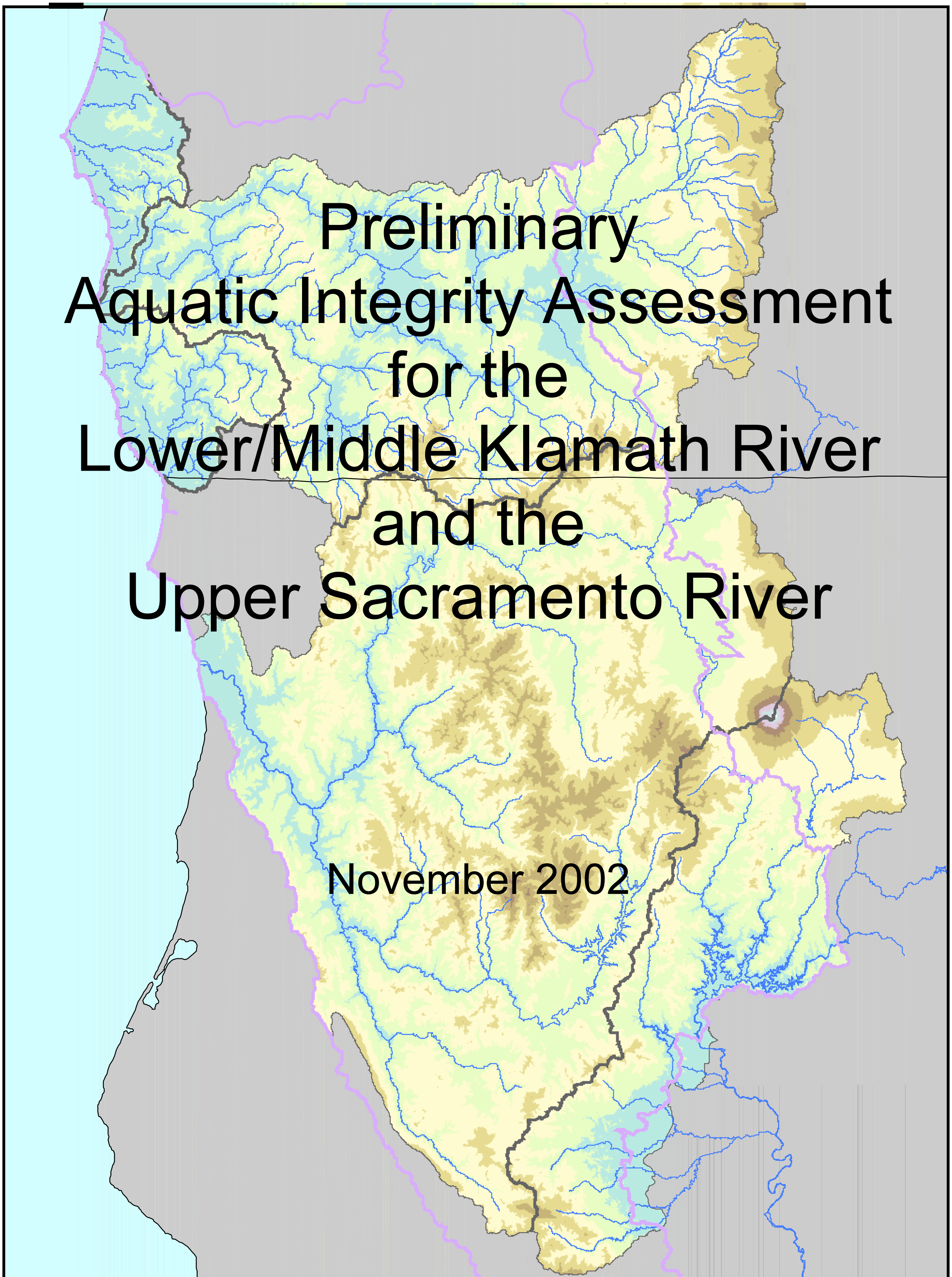

Preliminary Aquatic Integrity Assessment for the Lower/Middle Klamath River and the Upper Sacramento River

November 2002

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Prepared for the
World Wildlife Fund

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Introduction

This analysis of relative aquatic habitat integrity in the Lower/Middle Klamath and the Upper Sacramento, was requested by World Wildlife Fund to inform the comprehensive conservation plan being pursued in the Klamath-Siskiyou Terrestrial Ecoregion. This plan is based on David Brower's concept of planetary CPR (Conservation, Protection, Restoration), and aims to: conserve, protect, and restore the Klamath-Siskiyou ecoregion in harmony with local communities. Through this plan, regional conservation planning has focused on three broad (ecoregion wide) conservation goals: (1) Conservation of 5-10% of the 1,416,450 hectares (3.5 million acres) of private lands through conservation easements, fee-title acquisitions, and market-based solutions; (2) Protection of 30-40% of the 2,630,550 hectares (6.5 million acres) of public lands; and (3) Restoration of focal species (e.g., salmon) and keystone ecosystem processes (e.g., fire).

This assessment of aquatic habitat integrity focuses on mapping human impacts and identifying GIS data gaps within California planning watersheds in the Lower and Middle Klamath basins and tributaries and the Upper Sacramento River (Figure 1). Our primary focus is on the relative health of salmonid habitat variables. This report includes a preliminary prioritization of watersheds for salmonid conservation and restoration efforts. The model layers have been compared to additional data layers to highlight areas which have been significantly impacted by human activities. In addition, the data collected for this assessment have been integrated with data collected for Southwestern Oregon to develop a preliminary aquatic integrity assessment for the central Klamath-Siskiyou ecoregion. These analyses are steps in an effort to highlight basins containing relatively high quality aquatic habitat and identify priority targets for aquatic habitat conservation, preservation and restoration.

Basin Descriptions

Klamath Basin

The Klamath River basin drains approximately 25,100 sq. km (9,691 square miles) in Southern Oregon and Northern California. The basin is separated into two sections by a set of 4 hydroelectric dams. The lower section of the Klamath covers 18,803 sq. km (7,260 sq. miles) and includes the highly dissected and densely forested Trinity River drainage (7,692 sq. km; 2,970 sq. miles), Salmon River drainage (1,943 sq. km; 750 sq. miles), Scott River drainage (2,108 sq. km; 814 sq. miles) and Shasta River drainage (881 sq. km; 340 sq. miles). This analysis focuses on the section of the Klamath basin within the Klamath-Siskiyou ecoregion (the lower/middle Klamath River, below Iron Gate Dam, and tributaries of this section of the Klamath) and the Upper Sacramento River. This analysis is focusing on anadromous fish habitat integrity issues, and salmonids have been restricted to the lower/middle sections of the Klamath by Iron Gate Dam.

The salmonid range maps included here (Figure 2) were created by Moyle and Randall, and incorporated fish locations from 10 databases. While these fish range maps of

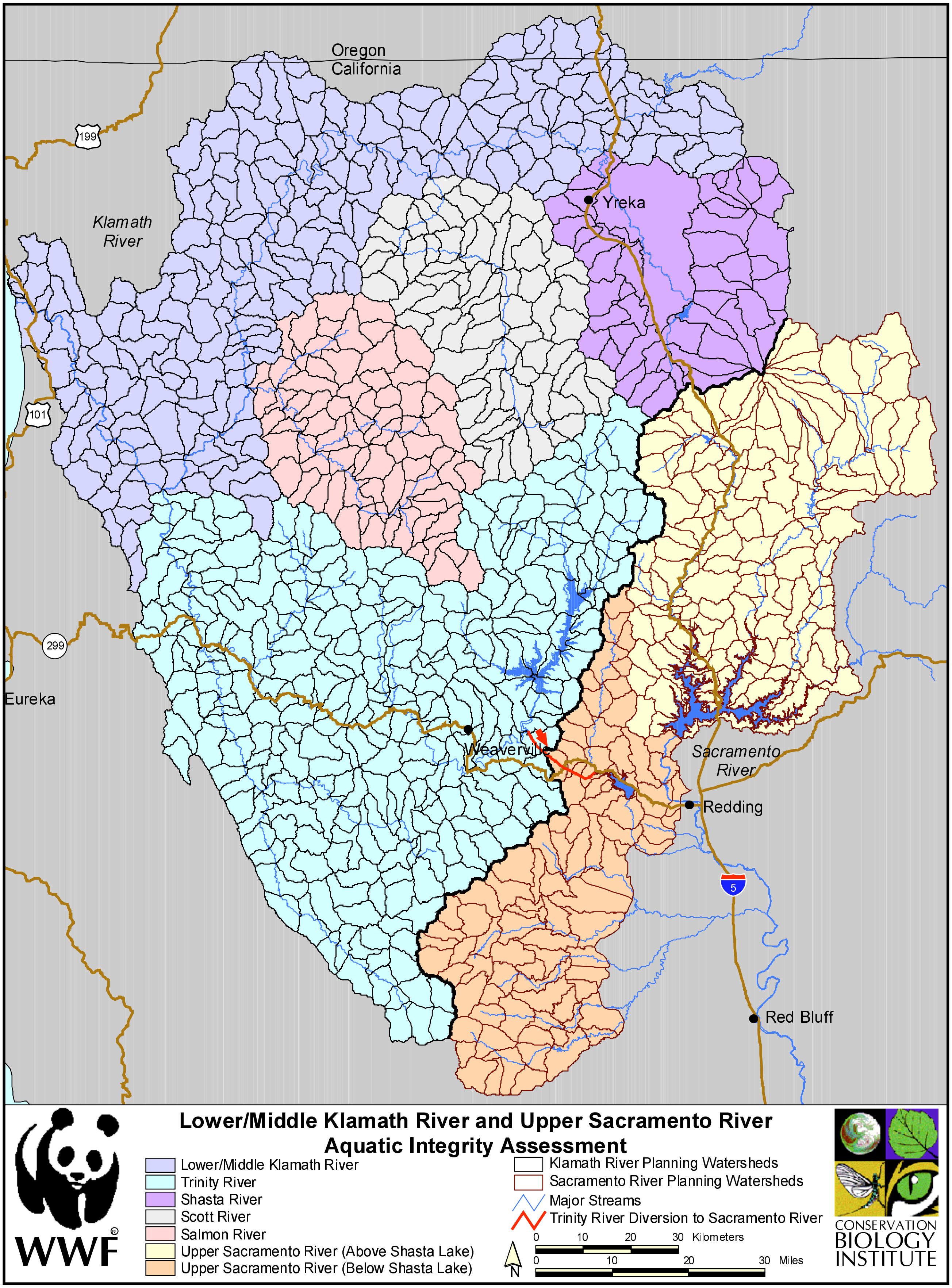

Figure 1. CALWATER 2.2 Planning Watersheds: Lower/Middle Klamath River and Upper Sacramento River

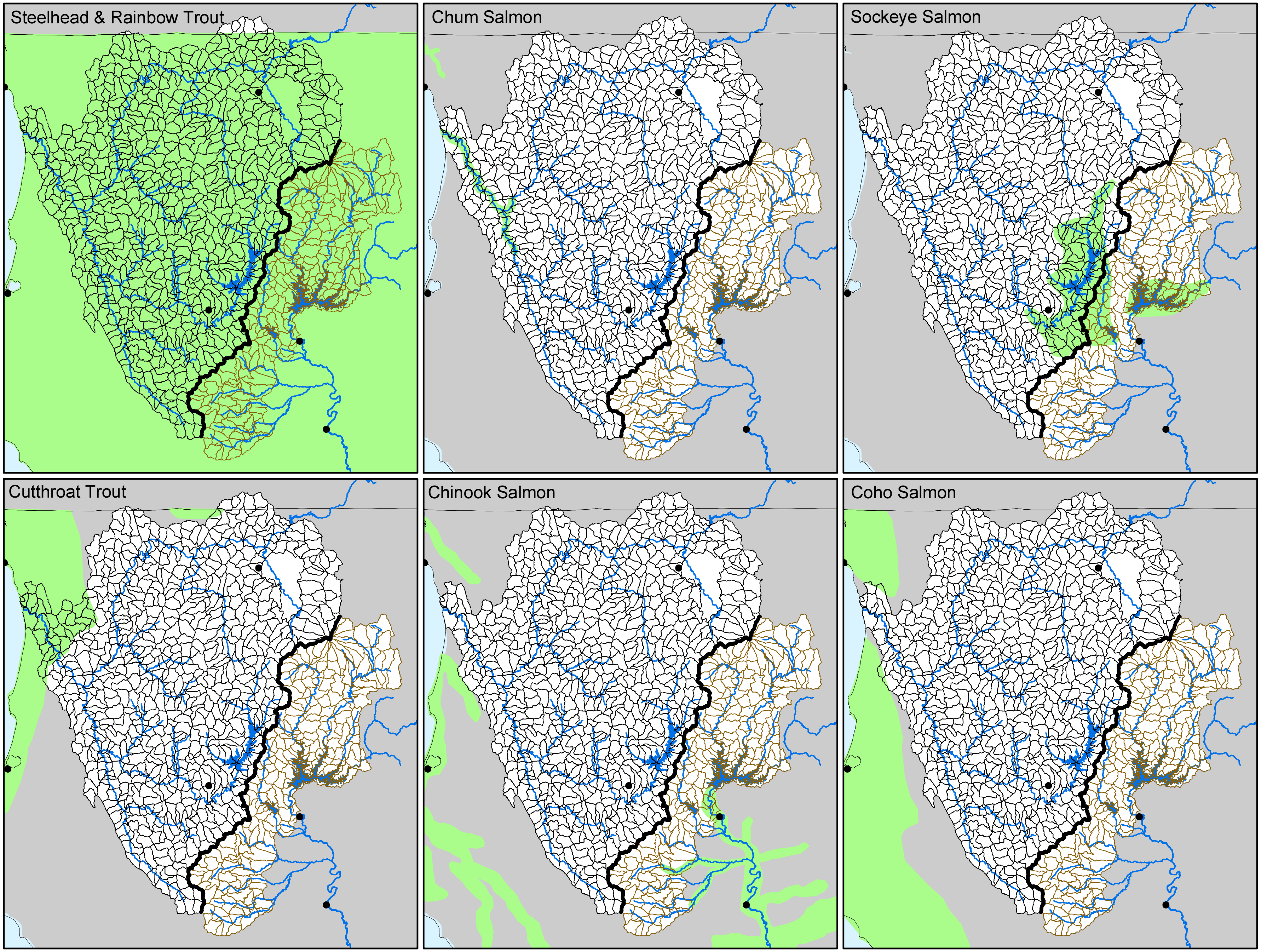

Figure 2. California Salmonid Distributions (Data from Moyle and Randall)

steelhead & rainbow trout (*Oncorhynchus mykiss*), Cutthroat Trout (*Oncorhynchus clarki clarki*), Chum salmon (*Oncorhynchus keta*),Chinook salmon (*Oncorhynchus tshawytscha*), Sockeye salmon (*Oncorhynchus nerka*), and Coho salmon (*Oncorhynchus kisutch*) do not show extensive distribution of salmonids in the Klamath basin; Coho, Chinook, steelhead trout, and coastal cutthroat trout are all found in the basin. In this year's fish kill, on the lower Klamath (September 2002), 35,000 Chinook, Coho, and steelhead died due to low streamflows, high stream temperatures and the epidemic spread of two naturally occurring parasites that destroyed the gills of the fish. Historically Chinook, Coho, and steelhead all entered Klamath Lake in the upper part of the basin and likely inhabited the uppermost tributaries of the basin.

It's been estimated that in northern California the Coho salmon population, including hatchery fish, may be only 6% of the abundance of the 1940s population. They have been eliminated in many streams and in some watersheds adults are observed only one year in three, thus two of the spawning lines have been lost. While there has been, and continues to be, much discussion about the cause of the declines of anadromous fish stocks, one of the key impacts is the degradation and loss of freshwater habitat. Among the factors contributing to freshwater habitat degradation and loss are human activities that cause the alteration and loss of riparian vegetation and associated decreases in instream large woody debris and nutrient inputs, increased rates of stream channel structure modification and simplification, changes in the hydrologic regime (most significantly decreases in baseflow), discontinuity in stream and groundwater connectivity, and alteration of water chemistry. Other factors impacting salmonid populations include overfishing, interactions with hatchery fish and ocean habitat changes. Klamath basin Coho and steelhead trout have both been reviewed by the National Marine Fisheries Service (NMFS) under the Endangered Species Act (ESA) and Coho are federally listed as a threatened species.

The Klamath Basin has a long history of human activities that have altered freshwater habitat. During the 1850s the expansion of gold mining into the middle reaches of the Klamath were accompanied by the establishment of farming communities and associated agricultural and ranching land use changes. Commercial timber harvest and commercial fishing increased in the lower basin in the late 1880s. The hydrologic connectivity of Klamath has been extensively altered by the development of many water-diversion projects, and currently the agricultural irrigation diversions are significant not only in the upper basin, but also in the Shasta, Scott and Trinity basins. The first large dam was built in 1892 on the Shasta River. In the Upper Klamath, the Upper Klamath Irrigation Project was created in 1905, the first large dam on the mainstem of the Klamath River was completed in 1917, in the Ward's Canyon area and Iron Gate Dam was completed in 1962. Water allocation in the Klamath basin has become a highly contested issue and has gained large amounts of national media attention over the past few years.

The Trinity River is the largest tributary to the Klamath River and joins the mainstem of the Klamath at river km 69 (river mile 43). One of the most significant impacts on the Trinity River hydrologic regime is the Trinity Diversion project in the Upper Trinity basin.

As much as 90% of Upper Trinity streamflow is diverted, through the Clear Creek Tunnel, into the Sacramento basin. Much of this water is destine to be used by the Central Valley Irrigation Project.

The Salmon River joins the mainstem of the Klamath at river km 109 (river mile 68). This tributary is heavily forested and more than 98% is managed by the National Forest Service. Approximately 46% of the basin is managed as Wilderness Areas. These wilderness areas are primarily in headwater stream drainages at higher elevations. The Salmon River is the only major tributary to the Klamath that is not impacted by significant water diversion projects. The primary human impacts are related to road construction, forest harvest and frequent wildfires, which contribute to elevated summer stream temperatures and increased landslide frequency.

The Scott River joins the mainstem of the Klamath at river km 230 (river mile 143), 76 km (47 miles) downstream from Iron Gate Dam. It is estimated that there are 13,800 hectares (34,100 acres; 6.5% of the basin) is actively irrigated in the Scott valley. As much as 118,908,436 cubic meters (96,400 acre-feet) of water is diverted through 200 diversions over a distance of 386 km (240 miles) of ditches and pipelines during the growing season. These water diversions regularly cause stream reaches to go dry between July and September.

The Shasta River joins the mainstem of the Klamath at river km 283 (river mile 176), approximately 23 km (14 miles) downstream from Iron Gate Dam. This basin receives very little rainfall, between 28 and 43 centimeters (11 and 17 inches) per year, and contains extensive agricultural lands. It is estimated that 20,235 hectares (50,000 acres; 23% of the basin) are actively irrigated. Irrigation water is primarily supplied by springs and groundwater withdrawals and groundwater recharge is dependent on melt water from winter snow pack. The Dwinnell Dam was built in 1928, creating a terminal barrier for fish migration and creating Lake Shastina. Water temperatures and nutrient loads are high in the lake and have a significant impact on the downstream reach of the river.

Upper Sacramento

The Sacramento River drains the northern central part of California. The Sacramento is California's largest river. It stretches 618 km (384 miles) from its headwaters near Mount Shasta to its mouth at the Delta. The watershed includes the eastern slopes of the Coast Ranges, the southern slopes of Mt. Shasta, and the western slopes of the southernmost region of the Cascades and the Northern section of the Sierra Nevada. The Sacramento carries 31% of the state's total runoff water. All Chinook salmon runs stop at Keswick Dam, south of Shasta Lake. The Klamath-Siskiyou ecoregion overlaps with parts of the upper and northwestern Sacramento basin. The Upper Sacramento above Lake Shasta (not including the Pit River) covers 3,717 sq. km (1,435 sq. miles) and the Northwestern Sacramento drainages included in this analysis (below Lake Shasta) drain 2,590 sq. km (1,000 sq. miles).

Klamath and Sacramento Planning Watershed Aquatic Habitat Assessment

The 2000 Rogue River aquatic integrity analysis used road density, road-stream intersections, forest change and fish barriers as surrogate indicators of watershed integrity. These data layers are included in the current analysis. This section describes the data, ordinal scores and aquatic integrity models created for the Lower/Middle Klamath and Upper Sacramento.

High road density contributes to increased levels of erosion and sedimentation and consequent alterations to hydrological patterns and degradation of water quality (OCSRI 1997). In addition, watersheds with higher road densities provide easier human access and are correlated with higher levels of disturbances from human activities that degrade water quality and aquatic habitat integrity (Frissell et al. 1996, Roth et al. 1996).

Road-stream intersections are the main delivery point of road related sediments into streams (Case et al. 1994). Increased sediment loads decrease salmonid food supplies and alter spawning and rearing habitat. Sediment and water influx at road-stream intersections contribute to bank erosion, channel widening, flooding, loss of critical pool habitat, and clogging of interstitial spaces in the streambed gravels (Hicks et al. 1991). Road-stream intersections often create physical barriers to fish migration, leading to habitat fragmentation.

Disturbance of > 25% of forest cover in a watershed, due to forest harvest, wildfire, wind throw, or forest pests/diseases, has been correlated with increases in ambient air temperatures and stream temperatures (Theurer et al. 1984, Barthalow 1989, and Essig 1998). Stream water temperature is a critical factor for salmonid health. Stream temperatures between 21^{o}C and 26^{o}C are considered below optimal conditions and temperatures above 26^{o}C are generally lethal. Salmonids are more susceptible to disease and less likely to feed and grow well in sub-optimal stream temperature conditions. High stream temperatures also correspond to low levels of dissolved oxygen (D.O.) and Rilling et al. (1996) observed that D.O. levels < 5 mg/L were lethal. Forest harvest practices, particularly clearcuts, create significant openings in forest cover. Other forest harvest impacts on aquatic habitat integrity include decreased riparian cover, decreased large woody debris input to streams with consequent decreases in stream channel complexity, and increased sedimentation and landslide hazards.

Fish barriers were not used in this analysis of the Lower/Middle Klamath and Upper Sacramento. According to the national inventory of dams, there are 36 permanent dams located the study area. We were not able to find a larger database of fish barriers, comparable to the data set developed by the Rogue Basin Fish Access Team. Finding or developing this data layer seems a critical step in the identification of aquatic habitat conservation, protection and restoration projects. Many in-stream restoration projects focus on fish barrier alteration or removal, and an analysis of aquatic habitat connectivity would be valuable in prioritizing these efforts. Fish barriers impede and sometimes terminate upstream and downstream migration. In addition, barriers alter the natural hydrologic regime of the stream system.

The extensive mineral deposits in the Klamath-Siskiyou ecoregion are due to the underlying rock lithology combined with magnetic, hydrothermal, and weathering processes accompanying their deposition (Coleman and Kruckeberg 1999). The most important of these have been the gold deposits resulting in a long history of placer mining in the rivers of this region (Orr and Orr 1996). Placer gold mining expanded into northern California during the 1850s and concentrated areas of placer mine activity have covered many of the rivers and streams in the region. Mining is a constant threat to the ecological integrity of the area in a number of ways. Lode mining of nickel, cobalt, chromium and other minerals physically disturbs the soils, crushing and uprooting vegetation, displacing plants and animals, and fragmenting habitats by creating gaps and road corridors with heavy traffic.

Placer mining operations along stream benches utilize heavy equipment and withdraw water from streams. These operations alter the landscape by creating mine pits, tailings piles and settling ponds for mine wastes. Instream placer deposits occur where stream velocities are slower and bedload and suspended sediments are deposited. Instream placer mining operations congregate along ecologically important, low gradient stream reaches where gold is most likely to be deposited along with gravel or sand (USDI Bureau of Land Management 1997). These techniques disturb stream substrates and impact instream structure. Many of these low gradient reaches are critical spawning habitat for wild salmon, steelhead and cutthroat trout (National Marine Fisheries Service 1998). The Mineral Availability System and Mineral Industry Location data layer from the EPA BASINS database has been included in this analysis as an initial data layer representing the regional impacts of mining on aquatic integrity. Further development of mining claims density data layers from the BLM Land and Mineral Records-LR2000 online database would provide a more detailed view of the extent of current mining claims and the potential for recreational and industrial mining impacts.

Watershed Boundaries

One of the objectives of this analysis is to integrate data from the Klamath and Sacramento rivers with data from Rogue River and other rivers within the Klamath-Siskiyou ecoregion. The Rogue River and southern Oregon coastal streams analysis summarized data at the 6th field hydrologic unit (HU) scale. Sixth field HUs are developed at the state and regional level and have been developed for Oregon. However, California has developed a different watershed delineation scheme, CALWATER 2.2, based on the State Water Resources Control Board planning watershed numbering scheme. The planning watersheds are similar in size to 6th field HUs and were used in this analysis (Figure 1). Table 1 lists the CALWATER ID number prefixes. The watersheds that cross the California/Oregon boundaries were extended into Oregon by on-screen digitizing in ArcMap following the ridgelines on the 30m digital elevation models (DEM).

Table 1: CALWATER2.2 Basin Identification Numbers

Major Basins	CALWATER ID Basin Number Prefixes
Lower Klamath River	1105.1#
Middle Klamath River	1105.3#
Trinity River	1106.#
Salmon River	1105.2#
Scott River	1105.4#
Shasta River	1105.5#
Upper Sacramento above Shasta Lake	5506.#, 5525.#, 5505.#
Northwestern Sacramento below Shasta Lake	5524.#

There are a total of 870 planning watersheds in the sections of the Lower/Middle Klamath and Upper Sacramento rivers that overlap the Klamath-Siskiyou ecoregion. There are 655 in the Klamath basin and 215 in the Upper Sacramento basin. The planning watersheds vary significantly in size (minimum: 290 hectares (715 acres), maximum: 46,560 hectares (115,045 acres), mean: 3,010 hectares (7,436 acres)). Due to this variation in area, we have altered the methods for analysis of point data to account for watershed area. Point counts have been divided by watershed area to normalized the estimate of the area impacted by road-stream intersections and mineral industry activities.

Roads

The 1:24,000 roads coverage for this analysis was assembled from the California Forest and Fire Protection Watershed Assessment coverages, USGS digital line graphics, and on-screen digitizing (in ArcMap) of USGS digital raster graphics (DRGs) where the vector data does not already exist. Once these layers were completed they were appended together. Road length and road density were calculated for the CALWATER planning watersheds. Road density was calculated as km/km^2 for each watershed. The resulting road densities were grouped into five ordinal categories (high density, very poor habitat = 1 to low density, very good habitat = 5) using natural breaks (Jenks and Caspell 1971). Figure 3 illustrates the roads coverage and the road density scores. Table 2 lists the scores and natural breaks determined for road density in the Lower/Middle Klamath and Upper Sacramento. Areas of lowest road densities correspond with the wilderness areas in the Klamath, Trinity and Salmon basins.

Table 2: Road Density Scores for CALWATER Basins

Road Density (km/km2)	Road Density Score	# of Watersheds	Description
0.000 – 0.766	5	171	Very Good
0.766 – 1.350	4	192	Good
1.350 – 1.907	3	243	Moderate
1.907 – 2.607	2	190	Poor
2.607 – 4.188	1	74	Very Poor

Streams

The available 1:24,000 streams coverages were not used in this analysis because, neither the California Forest and Fire Protection Watershed Assessment stream coverage, nor the US Forest Service stream coverage were complete and when compared against one another the density of stream lines did not match between the coverages. In addition to these concerns about data quality, data were not available for 92 quads and needed to be created from the DRGs.

The 1:24,000 streams coverage used in this analysis was created from the 30m DEM using ArcMap hydrology routines. The resulting coverage was compared and areas of low/no gradient streaking were corrected against the existing stream coverages or against the USGS DRGs where no stream coverage exists. Corrections were made to represent streams that are intercepted by irrigation structures, but the irrigation structures were not digitized. Developing a coverage of these irrigation structures is an important component for further analysis of the hydrologic connectivity and aquatic integrity of this region.

Stream length and stream density were calculated for the CALWATER planning watersheds. Figure 4 was included to highlight the areas where streams are discontinuous (watersheds highlighted in yellow) due to irrigation structures.

Road-Stream Intersections

The 1:24,000 roads and streams coverages were used to calculate road-stream intersections using the ArcView extension "Theme Intersections to Points (TIPs)". These road-stream intersections were counted within each CALWATER planning watershed and then divided by the watershed area to normalize the data and account for the variation in size of the planning watersheds. Figure 5 illustrates the road-stream intersections and road-stream intersection scores. Table 3 lists the scores and natural breaks determined for normalized road-stream intersections in the Lower/Middle Klamath and Upper Sacramento.

Table 3: Road-Stream Intersection Scores for CALWATER Basins

Road-Stream Intersections	Road-Stream Intersection Score	# of Watersheds	Description
0 – 15	5	345	Very Good
16 – 34	4	283	Good
35 – 60	3	180	Moderate
61 – 143	2	61	Poor
144 – 323	1	1	Very Poor
Road-Stream Intersections/Hectares	**Road-Stream Intersection Score**	**# of Watersheds**	**Description**
0.0000 – 0.0040	5	221	Very Good
0.0040 – 0.0085	4	274	Good
0.0085 – 0.0136	3	219	Moderate
0.0136 – 0.0204	2	113	Poor
0.0204 – 0.0436	1	43	Very Poor

Forest Change

The percent of forest harvested between 1972 and 1992 was summarized by CALWATER planning watershed. This data layer was developed from an analysis of

Multispectral Scanner (MSS) images for the Klamath-Siskiyou ecoregion. Forest harvest was calculated as a percentage of forested area, because not all of the watersheds are completely forested. The percentage of forest harvest in each watershed was assigned an ordinal score (1-5) using natural breaks. Figure 6 illustrates the forest disturbance data and the percentage of forest cut between 1972 and 1992. Table 4 lists the scores and natural breaks determined for the percentage of forest harvested in the Lower/Middle Klamath and Upper Sacramento. It should be noted that two of the areas which show high percentages of forest cut (the Shasta Valley and the northwestern Sacramento Valley) have very low percentages of forest in 1972, and are areas with naturally low forest density. The areas that have been most impacted by forest harvest are the watersheds surrounding the mouth of the Klamath and the Salmon river watersheds surrounding the confluence of the north and south forks of the river. This area is primarily National Forest Service land between the Marble Mountain and Trinity Alps Wilderness Areas.

Table 4: Percent of Forest Cut 1972-1992 (Cut Hectares / Forest Hectares) Scores for CALWATER Basins

Percent of Forest Cut	Forest Cut Score	# of Watersheds	Description
0.0% – 6.7%	5	471	Very Good
6.7% – 16.1%	4	254	Good
16.1% – 31.0%	3	90	Moderate
31.0% – 54.4%	2	33	Poor
54.4% – 100.0%	1	22	Very Poor

Mineral locations

A total of the mineral locations from the Mineral Availability System and Mineral Industry Location data layer (EPA BASINS) was summed within each CALWATER planning watershed and then divided by the watershed area to normalize the data and account for the variation in size of the planning watersheds. Figure 7 illustrates the primary mineral commodity for each mineral location and the mineral location scores. Table 5 lists the scores and natural breaks determined for normalized mineral locations in the Lower/Middle Klamath and Upper Sacramento. Based on these data, some of the heaviest mining activity has occurred along the mainstem and tributaries of the middle Klamath, in the headwaters of the north fork of the Salmon, in the watersheds in the middle reaches of the Trinity, and in the watersheds just downstream of Shasta Lake along the Sacramento.

Table 5: Number of Mining Industry Location (MIL/MAS Database) Scores for CALWATER Basins

# of Mineral Locations	Mining Location Score	# of Watersheds	Description
0 – 2	5	491	Very Good
3 – 8	4	234	Good
9 – 15	3	92	Moderate
16 – 24	2	40	Poor
25 – 44	1	13	Very Poor
# of Mineral Locations/Hectares	**Mining Location Score**	**# of Watersheds**	**Description**
0.00000 – 0.00111	5	533	Very Good
0.00112 – 0.00296	4	199	Good
0.00297 – 0.00538	3	85	Moderate
0.00539 – 0.00841	2	36	Poor
0.00842 – 0.01951	1	11	Very Poor

Preliminary Aquatic Habitat Integrity Models for Lower/Middle Klamath and Upper Sacramento

Two preliminary models of relative aquatic habitat condition are presented here. The first model (Model 1) integrates the three components that were used as surrogates for aquatic habitat quality (road density, normalized road-stream intersections, and percentage of forest harvested) in the initial Rogue River analysis. Ordinal scores (1-5) for each component were summed to calculate a composite score (3-15) and all three components shared equal importance in the calculation. The second model (Model 2) includes the mineral locations ordinal score (1-5), resulting in values ranging from 4-20 with each component sharing equal importance in the calculation. Each of the composite scores were ranked using natural breaks to deliver a score of relative aquatic habitat integrity from 5 (very good) to 1 (very poor). Figure 8 illustrates these preliminary aquatic habitat condition models and table 6 lists the range of scores. Areas of high aquatic integrity overlap with GAP 1 protected areas (Siskiyou Wilderness Area, Marble Mountain Wilderness Area, Trinity Alps Wilderness Area, Yollo-Bolly-Middle Eel Wilderness Area). Areas of low aquatic integrity scores highlight watersheds in the upper Salmon River, the Scott and Shasta drainages, and the upper Trinity River.

Table 6: Summary of Model 1 & Model 2 Composite Scores

Cumulative Score	Model 1 Ordinal Score	# of Watersheds	Description
4 – 6	1	24	Very Poor
7 - 8	2	113	Poor
9 – 10	3	215	Moderate
11 – 12	4	252	Good
13 – 15	5	267	Very Good
Cumulative Score	**Model 2 Ordinal Score**	**# of Watersheds**	**Description**
7 – 10	1	37	Very Poor
11 – 13	2	174	Poor
14 – 15	3	217	Moderate
16 – 17	4	220	Good
18 – 20	5	222	Very Good

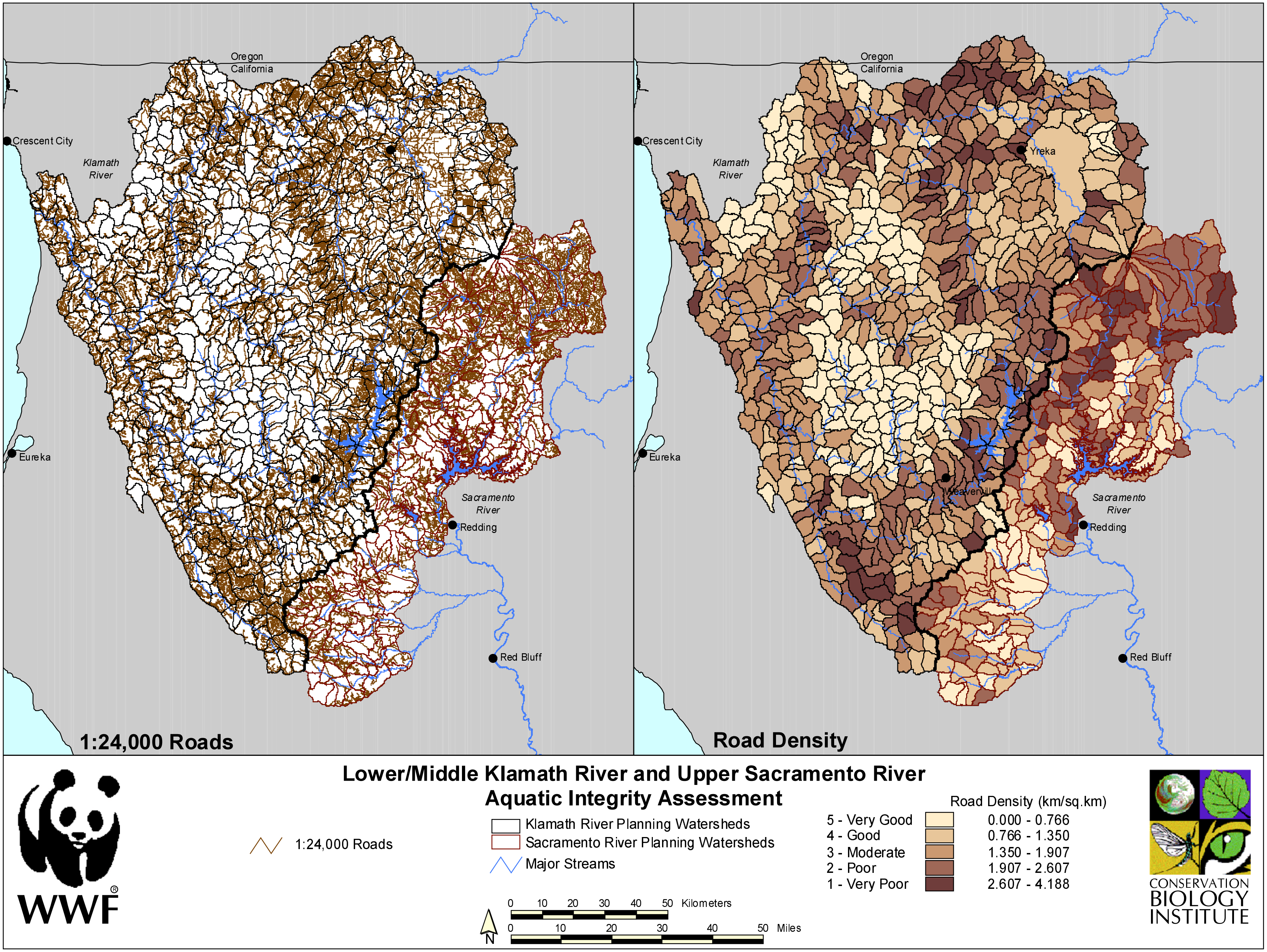

Figure 3. 1:24,000 Roads & Road Density Scores

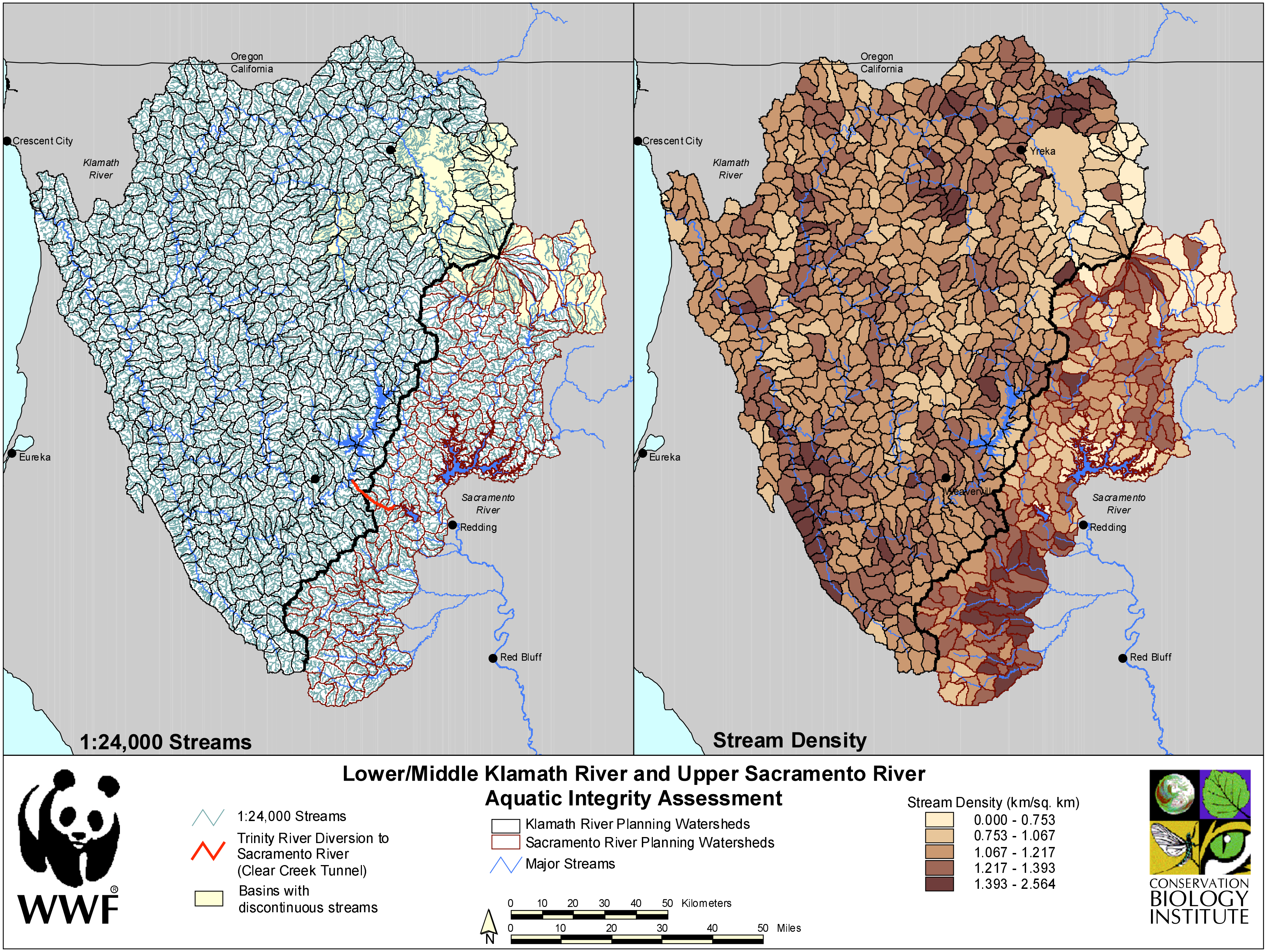

Figure 4. 1:24,000 Streams & Stream Density

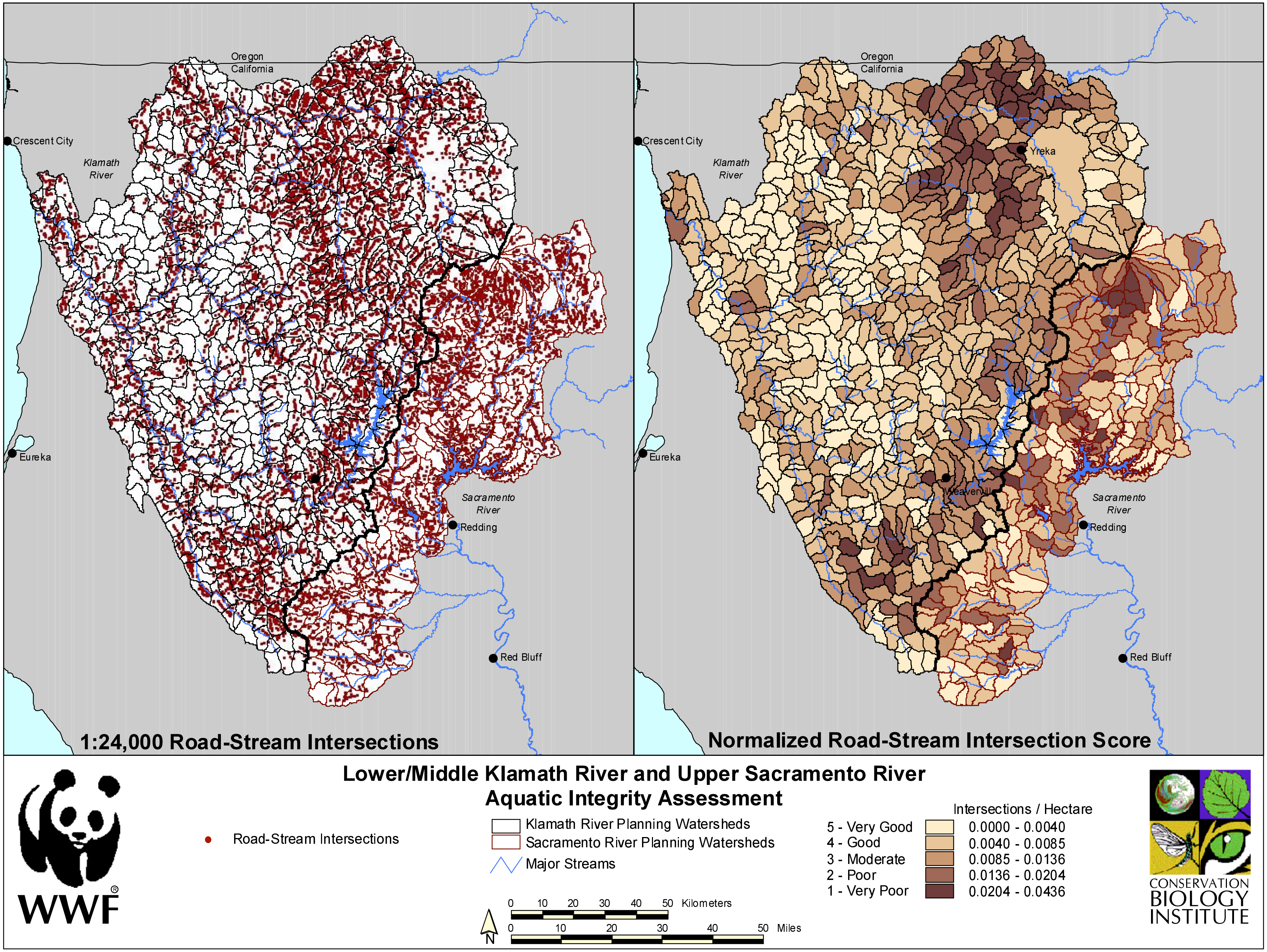

Figure 5. Road-Stream Intersections & Road-Stream Intersection Scores

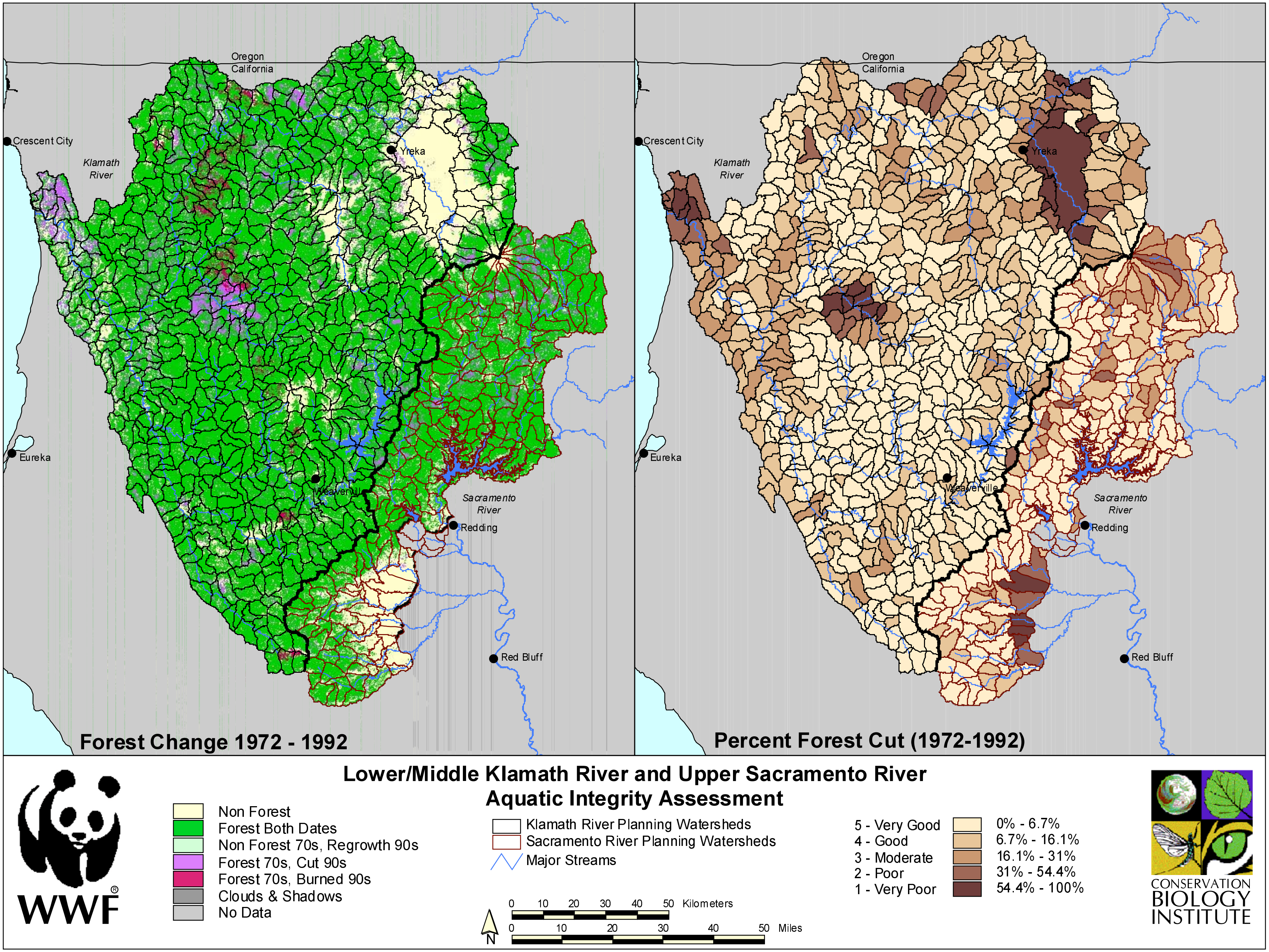

Figure 6. 1972-1992 Forest Change & Forest Cut Scores

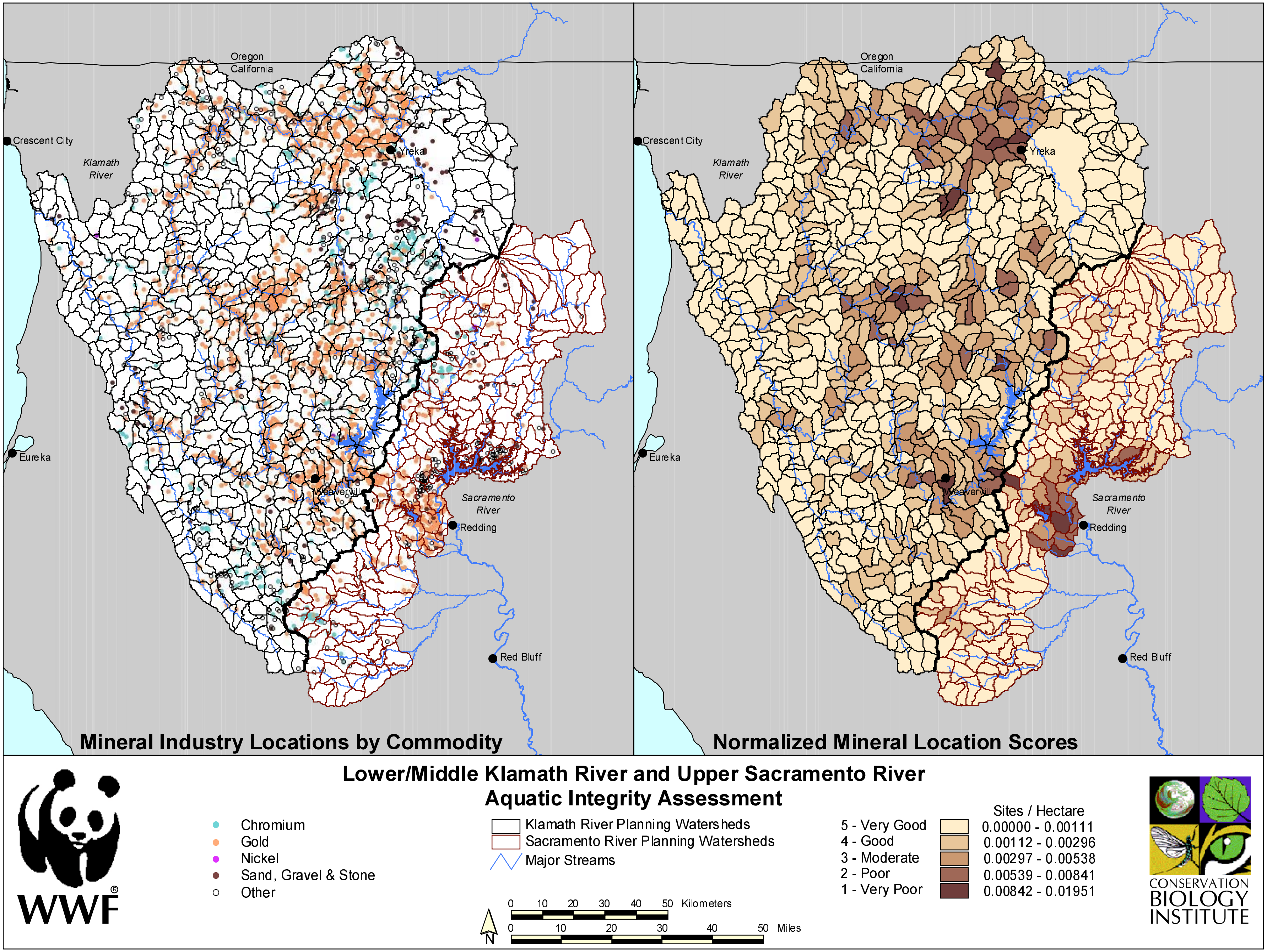

Figure 7. Mineral Industry Locations & Mineral Locations Scores

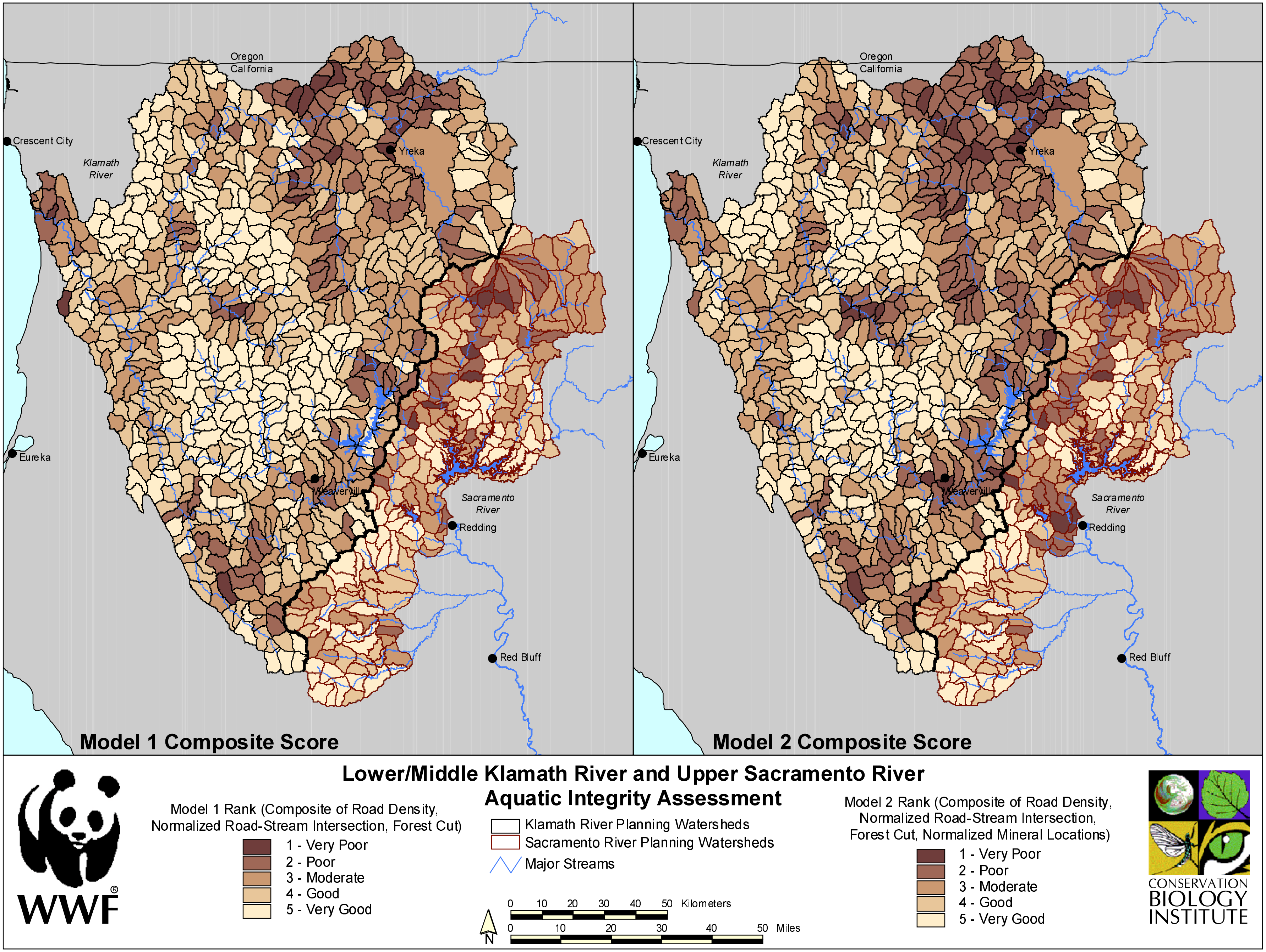

Figure 8. Preliminary Models of Klamath/Sacramento Aquatic Integrity

Lower/Middle Klamath and Upper Sacramento - Auxiliary Data

In addition to the data layers that were used to develop the preliminary aquatic habitat assessment, a number of other data layers representing ecosystem characteristics, land use patterns, and ecosystem disturbance have been collected. These data layers have been summarized and are graphically presented for comparison with the preliminary models. In addition, this section presents lists of data that are either only available for small sections of the basins or not currently available. There are a number of ways that these data layers might be integrated into an aquatic integrity analysis, and we identify data sets that would provide key information in the analysis of aquatic habitat integrity.

Ecosystem Characteristics

Aquatic Features

One of the key components to freshwater biodiversity conservation planning is the identification of the key aquatic species and features (Abell et al. 2002). While the current analysis focuses on salmonid habitat conservation, preservation and restoration, there are other aquatic species and aquatic habitats in the region that should be considered. The USGS geonames database provides point locations of major, named lakes, springs, swamps and waterfalls and would allow an initial examination of clusters of aquatic features. This database is available, but is not presented here. For an in-depth analysis of aquatic features a more detailed data set, specific to this area, should be identified to help identify areas of high aquatic habitat diversity.

Elevation and Slope

The elevation and percent slope of the region are illustrated in Figure 9. These maps were created from the USGS 30m DEM. Currently, the USGS 10m DEMs do not completely cover these basins. These maps of elevation and slope show distinct differences in the topography of the Klamath tributaries from west to east. In the western part of the basin the Trinity and Salmon rivers are highly dissected with headwaters in the Trinity Alps and Marble Mountains. The valleys are narrow and generally surrounded by steep slopes. To the east, the Scott and Shasta rivers have flatter topography with wider valleys.

Low gradient reaches, < 3%, are critical spawning and rearing habitat for wild salmon, steelhead and cutthroat trout (National Marine Fisheries Service 1998). All stream reaches with channel gradients less than 20% are considered to be potential fish bearing streams except where fish barriers exist (National Marine Fisheries Service 1998). There are a number of important, low gradient areas on the mainstems of the Trinity and the Klamath. The areas of low slope in the Scott and Shasta valleys overlap with areas where numerous irrigation waterways and engineered structures have altered stream connectivity.

Serpentine Soils

Serpentine (Ultramafic) geology produces soils that are unique in many of their physical and chemical properties. These soils have high concentrations of mineral elements, particularly nickel, chromium, iron, magnesium, and cobalt. The mineral imbalance and toxicity of these soils contribute to the unusual flora of the area and high numbers of individual species. Wet serpentine soils support diverse wetland communities, the most spectacular of which is the *Darlingtonia* fen. These wetland communities are particularly sensitive to changes in hydrologic regimes. Ironically, the feature that makes the region such a botanical treasure (highly mineralized soils) also creates a major conservation conflict – mining. Figure 10 illustrates the extent of serpentine soils in the Klamath and Upper Sacramento basins. This data layer was created from the NRCS STATSGO soil survey maps. Digital state soil survey (SSURGO) maps do not exist for the entire region at this time. Table 7 summarizes the percentage of serpentine soils in the Klamath and Sacramento basins. Serpentine soils make up approximately 11% of soils in the basins.

Table 7: Percentage of Serpentine Soils

Serpentine Soils	# of Basins
>0% - 20%	162
20% - 40%	86
40% - 60%	45
60% - 80%	31
80% - 100%	20

Land and Water Use / Land Cover

Ownership

The ownership in the Lower/Middle Klamath and Upper Sacramento basins is more public than private, 64% and 36% respectively. Public lands are concentrated in the lower reaches of the Klamath mainstem, in the Scott and Shasta basins, and in the northwestern Sacramento (Figure 11). The ICRB ownership (1997) data set does not distinguish between land uses, (e.g. industrial forest vs. non-industrial forest). Distinguishing between land use as well as ownership would be very useful for prioritizing conservation and restoration efforts in the subregion. Table 8 summarizes the percentage of private lands in the basins.

Table 8: Percentage Privately Owned Land

Private Land	# of Basins
0% - 20%	428
20% - 40%	96
40% - 60%	123
60% - 80%	104
80% - 100%	119

Protected Areas

Wilderness areas and other protected areas are illustrated in Figure 12. There are 396,355 hectares (979,381 acres) of strictly protected (GAP 1 status) land in the subregion, approximately 15% of the total area in the basins. These areas are concentrated in the Trinity and Salmon basins in the Siskiyou Wilderness, Marble Mountain Wilderness, Trinity Alps Wilderness, and Yollo-Bolly-Middle Eel Wilderness areas. Another 85,940 hectares (212,355 acres) are moderately protected (GAP 2 status), adding another 3% of the area to the area protected, totaling 18% of the subregion having strict or moderate protected status. Table 9 summarizes the percentage of strictly protected lands in the basins.

Table 9: Percentage of Strictly Protected Area

Strictly Protected (GAP 1)	# of Basins
0% - 20%	695
20% - 40%	40
40% - 60%	27
60% - 80%	13
80% - 100%	95

Roadless Areas

Two roadless areas coverages are included in this assessment. The Forest Service (FS) inventoried roadless areas coverage was developed based on completed forest plans. There are 262,828 hectares (649,438 acres) of inventoried roadless areas in the subregion, approximately 10% of the total area in the basins. The FS inventoried roadless areas show a high degree of coincidence with areas designated as late seral reserves (LSRs). LSRs are areas designated to serve as habitat for late seral and old-growth species. The CBI roadless areas coverage includes the FS inventoried roadless areas along with non inventoried FS roadless areas and Bureau of Land Management areas. This analysis expands the area of roadless areas to 750,074 hectares (1,853,407 acres), approximately 28.6% of the total area in the basins. These areas are concentrated in the Salmon and Trinity subbasins (Figure 13). Table 10 summarizes the percentage of roadless areas in the basins. These estimates do not include the protected roadless areas in designated Wilderness areas. Combined with GAP 1 & 2 protected areas, roadless and protected areas cover 47% of the subregion.

Table 10: Percentage of Inventoried and Total Roadless Areas

FS Inventoried Roadless Areas	# of Basins	CBI Roadless Areas	# of Basins
0% - 20%	696	0% - 20%	448
20% - 40%	76	20% - 40%	100
40% - 60%	53	40% - 60%	106
60% - 80%	25	60% - 80%	103
80% - 100%	20	80% - 100%	113

Landsat 2000 ETM+ imagery

A recently completed analysis of Landsat 2000 ETM+ imagery, provides a more recent look at the forest cover in the subregion. This data layer was not categorized in the same way as the MSS 1972-1992 forest change analysis and is presented here merely as an additional data layer, rather than as an extension of the forest change analysis. Categorization of these data to match the MSS forest change data would extend the timestep of the forest disturbance data set. Figure 14 illustrates the Landsat imagery and the percent of old and mature conifer forest in the subregion, 551,061 hectares (1,361,654 acres) were categorized as old conifer forest and 687,569 hectares (1,698,959 acres) were categorized as mature conifer forest (47% of the subregion is categorized as old or mature conifer forest). On the flip side, there are 226,317 hectares (559,221 acres) of young conifer forest and 49,507 hectares (122,330 acres) of young regenerating forest in the subregion (10.5% of the subregion), much of this is concentrated along the mainstem of the Klamath, downstream of the confluence with the Trinity river. A little less than half of the these hectares of young conifer and regenerating forest are in the 200m stream buffers (112,318 hectares; 277,533 acres; 4.3%). Table 11 summarizes the percentage of young & regenerating and old & mature forest cover in the watersheds.

Table 11: Landsat 2000 ETM+ Imagery – Seral Stages Categories

Landsat 2000 Young Conifer & Regenerating Forest	# of Basins	Landsat 2000 Old & Mature Conifer	# of Basins
0% - 20%	663	0% - 20%	38
20% - 40%	163	20% - 40%	72
40% - 60%	35	40% - 60%	127
60% - 80%	8	60% - 80%	375
80% - 100%	1	80% - 100%	258
200m Buffer Landsat 2000 Young Conifer & Regenerating Forest	**# of Basins**	**200m Buffer Landsat 2000 Old & Mature Conifer**	**# of Basins**
0% - 20%	666	0% - 20%	50
20% - 40%	161	20% - 40%	67
40% - 60%	33	40% - 60%	101
60% - 80%	9	60% - 80%	341
80% - 100%	1	80% - 100%	311

Water Rights

Klamath River water rights issues are often highlighted in the media. Water rights data were not incorporated into this analysis, but would be an imperative part of any complete analysis of aquatic habitat integrity for prioritization of conservation and restoration programs, particularly in basins with significant irrigation pressures. The California Division of Water Rights declined to make the water rights GIS database, including information about points of diversion and place of use, available at this time due to national security issues.

Wild and Scenic Rivers

Sections of both the mainstem Klamath and Trinity rivers were designated Wild and Scenic rivers in January of 1981 (Figure 12). There are three designation types in the Wild and Scenic river program. Wild river reaches are undeveloped, with river access

via trail only. Scenic river reaches are undeveloped, but have some river access via road. Some development is allowed along recreational river reaches.
The mainstem of the Klamath river is designated from the mouth of the river to 1,097 meters (3,600 feet) below Iron Gate Dam. The designation extends along the Salmon River from its confluence with the Klamath to the confluence of the north and south forks of the Salmon River, up the North Fork of the Salmon River to the southern boundary of the Marble Mountain Wilderness Area, and up the south fork of the Salmon River to the Cecilville Bridge. The designation also extends up the Scott River from its confluence with the Klamath to its confluence with Schackleford Creek and includes all of Wooley Creek. This designation added 19 km (12 miles) of wild river, 39 km (24 miles) of scenic river, and 402 km (250 miles) of recreation river designations to the Wild and Scenic rivers system.

The mainstem of the Trinity river is designated from the confluence with the Klamath River to 91 meters (100 yards) below Lewiston Dam. The designation extends up the North Fork to the southern boundary of the Salmon-Trinity Primitive Area, up the South Fork to the California State Highway 36 bridge crossing, and includes the New River from the Trinity River confluence to the Salmon-Trinity Primitive Area. This designation added 71 km (44 miles) of wild river, 63 km (39 miles) of scenic river, and 193 km (120 miles) of recreation river designations to the Wild and Scenic rivers system.

Restoration Projects

In planning conservation and restoration projects, it is helpful to know where and what has been done in the past. Three databases of restoration projects, totaling 451 projects are included in Figure 15. These projects were completed in the mid-1990s by the CA Fish and Game Department, US Fish and Wildlife, Bureau of Land Management and the Forest Service. This information is by no means complete, and ideally a database that includes all projects completed in the last couple of decades would be available for an analysis of restoration project prioritization. Restoration projects are often undertaken without an examination of the degree of success of prior projects. Developing subbasin databases of past and active restoration projects should be a priority in the analysis of human impacts on aquatic ecosystems and basinwide aquatic connectivity.

Ecosystem Disturbance Regimes

Wildfire

A summary of wildfire activity developed by the USFS Pacific Southwest Research Station provides annual wildfire perimeter data (1910-1994). During this time some areas have burned multiple times, and in this analysis multiple burns are summarized as a total number of hectares burned in each watershed, thus if the percent of watershed burned between 1910-1994 is greater than 100%, there are areas in that watershed that have burned more than once between 1910-1994. There are concentrated areas of frequent/extensive wildfire activity in the Siskiyou Wilderness, the

Trinity Alps Wilderness and between the Trinity Alps Wilderness and the Marble Mountains Wilderness, and in the Cottonwood Creek area of the Sacramento basin (Figure 16). A total of 594,955 hectares (1,470,115 acres) burned in the subregion between 1910-1994 (22.7% of the area). Table 12 summarizes the percentage of wildfire between 1910-1994 in the watersheds

Table 12: Wildfire 1910-1994

Fires 1910-1994	# of Basins
0% - 25%	598
25% - 50%	108
50% - 75%	68
75% - 100%	49
100% - 206.9%	47

Summary of Additional Data Needs

This list of additional data sets, provides a starting point for continued aquatic analysis in the Klamath Siskiyou ecoregion. Some of these data layers are available for small areas within the Lower/Middle Klamath basin and/or the Upper Sacramento basin, including the KRIS databases, California Fish and Game database, or national forest databases. However, none of these data sets are currently available for the entire study area.

Aquatic Features/Habitat:
- Linear Fish Maps
- Hatchery Releases
- Aquatic Invertebrates
- Stream Survey Data (Channel Complexity, Large Woody Debris)
- Groundwater Connectivity

Land Use:
- Ownership Categories (Industrial/Non Industrial Forest, Irrigated Agricultural Lands)

Water Use:
- Fish Barriers
- Irrigation/Water Diversion Structures (Ditches, Aqueducts, Canals)
- Water Rights (Point Of Diversion, Place Of Use)

Water Quality:
- Pesticide/Herbicide/Insecticide Use
- Landslide Hazard
- Permitted Pollution Discharges, Excess Pollution Discharges
- Stream Temperature

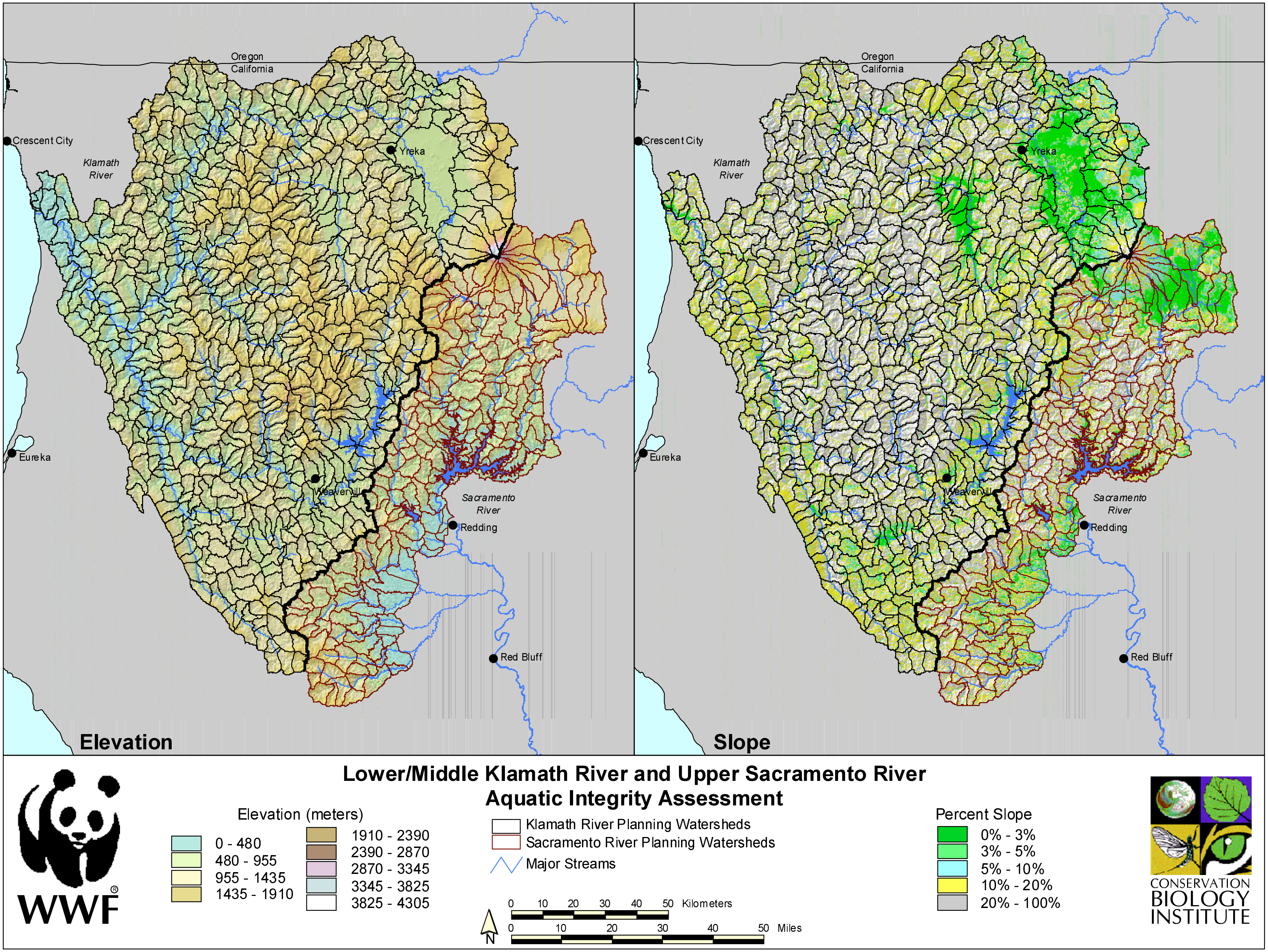

Figure 9. Elevation & Slope (USGS 30 meter Digital Elevation Model)

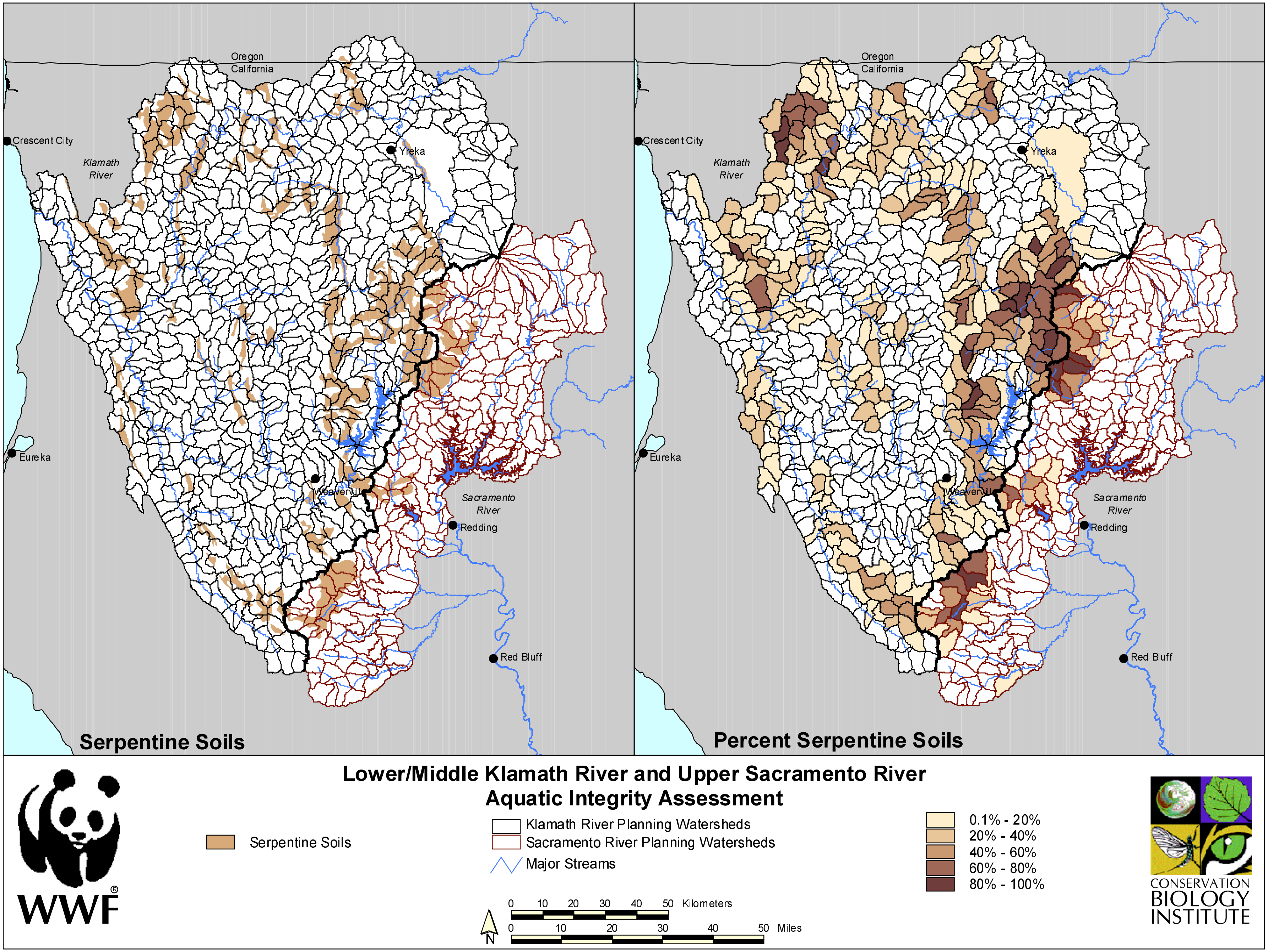

Figure 10. Serpentine Soils (NRCS STATSGO Data)

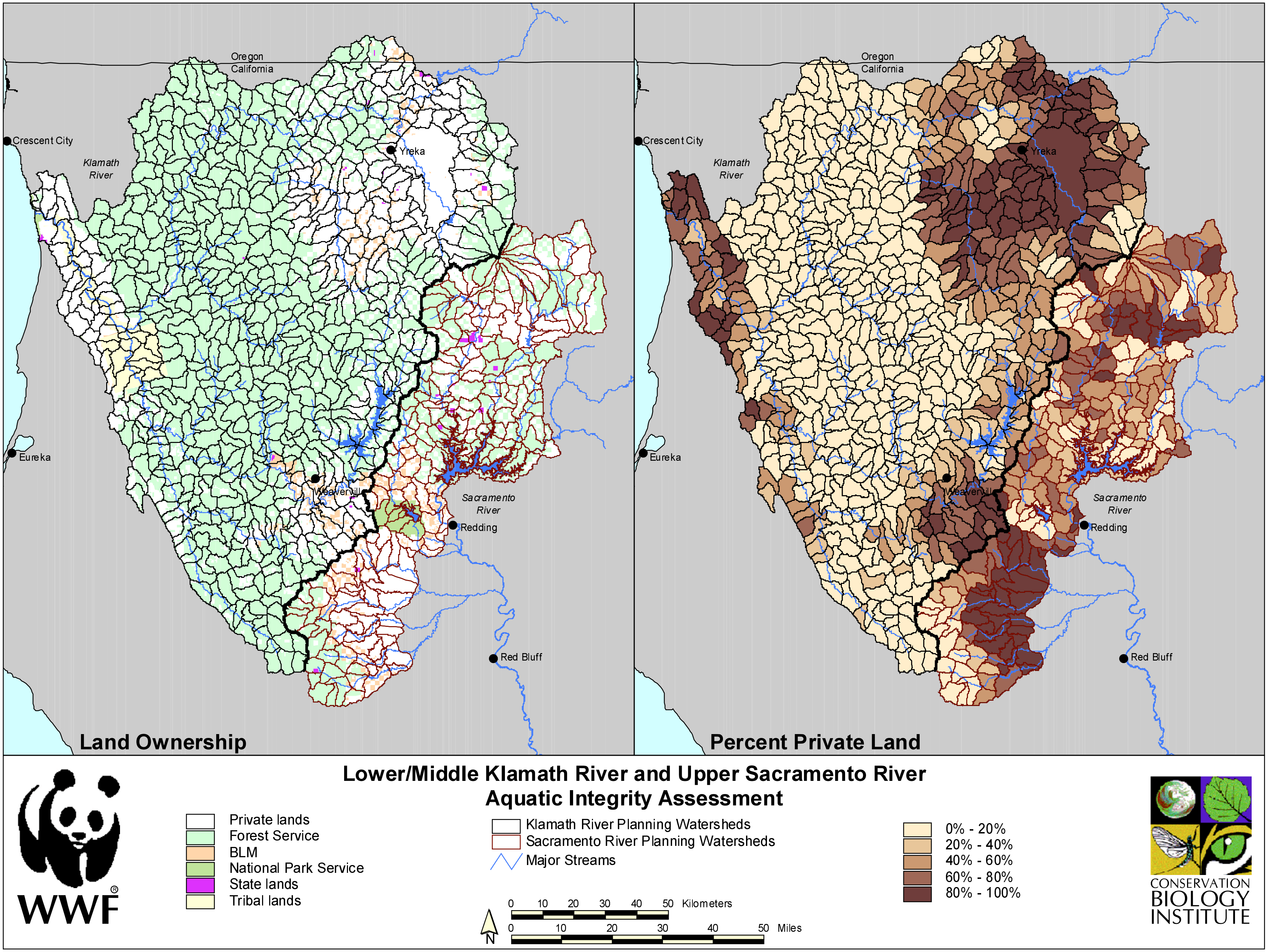

Figure 11. Land Ownership

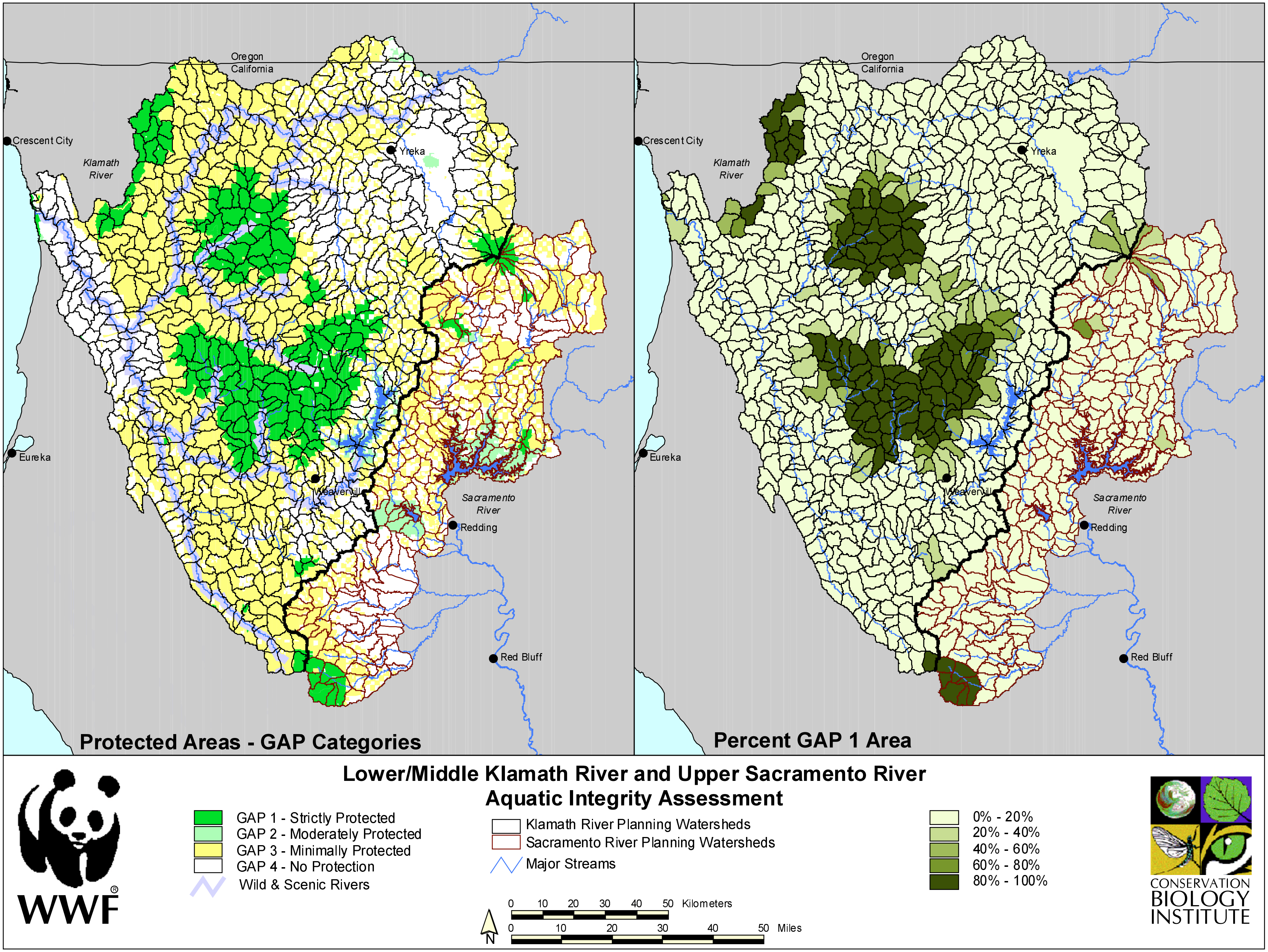

Figure 12. Protected Areas

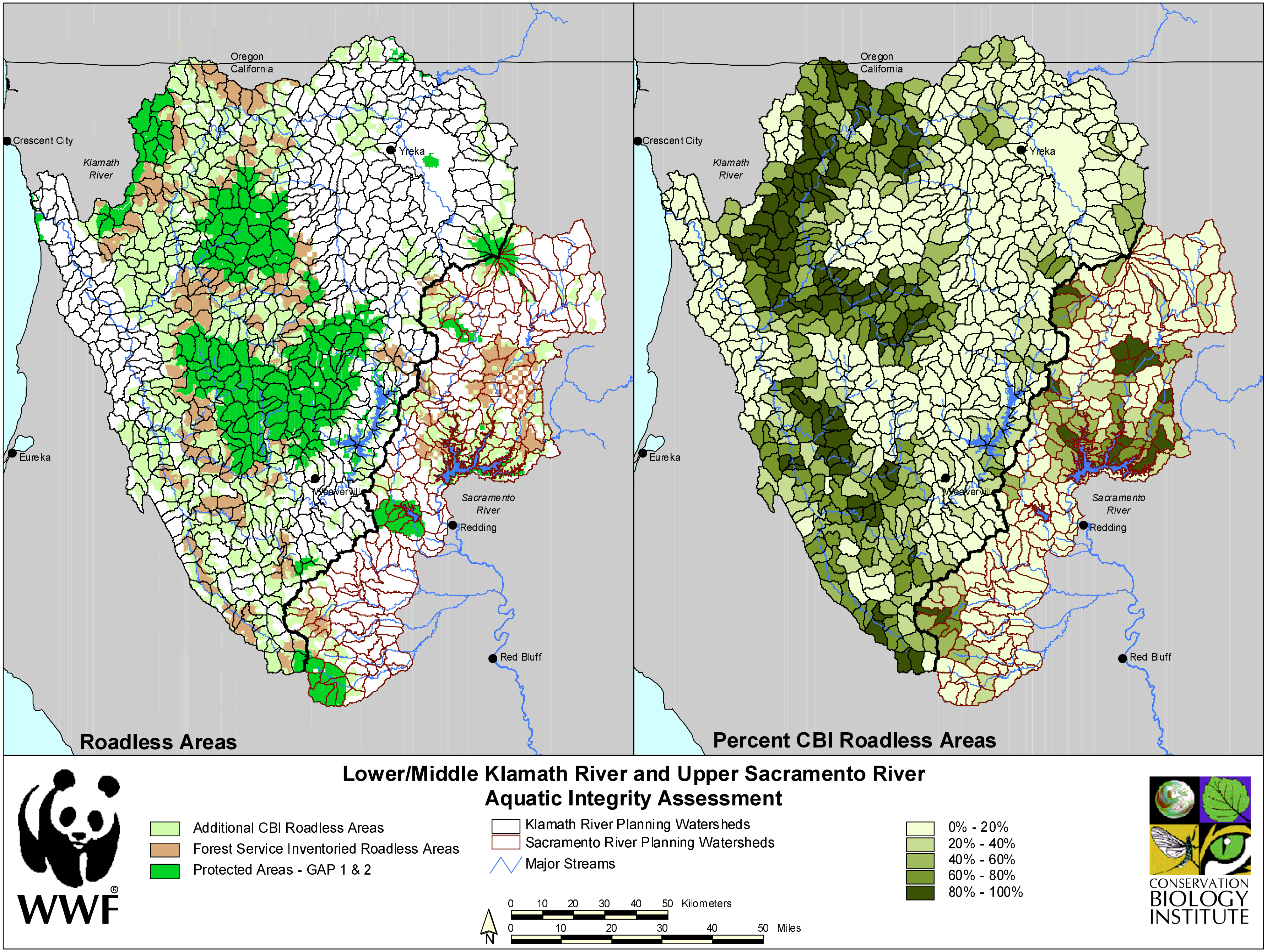

Figure 13. Roadless Areas

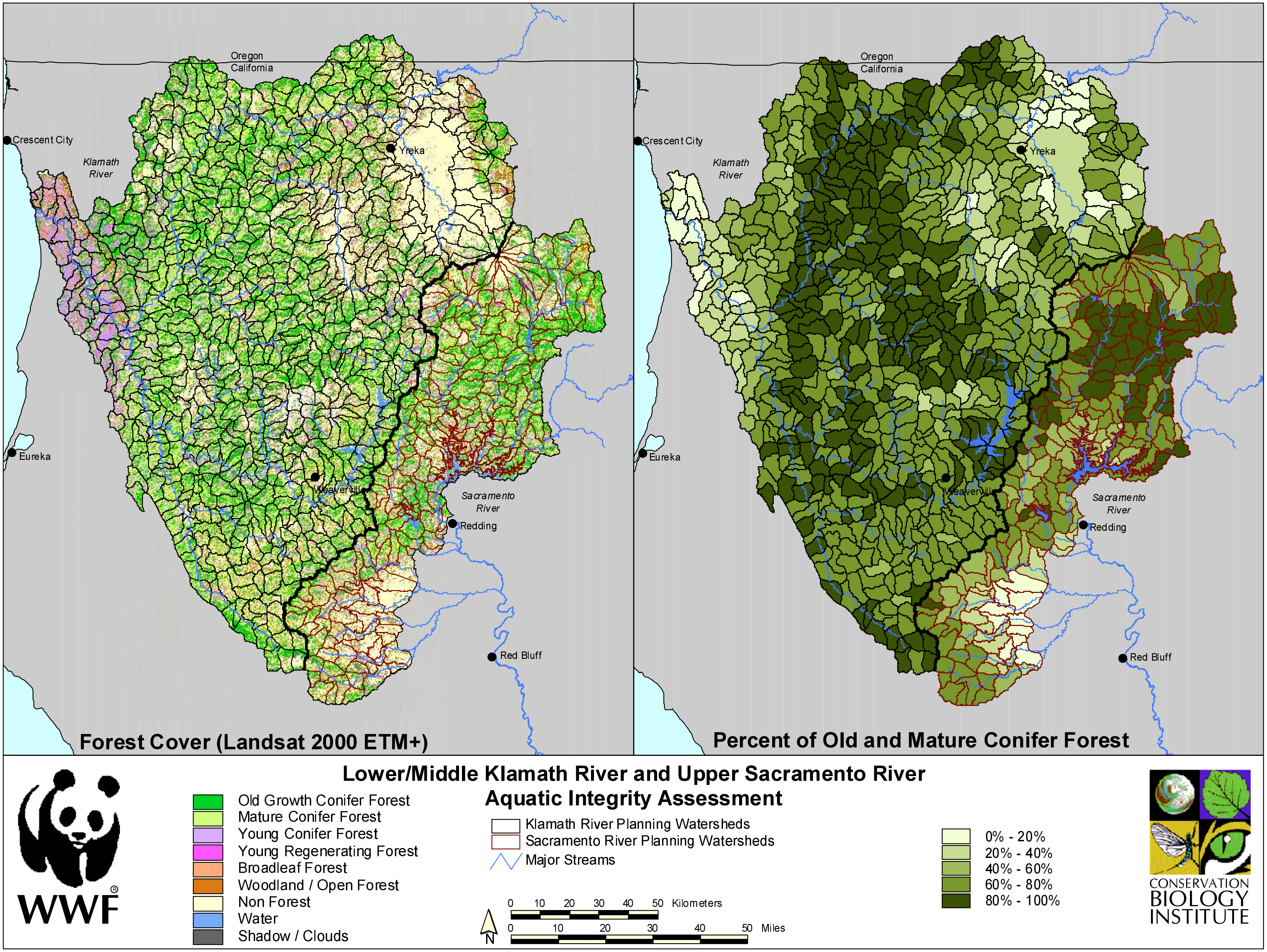

Figure 14. Forest Cover (Landsat 2000 ETM+)

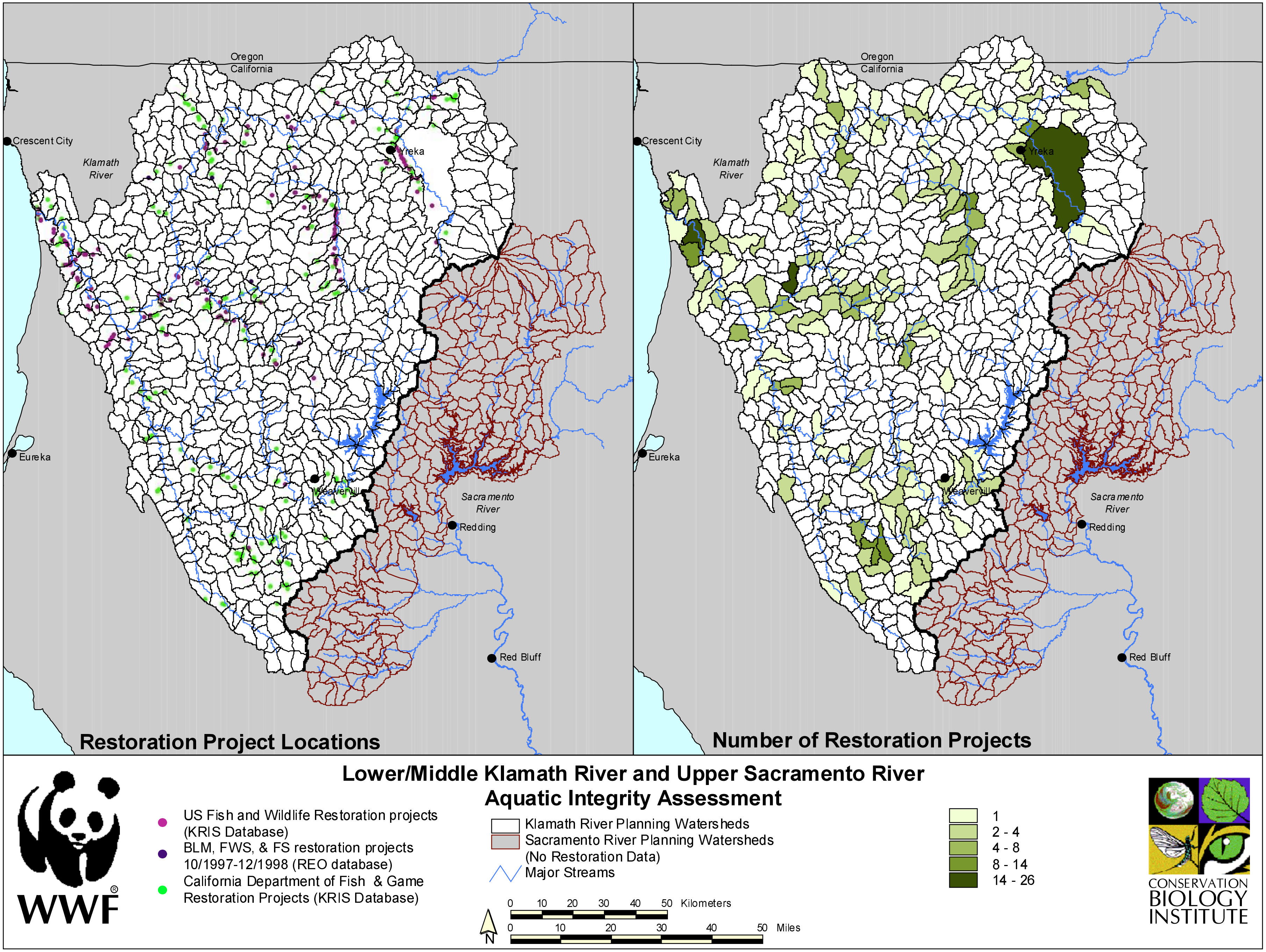

Figure 15. Stream Restoration Projects

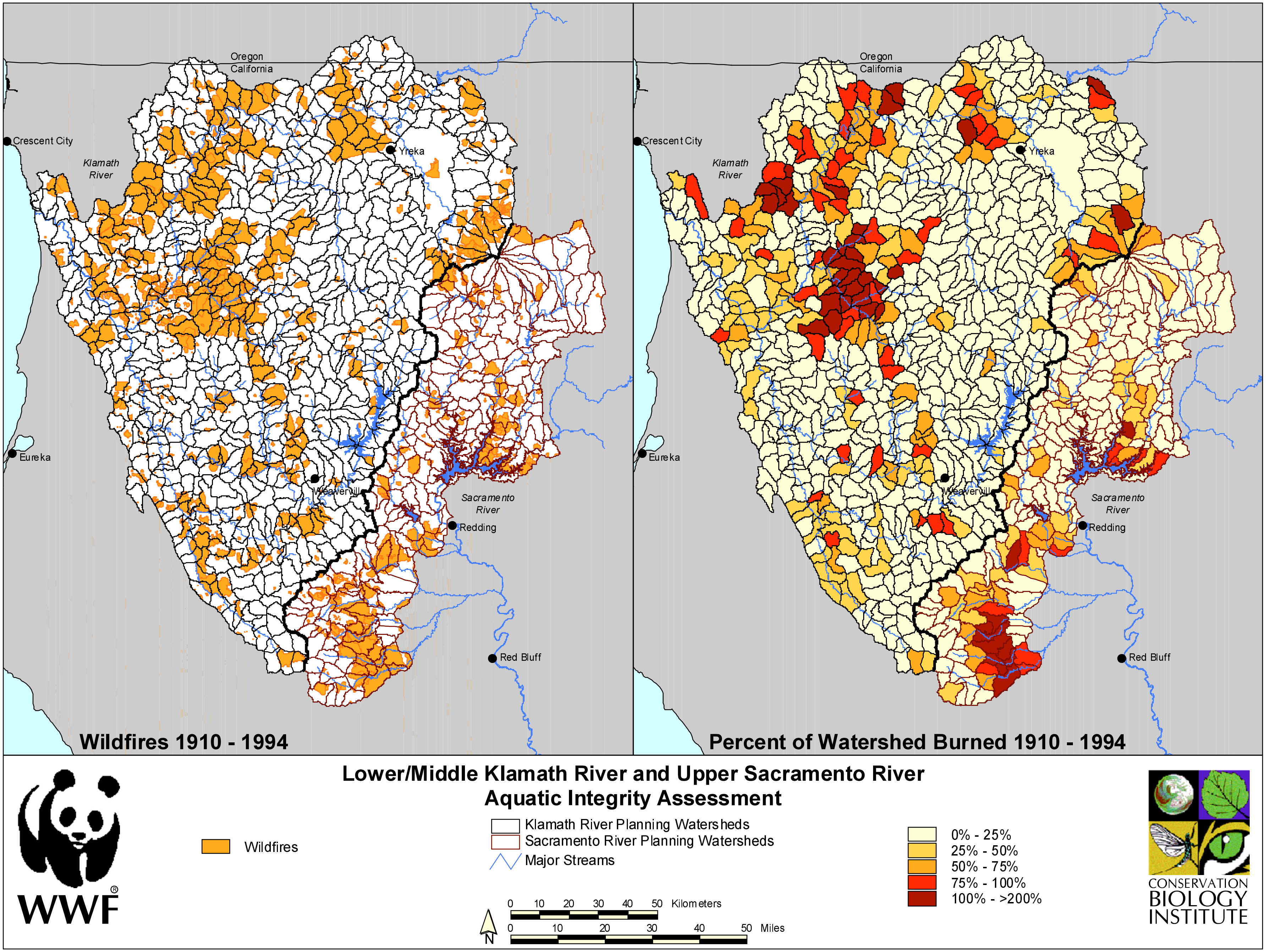

Figure 16. Wildfire

Integration of Rogue, Klamath, & Sacramento Data: Preliminary Klamath-Siskiyou Ecoregion Aquatic Habitat Integrity Assessment

This section presents the results of integrating the data from the Rogue basin analysis and the Klamath/Sacramento analysis. The data were scored after the data sets were integrated to provide relative scores for the 6th field watersheds and the generally smaller CALWATER planning watersheds. All data sets that are area dependent have been normalized to account for the differences in size between the 6th field watershed and the CALWATER planning watersheds. All scores were determined using natural breaks, and scores were assigned ordinal ranks 1-5 (very poor – very good). Figures 17, 18, 19, and 20 illustrate scores for road density, road-stream intersections, forest change, and mineral locations. Table 13 summaries the scores by watersheds.

Note: This comparison is based on roads and streams data that are comparable, but not from identical sources. The streams data in the Rogue River Basin were not created from the digital elevation model in the same manner as the Klamath and Sacramento, and the data layer shows variability in stream density throughout the basin. In addition, caution should be used when interpreting the maps due to the disparity in watershed grain (larger watershed areas in the Rogue Basin, smaller watershed areas in the Klamath and Sacramento). For example, watersheds with high road density due to urban areas cover more area in the Rogue than similar areas in the Klamath.

Table 13: Klamath-Siskiyou Aquatic Integrity Scores

Road Density	# of Basins	Ordinal Score	Description			
0.000-0.882	216	5	Very Good			
0.882-1.628	359	4	Good			
1.628-2.368	310	3	Moderate			
2.368-3.577	202	2	Poor			
3.577-6.885	39	1	Very Poor			
Normalized Intersections	**# of Basins**	**Ordinal Score**	**Description**		**Intersections**	**# of Basins**
0.00000 – 0.00572	356	5	Very Good		0-32	642
0.00573 – 0.01204	377	4	Good		33-86	328
0.01205 – 0.02038	258	3	Moderate		87-184	100
0.02039 – 0.03308	100	2	Poor		185-389	49
0.03309 – 0.05708	36	1	Very Poor		390-731	8
Forest Cut	**# of Basins**	**Ordinal Score**	**Description**			
0.00%- 5.93%	498	5	Very Good			
5.93% - 13.95%	382	4	Good			
13.95% - 26.70%	167	3	Moderate			
26.70% - 52.00%	55	2	Poor			
52.00% - 100.00%	25	1	Very Poor			
Normalized Mineral Locations	**# of Basins**	**Ordinal Score**	**Description**		**Mineral Locations**	**# of Basins**
0.00000 – 0.00099	672	5	Very Good		0-4	756
0.00100 – 0.00262	261	4	Good		5-12	243
0.00263 – 0.00491	120	3	Moderate		13-23	92
0.00492 – 0.00878	58	2	Poor		24-41	29
0.00879 – 0.01951	16	1	Very Poor		42-71	7

Two preliminary models of relative aquatic habitat condition are also presented (Figures 21 & 22). The first model integrates the three components that were used as surrogates for aquatic habitat quality (road density, normalized road-stream intersections, and percentage of forest harvested) in the initial Rogue River analysis. Ordinal scores (1-5) for each component were summed to calculate a composite score (3-15) and all three components share equal importance in the calculation. The second model includes the mineral locations ordinal score (1-5), resulting in a value range from 4-20 with each component sharing equal importance in the calculation. Each of the composite scores were ranked using natural breaks to deliver a score of relative aquatic habitat integrity from 5 (very good) to 1 (very poor). Table 14 lists the range of scores.

Table 14: Klamath-Siskiyou Preliminary Aquatic Integrity Models

Model 1 Score	**# of Basins**	**Ordinal Score**	**Description**
4 – 6	33	1	Very Poor
7 - 8	112	2	Poor
9 – 10	243	3	Moderate
11 – 12	346	4	Good
13 – 15	393	5	Very Good
Model 2 Score	**# of Basins**	**Ordinal Score**	**Description**
6 – 10	28	1	Very Poor
11 – 13	210	2	Poor
14 – 15	262	3	Moderate
16 – 17	312	4	Good
18 – 20	315	5	Very Good

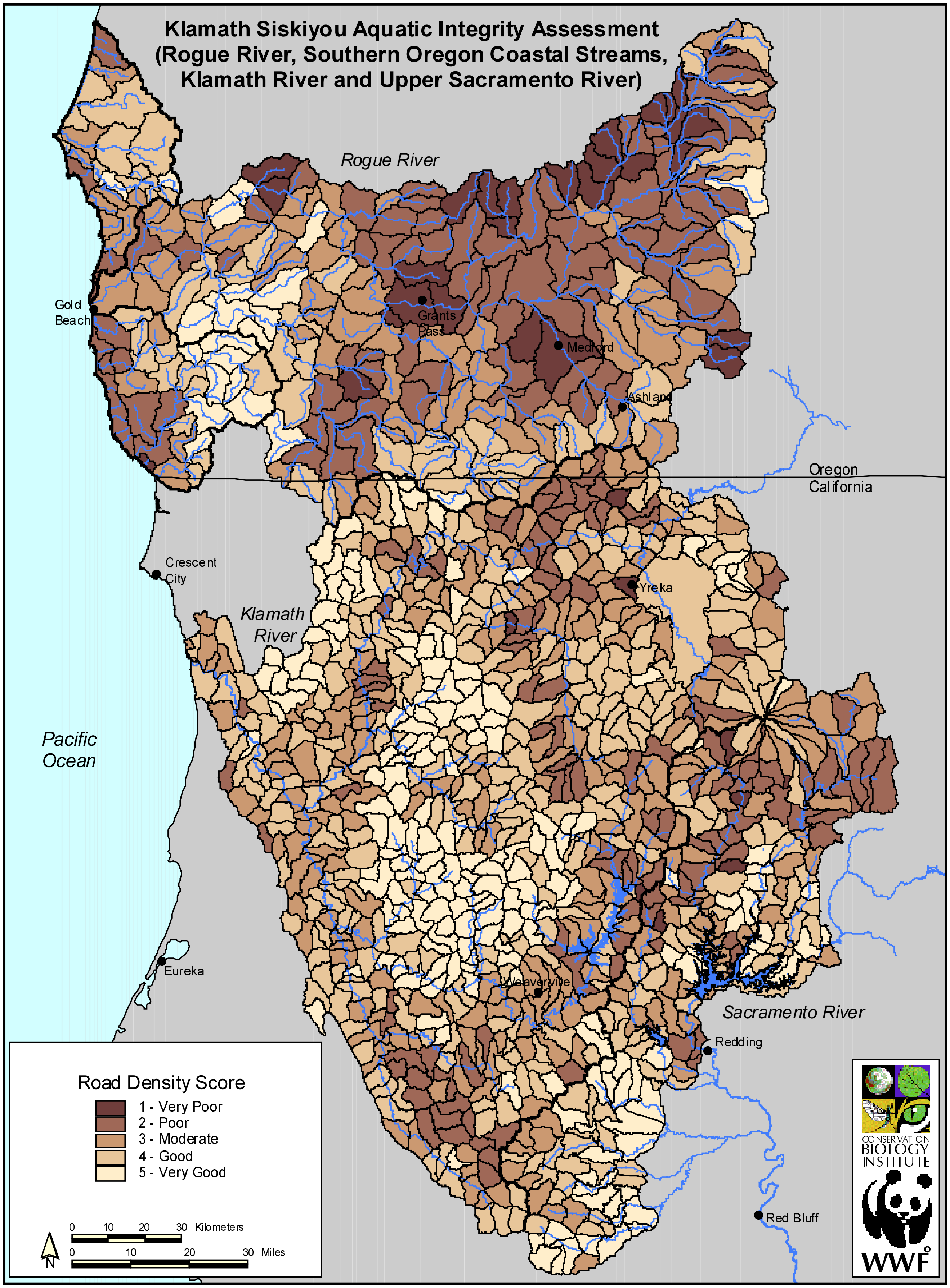

Figure 17. Klamath-Siskiyou Road Density Score

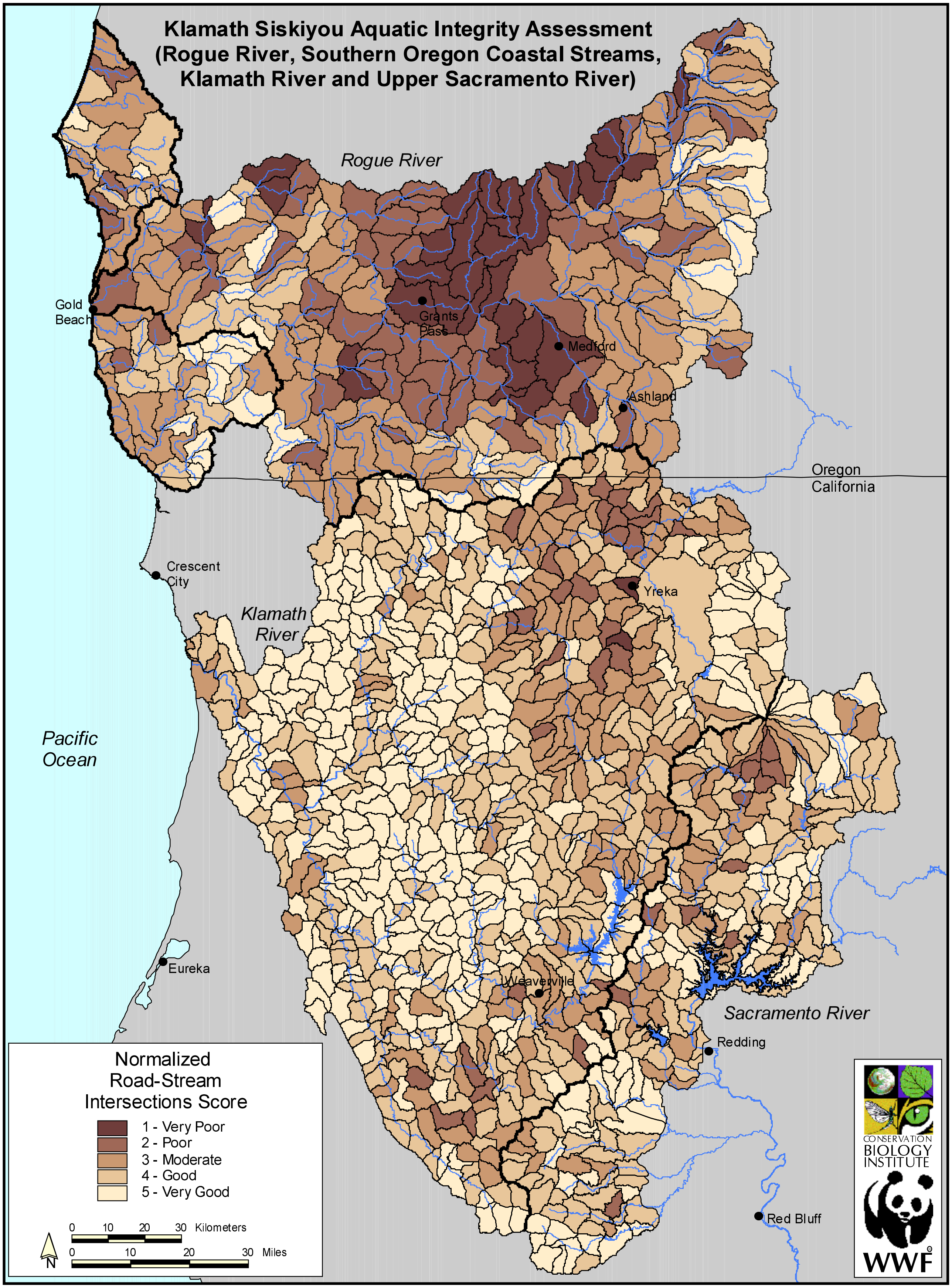

Figure 18. Klamath-Siskiyou Road-Stream Intersections Score

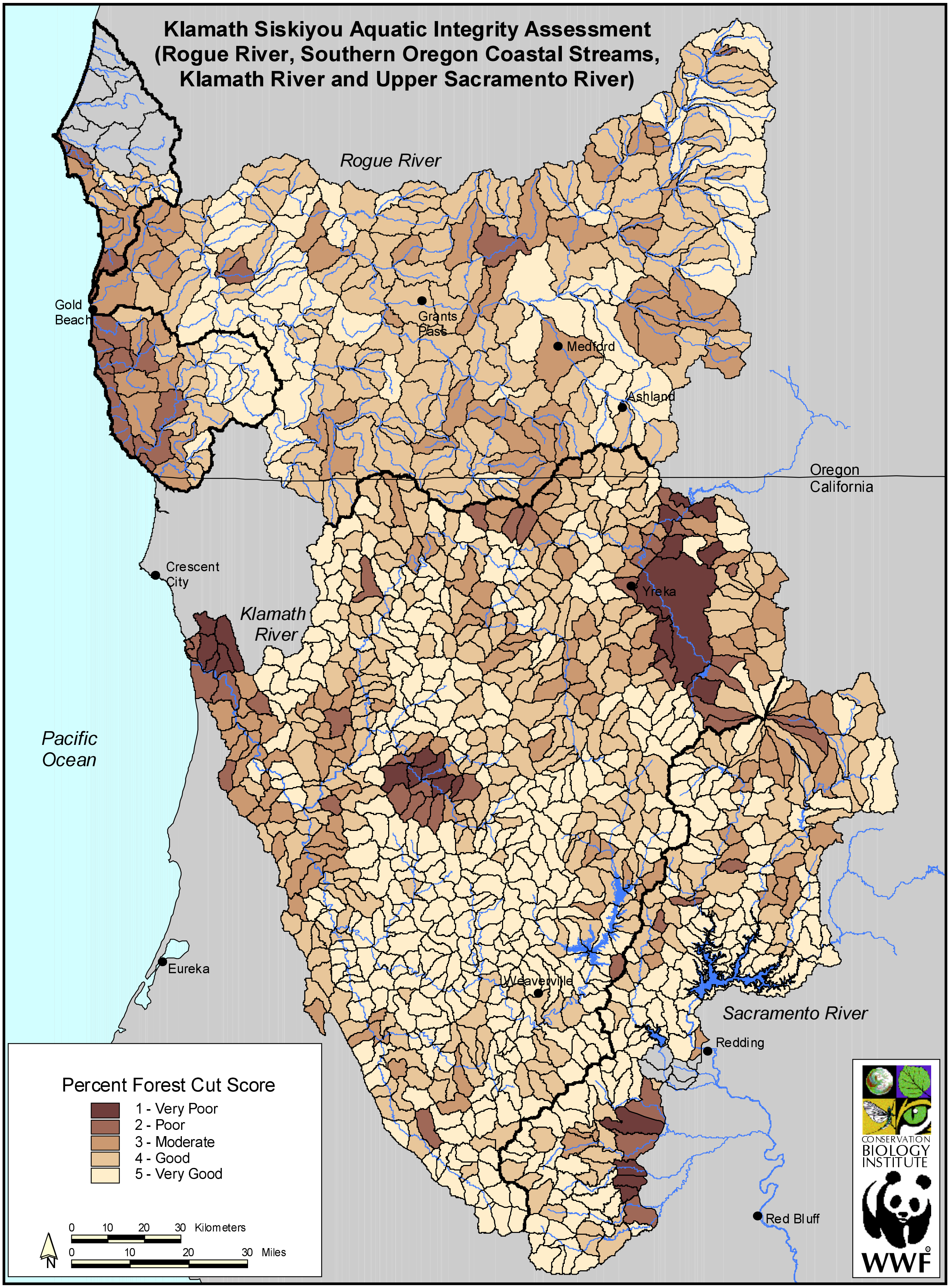

Figure 19. Klamath-Siskiyou Forest Cut Score

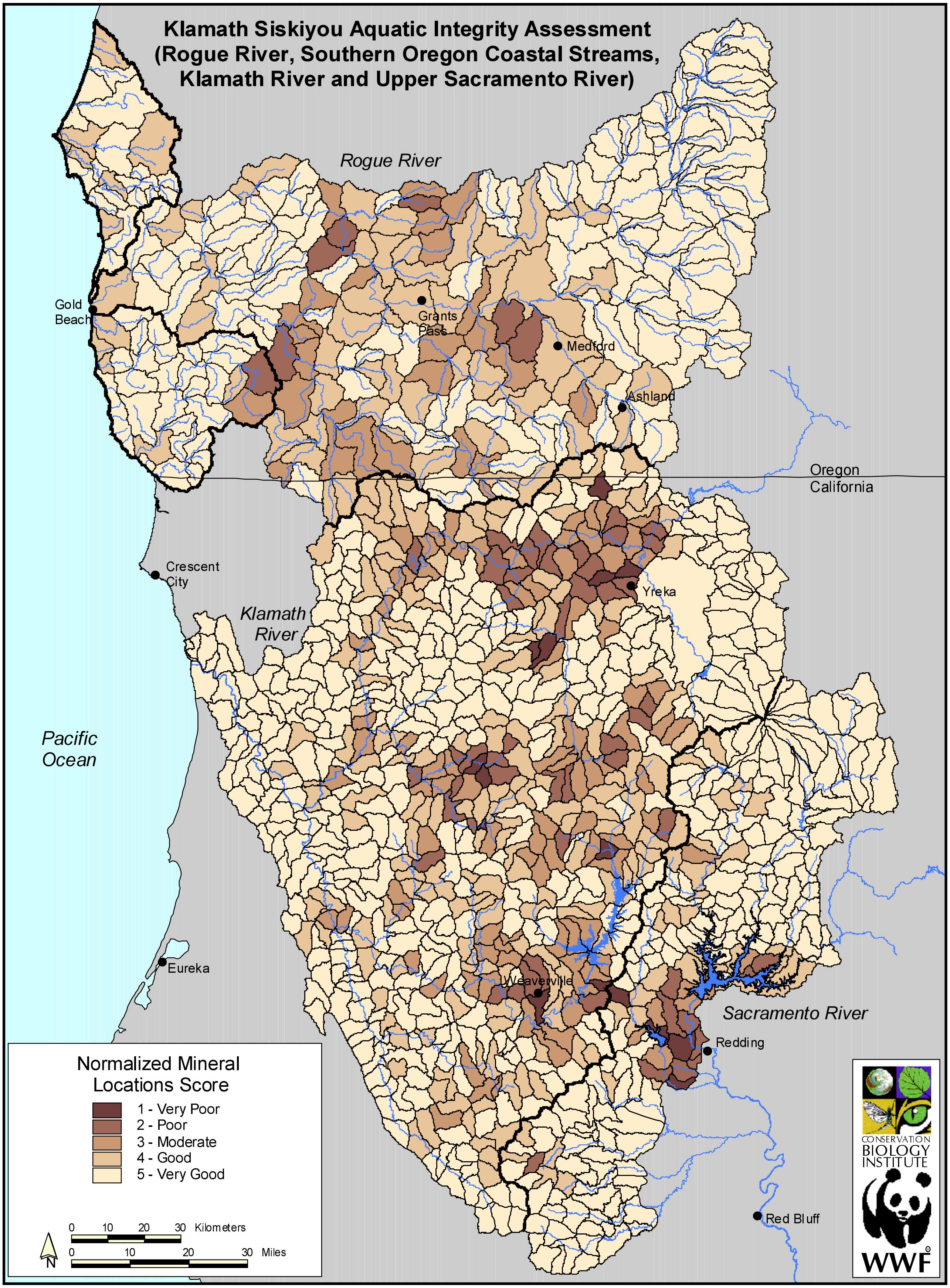

Figure 20. Klamath-Siskiyou Mineral Industry Locations Score

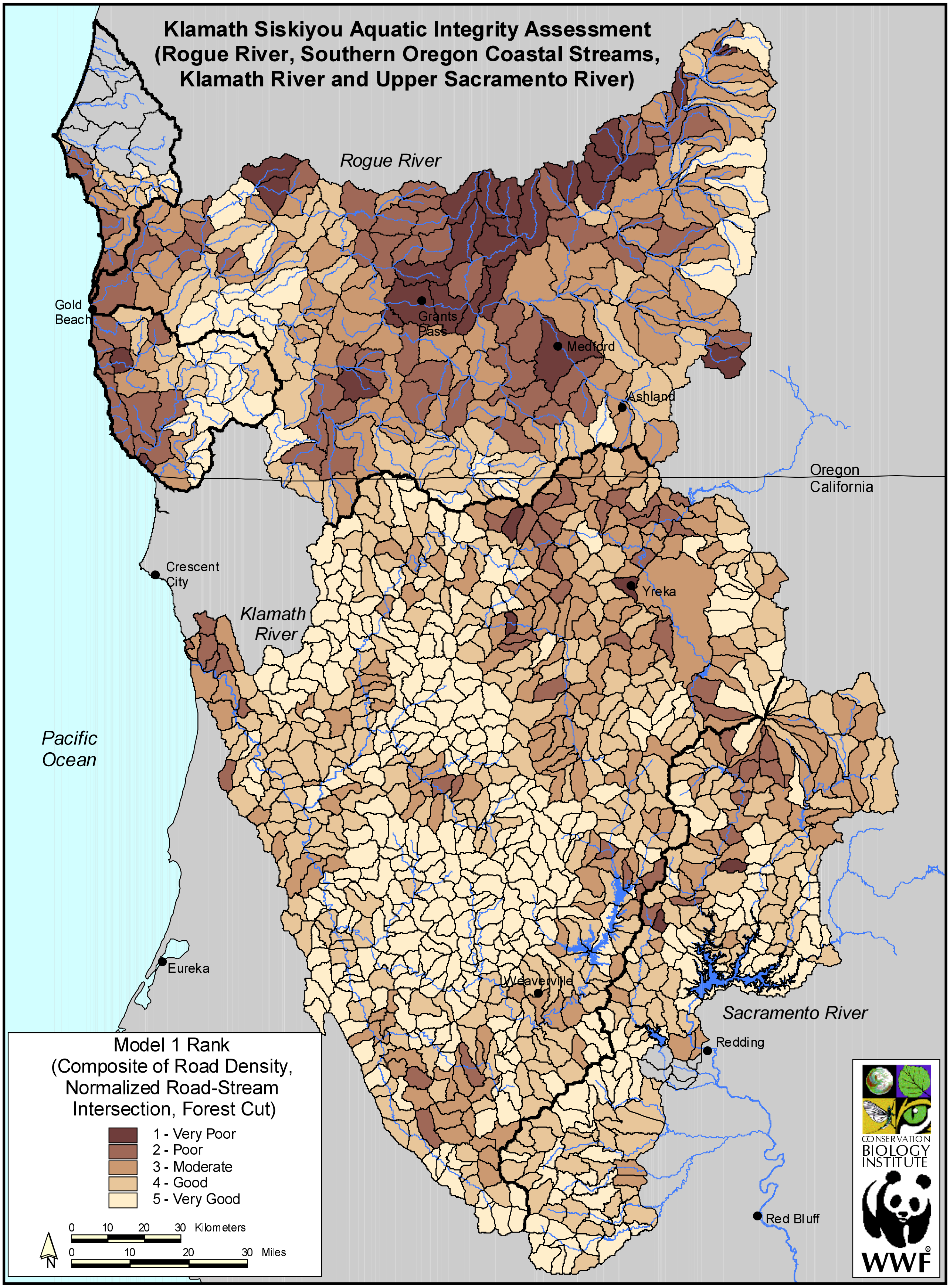

Figure 21. Preliminary Model of Klamath-Siskiyou Aquatic Integrity (Model 1)

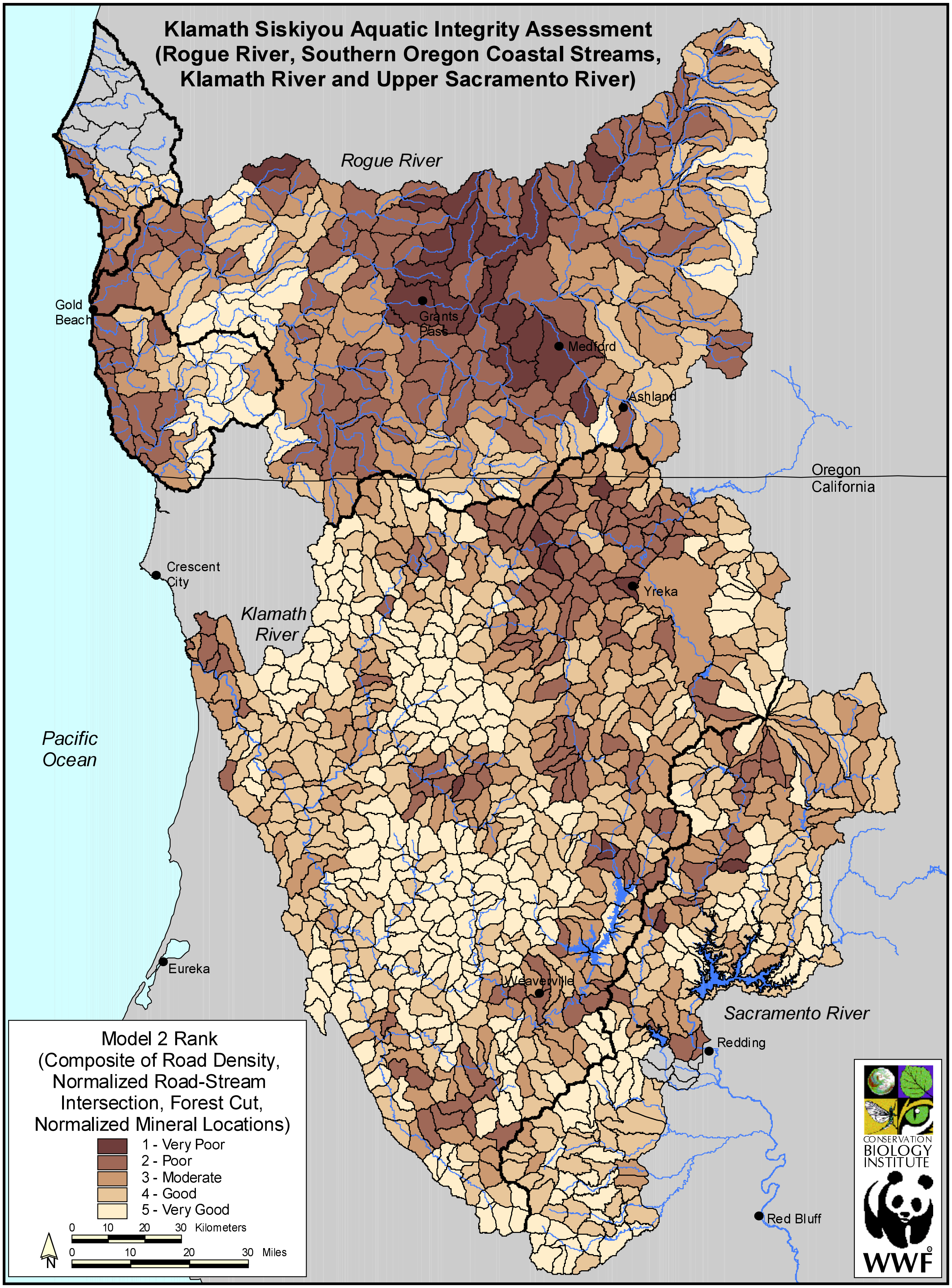

Figure 22. Preliminary Model of Klamath-Siskiyou Aquatic Integrity (Model 2)

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Appendix A

Example of Klamath/Sacramento Planning Watersheds Data Table (ktsmodel1.xls)

KTSMODEL1.XLS	Data Attribute	Attribute Label	Data Example
	Calwater ID Number	IDNUM	1105.310101
	Hydrologic Sub-Area Name	HSANAME	Ukonom (not named)
	Super Planning Watershed Name	SPWSNAME	Elk Creek
	Planning Watershed Name	PWSNAME	Toms Valley Creek
	Coverage ID	KTSCW_MODE	154
	Area (sq. meters)	AREA	28601688
	Area (acres)	ACRES	7067.5
	Area (sq. Km)	SQKM	28.6
	Length of Streams in basin (Km)	STRMLNGTH_	32.0
	Stream Density	STRM_DENS	1.118
	Length of Roads in basin (Km)	RDLNGTH_KM	10.2
	Basins with disconnected streams	CONNECT	0
	large dams (#/basin)	DAMS_	0
Model Data Layers	Road density (m/sq. meter)	RD_DENS	0.357
	road-stream intersections (#/basin)	INTR_RDSTR	11
	normalized road-stream intersections (#/basin)/area	N_INTR_RDS	0.00156
	percent forest cut (cut area/forest area)	P_CUTFORES	0.031
	Mineral Locations (#/basin)	TOTMINES_	1
	normalized mineral locations (#/basin)/area	NORM_MINES	0.000141
Scores	Road density score	RD_SCORE	5
	road-stream intersections score	RDSTRM_SCO	5
	normalized road-stream intersections score	RDSTRM_SCO	5
	forest cut score	FC_SCORE	5
	mineral location score)	M_SCORE	5
	normalized mineral location score	N_MSCORE	5

KTSMODEL1.XLS	Data Attribute	Attribute Label	Data Example
Composite Scores	model 1 score (road density, norm road-stream intersections, forest cut)	SCORE1B	15
	model 2 score (road density, norm. road-stream intersections, forest cut, norm. mineral locations)	SCORE4	20
Auxiliary Data	Minimum elevation	MIN_30M	718
	Maximum elevation	MAX_30M	2111
	Mean elevation	MEAN_30M	1382
	Median elevation	MEDIAN_30M	1390
	Acres Burned 1910-1994	ABURN_1094	1442.2
	Private Land (acres)	A_PRVTLND	0.0
	Public Land (acres)	A_PBLCLND	7067.5
	Strictly Protected (acres)	GAP1ACRES	4879.8
	Moderately Protected (acres)	GAP2ACRES	0.0
	"Minimally Protected (acres)	GAP3ACRES	2187.7
	Not Protected (acres)	GAP4ACRES	0.0
	Forest Service Inventoried Roadless Areas (acres)	A_IRARDLS	2181.4
	CBI Roadless Areas (acres)	A_CBIRDLS	2160.9
	Acres of Serpentine soils	A_SERP	0.0
	Restoration Projects (#/basin)	RESTORE_	0.0
Forest Disturbance 1972-1992	No Data (acres)	A_ND	0.0
	Non Forest (acres)	A_NF	402.1
	Forest Both Dates (acres)	A_FRST	5426.3
	Non Forest 1972, Regrowth 1992 (acres)	A_REGRWTH	89.0
	Forest 1972, Clearcut 1992 (acres)	A_CUT	207.3
	Forest 1972, Burned 1992 (acres)	A_BURN	946.5
	Clouds/Shadows (acres)	A_CLDSHD	0.0
	Water (acres)	A_WATER	1.8
	Forest (acres)	A_FAREA	6669.0

KTSMODEL1.XLS	Data Attribute	Attribute Label	Data Example
Forest Cover (Landsat 2000 ETM+ imagery)	Old Conifer Forest (acres)	A_OCF	2429.8
	Mature Conifer Forest (acres)	A_MCF	2351.8
	Old + Mature Conifer Forest (acres)	A_OMCF	4781.6
	Young Conifer Forest (acres)	A_YCF	483.9
	Young Regenerating Forest (acres)	A_YRF	75.8
	Young Conifer + Regenerating Forest (acres)	A_YCRF	559.7
	Broadleaf Forest (acres)	A_BF	276.9
	Open Forest (acres)	A_OF	110.5
	All Forest (acres)	A_ALLF	5728.7
	Non Forest (acres)	A_NF2000	730.3
	Water (acres)	A_WTR	6.9
	Shadow/Clouds (acres)	A_SHDCLD	604.5
	Total Acres	A_TA2000	7070.4
Forest Cover 2000 (200m buffer analysis)	Acres of Old Conifer Forest in Buffer	BUFA_OCF	1077.7
	Acres of Mature Conifer Forest in Buffer	BUFA_MCF	1093.9
	Acres of Old + Mature Conifer Forest in Buffer	BUFA_OMCF	2171.6
	Acres of Young Conifer Forest in Buffer	BUFA_YCF	163.9
	Acres of Young Regenerating Forest in Buffer	BUFA_YRF	28.5
	Acres of Young Conifer and Regenerating Forest in Buffer	BUFA_YCRF	192.4
	Acres of Broadleaf Forest in Buffer	BUFA_BF	95.0
	Acres of Open Forest in Buffer	BUFA_WOF	23.6
	Acres of Total Forest in Buffer	BUFA_ALLF	2482.6
	Acres of Non Forest in Buffer	BUFA_NF	135.7
	Acres of Water in Buffer	BUFA_WATER	3.6
	Acres of Shadow/Clouds in Buffer	BUFA_SC	266.2
	Total Acres	BUFA_TOTAL	2888.0

Appendix B

Example of Rogue/Southern Oregon/Klamath/Sacramento Planning Watershed and Sixth Field HUs Data Table (rbkts_ksmodel2.xls)

RBKTS_KSMODEL2.XLS	Data Attribute	Attribute Label	Data Example
	Calwater ID Number	ID_NUM	No number (1105.310101)
	6th field hydrologic unit code	HUC_6	171003070101
	area (sq. meters)	AREA	81278725.234
	area (acres)	ACRES	20083.974
Model Data	road density (m/sq. meter)	RD_DEN	1.095090
	road-stream intersections (#/basin)	INTR	88
	percent forest cut (cut area/forest area)	PCUT	0.94
	mineral locations (#/basin)	MINES	0
	normalized road-stream intersections (#/basin)/area	N_INTR	0.004382
	normalized mineral locations (#/basin)/area	N_MINES	0.000000
Scores	road density score	RD_SCORE	4
	normalized road-stream intersections score	NI_SCORE	4
	forest cut score	FC_SCORE	5
	normalized mineral location score	NM_SCORE	5
Composite Scores	model 1 score (road density, norm road-stream intersections, forest cut)	ORIG_SCORE	13
	model 2 score (road density, norm. road-stream intersections, forest cut, norm. mineral locations)	SCORE2	18