A Riverscape Perspective of Salmon Habitat Assessment on Tribal Ceded Lands

Presentation to USGS Water Science Center, 20 March 2012

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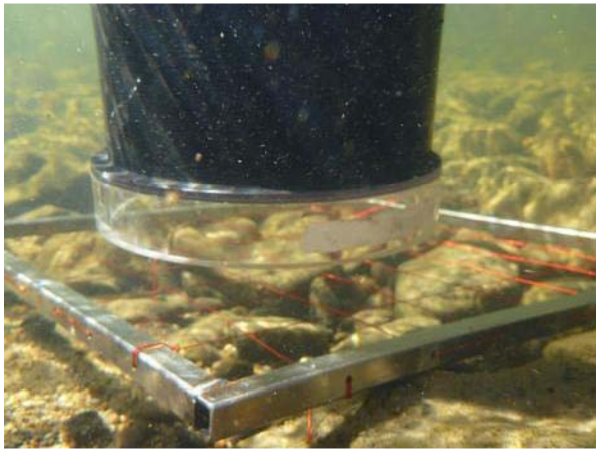
Columbia River Inter-Tribal Fish Commission
BPA Project # 2009-004-00





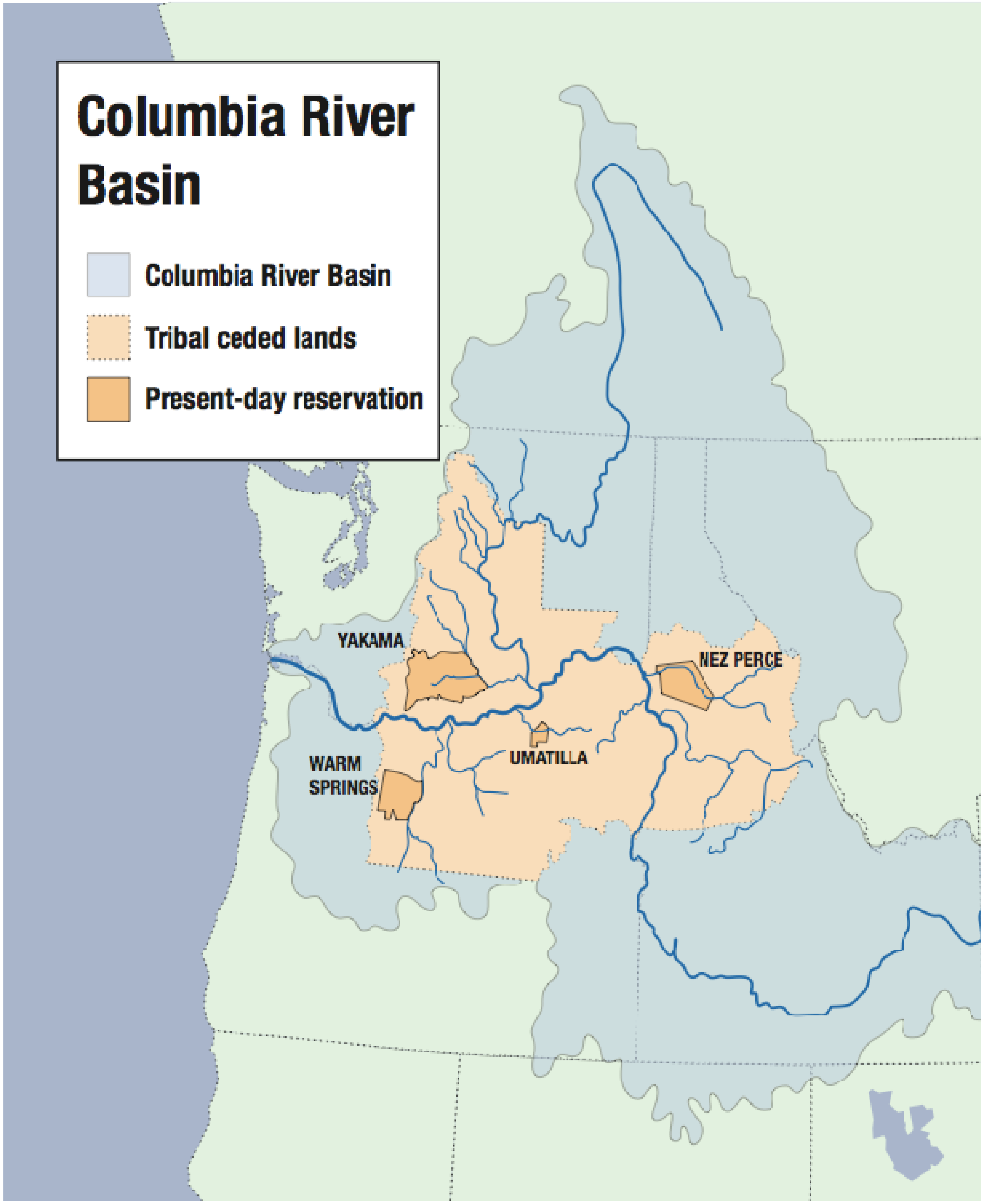
Objectives

1) Introduce a monitoring program for spring Chinook salmon habitat conditions

2) Describe preliminary results on the riverscape context of fish-habitat relationships

   a) Influence of landscape-scale features on site-level fish habitat metrics (Pacific Northwest)

   b) A statistical approach to linking habitat to juvenile Chinook salmon distribution (upper Grande Ronde)



Tribal lands ceded in 1855 Treaty

Arrival of the Nez Perce Indians to the Wallawalla Treaty
May the 1855

"…the right of taking fish at all usual and accustomed places… together with the privilege of hunting, gathering roots and berries..."

—1855 Treaty with the Yakima

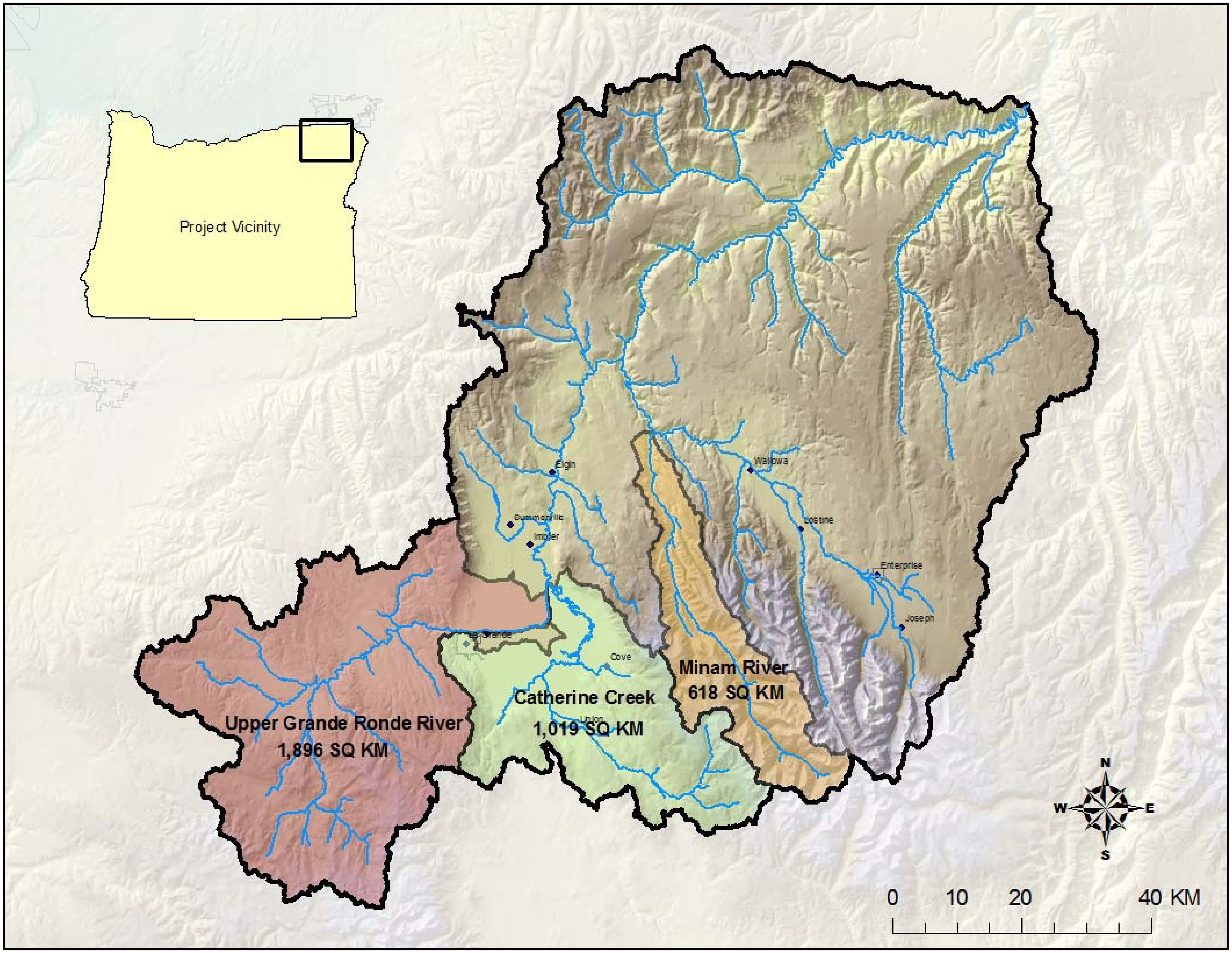
1977

CRITFC formed "to ensure a unified voice in the overall management of the fishery resources, and as managers, to protect reserved treaty rights through the exercise of the inherent sovereign powers of the tribes."

2008

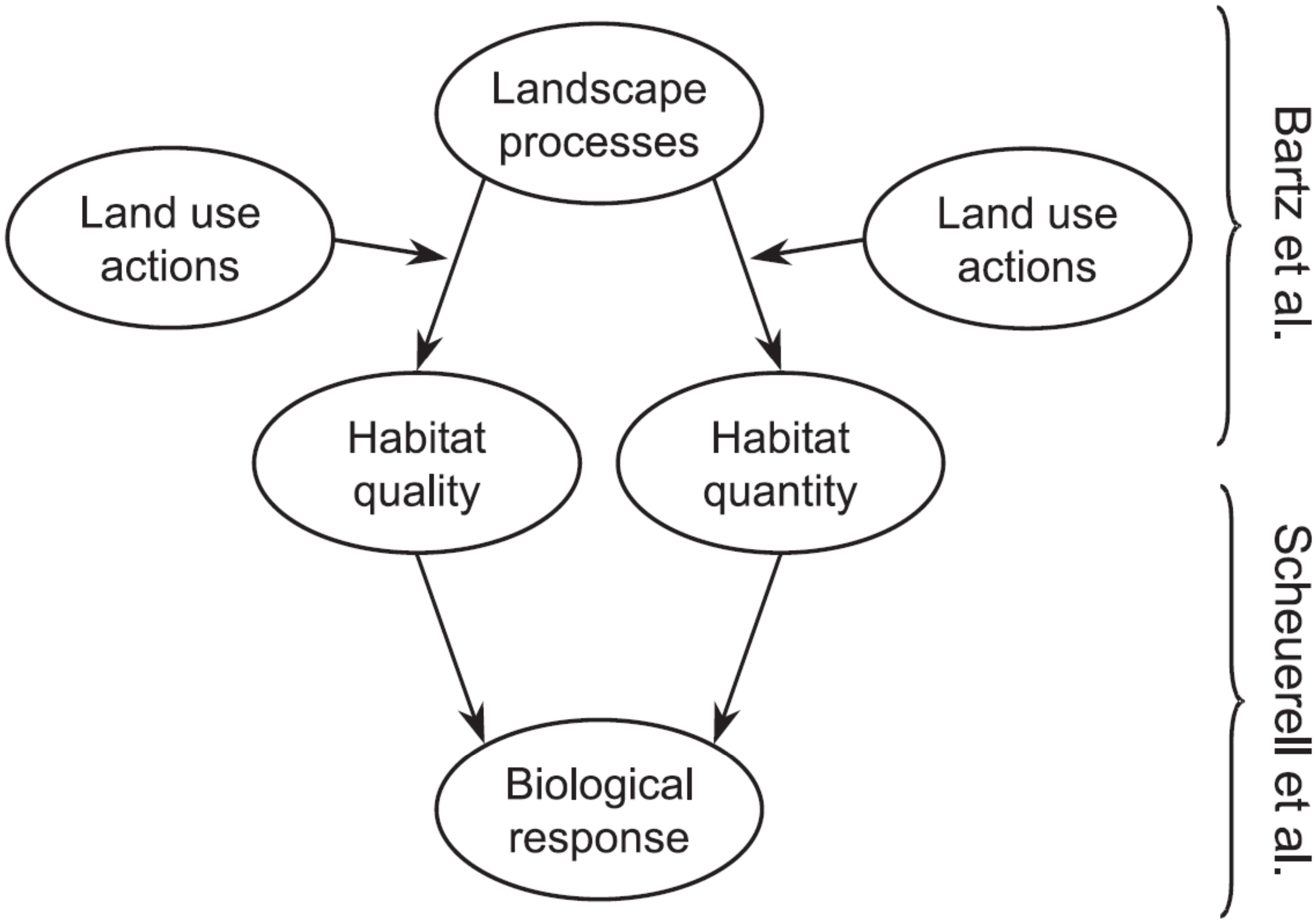
The **Columbia Basin Fish Accords*** set aside almost $1 billion to implement Tribal fishery projects [including monitoring and assessment].

**The Nez Perce Tribe declined to be a party of the Accords agreement, but approved CRITFC participation.*



Project Vicinity
Elgin
Summerville
Imbler
Wallowa
Lostine
Enterprise
Joseph
Cove
Union
Upper Grande Ronde River
1,896 SQ KM
Catherine Creek
1,019 SQ KM
Minam River
618 SQ KM
N
S
E
W
0
10
20
40 KM

Conceptual modeling framework



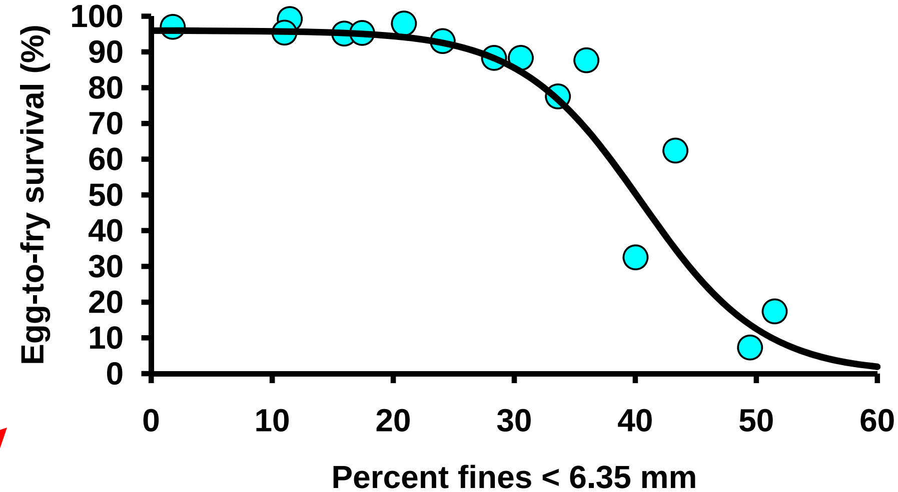
Can. J. Fish Aquat. Sci. 63: 1596–1607 (2006)

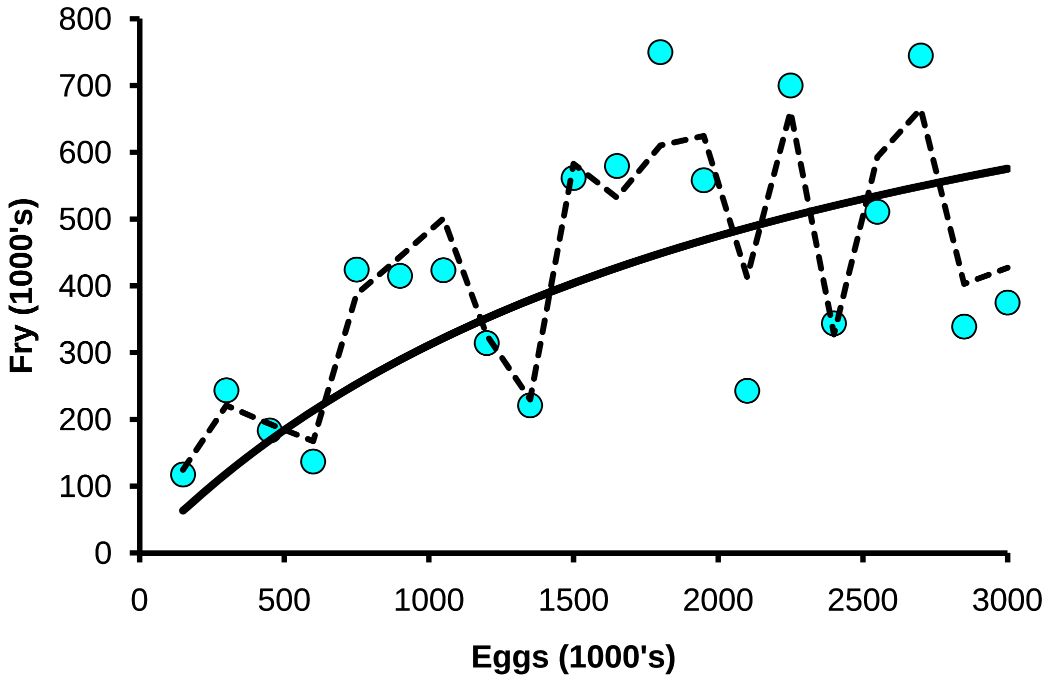
Life cycle model

Beverton-Holt Model

$$N_{i+1,t+1} = \frac{N_{i,t}}{\left(\frac{1}{p_{i,t}}\right) + \left(\frac{1}{c_{i,t}}\right) N_{i,t}}$$

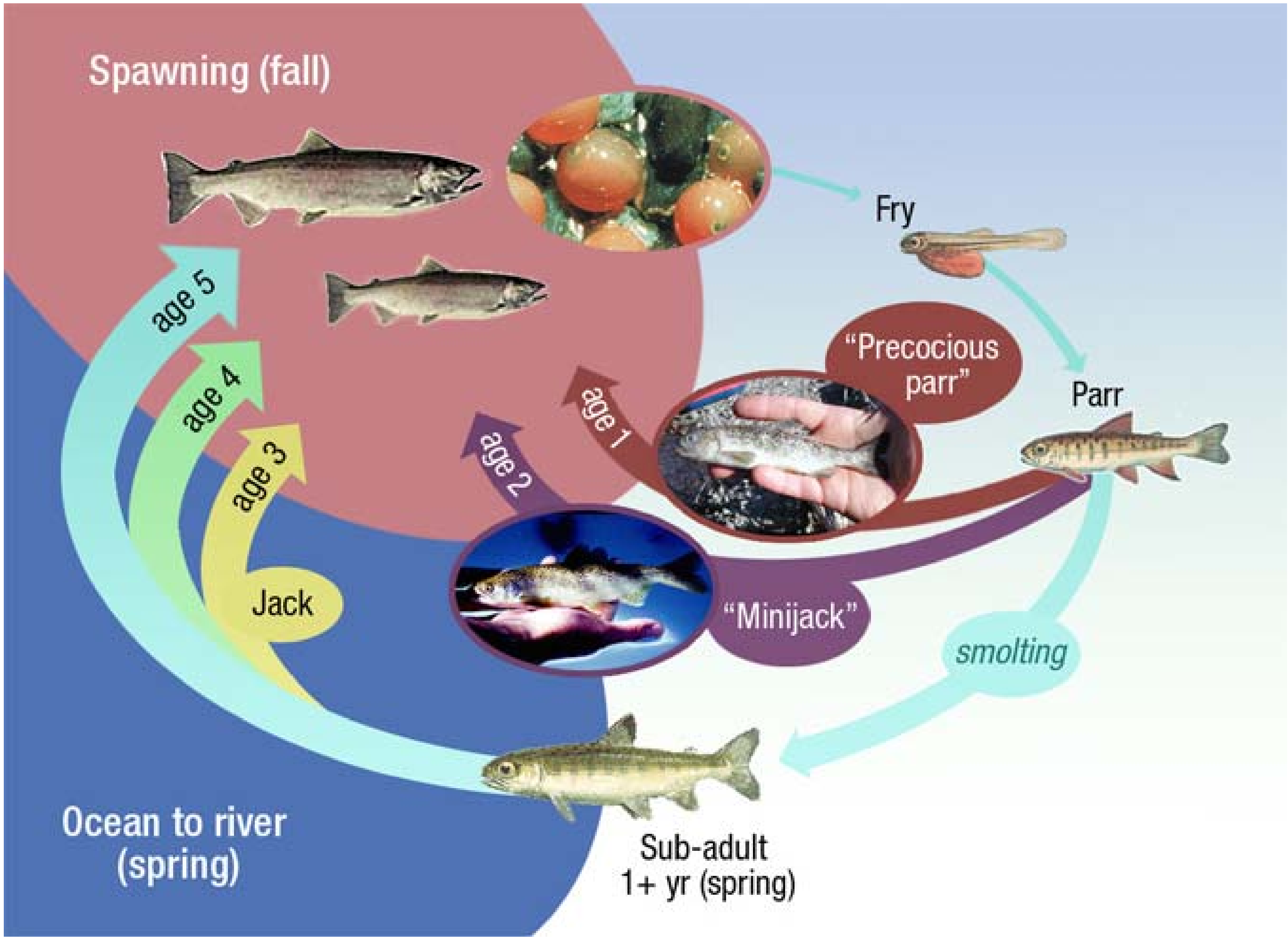
Tappel & Bjorn 1983





Model structure from Sharma et al. (2005)

Life cycle of spring Chinook salmon



Northwest Fisheries Science Center

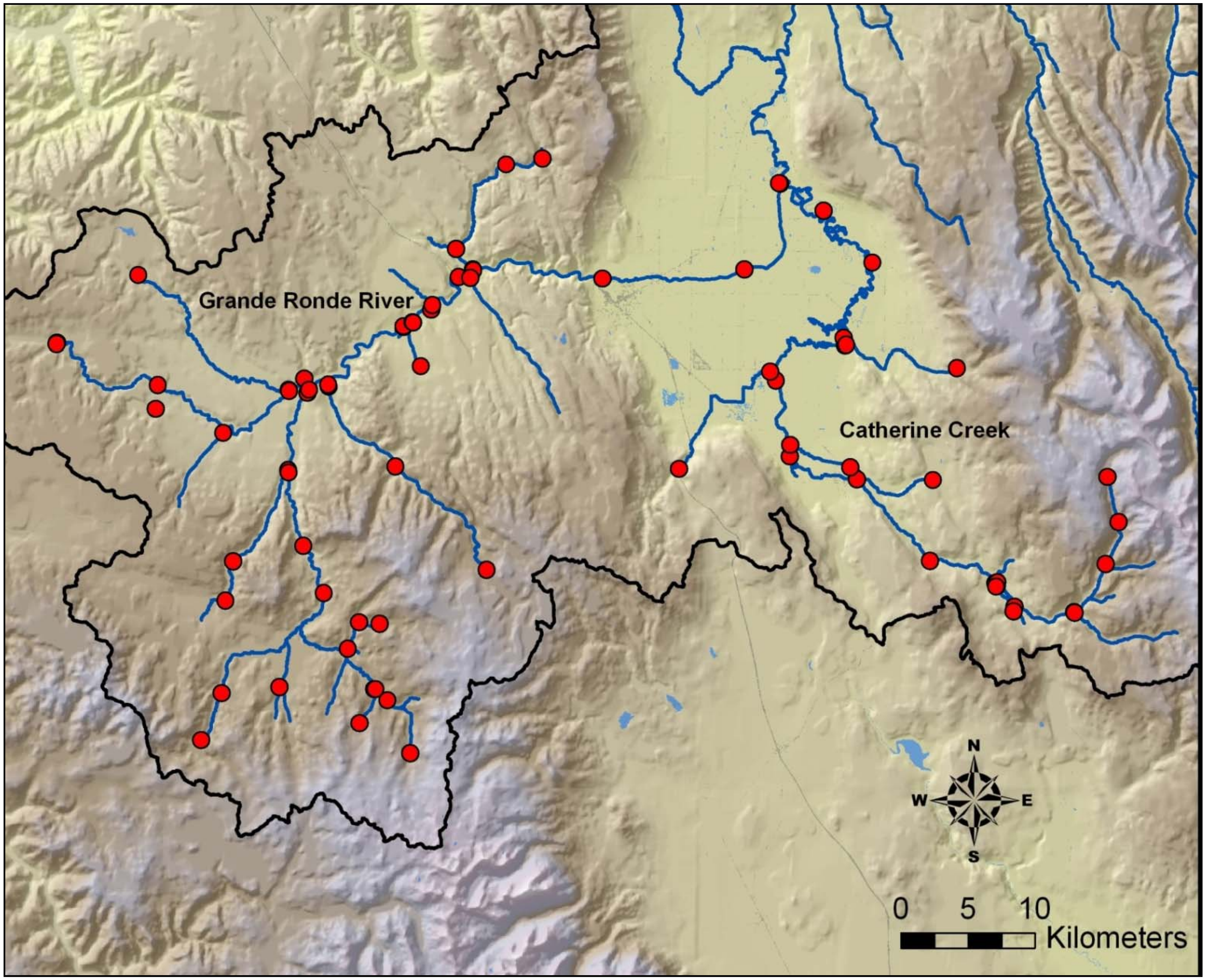
Habitat Metrics

- Channel unit type (pools, riffles, runs).
- Channel unit dimensions (surface area, depth, volume)
- Cover (LWD, boulders, undercut banks, overhanging vegetation)
- Surface and subsurface sediment size composition.
- Channel slope
- Bank stability
- Bankfull width and depth
- Riparian canopy cover
- Solar input
- Discharge
- Water and air temperature
- Water Chemistry (DO, conductivity, pH, alkalinity)

Biological Metrics

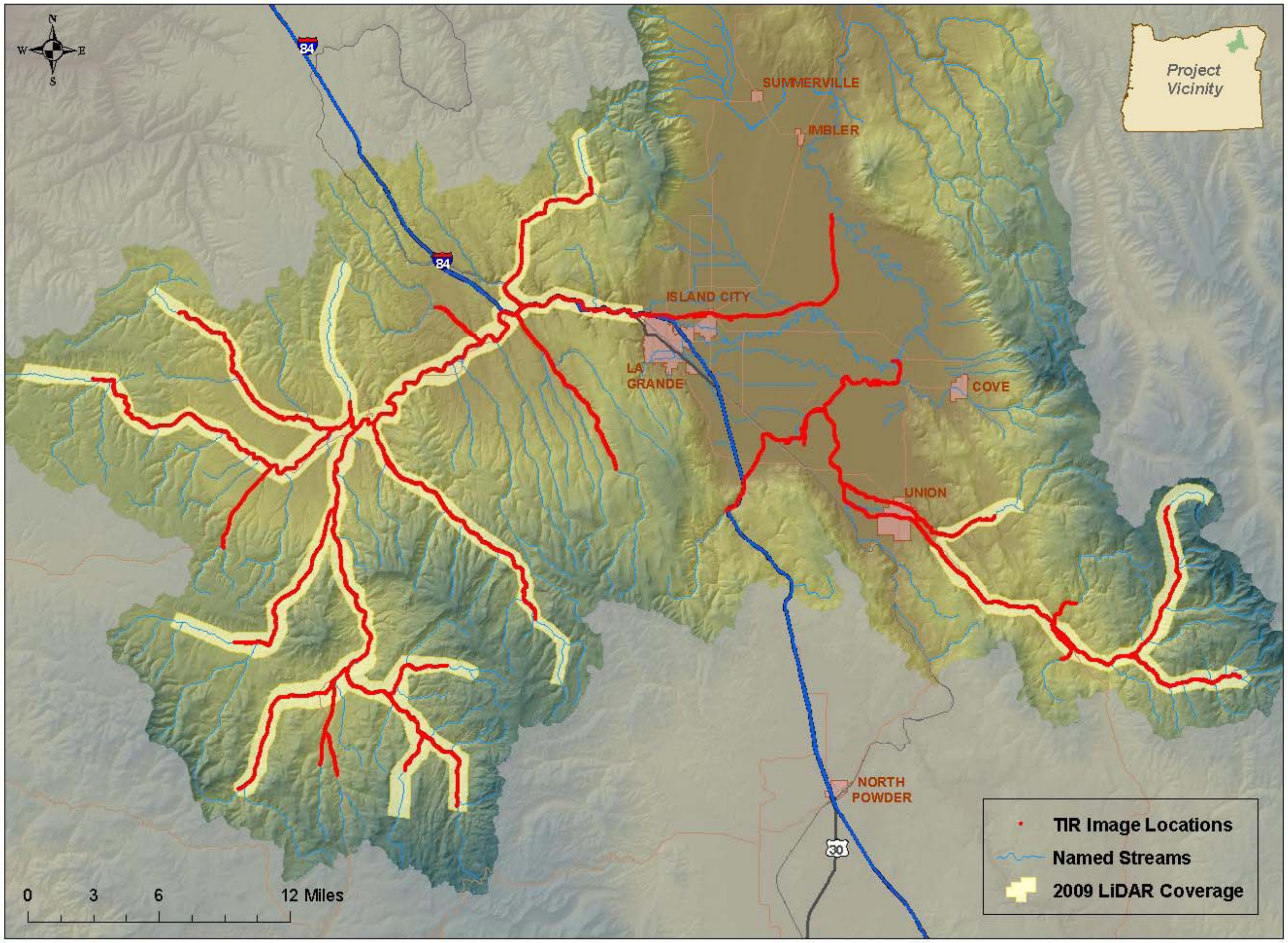
- Fish size and density (via snorkel surveys)
- Benthic macroinvertebrates
- Drift macroinvertebrates

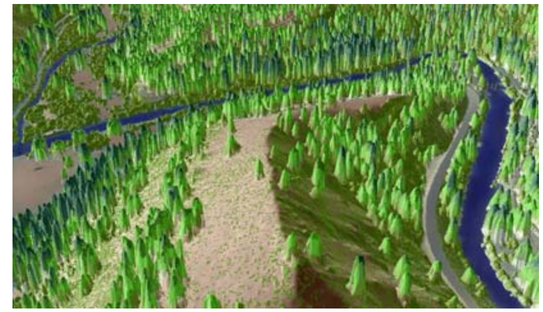
Temperature & streamflow monitoring



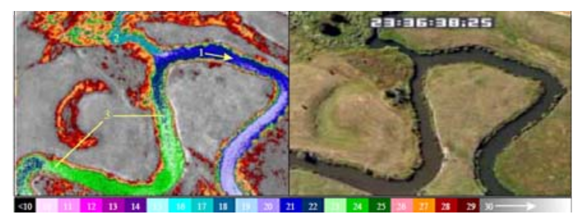
- Continuous stream temperature at 79 sites in 2010.
- Flow measurements at same locations during 2-week low-flow
- Data used to calibrate FLIR data and Heat Source model
- Assembled all available temperature and streamflow data from various agencies into database.

LIDAR and TIR coverage



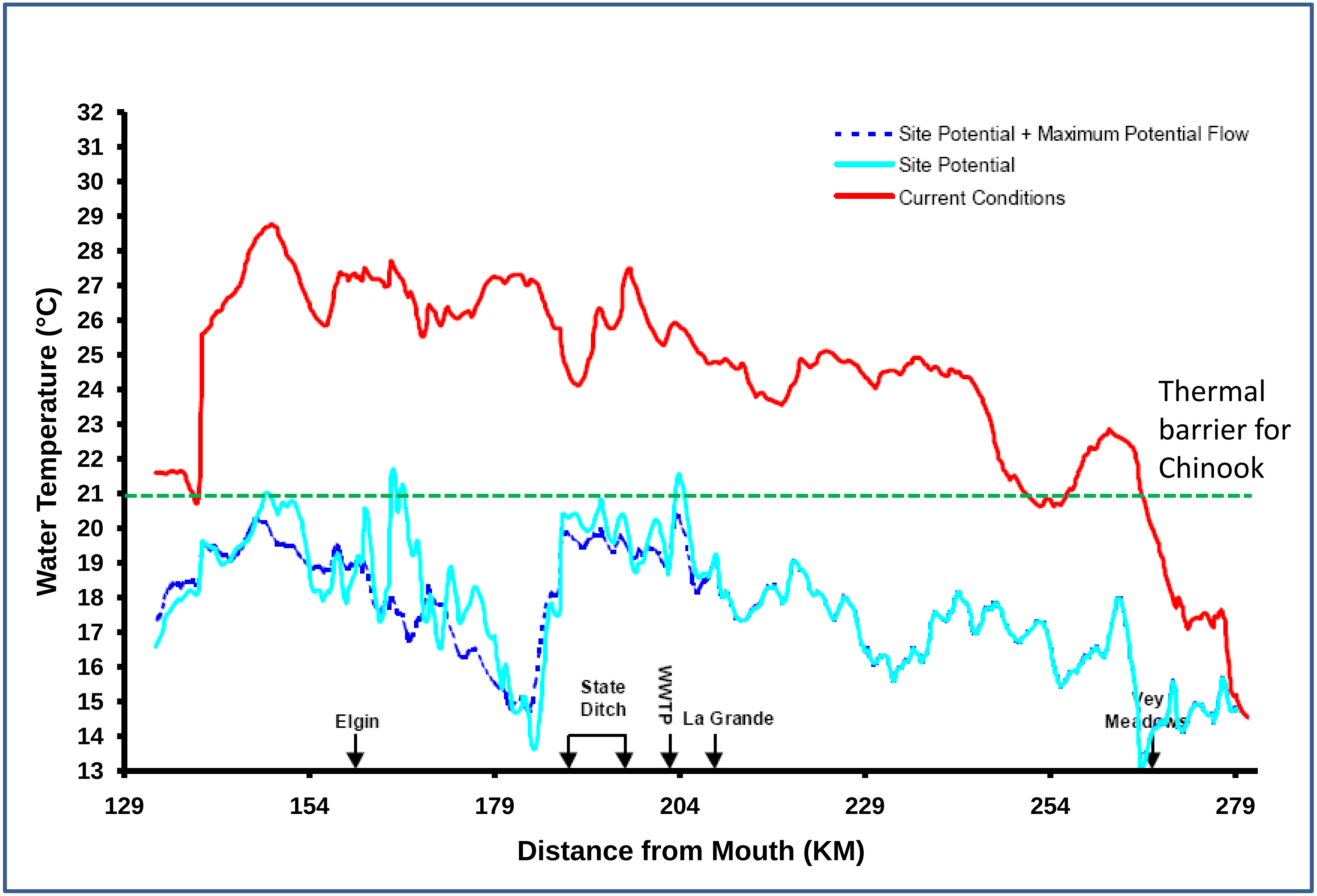


- LiDAR for 80K acres in 2009.
- Thermal infrared imagery (TIR) for364 river km in 2010.



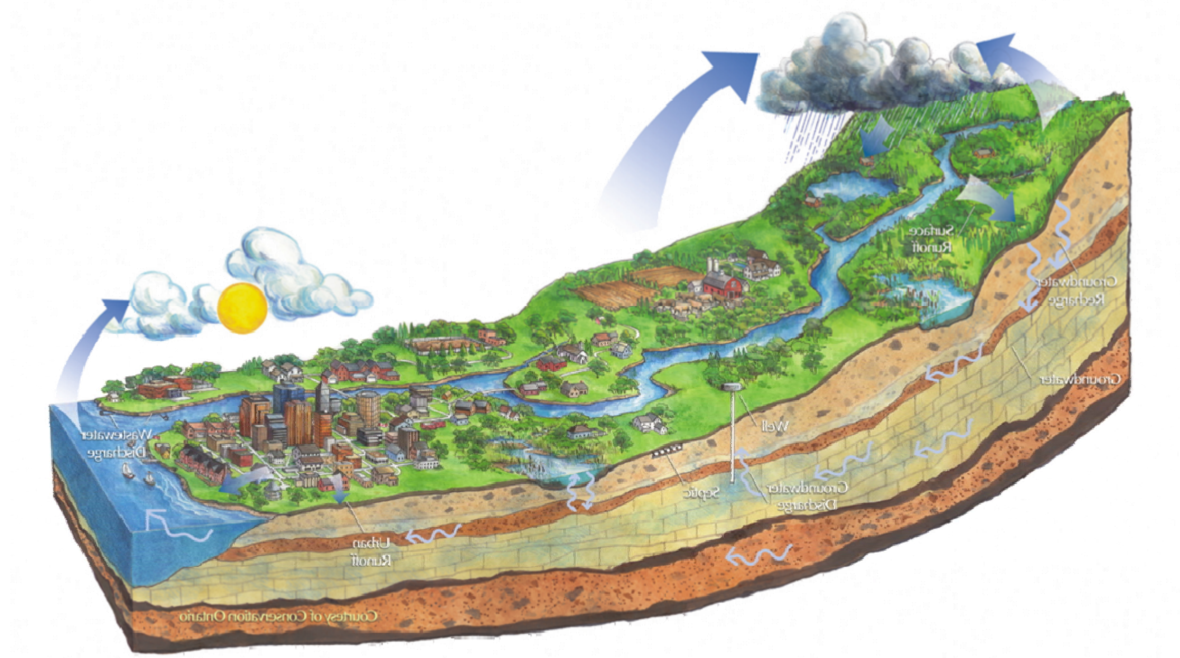
From Watershed Sciences (2010)

Grande Ronde River Temperature for Current Condition and Site Potential



Oregon Department of Environmental Quality (ODEQ) 2000

Streamflow analyses – Val Kelly, USGS Water Science Center



- Relative importance of groundwater across large-scale geologic gradients (Can this gradient be used to estimate attributes of low-flow regime for ungaged sites?)
- Specific objectives:
  - Evaluate existing streamflow record for key components of low-flow regime
    - Baseflow stability and variability
  - Identify key watershed factors associated with low-flow regime (e.g., volcanic vs. basalt geology) and utilize them to estimate low-flow regime for ungaged sites (canonical correlation analysis)

Objectives

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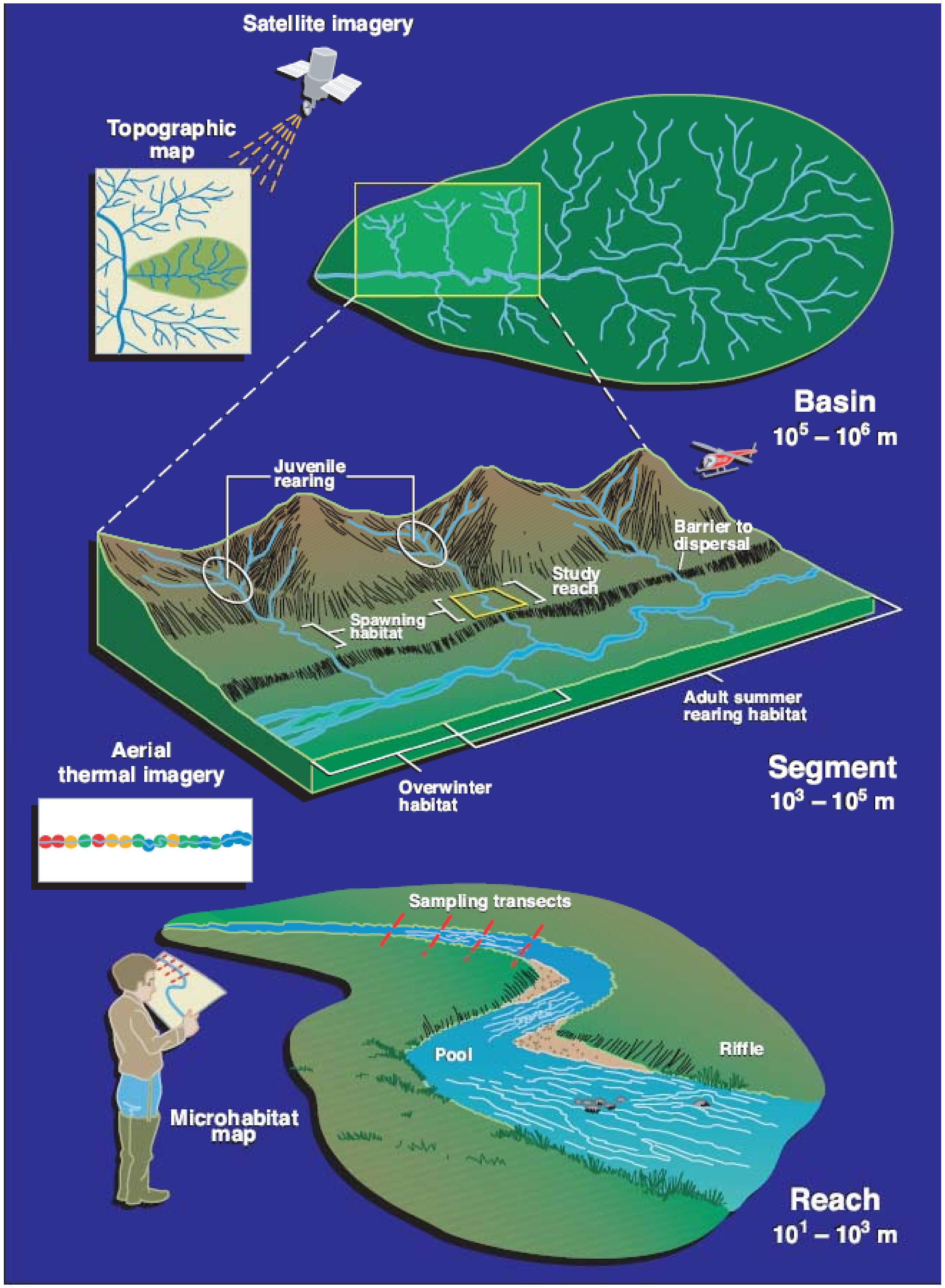
    a) Influence of landscape-scale features on site-level fish habitat metrics (Pacific Northwest)

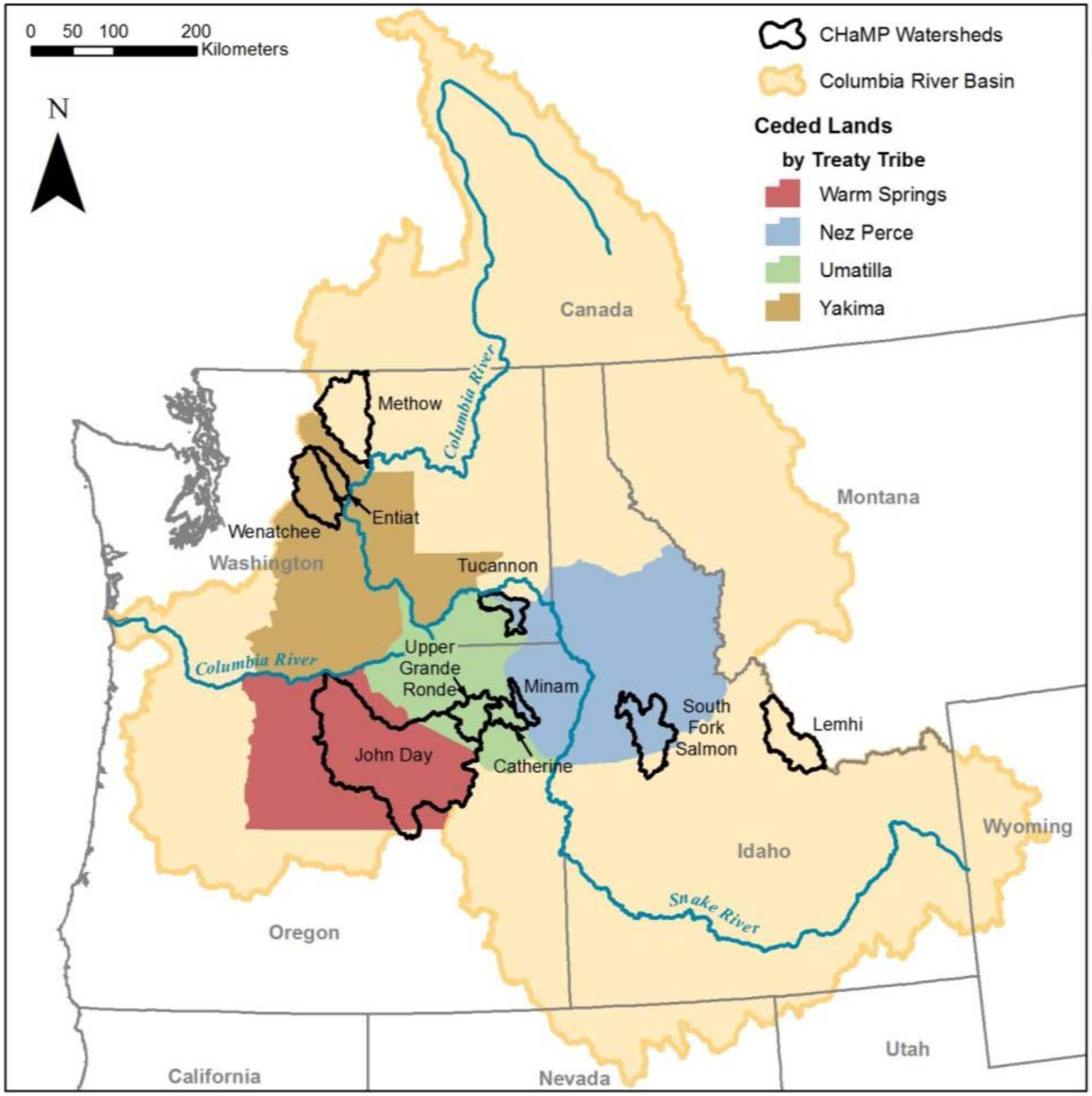


The Riverscape Approach

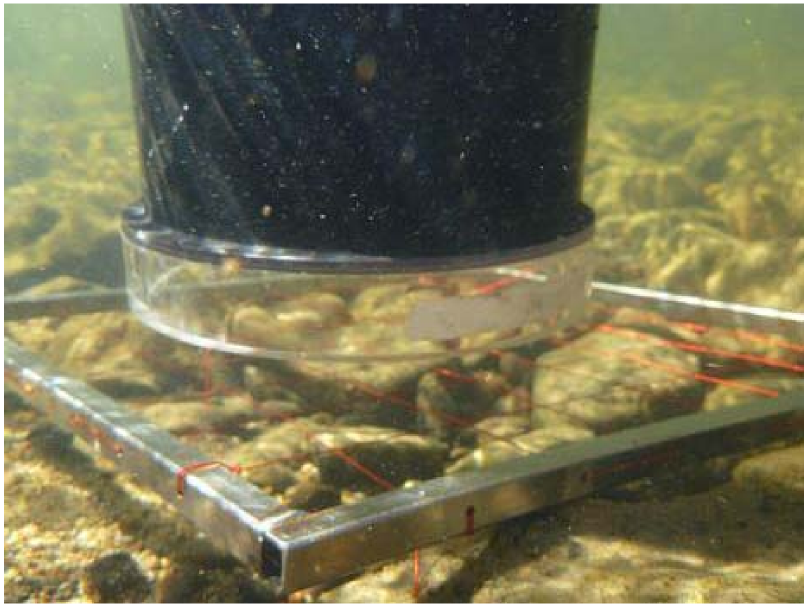
Frissell *et al.* 1986
Fausch *et al.* 2002

Columbia habitat monitoring program (CHaMP) study design

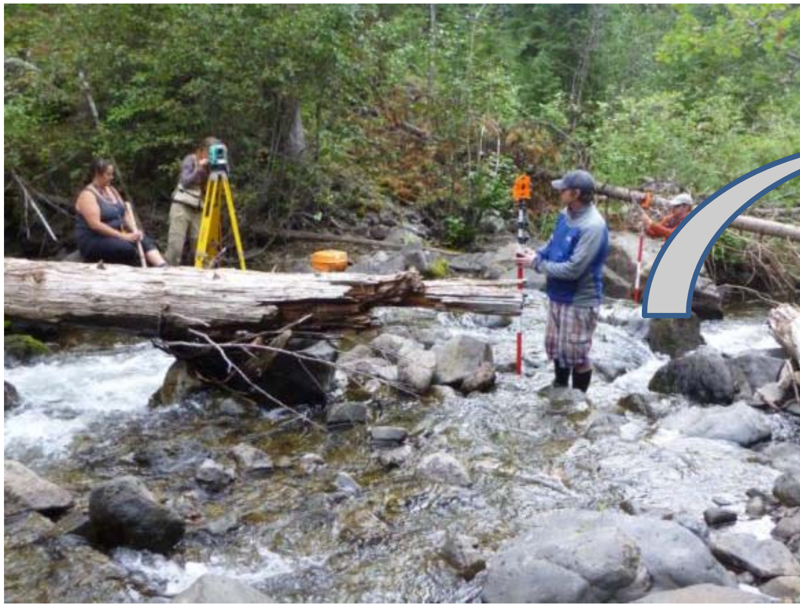
- Eight watersheds in Columbia River basin
- Spatially balanced (GRTS)
- 3-yr rotating panels
- Stratification of source, transport, response channel types



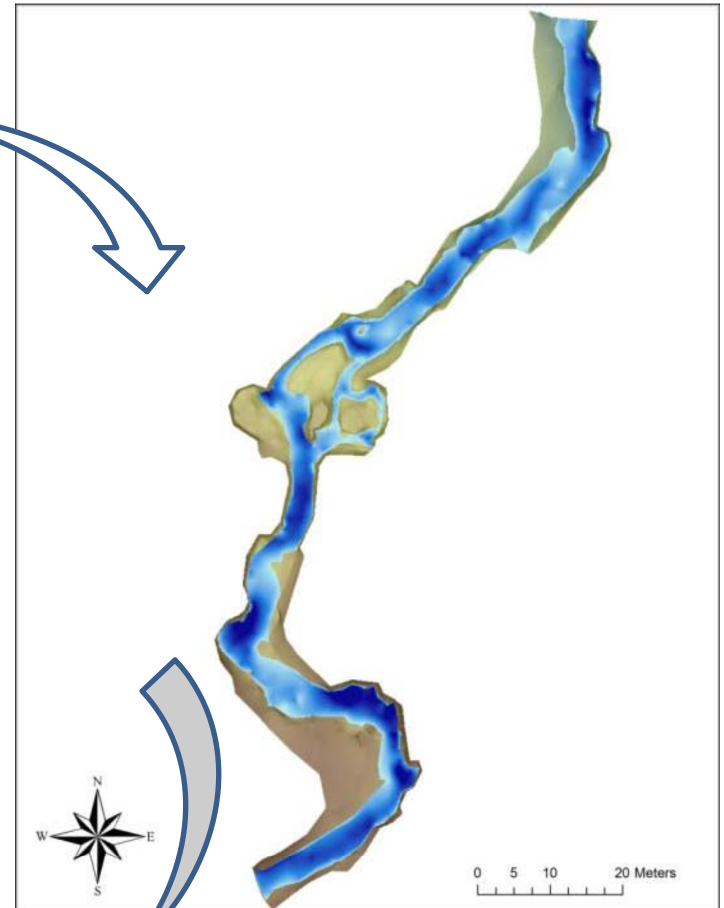
CHaMP methods – Field Survey



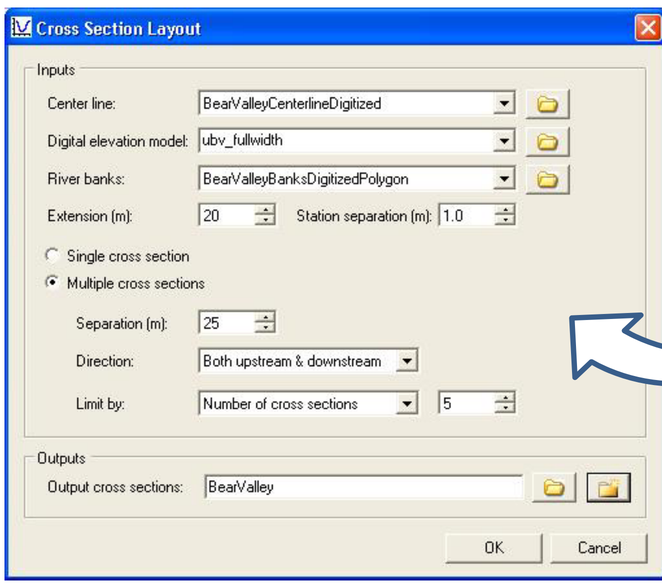
Generating CHaMP metrics



Field Survey



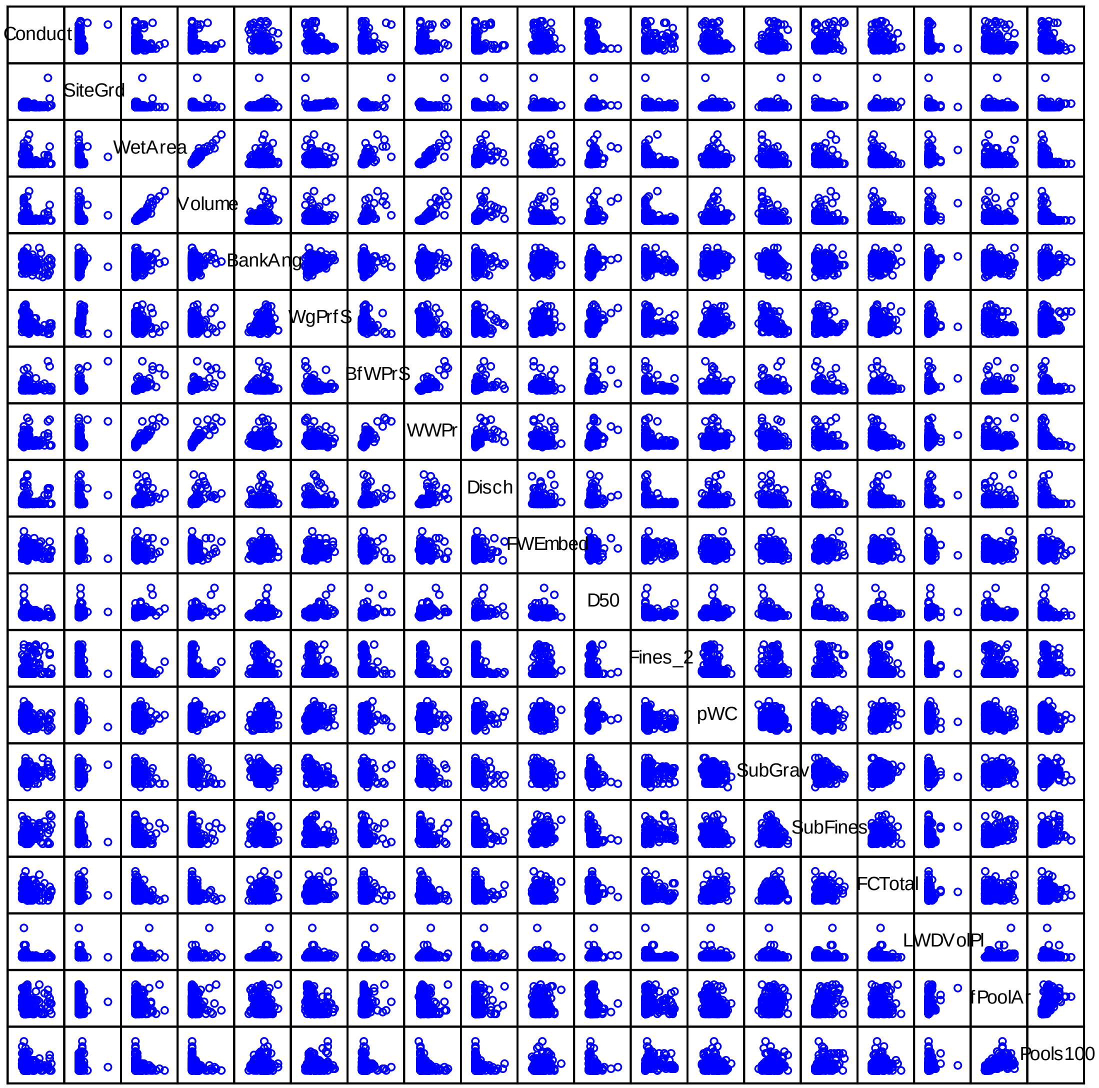
GIS post-processing



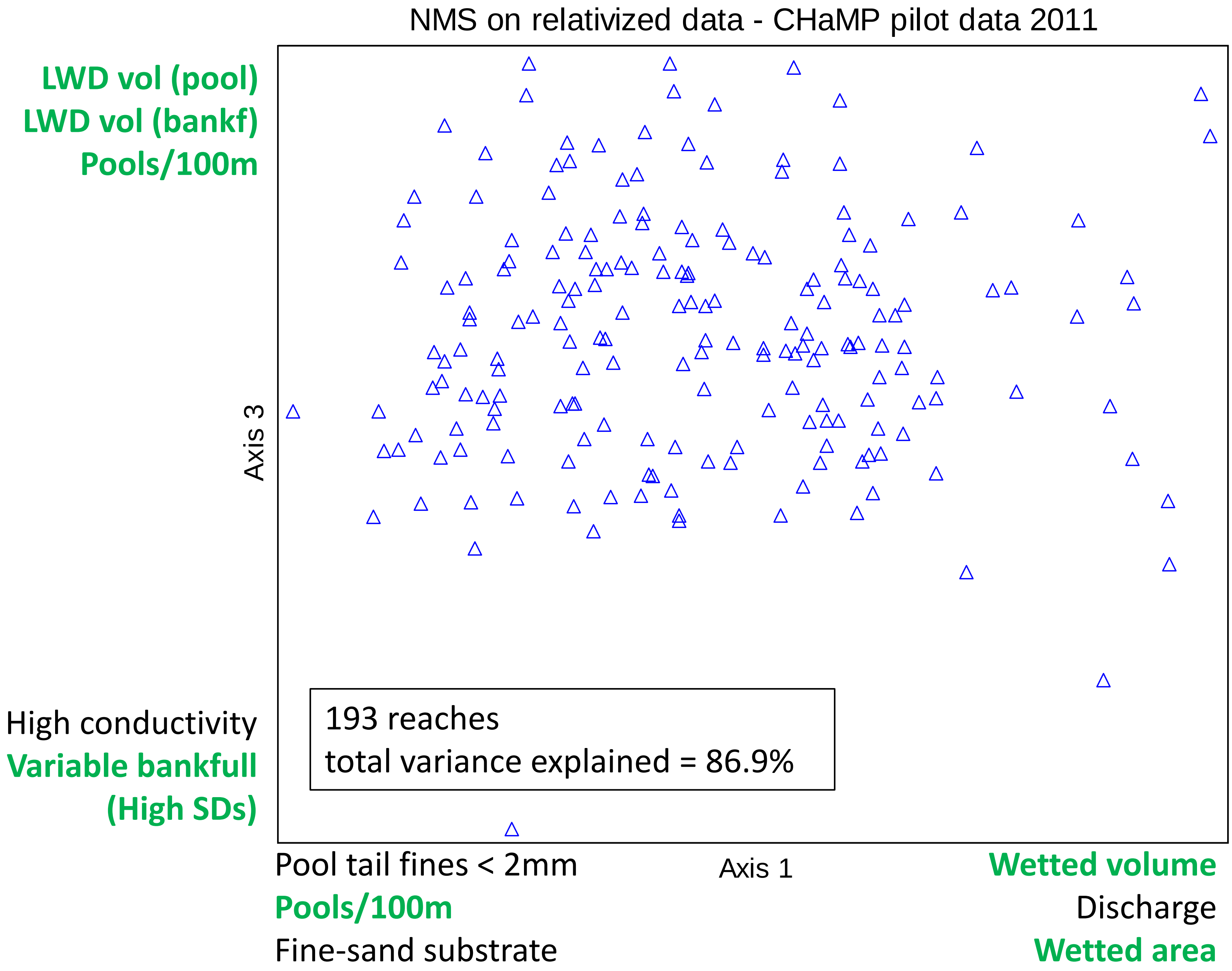
River Bathymetry Toolkit (RBT)

Multivariate methods

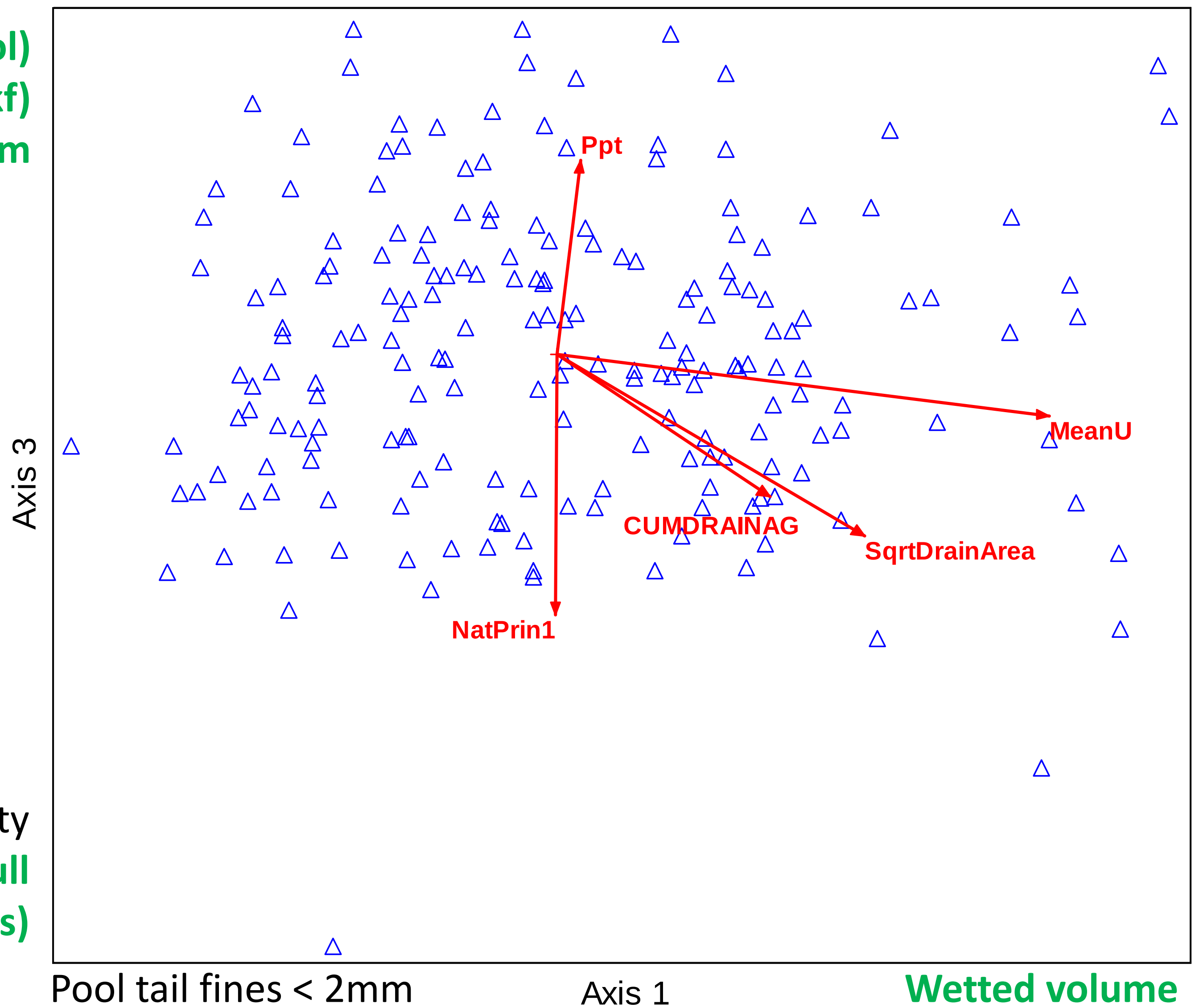
Scatterplot matrix - CHaMP pilot data 2011



- Ordination: NMDS
  - No assumption of normality
  - Allows for non-linear relationships among metrics
  - General relativization of metric totals
- Pearson correlations (biplots) of quantitative landscape variables
- MRPP to test for group effects in categorical landscape variables


NMS on relativized data - CHaMP pilot data 2011
LWD vol (pool)
LWD vol (bankf)
Pools/100m
High conductivity
Variable bankfull
(High SDs)
Axis 3
193 reaches
total variance explained = 86.9%
Pool tail fines < 2mm
Pools/100m
Fine-sand substrate
Axis 1
Wetted volume
Discharge
Wetted area

NMS on relativized data - CHaMP pilot data 2011

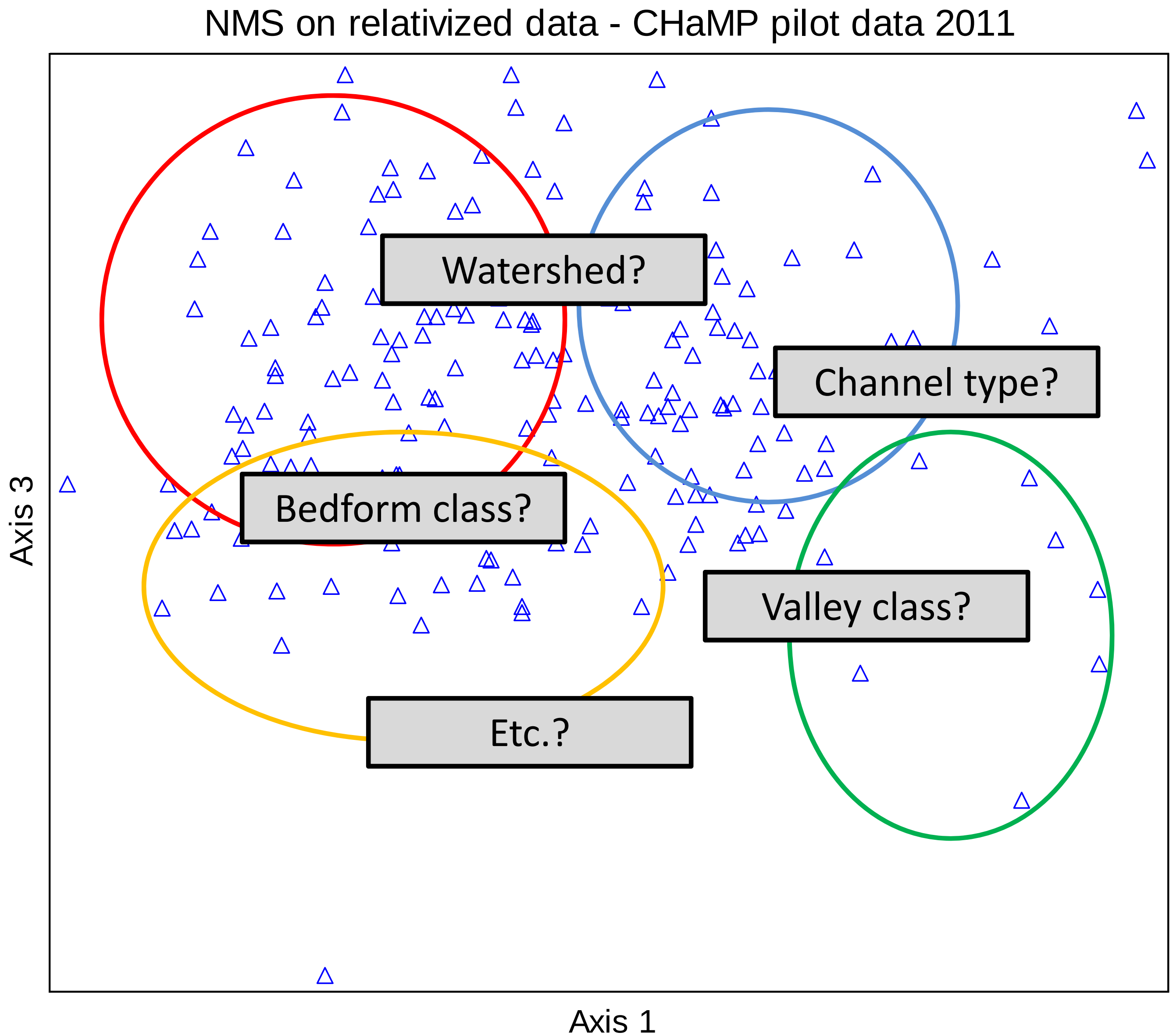


LWD vol (pool)
LWD vol (bankf)
Pools/100m

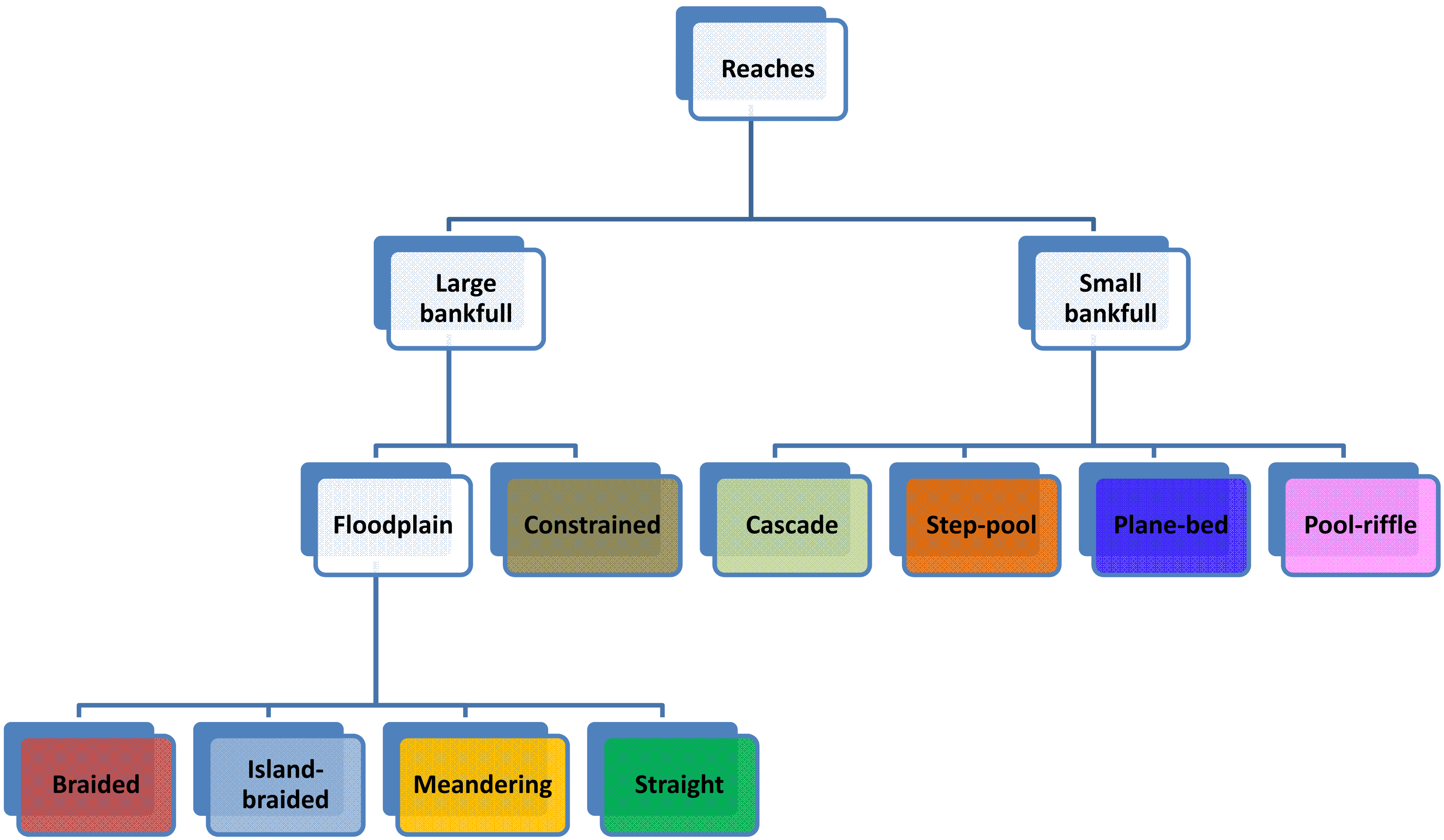
High conductivity
Variable bankfull
(High SDs)

Pool tail fines < 2mm
Pools/100m
Fine-sand substrate

Wetted volume
Discharge
Wetted area


NMS on relativized data - CHaMP pilot data 2011
Watershed?
Channel type?
Bedform class?
Valley class?
Etc.?
Axis 3
Axis 1

Beechie channel classification (in review)



Simplified channel classification

- Reaches
  - Large bankfull
    - Floodplain
      - Braided
      - Island-braided
      - Meandering
      - Straight
    - Constrained
  - Small bankfull
    - Cascade
    - Step-pool
    - Plane-bed
    - Pool-riffle

“Mountain”

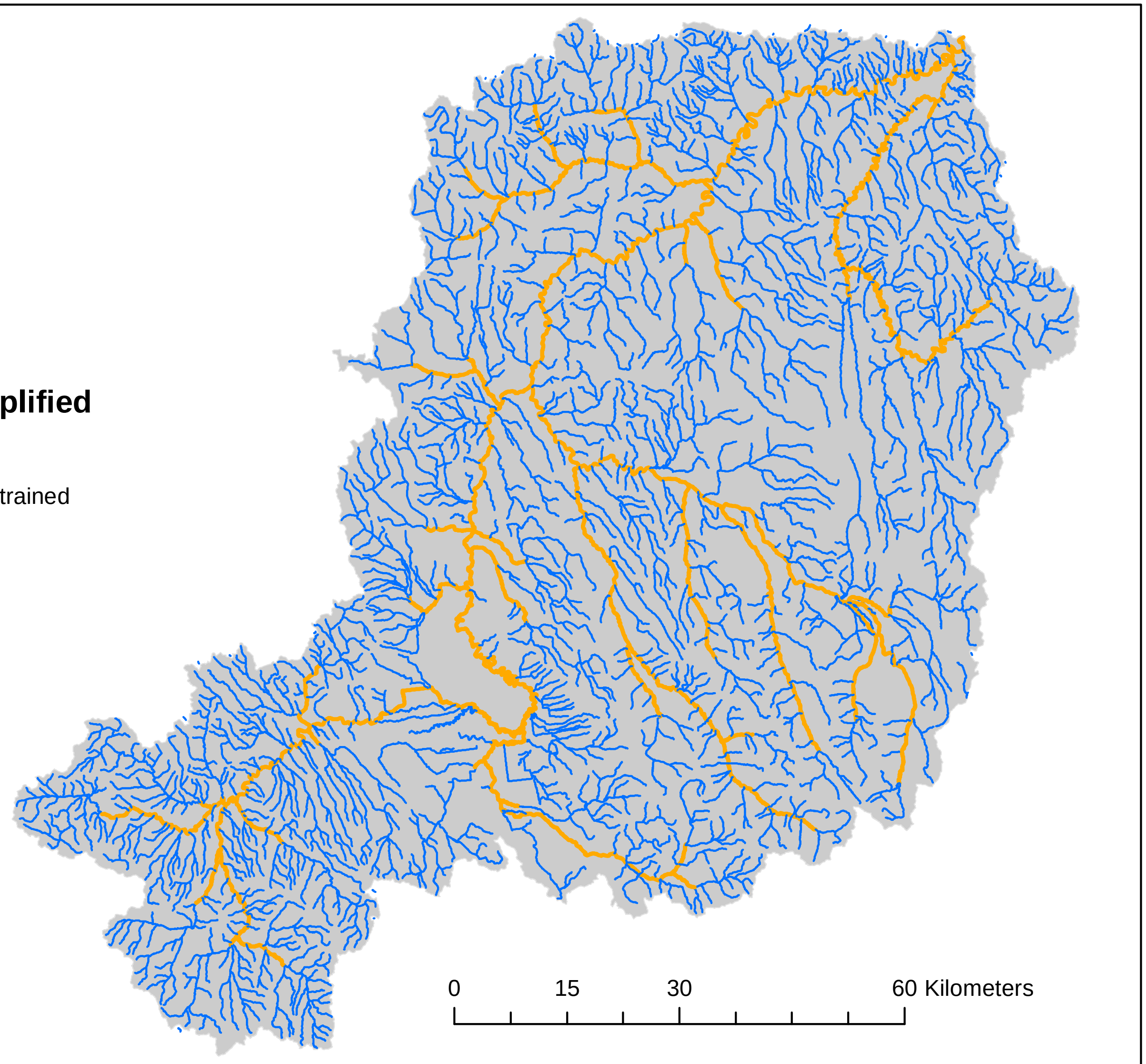
“Floodplain & Constrained”

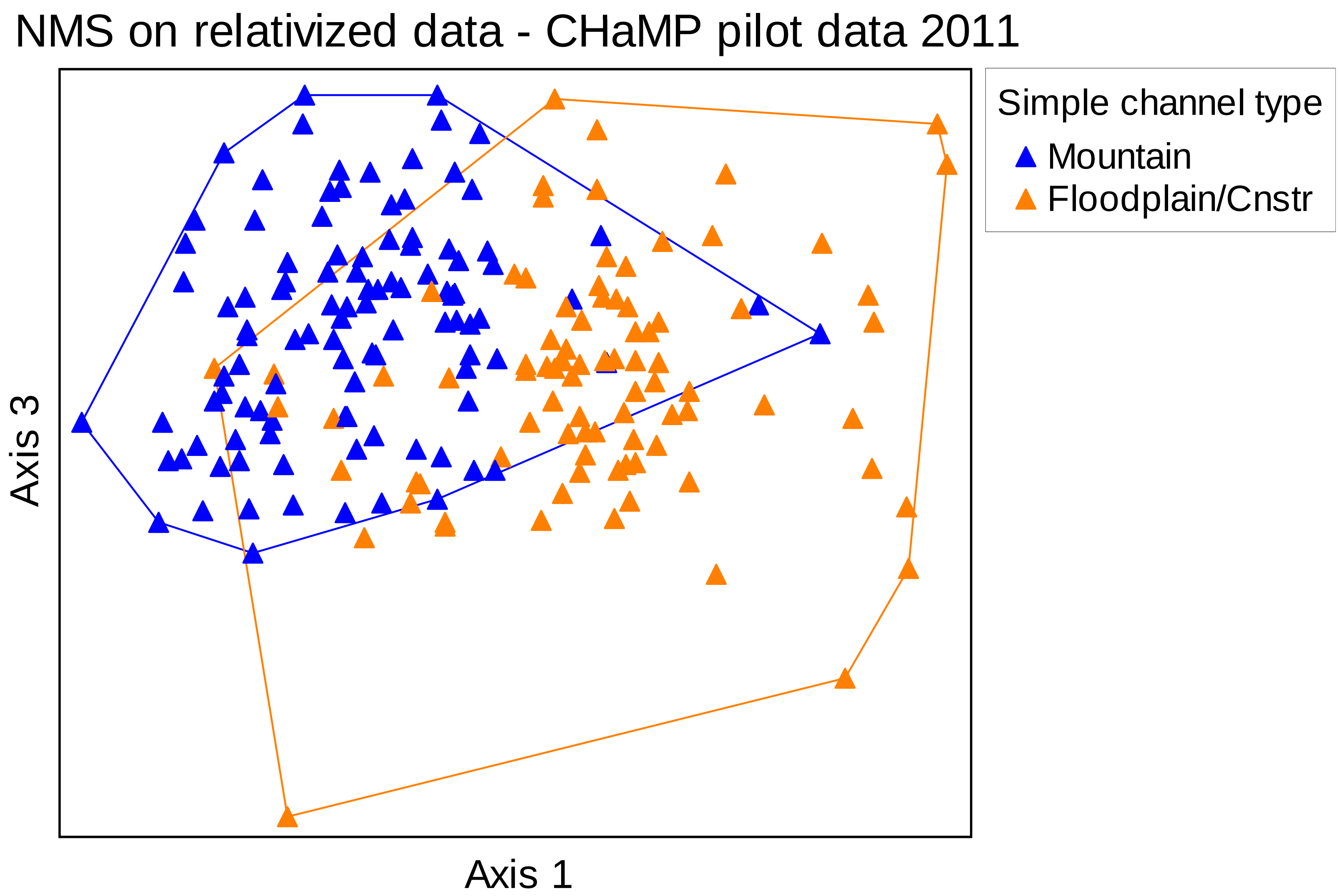
MRPP results for group differences

Group	No. groups*	*A-statistic*	*Rating (A/N)*100*	*P-value*
Channel type - simplified	2	0.17	8.50	$< 1.0 \times 10^{-8}$
Valley class (source, trans, depos)	3	0.19	6.67	$< 1.0 \times 10^{-8}$
Channel type (Beechie)	8	0.24	3.00	$< 1.0 \times 10^{-8}$
Watershed	8	0.23	2.88	$< 1.0 \times 10^{-8}$
Crew's bedform designation	5 (7)	0.08	1.60	$< 1.0 \times 10^{-8}$

*Values in parentheses are original group numbers before exclusion based on site membership < 2

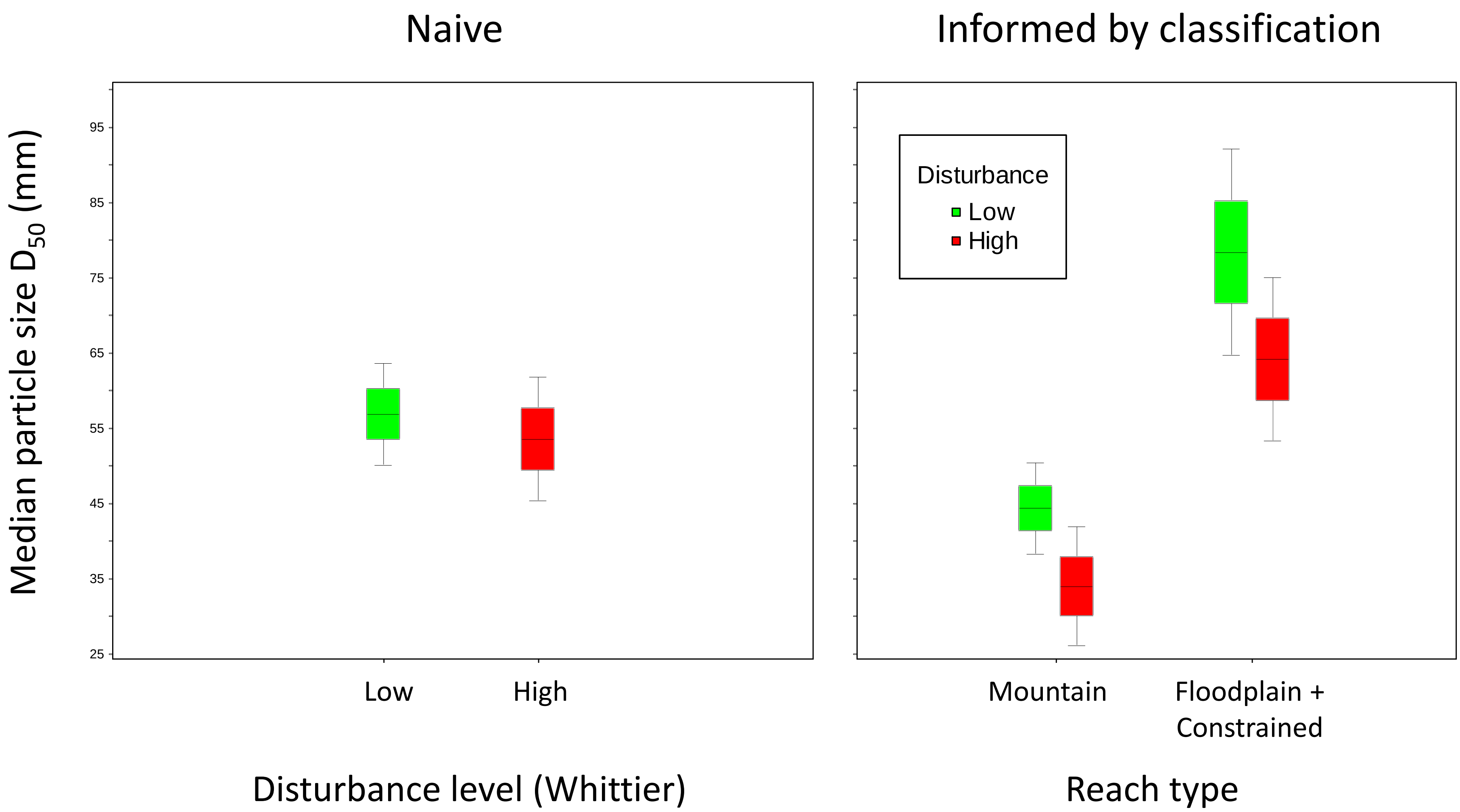
Simplified channel classification

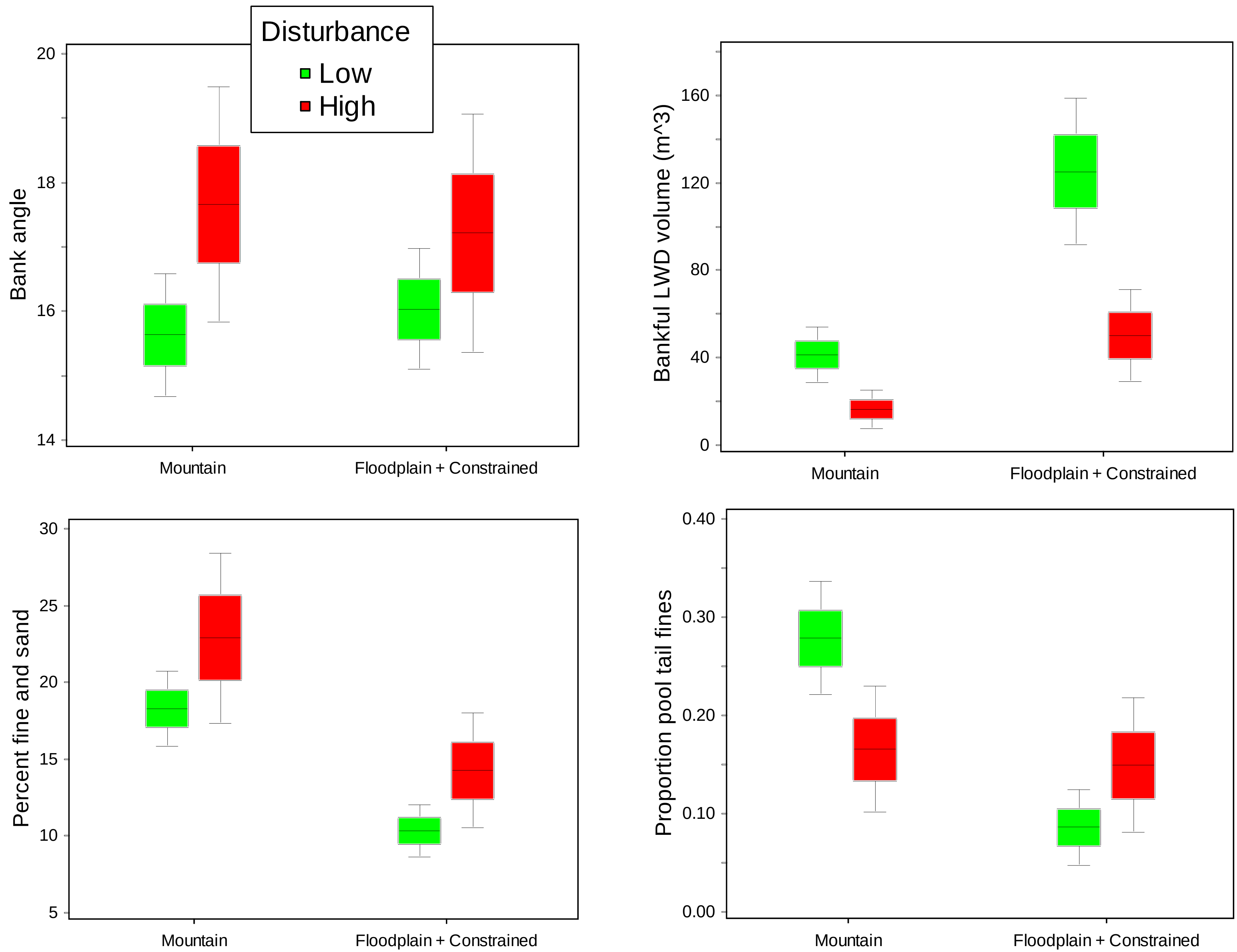



NMS on relativized data - CHaMP pilot data 2011
Axis 3
Axis 1
Simple channel type
Mountain
Floodplain/Cnstr

Difference between naïve *vs.* informed analysis

(Disturbance categories from Whittier *et al.,* in review)





Disturbance
Low
High
Bank angle
20
18
16
14
Mountain
Floodplain + Constrained
Bankful LWD volume (m^3)
160
120
80
40
0
Mountain
Floodplain + Constrained
Percent fine and sand
30
25
20
15
10
5
Mountain
Floodplain + Constrained
Proportion pool tail fines
0.40
0.30
0.20
0.10
0.00
Mountain
Floodplain + Constrained

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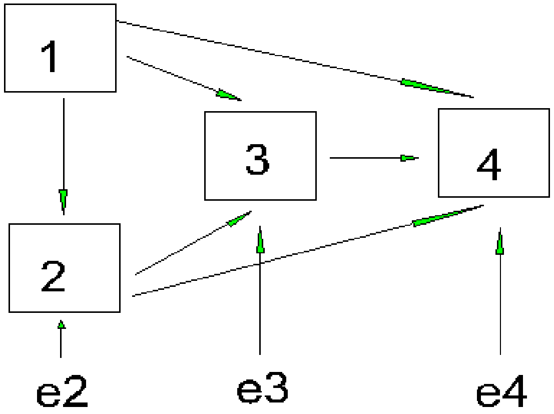
Structural Equation Modeling



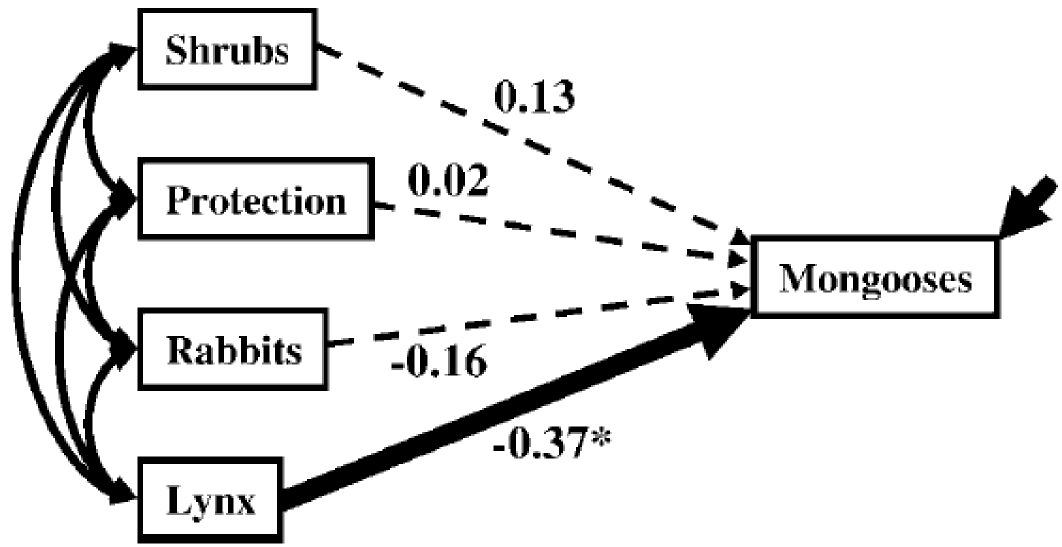
- Path analysis developed by Seawall Wright (1918, 1921) to understand multiple causes and multiple responses
- Modern SEM involves analysis of covariance matrix to reveal causal relationships
- Model building and evaluation best represented graphically

Structural equation modeling (SEM)

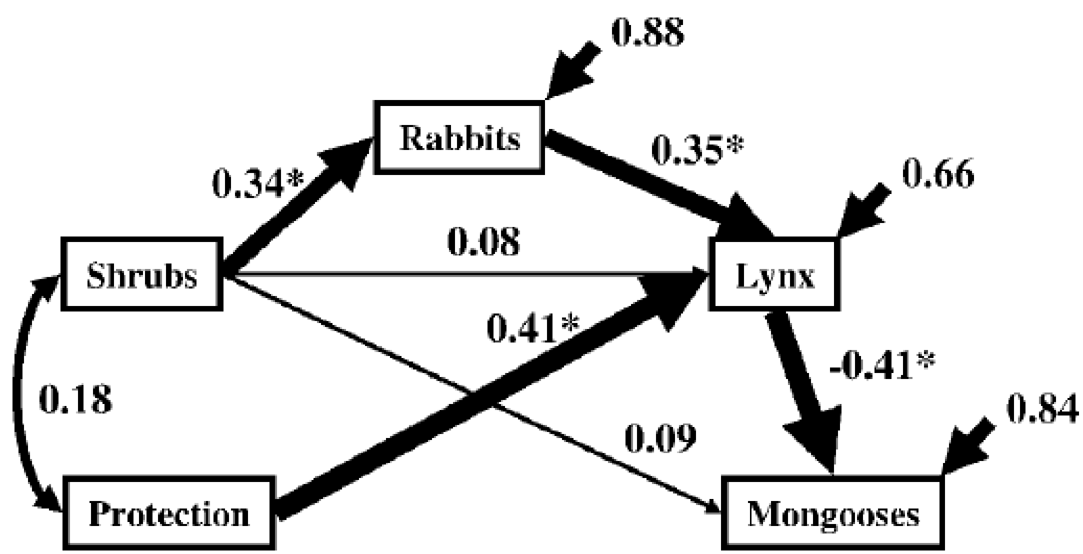
Mongoose & lynx in Spanish protected areas

(Palomares et al. 1998*, J. Animal Ecology*)

❖ Multiple linear regression reveals that lynx reduce mongoose populations



❖ SEM reveals a more informative story…

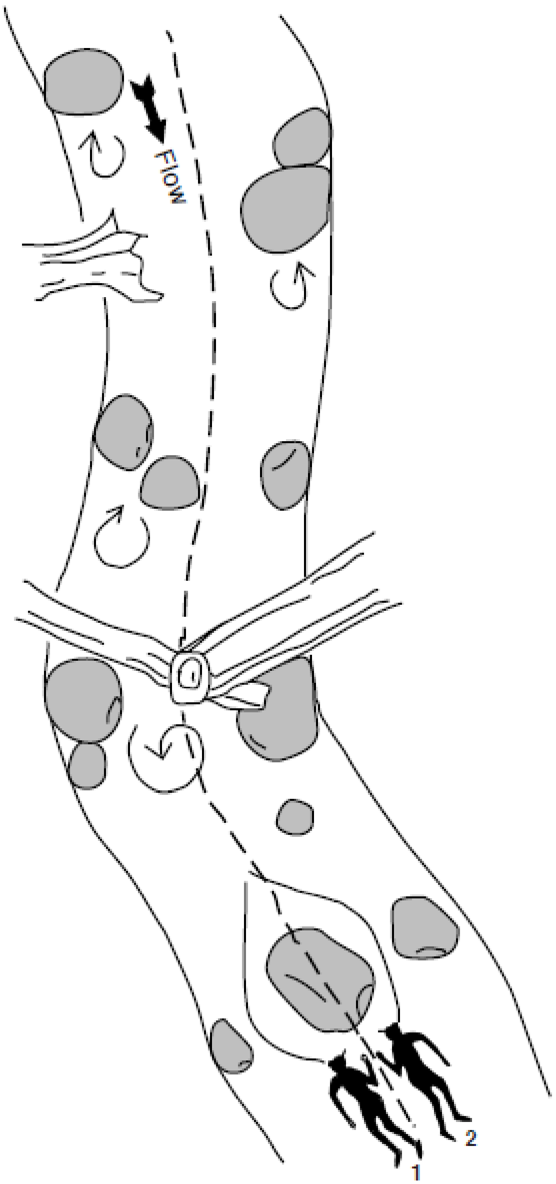


Current habitat condition of upper Grande Ronde River

- ❖ Spring Chinook salmon and steelhead listed as “Threatened” under ESA

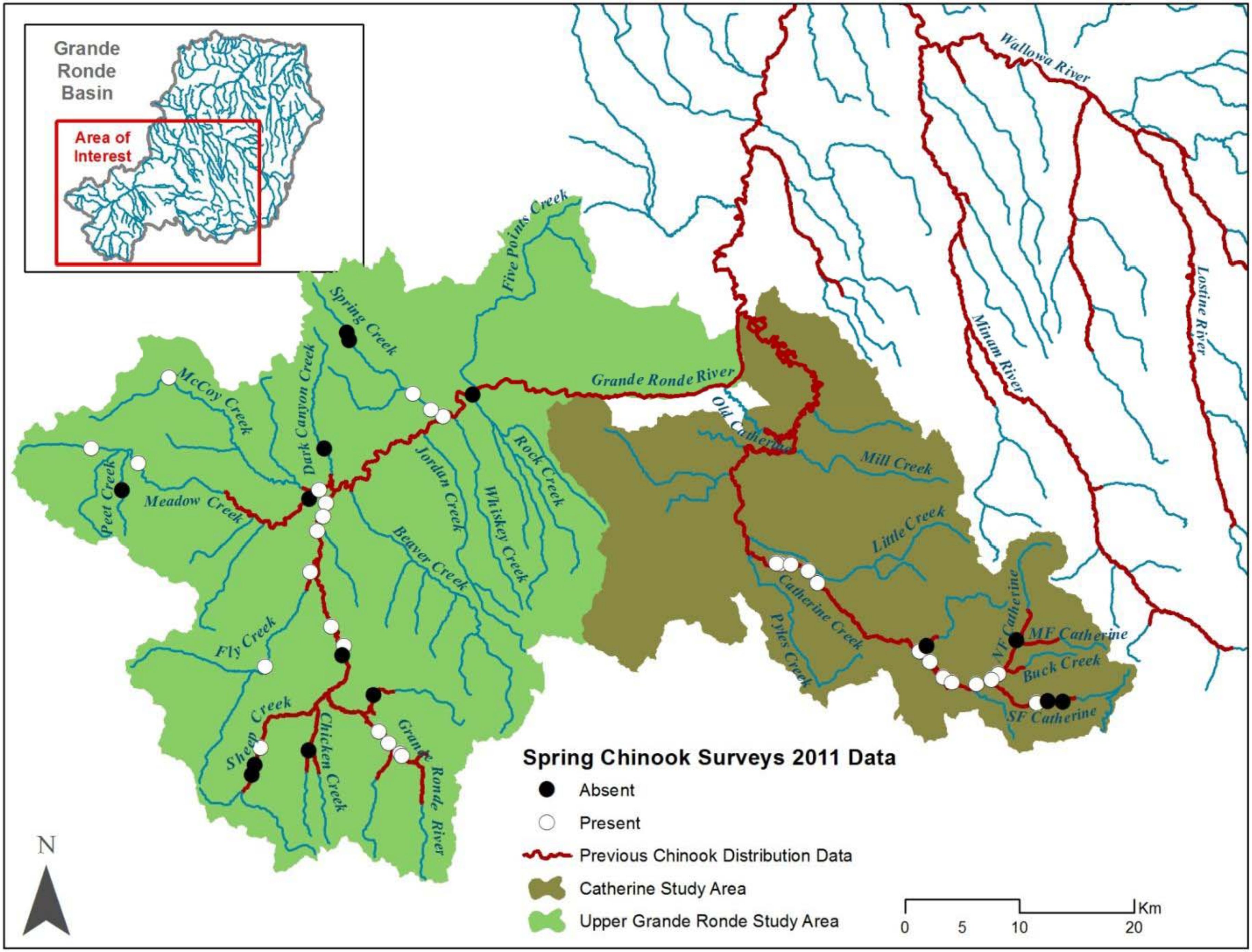
- ❖ Upper Grande Ronde and Catherine Creek listed as “Critical Habitat”

- ❖ Heavily degraded habitat from timber harvest, agriculture and irrigation, and cattle grazing



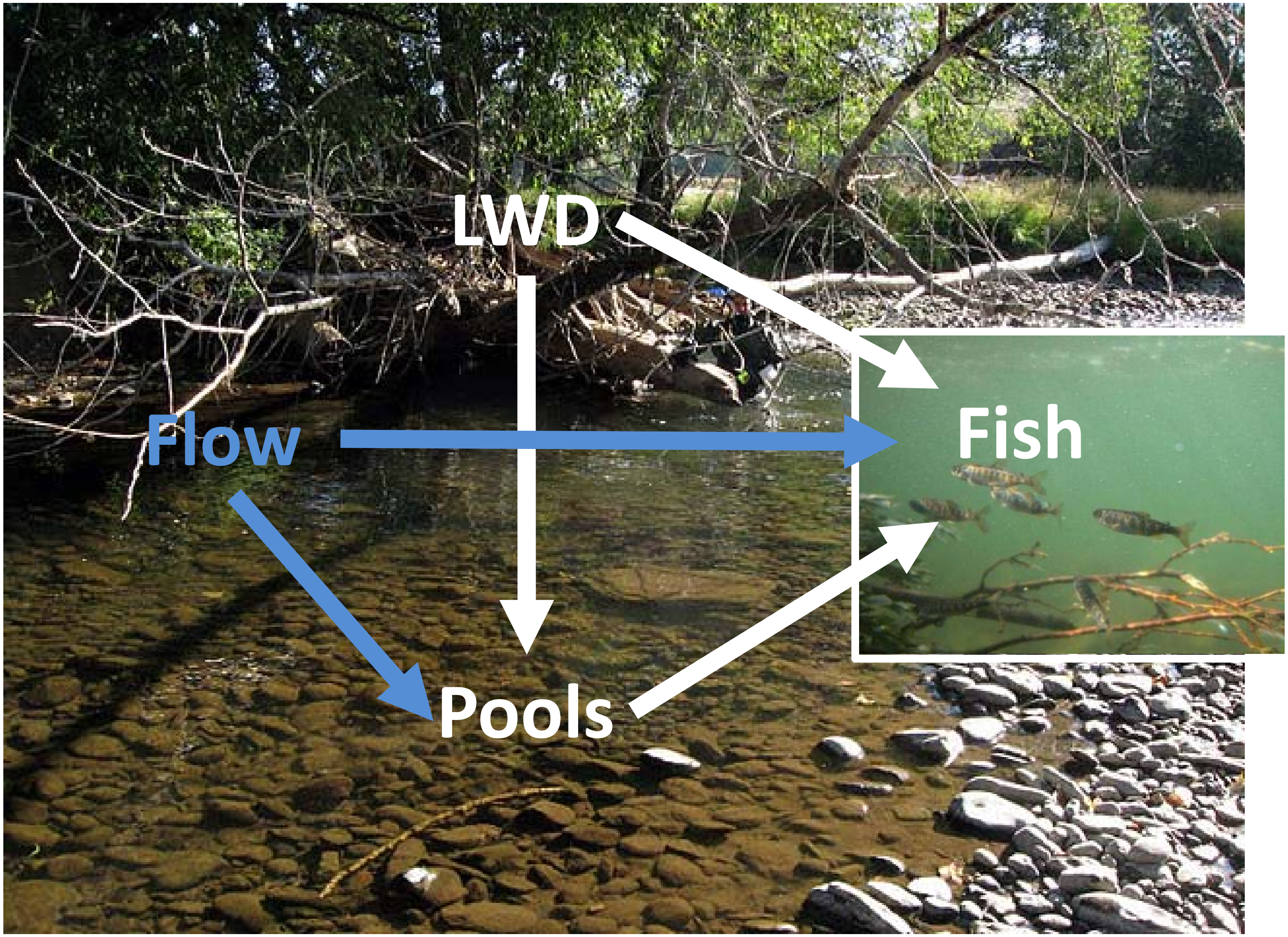
Snorkel surveys

- ❖Abundance & density of salmonids by species & size class (Thurow 1994, O'Neal 2007)
- ❖In collaboration with ODFW La Grande
- ❖Data aggregated to reach scale (52 reaches for analysis)

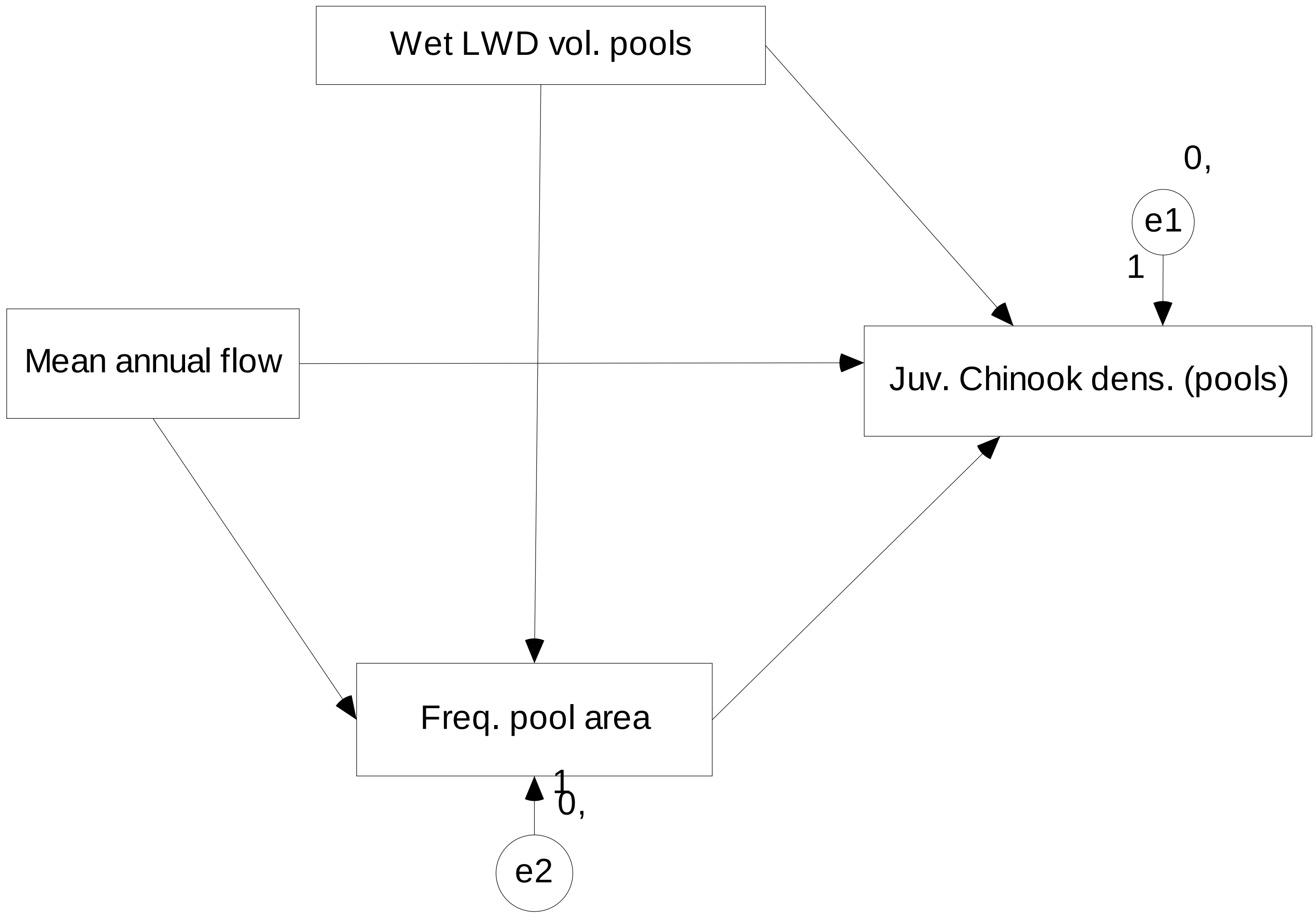


Grande Ronde Basin
Area of Interest
Spring Creek
McCoy Creek
Dark Canyon Creek
Five Points Creek
Grande Ronde River
Old Catherine
Mill Creek
Wallowa River
Minam River
Lostine River
Peet Creek
Meadow Creek
Jordan Creek
Whiskey Creek
Rock Creek
Beaver Creek
Little Creek
Catherine Creek
Pyles Creek
NF Catherine
MF Catherine
Buck Creek
SF Catherine
Fly Creek
Sheep Creek
Chicken Creek
Grande Ronde River
Spring Chinook Surveys 2011 Data
Absent
Present
Previous Chinook Distribution Data
Catherine Study Area
Upper Grande Ronde Study Area
N
0
5
10
20
Km

Interaction among LWD, pools, and juvenile Chinook

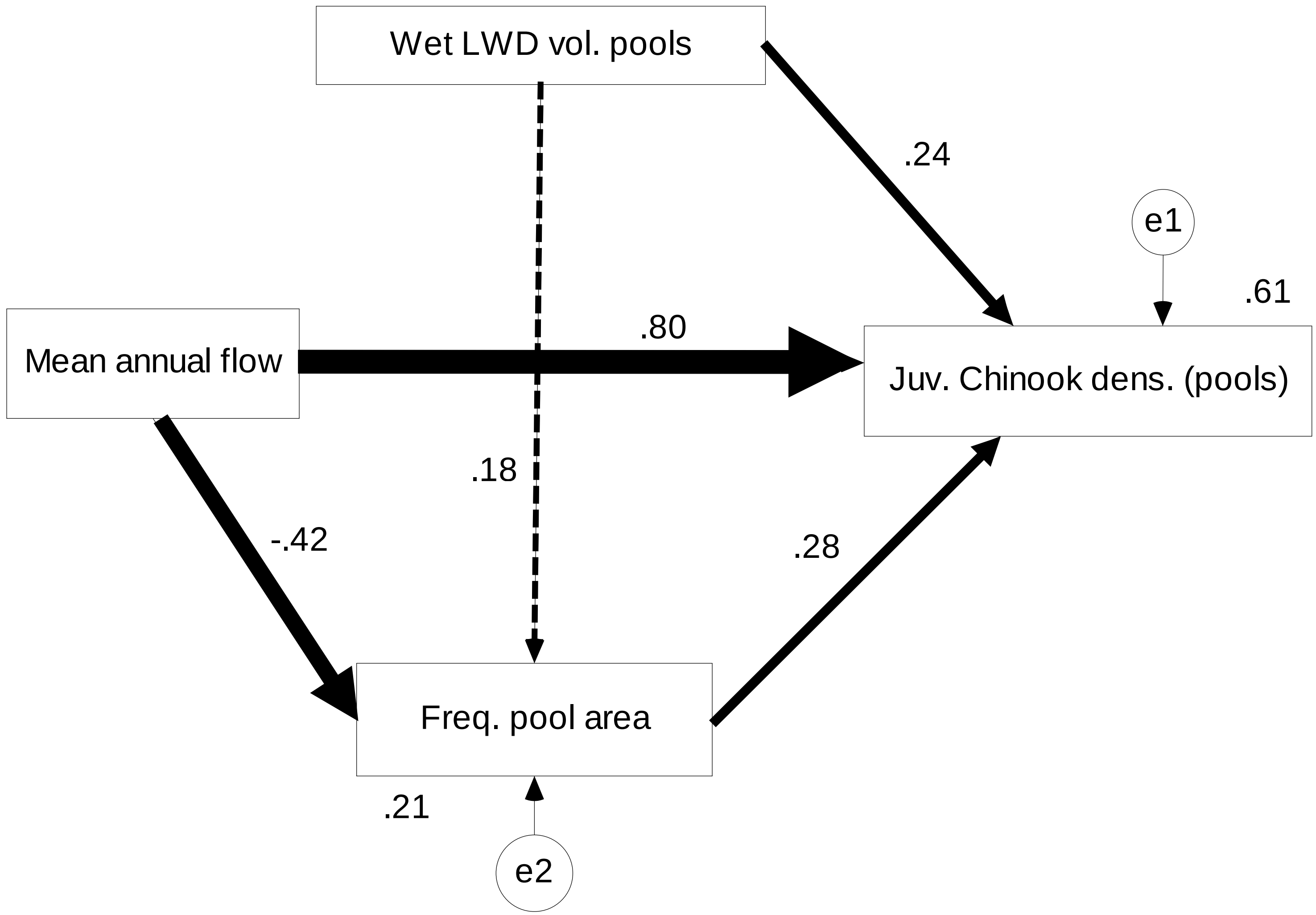


Hypotheses for structural equation modeling (SEM)

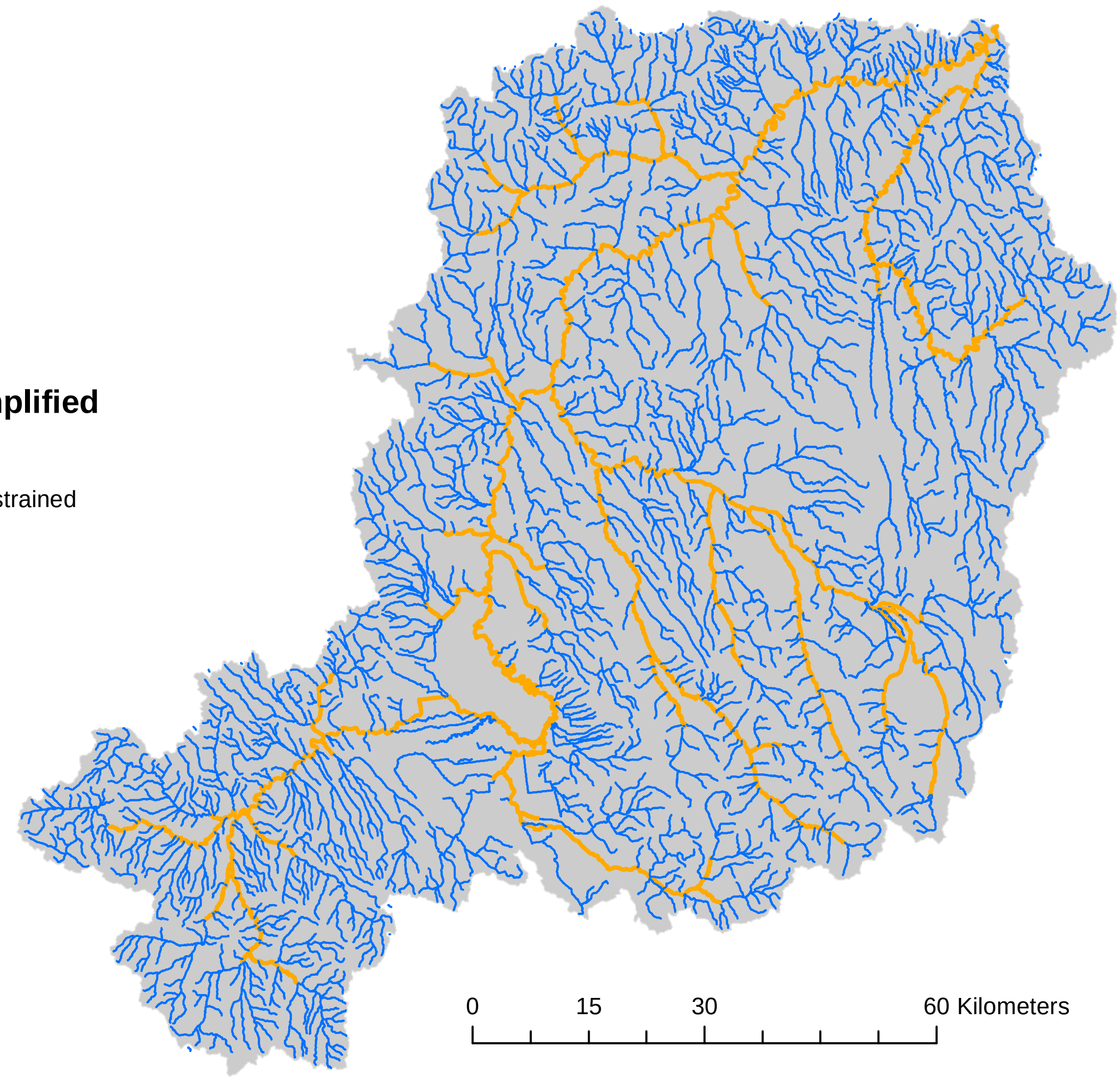


Results for SEM global model

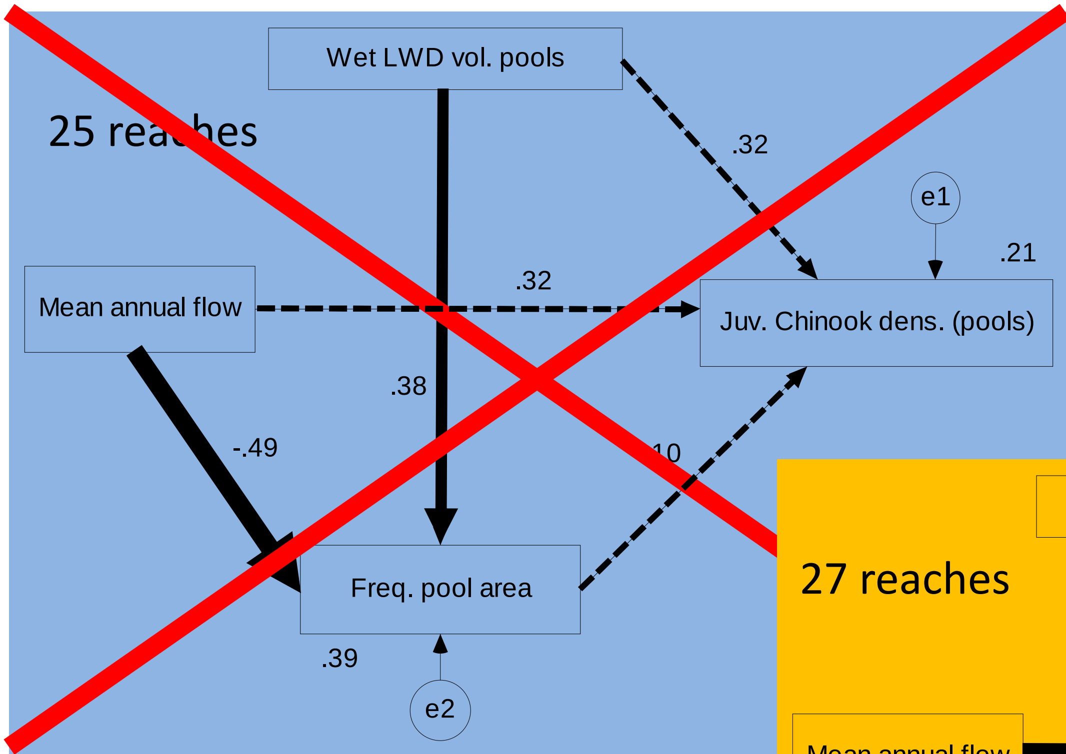
(all metrics Box-Cox transformed)



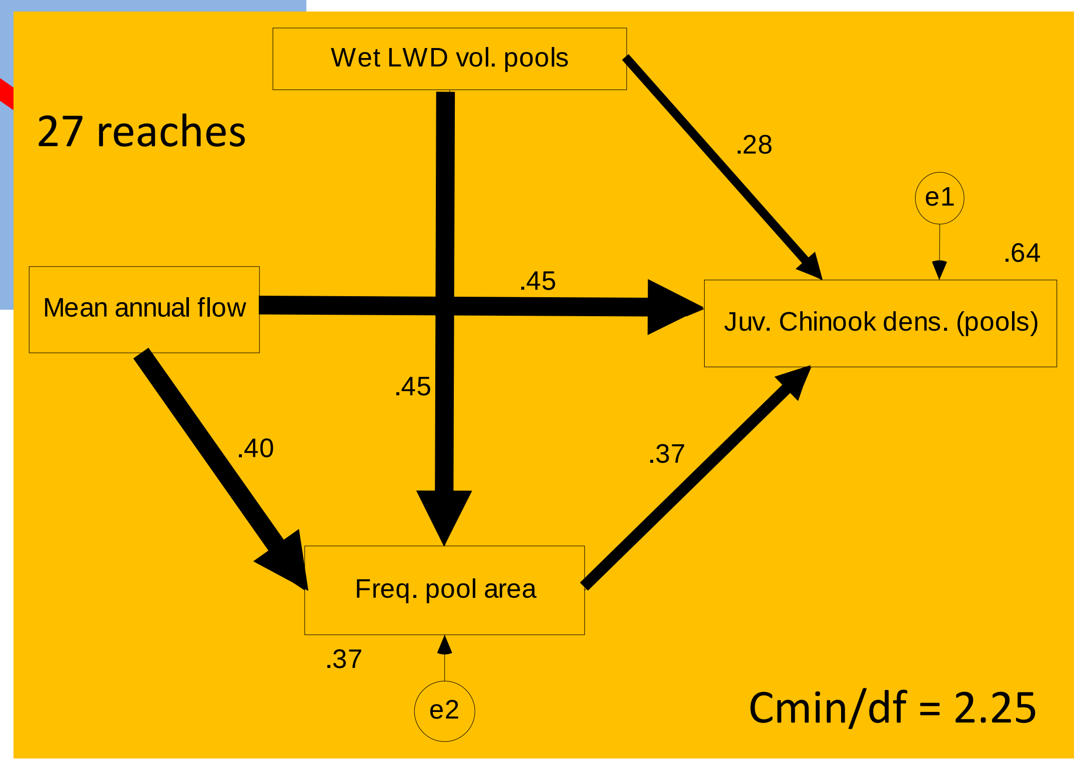
Simplified channel classification



Results for SEM multi-group model



"Mountain"

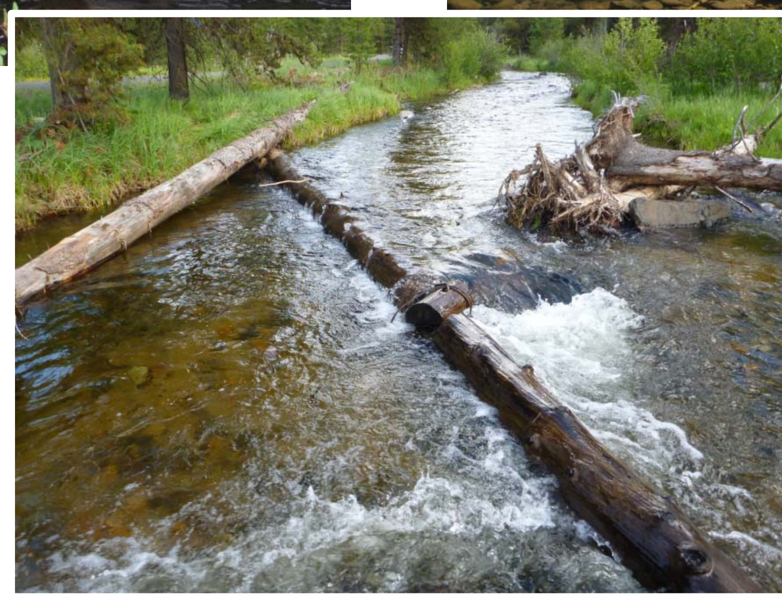


"Floodplain & Constrained"

Restoration via natural and artificial wood recruitment

Dry, natural wood

Wet, natural wood



USFS wood placement

Conclusions

- Life cycle modeling approach can help guide restoration efforts

- Riverscape context of restoration

  - Simple stream classification explained differences in landscape-fish habitat dynamics

  - Mean annual streamflow (or watershed position) was a controlling variable for fish-habitat relationships

  - Large wood had direct & indirect effects on fish, via direct refuge habitat and through geomorphology

- Managers want simple answers (e.g., how much wood to add?), but ecology is complex

  - Structural equation modeling is one tool for simplifying complex landscape-fish habitat processes

Acknowledgements

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ODFW – Rich Carmichael, Ted Sedell, Chris Horn, and others

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