Fish-habitat relationship development

ISEMP and CHaMP Development Team

January 11, 2013

Ultimate goal of ISEMP and CHaMP is to develop fish-habitat relationships that feed management decision-making processes

- Habitat quality / quantity assessments
  - status monitoring
  - FCRPS BO, Recovery Plan progress evaluation
- Restoration action planning
  - rehabilitation program design
  - project prioritization

Fish-habitat relationship development methods that ISEMP / CHaMP and partners are employing

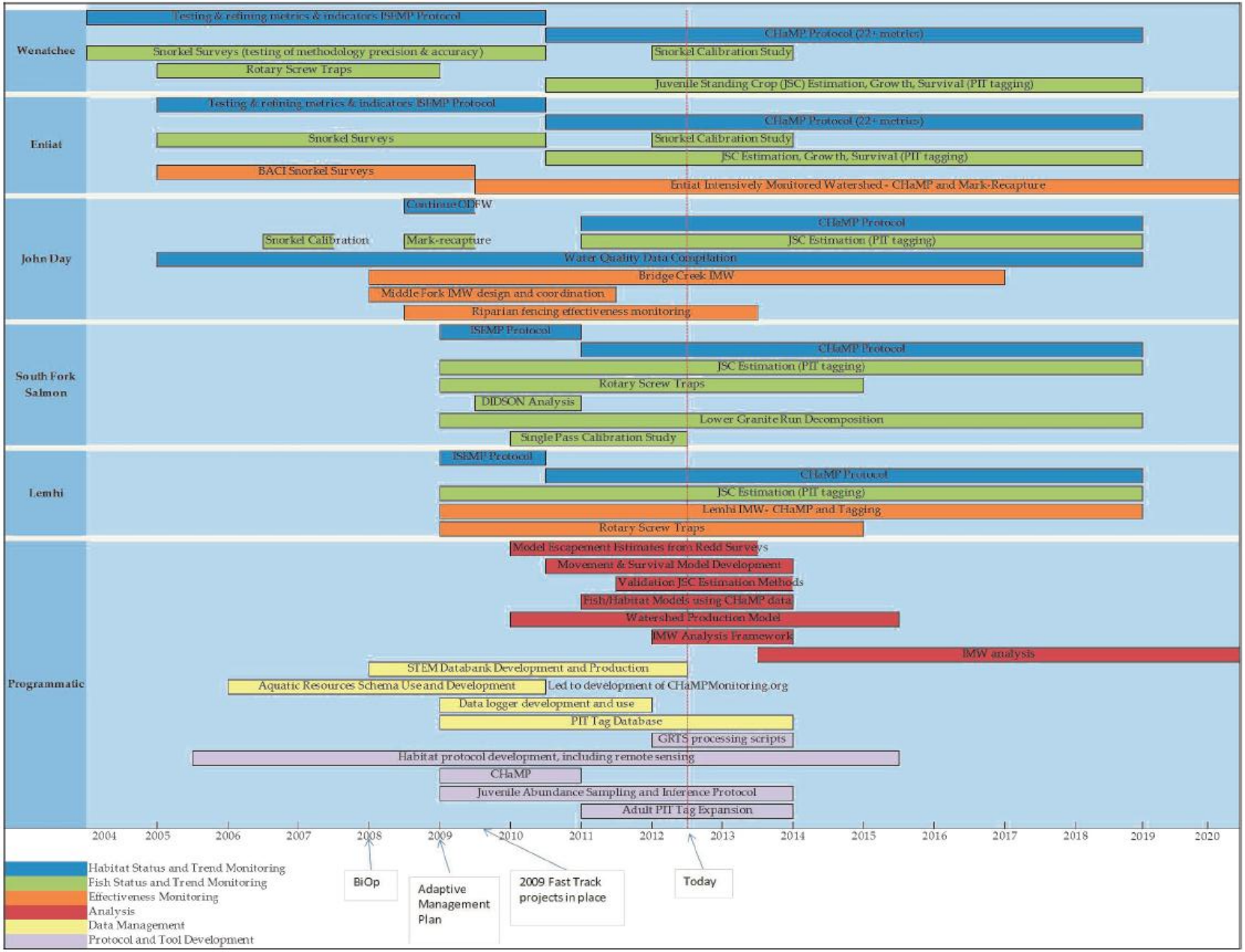
1. Unstructured correlation between fish and habitat metrics

2. Structured correlation between fish and habitat metrics
   - 2.1 Habitat Suitability Indices
   - 2.2 Structural Equation Modeling

3. Mechanistic modeling
   - 3.1 Bioenergetic based models
   - 3.2 Production function based models

4. Experimental design

ISEMP – CHaMP Timeline



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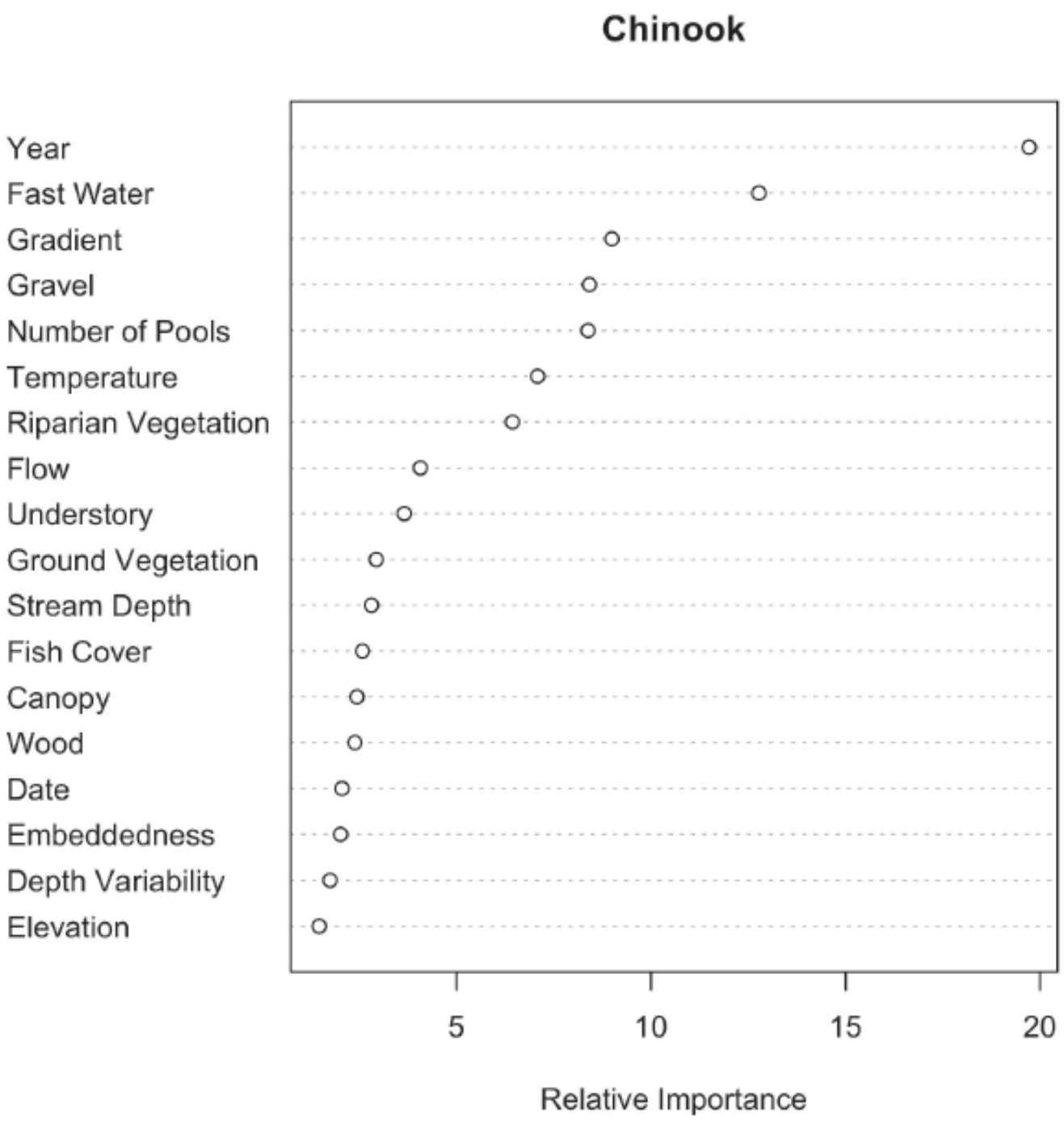
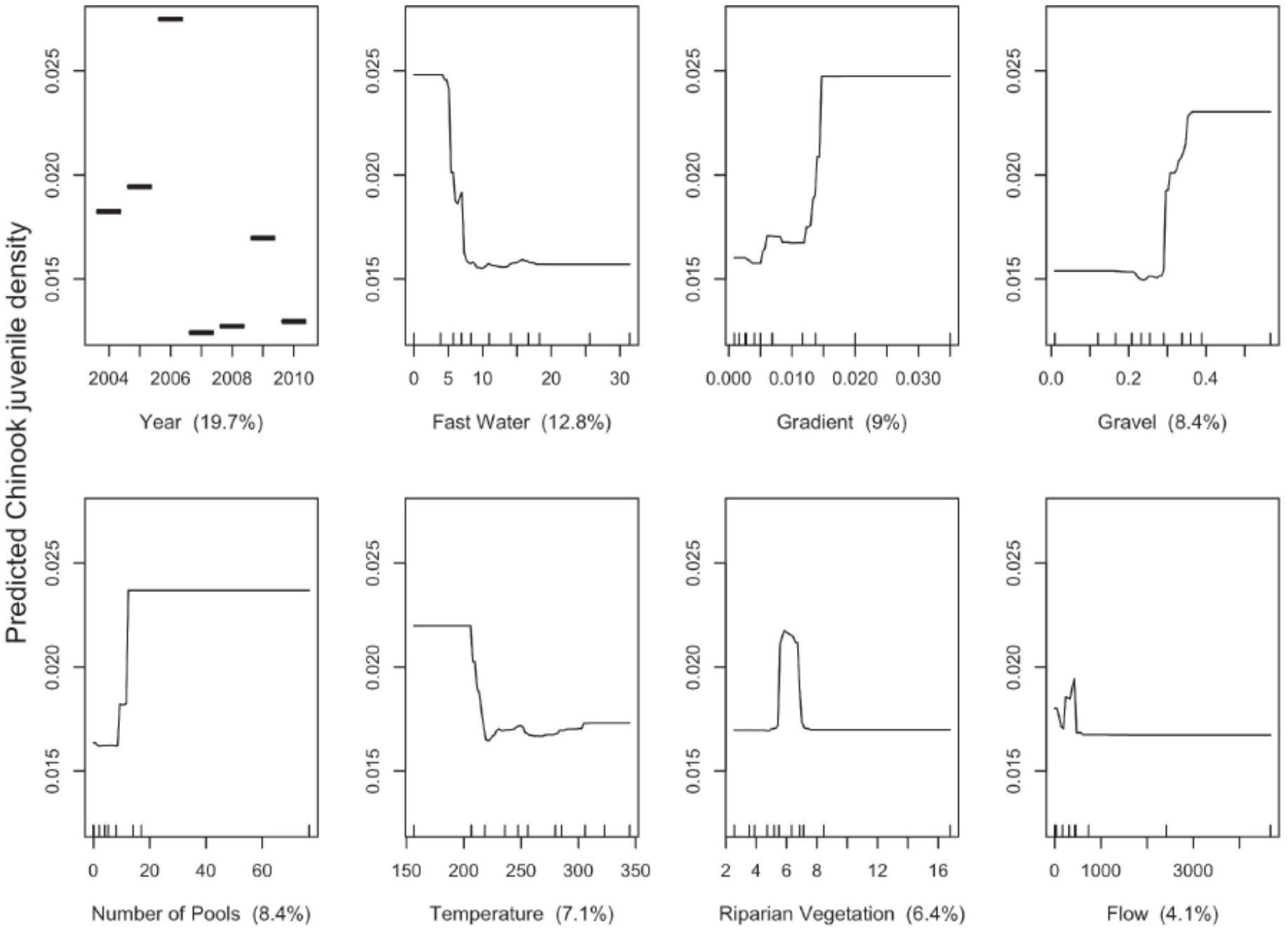
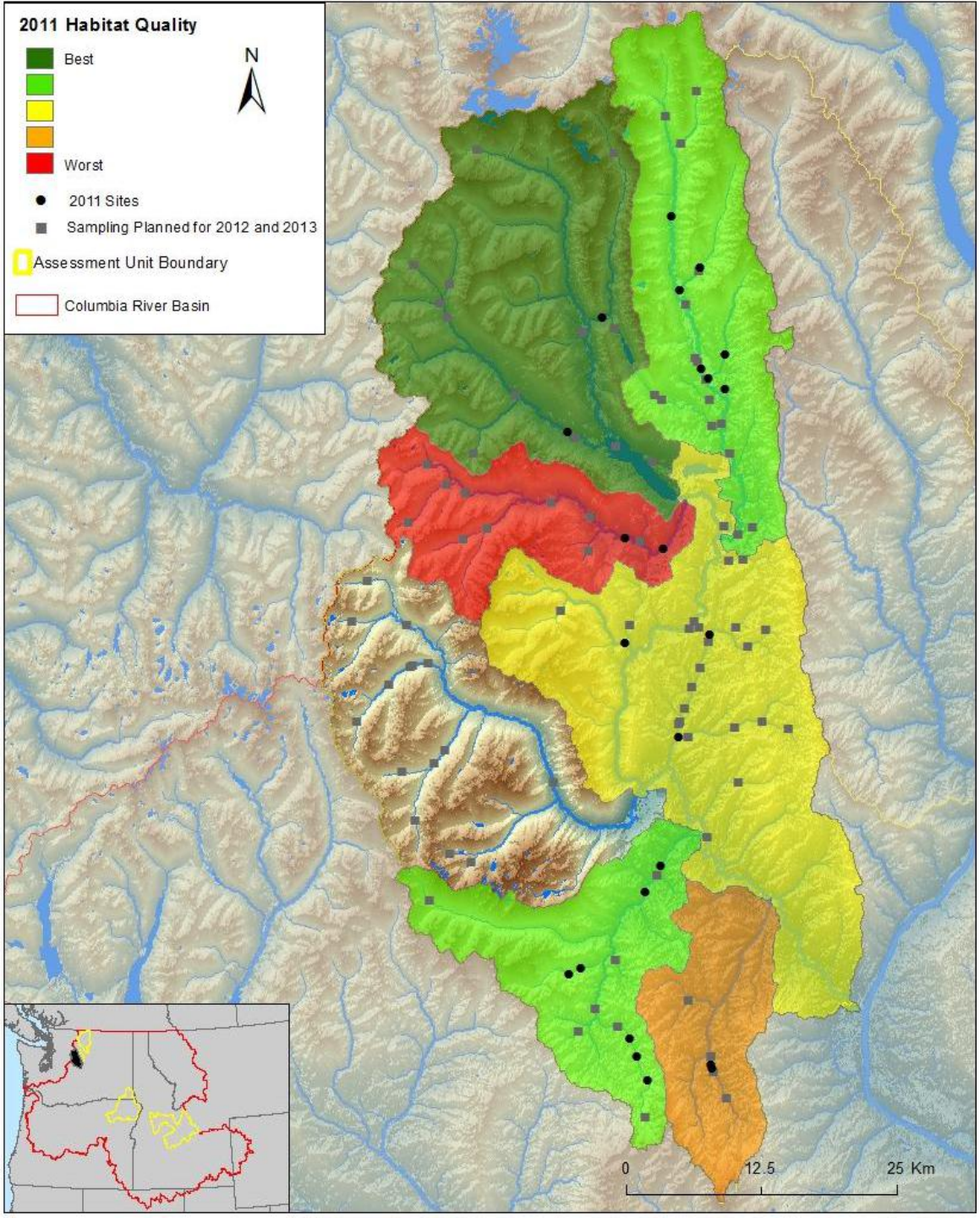
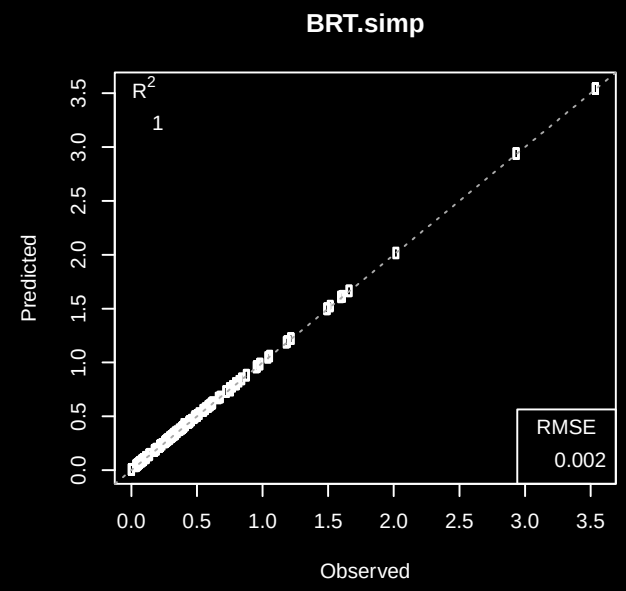
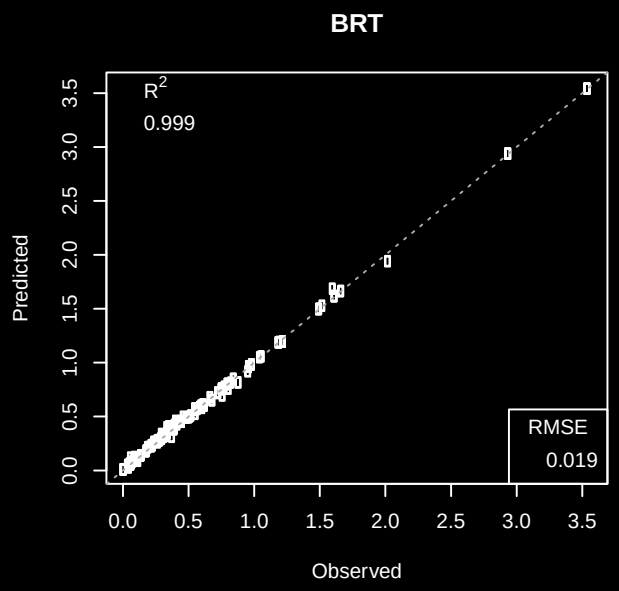

Chinook
Year
Fast Water
Gradient
Gravel
Number of Pools
Temperature
Riparian Vegetation
Flow
Understory
Ground Vegetation
Stream Depth
Fish Cover
Canopy
Wood
Date
Embeddedness
Depth Variability
Elevation
5
10
15
20
Relative Importance

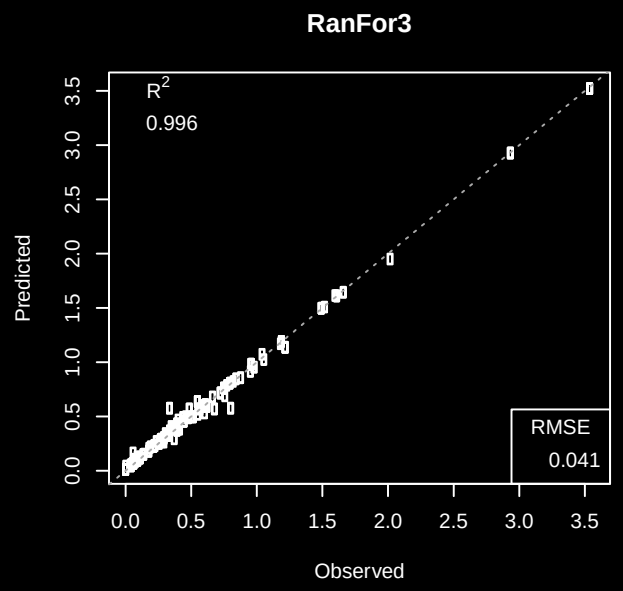

Predicted Chinook juvenile density
0.015
0.020
0.025
2004
2006
2008
2010
Year (19.7%)
0
5
10
20
30
Fast Water (12.8%)
0.000
0.010
0.020
0.030
Gradient (9%)
0.0
0.2
0.4
Gravel (8.4%)
0
20
40
60
Number of Pools (8.4%)
150
200
250
300
350
Temperature (7.1%)
2
4
6
8
12
16
Riparian Vegetation (6.4%)
0
1000
3000
Flow (4.1%)

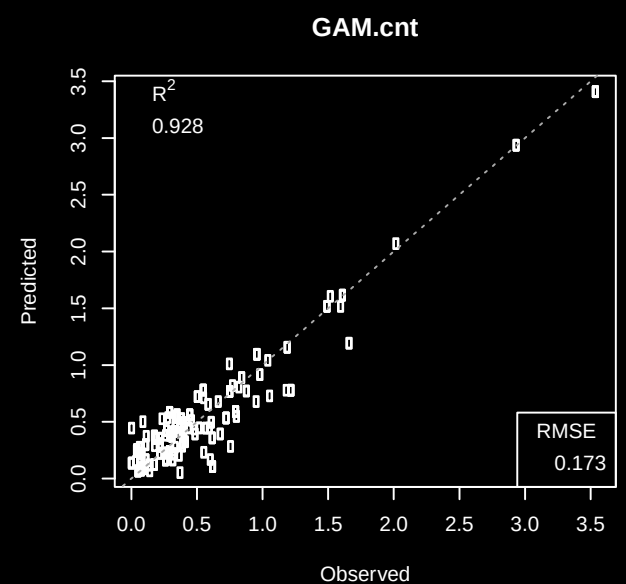

2011 Habitat Quality
Best
Worst
N
2011 Sites
Sampling Planned for 2012 and 2013
Assessment Unit Boundary
Columbia River Basin
0
12.5
25 Km

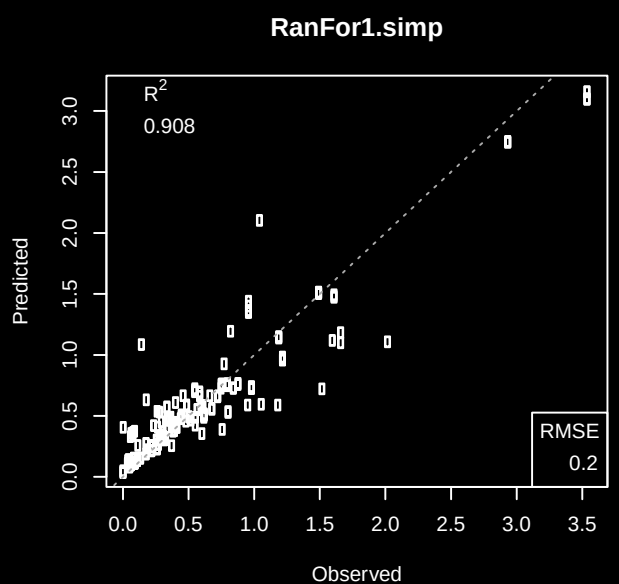
Predicting Density of All Salmonids

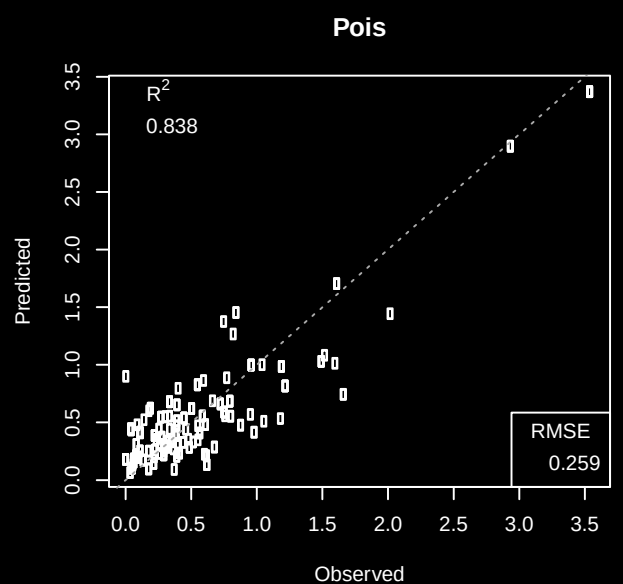




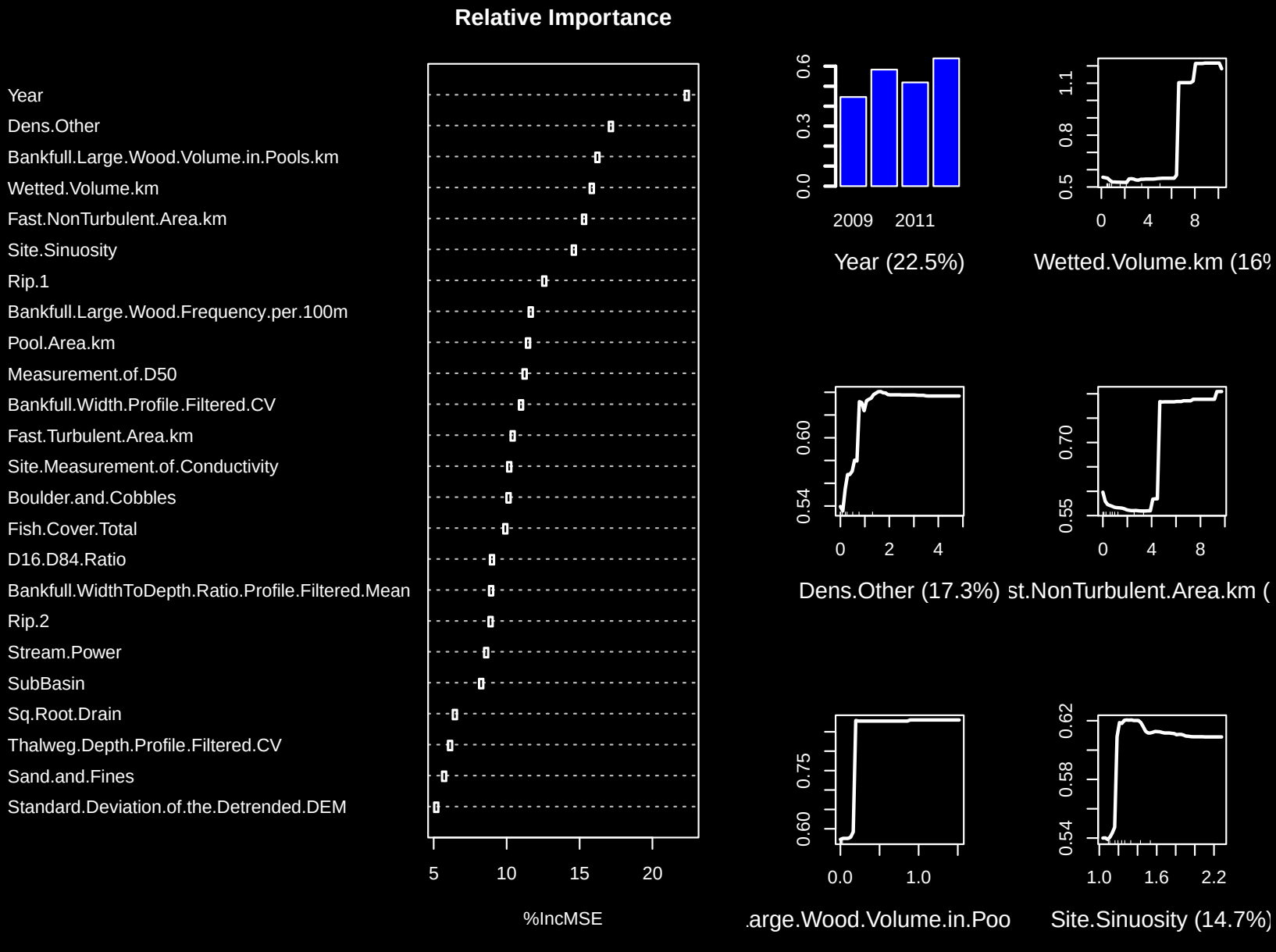








All Salmonids – Random Forest Model



Fish-habitat relationship development methods that ISEMP / CHaMP and partners are employing

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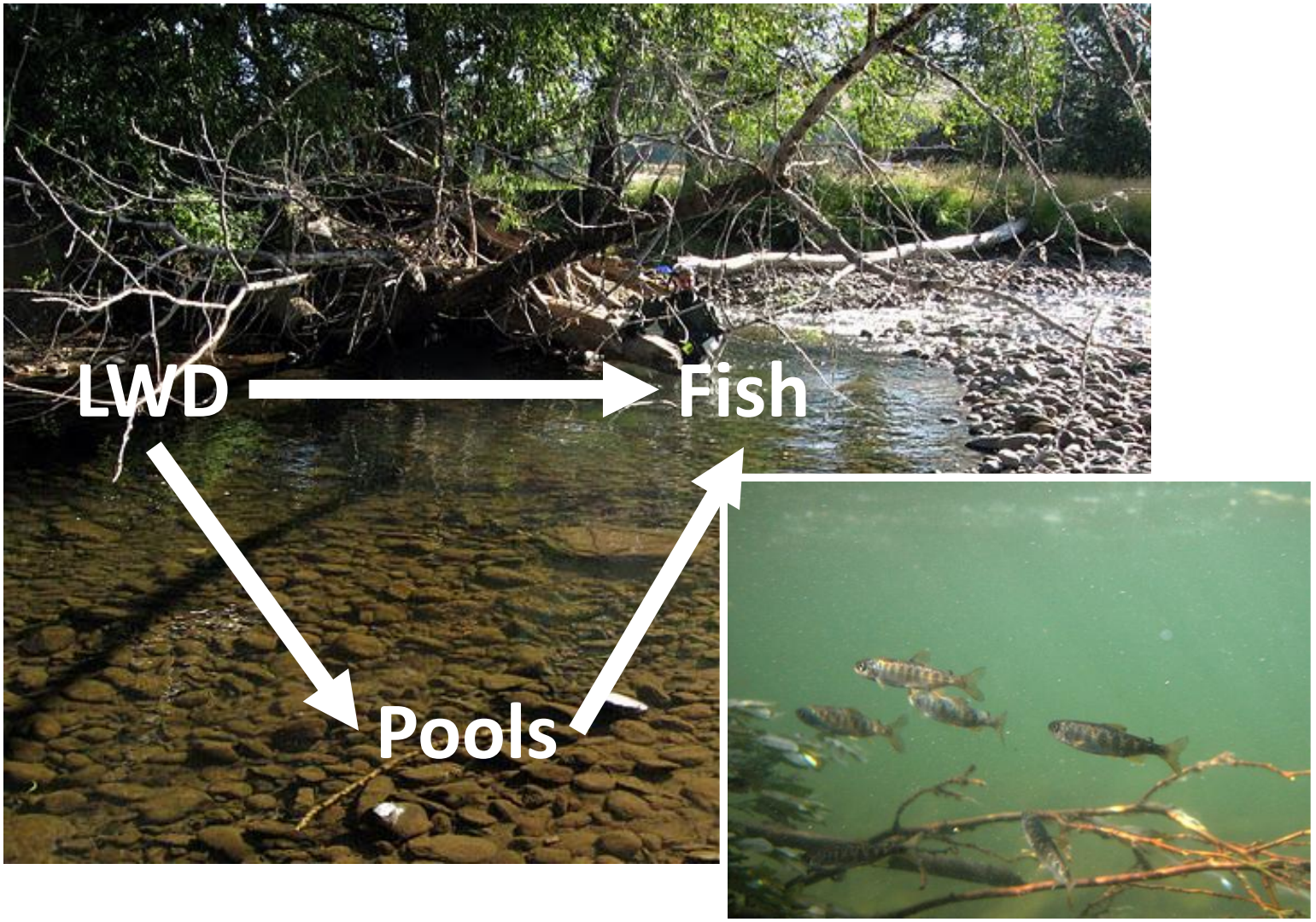
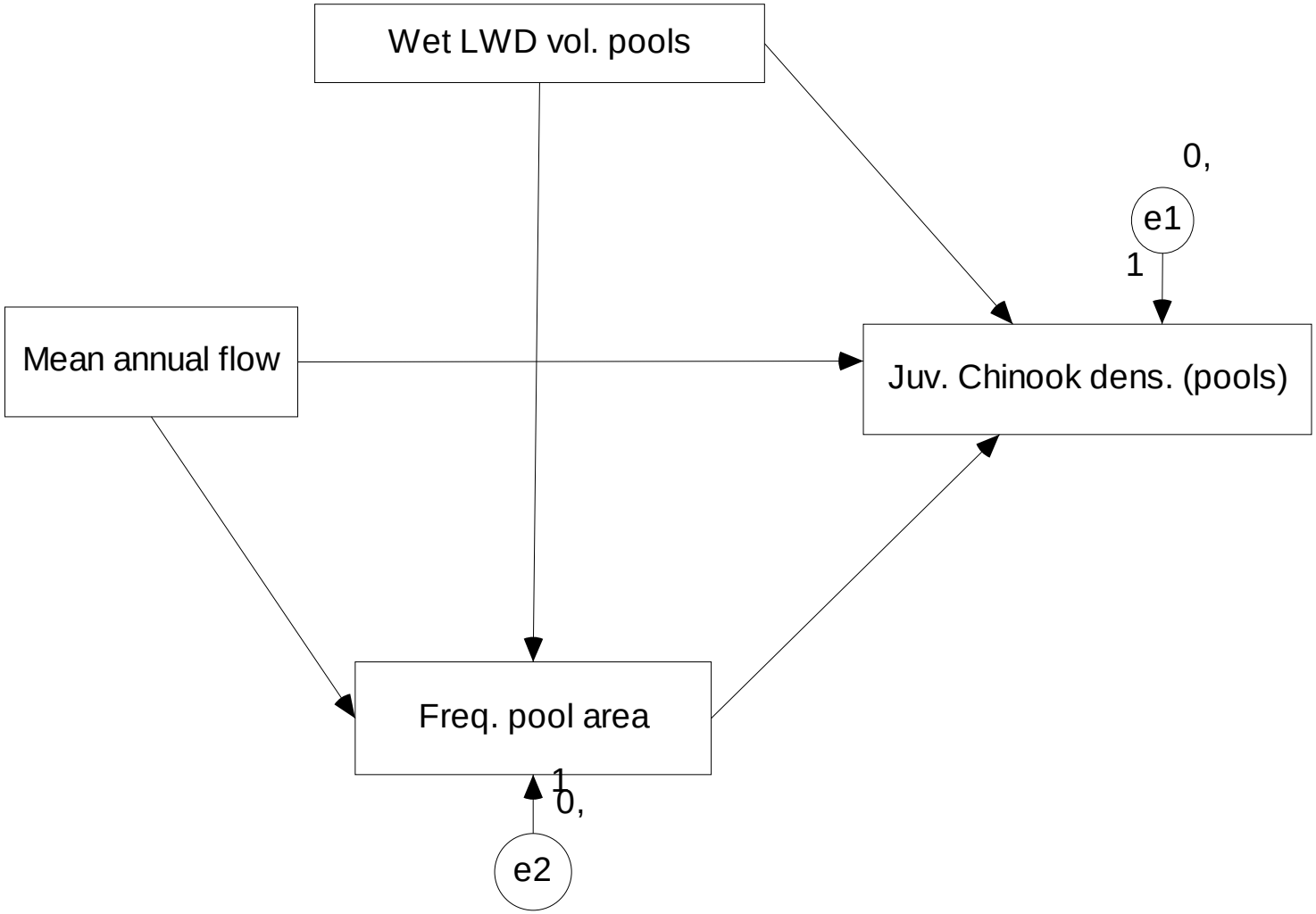
4. Experimental design

Interaction among LWD, pools, and juvenile Chinook

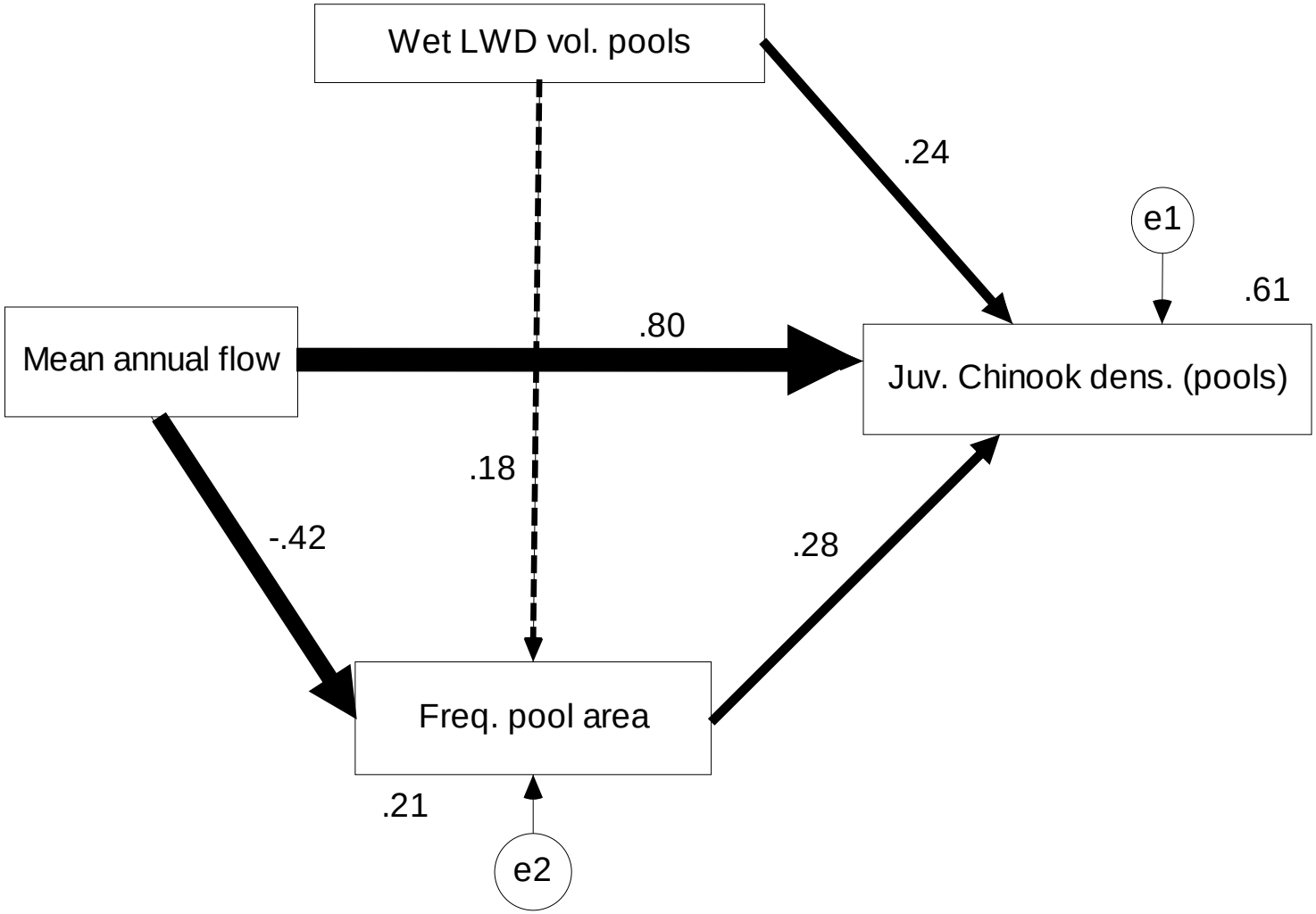


SEM – Graphical Hypotheses

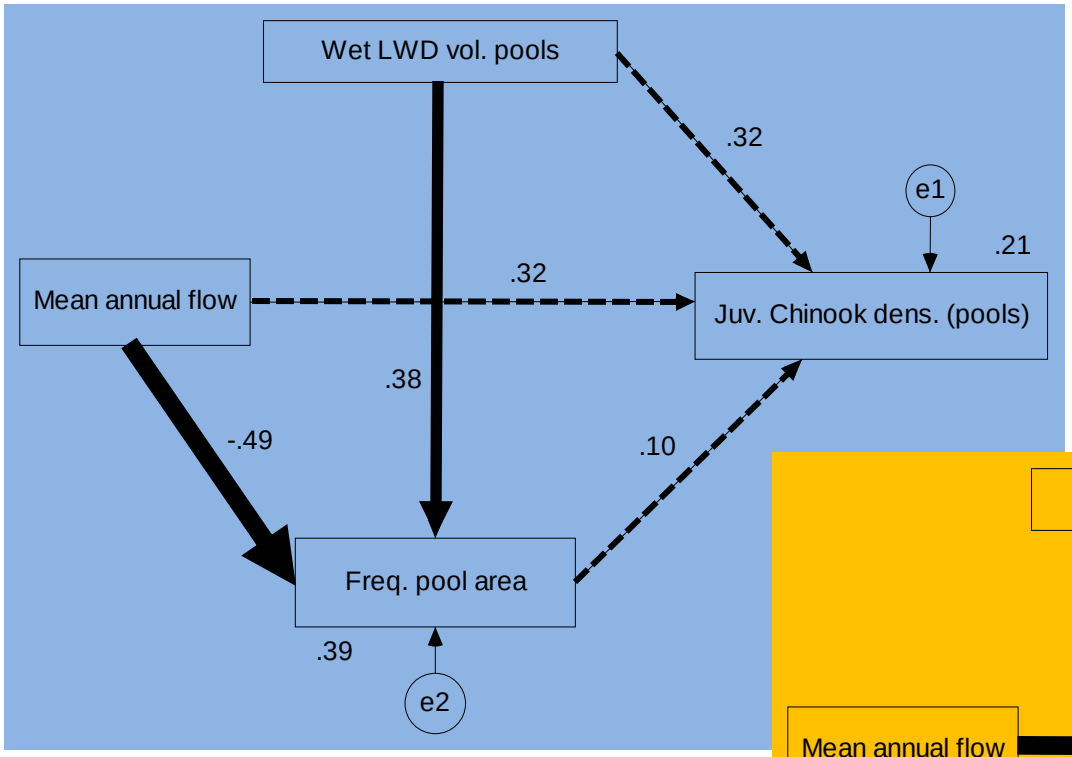


SEM – Global Model Results

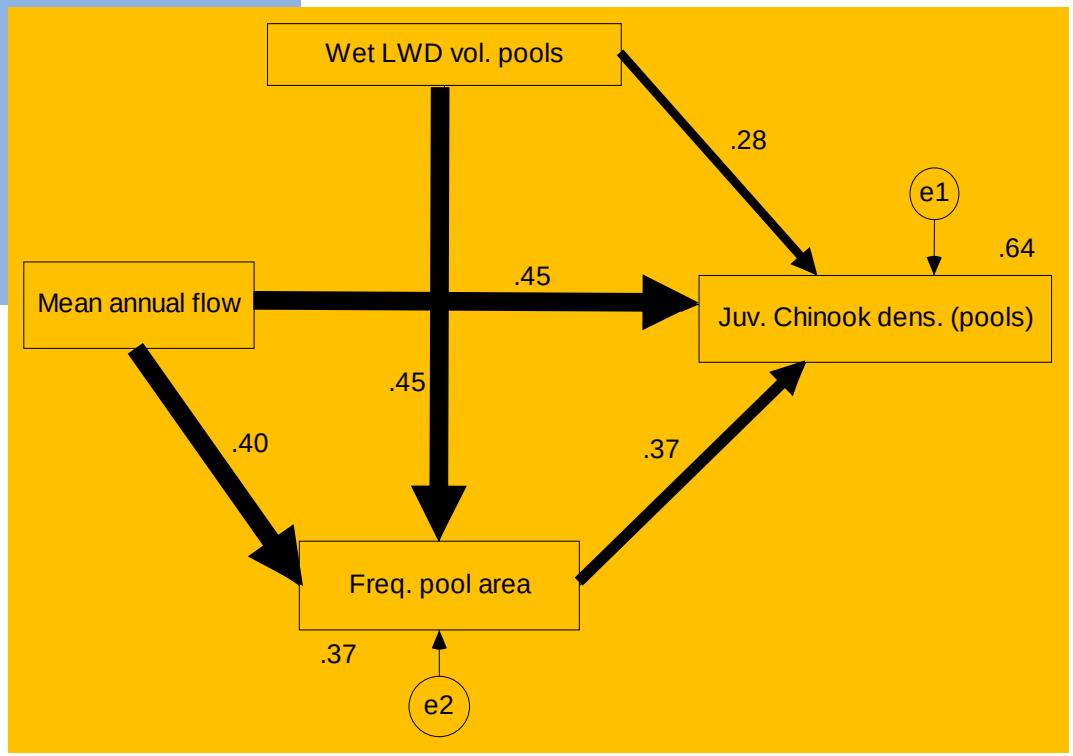
(all metrics Box-Cox transformed)



Do Ecological Systems Behave Differently by Channel Type?



"Mountain"



"Floodplain & Constrained"

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ISEMP Watershed Model

-Multi-Stage Beverton-Holt

$$R_{t+1} = \frac{aS_t}{b + S_t} \longrightarrow N_{i+1,t+1} = \frac{N_{i,t}}{\frac{1}{p_{i,t}} + \frac{1}{c_{i,t}} N_{i,t}}$$

where

- $N_{i,t}$ = number of fish at life stage (i), time (t)
- $N_{i+1, t+1}$ = number of fish in next life-stage (i+1) and time (t+1)
- $p_{i,t}$ = **productivity**, or maximum survival rate for life-stage (i)
- $c_{i,t}$ = **carrying capacity**, or maximum numbers that survive life-stage (i)
- Moussalli & Hilborn (1986)

How to relate to habitat?

ISEMP Watershed Model

-Sharma et al (2005)

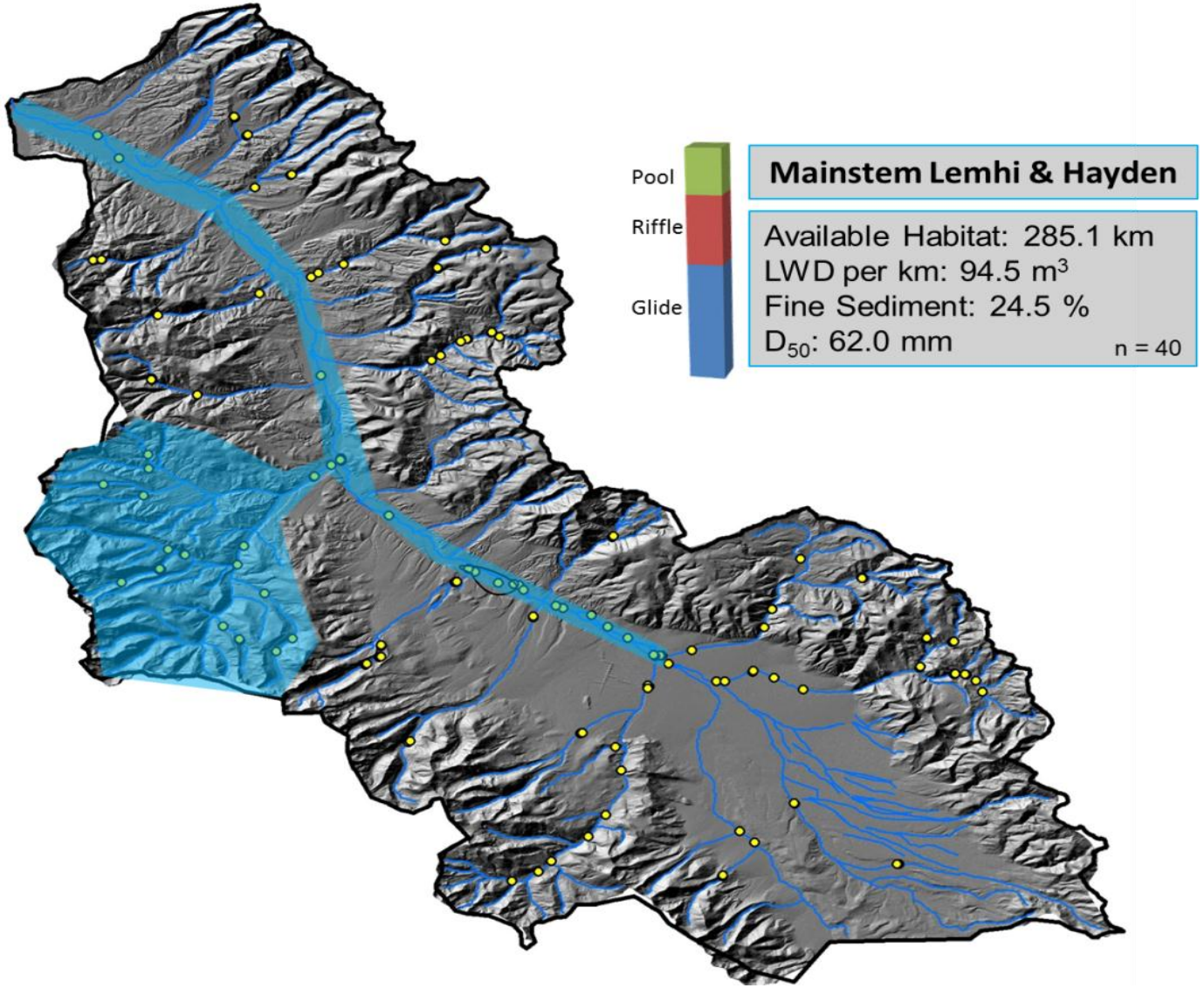
$$N_{i+1,t+1} = \frac{N_{i,t}}{\frac{1}{p_{i,t}} + \frac{1}{c_{i,t}} N_{i,t}}$$

The Basic Watershed Model

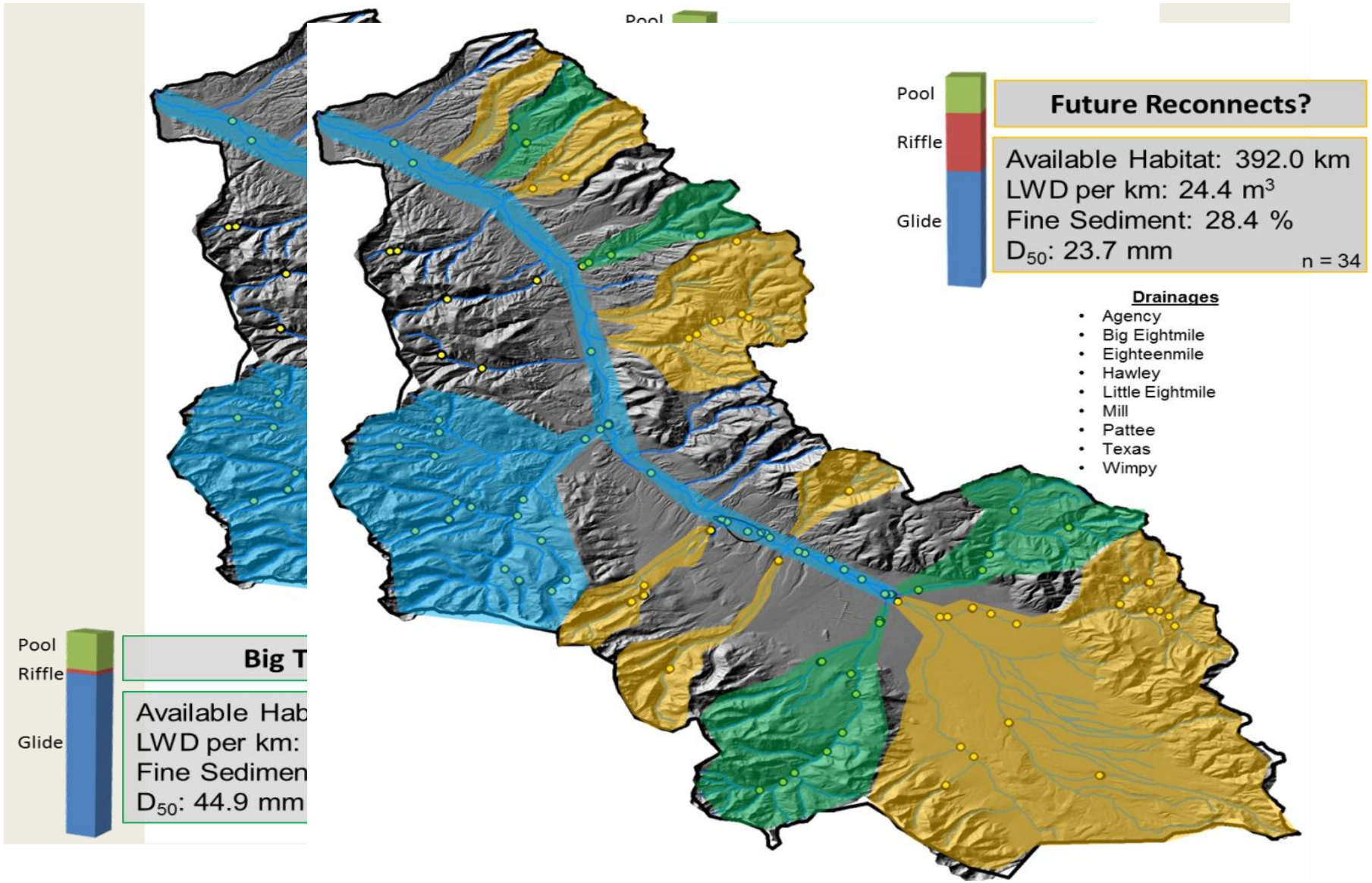
$$N_{k,i+1_t} = \frac{N_{k,i_t}}{\frac{1}{Sr_i \times \frac{\sum_{q=1}^{n} \left[E_{i,q}\right] \times \left[L_{q,k}\right]_t}{\sum_{q=1}^{n} \left[L_{q,k}\right]_t}} + \frac{1}{A_k \times \sum_{j=1}^{n} \left[\left[\sum_{q=1}^{n} \left[M_{j,q}\right] \times \left[L_{q,k}\right]_t \right] \times \left[D_{j,i}\right] \right]} N_{k,i_t}}$$

ISEMP Watershed Model

- Existing “Anadromous” Habitat in Lemhi

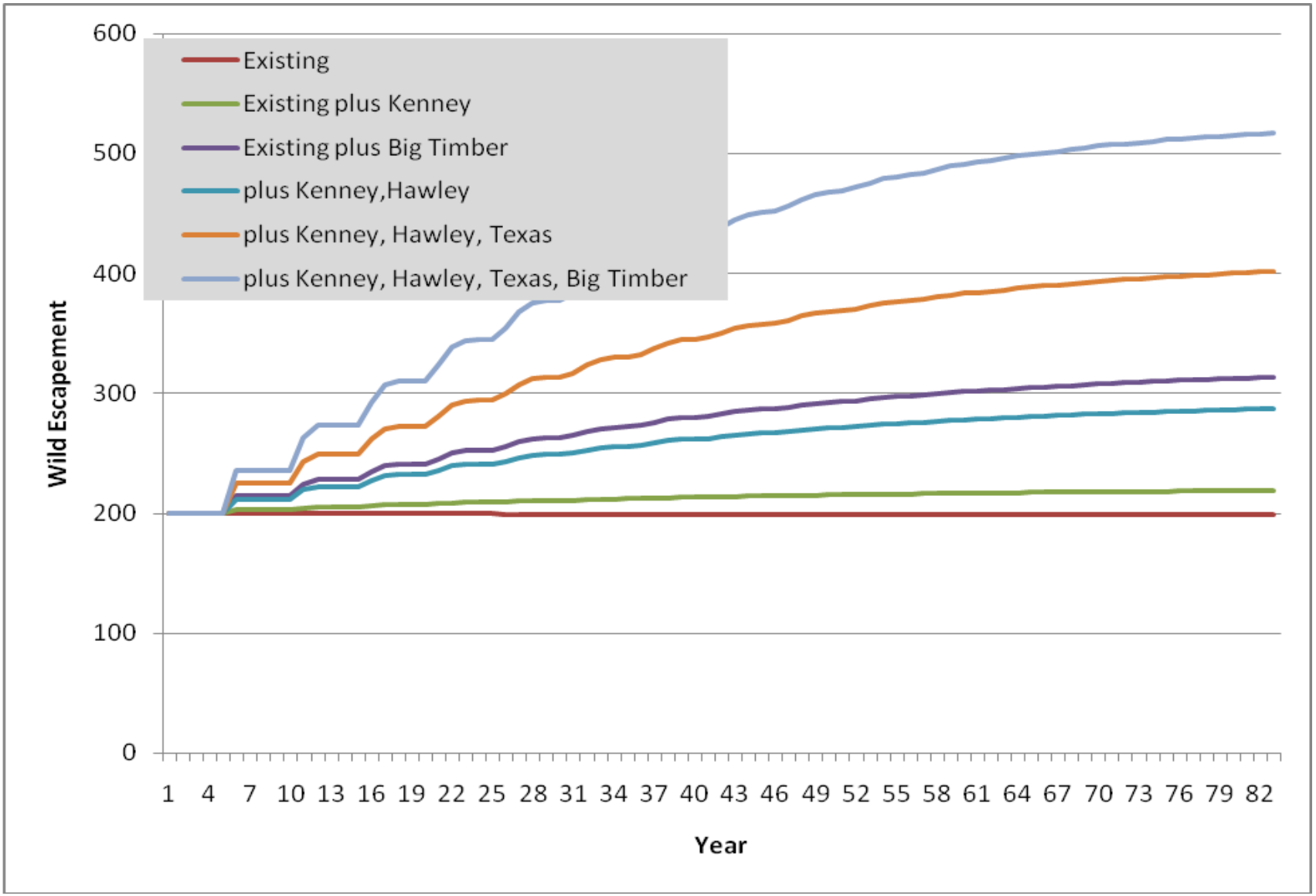


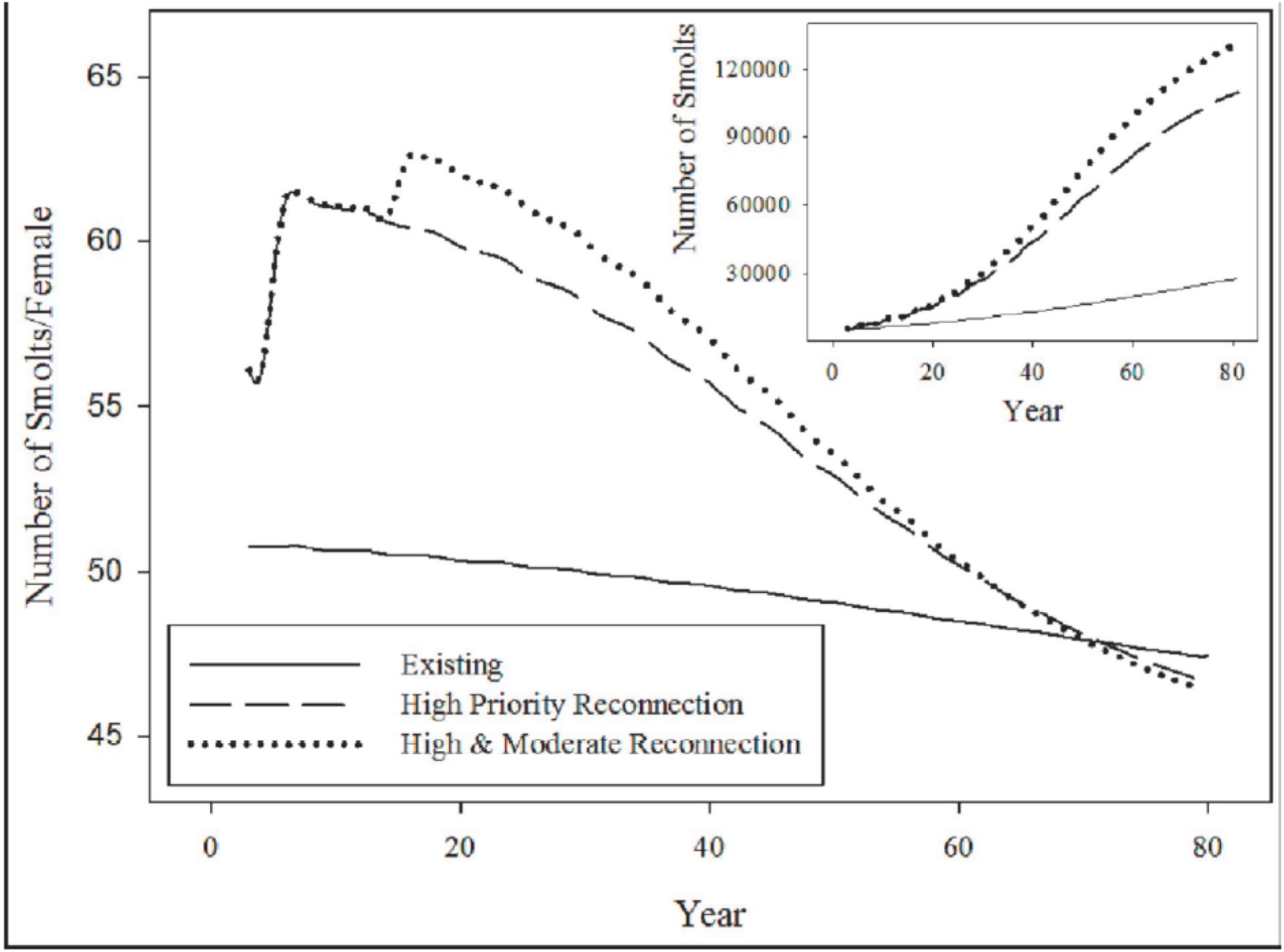
ISEMP Watershed Model
-Planned and potential habitat



ISEMP Watershed Model

- Example Watershed (Lemhi)




Number of Smolts/Female
65
60
55
50
45
0
20
40
60
80
Year
Existing
High Priority Reconnection
High & Moderate Reconnection
Number of Smolts
120000
90000
60000
30000
0
20
40
60
80
Year

ISEMP Watershed Model

- Flexible modeling environment that informs freshwater productivity as a function of:
  - Management actions
  - Habitat conditions
  - Fish population characteristics

- Informs management actions (i.e. Lemhi tributary reconnections)
  - Work in the Lemhi emulates other management actions
    - Instream structure placement to increase pool area
    - Riparian rehabilitation to decrease water temperature
    - Etc.
  - Identify the life-stage(s) that limit a populations productivity

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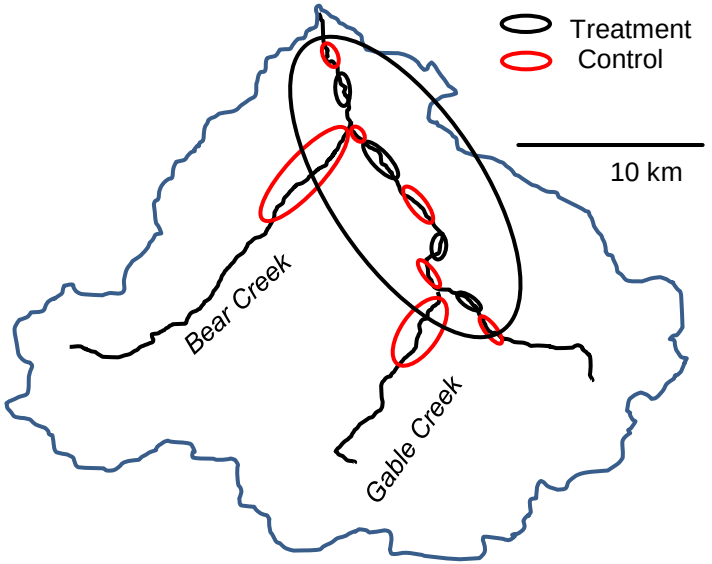
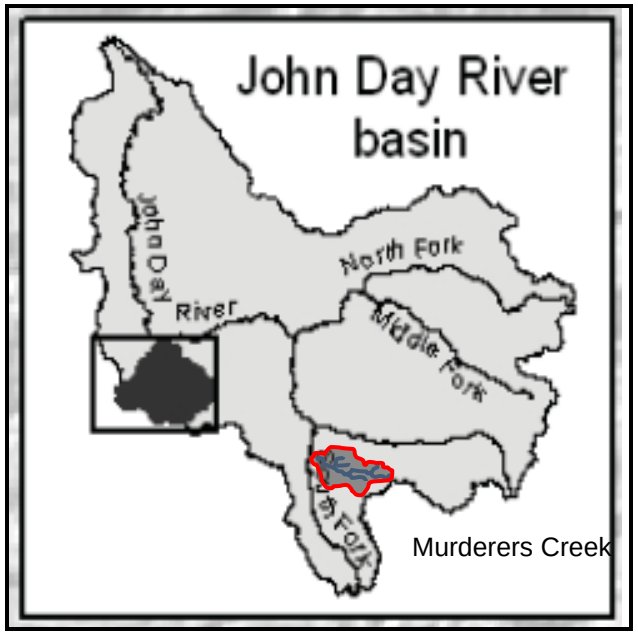
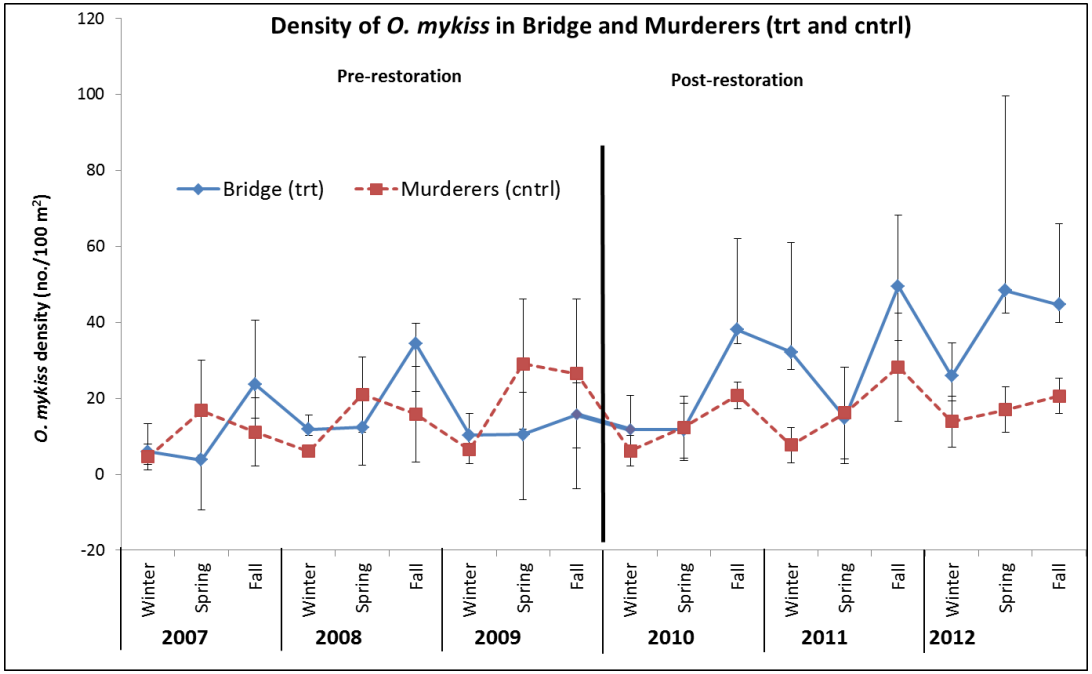
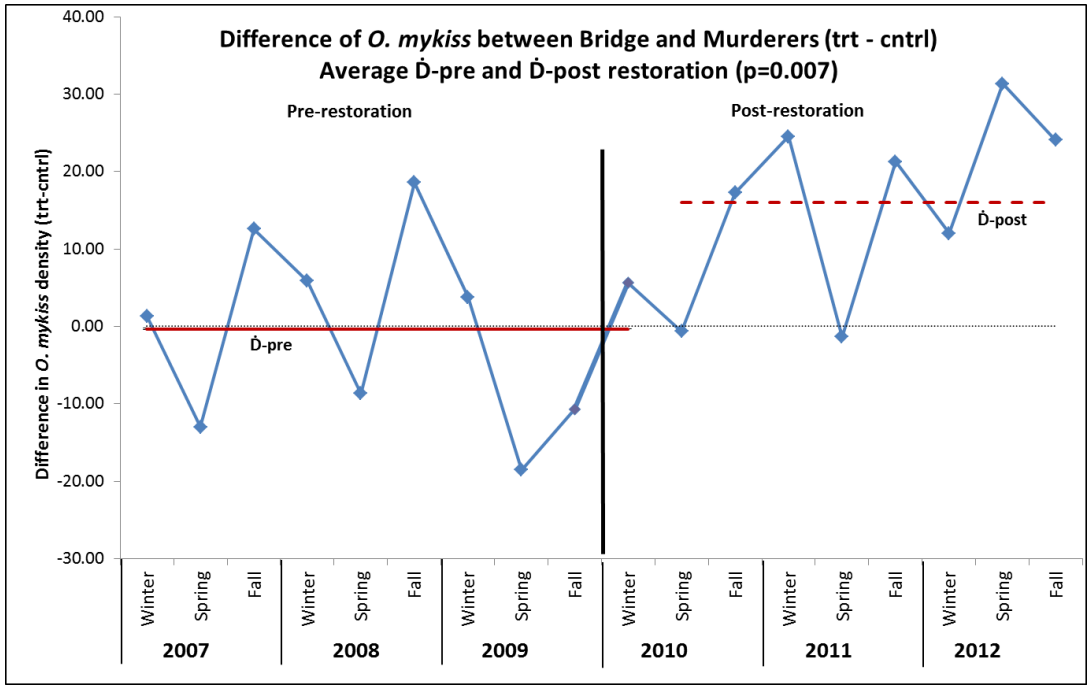
Bridge Creek IMW

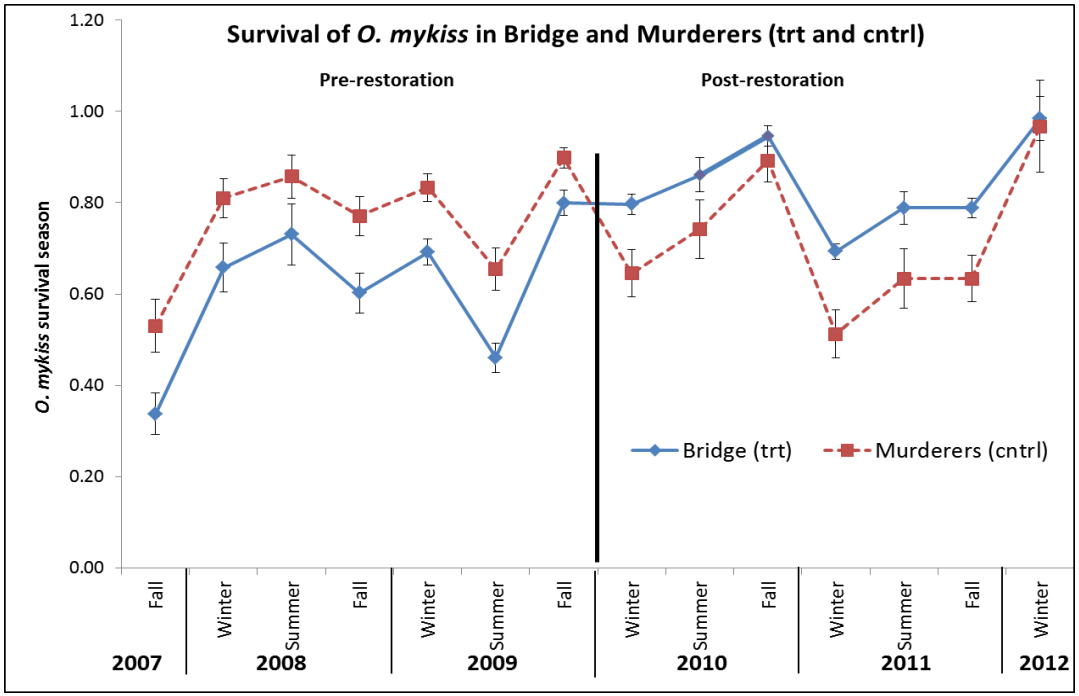




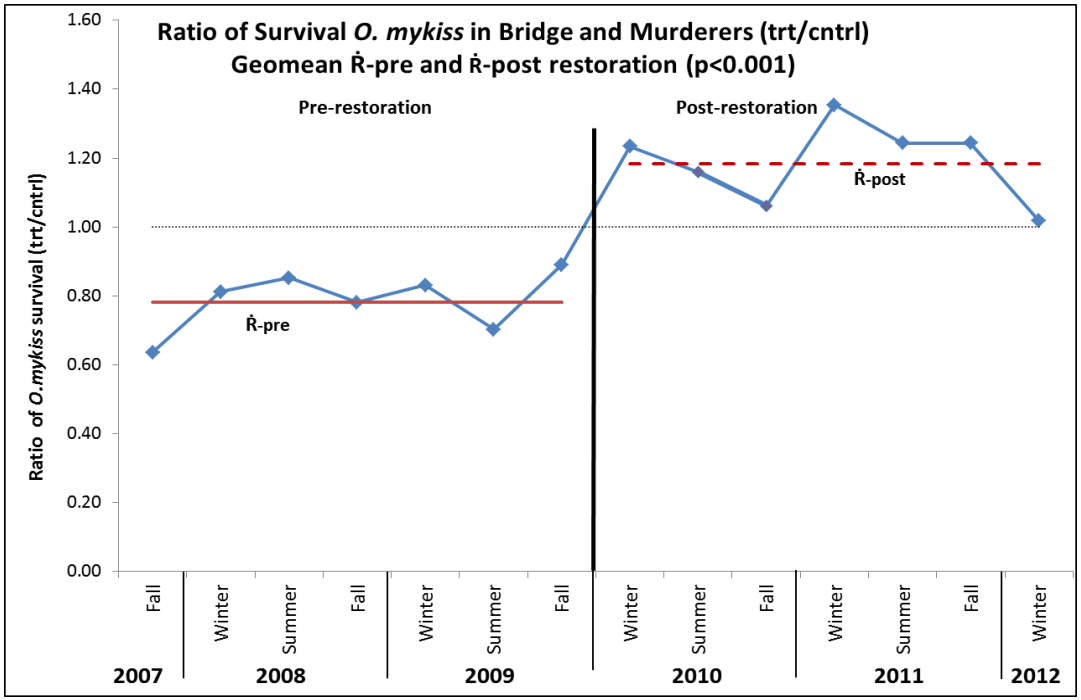


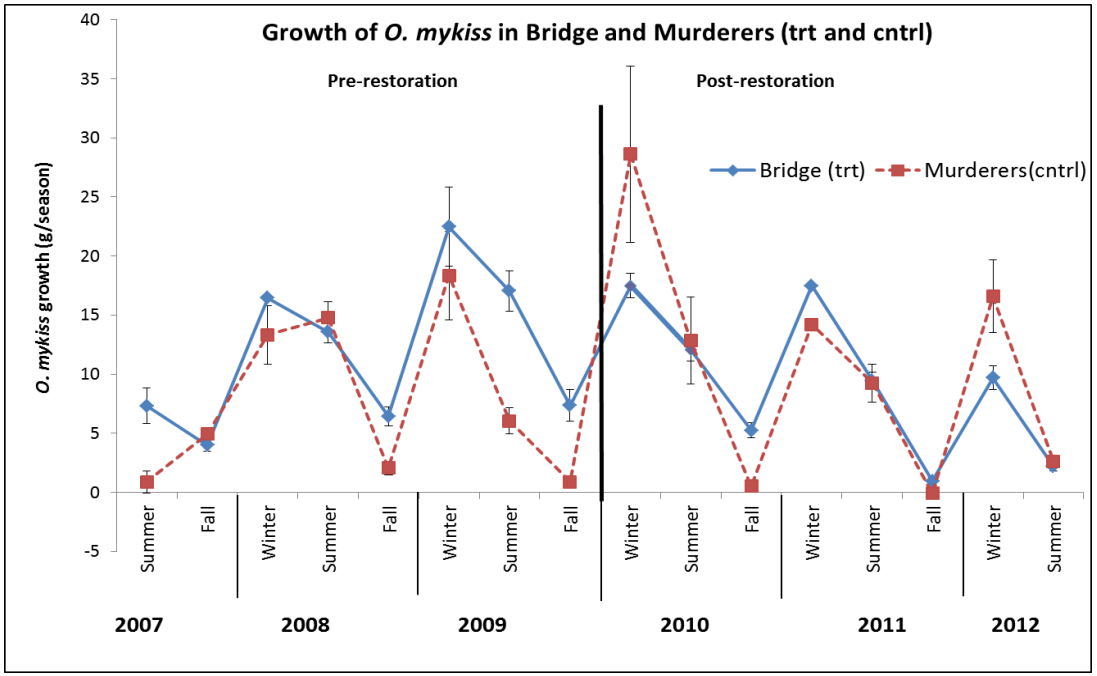
Density as a response to treatment actions



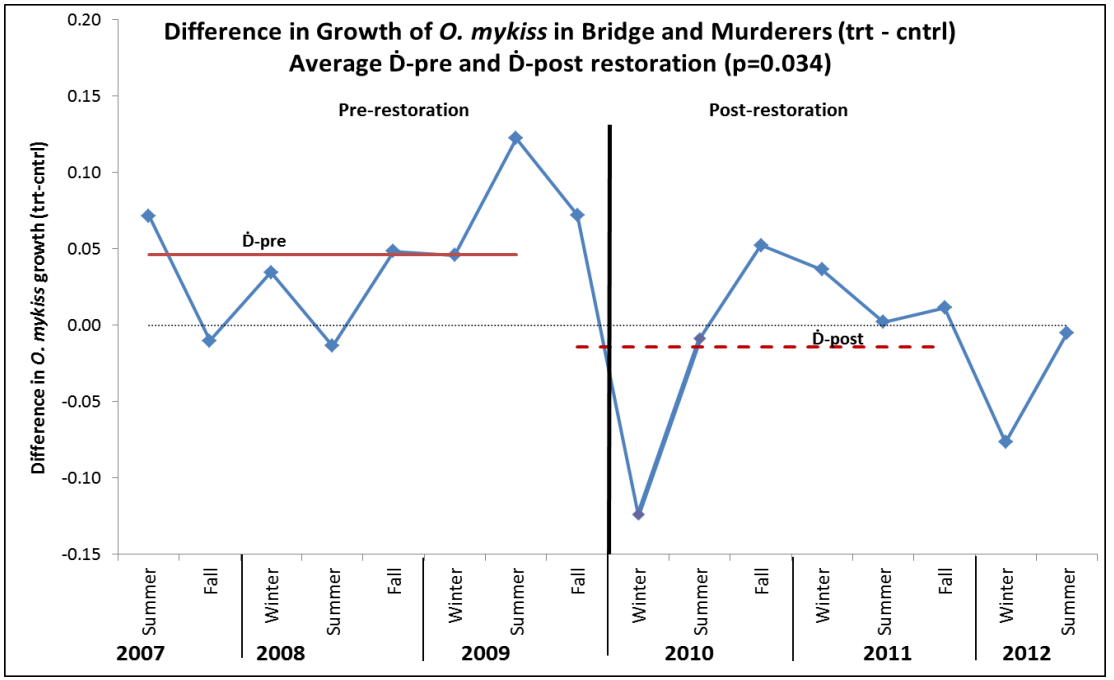


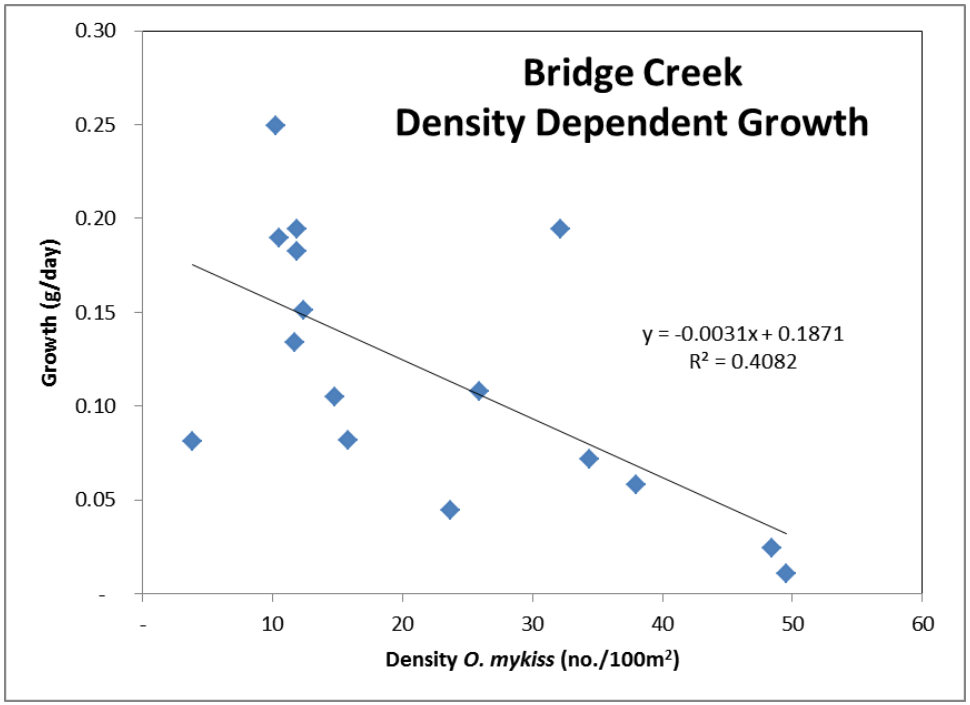
Survival as a response to treatment actions



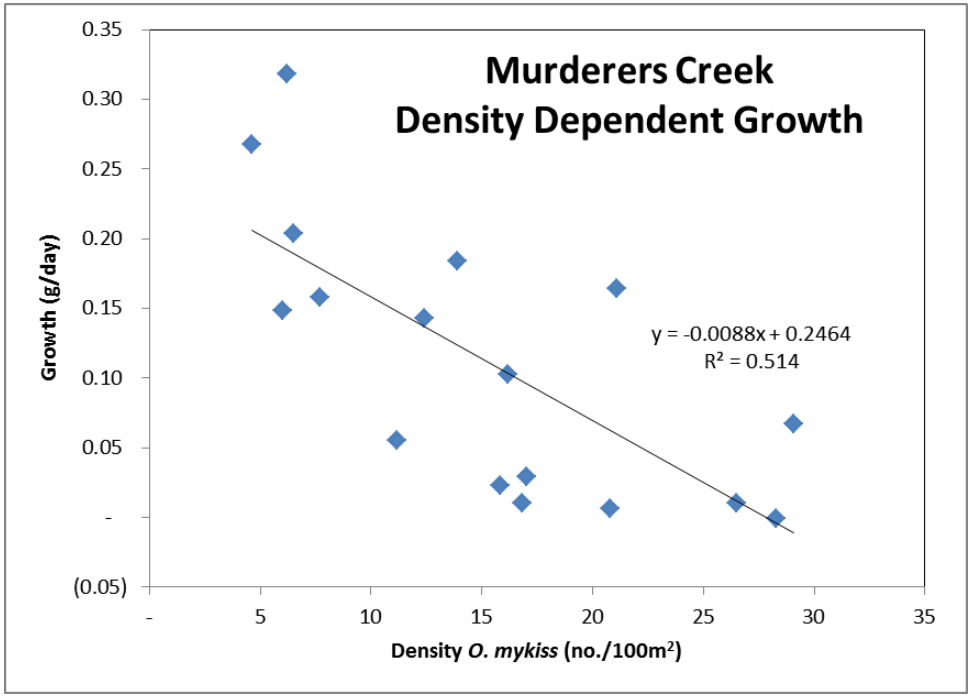


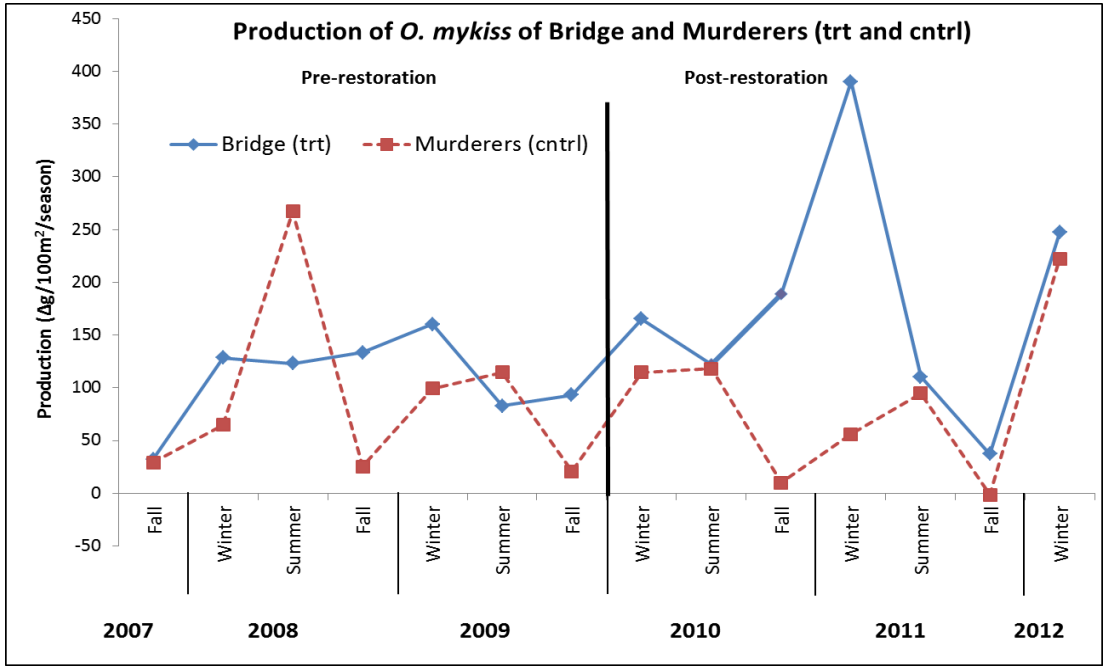
Growth as a response to treatment actions



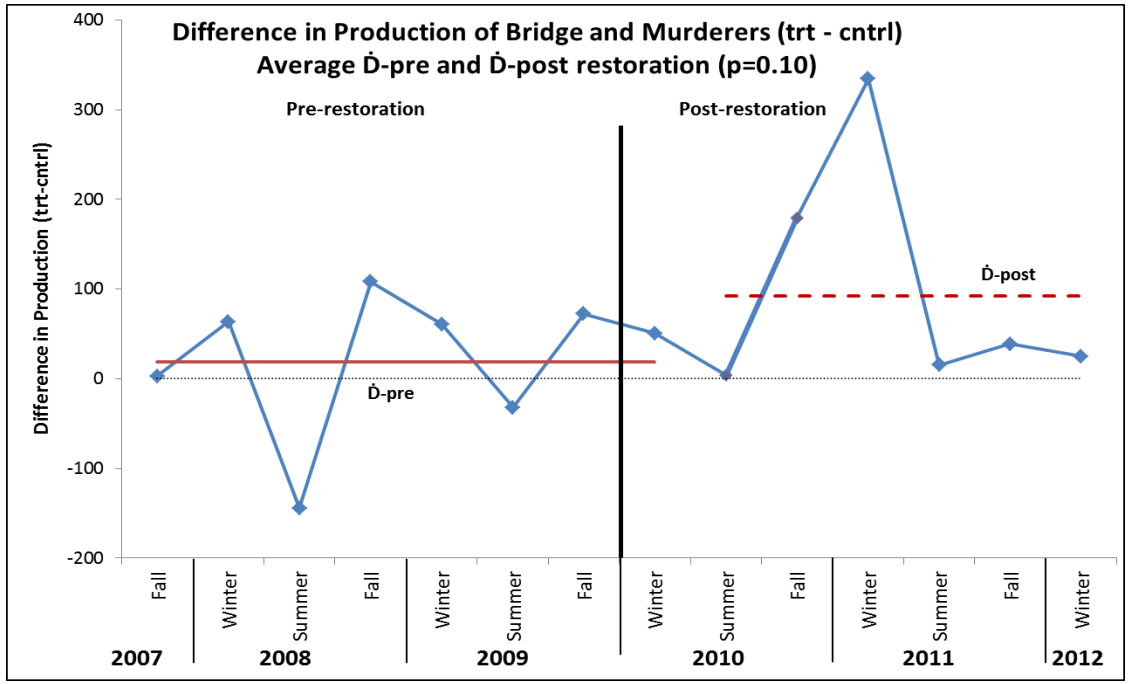


Why not Growth as a response to treatment actions





Production as a response to treatment actions

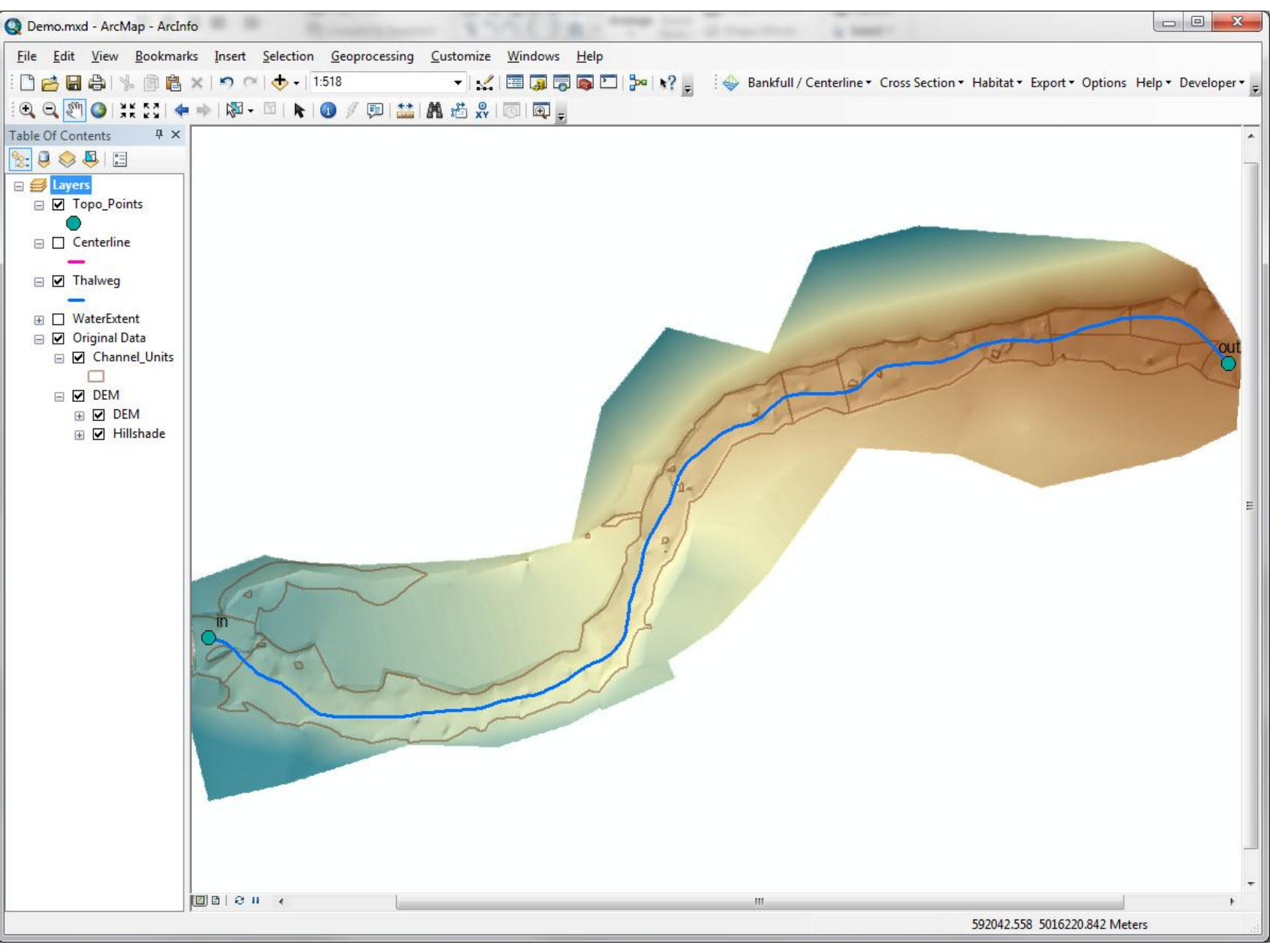


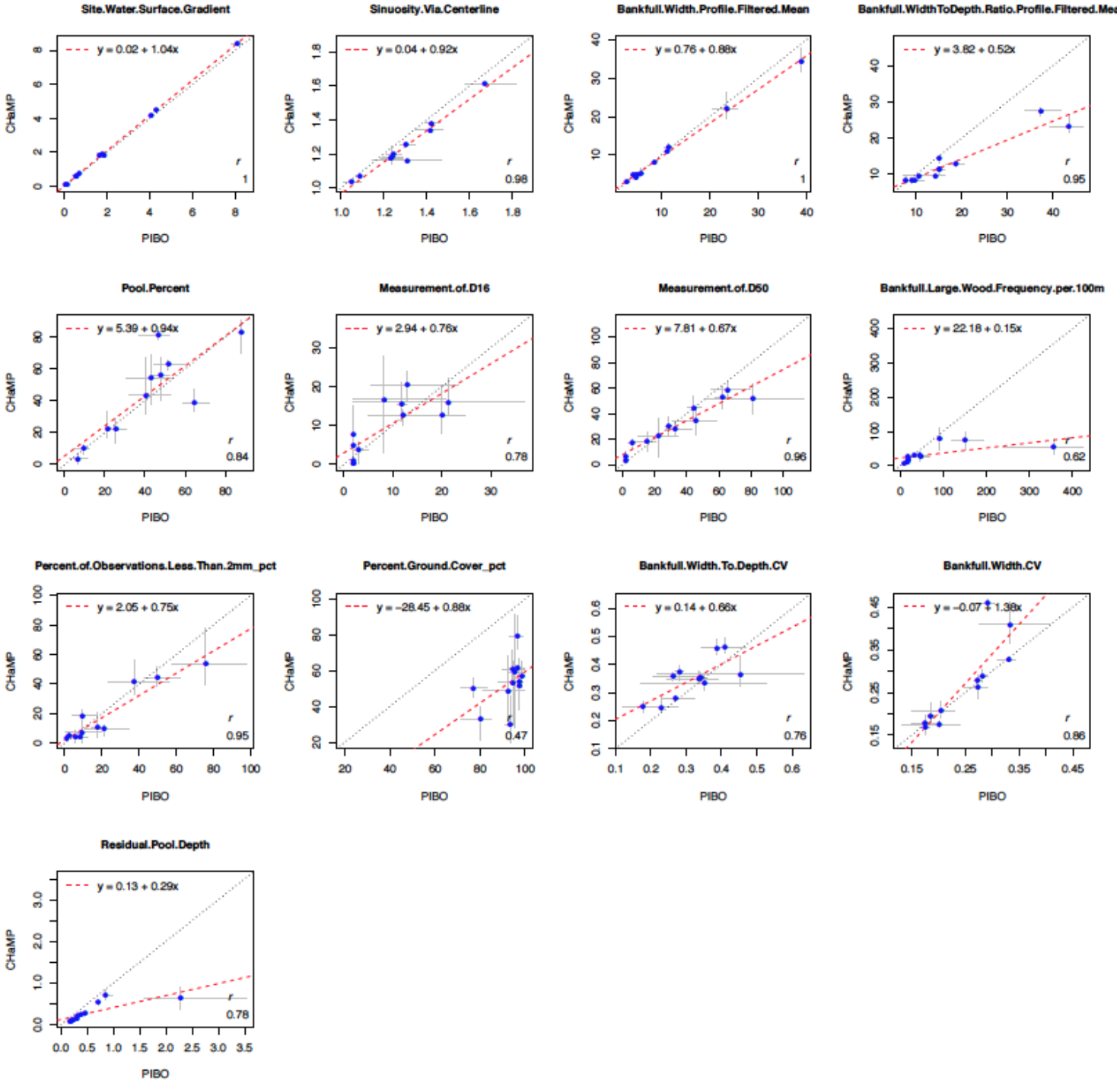
Yes, fish-habitat relationships that are characterized by ISEMP / CHaMP work in a manner that supports decision-making

- Status of habitat q/q
- Projections of action impacts on fish
- Direct demonstration of actions' effect on fish
- Not done yet…

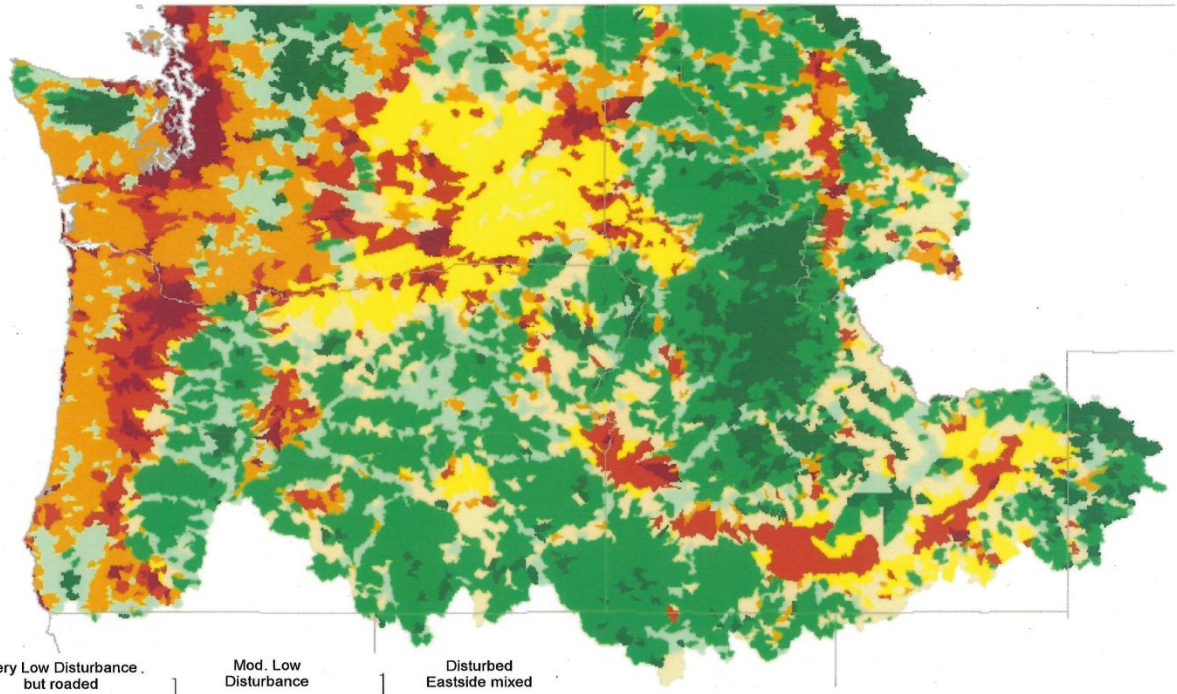
Next steps

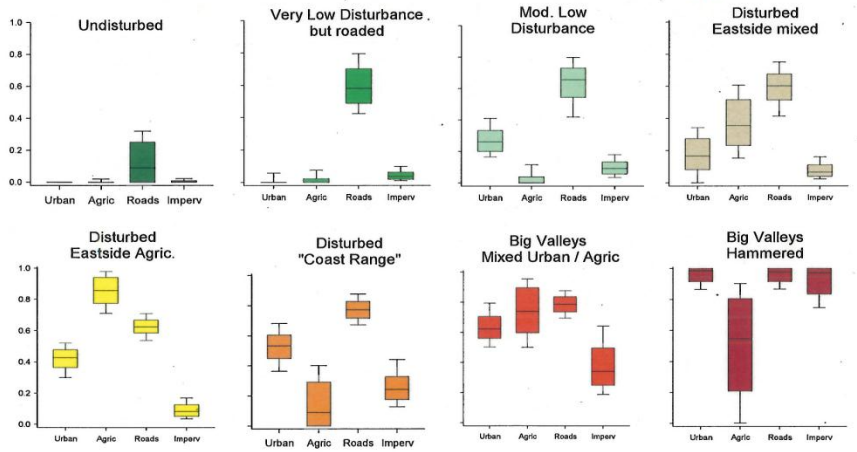
- Refine habitat metrics
  - what are the “best” indicators of habitat quality?
- Refine correlation methods (structured and not)
  - to support broad scale (extrapolation) habitat assessments
  - maximize utility of regional monitoring data
- Refine mechanistic methods
  - as basis for monitoring program refinement
  - as knowledge base for restoration planning
- Continue experimental (IMW) based contrast development
  - Broaden treatment type response set
- Acknowledge ISAB/ISRP’s patience / confidence / magnanimity
  - 8 years of work finally yielding to our vision

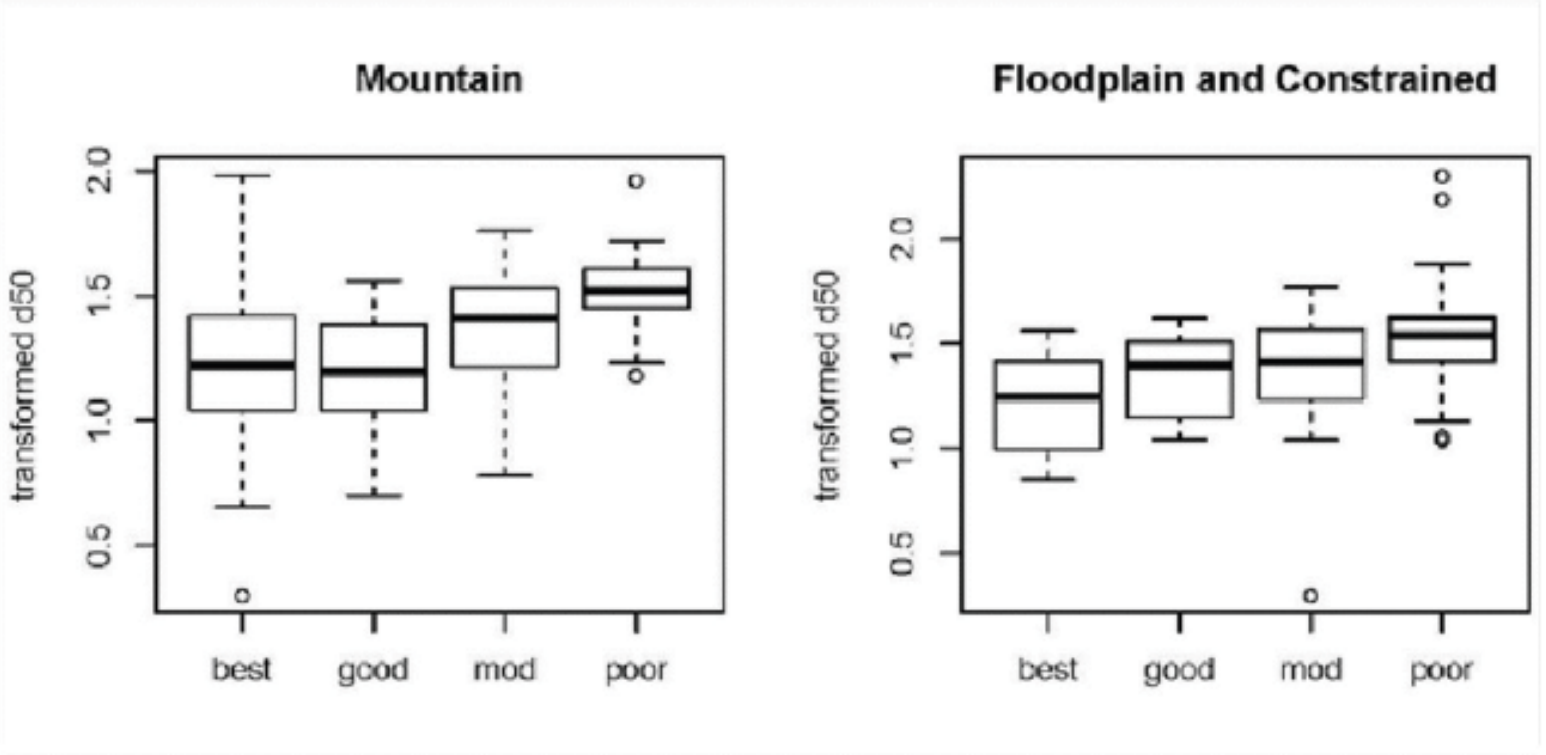

Demo.mxd - ArcMap - ArcInfo
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
1:518
Bankfull / Centerline Cross Section Habitat Export Options Help Developer
Table Of Contents
Layers
Topo_Points
Centerline
Thalweg
WaterExtent
Original Data
Channel_Units
DEM
DEM
Hillshade
in
out
592042.558 5016220.842 Meters


Site.Water.Surface.Gradient
y = 0.02 + 1.04x
r
1
Sinuosity.Via.Centerline
y = 0.04 + 0.92x
r
0.98
Bankfull.Width.Profile.Filtered.Mean
y = 0.76 + 0.88x
r
1
Bankfull.WidthToDepth.Ratio.Profile.Filtered.Mea
y = 3.82 + 0.52x
r
0.95
Pool.Percent
y = 5.39 + 0.94x
r
0.84
Measurement.of.D16
y = 2.94 + 0.76x
r
0.78
Measurement.of.D50
y = 7.81 + 0.67x
r
0.96
Bankfull.Large.Wood.Frequency.per.100m
y = 22.18 + 0.15x
r
0.62
Percent.of.Observations.Less.Than.2mm_pct
y = 2.05 + 0.75x
r
0.95
Percent.Ground.Cover_pct
y = −28.45 + 0.88x
r
0.47
Bankfull.Width.To.Depth.CV
y = 0.14 + 0.66x
r
0.76
Bankfull.Width.CV
y = −0.07 + 1.38x
r
0.86
Residual.Pool.Depth
y = 0.13 + 0.29x
r
0.78
CHaMP
PIBO

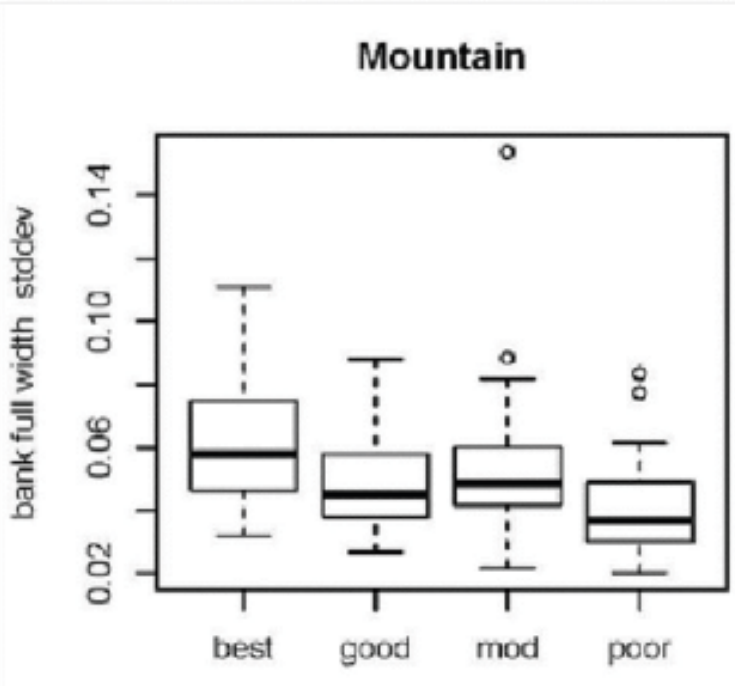
Human disturbance based watershed classification

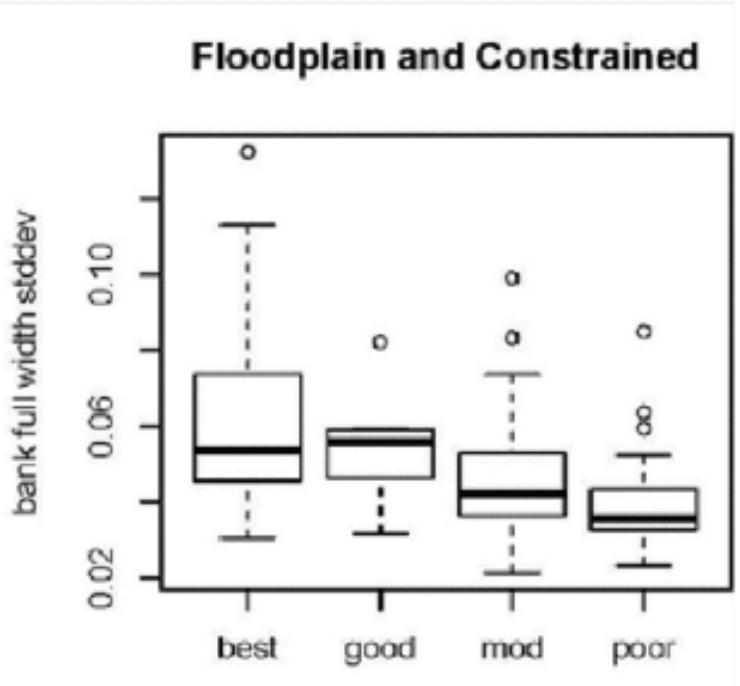





Mountain
transformed d50
0.5
1.0
1.5
2.0
best
good
mod
poor

Floodplain and Constrained
transformed d50
0.5
1.0
1.5
2.0
best
good
mod
poor


Mountain
bank full width stddev
0.02
0.06
0.10
0.14
best
good
mod
poor


Floodplain and Constrained
bank full width stddev
0.02
0.06
0.10
best
good
mod
poor