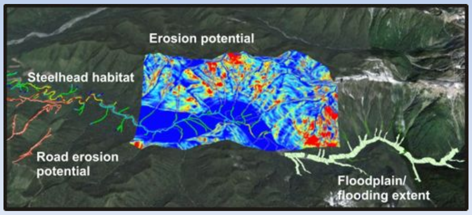
NetMap

Watershed Database and Analysis System

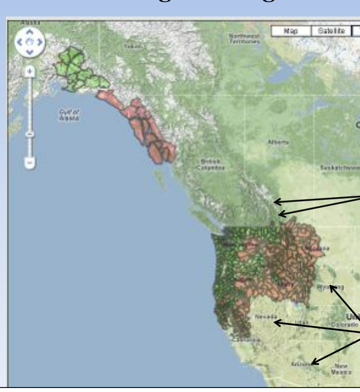


Earth Systems Institute
Seattle/Mt. Shasta/Fort Collins

NetMap: A collaborative enterprise since 2007

- -US National Forests (WA, OR, NCA, AK, ID, MT)
- -US Forest Service Research: PNW; PSW, RMRS
- -NOAA
- -BLM
- -EPA
- -Oregon Dept. Forestry
- -State Fish and Game
- -NGOs
- -Watershed Councils
- -First Nations
- -Universities
- -Foothills Research (Alberta)
- -Private (West Fraser, US companies)
- -International (Spain, China, Russia)

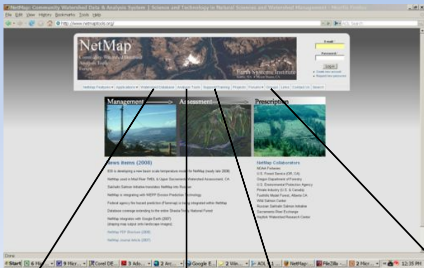
Current and Pending Coverage



2 million ha
Alberta

2013

www.netmaptools.org



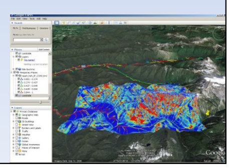
Digital Landscapes (smart stream layer)

Analysis Tools

Support/ maintenance

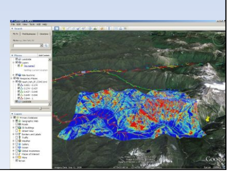
Advisory Groups

***Why?** – to provide analyses and information previously unavailable to agencies and other stakeholders*



***Why?** – to provide analyses and information previously unavailable to agencies and other stakeholders*

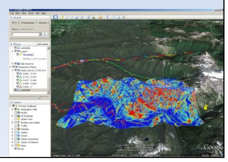
Where are the best fish habitats located? Where do they overlap with land use stressors?



***Why?** – to provide analyses and information previously unavailable to agencies and other stakeholders*

Where are the best fish habitats located? Where do they overlap with land use stressors?

Which road segments pose the greatest threats to erosion, water quality and to aquatic habitats?

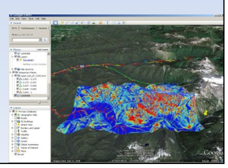


***Why?** – to provide analyses and information previously unavailable to agencies and other stakeholders*

Where are the best fish habitats located? Where do they overlap with land use stressors?

Which road segments pose the greatest threats to erosion, water quality and to aquatic habitats?

At what locations are energy pipelines most susceptible to erosion or flooding impacts?



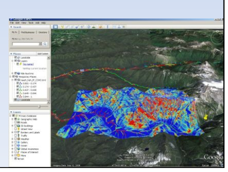
***Why?** – to provide analyses and information previously unavailable to agencies and other stakeholders*

Where are the best fish habitats located? Where do they overlap with land use stressors?

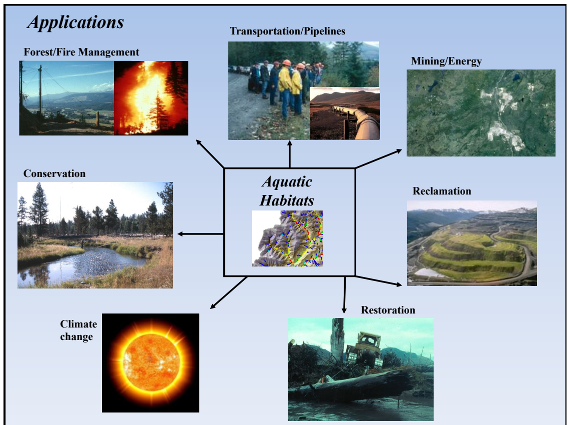
Which road segments pose the greatest threats to erosion, water quality and to aquatic habitats?

At what locations are energy pipelines most susceptible to erosion or flooding impacts?

Where is wildfire related erosion and flooding risk the greatest?



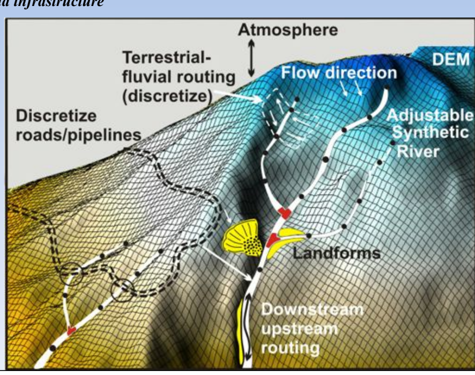
Applications

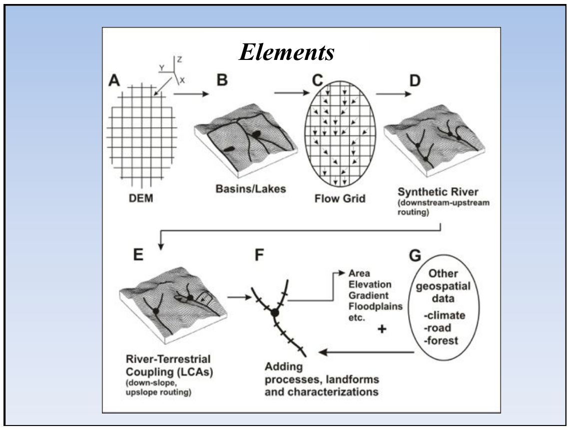


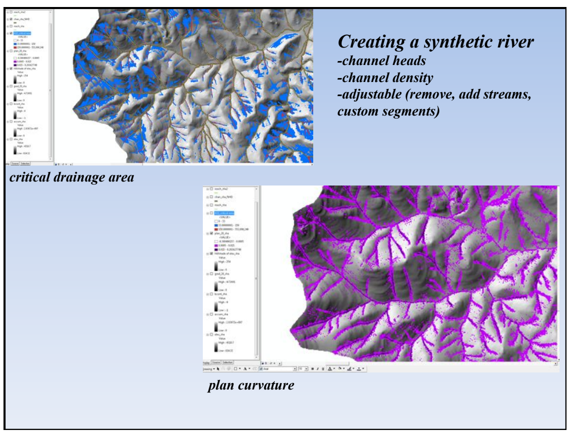
Components

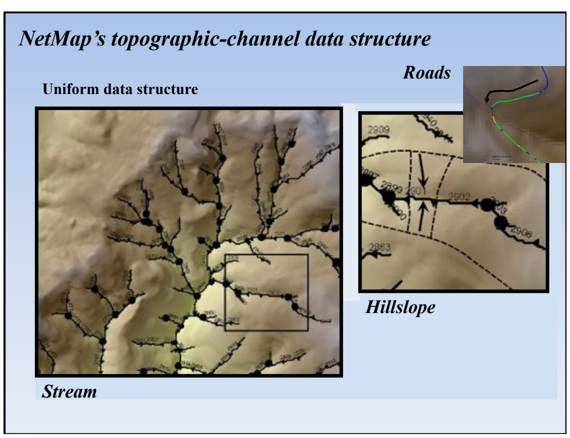
(1) Digital Landscapes
(2) Community Tools
(3) Analyses
(4) Support & Maintenance

A digital landscape is a virtual environment where landforms and physical and biological processes are placed in context with spatial patterns of human activities and infrastructure

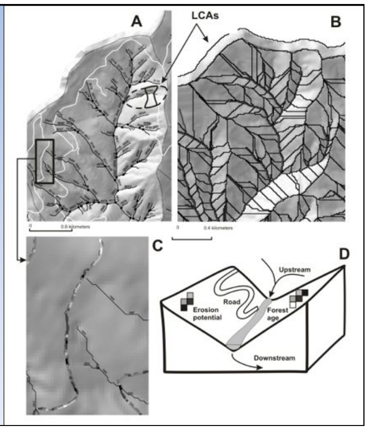



Elements
A
B
C
D
DEM
Basins/Lakes
Flow Grid
Synthetic River
(downstream-upstream routing)
E
F
G
Area
Elevation
Gradient
Floodplains
etc.
+
Other geospatial data
-climate
-road
-forest
River-Terrestrial Coupling (LCAs)
(down-slope, upslope routing)
Adding processes, landforms and characterizations


Creating a synthetic river
-channel heads
-channel density
-adjustable (remove, add streams, custom segments)
critical drainage area
plan curvature


NetMap's topographic-channel data structure
Uniform data structure
Roads
Hillslope
Stream

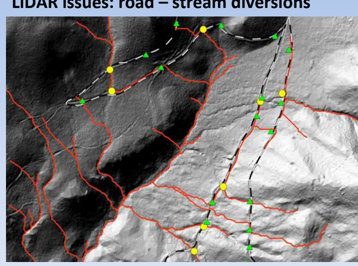
Discretize
-channels
-hillsides
-roads/pipelines



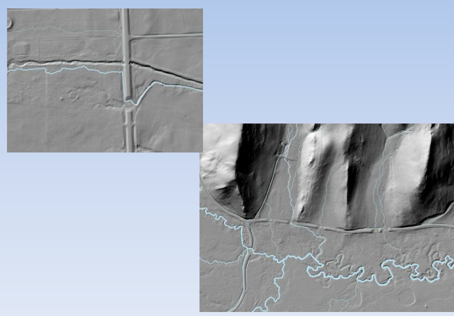
Smart stream layer | **Smart digital landscape**

Channel Attributes	Landforms and Process Characterizations
Gradient	Floodplains
Shear stress	Alluvial fans
Bed substrate	Tributary confluences
Channel classification	Erosion potential
Fish habitats	Hillslope - gradient and convergence (mass wasting)
Channel width and depth	Hillslope – slope profile (surface erosion)
Elevation	Valley width and transitions
Distance to outlet	Debris flows
Radiation loading etc.	Drainage density etc.

LiDAR issues: road – stream diversions



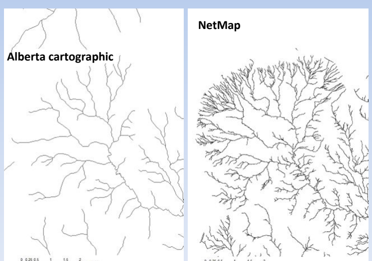
Correcting networks



Alberta – what else is available?

#1: stream layer (1:20,000 cartographic), drainage density (1.1 km km^{-2} vs 5.0)

	NetMap (SY)[1]	Canada (CG)
DEM	Y	Y
Stream layer	Y	Y
Other landforms[3]	Y	Y[12]
Adjustable[4]	Y	N
Downstream-upstream routing[5]	Y	N
Downslope-upslope routing[6]	Y	N
Element discretization[7]	Y	N
Network completeness[8]	Y	N
Consistency[9]	Y	Y
Tools[10]	Y	N
Total score	100%	40%



Alberta – what else is available?

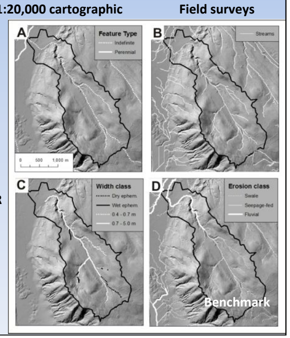
#2: stream layer (1m LiDAR synthetic [Univ. of New Brunswick]), drainage density (4.6 km km^{-2} vs 5.0)

	NetMap (SY)[1]	Canada (SY)
DEM	Y	Y (LiDAR)
Stream layer	Y	Y
Other landforms[3]	Y	N
Adjustable[4]	Y	N
Downstream-upstream routing[5]	Y	N
Downslope-upslope routing[6]	Y	N
Element discretization[7]	Y	N
Network completeness[8]	Y	Y
Consistency[9]	Y	Y
Tools[10]	Y	N
Total score	100%	40%

1:20,000 cartographic

Field surveys

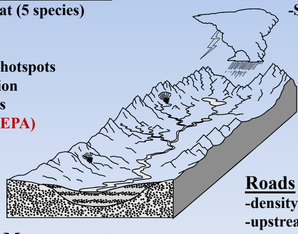
UNB LiDAR



NetMap's Community Tools
(ArcMap 10/10.1)

Aquatic habitat indices
- **-Fish habitat (5 species)**
- **-core areas**
- **-diversity**
- **-biological hotspots**
- **-classification**
- **-floodplains**
- **-estuaries (EPA)**

Erosion
- **-Shallow slide/debris flow**
- **-Surface erosion**
- **-Sediment yield**



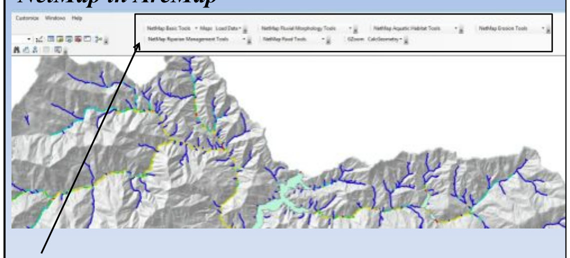
Vegetation
- **-riparian**
- **-fuels/fire risk**
- **-post fire**

Roads
- **-density (multi-scale)**
- **-upstream hab. length/quality**
- **-stability**
- **-drainage diversion (NOAA)**
- **-surface erosion (RMRS)**

Riparian Management
- **-habitat**
- **-wood recruitment (USFS)**
- **-thermal load**
- **-erosion**

Google Earth Interface/online tech help

NetMap in ArcMap



~70 tools/100+ parameters
- ***-Basic Tools***
- ***-Fluvial Morphology***
- ***-Aquatic Habitat***
- ***-Erosion***
- ***-Riparian Management***
- ***-Transportation/Energy***

3.0 Fluvial Morphology Module

3.1 Flow Calculations (mean annual flow, Other Q [2013])

3.2 Hydraulic/Planform Geometry
- *Channel width*
- *Channel depth*
- *Flow velocity*
- *Bed shear stress*
- *Substrate D50/Classes*
- *Channel sinuosity*

3.3 Network Variables
- *Channel gradient*
- *Maximum downstream gradient*
- *Drainage area*
- *Mean annual precipitation*
- *Stream order*
- *Stream power*
- *Tributary Confluence environments*

3.4 Channel Classification
- *Generic*
- *Rosgen*
- *Headwater (2013, funded, State of WA)*
- *Confinement*

3.5 Drainage and Junction Density (subbasin scale)

3.6 Floodplain Mapping

3.7 Alluvial fan mapping (summer 2013)

3.8 Landslide – Channel interactions

3.9 Define Channel Heads (trim network top down)

4.0 Wood Accumulation Types

4.0 Aquatic Habitat Module

4.1 Define Fish Distribution

4.2 Create Aquatic Habitats
- *Intrinsic Potential (three anadromous species)*
- *Cutthroat Trout (Bayesian)*
- *Bull Trout (Empirical)*

4.3 Core Habitats

4.4 Habitat Diversity

4.5 Cumulative Habitat Length and Quality

4.6 Beaver Habitat

4.7 Channel Disturbance Index

4.8 Piscicide Tool

4.9 Estuary mapping-classification (Puget Sound)

4.10 Riparian and upland wetland screening (proposed)

6.0 Transportation/Energy Module

6.1 Import Road/pipeline Layer (discretize)

6.2 Corridor (road, pipeline) Density
- Subbasin scale
- Stream Segment/Network Scale

6.3 Road Segmentation for drain points (drainage diversion, road erosion)

6.4 Road (other corridor) Stability

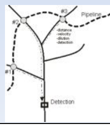
6.5 Road (other corridor) in Floodplains

6.6 Habitat Upstream of Road (and other corridors)

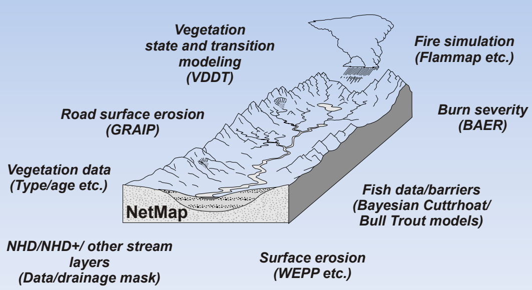
6.7 Road (other corridor) stream overlap classification; habitat; debris flow; gully

6.8 Road Surface Erosion (GRAIP - lite, WEPP)

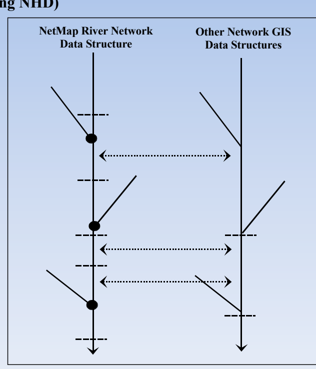
6.9 Toxic spill upstream tracer (proposed)



A platform for other programs, tools, and databases

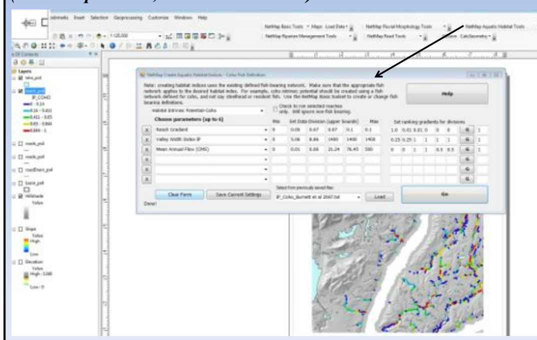


Information transfer between NetMap and other stream databases (including NHD)



Applications: urban and agriculture

Coho salmon habitat – where are the best habitats located? (intrinsic potential, Burnett et al. 2007)



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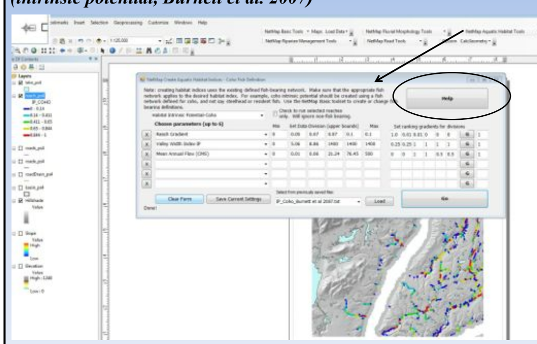
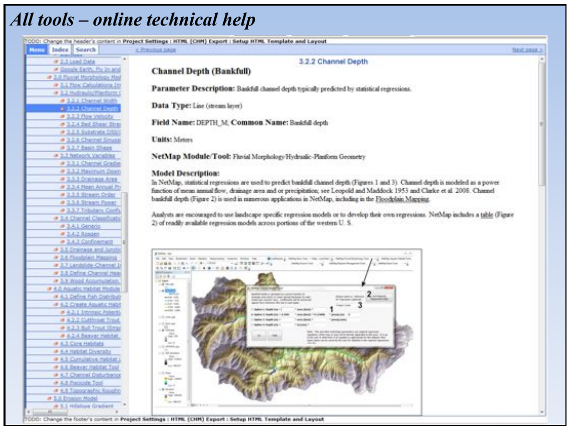
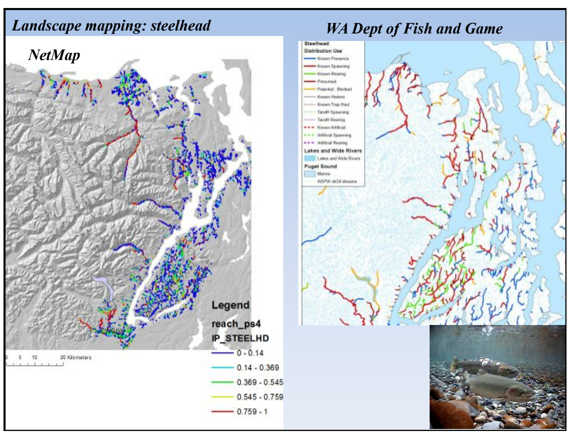
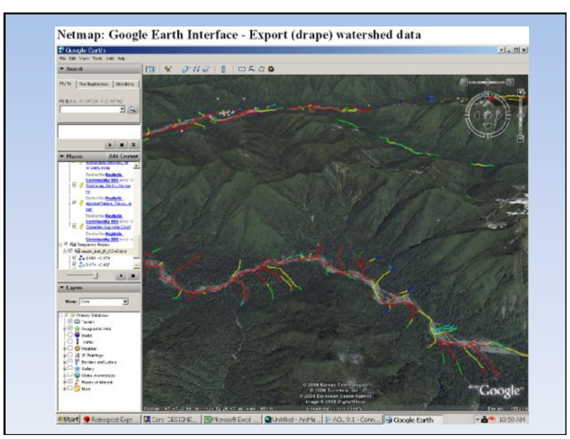
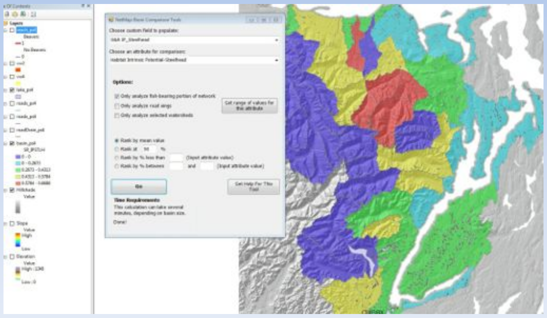



All tools – online technical help
3.2.2 Channel Depth
Channel Depth (Bankfull)
Parameter Description: Bankfull channel depth typically predicted by statistical regressions.
Data Type: Line (stream layer)
Field Name: DEPTH_M; Common Name: Bankfull depth
Units: Meters
NetMap Module/Tool: Fluvial Morphology/Hydraulic-Platform Geometry
Model Description:

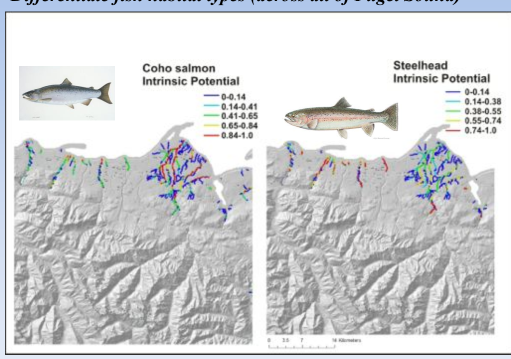

Landscape mapping: steelhead
WA Dept of Fish and Game
NetMap
Legend
reach_ps4
IP_STEELHD
0 - 0.14
0.14 - 0.369
0.369 - 0.545
0.545 - 0.759
0.759 - 1


Netmap: Google Earth Interface - Export (drape) watershed data

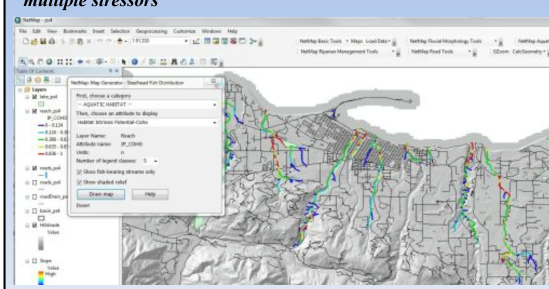
Steelhead habitat, classify using Sort & Rank Tool



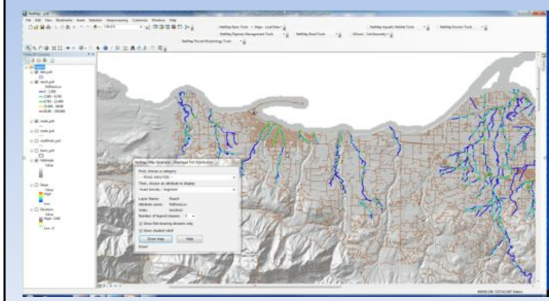
Differentiate fish habitat types (across all of Puget Sound)



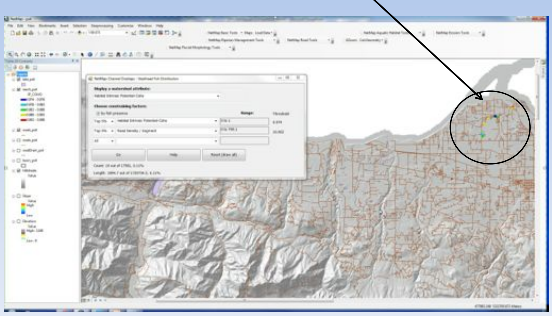
Quickly search for intersections of sensitive habitats with single or multiple stressors



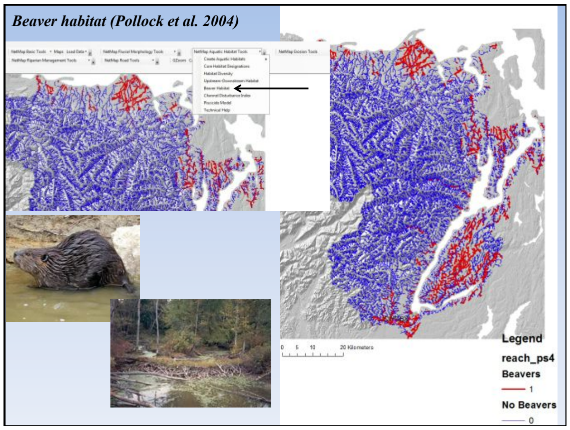
Road density – a stressor



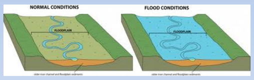
Where does the highest 5% of road density (stream segment scale) intersect the top 5% of coho salmon quality?

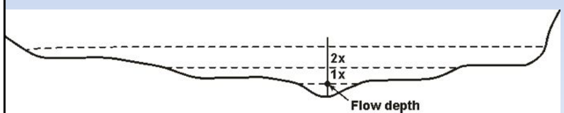


Beaver habitat (Pollock et al. 2004)

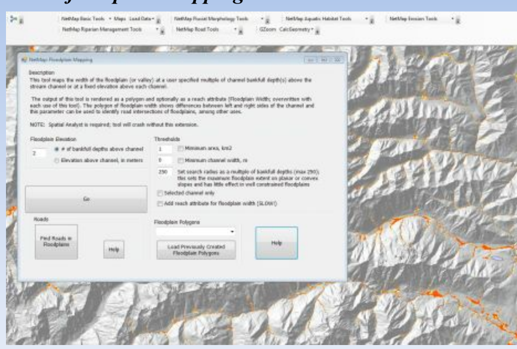


Flexible floodplain mapping

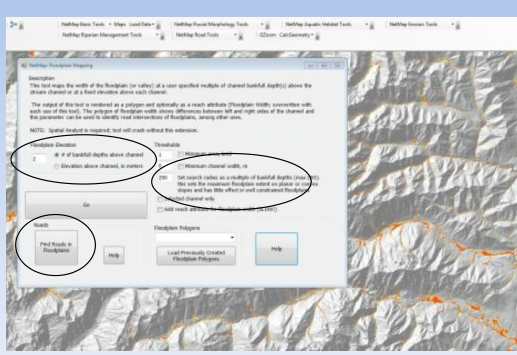




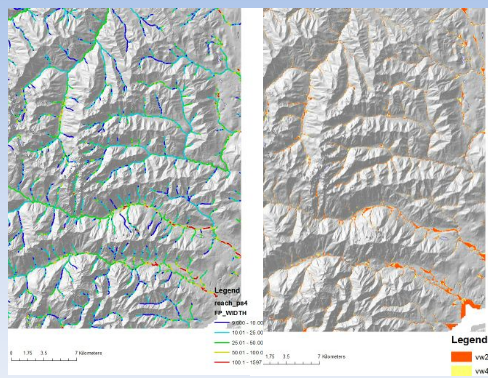
Flexible floodplain mapping



Flexible floodplain mapping

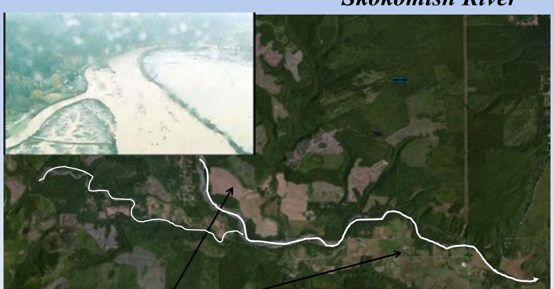


Mapping floodplains: regulatory or part of habitat mapping/prediction



Mapping floodplains: identifying where obscured

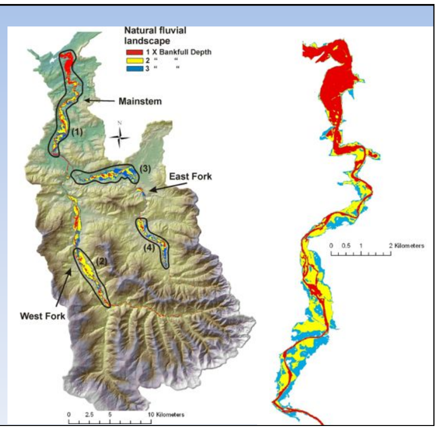
Skokomish River



Development

Mapping floodplains: identifying where developed (restoration)

Floodplain mapping for restoration planning

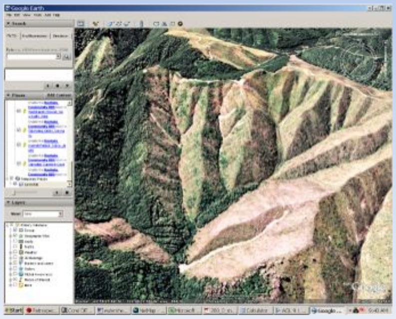


Applications: the rural, upstream domain

-forestry
-roads
-erosion
-wildfire

Where are the most erosion prone areas located?
Which areas are most sensitive to land uses?
What are the best buffer designs to mitigate erosion?

***NetMap shallow failure-gully potential** (Miller and Burnett 2007)*



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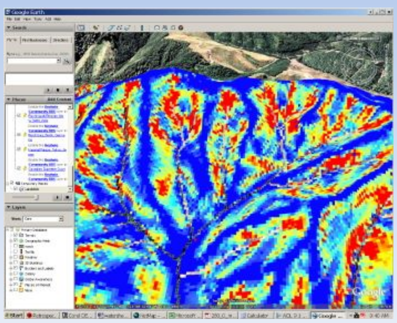
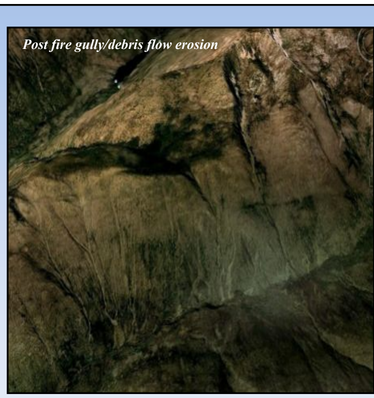
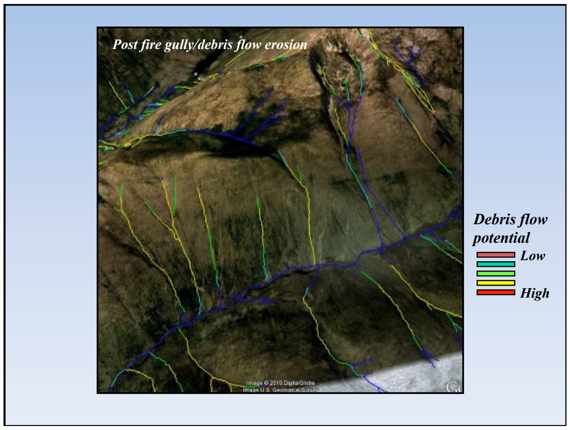
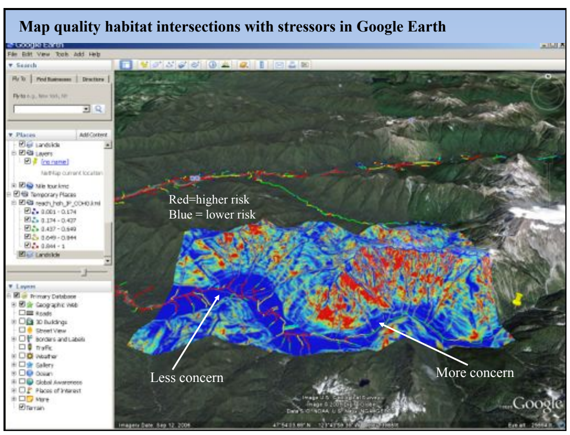
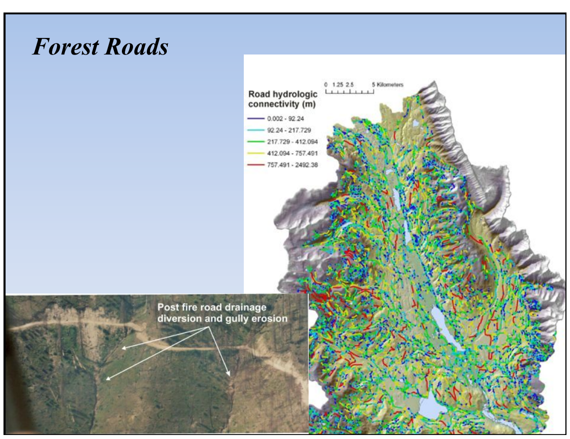
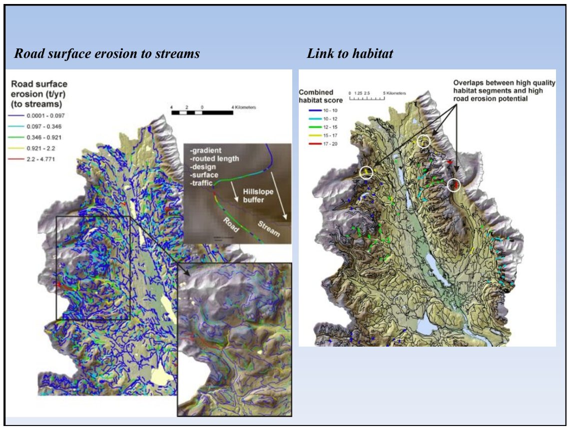


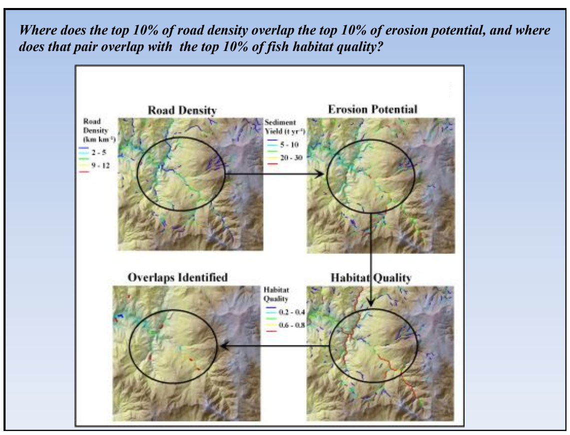


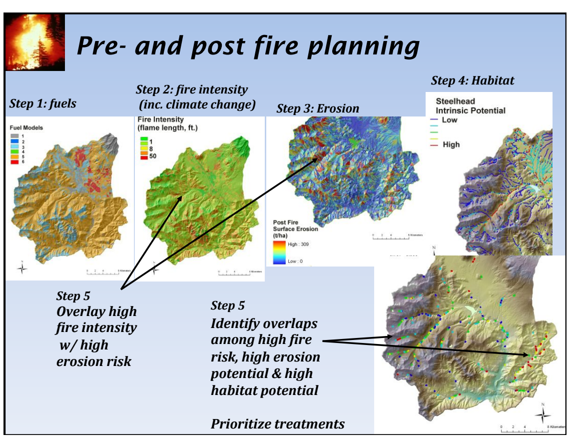

Post fire gully/debris flow erosion
Debris flow potential
Low
High


Map quality habitat intersections with stressors in Google Earth
Red=higher risk
Blue = lower risk
Less concern
More concern

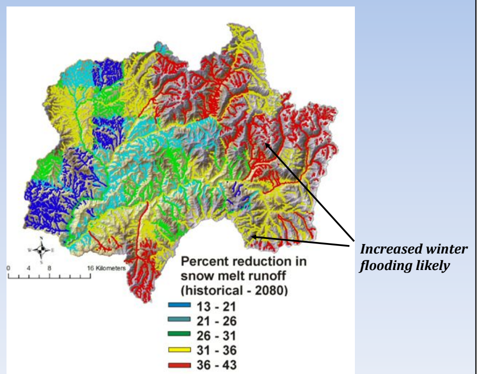

Forest Roads
Road hydrologic connectivity (m)
0.002 - 92.24
92.24 - 217.729
217.729 - 412.094
412.094 - 757.491
757.491 - 2492.38
0 1.25 2.5 5 Kilometers
Post fire road drainage diversion and gully erosion


Road surface erosion to streams
Link to habitat
Road surface erosion (t/yr) (to streams)
0.0001 - 0.097
0.097 - 0.346
0.346 - 0.921
0.921 - 2.2
2.2 - 4.771
-gradient
-routed length
-design
-surface
-traffic
Hillslope buffer
Road
Stream
Combined habitat score
Overlaps between high quality habitat segments and high road erosion potential


Where does the top 10% of road density overlap the top 10% of erosion potential, and where does that pair overlap with the top 10% of fish habitat quality?
Road Density
Erosion Potential
Road Density (km km⁻¹)
2 - 5
9 - 12
Sediment Yield (t yr⁻¹)
5 - 10
20 - 30
Overlaps Identified
Habitat Quality
Habitat Quality
0.2 - 0.4
0.6 - 0.8

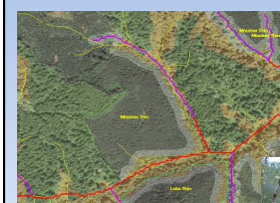

Pre- and post fire planning
Step 1: fuels
Step 2: fire intensity (inc. climate change)
Step 3: Erosion
Step 4: Habitat
Fuel Models
Fire Intensity (flame length, ft.)
Steelhead Intrinsic Potential
Low
High
Post Fire Surface Erosion (t/ha)
Step 5
Overlay high fire intensity w/ high erosion risk
Step 5
Identify overlaps among high fire risk, high erosion potential & high habitat potential
Prioritize treatments

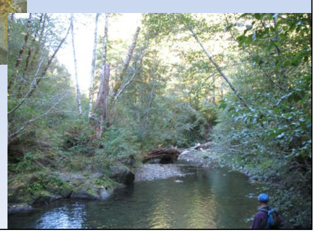
Climate change, applying downscaled GCM predictions (UW Climate Impact Group)



Spatially Explicit Riparian Management

NetMap





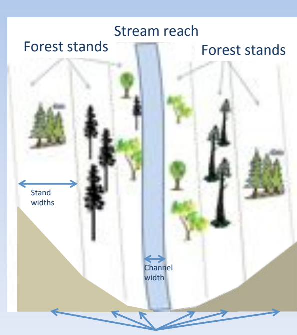
A procedure for riparian management planning based on assessment of
-forest growth
-riparian processes
-fish habitat

Reach Scale Wood Recruitment

Mortality types include suppression, fire, insect, disease, & wind-throw.

Bells and Whistles:
- channel width,
- stand width,
- hillslope gradient,
- bank erosion,
- wood decay,
- taper equations,
- thinned trees that are tipped, and
- size of resulting wood pieces

Inputs: stand tables from forest growth models
Outputs: 10 types of plots



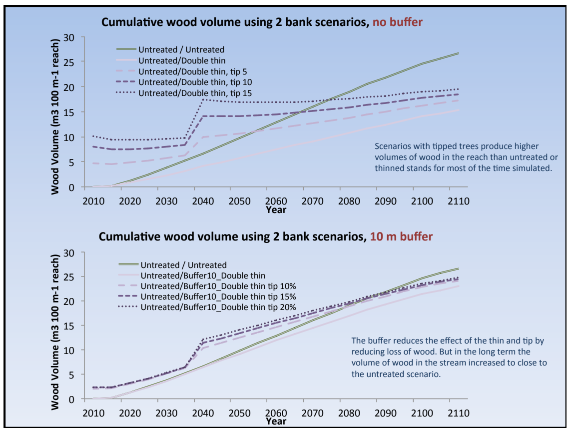
Kozak, 1988; Bilby et al, 1999; Benda and Sias 2003; Sobota et al, 2006; Hibbs et al, 2007; and more.

Scenarios

- Left bank is always no action scenario (70 m)
- Right bank treatment scenarios (11)
- Double entry thin, 70 TPA: 2010, 2040
- All other parameters held constant

Right bank scenarios

Stand1	Stand2
No action (**10 m**)	No action (**60 m**)
No action	Thinned
No action	Thin & tip 5%
No action	Thin & tip 10%
No action	Thin & tip 15%
No action	Thin & tip 20%
Thinned (**70 m**)	
Thin & tip 5%	
Thin & tip 10%	
Thin & tip 15%	
Thin & tip 20%	



Total volume of cumulative wood over time

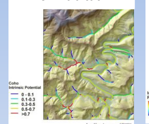
(sorted by increasing volume)

Total cumulative wood	Volume (m^3 100 m^{-1} reach) (percent change from reference)
Untreated/Double thin	156 (-42%)
Untreated/Double thin, tip 5%	232 (-14%)
Untreated/Buffer10_Double thin	243 (-10%)
Untreated/Untreated (reference condition)	271
Untreated/Double thin, tip 10%	284 (5%)
Untreated/Buffer10_Double thin tip 10%	288 (6%)
Untreated/Buffer10_Double thin tip 15%	299(10%)
Untreated/Buffer10_Double thin tip 20%	305 (13%)
Untreated/Double thin, tip 15%	324 (20%)

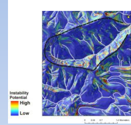
Tree tipping from thinning operations combined with riparian buffers offer the highest volumes of wood loadings

Forest Growth

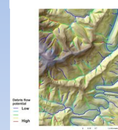
Fish Habitat



Erosion

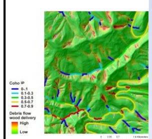


Debris Flow

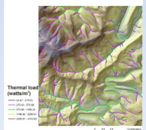


Assess environments: reach scale (project) and watershed scale using a mix of advanced analysis tools and field work

Upslope Wood

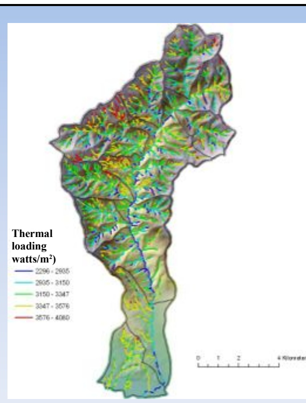


Thermal

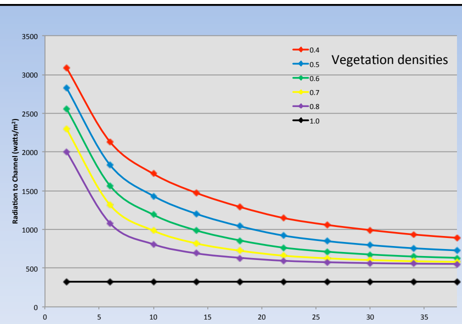


Wood sources & recruitment

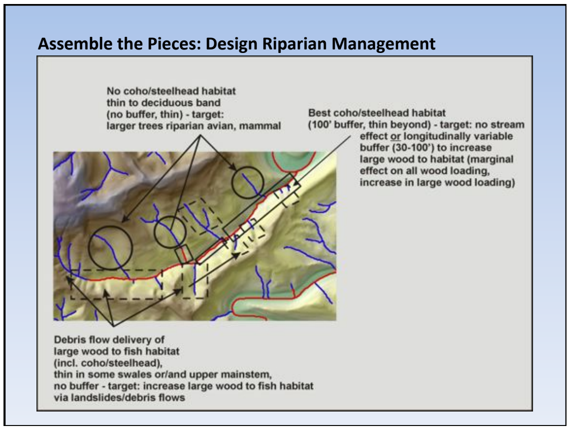
Sensitivity analysis: which channels are most sensitive to changes in riparian veg?

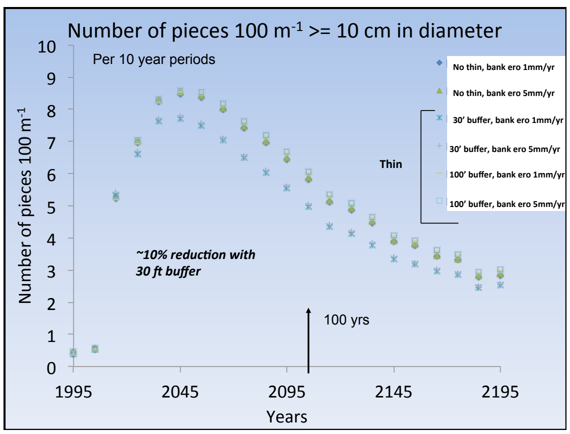


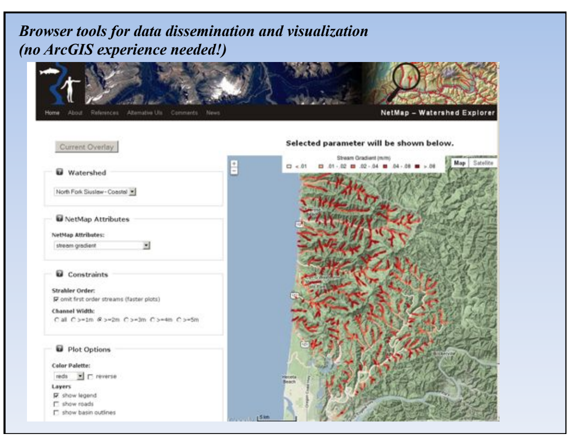
Fully forested versus no vegetation (bare)



Radiation versus Buffer Width, Variable Densities, Height =50m, Stream Channel Width=10m


Assemble the Pieces: Design Riparian Management
No coho/steelhead habitat
thin to deciduous band
(no buffer, thin) - target:
larger trees riparian avian, mammal
Best coho/steelhead habitat
(100' buffer, thin beyond) - target: no stream
effect or longitudinally variable
buffer (30-100') to increase
large wood to habitat (marginal
effect on all wood loading,
increase in large wood loading)
Debris flow delivery of
large wood to fish habitat
(incl. coho/steelhead),
thin in some swales or/and upper mainstem,
no buffer - target: increase large wood to fish habitat
via landslides/debris flows


Number of pieces 100 m-1 >= 10 cm in diameter
Per 10 year periods
No thin, bank ero 1mm/yr
No thin, bank ero 5mm/yr
30' buffer, bank ero 1mm/yr
30' buffer, bank ero 5mm/yr
100' buffer, bank ero 1mm/yr
100' buffer, bank ero 5mm/yr
Thin
~10% reduction with
30 ft buffer
100 yrs
Number of pieces 100 m-1
Years
0
1
2
3
4
5
6
7
8
9
10
1995
2045
2095
2145
2195


Browser tools for data dissemination and visualization
(no ArcGIS experience needed!)
NetMap – Watershed Explorer
Current Overlay
Selected parameter will be shown below.
Watershed
NetMap Attributes
Constraints
Plot Options
Map
Satellite

Access databases and tools, and support and maintenance