Fire & Fish

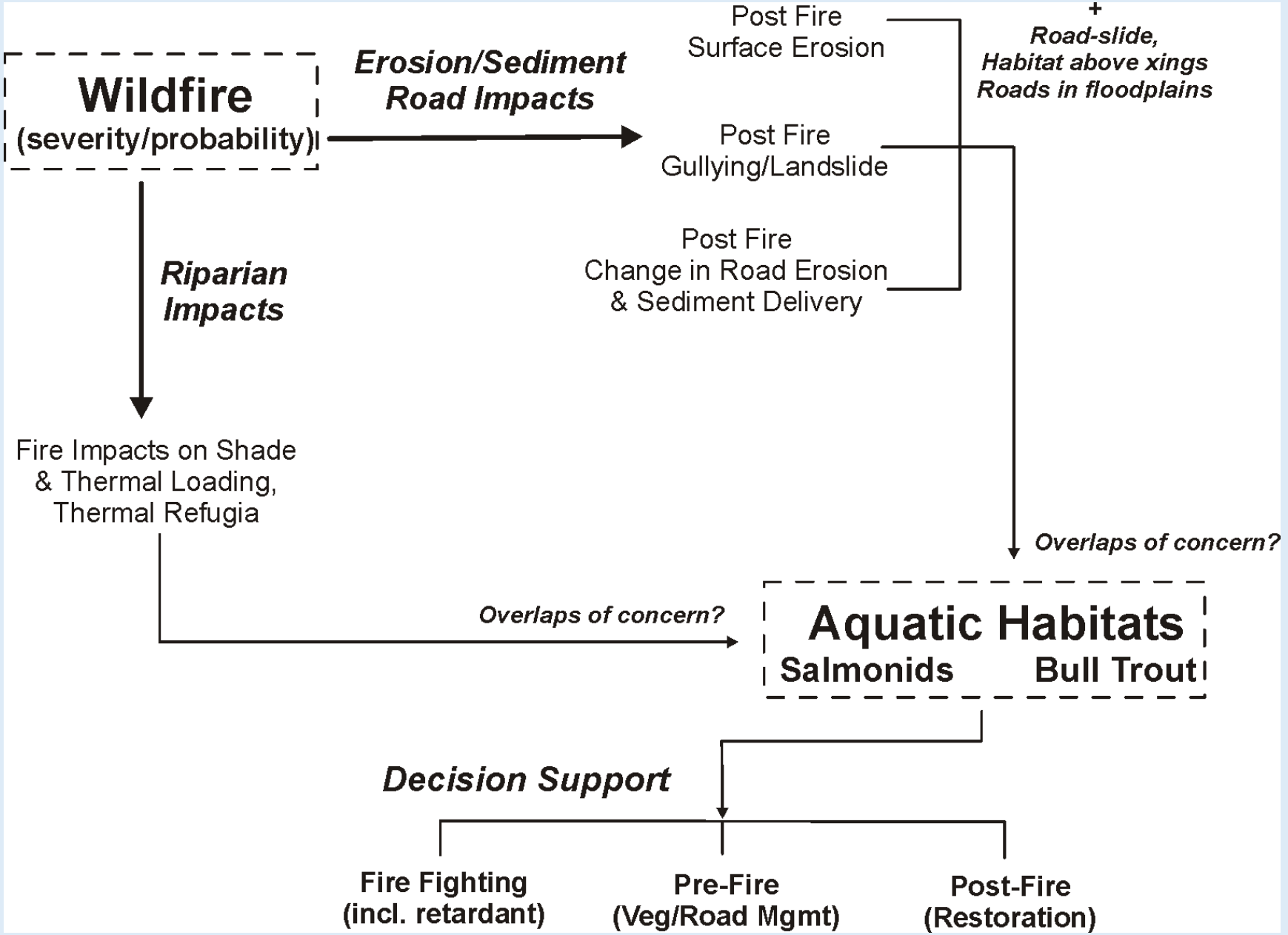
Decision Support for Pre Fire, Fire Fighting and Post Fire

(Pilot Project, Malheur National Forest, Eastern Oregon)

TerrainWorks (NetMap), in Collaboration with US Forest Service, PNW Corvallis and Malheur National Forest

Summer, 2015

Approach


Wildfire
(severity/probability)
Erosion/Sediment
Road Impacts
Post Fire
Surface Erosion
+
Road-slide,
Habitat above xings
Roads in floodplains
Post Fire
Gullying/Landslide
Post Fire
Change in Road Erosion
& Sediment Delivery
Riparian
Impacts
Fire Impacts on Shade
& Thermal Loading,
Thermal Refugia
Overlaps of concern?
Overlaps of concern?
Aquatic Habitats
Salmonids
Bull Trout
Decision Support
Fire Fighting
(incl. retardant)
Pre-Fire
(Veg/Road Mgmt)
Post-Fire
(Restoration)

Pre Fire Management Activities	Data layers	Purpose
Forest Restoration (fuels reduction, thinning including in riparian zones, prescribed burns)	-Fire severity and fire probability -Post fire surface erosion -Post fire landslide/gully erosion -Fish habitats -Thermal refugia (impacts to)	-Reduce potential for post fire erosion and sediment delivery to streams (impacts on sensitive fish habitats) -Protect critical fish-riparian habitats (key habitats, refuges)
Road Restoration (upgrade surfacing, increase drains, improve stream crossings, storage, decommissioning)	-Road surface erosion & sediment delivery potential (fire impacts on increased sediment delivery potential) -Road instability potential/fire increased -Roads in floodplains -Cumulative habitat above roads crossings	-Reduce potential for post fire erosion and sediment delivery (also in non-fire conditions) -Reduce potential for road related landsliding/gullying -Remove fish barriers
Firefighting	**Data layers**	**Purpose**
Firefighting, including retardant use	-All stream buffered (300') - avoidance -Perennial stream buffered only - avoidance -Identify high value aquatic/riparian – non avoidance	-Avoid retardant pollution in surface waters -Protect critical aquatic/riparian habitats
Post Fire Management Activities (BAER)	**Data layers**	**Purpose**
Land surface restoration (mulching, surface disturbance, planting)	Same data layers as above for Forest Restoration, except in a post fire environment (using BARC maps)	Similar purpose to Forest Restoration except in a post fire environment
Road restoration (upgrade surfacing, increase drains, improve stream crossings, storage, decommissioning)	Same data layers as above for Road Restoration, except in a post fire environment (using BARC maps)	Similar purpose to Road Restoration except in a post fire environment

Models and Sources

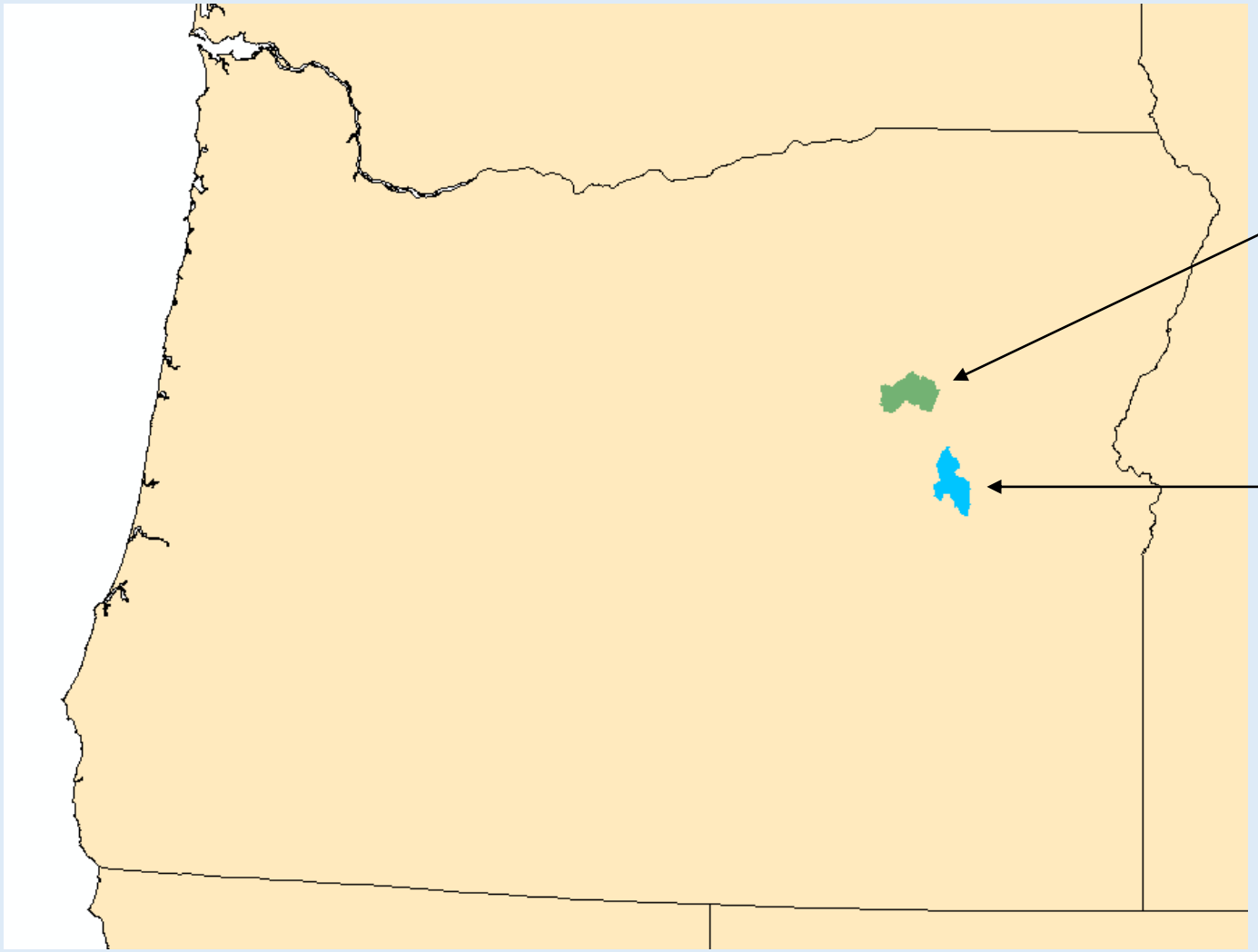
DEMs – LiDAR and 10 m
Synthetic River Networks (stream layers) NetMap (www.terrainworks.com)
Fire severity and probability (Flammap)
Post fire surface erosion (WEPP – Disturbed)
Post fire gully potential (Parker et al. 2010)
Post fire landsliding/gullying (Miller and Burnett 2007, 2008, NetMap)
Post fire road surface erosion and sediment delivery (GRAIP-Lite w/ modified sediment delivery)
Bull Trout Habitat (NorWest and US Forest Service stream layer)
Salmon habitat (Intrinsic Potential Chinook and steelhead, Burnett et al. 2007)
Shade/thermal loading/thermal refugia (NetMap and Groom et al. 2011)
Road – stability (NetMap)
Cumulative habitat length above roads (NetMap)

Refer to NetMap's online technical help manuals for additional information

Data Deliverables

Data Type	Raster	Road	Polygon	Reach Segment	Reach, routed	Aggregated HUC 6th Polygon
1) Fire severity	X			X	X	X
2) Fire probability	X			X	X	X
3) Bull trout/Redband presence				X		X
4) Salmon intrinsic potential (chinook, steelhead, coho)				X	X	X
5) Post fire surface erosion (WEPP-Disturbed)	X			X	X	X
6) Post fire landslide potential	X			X	X	X
7) Post fire gully potential						
8) Current shade-thermal energy/thermal refugia (LEMMA)				X	X	X
9) Post fire shade-thermal energy/thermal refugia (LEMMA reduced)				X	X	X
10) Thermal difference (sensitivity) map (#5 –# 6)				X	X	X
11) Road Sediment production		X		X	X	X
12) Road sediment delivery (no fire)		X		X	X	X
13) Road sediment delivery difference (no fire-fire)		X		X	X	X
14) Cumulative habitat length above road crossings				X		
15) Road – landslide/gully potential		X				
16) Retardant no go – all channels buffererd			X			
17) Retardant no go – ephemeral channels removed			X			

Pilot Areas

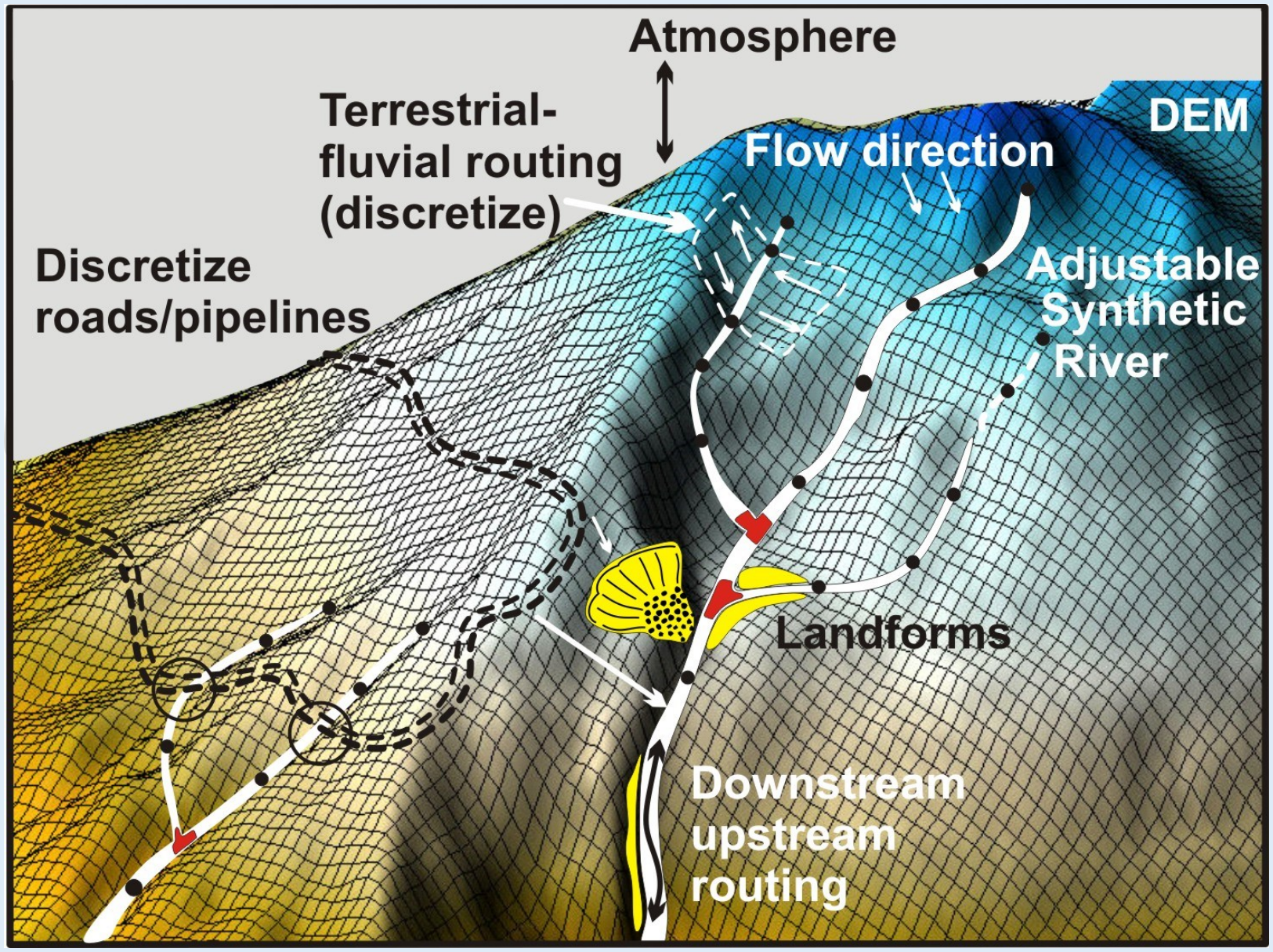


Camp Creek watershed
(1 m LiDAR DEM)

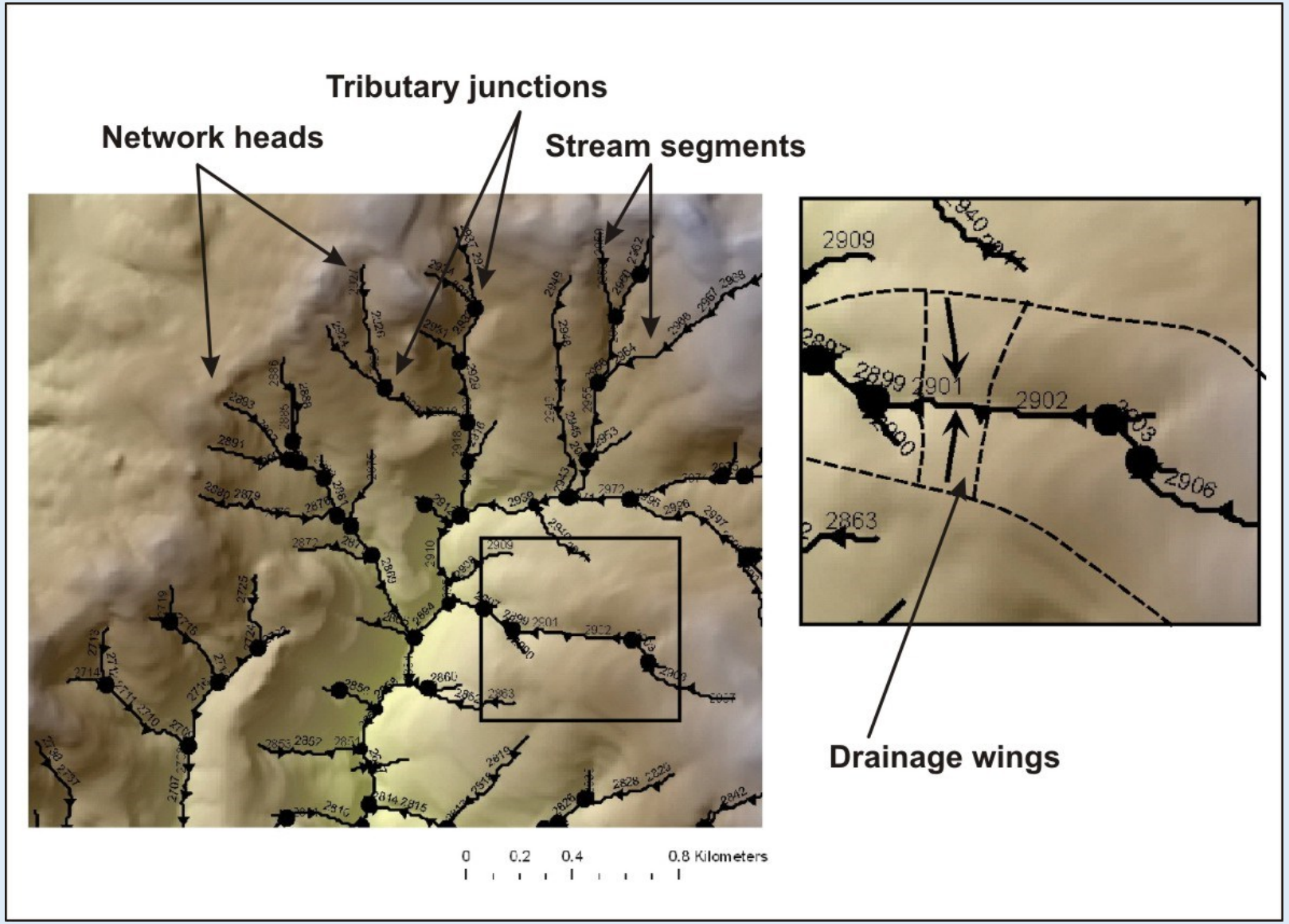
Upper North Fork Malheur
(10 m DEM)

The analysis depends on NetMap's synthetic river network and virtual watersheds

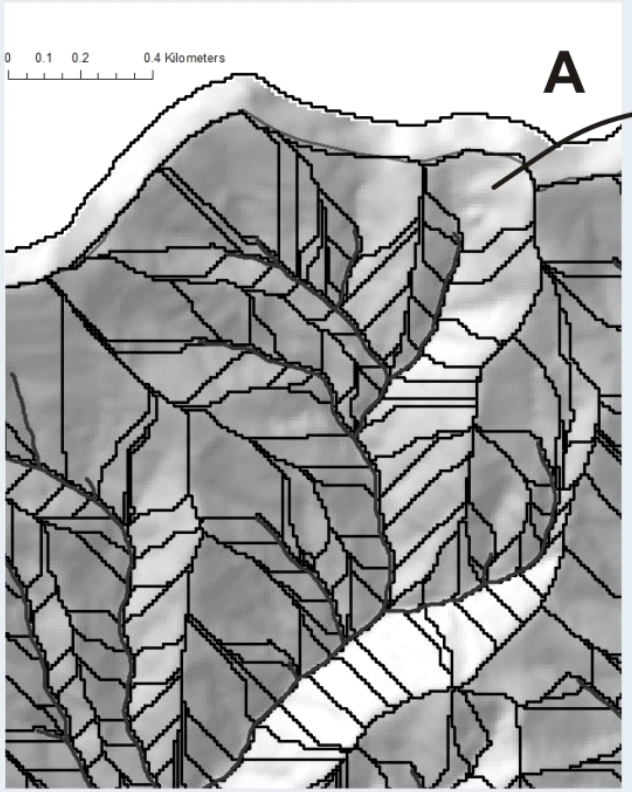
Go to www.terrainworks.com to learn about how synthetic river networks and virtual watersheds are built, and their capabilities

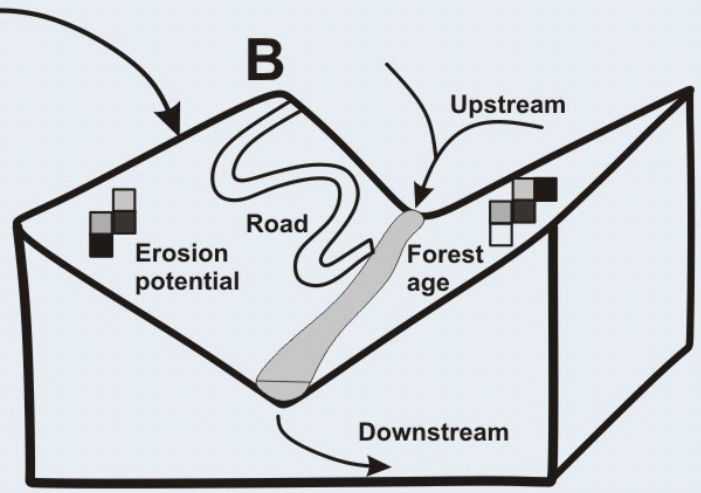


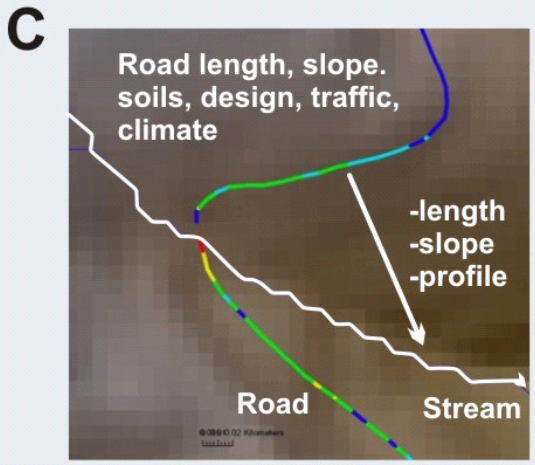
The fire and fish analysis requires that terrestrial information (on hillsides) be transferred to channel networks, so that fire related stressors (erosion, roads) can be directly linked to fish habitats, at the scale of individual channel segments.



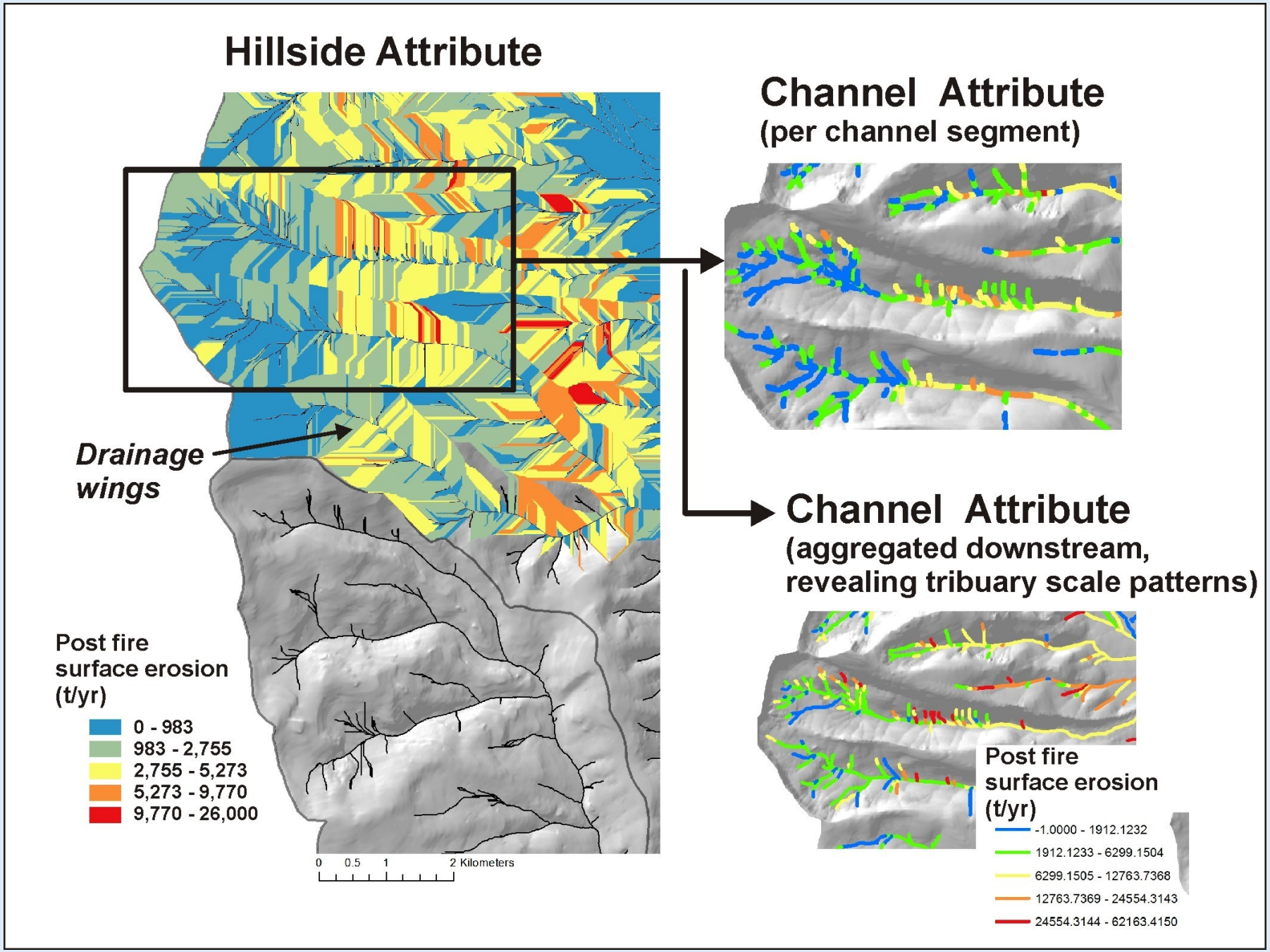
Drainage wings (discretize landscapes and land uses)



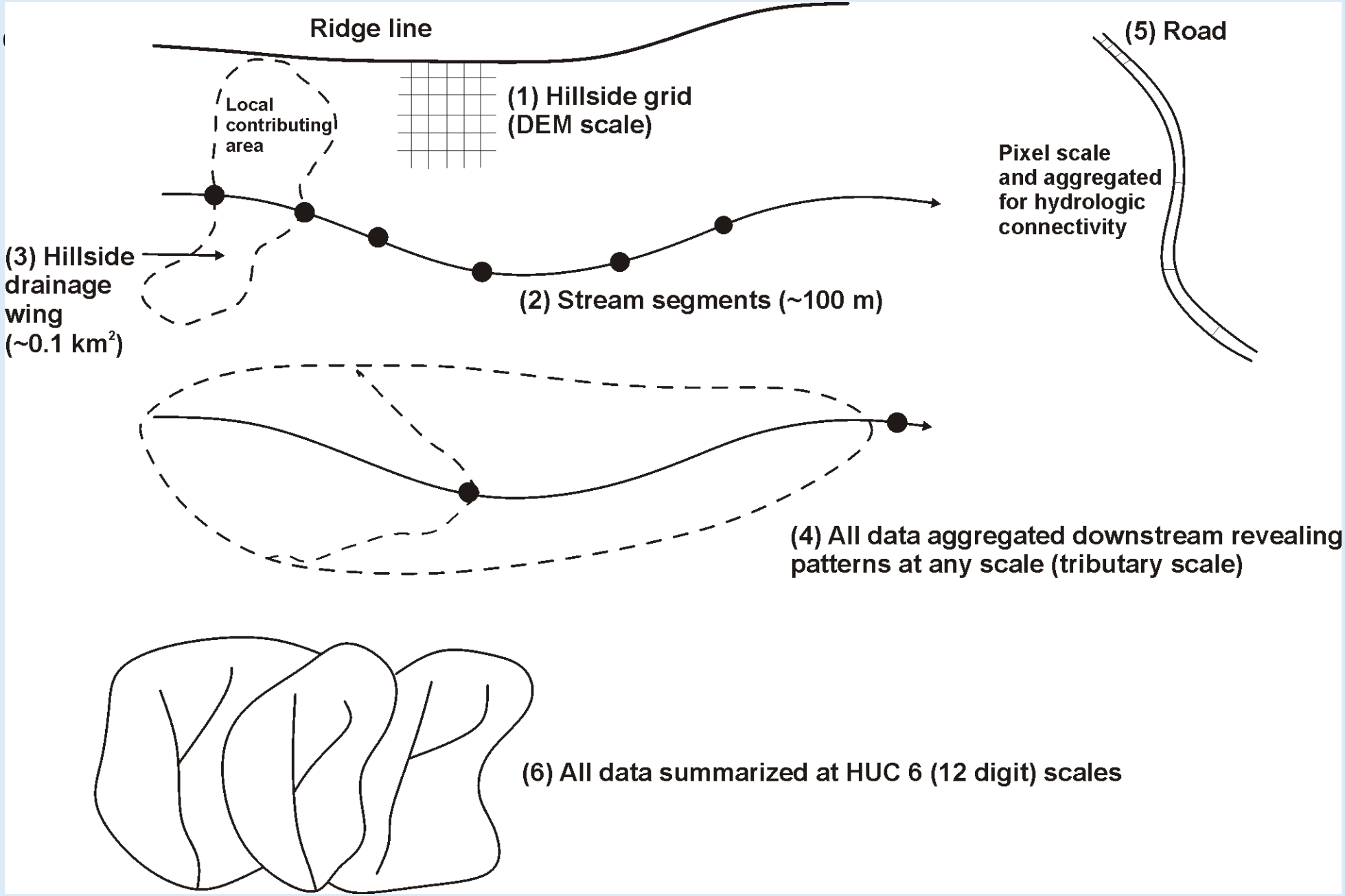




An example about how a hillside attribute (post fire erosion) is transferred to individual channel segments, and aggregated downstream

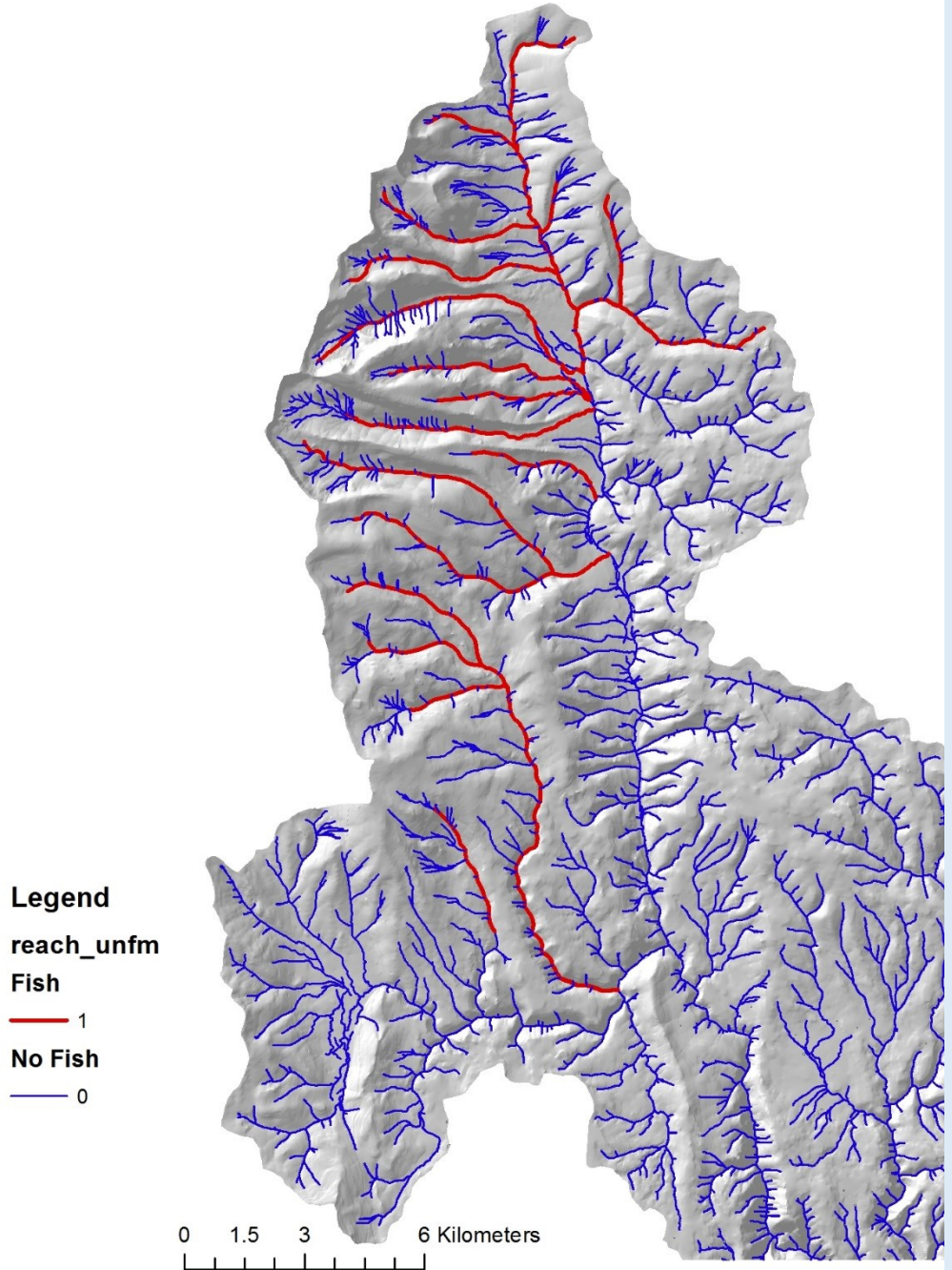


Data spatial scal

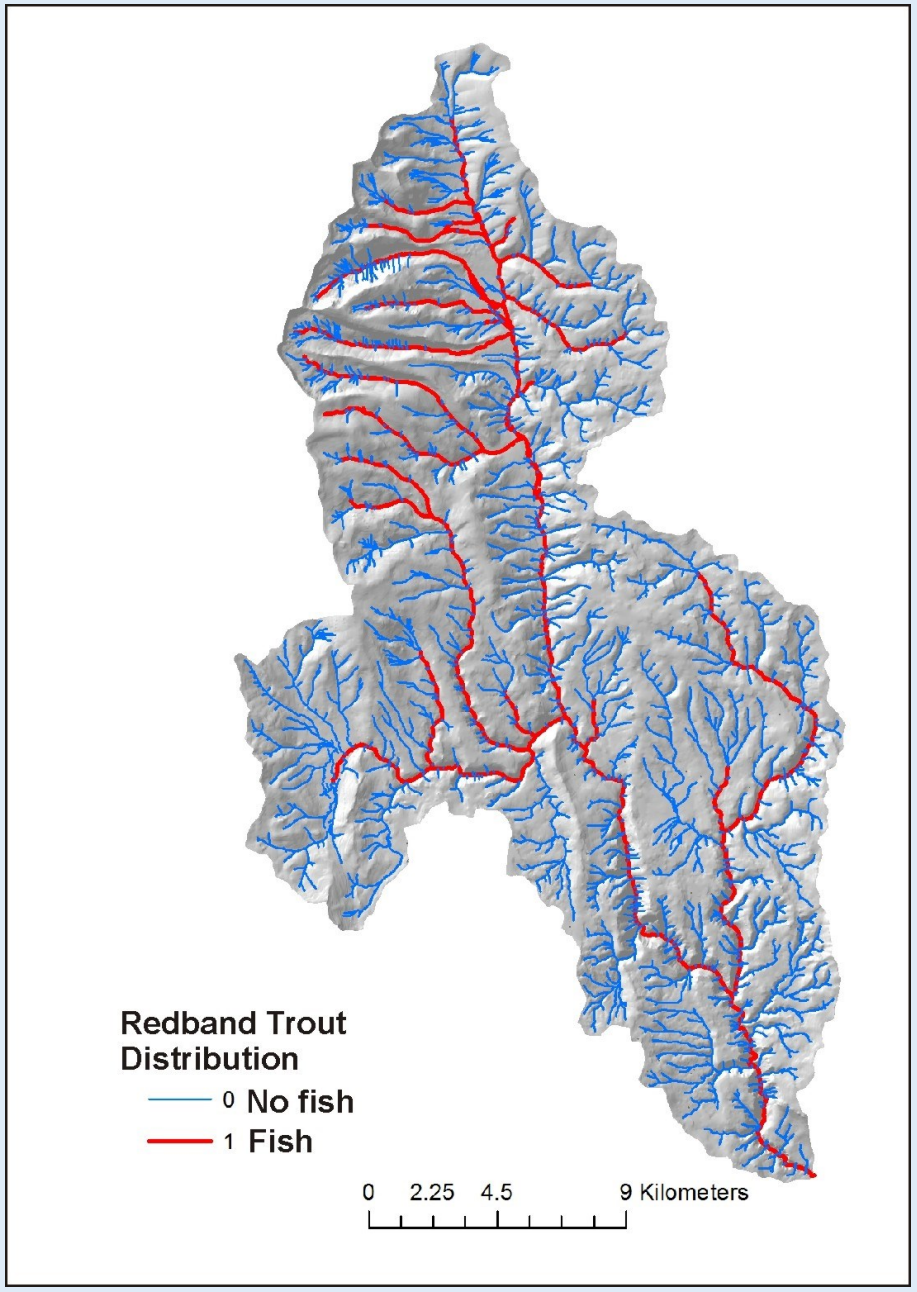


Data Deliverable: Fish Habitat

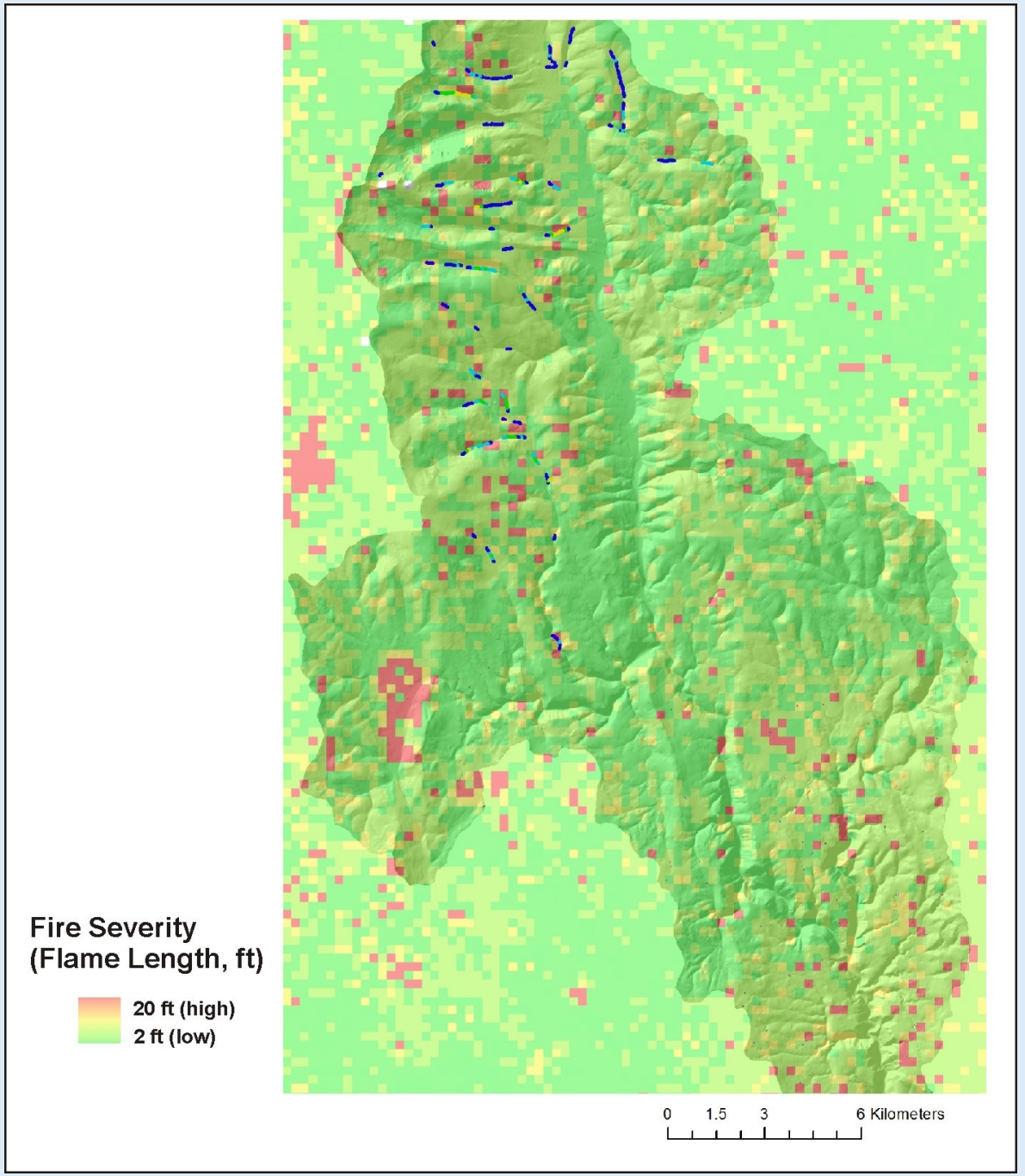
Bull Trout (*Salvelinus confluentus*)



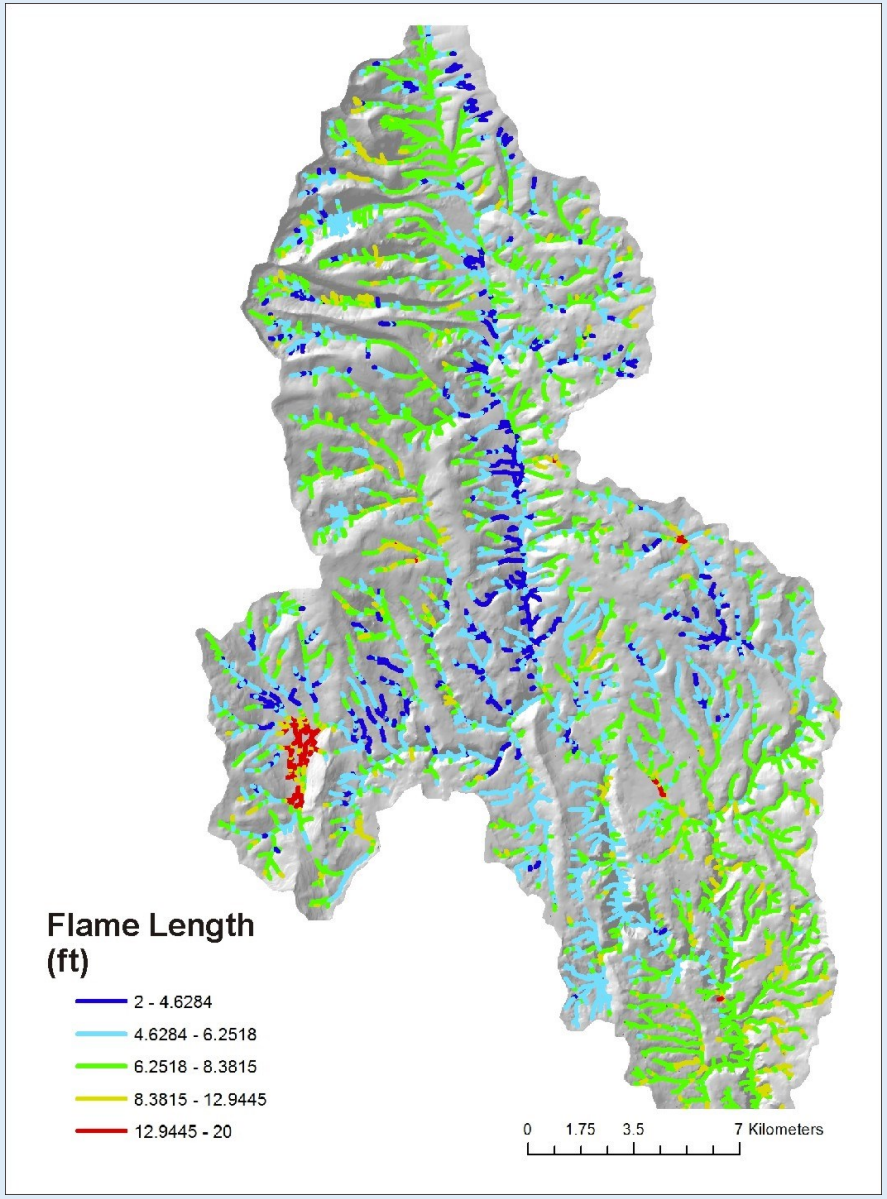
Fish Habitat: Redband Trout (subspecies of *Oncorhynchus mykiss)*



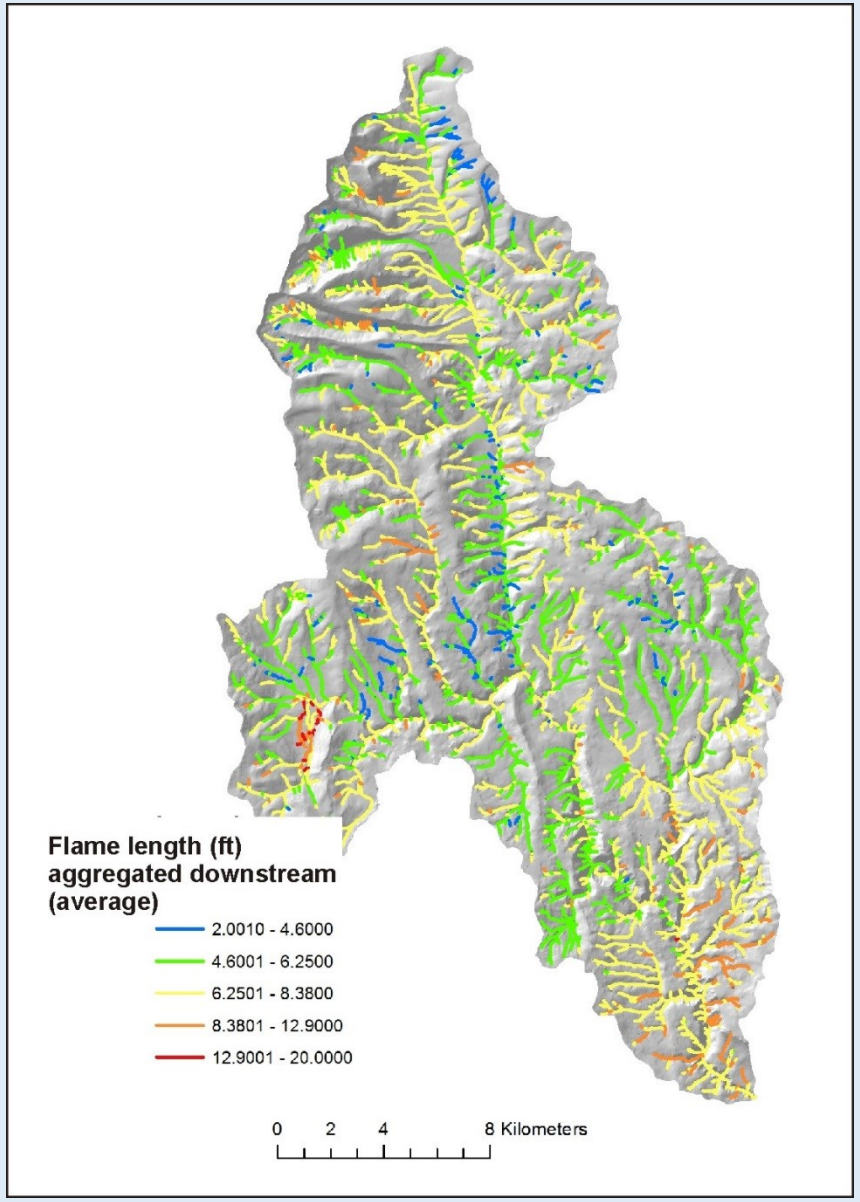
Data Deliverables
Fire Severity (hillside, Flammap)



Fire Severity (channel, fish eye)



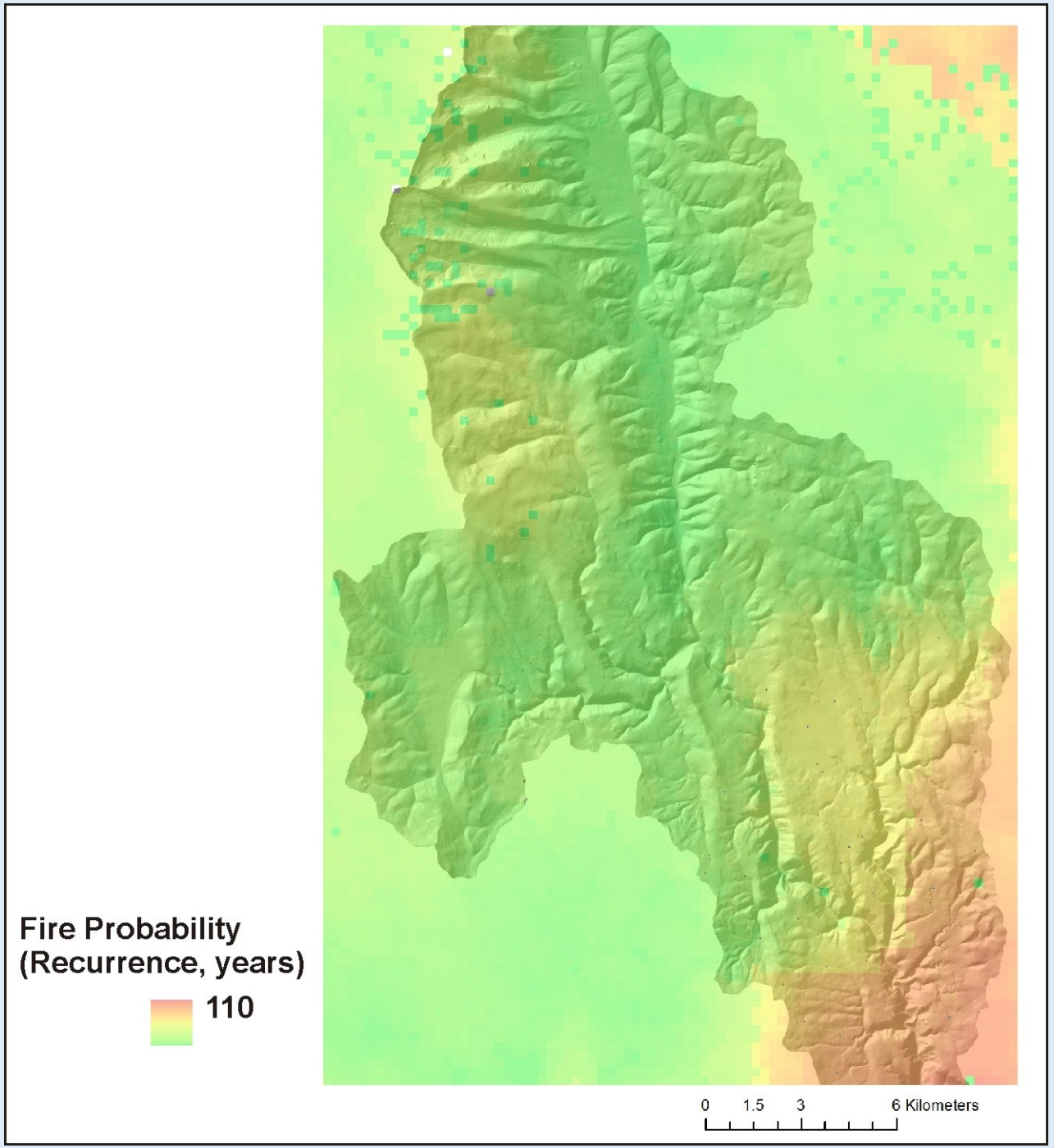
Fire Severity, Aggregated Downstream (tributary scale patterns)



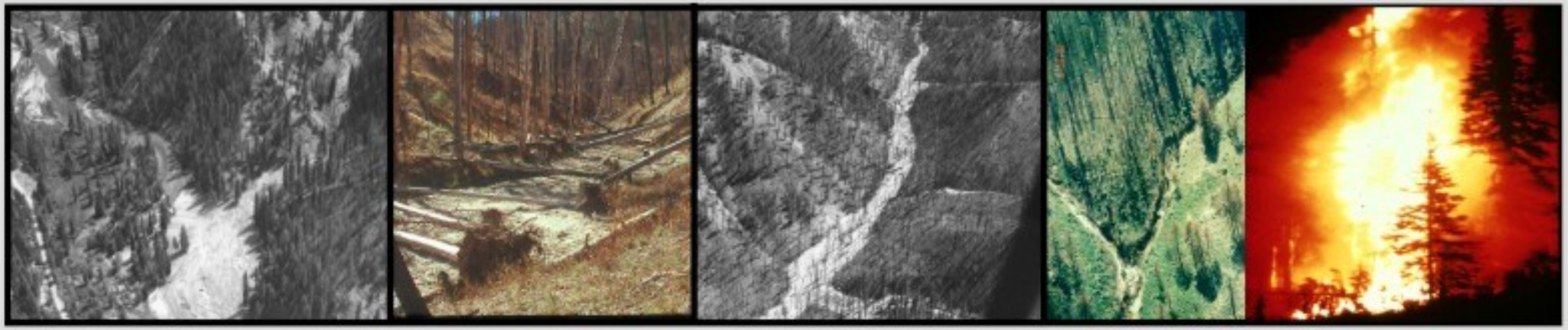
Why are hillslope attributes reported to channels, via drainage wings?

This facilitates comparing hillslope related stressors (fire severity, erosion, roads etc.) to fish habitats, a channel attribute.

Fire Probability

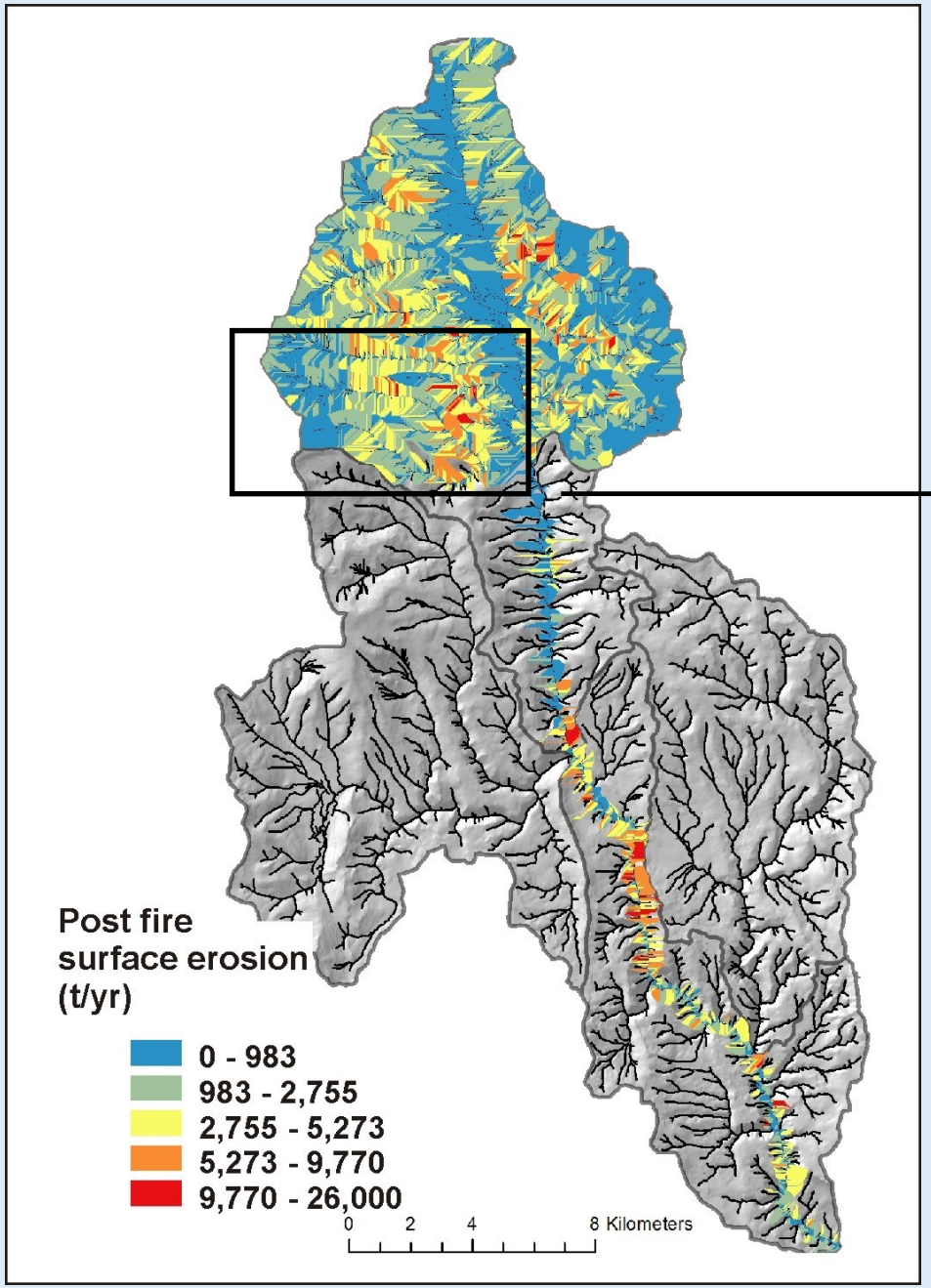


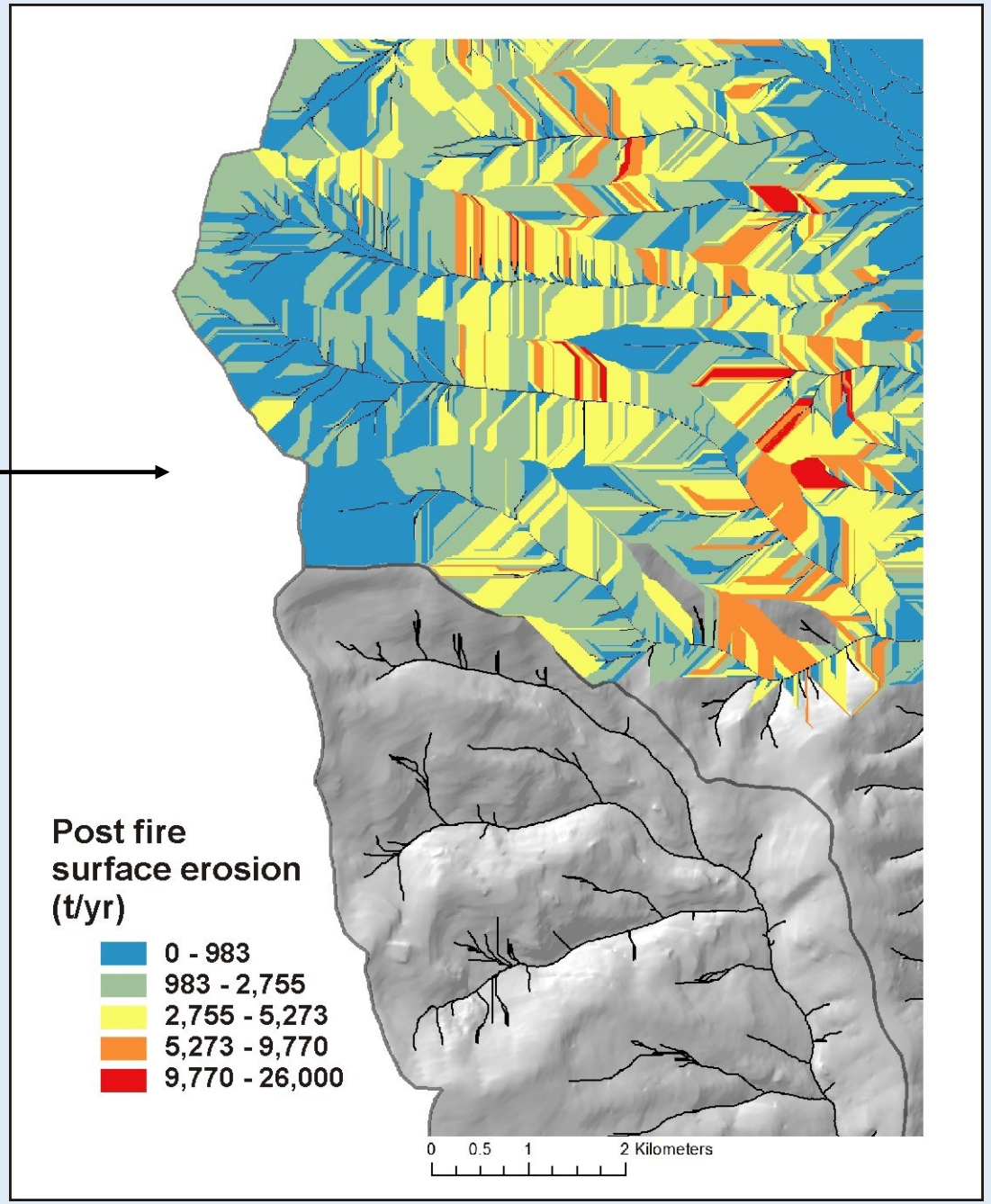
Fire Cascade Impacts on Aquatic Ecosystems



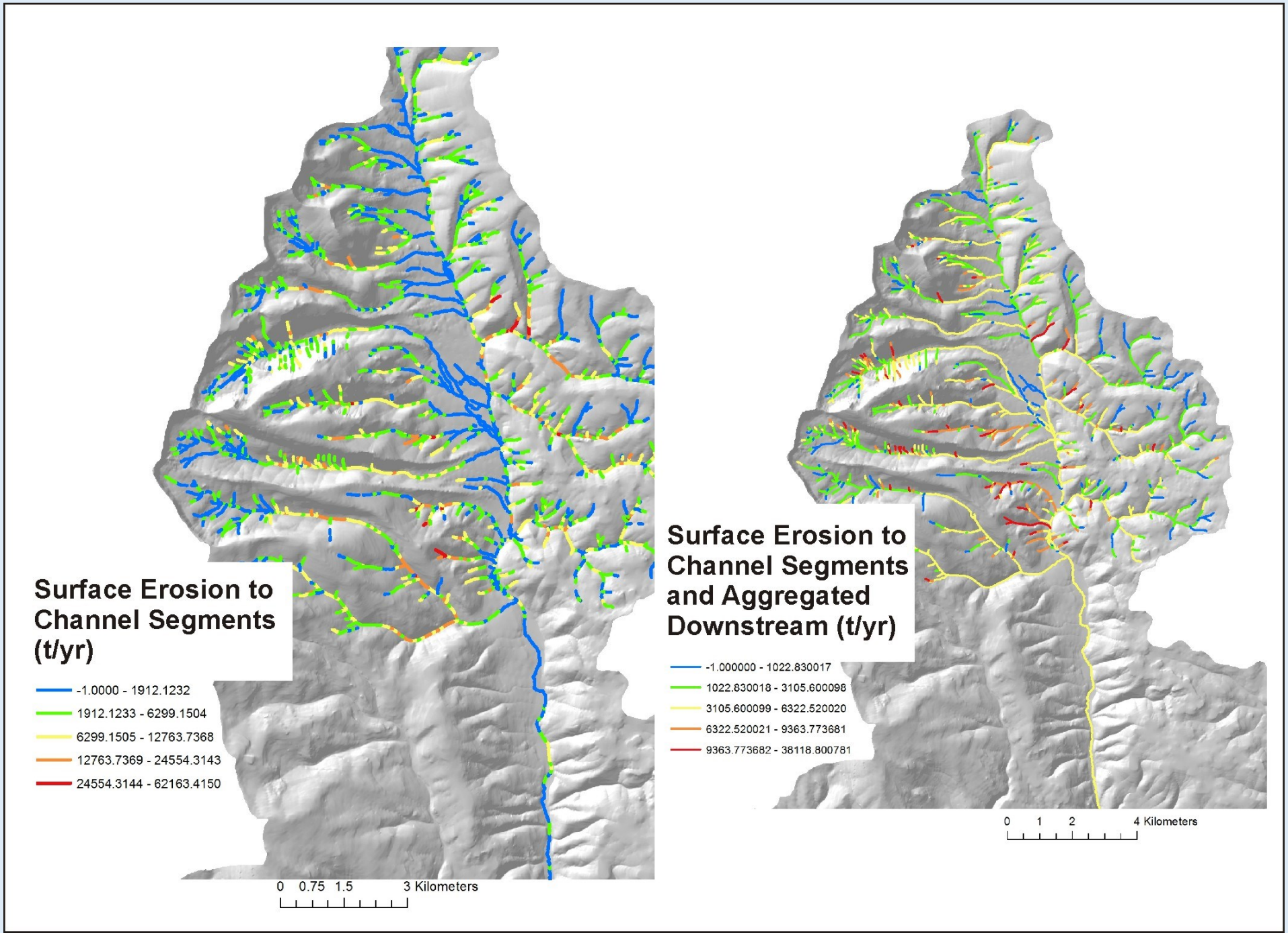
Fisheries/ Water Quality Impacts ← **Sedimentation** ← **Post Fire Erosion**

Post Fire Surface Erosion (WEPP, disturbed)

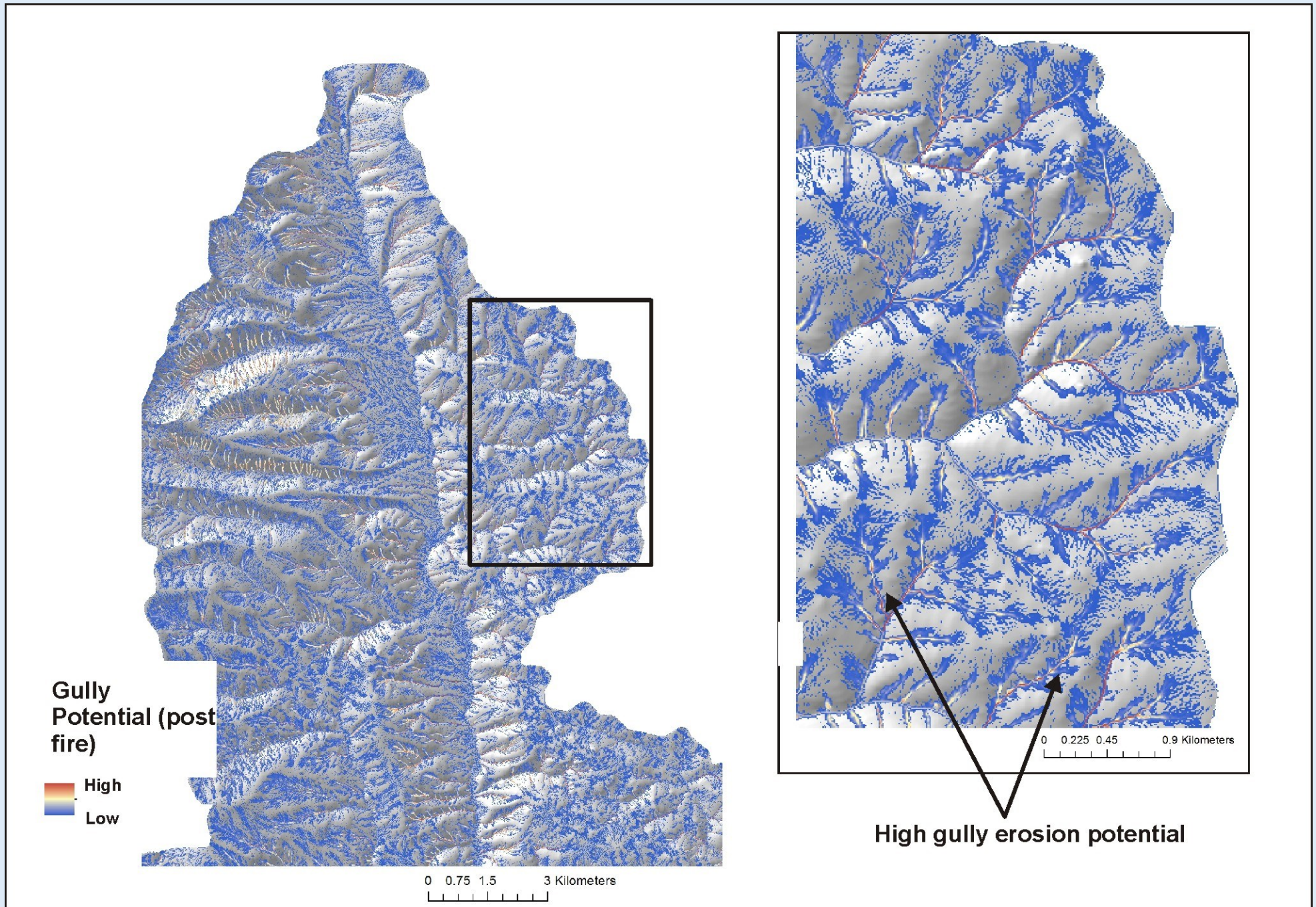




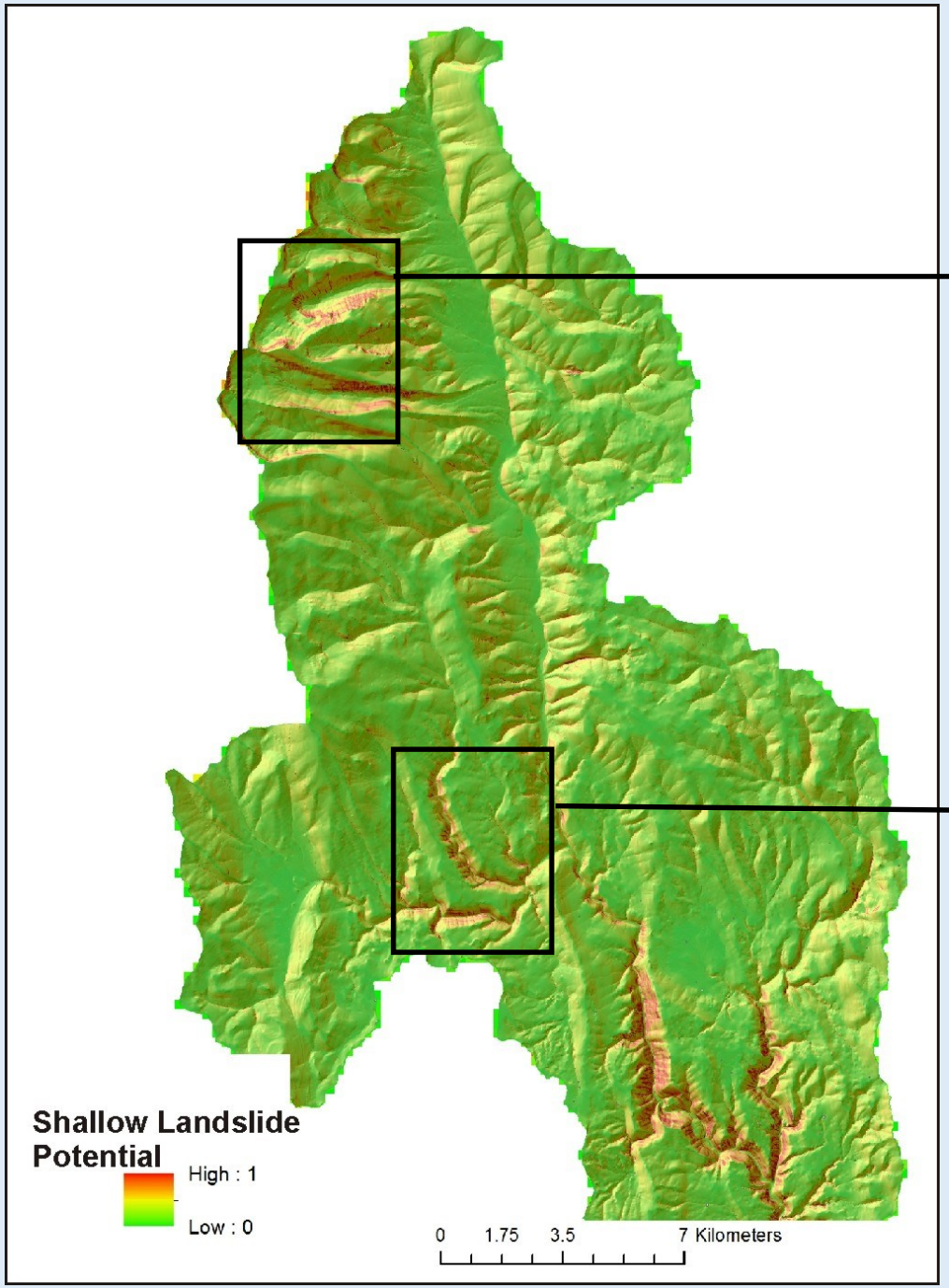
Post Fire Surface Erosion (WEPP, disturbed, e.g., function of fire severity) reported to stream channels and aggregated downstream

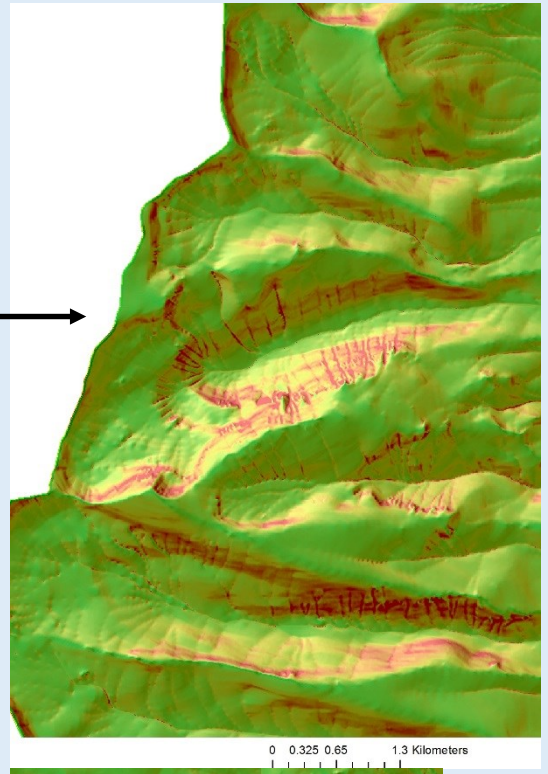


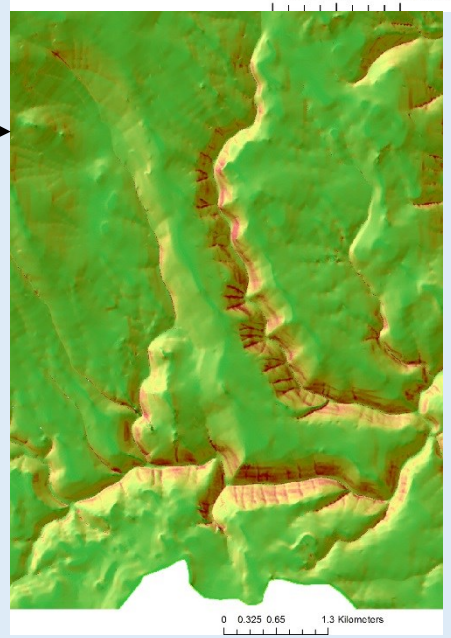
Post Fire Gully Potential



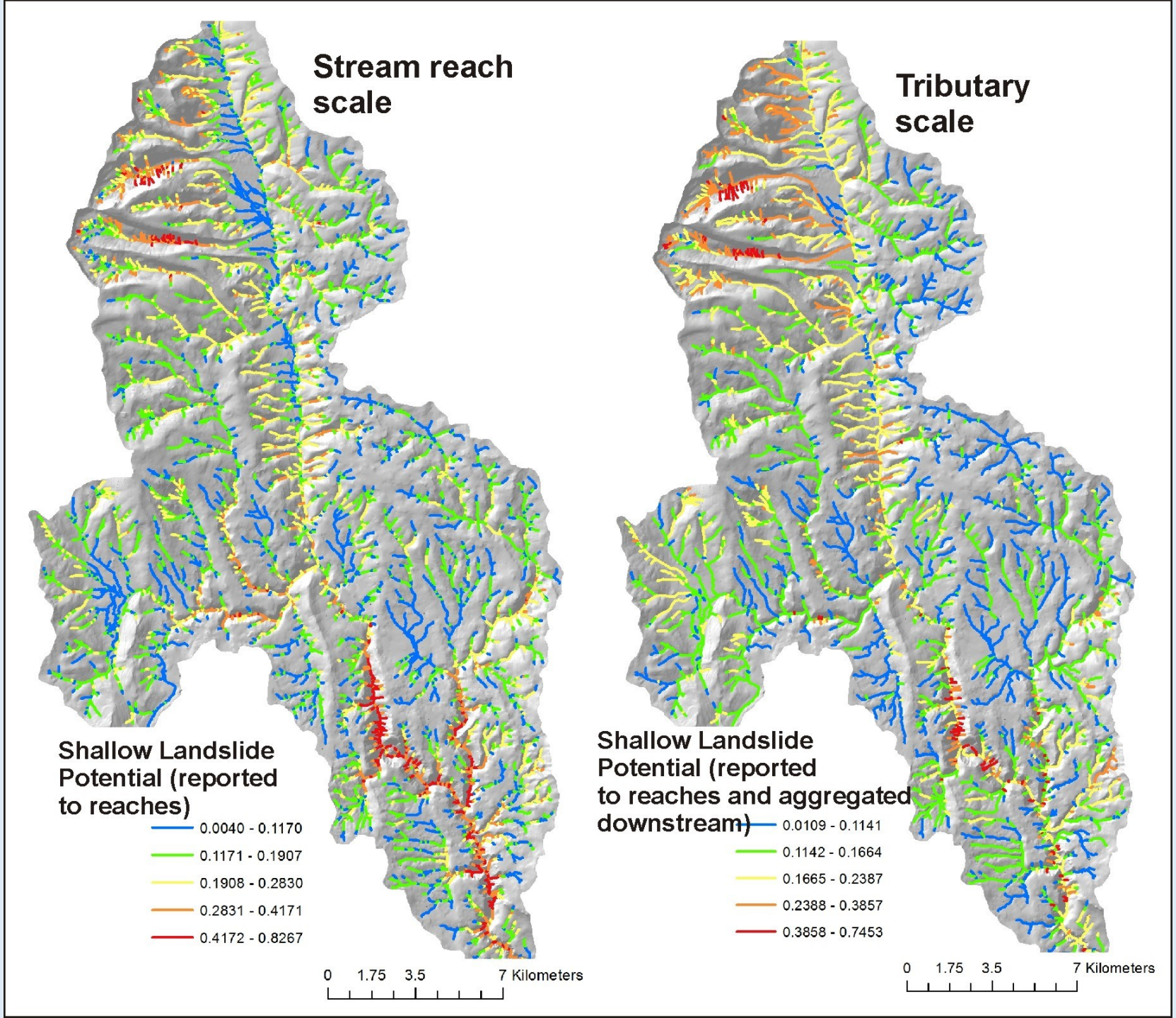
Shallow Landslide-Debris Flow Potential







Shallow landslide potential reported to channel segments and aggregated downstream



Road Surface Erosion and Sediment Delivery to Streams, Post Fire

Post Fire Road Surface Erosion (Sediment Production)

GRAIP-Lite model of road surface erosion (in NetMap)

(USFS, Rocky Mountain Research Station, Boise ID)

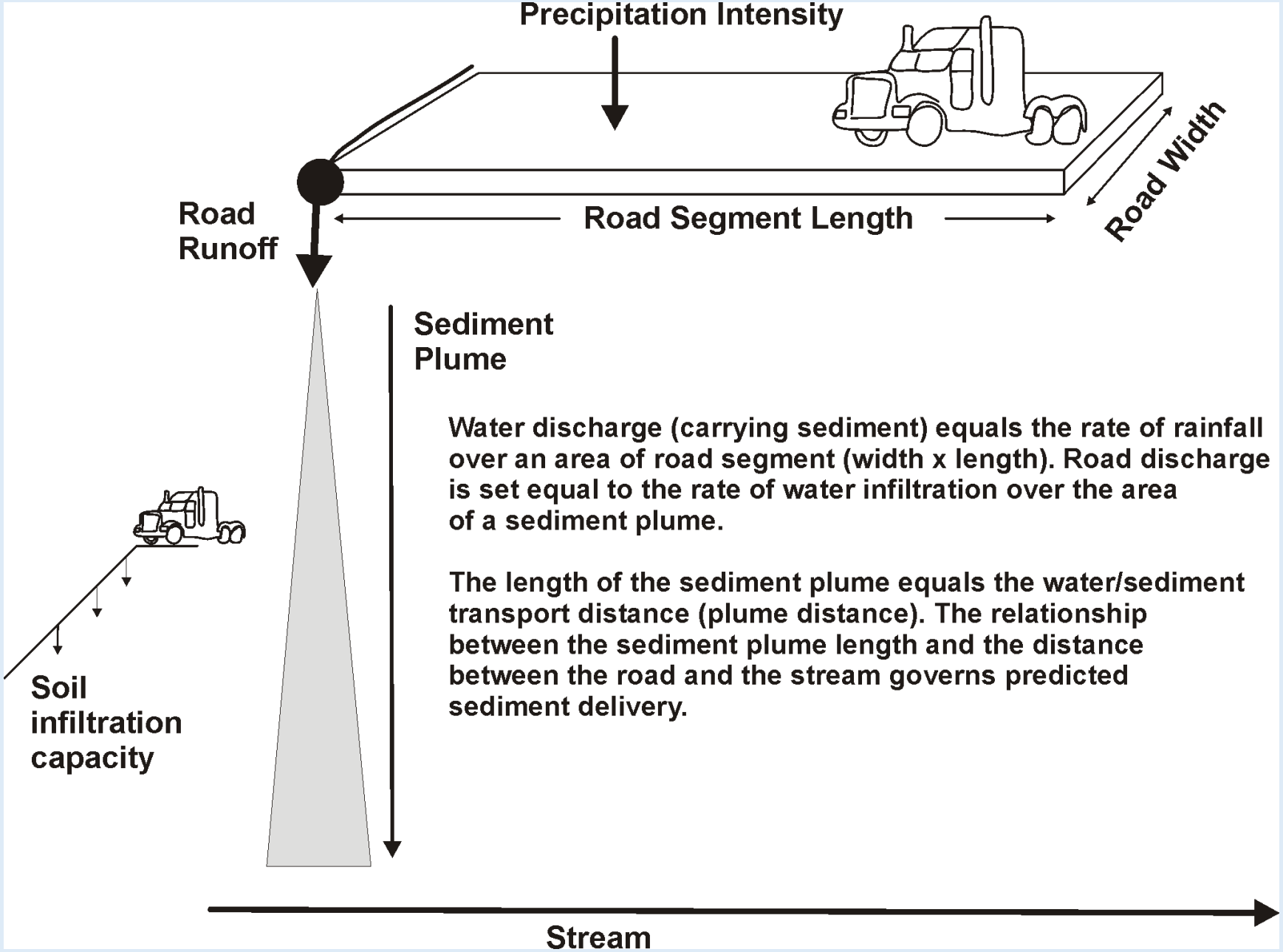
$$E = B * R * S * V$$

where E is road sediment production to streams (kg/yr), B is the "base" surface erosion rate (empirical), R is the elevation difference between the road segment end points (length), S is the road surface factor and V is the vegetation factor.

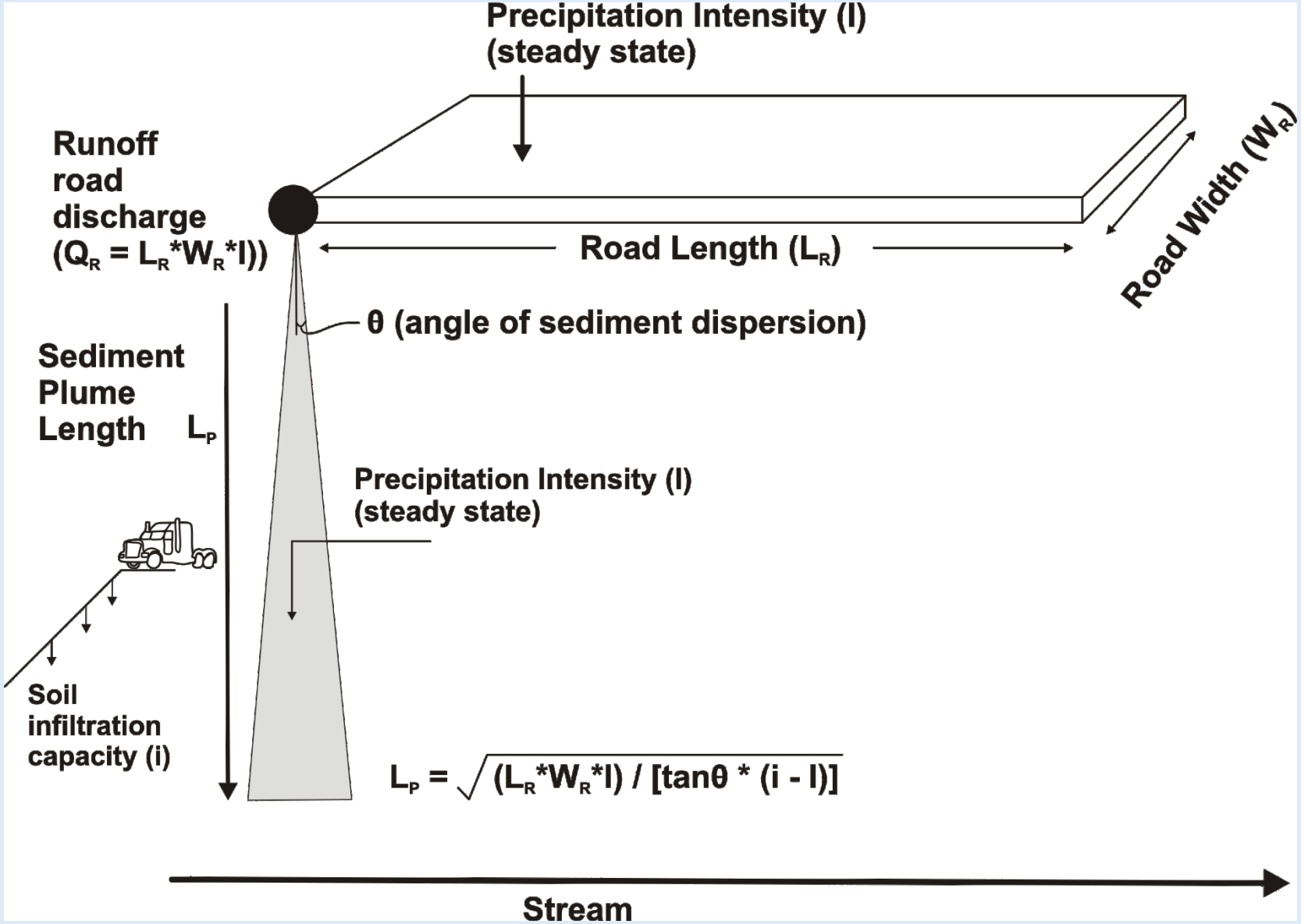
V = 1 – 0.86x, where x is the fraction of the road length where flow path vegetation (ditch) is greater than 25%; R (elev. diff) is slope x road segment (hydrologic) length.

- Example base rates:
- Oregon Coast Range = 79 kg/yr
- Idaho Batholith = 33 kg/yr
- Montana (Belt sedimentary) = 7 kg/yr
- Eastern Oregon (Umatilla, Basalt) = 1.5 kg/kg
- Eastern Sierra (SPI) = 11 kg/yr

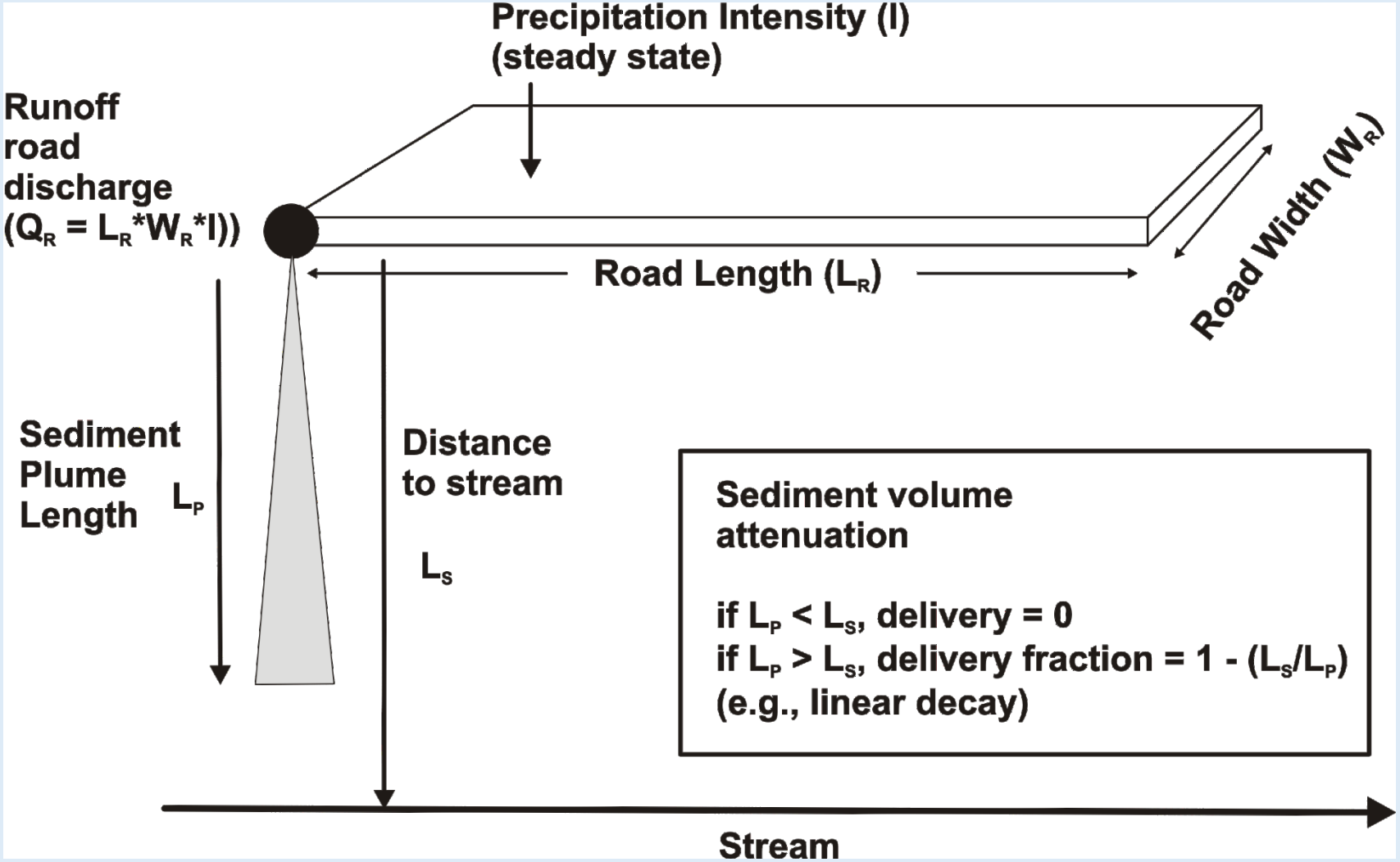
Road sediment delivery to streams (NetMap - conservation of mass)



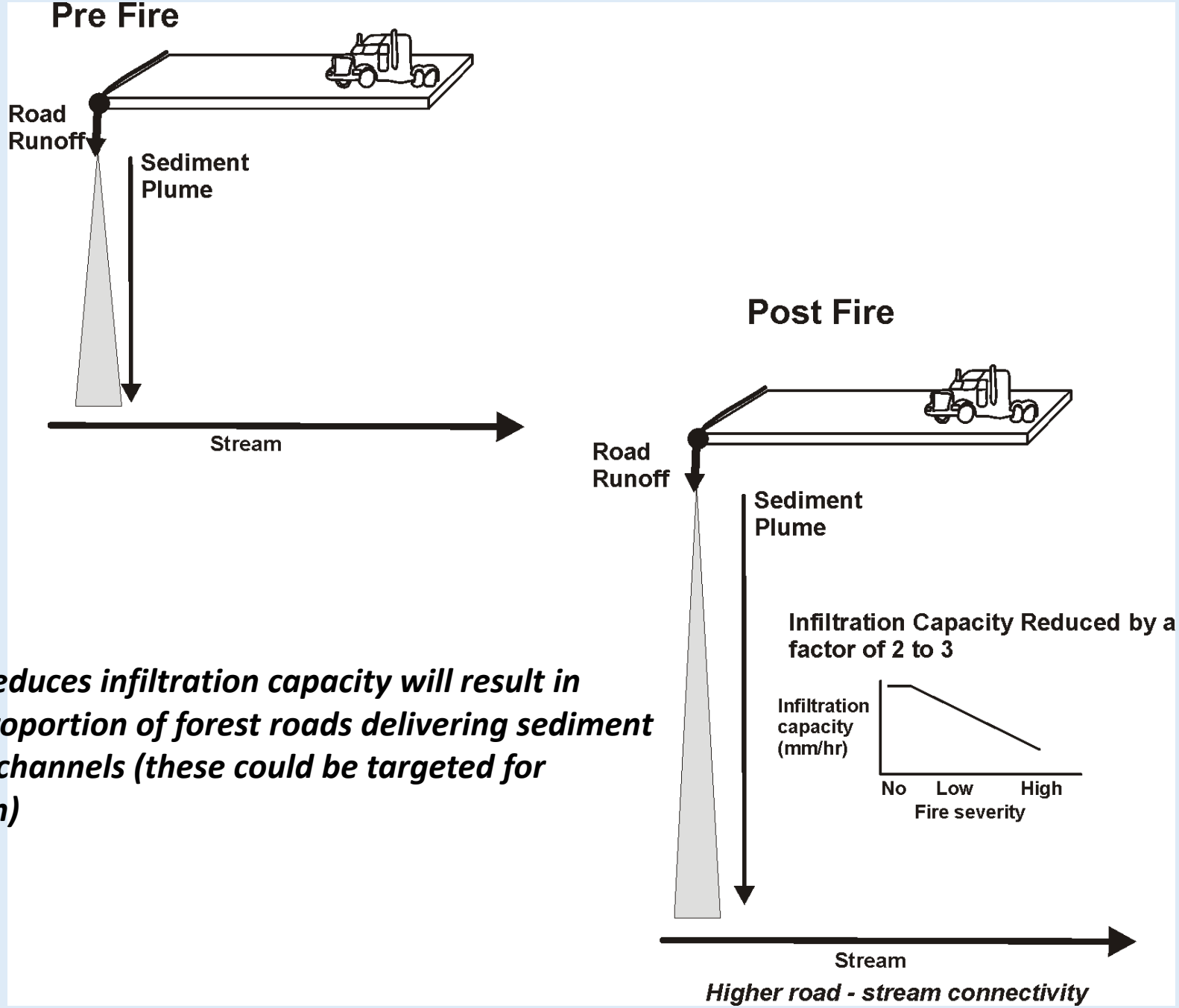
Road sediment delivery to streams (NetMap model)



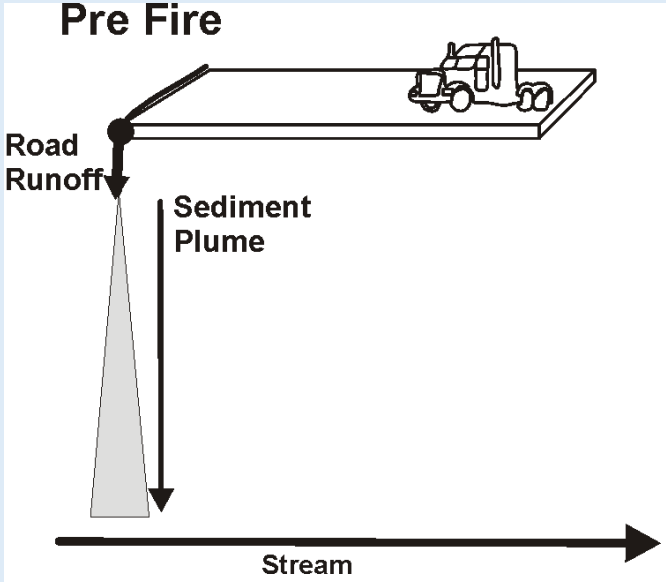
Road sediment delivery to streams (NetMap model)



Fire Effects on Road Erosion Sediment Delivery to Streams



Fire that reduces infiltration capacity will result in a larger proportion of forest roads delivering sediment to stream channels (these could be targeted for restoration)



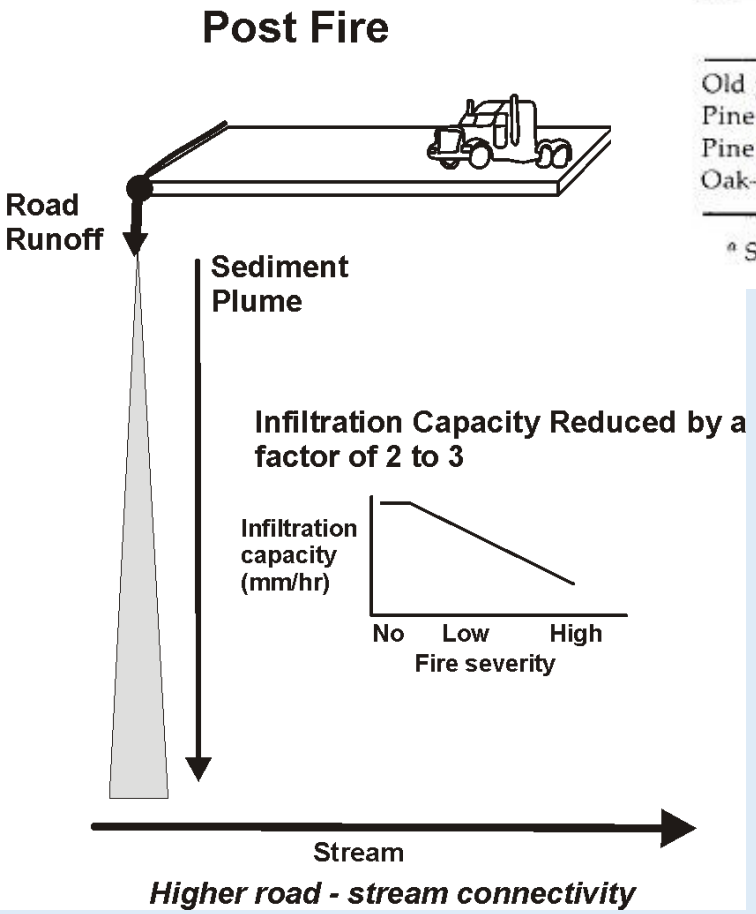


TABLE I

Infiltration Capacity[a]

Ecosystem	Capacity (mm hr^{-1})
Undisturbed forest floor	60
Forest floor without litter and humus layers	49
Forest floor burned annually	40
Pasture, unimproved	24
Succession vegetation	
Old pasture	43
Pine forest, 30 yr old	75
Pine forest, 60 yr old	63
Oak–hickory forest	76

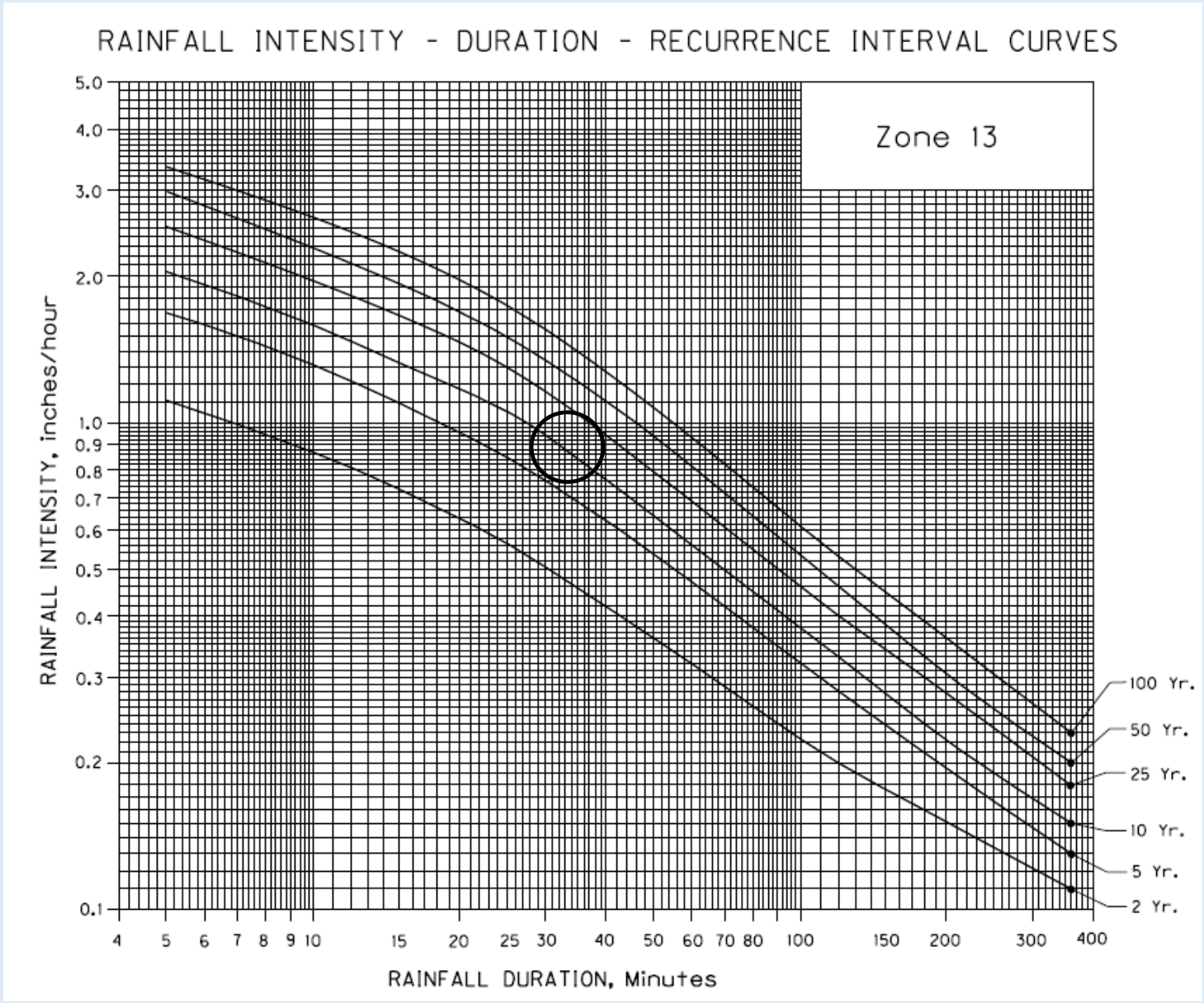
[a] Source: Lull (1964, pp. 6-14, 6-15).

Low severity = 50 mm/hr

Moderate severity = 40 mm/hr

High severity = 20 mm/hr

Design storm (short duration, high intensity)



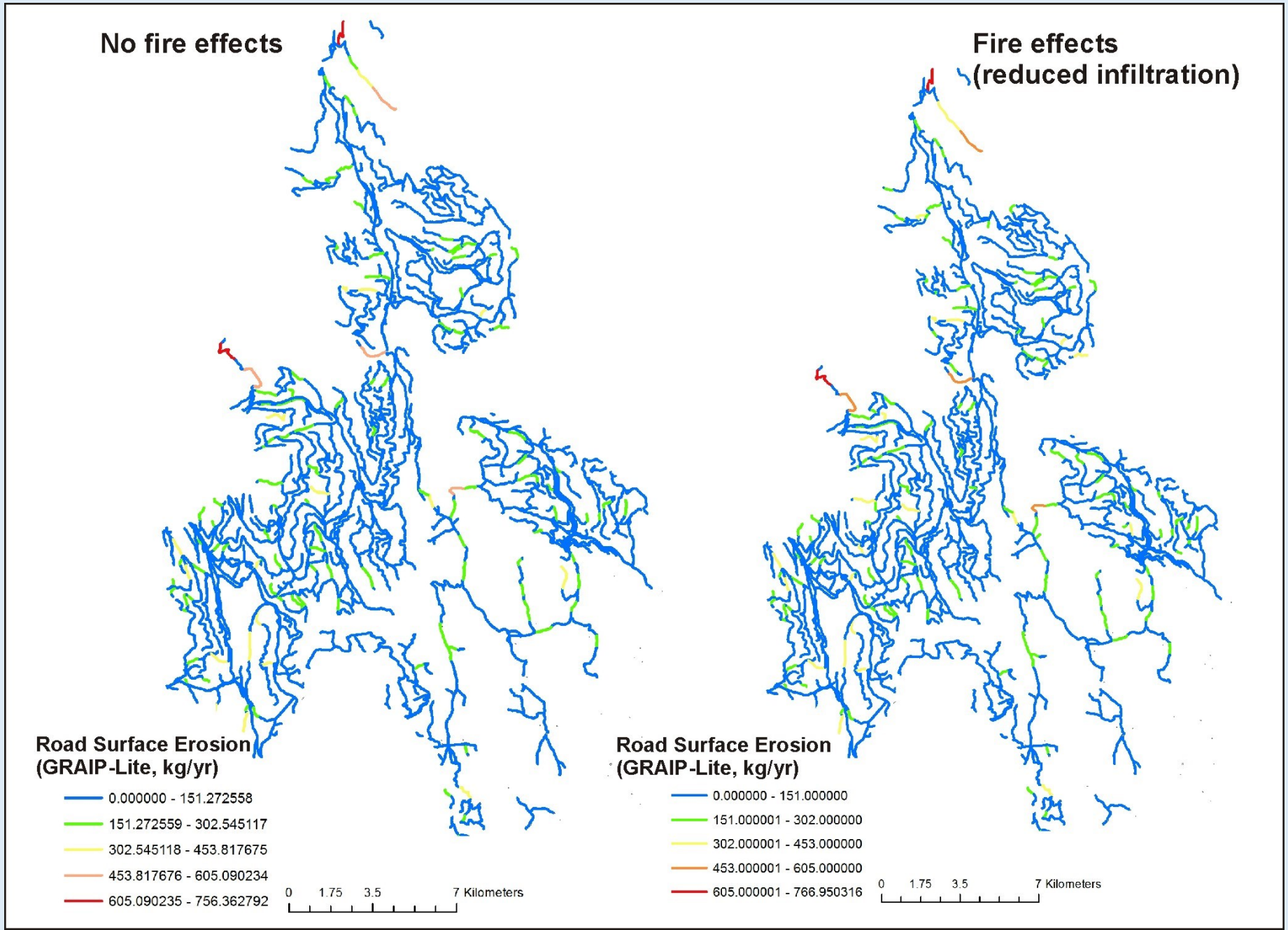
0.92 in/hr (23 mm/hr)

ftp://ftp.odot.state.or.us/techserv/Geo-Environmental/Hydraulics/Hydraulics%20Manual/Chapter_07/Chapter_07_appendix_A/CHAPTER_07_APPENDIX_A.pdf

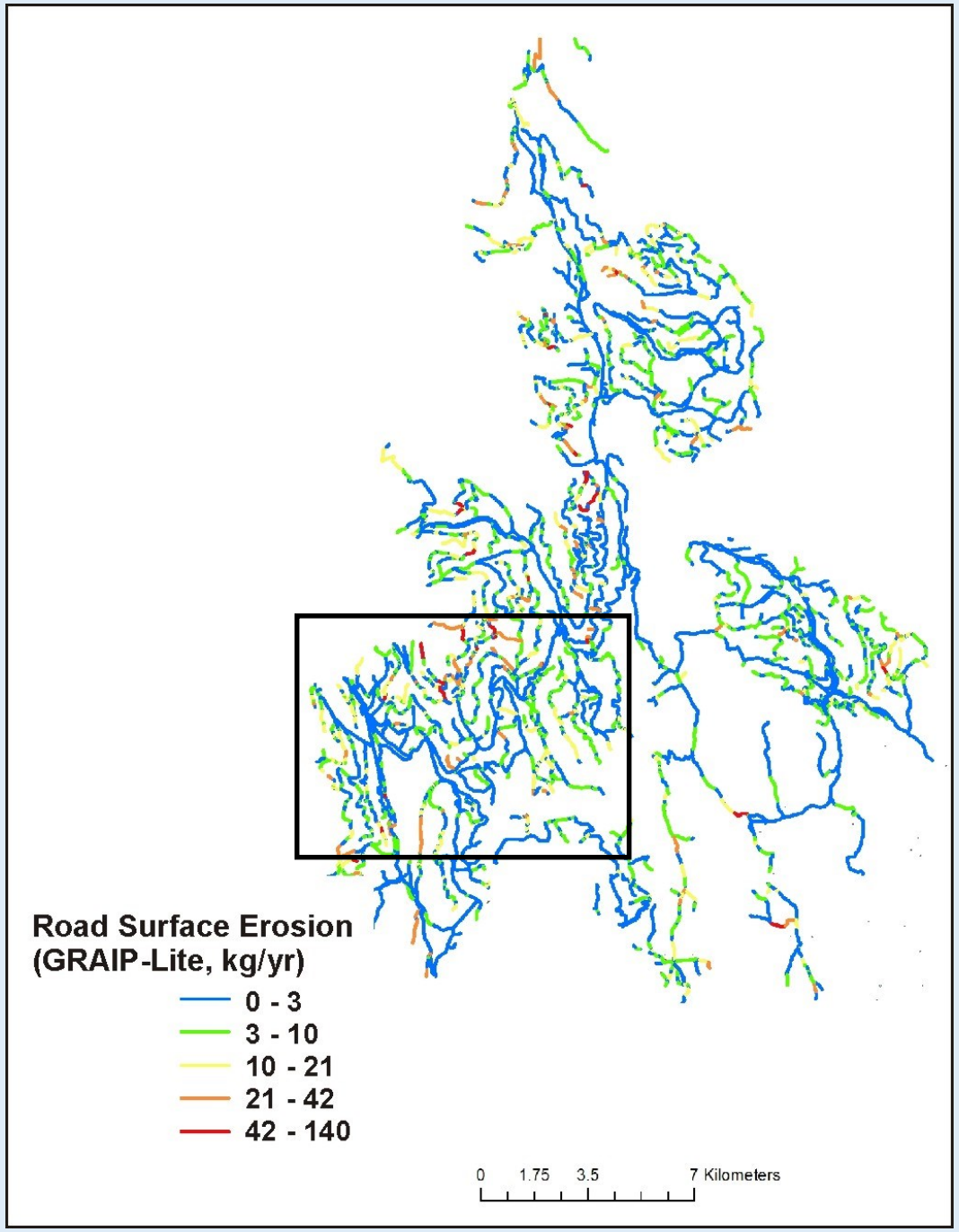
Road erosion results, pre and post fire

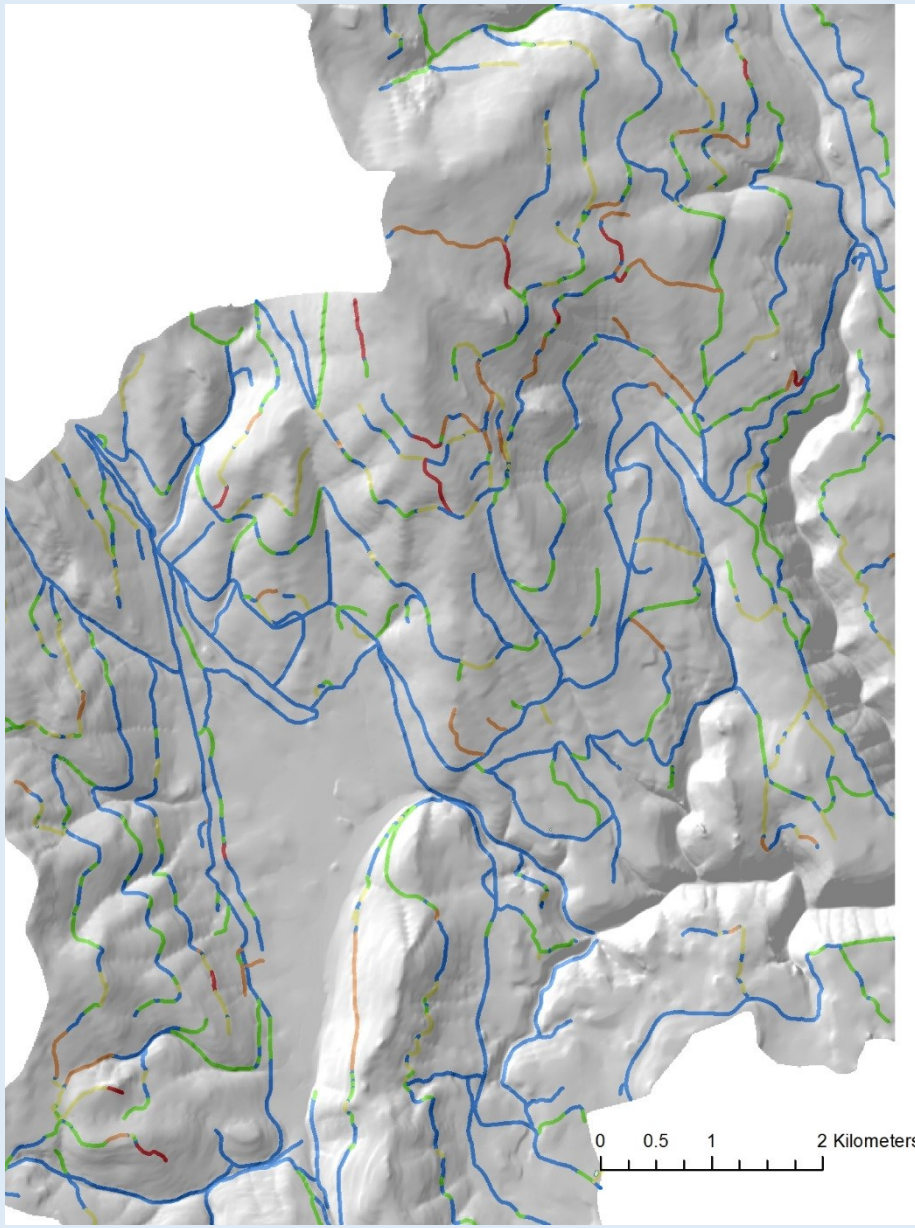
It is difficult to see the changes in these maps because of the broad legend categories.

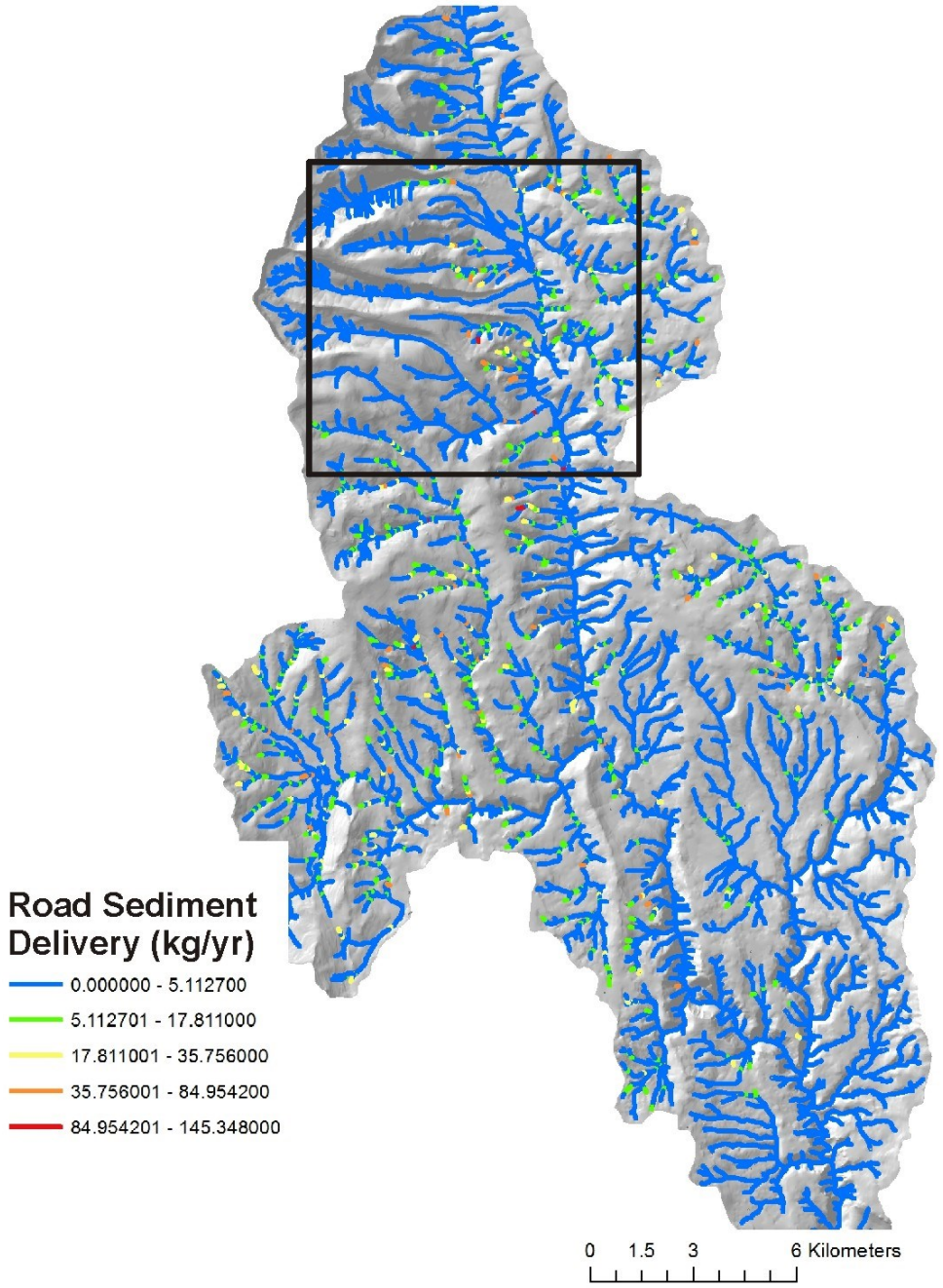
See following slide for the difference between no fire and fire.

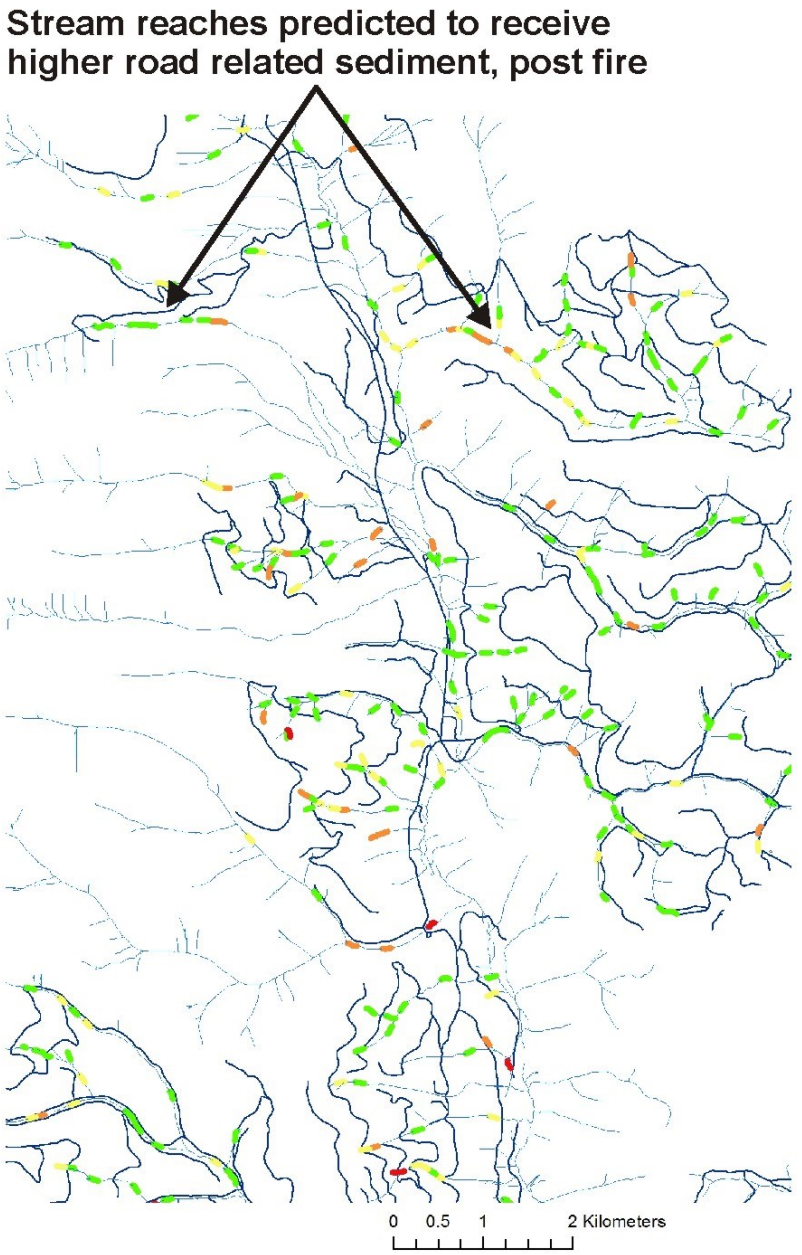


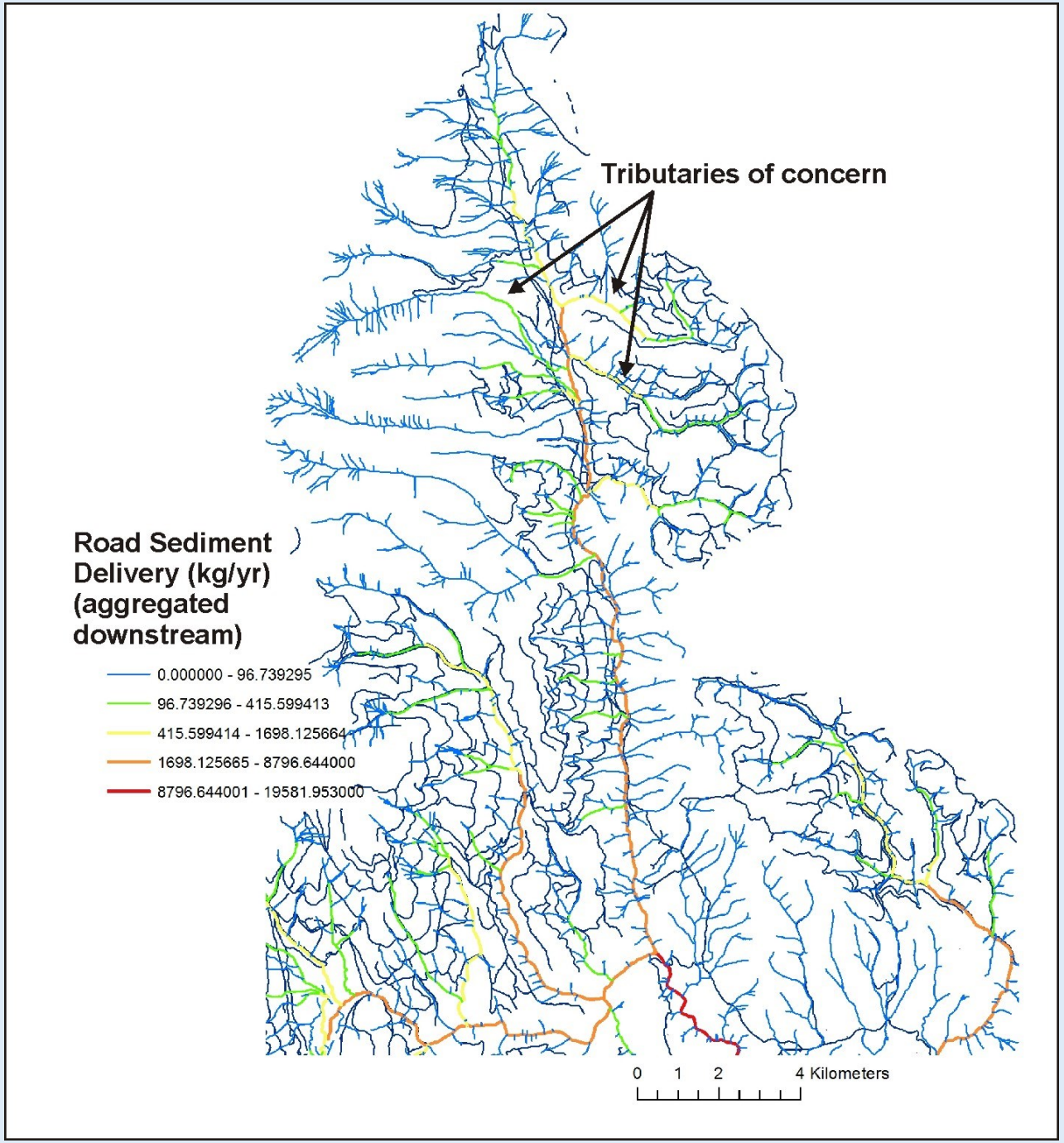
Road erosion difference map, where fire should have the largest effect of increasing sediment delivery





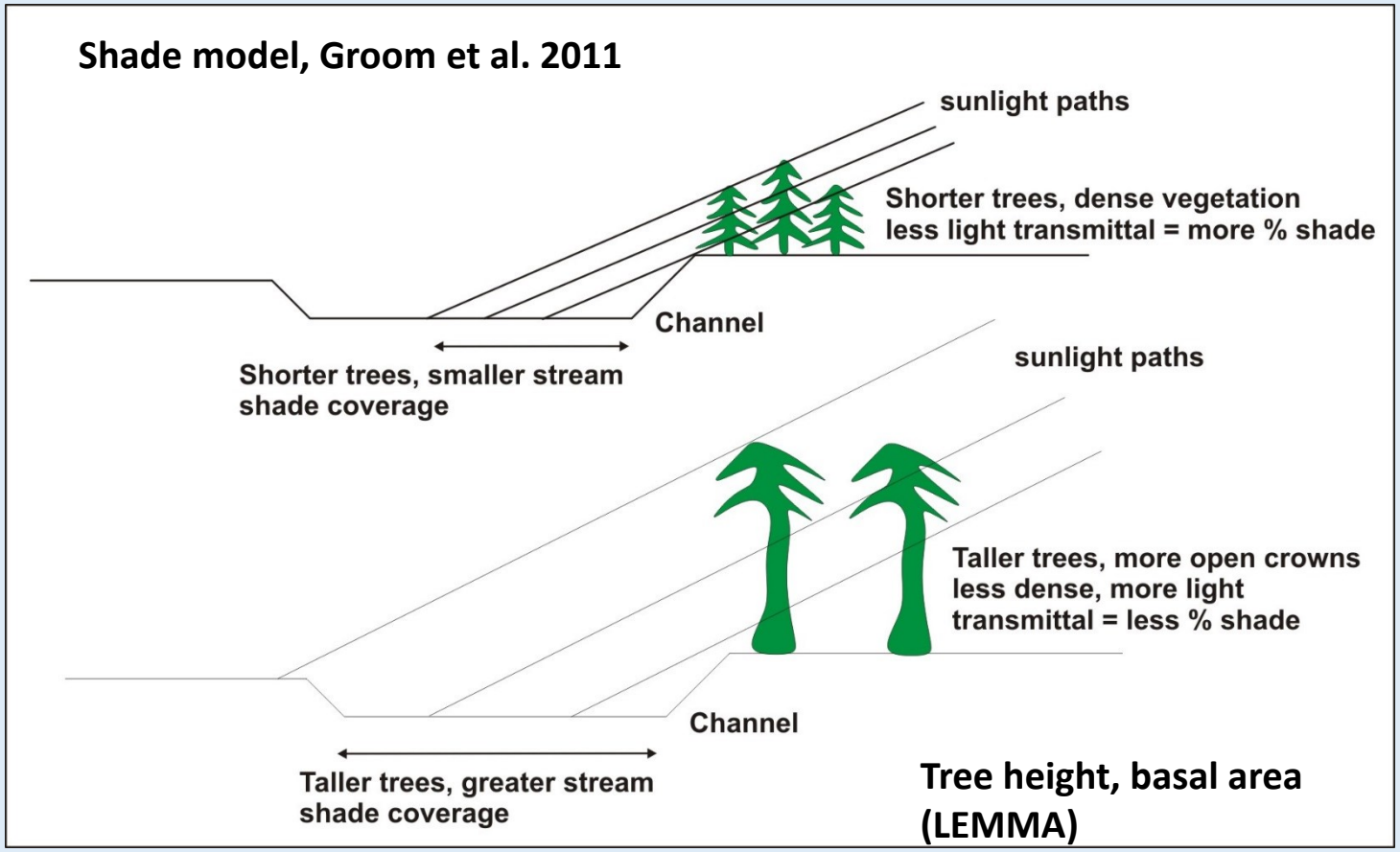

Road Sediment Delivery (kg/yr)
0.000000 - 5.112700
5.112701 - 17.811000
17.811001 - 35.756000
35.756001 - 84.954200
84.954201 - 145.348000
0 1.5 3 6 Kilometers

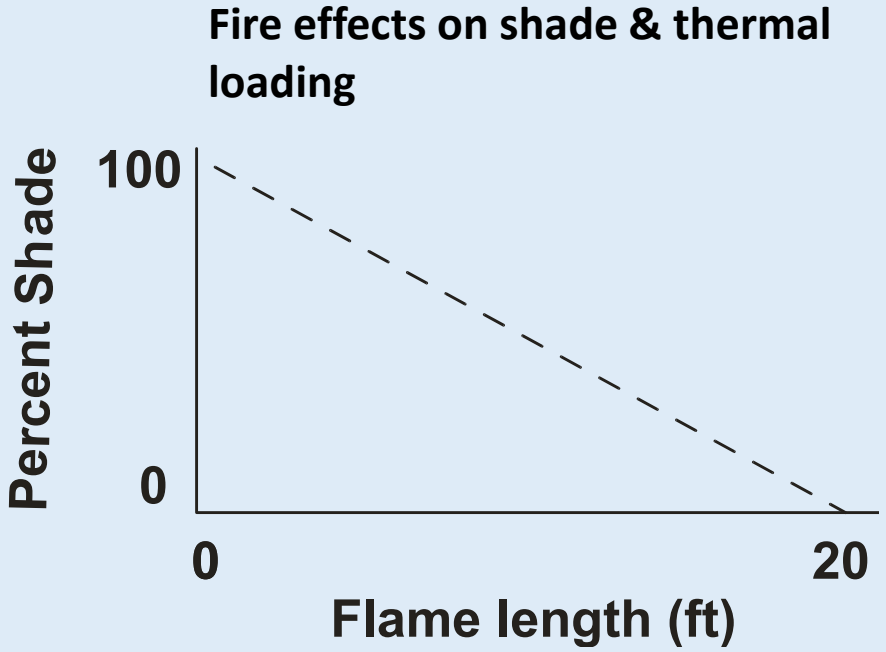

Stream reaches predicted to receive higher road related sediment, post fire
0 0.5 1 2 Kilometers


Tributaries of concern
Road Sediment Delivery (kg/yr) (aggregated downstream)
0.000000 - 96.739295
96.739296 - 415.599413
415.599414 - 1698.125664
1698.125665 - 8796.644000
8796.644001 - 19581.953000
0 1 2 4 Kilometers

Riparian Zones: Impacts from Fire, Loss of Shade, Increases in Thermal Loading and Loss of Cool Water Refugia

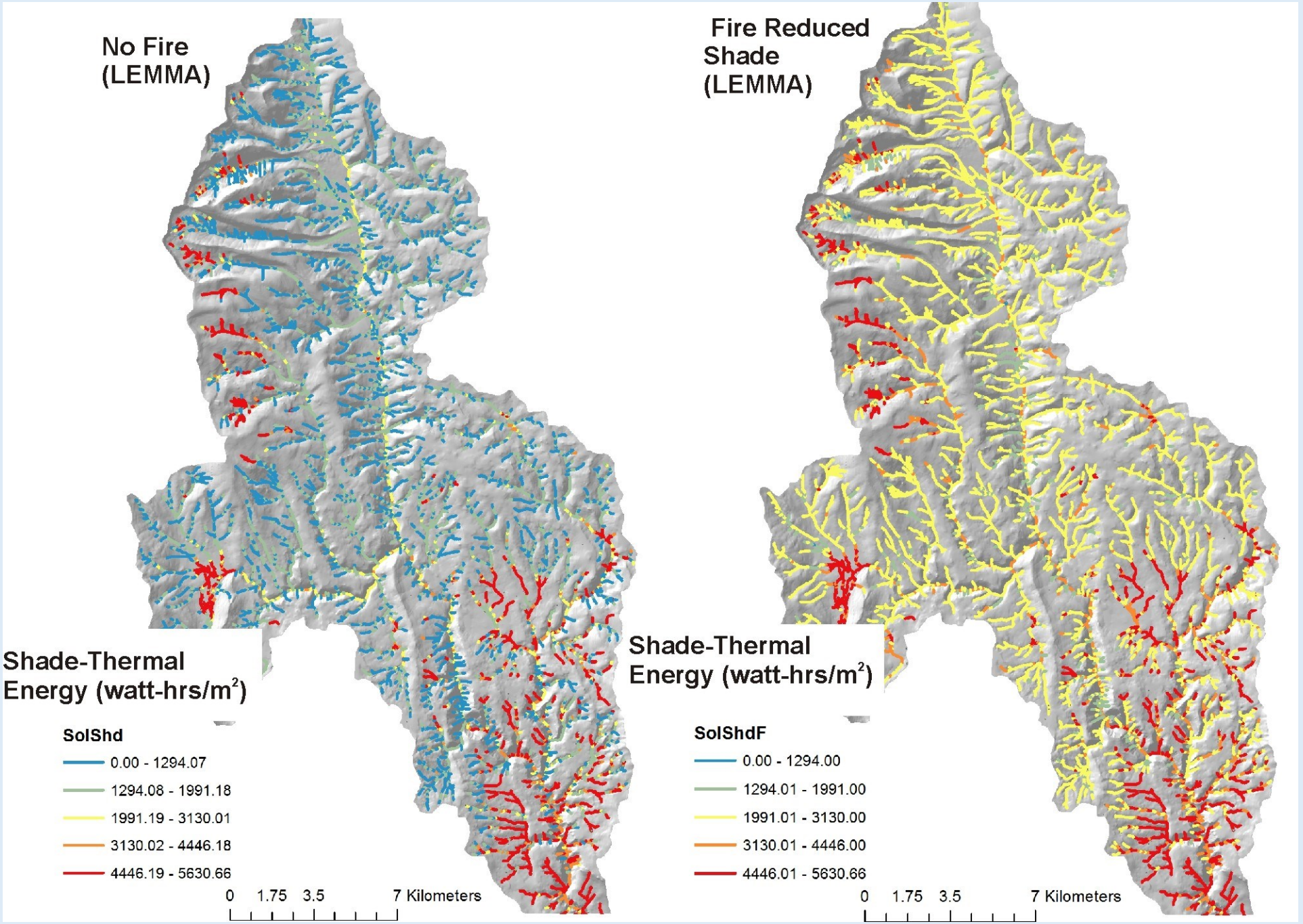
Riparian – Current Shade/Thermal Energy





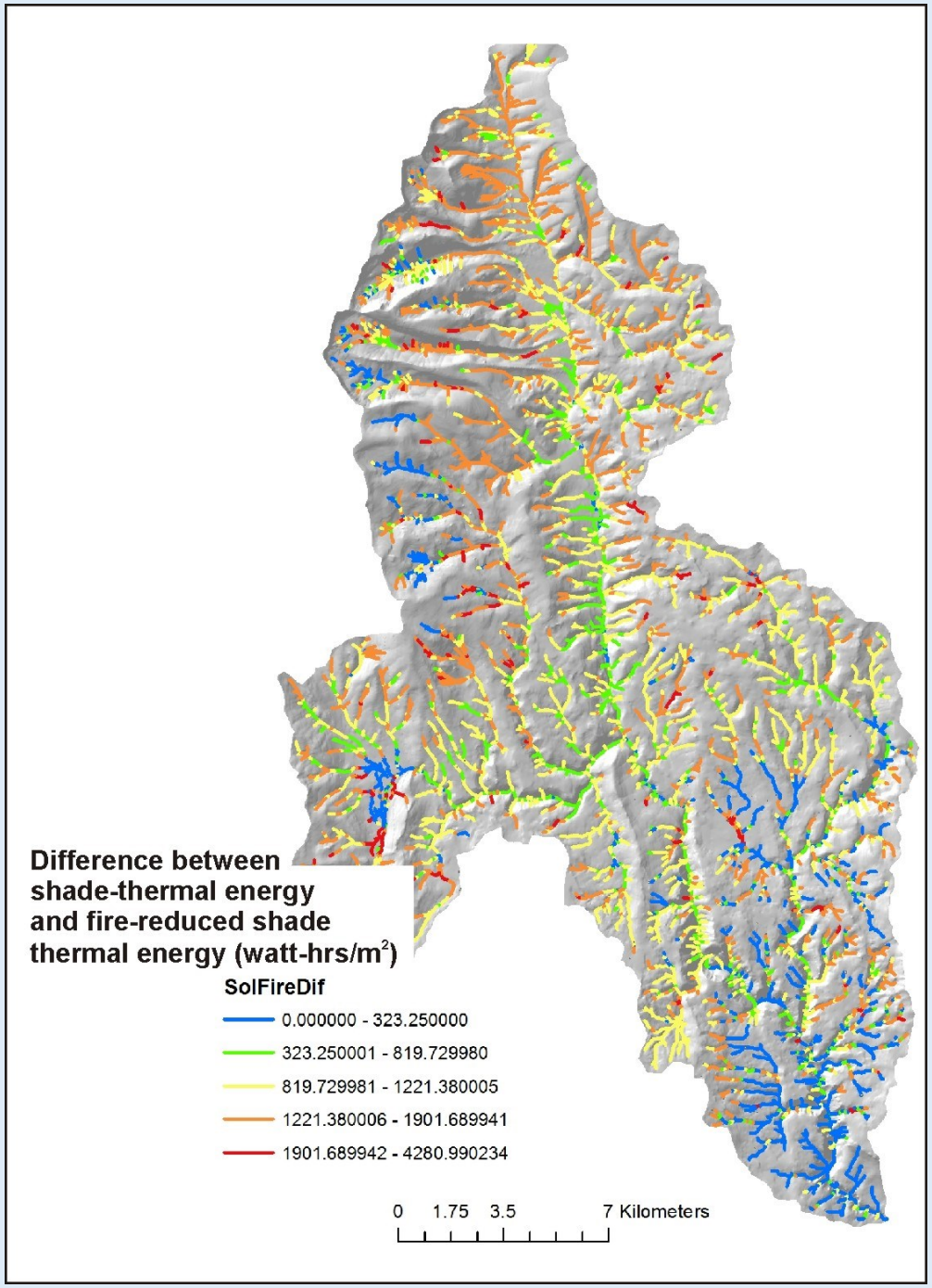
(where fire would have the largest impacts on the thermal regime, including loss of thermal refugia)

Riparian – Current Shade/ Thermal Energy



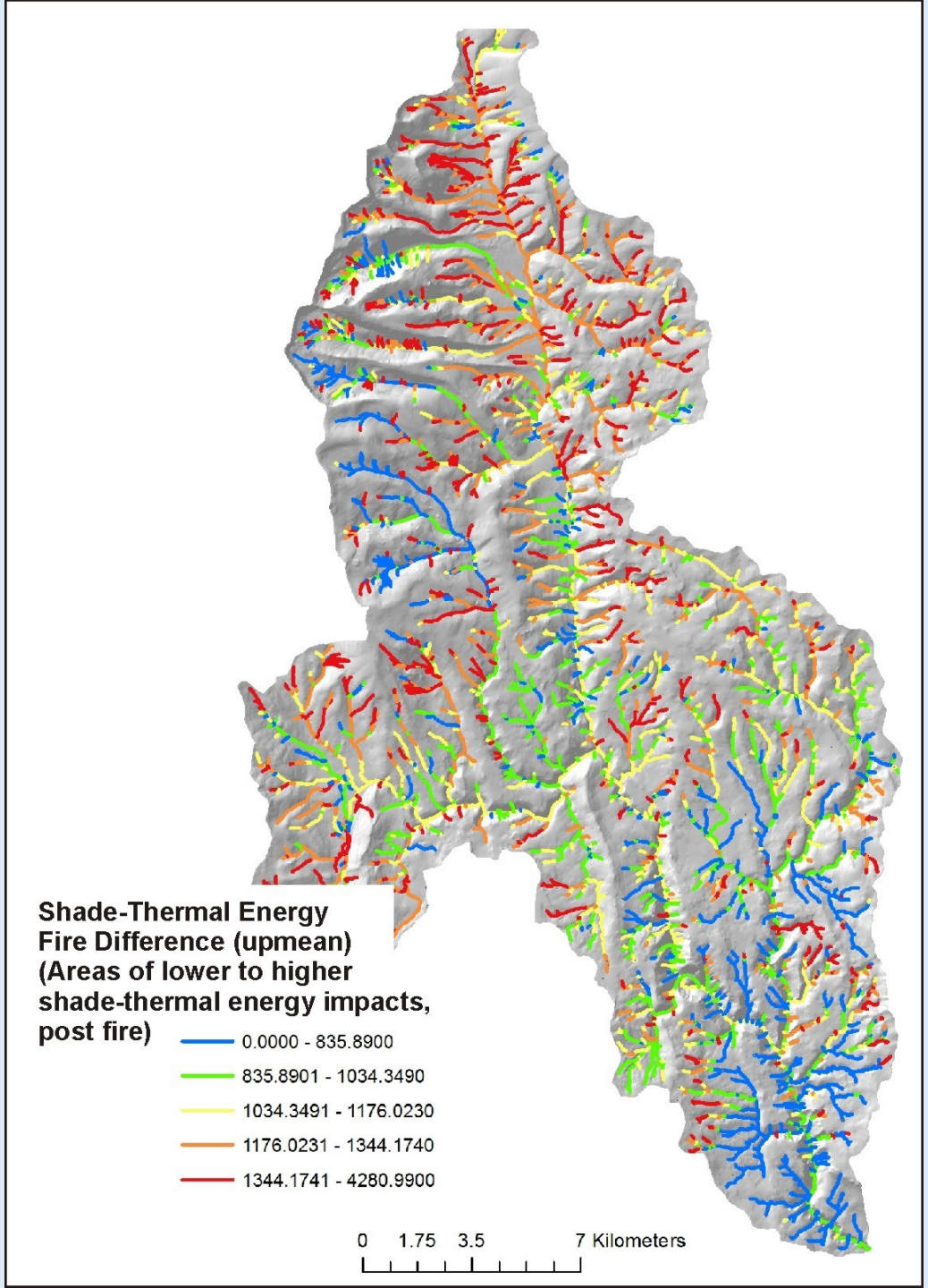
Difference between current shade-thermal energy and fire reduced shade thermal energy.

Shows reaches where the greatest impacts to shade and increases in thermal energy are predicted to occur



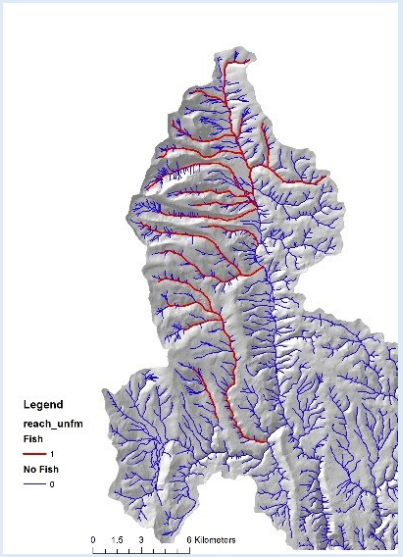
Difference between current shade-thermal energy and fire reduced shade thermal energy, but aggregated downstream (running average).

Shows multi-reach or tributary scale impacts to shade and increases in thermal energy, e.g., stream segments and tributaries where thermal refugia will be reduced.



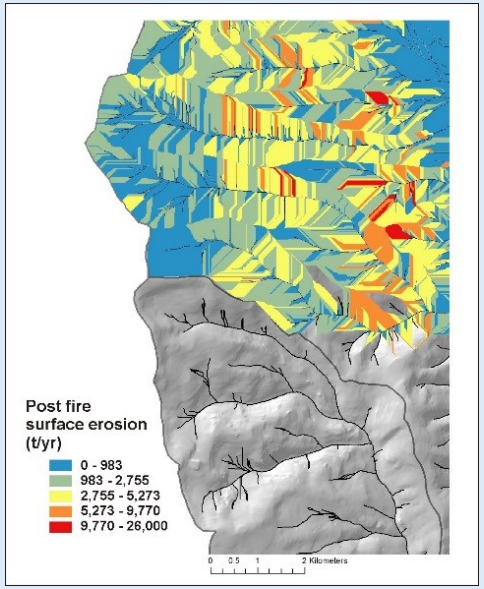
Decision Space: Spatially Explicit Maps (visual - qualitative)

Fish habitat



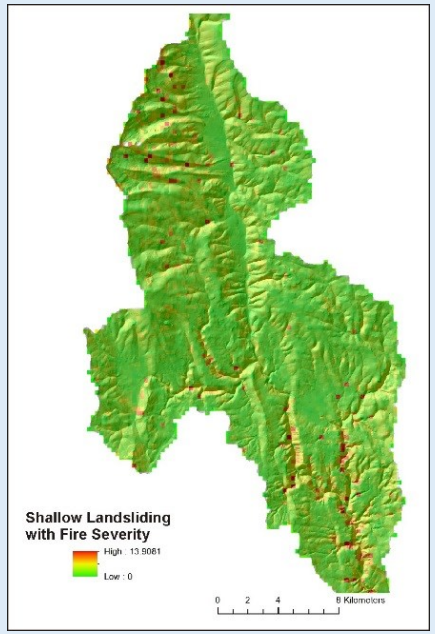
+

Surface Erosion Potential

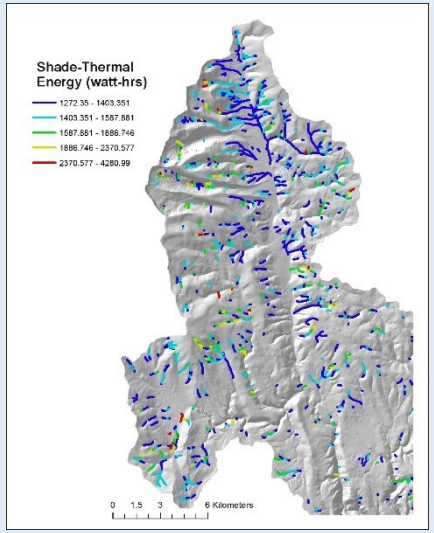


+

Landslide Potential

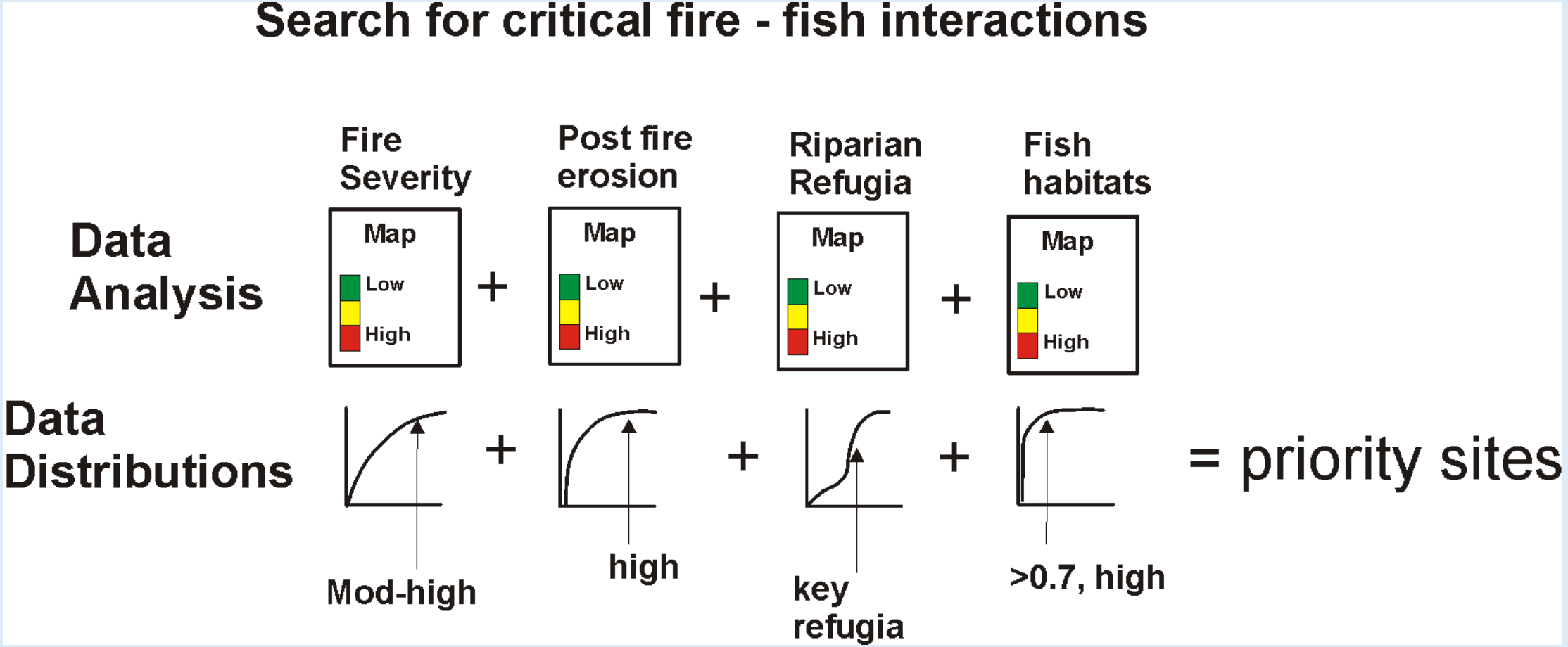


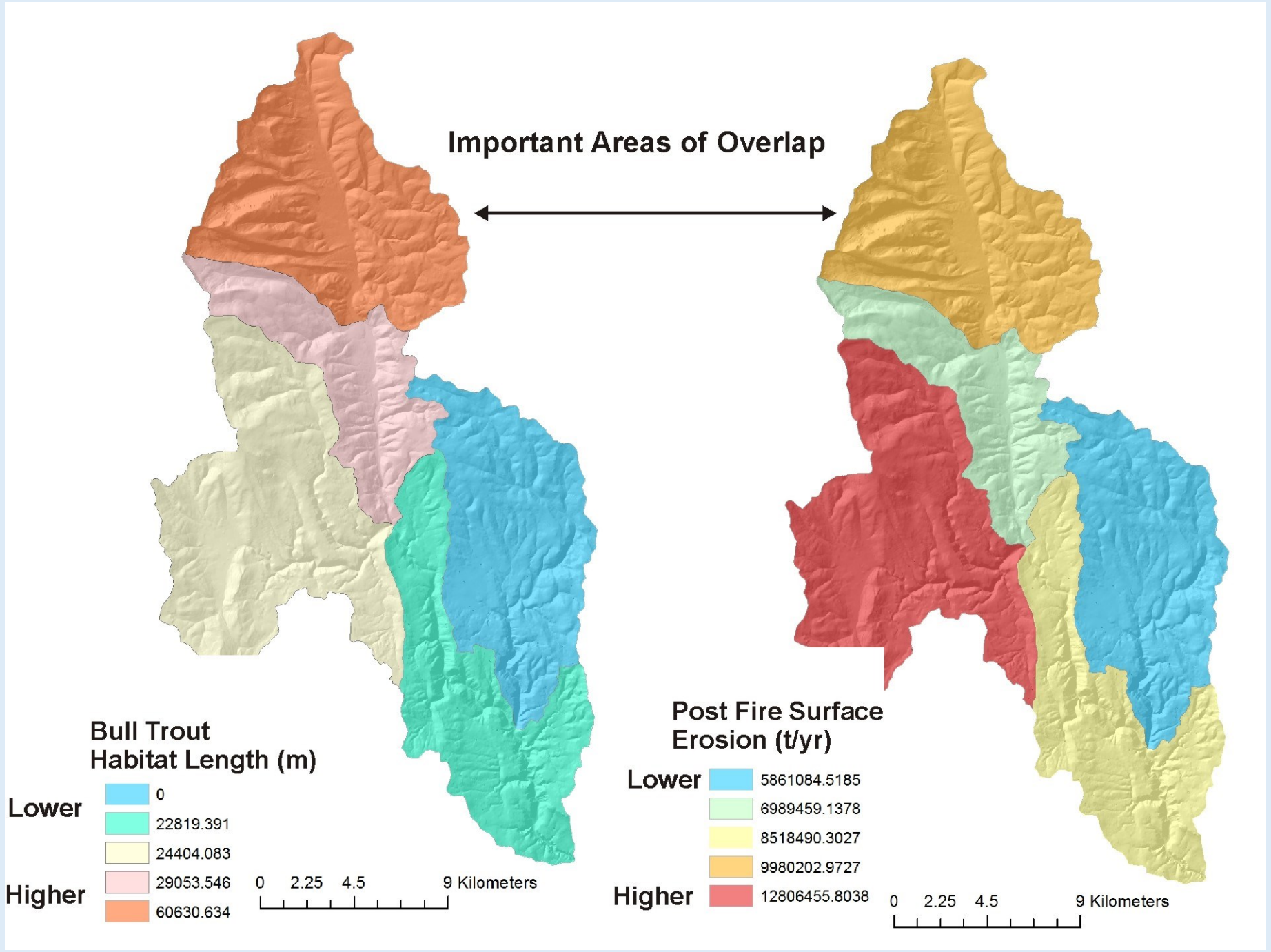
+ **Impacts on thermal refugia**



= priority sites for protection (pre fire management, firefighting)

Decision Space: Spatially Explicit Quantitative




Important Areas of Overlap
Bull Trout
Habitat Length (m)
Lower
Higher
0
22819.391
24404.083
29053.546
60630.634
0 2.25 4.5 9 Kilometers
Post Fire Surface
Erosion (t/yr)
Lower
Higher
5861084.5185
6989459.1378
8518490.3027
9980202.9727
12806455.8038
0 2.25 4.5 9 Kilometers

Fire Fighting
(Retardant Avoidance/Yes Areas)

Retardant YES Line Mapping

A GIS Based Approach

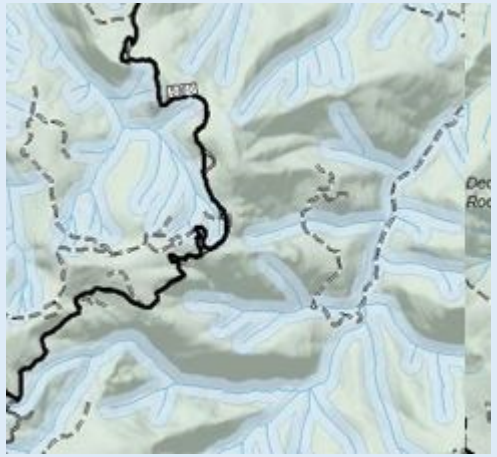
Willamette National Forest

Modeled on the Deception Fire - Middle Fork Ranger District

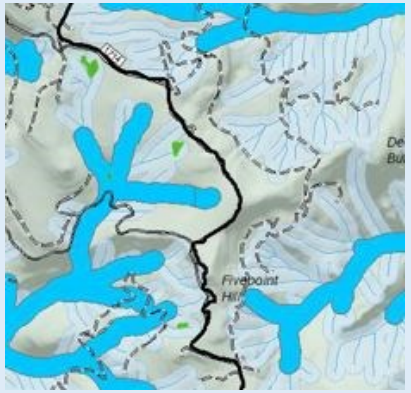
February, 2015

Nikki Swanson, Willamette +

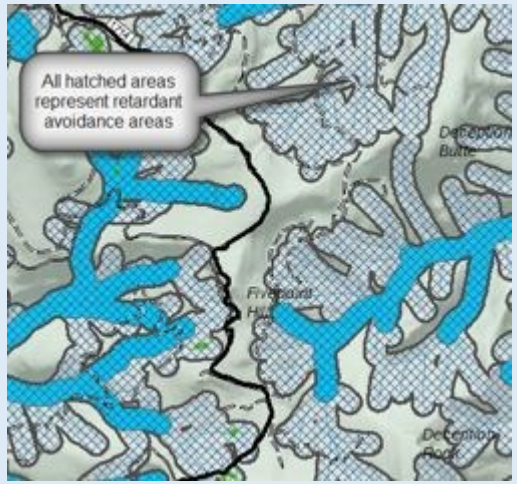
Step 1. NHD flow lines, buffering 300 ft each side.



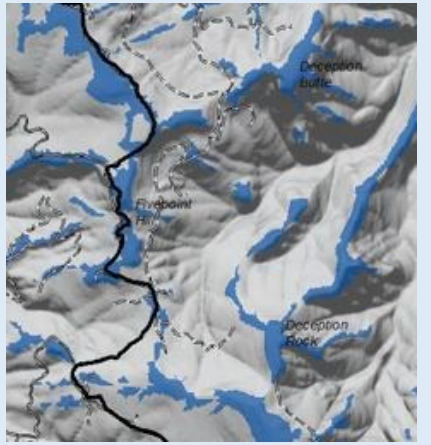
Step 2. Add SHABs/wet meadows /lakes & National Retardant Avoidance Layer



Step 3. Map retardant avoidance areas



Step 4. Map ridgetops.



Step 5. Retardant YES areas

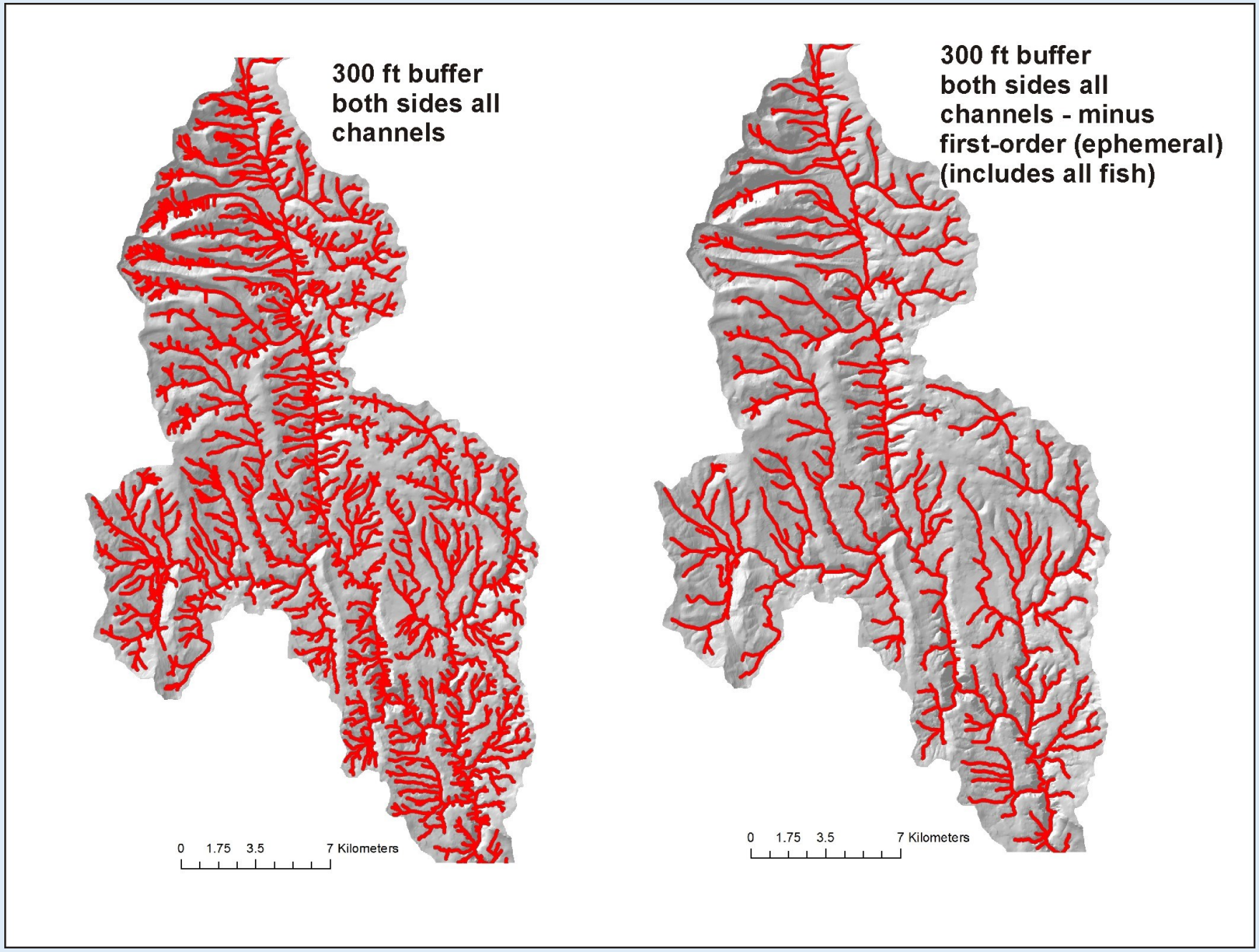
Fire & Fish: Retardant Avoidance/Yes areas (modified)

Step 1: NetMap stream layer (more comprehensive, more consistent) – delineate a 300 ft buffer both sides of all streams – Retardant Avoidance Areas.

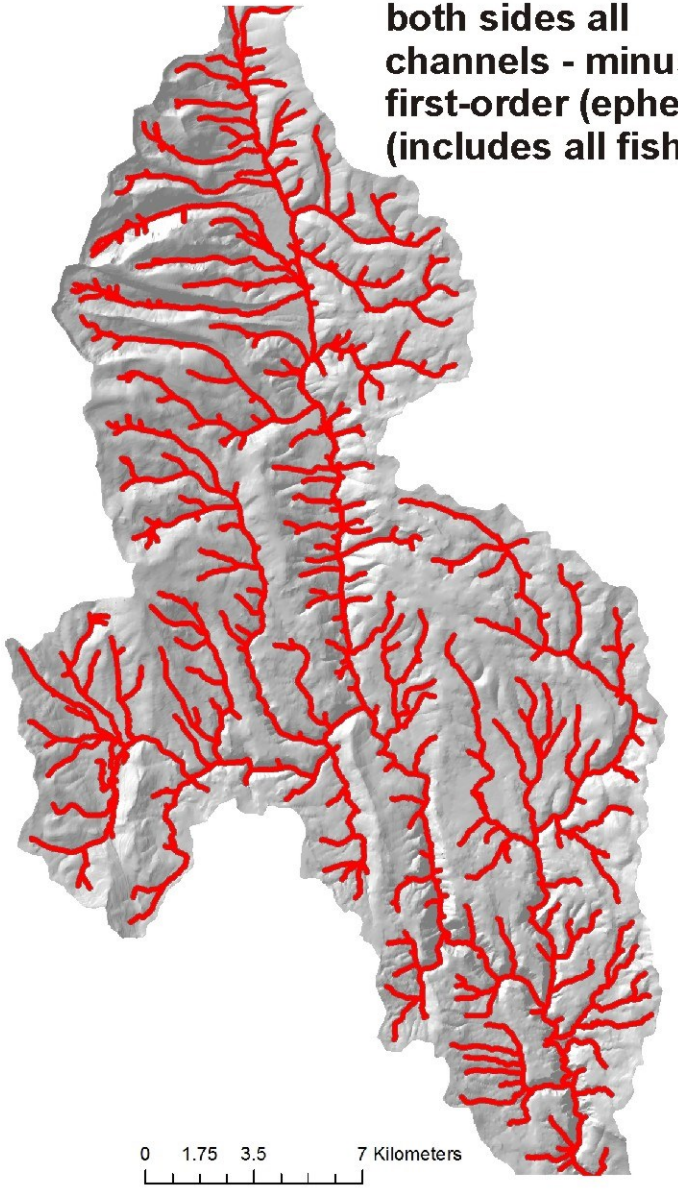
Step 2. Remove headwater channels likely to be dry during fire season (first-order streams, likely ephemeral, dry in fire season).

Step 3. Identify critical fish – riparian environments (thermal refugia, floodplains) and REMOVE these from avoidance areas (they become optionally a retardant YES area). Reasoning: Short term vs longer term impacts.

Fire retardant avoidance areas

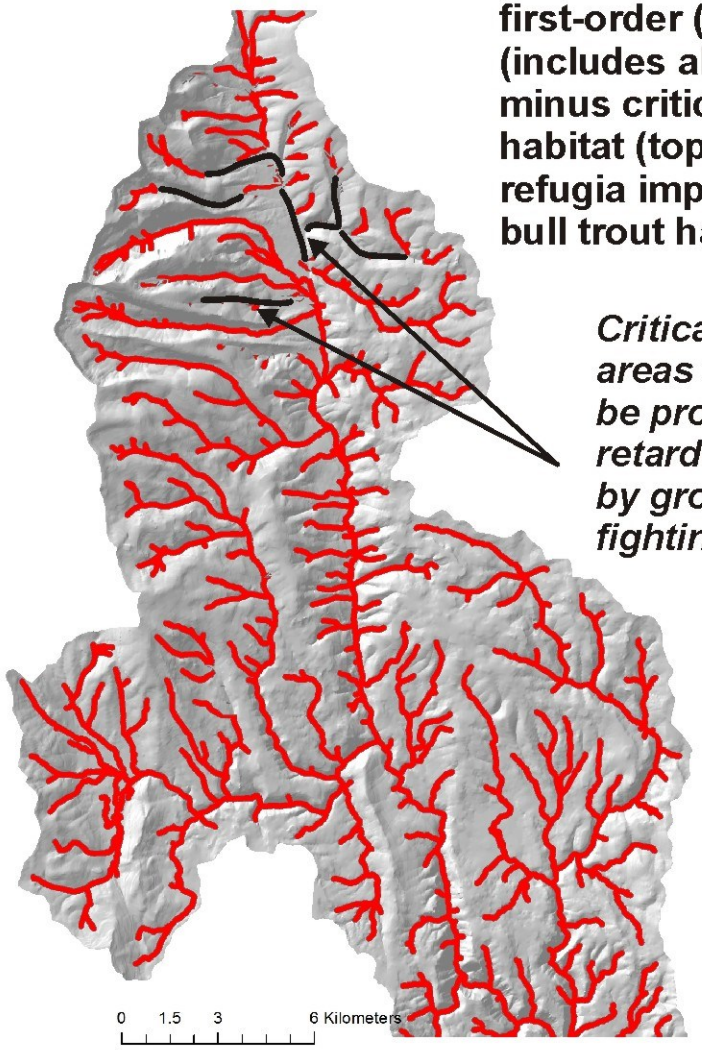


300 ft buffer both sides all channels - minus first-order (ephemeral) (includes all fish)



300 ft buffer both sides all channels - minus first-order (ephemeral) (includes all fish), minus critical refuge habitat (top 30% refugia impacts + bull trout habitat

Critical riparian areas that could be protected by retardant and or by ground fire fighting

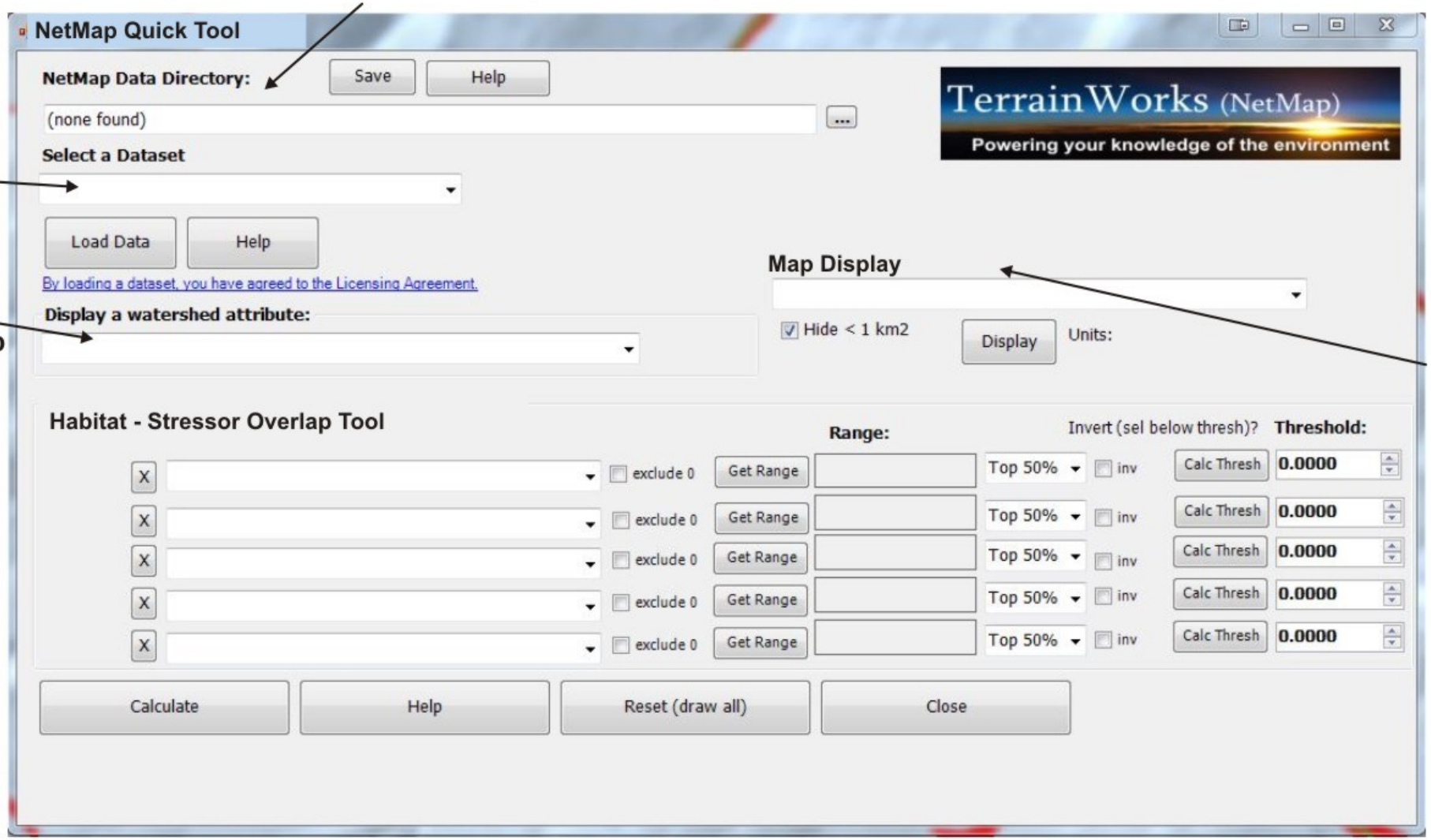


Locate the directory where your NetMap datasets are stored

Select and load a NetMap dataset

Display an attribute on the map that contains the results from the habitat-stressor analysis

Select individual maps from a drop down organized by topic



Conduct Habitat - Stressor Analyses, choose up to five individual reach attributes (habitat quality, floodplains, thermal refugia, effects of current shade on thermal energy, current in-stream wood recruitment potential, shallow landslide and debris flow risk etc.). For example, where does the highest 10% of coho salmon habitat potential overlap with the lowest 10% of in-stream wood recruitment (highlighting sites for in-channel restoration). Or where does the highest 10% of coho salmon habitat overlap the highest 10% of debris flow risk (to identify sites for additional slope stability protection). See examples below.

Drop down attribute list in NetMap's Fire and Fish Quick Tool

Fire

[flamelen_unfm] Fire Severity-Hillside
[flam_loc] Fire Severity-Channel
[flam_cum] Fire Severity-Aggregated
[AvgaFlame] HUC6-summarized Fire Severity

Aquatics

[fish_bull**]** Bull Trout (presence/absence)
[SumLBull] HUC6-summarized Bull Trout Length

[fish_redb**]** Redband Trout (presence/absence)
[SumLRedb] HUC6-summarized Red Band Length

[IP_Steelhd] Steelhead IP
[AvgIPStlnd] HUC6-summarized Steelhead IP

[IP_Chinook] Chinook IP
[AvgIPChinook] HUC6-summarized Chinook IP

Erosion

[WEPPSlop] Surface Erosion(Fire)-Hillside
[SumWepp] HUC6-summarized Surface Erosion
[WEPP} Surface Erosion(Fire)-Channel
[WEPP_Cum] Surface Erosion(Fire)-Aggregated

[Gully] Gully Potential-Hillside
[AvgGully] HUC6-summarized Gully Erosion
[Gully_Loc] Gully Potential-Segment
[Gully_Cum] Gully Potential-Aggregated

[GEP] Shallow Landslide Potential-Hillside
[AvgGEP] HUC6-summarized Landslide Potential
[GEP] Shallow Landslide-Channel
[GEP_Cum] Shallow Landslide-Aggregated

Roads

[SedProd] Sediment Production-Road
[SedDel] Sediment Delivery-Road
[SedDelF] Fire Sediment Delivery-Road
[Del_Fdif] Difference-Road
[Length_M] Road Drainage Length
[ToStream_M] Distance to Stream

[Graip] Sediment Delivery-Channel
[SumGDel] HUC6-summarized Sediment Delivery
[Graip_Cum] Sediment Delivery-Aggregated
[GraipF] Fire Sediment Delivery-Channel
[SumGFDel] HUC6-summarized Sediment Delivery Fire
GraipCumF] Fire Sediment Delivery-Aggregated
[GraipDif] Difference-Channel
[SumGDif] HUC6-summarized Sediment Delivery Difference
[GraipCfdif] Difference-Aggregated

Riparian

[SolShd] CurrentShade-Thermal-Channel
[SumSolShd] HUC6-summarized Shade-Thermal Energy

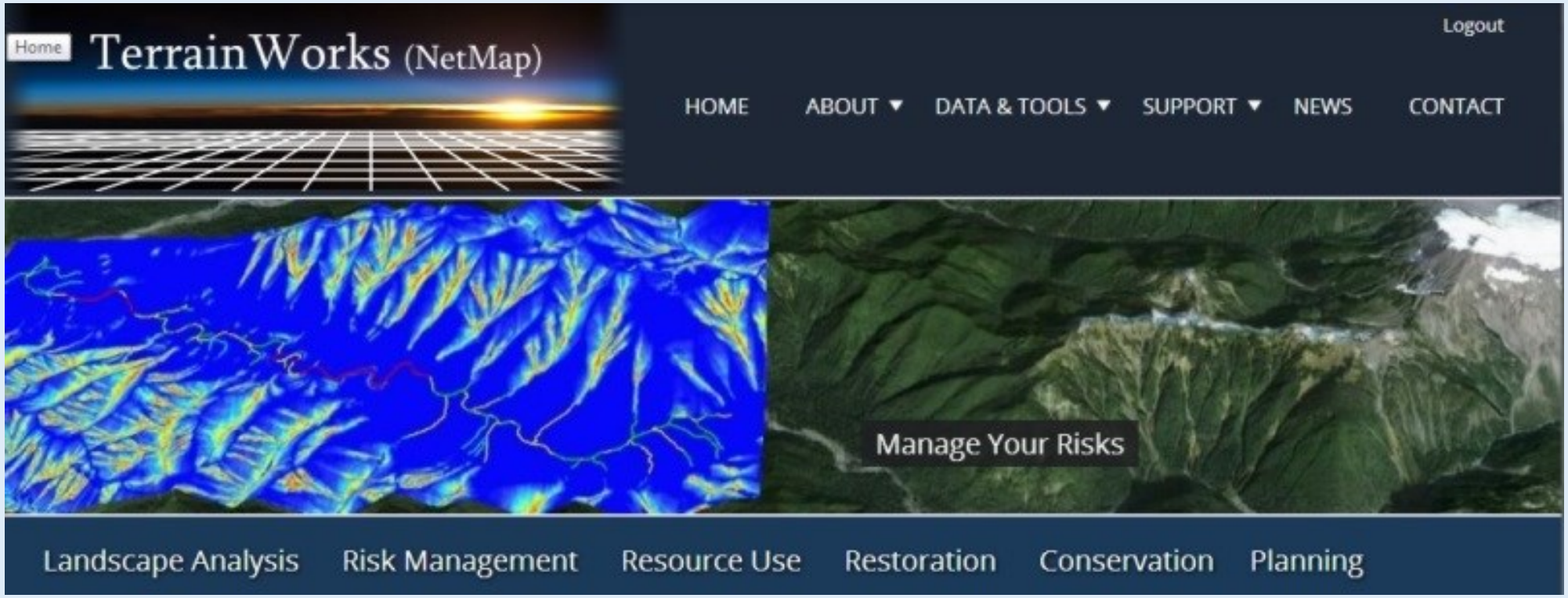
[SolShdF] FireShade-Channel
[SumSolShdF] HUC6-summarized Shade-Thermal Energy Fire
[SolFireDif] Difference-Channel
[SumSolShdF] HUC6-summarized Shade-Thermal Energy Difference
[solardif_r] Difference-Aggregated

Thermal Refugia

[SolMean] Aggregated Shade-Thermal Energy (SolShd)
[TrbThrm] Thermal Refugia-Confluences
[TrbThrmSc] Thermal Refugia-Confluences, scaled by tributary-mainstem drainage area (flow)
[FPchg] Thermal Refugia-Floodplains

[vw_2] Floodplain-Polygon
[FP_WIDTH] Floodplain-Segment

Presentation Complete



TerrainWorks designs and builds the most advanced watershed and landscape analysis system in the world. Learn more about NetMap virtual watersheds, watershed analysis tools, online technical help and tools at: www.terrainworks.com. Contact us with questions, we are here to help.