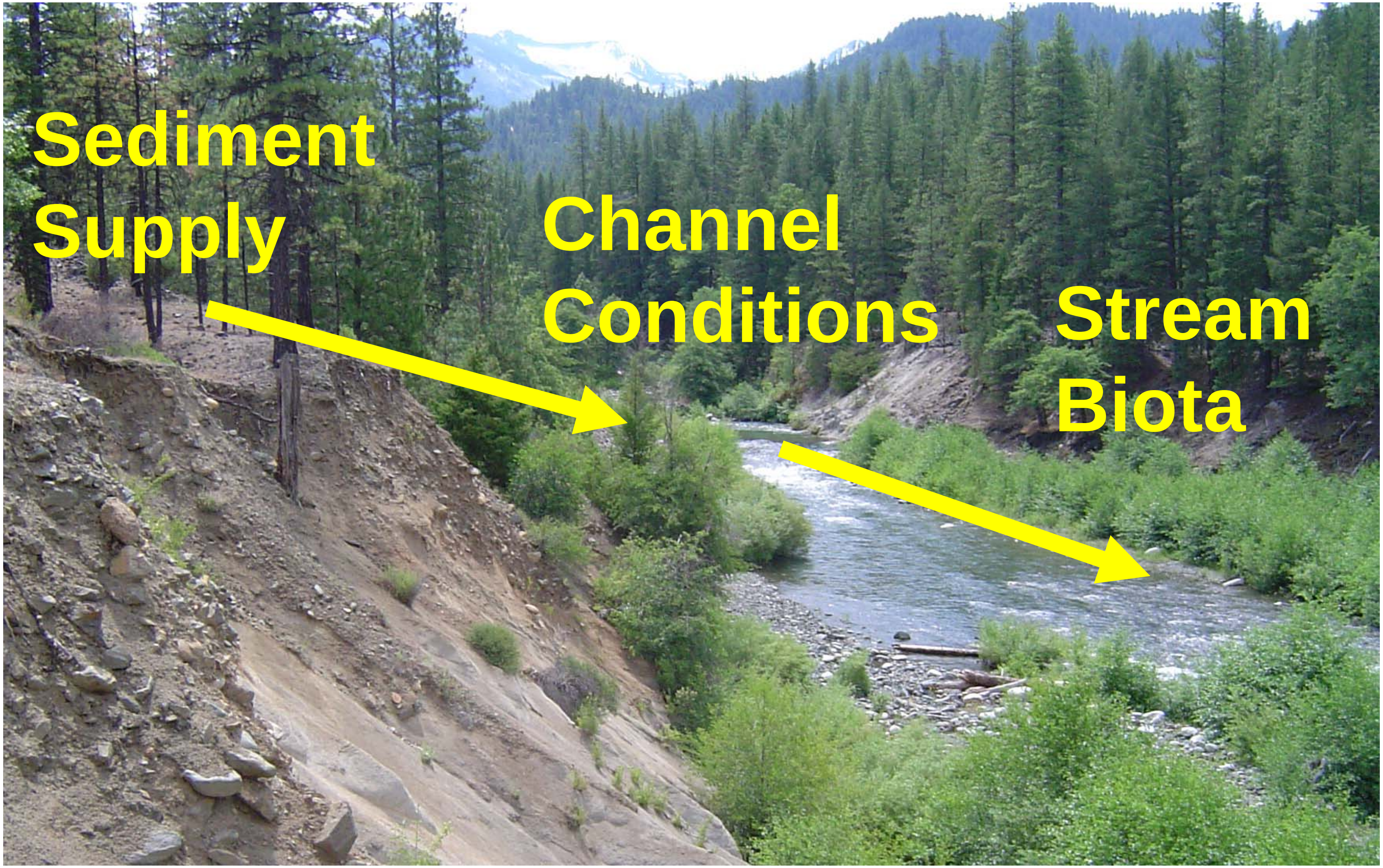
Cumulative Effects of Forestry Practices on Benthic Macroinvertebrate Assemblages in the Klamath National Forest Over a Range of Temporal and Spatial Scales

Matthew R. Cover, CSU Stanislaus
Juan de la Fuente, KNF
Alison H. Purcell, Humboldt St.
Rafael D. Mazor, SCCWRP
Vincent H. Resh, U.C. Berkeley

CWE of BMP on BMI in KNF

by
MRC of CSU STAN
JdlF of KNF
AHP of HSU
RDM of SCCWRP
VHR of UCB

Quantitative Linkages



Klamath National Forest

Effects of Forestry Management Practices (CWE) on BMI

Fine sediment

1. **Coarse: Regional scale**

   CA RivPACS model vs. KNF Sed supply model

Methods

1. Assembled several sets of biological data
   - UC Berkeley
   - Utah BugLab (all sites in Siskiyou County)
   - CMAP/EMAP programs (DFG ABL)

2. Matched taxa names from Klamath NF samples with OTU’s (operational taxonomic units)

3. Subsampled each site to 300 individuals

Methods continued…

4. Delineated catchments upstream of each sampling site (using GIS)
   - 141 unique catchments delineated
   - 310 samples (some sites sampled multiple times)

5. Calculated environmental parameters within each delineated catchment

(i.e. temperature, precipitation, watershed area, % sedimentary rock) to determine submodel

The Western Center for Monitoring and Assessment of Freshwater Ecosystems - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://129.123.10.240/WMCPortal/DesktopDefault.aspx?tabindex=2&tabid=27

Most Visited Getting Started Latest Headlines

General Concepts

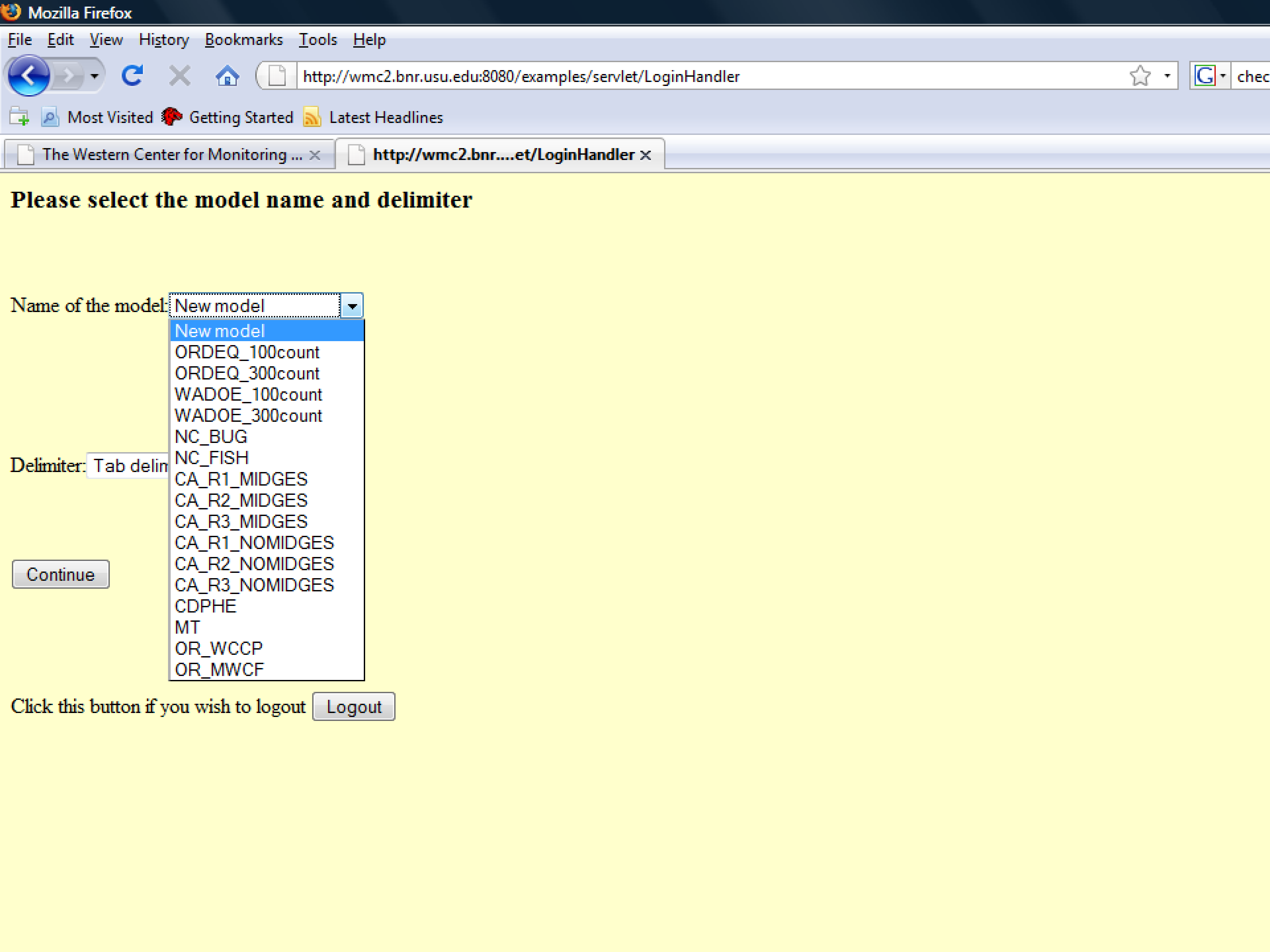
The Western Center for Monitoring and Assessment of Freshwater Ecosystems specializes in the development and application of empirical models designed specifically to assess the biological condition of streams, lakes, and wetlands. The technical and philosophical underpinnings of these models have been thoroughly discussed in the peer-reviewed literature, and the reader should consult these papers for details. Here, we provide a primer to aid your understanding of how predictive models work. We also describe how to use our internet accessible software to either run existing models to assess the condition of sites you have sampled or create new models customized for your specific needs.

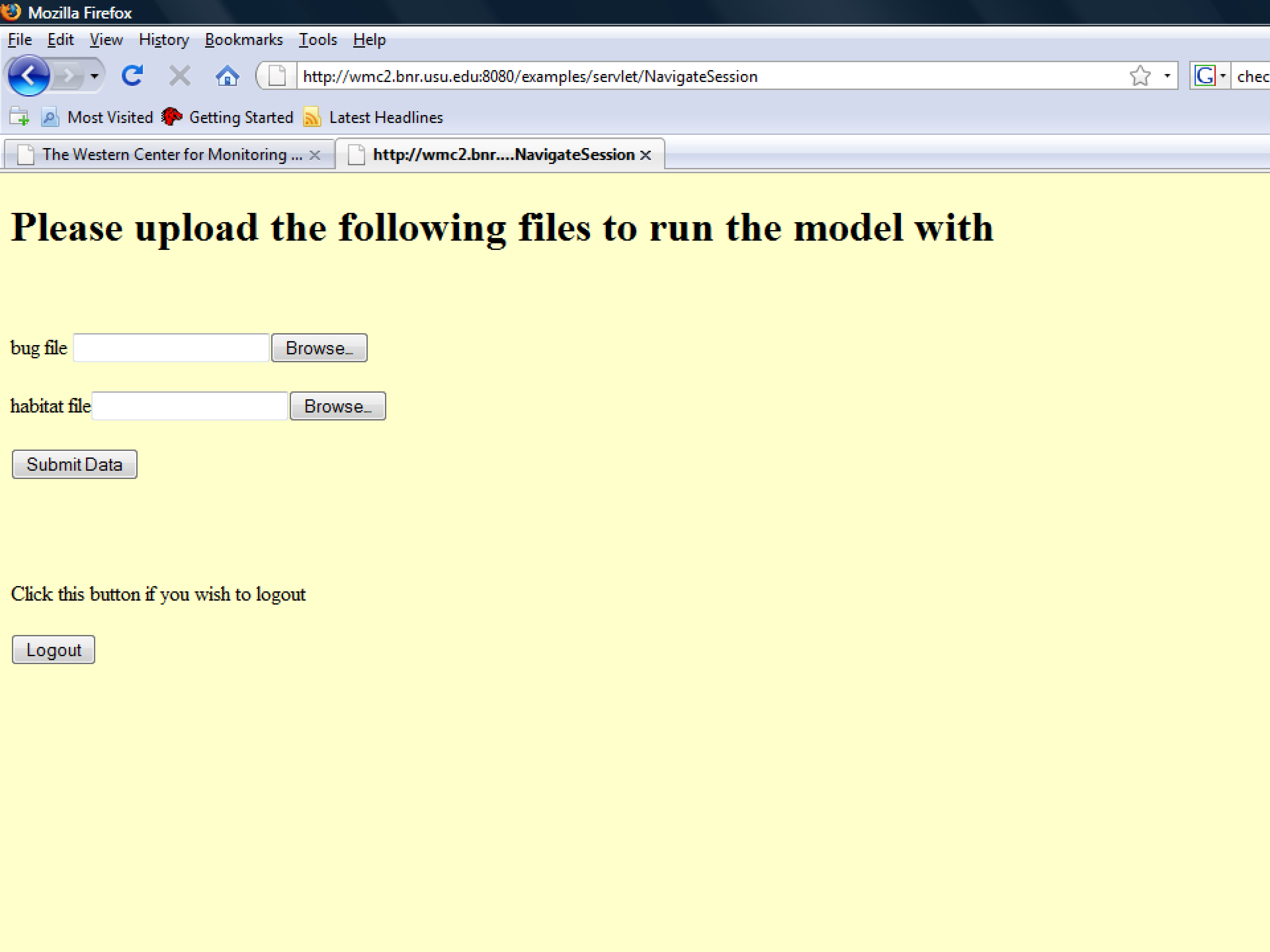
In this section:

- **Predictive Models Primer**
- **Using and Building Models**
- **Predictive Models Literature**
- **Run the Software**
- **Request Username/Password**

PDF Down

- Predictive Mo
- Montana Dat
- Using and Bu
- Literature
- Query Tool


Mozilla Firefox
File Edit View History Bookmarks Tools Help
http://wmc2.bnr.usu.edu:8080/examples/servlet/LoginHandler
Most Visited Getting Started Latest Headlines
The Western Center for Monitoring ...
http://wmc2.bnr....et/LoginHandler
Please select the model name and delimiter
Name of the model: New model
New model
ORDEQ_100count
ORDEQ_300count
WADOE_100count
WADOE_300count
NC_BUG
NC_FISH
CA_R1_MIDGES
CA_R2_MIDGES
CA_R3_MIDGES
CA_R1_NOMIDGES
CA_R2_NOMIDGES
CA_R3_NOMIDGES
CDPHE
MT
OR_WCCP
OR_MWCF
Delimiter: Tab delim
Continue
Click this button if you wish to logout
Logout

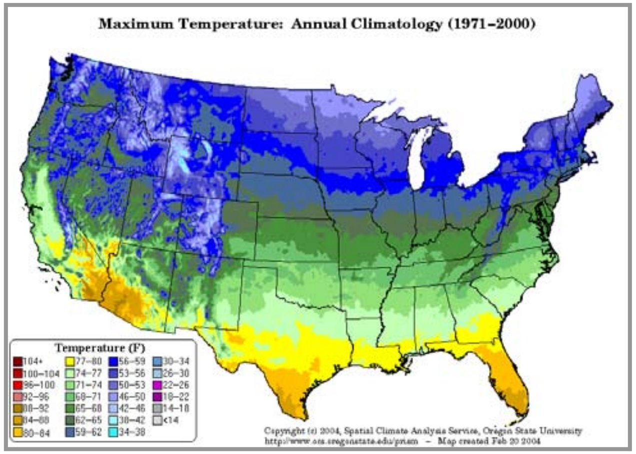


Mozilla Firefox
File Edit View History Bookmarks Tools Help
http://wmc2.bnr.usu.edu:8080/examples/servlet/NavigateSession
Most Visited
Getting Started
Latest Headlines
The Western Center for Monitoring ...
http://wmc2.bnr....NavigateSession
Please upload the following files to run the model with
bug file
Browse...
habitat file
Browse...
Submit Data
Click this button if you wish to logout
Logout

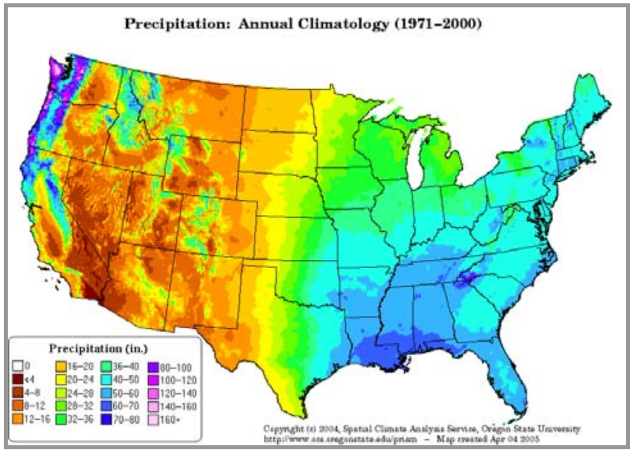
Assigning sites to appropriate submodel

(Oregon Climate Center PRISM GIS layers)

If mean monthly Temperature < 9.9°C



If mean monthly Temperature > 9.9°C



Submodel 3

If log mean annual Precipitation >2.952

Submodel 1

If log mean annual Precipitation <2.952

Submodel 2

Source: Chuck Hawkins

Then calculate predictor variables for sub-models (midges to subfamily)

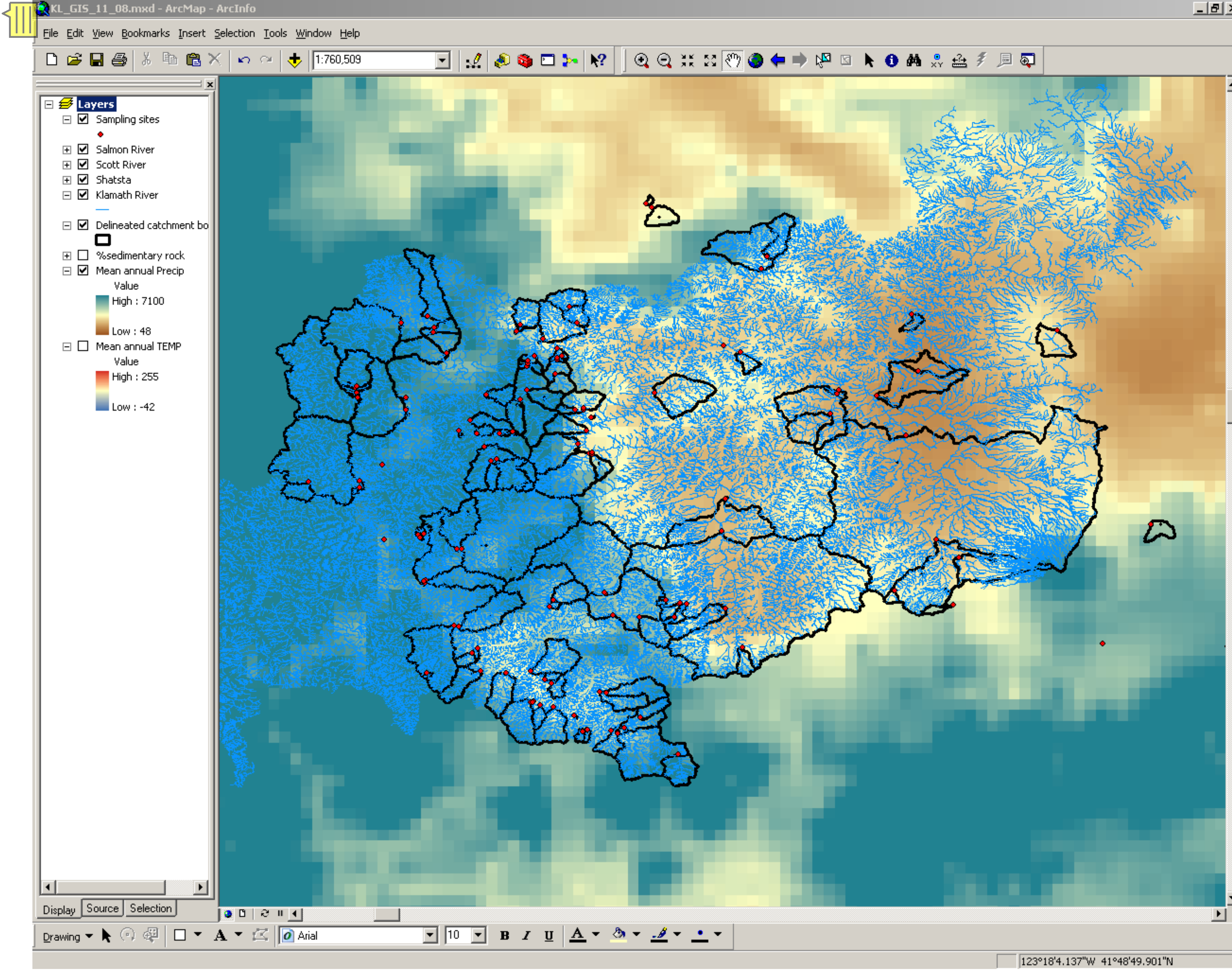
Submodel 1
Watershed Area
Temperature
Latitude

Submodel 2
Longitude
% Sedimentary Geology
Precipitation

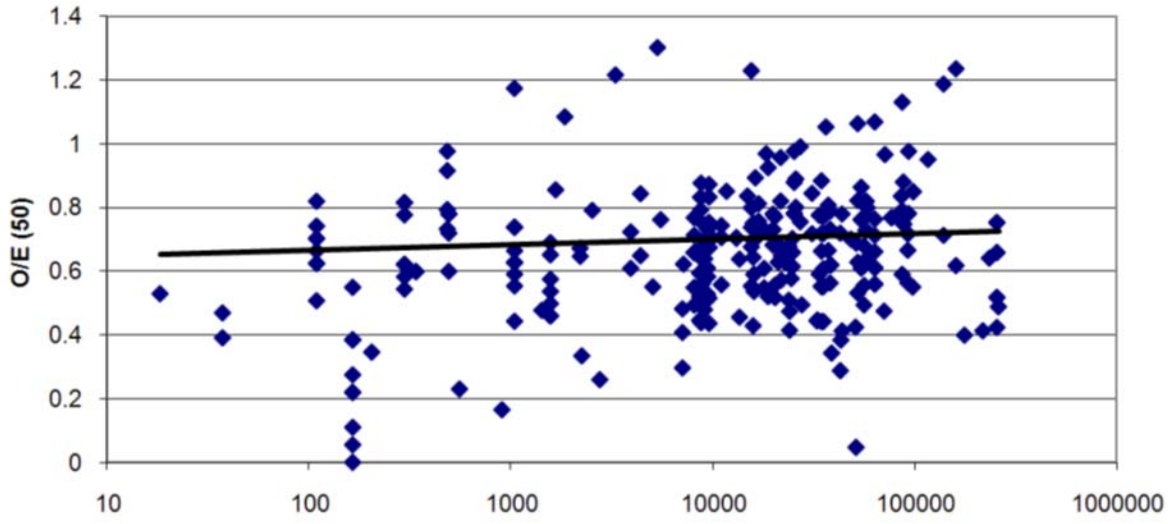
Submodel 3
Watershed Area
Temperature

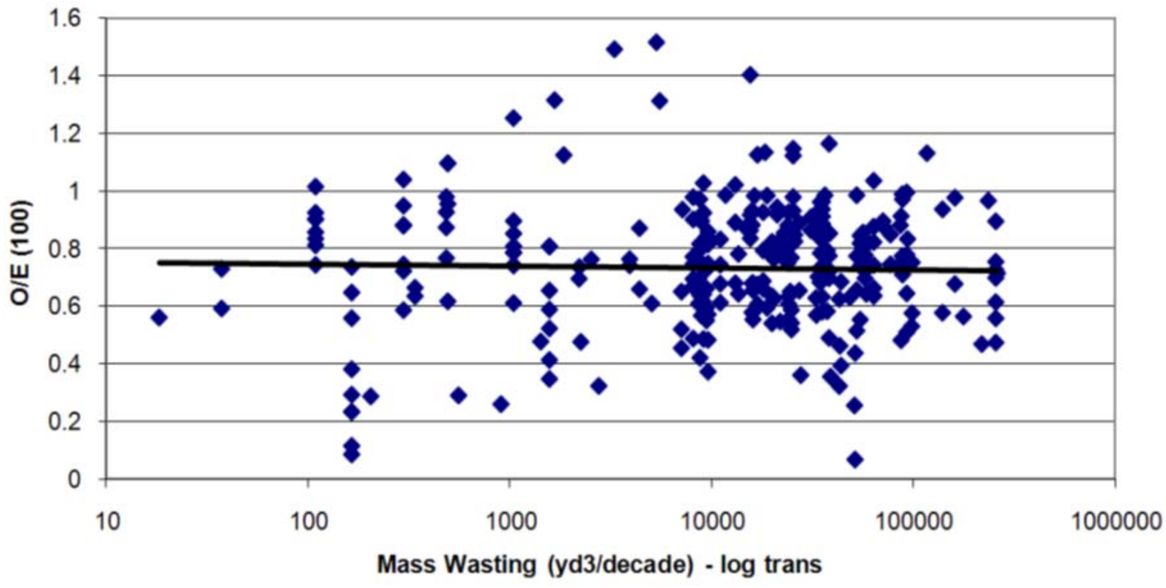
=% sedimentary geology (summarized from USGS maps, John Olsen, Utah State University)

Source: Chuck Hawkins

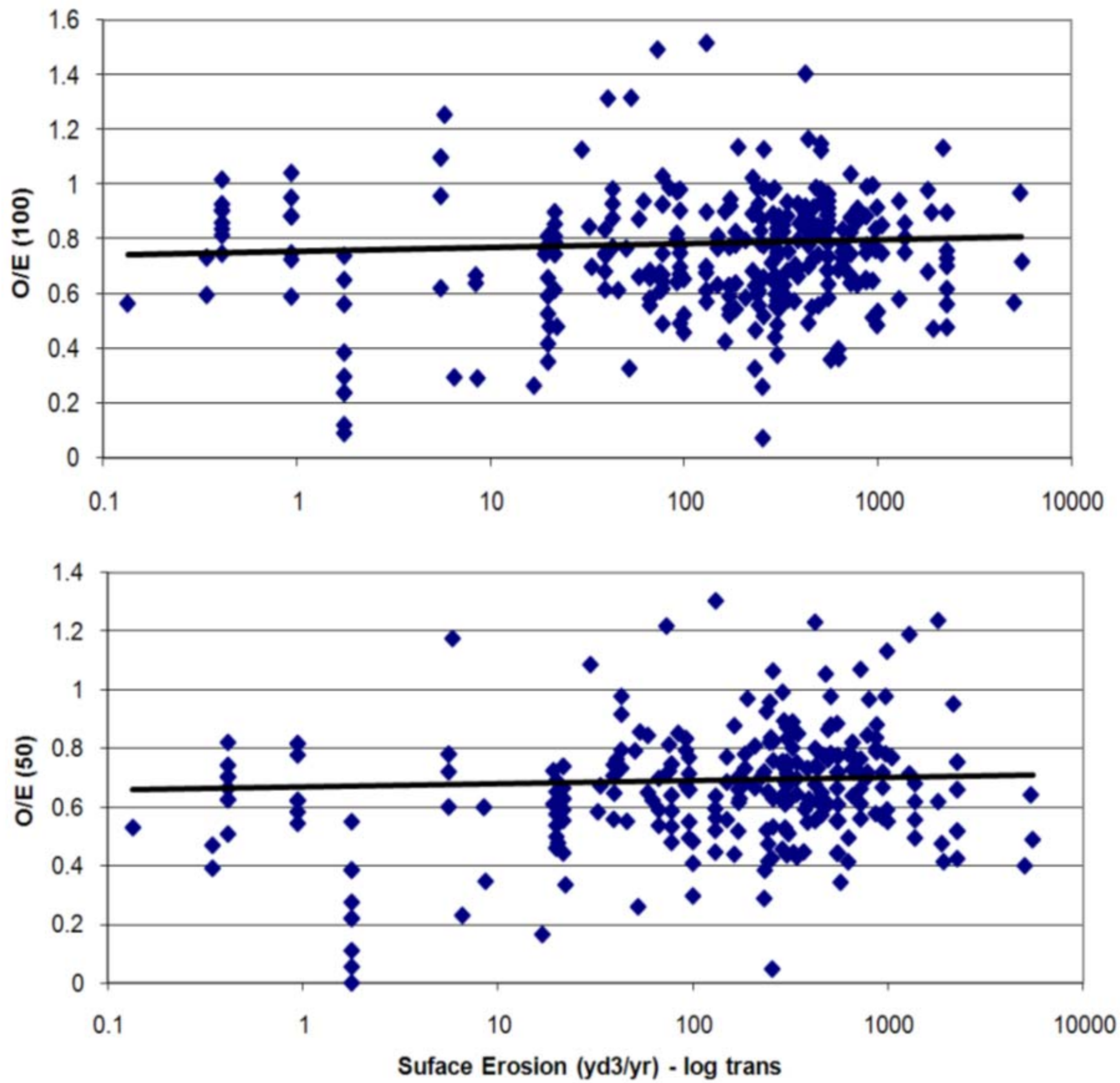

KL_GIS_11_08.mxd - ArcMap - ArcInfo
File Edit View Bookmarks Insert Selection Tools Window Help
1:760,509
Layers
Sampling sites
Salmon River
Scott River
Shatsta
Klamath River
Delineated catchment bo
%sedimentary rock
Mean annual Precip
Value
High : 7100
Low : 48
Mean annual TEMP
Value
High : 255
Low : -42
Display
Source
Selection
Drawing
Arial
10
123°18'4.137"W 41°48'49.901"N

O/E vs Mass Wasting





O/E vs USLE Surface Erosion



Effects of Forestry Management Practices (CWE) on BMI

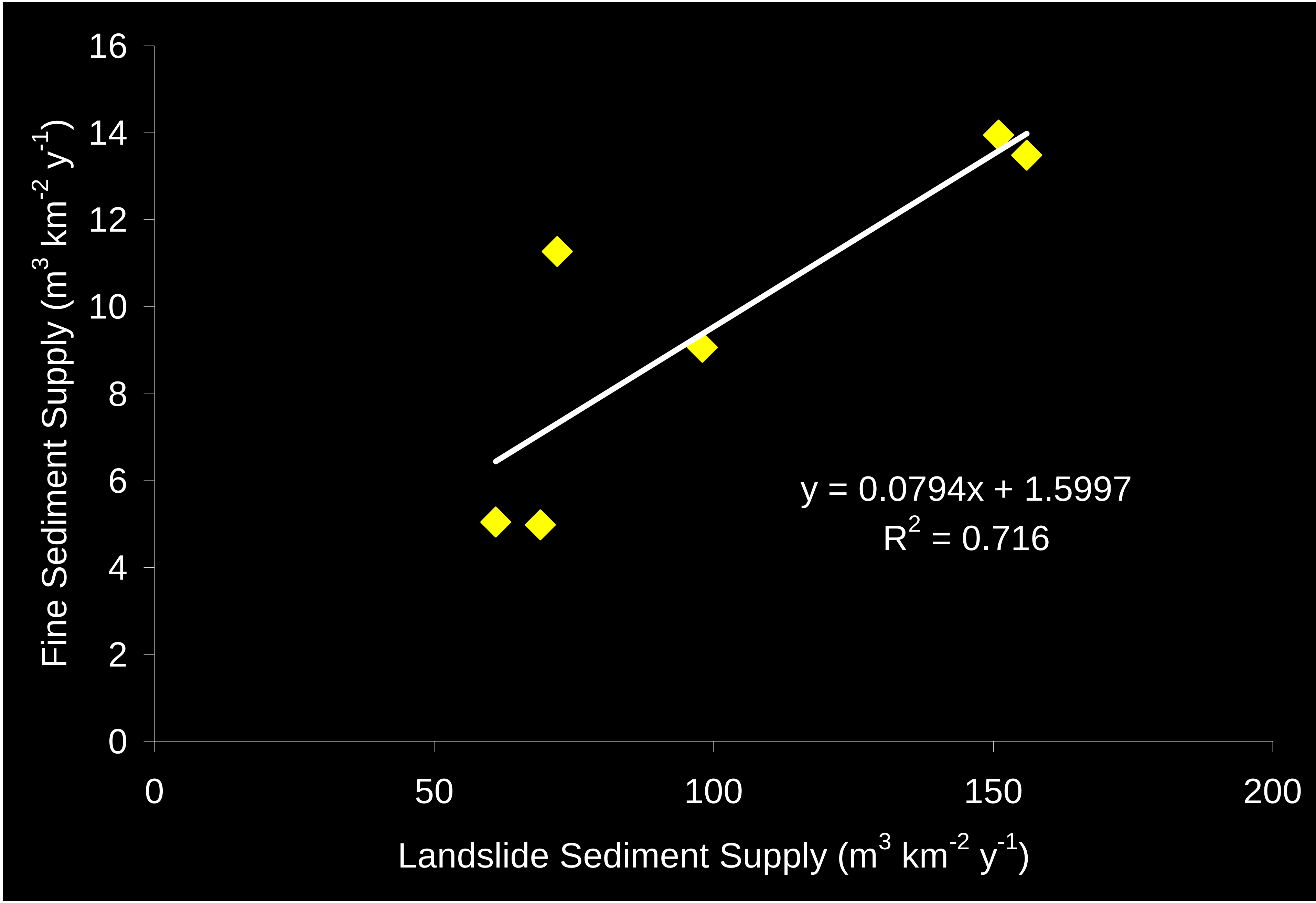
Fine sediment

1. **Coarse: Regional scale**

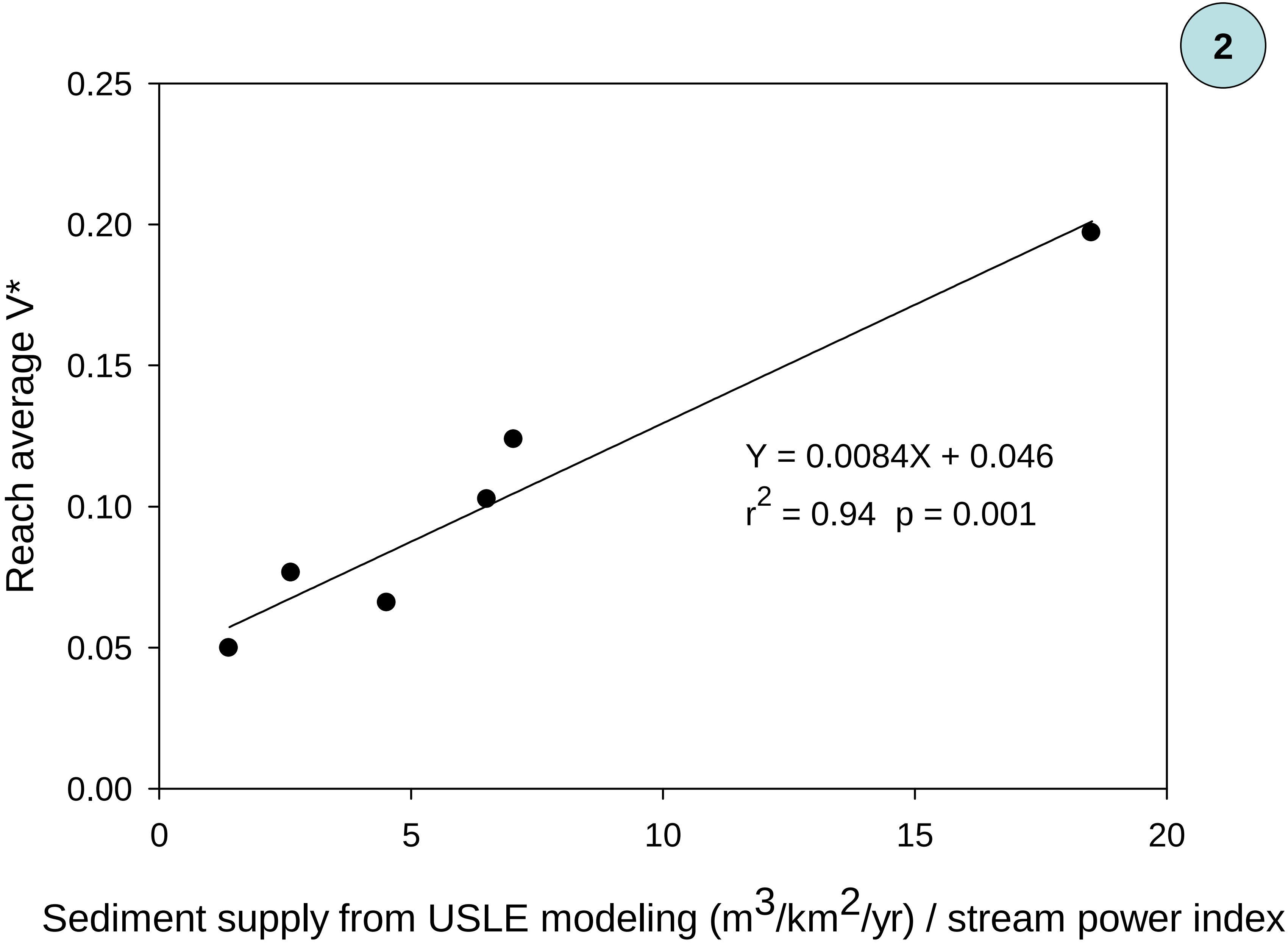
   CA RivPACS model vs. sed supply model

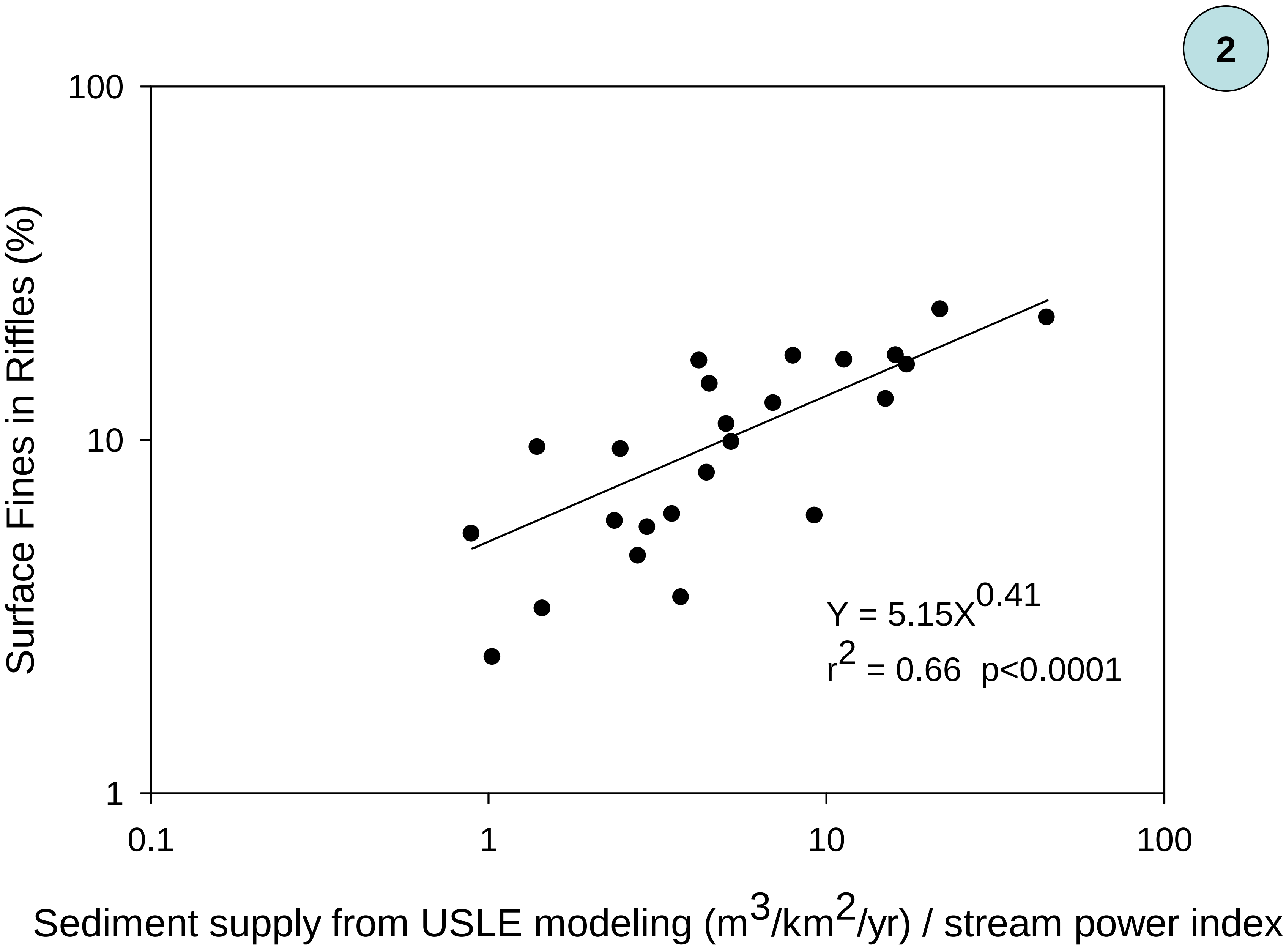
2. **Medium: Watershed scale**

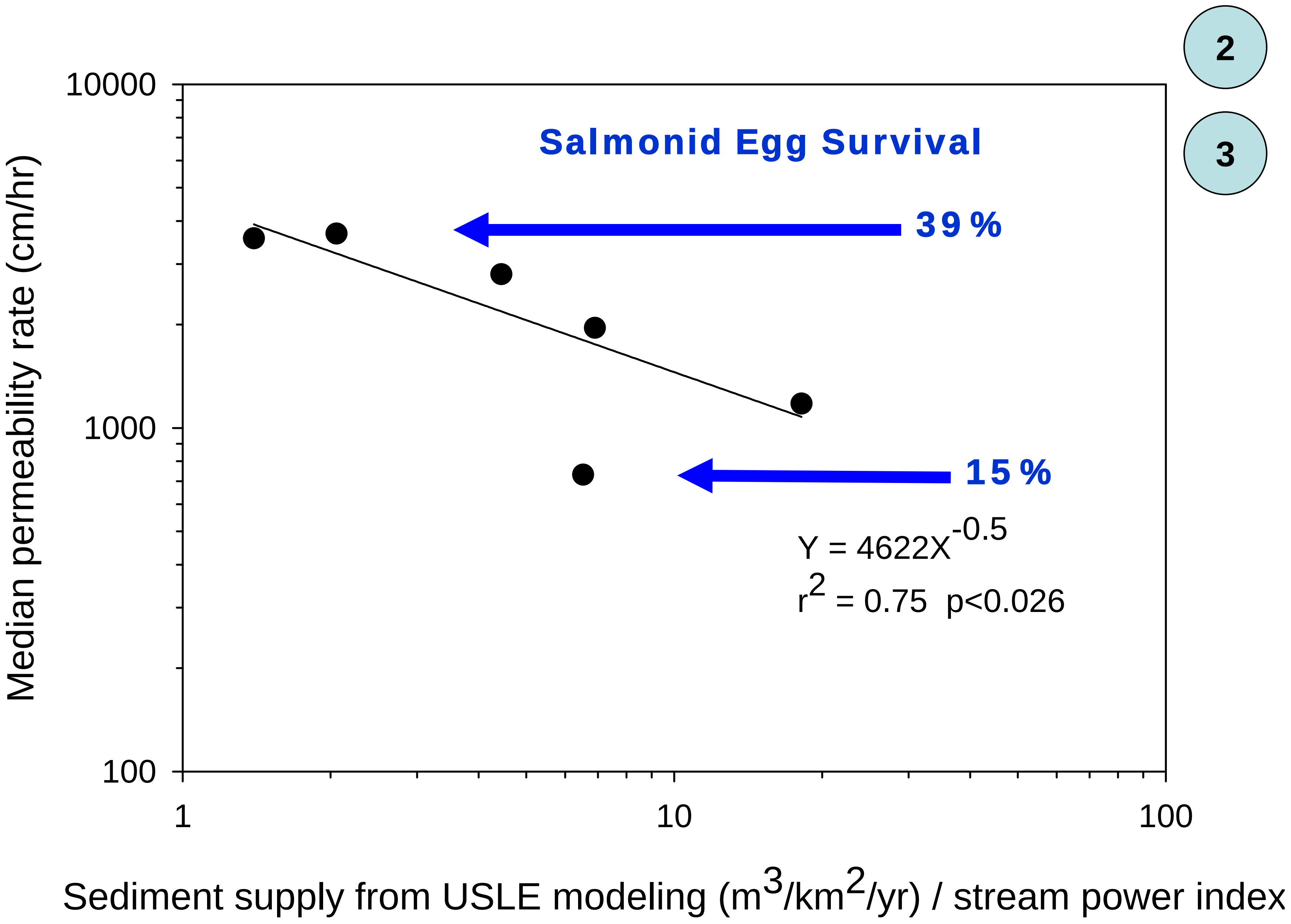
   Granitic watersheds w/ high sed. supply



Fine Sediment Supply (m3 km-2 y-1)
0
2
4
6
8
10
12
14
16
0
50
100
150
200
Landslide Sediment Supply (m3 km-2 y-1)
y = 0.0794x + 1.5997
R2 = 0.716

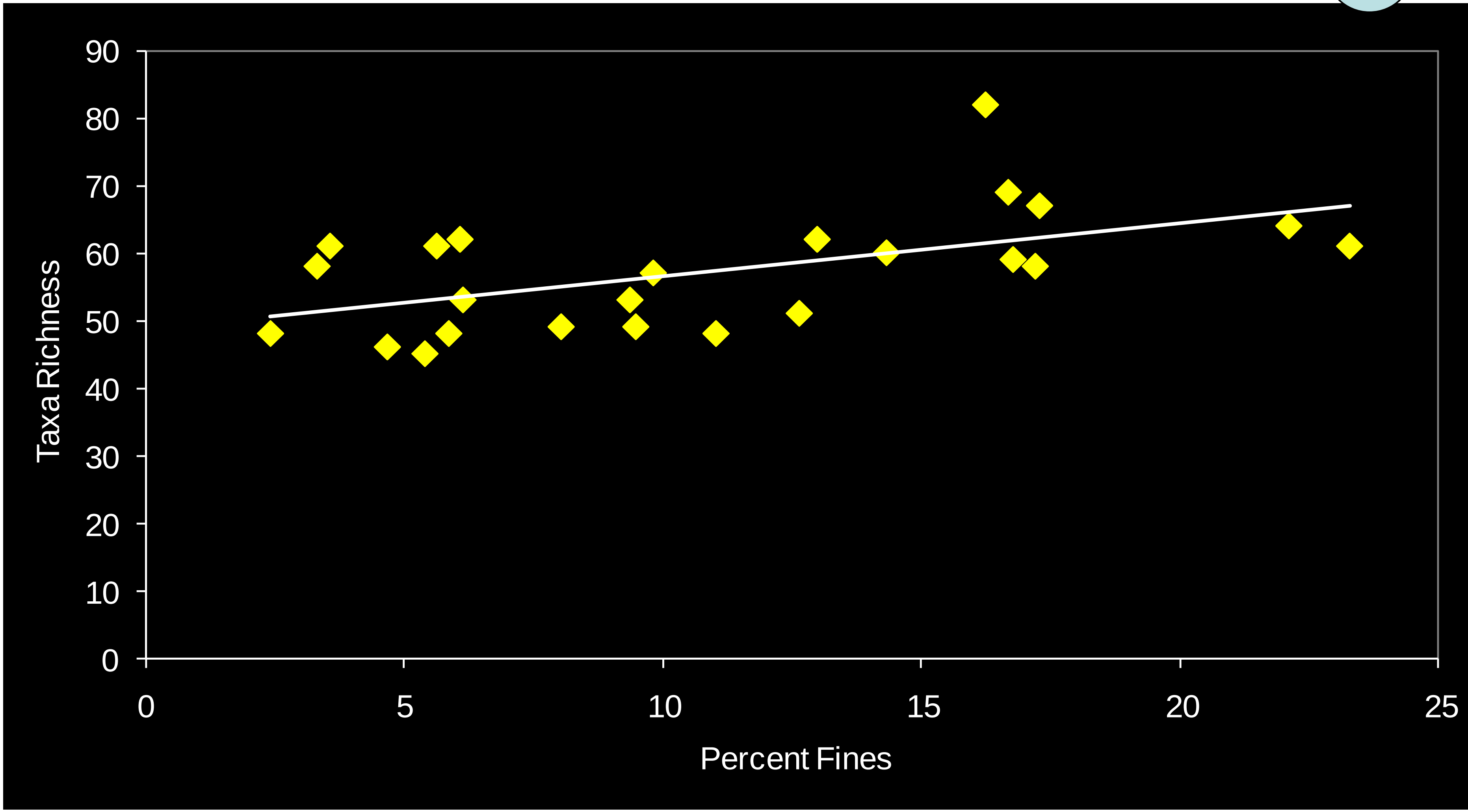

2
Reach average V*
0.25
0.20
0.15
0.10
0.05
0.00
0
5
10
15
20
Y = 0.0084X + 0.046
r2 = 0.94 p = 0.001
Sediment supply from USLE modeling (m3/km2/yr) / stream power index


2
100
10
1
0.1
1
10
100
Surface Fines in Riffles (%)
Y = 5.15X^0.41
r^2 = 0.66 p<0.0001
Sediment supply from USLE modeling (m^3/km^2/yr) / stream power index



2
3
Salmonid Egg Survival
39%
15%
Y = 4622X^-0.5
r^2 = 0.75 p<0.026
10000
1000
100
1
10
100
Median permeability rate (cm/hr)
Sediment supply from USLE modeling (m^3/km^2/yr) / stream power index

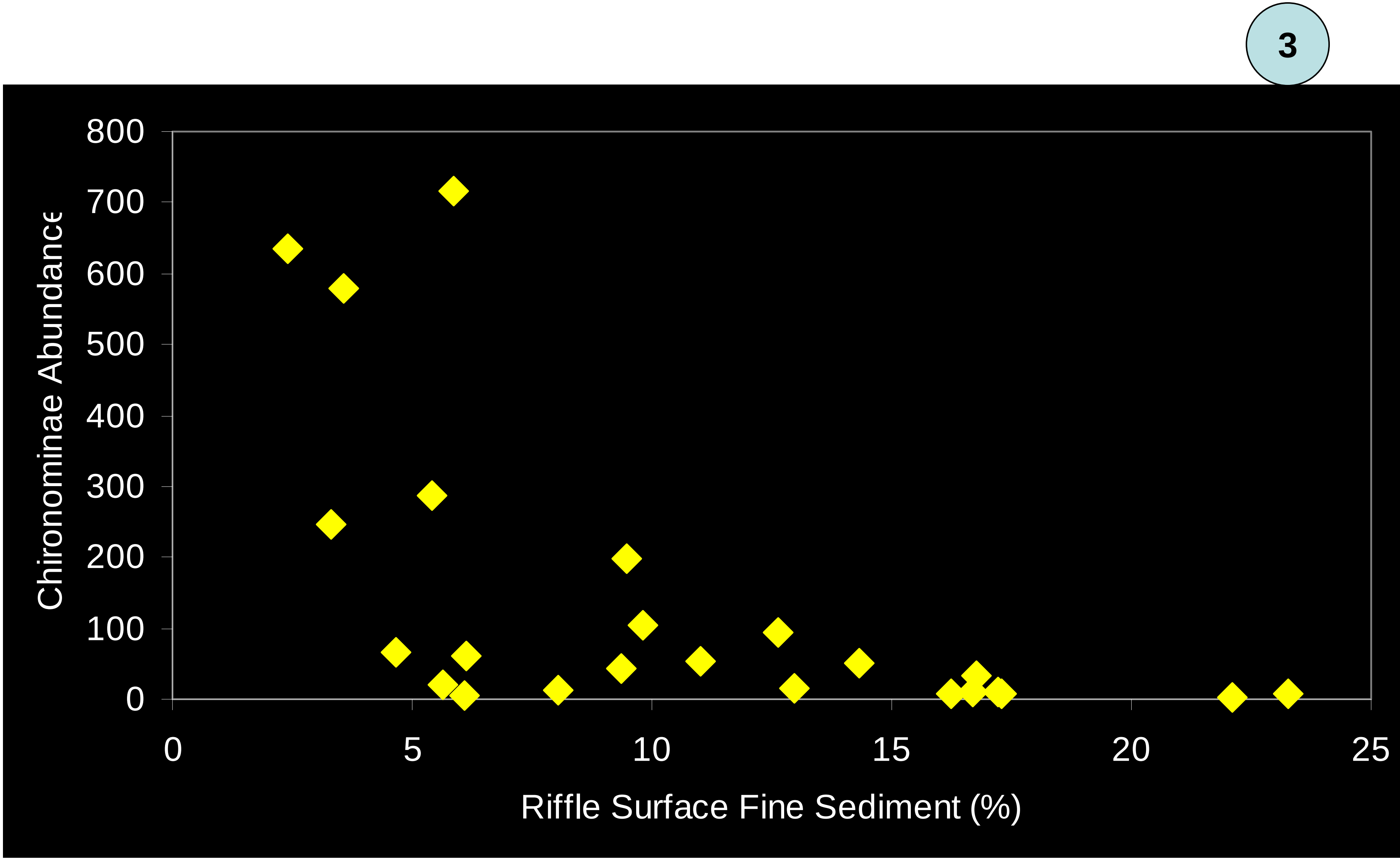
3



90
80
70
60
50
40
30
20
10
0
Taxa Richness
0
5
10
15
20
25
Percent Fines

	Fine Sediment			
	Simple Linear Regression		Partial Correlation	
Metrics and Taxa (Predicted Response to Fine Sediment)	r_{12}	**Sig. Prob.**	$r_{12.345678}$	**Sig. Prob.**
Taxa Richness (-)	0.50	0.012	0.18	0.49
Total Abundance (-)	-0.29	0.18	-0.28	0.26
EPT Richness (-)	0.46	0.023	0.07	0.80
EPT Abundance (-)	-0.18	0.39	-0.08	0.78
% Burrowing (+)	-0.32	0.13	0.40	0.097
% Vulnerable (-)	0.23	0.27	0.30	0.23

3



3
Chironominae Abundance
800
700
600
500
400
300
200
100
0
0
5
10
15
20
25
Riffle Surface Fine Sediment (%)

3

	Response	Size (mm)	Availability Score*
Chironominae	-	2-8	70.5
Epeorus (E)	-	7-18	63.6
Cinygmula (E)	-	7-18	63.6
Arctopsyche (T)	-	10-28	51.6
Oligochaeta	+	2-20	10.0
Attenella delantala (E)	+	5-9	22.5
Zapada columbiana (P)	+	5-10	52.6

*Radar 1997

Conclusions

- No relationship between fine sediment and benthic macroinvertebrate metrics

- A few taxa show potential for being useful bioindicators of fine sediment

Effects of Forestry Management Practices (CWE) on BMI

Fine sediment

1. **Coarse: Regional scale**

   CA RivPACS model vs. sed supply model

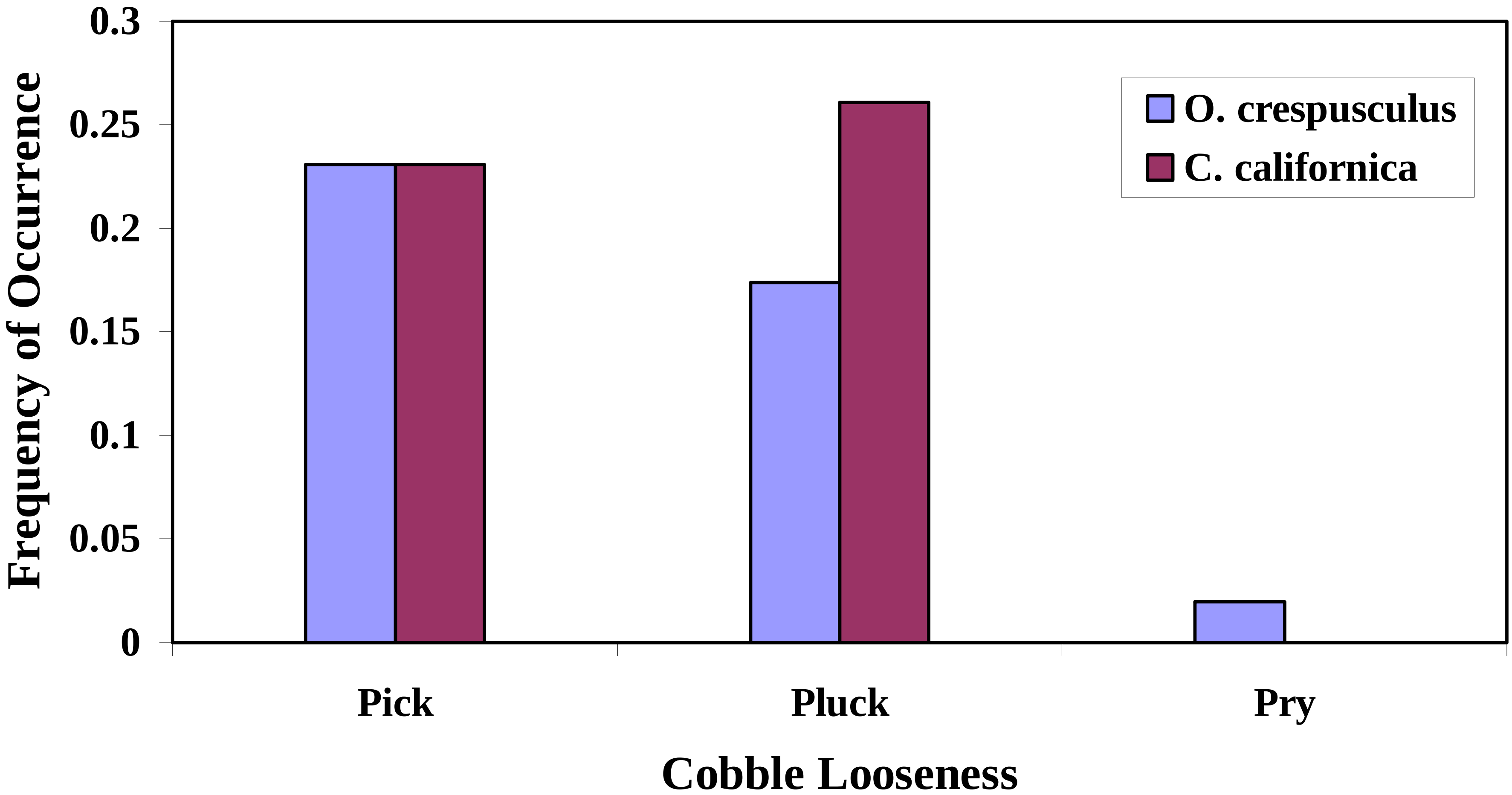
2. **Medium: Watershed scale**

   Granitic watersheds w/ high sed. supply

3. **Very Fine: Cobble scale**

   Large predators and embeddedness


NABS (www.benthos.org)


0.3
0.25
0.2
0.15
0.1
0.05
0
Frequency of Occurrence
O. crespusculus
C. californica
Pick
Pluck
Pry
Cobble Looseness

	Odds Ratios (95% Confidence Intervals)		
Variable	Either Predator	*O. crespusculus*	*C. californica*
Creek	**3.45 (1.22 - 9.76)**	**5.27 (1.08 - 25.78)**	2.19 (0.61 - 7.81)
Median Diameter*	1.14 (0.99 - 1.32)	1.08 (0.89 - 1.30)	1.12 (0.94 - 1.35)
Finger Crevice	**4.49 (1.65 - 12.13)**	2.91 (0.82 - 10.37)	**5.33 (1.47 - 19.35)**
Pick	**5.49 (1.98 - 15.20)**	**4.14 (1.14 - 14.99)**	3.40 (0.99 - 11.71)
Pry	**0.03 (0.003 - 0.21)**	**0.08 (0.01 - 0.64)**	N/A[1]
Embeddedness*	**0.66 (0.50 - 0.85)**	**0.72 (0.52 - 0.99)**	**0.67 (0.48 - 0.94)**
Subsurface Fines*	0.43 (0.76 - 2.41)	1.42 (0.14 - 14.57)	0.13 (0.01 - 1.21)
Silty Biofilm	1.9 (0.62 - 5.70)	2.8 (0.73 - 10.85)	0.84 (0.17 - 4.2)
Flow Habitat	2.6 (0.55 - 12.2)	0.99 (0.19 - 5.01)	N/A[2]

Effects of Forestry Management Practices (CWE) on BMI

Fine sediment

1. **Coarse: Regional scale**

   CA RivPACS model vs. sed supply model

2. **Medium: Watershed scale**

   Granitic watersheds w/ high sed. supply

3. **Very Fine: Cobble scale**

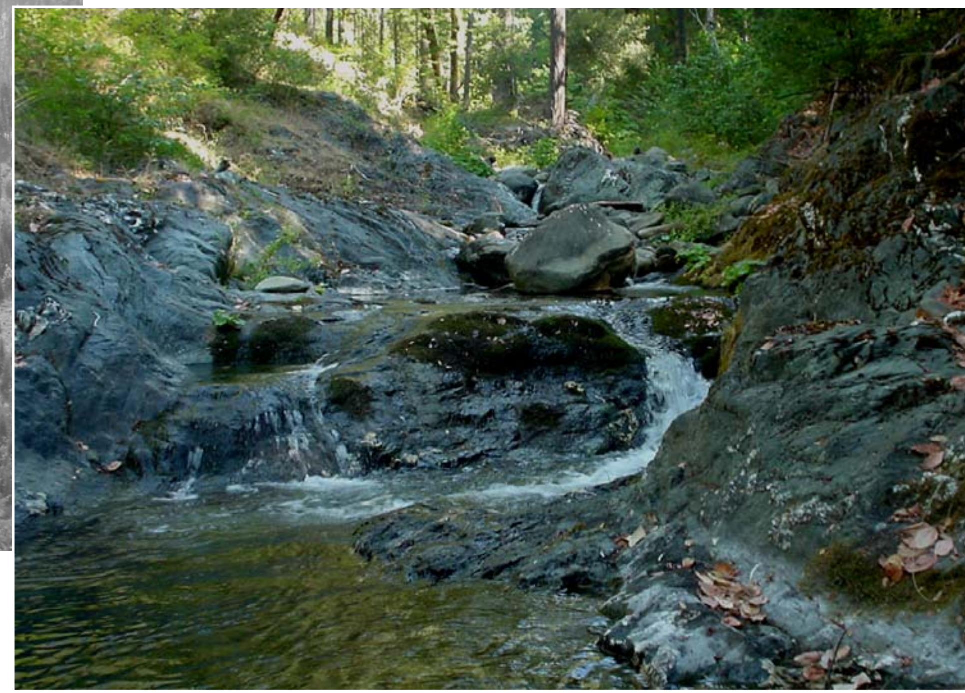
   Large predators and embeddedness

What is a debris flow?

Debris flows are catastrophic disturbances in mountain streams

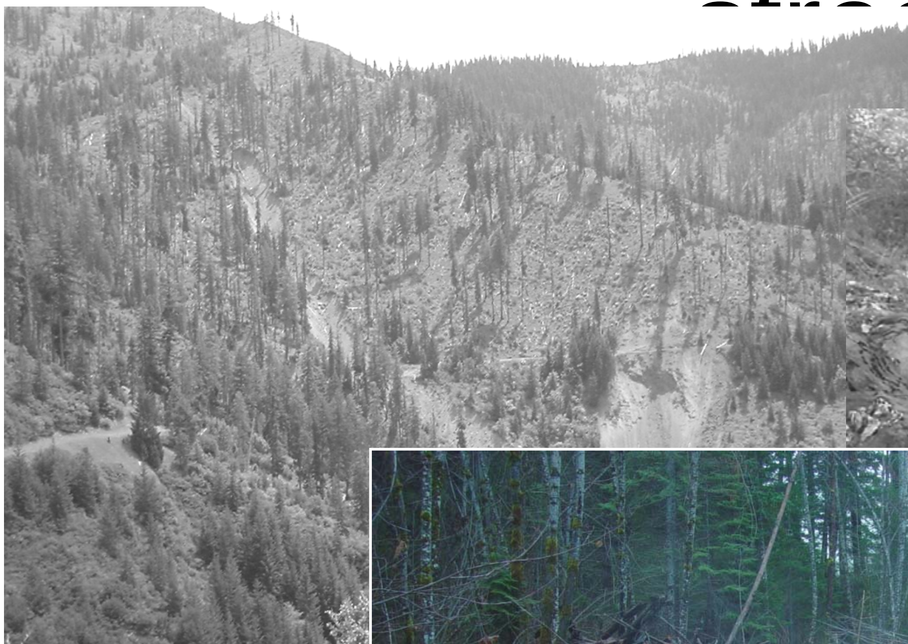
Hillslopes steeper than 100% (45°)

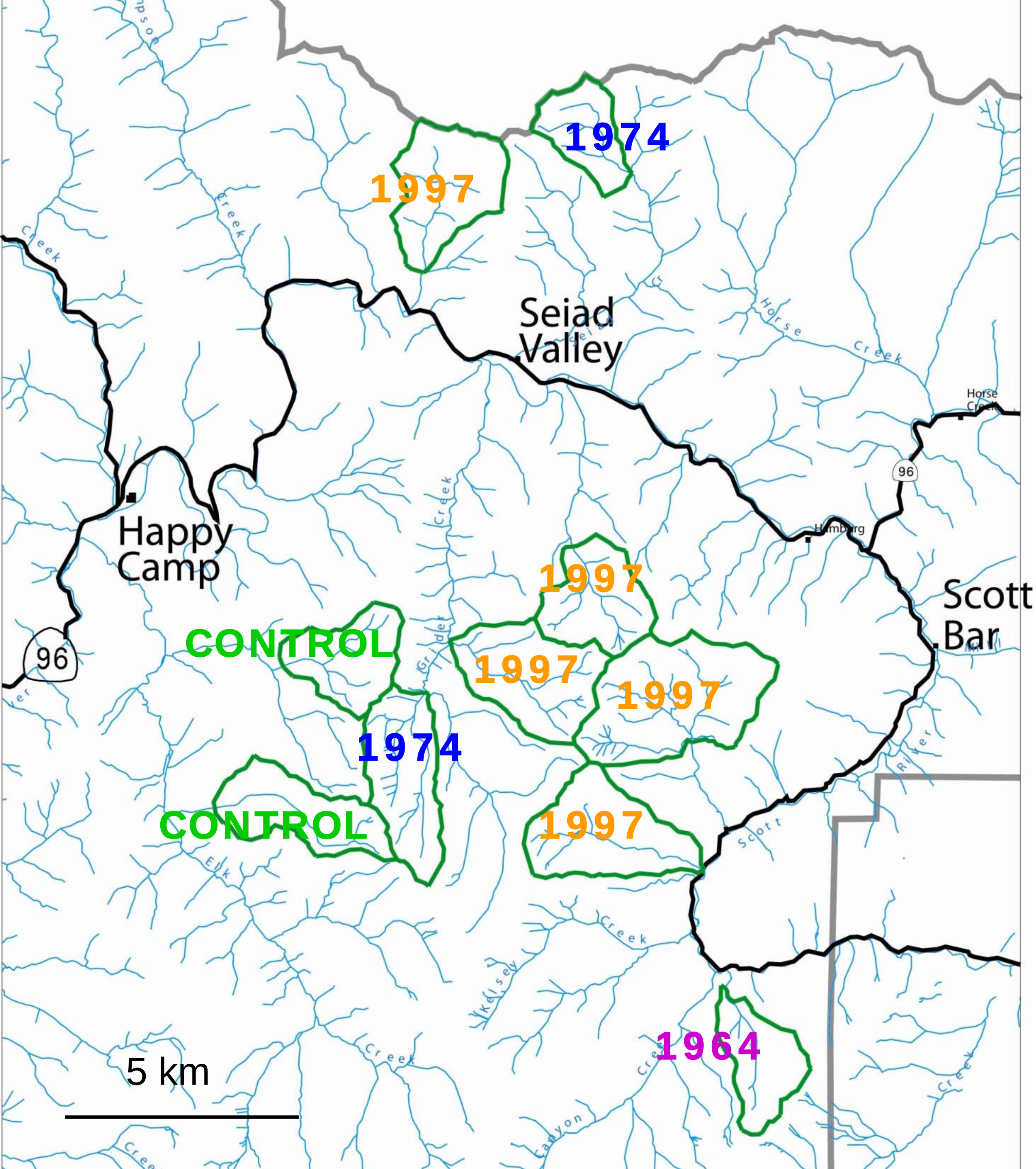
Debris flows are catastrophic disturbances in mountain streams



Scour headwater channels >10%

Debris flows are catastrophic disturbances in mountain streams





10 Basins

- 10-20 km^2
- 6-9% Slope
- 5 m wide

Natural Experiment

Debris Flows

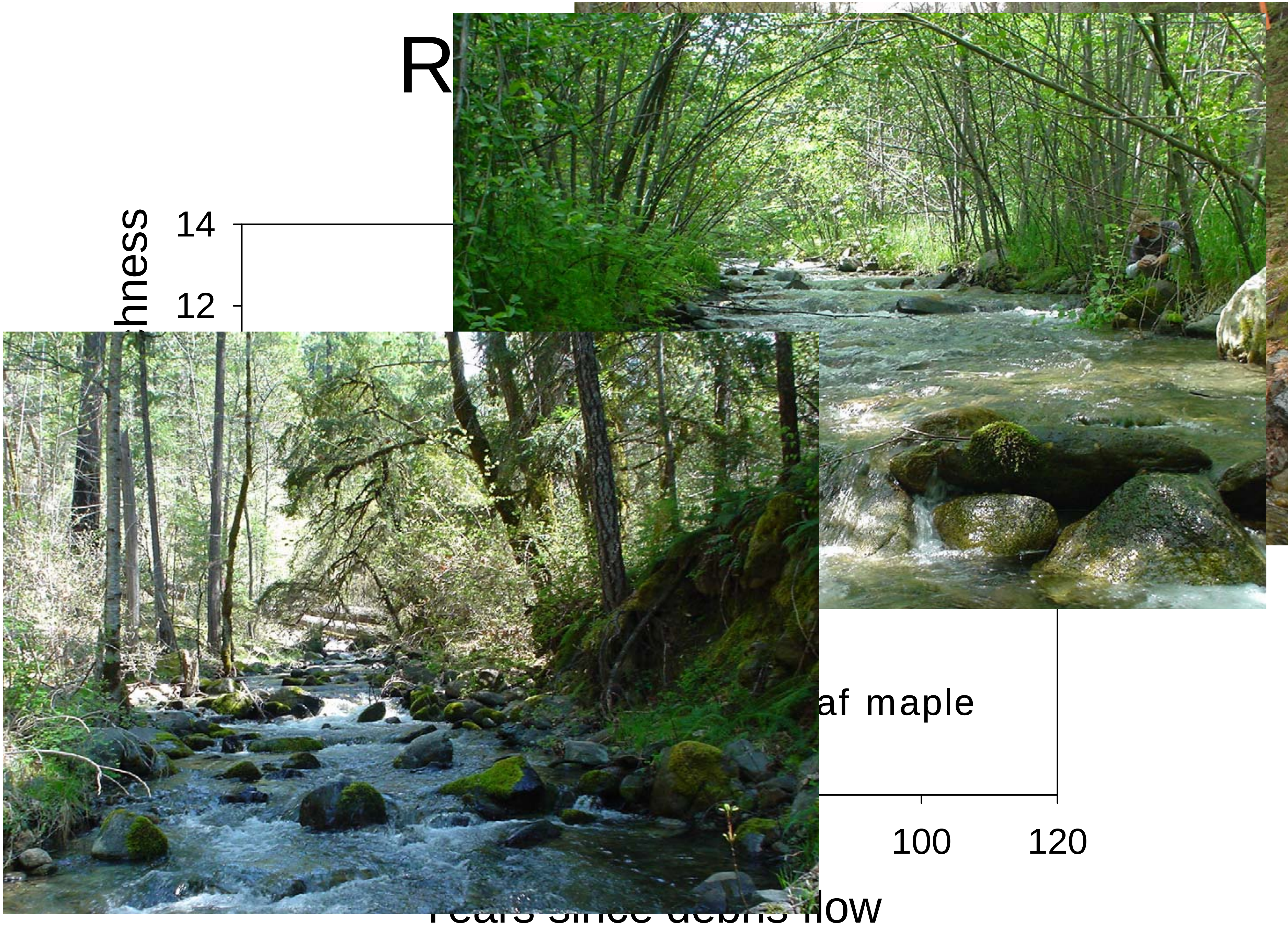
5- 1997

2- 1974

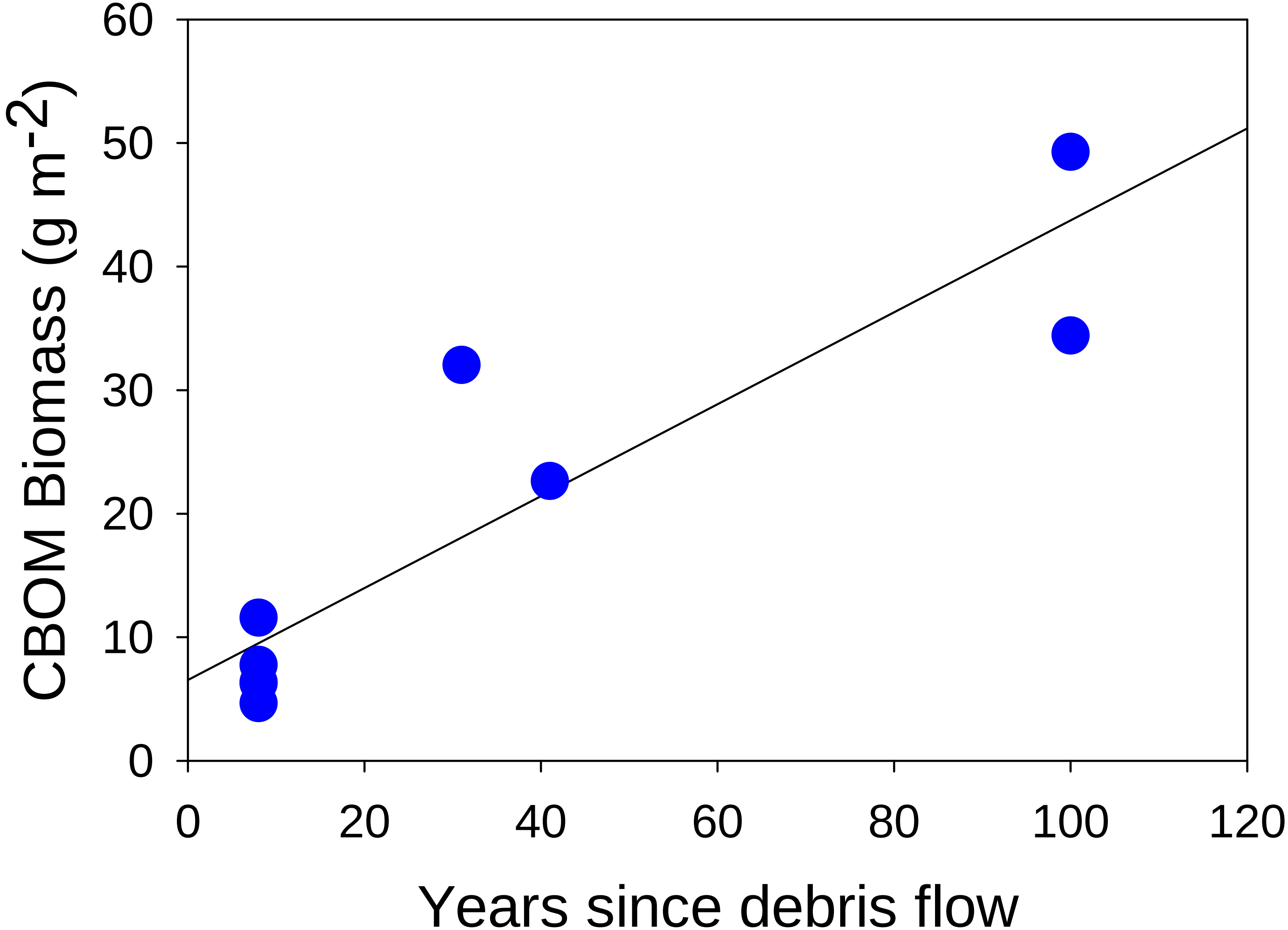
1- 1964

2- None last 100+ years

R



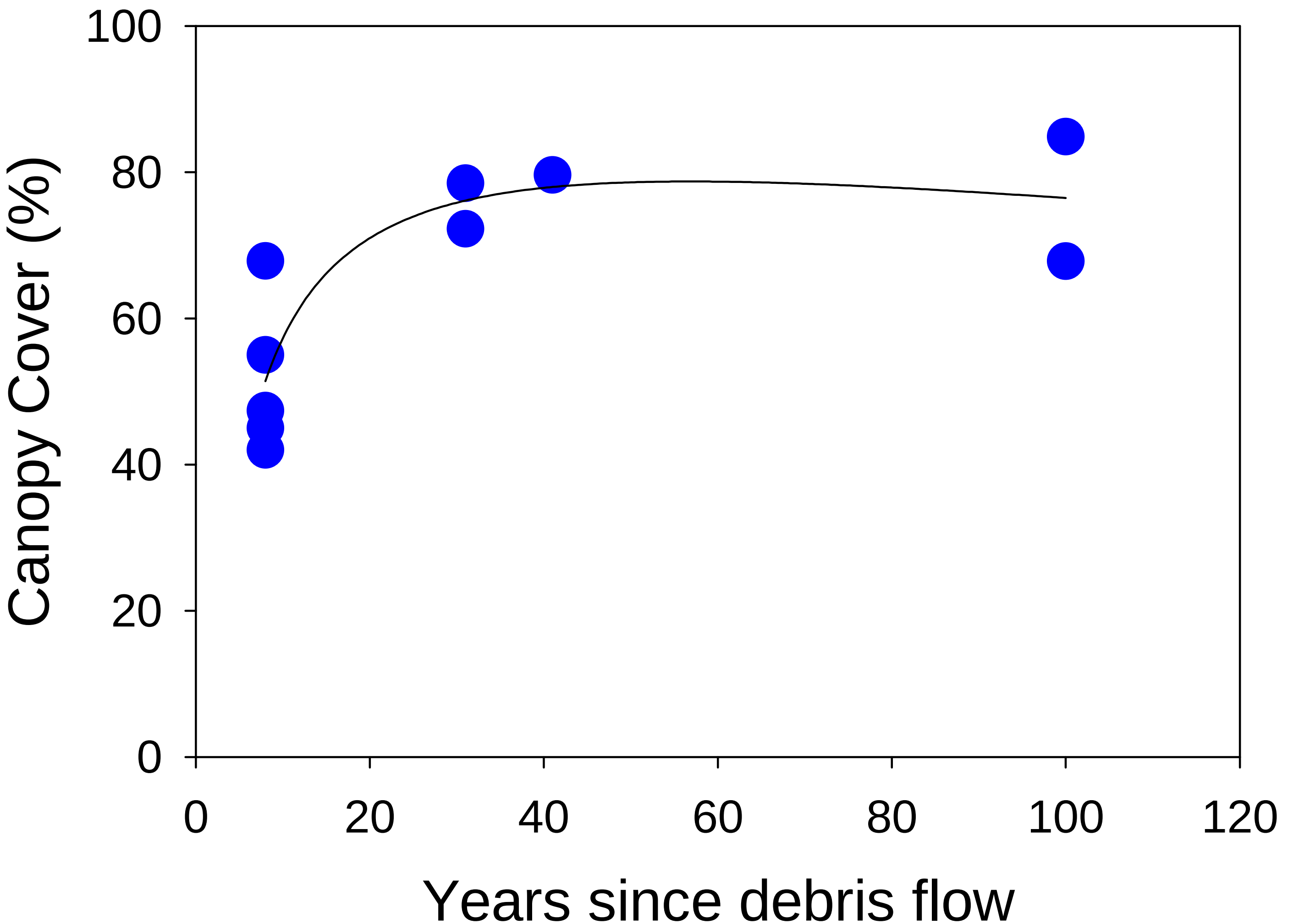
Coarse benthic organic matter



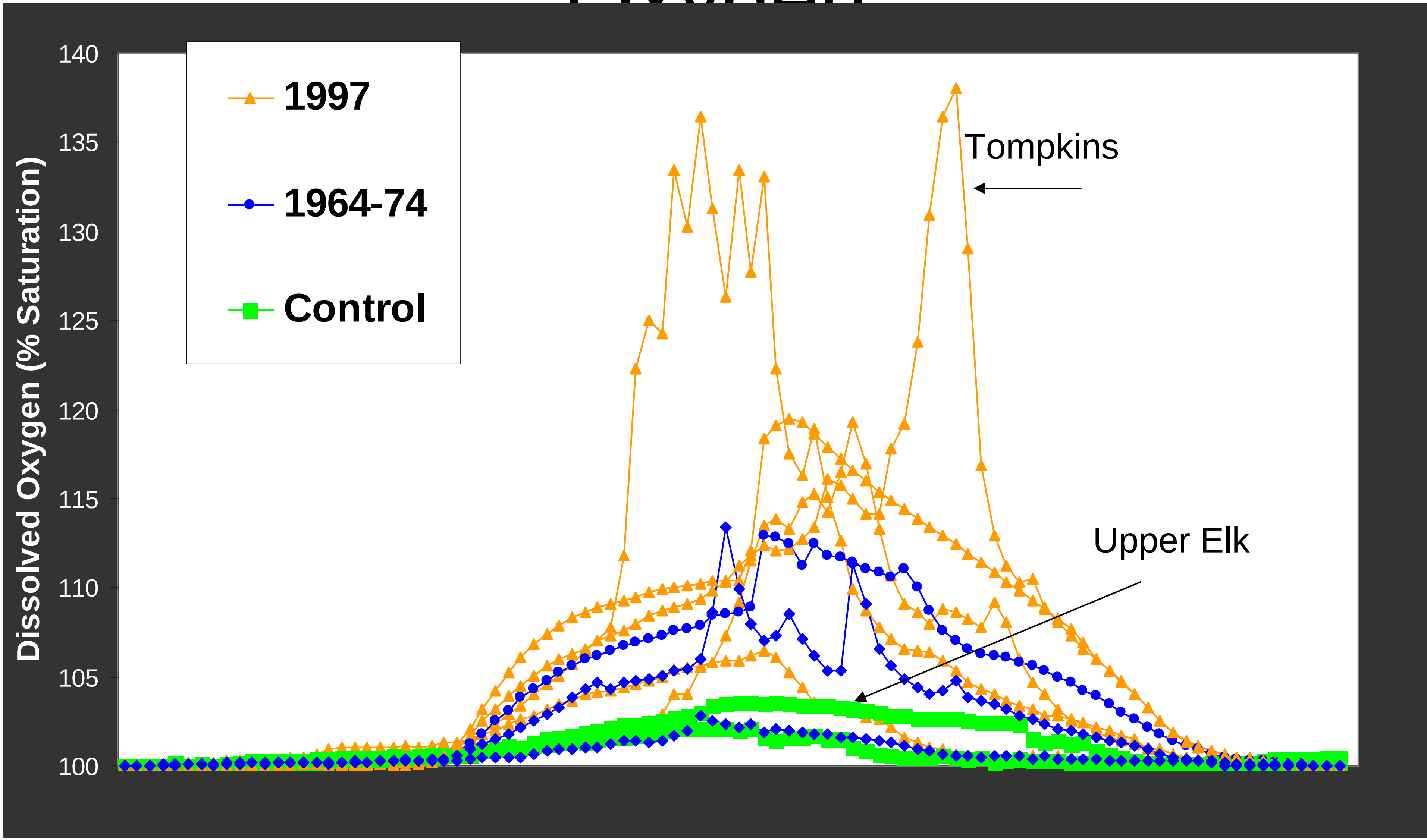
Invertebrate Shredders

	1997 DF	Older DF
Yoraperla (m^{-2})	3	169
Malenka (m^{-2})	36	131
Zapada columbiana (m^{-2})	5	152

Canopy Cover



Primary Productivity- Dissolved Oxygen



Invertebrate Grazers

	1997 DF	Older DF
Glossosma (m^{-2})	325	40
Epeorus (m^{-2})	44	226



Conclusions

- In **steep** mountains streams, even high sediment supply does not result in wholesale changes to the BMI assemblage
- A few taxa may show responses
- Rare, catastrophic geomorphic processes may have more significant and persistent impacts on stream communities