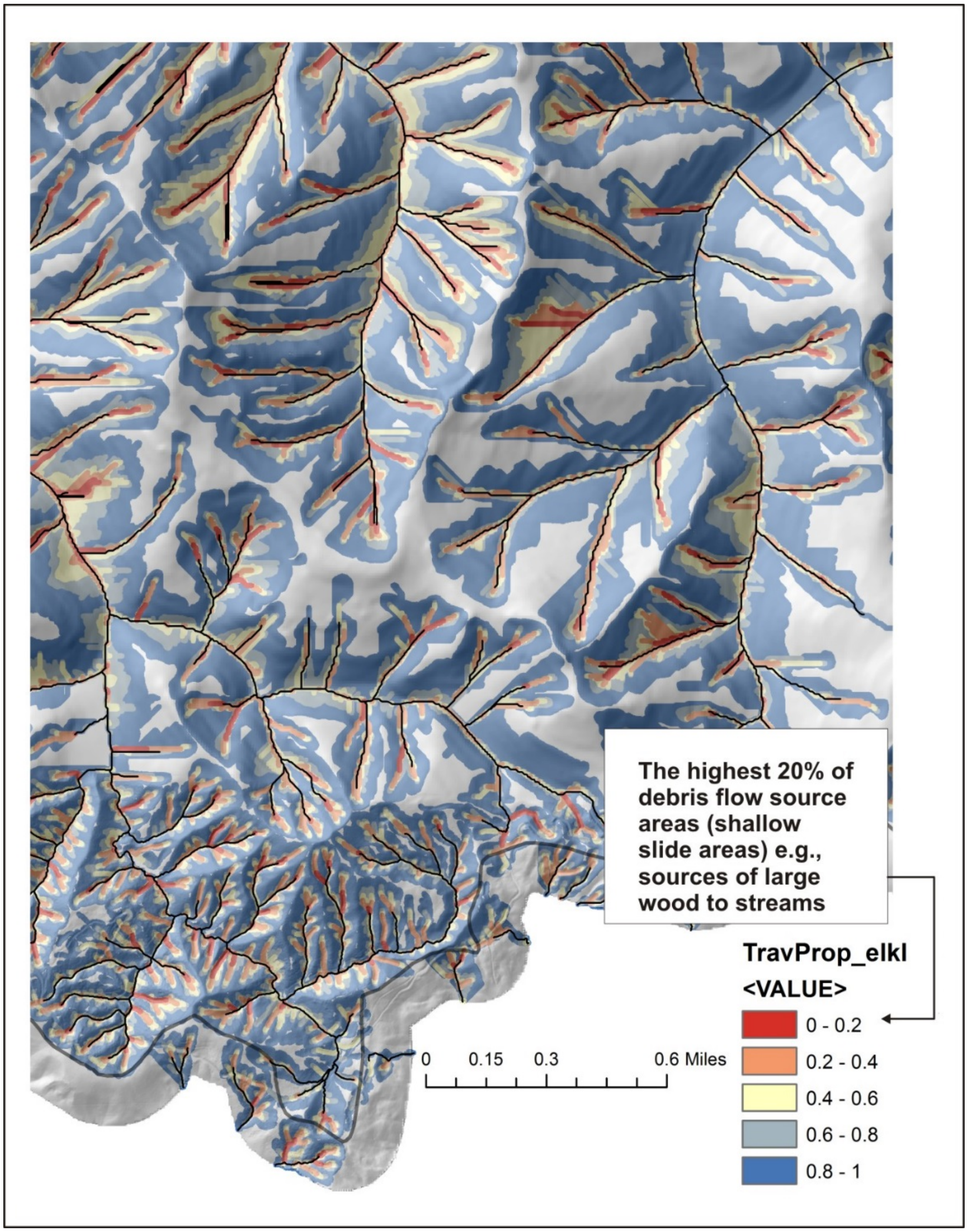

Figure 38. Trav_Prop, a NetMap attribute that can be used to identify upslope zones of large wood recruitment, in terms of cumulative probability of debris flow traversal in individual cells, and it is based on a gradient threshold for that traversal; default value is >=0.04. For example, the amount of traversal with a delivery of 0.2 will be higher than with a delivery of 0.02.

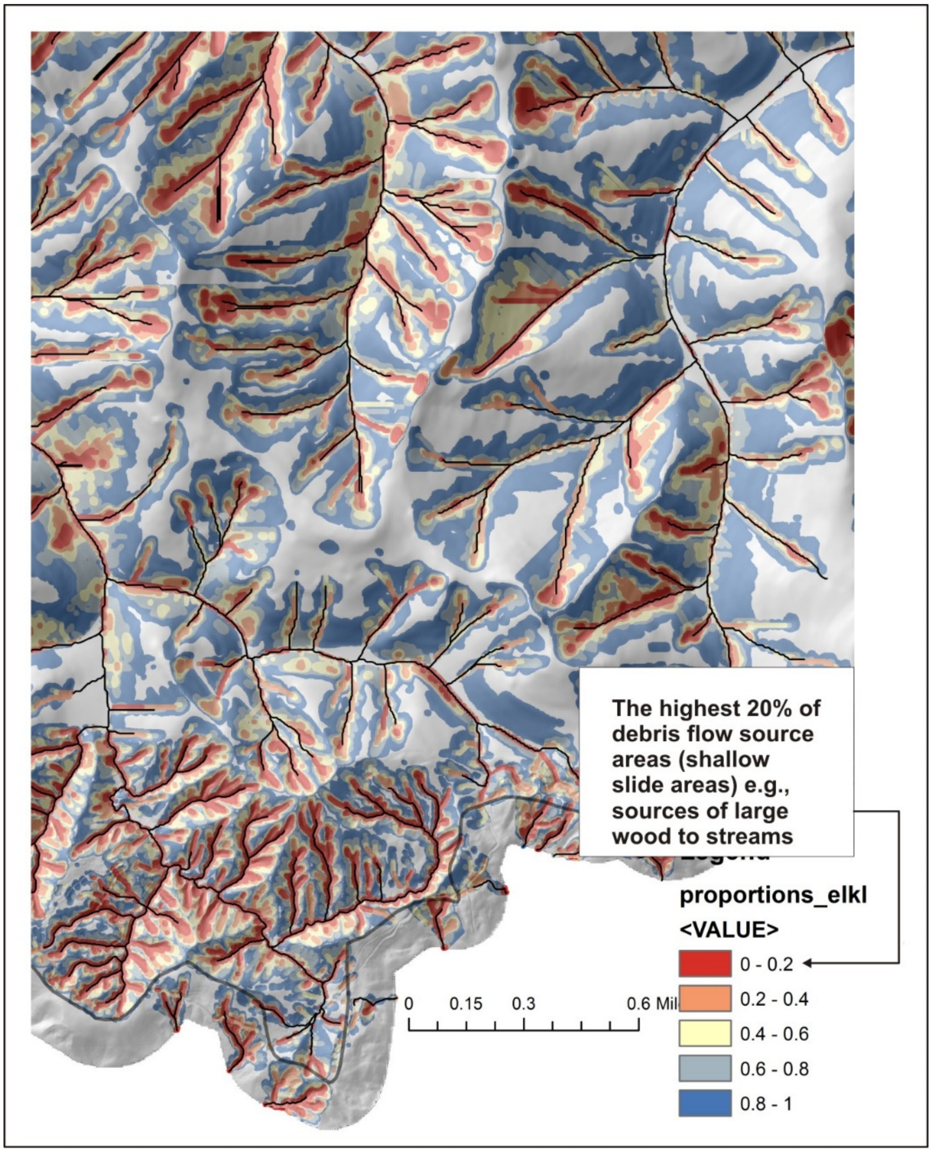

Figure 39. Proportions, a NetMap attribute that can be used to identify upslope zones of large wood recruitment, in terms of cumulative probability of 1) shallow landslide potential and debris flow runout in individual cells, and it is based on a gradient threshold for that traversal; default value is >=0.04. For example, the amount of traversal with a delivery of 0.2 will be higher than with a delivery of 0.02. This attribute combines Figures 37 and 38.

5.0 Setting Restoration Priorities

5.1 Linking NetMap Outputs to Current Restoration Planning Objectives and Site Selection

The Elk River – NetMap Restoration Watershed Analysis results can be used to help inform the existing set of restoration priorities (Elk Coho score sheet, Sept 1.xlsx). This is illustrated using three sites.

1) *Indian Creek: Wetlands/off-channel: Reconstruct lower 1/8 mile of channel to restore floodplain/wetlands habitats Good source of cold water. Note: Sediment is a major concern from tributaries from Indian Creek and below.* NetMap's analysis supports the selection of this site for restoration, particularly in terms of coho habitat potential, thermal refugia, current shade and added shade effectiveness and current in-stream wood (**Figure 40**).

2) *Swamp Creek: Wetlands/off-channel: Downstream of reservoirs: reconstruct channel to increase sinuosity and connect to floodplain. Add LWD. Remove gorse and improve riparian.* This site selection is also consistent with NetMap predictions (**Figure 41).**

3) *Bald Mountain Creek: Lower half-mile is high priority for riparian restoration (DEQ 2003). The lower two miles are 303d listed due to stream temp and habitat modification. The creek has high flows and a narrow floodplain. Hard to get LWD to stay. Sediment abatement from roads is a high priority in Bald Mountain Creek watershed. #2 road storm-proofing priority on WRLT list.* Although this site has some potential for restoration, it would be ranked on the lower end at the entire watershed scale (**Figure 42).**

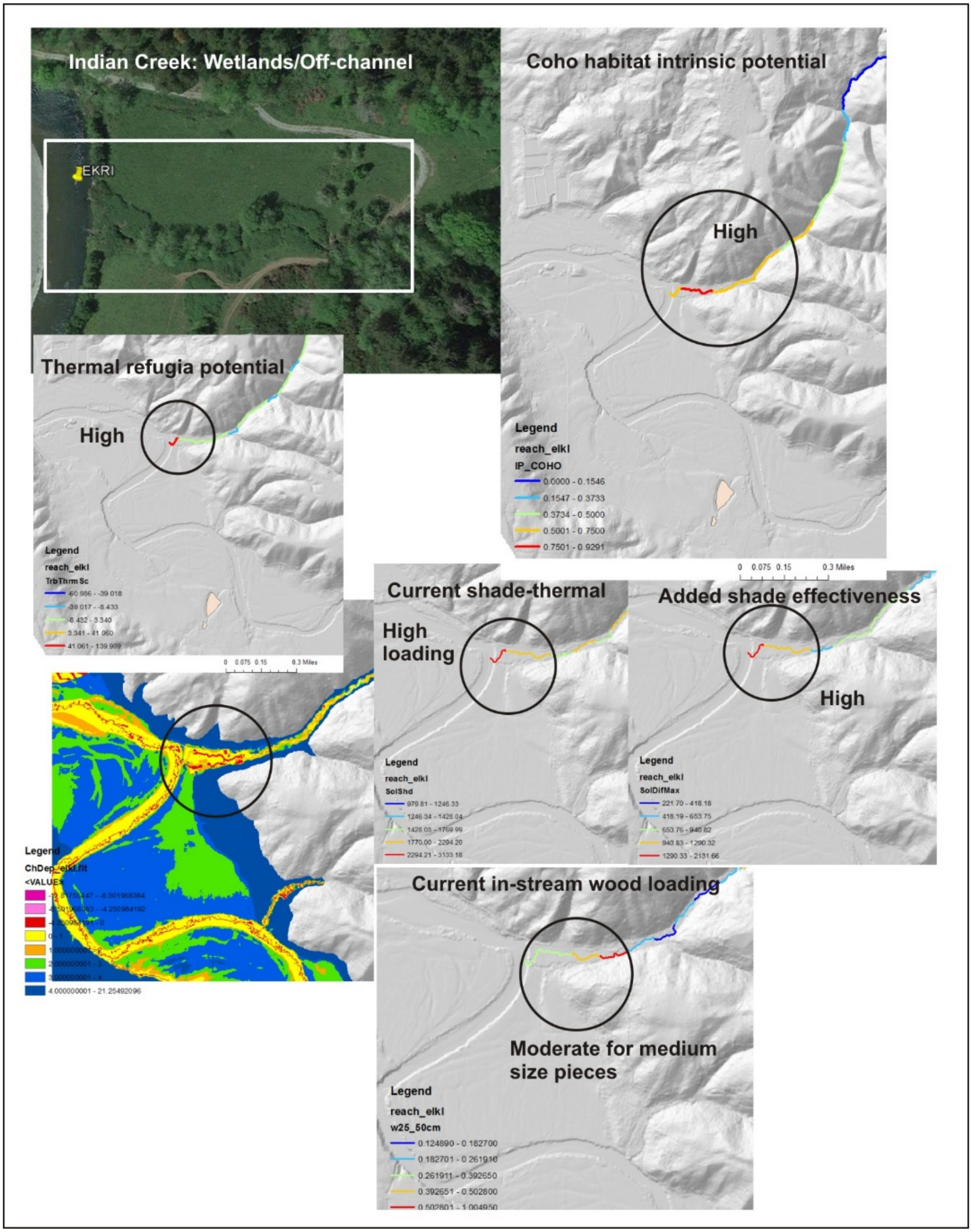

Figure 40. Indian Creek proposed restoration site.

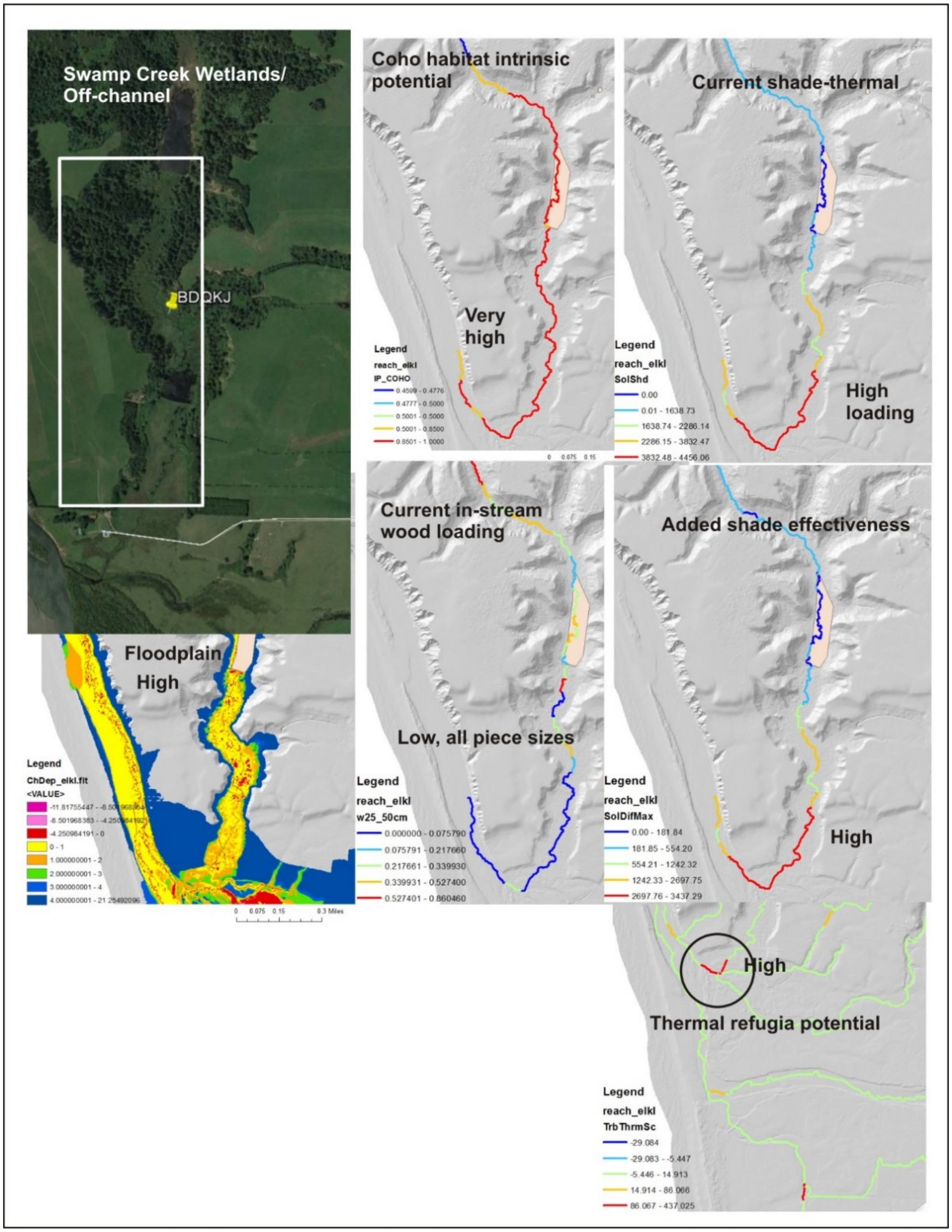

Figure 41. Swamp Creek proposed restoration site.

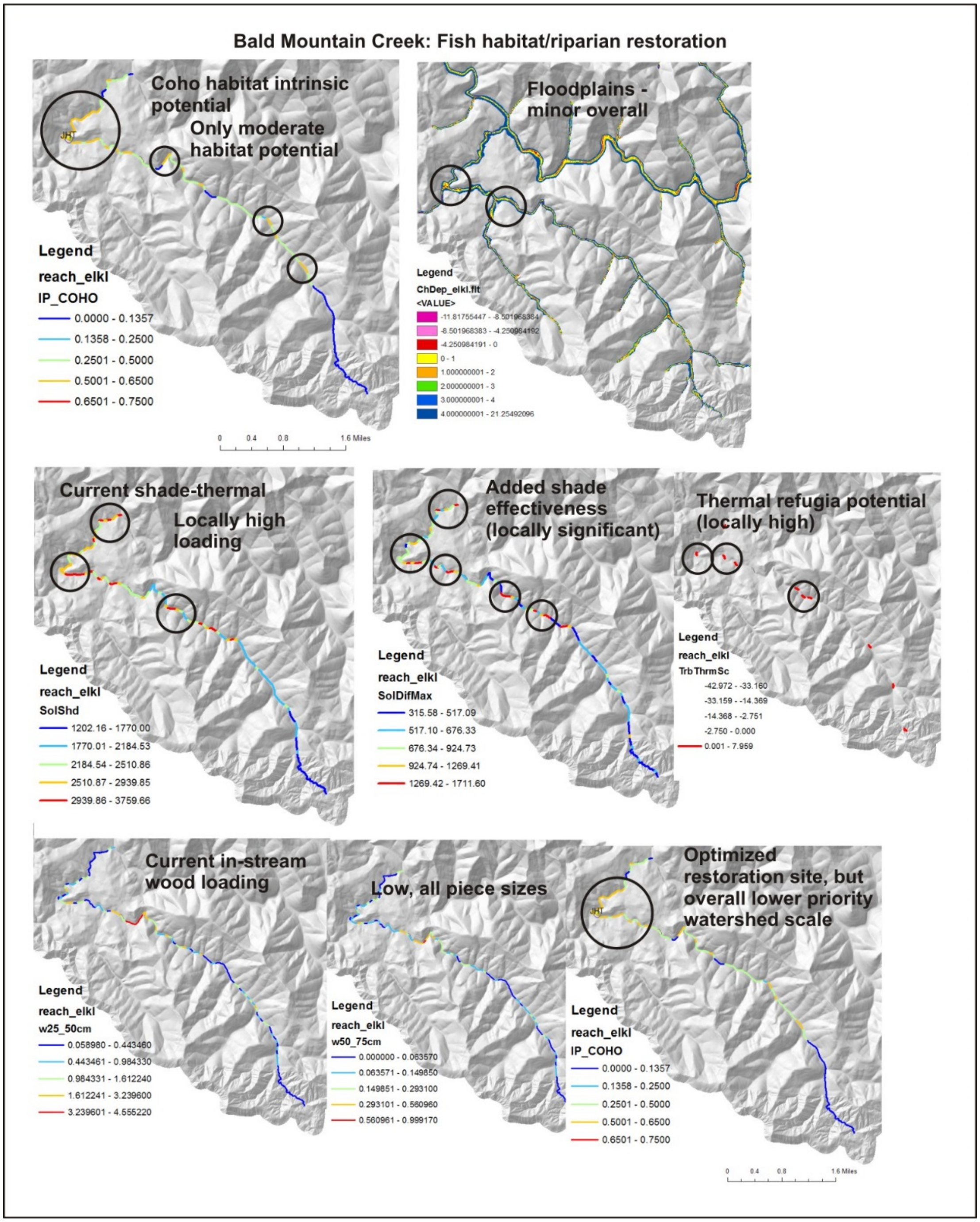

Figure 42. Bald Mountain proposed restoration site.

5.2 Where are the Best Coho Salmon Habitats?

The highest 10% of coho intrinsic potential values are identified in **Figure 43**. One hundred and ninety stream segments out of a total of 2009 were identified as having IP scores greater than 0.64 or 9.5% of all segments. This is equivalent to 18.3 km out of a total of 199 km or about 9% of the coho stream length. Intrinsic potential scores > 0.75 are often considered the best potential habitat quality; there are 161 channel segments, or 15.4 km, of coho habitat greater than 0.75 and 90% of it is located in the lower river basin (**Figure 44**).

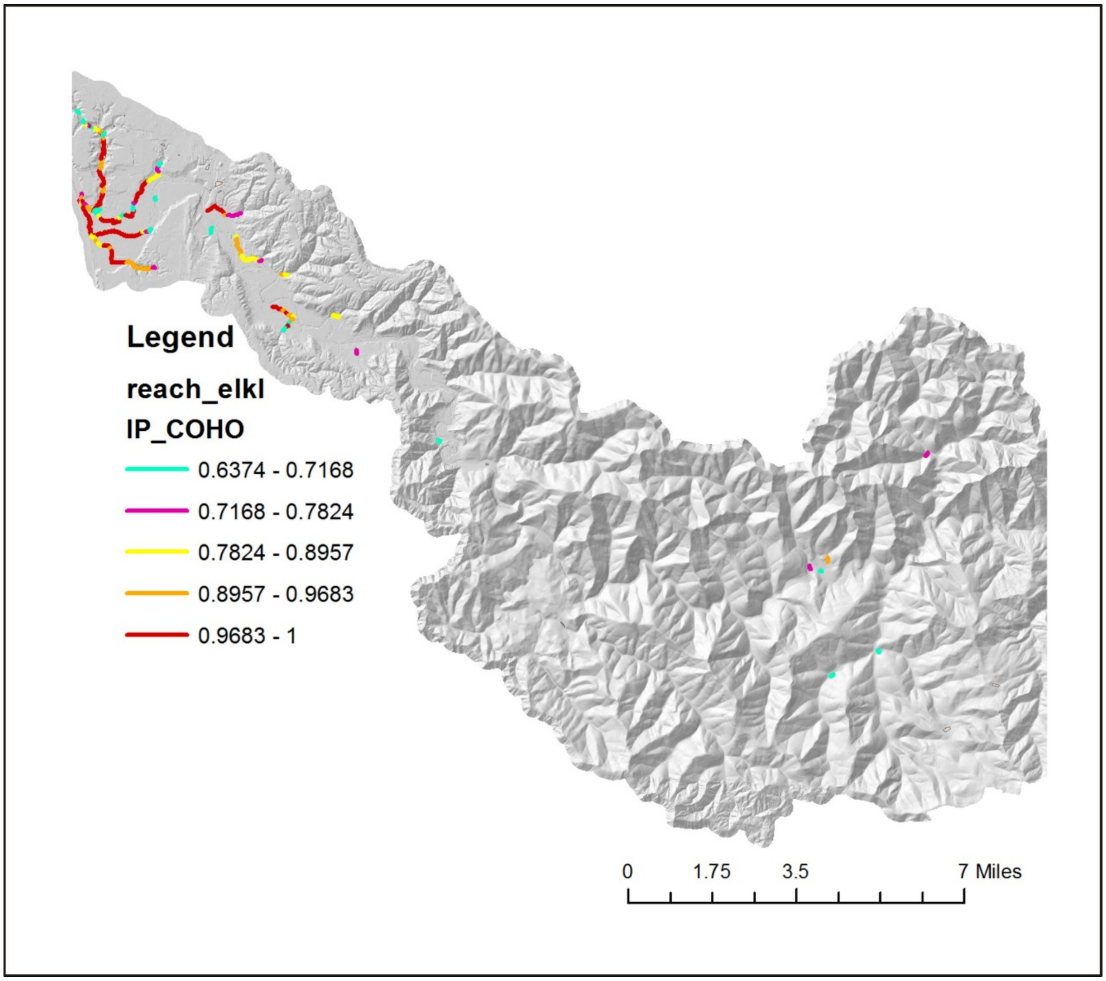

Figure 43. The highest 10% of coho IP scores in the Elk River watershed.

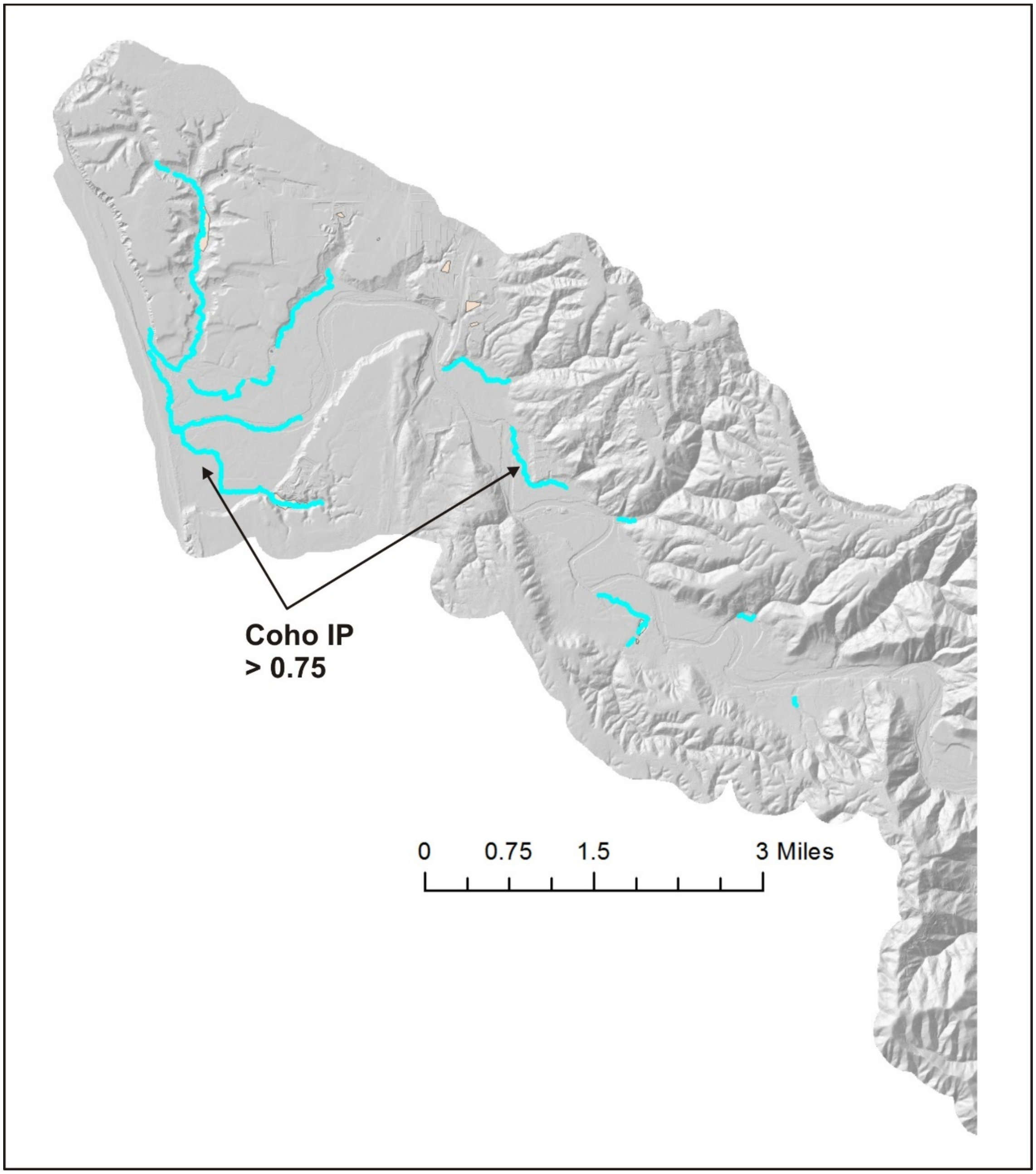

Figure 44. Coho IP scores > 0.75.

5.3 Where Additional Stream Shade is Needed Most?

To identify stream segments where additional shade would be most effective at reducing thermal loading to streams, the highest 10% effectiveness is mapped in **Figure 45**. One hundred and ninety-nine segments out of 2009 segments or a length of 19.7 km out of a total of 199 km of streams was identified.

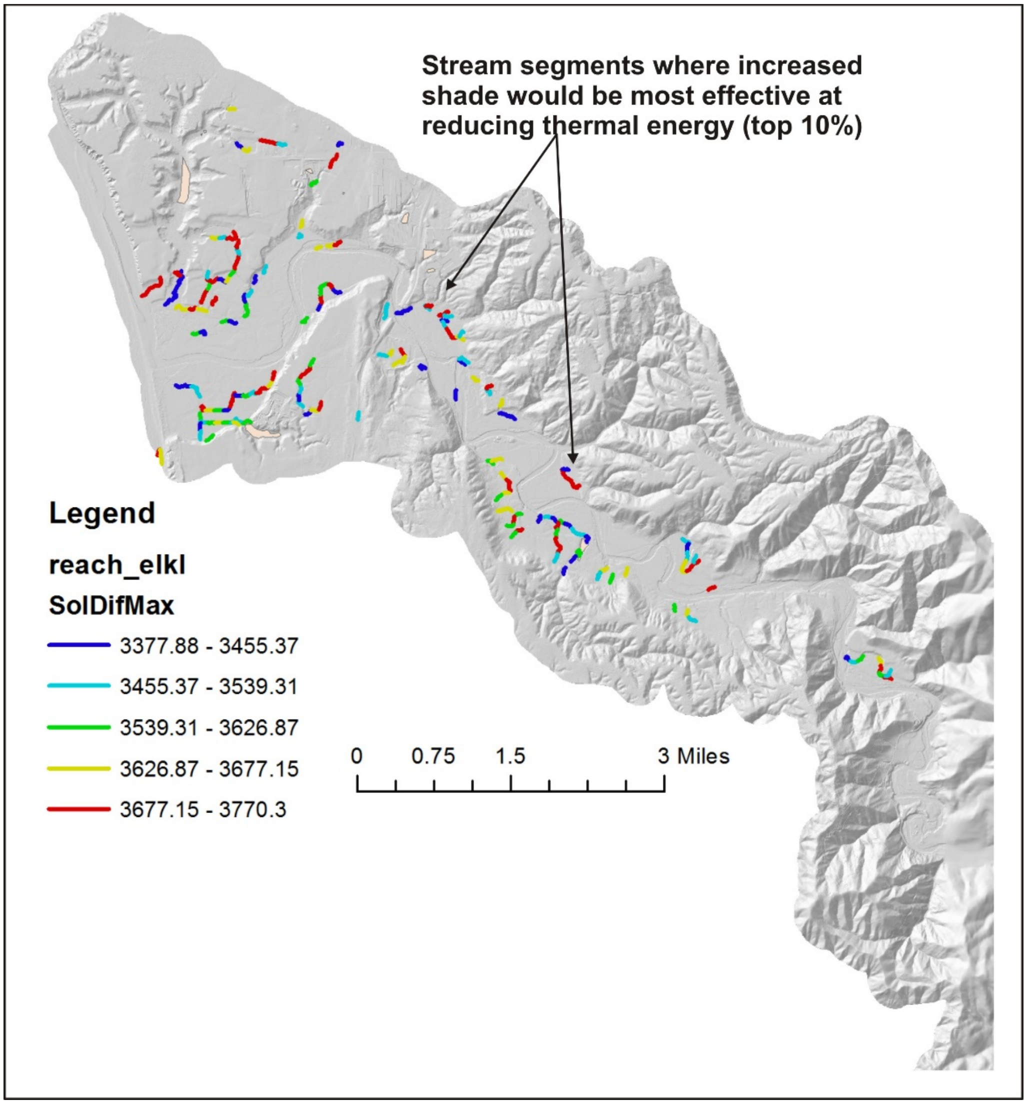

Figure 45. The highest 10% of reaches where additional shade would be most effective at reducing thermal loading.

5.4 Where In-Stream Wood is Needed Most?

The highest coho intrinsic potential could be overlaid onto those reaches with the lowest wood recruitment potential (average of all wood diameter classes). To illustrate this using NetMap, the highest 5% of coho IP scores were overlaid onto the lowest 60% of in-stream wood recruitment potential using NetMap's reach overlap tool. Eight five reaches out of a total of 2009 reaches or 8.4 km out of 199 km, about 4% of the total channel length, were identified to have this combination of attributes (**Figure 46**). All the selected reaches are located in the lower watershed.

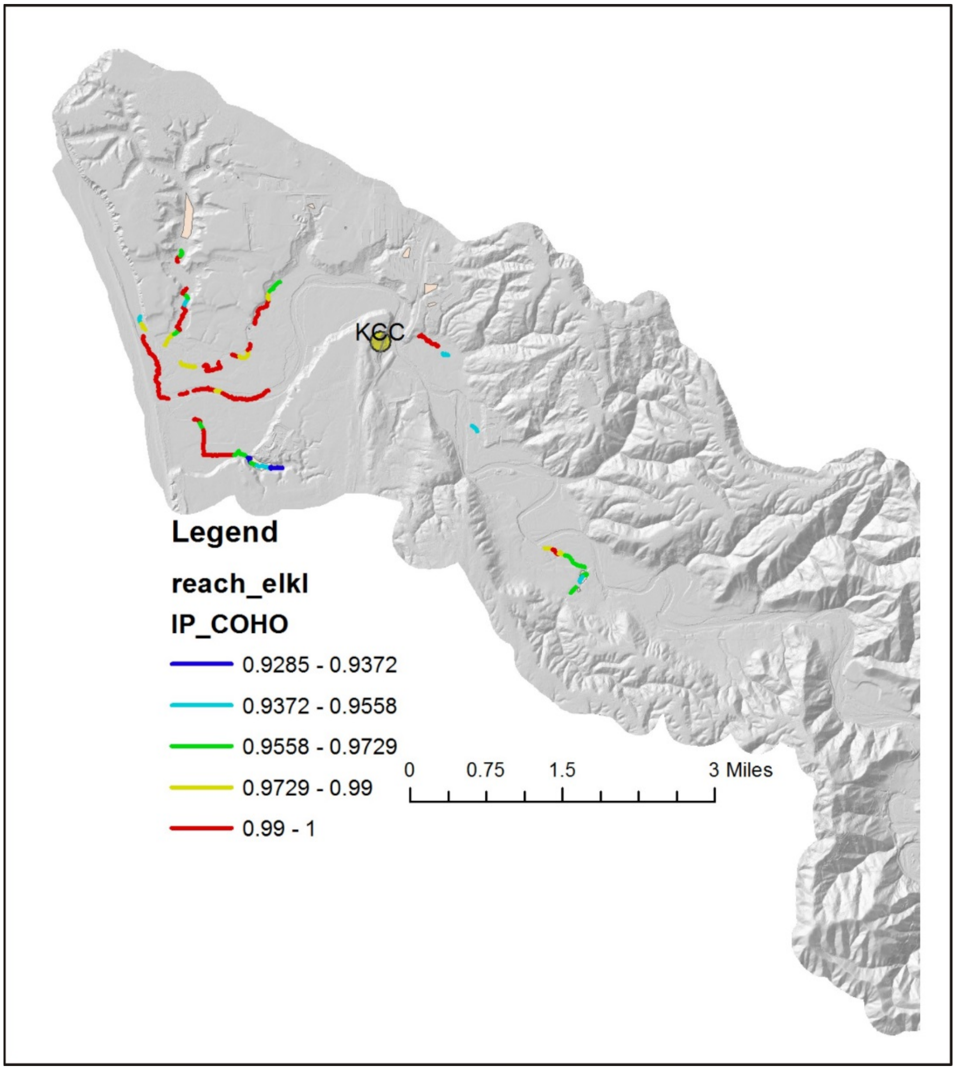

Figure 46. Locations where the highest 5% of coho IP scores overlap with the lowest 60% of in-stream wood recruitment potential.

5.5 Where Valley Floor-Floodplain Ecological Hotspots Could be Enhanced?

NetMap attributes of floodplains and valley floor elevations, coho IP, current shade/thermal loading (most effective sites for additional shade), current in-stream wood loading, and two cool water refugia types, were used to identify a provisional set of the best coho-floodplain sites for restoration (**Figure 47**).

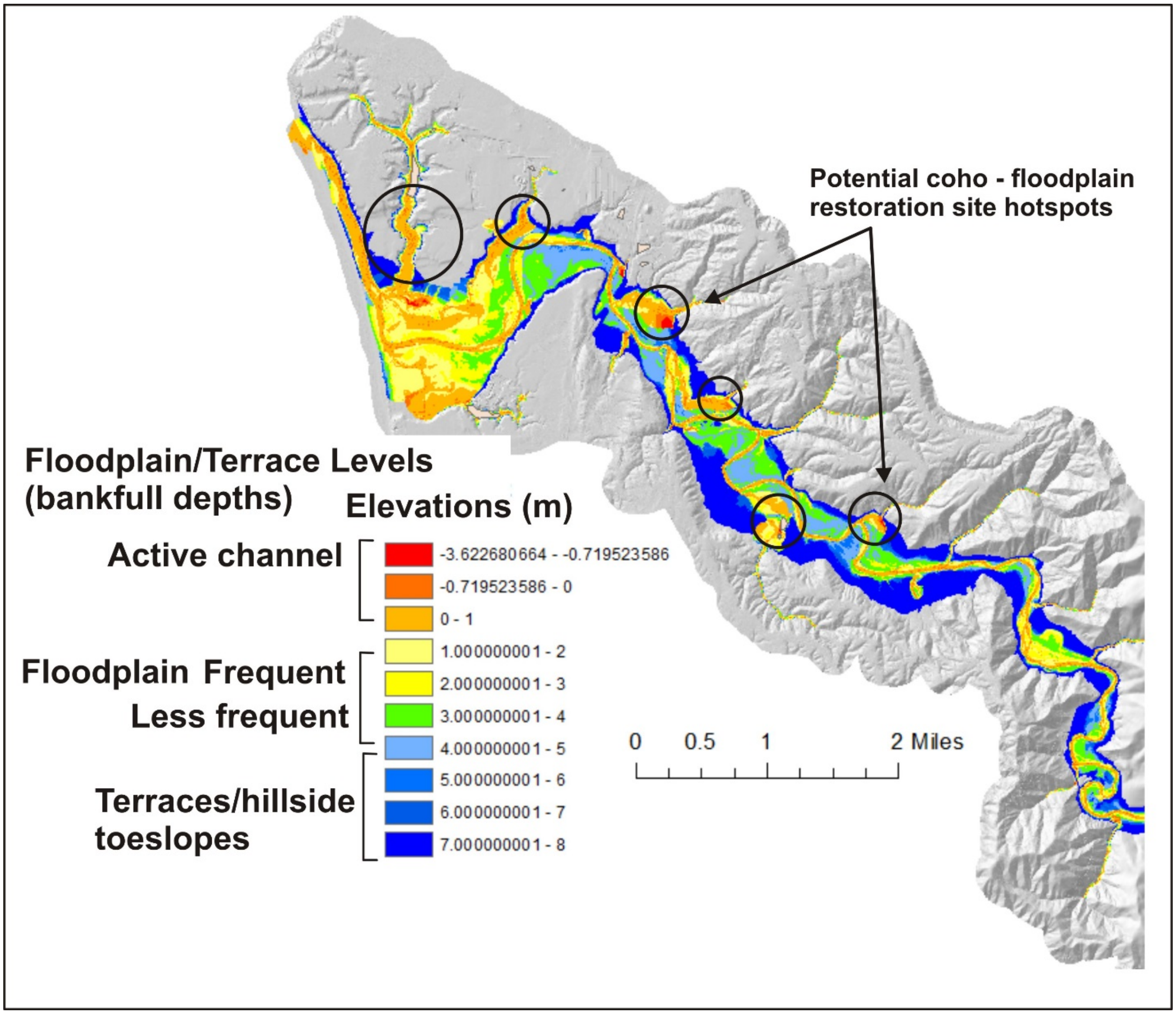

Figure 47. Provisional coho-floodplain restoration hotspots predicted using the NetMap restoration watershed assessment.

5.6 At What Locations Would Road Surface Upgrades Reduce Sediment Delivery?

See Figure 30.

5.7 At What Locations Would New Drainage Features Optimize Reductions in Road-Stream Connectivity and Sediment Delivery to Streams?

See Figures 31 and 32.

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