Modeling relationships between CHaMP metrics and landscape characteristics in the Upper Grande Ronde River basin

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Columbia River Inter-Tribal Fish Commission

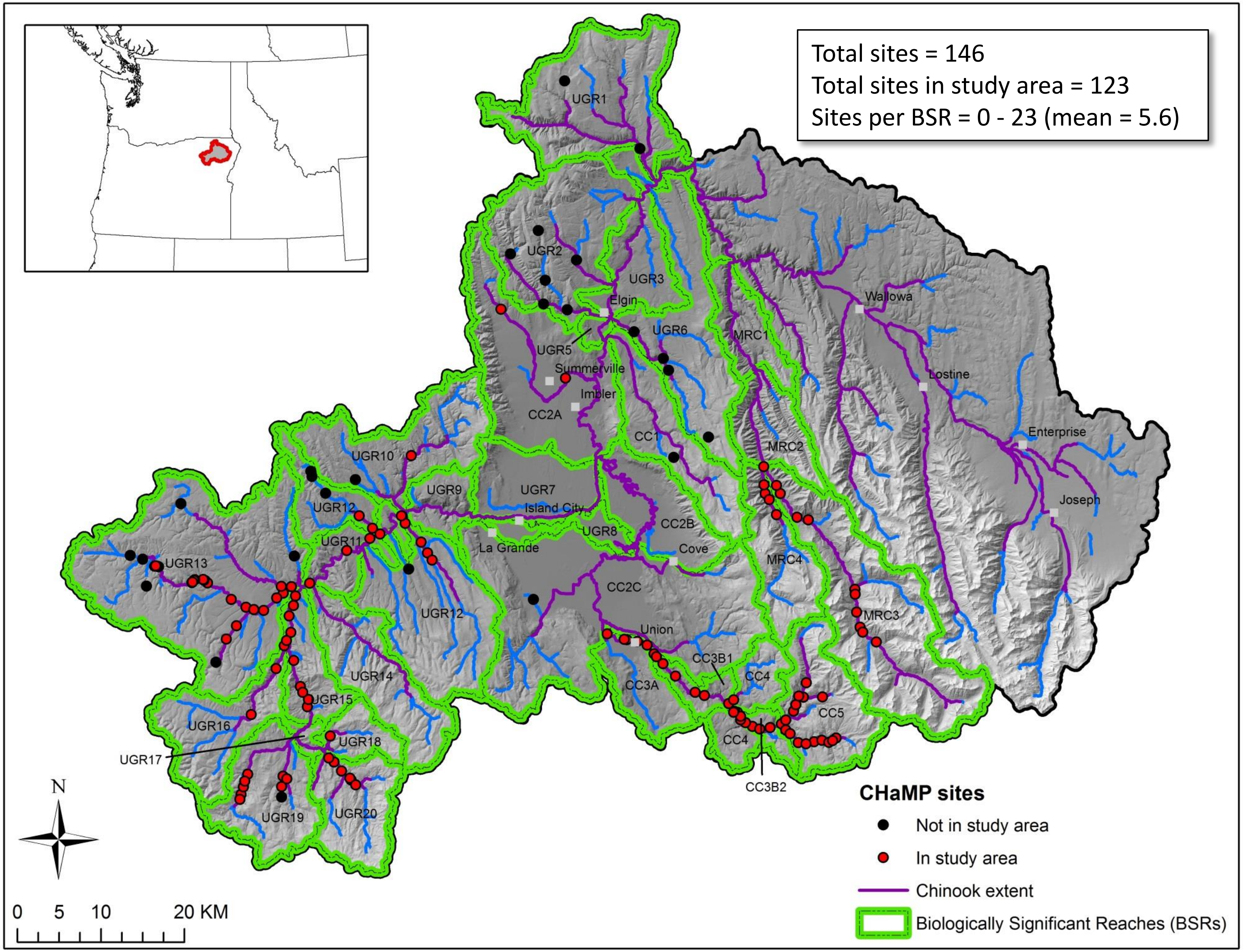
Columbia Habitat Monitoring Program
Advanced Training Workshop, June 4, 2015

Objectives:

1) Develop statistical models relating CHaMP habitat metrics to landscape characteristics that can be used to extrapolate CHaMP data to unsampled areas.

2) Roll-up CHaMP metrics to the Biologically Significant Reach (BSR) scale for use in life-cycle modeling.

Total sites = 146
Total sites in study area = 123
Sites per BSR = 0 - 23 (mean = 5.6)



Possible Methods for Data Extrapolation

1. **Generalized Random Tessellation Stratified (GRTS)**
    - Average for entire population
    - Average for BSRs
    - Average by geomorphic classification (River Styles or other)

2. Correlation with spatially continuous **rapid assessment data**
    - Oregon Aquatic Inventories data
    - New rapid assessment protocol designed to cross-walk with CHaMP

3. **Linear mixed-effects models** based on remote sensing data

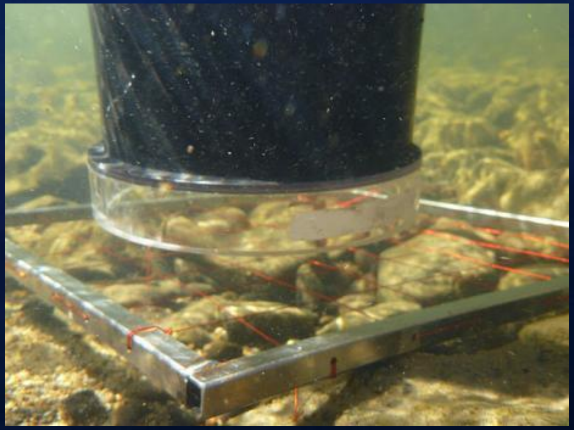
4. **Spatial statistical network models** based on remote sensing data and spatial autocorrelation among sites

Dependent Variables (CHaMP Metrics)

Percent Pools

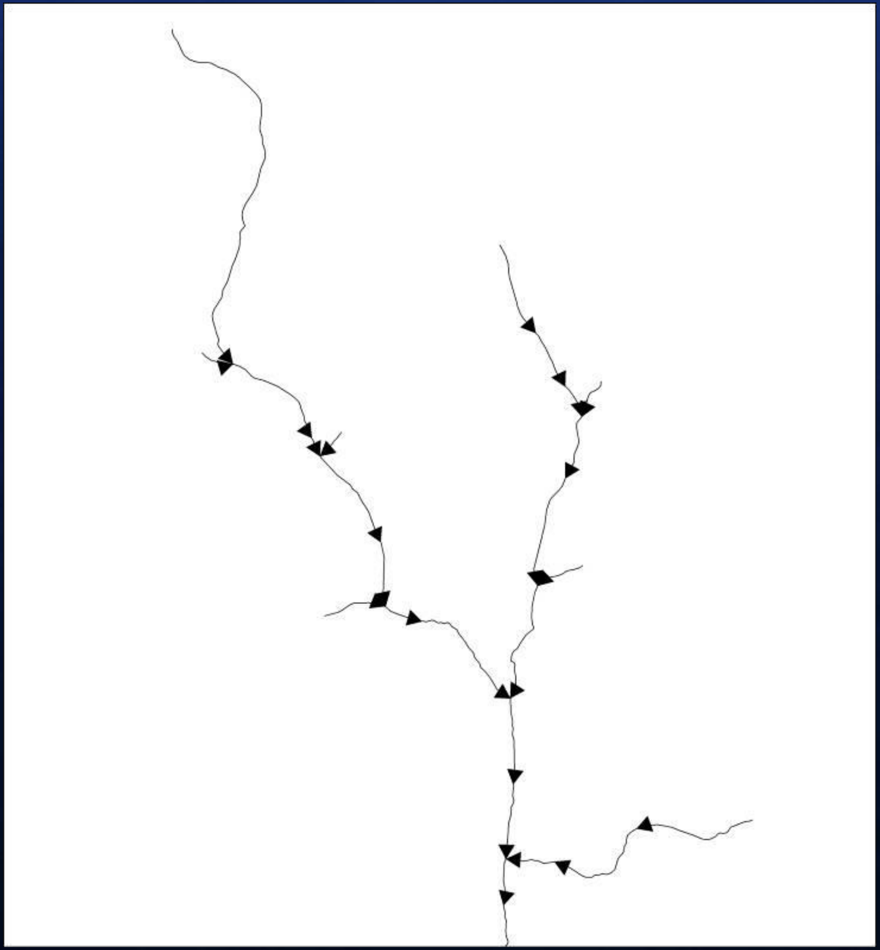
Large Wood Frequency

Pool Tail Fines < 2 mm

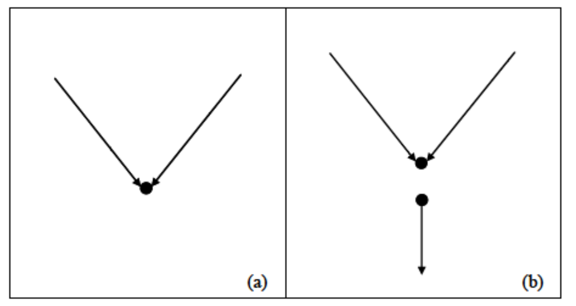


Build a Landscape Network

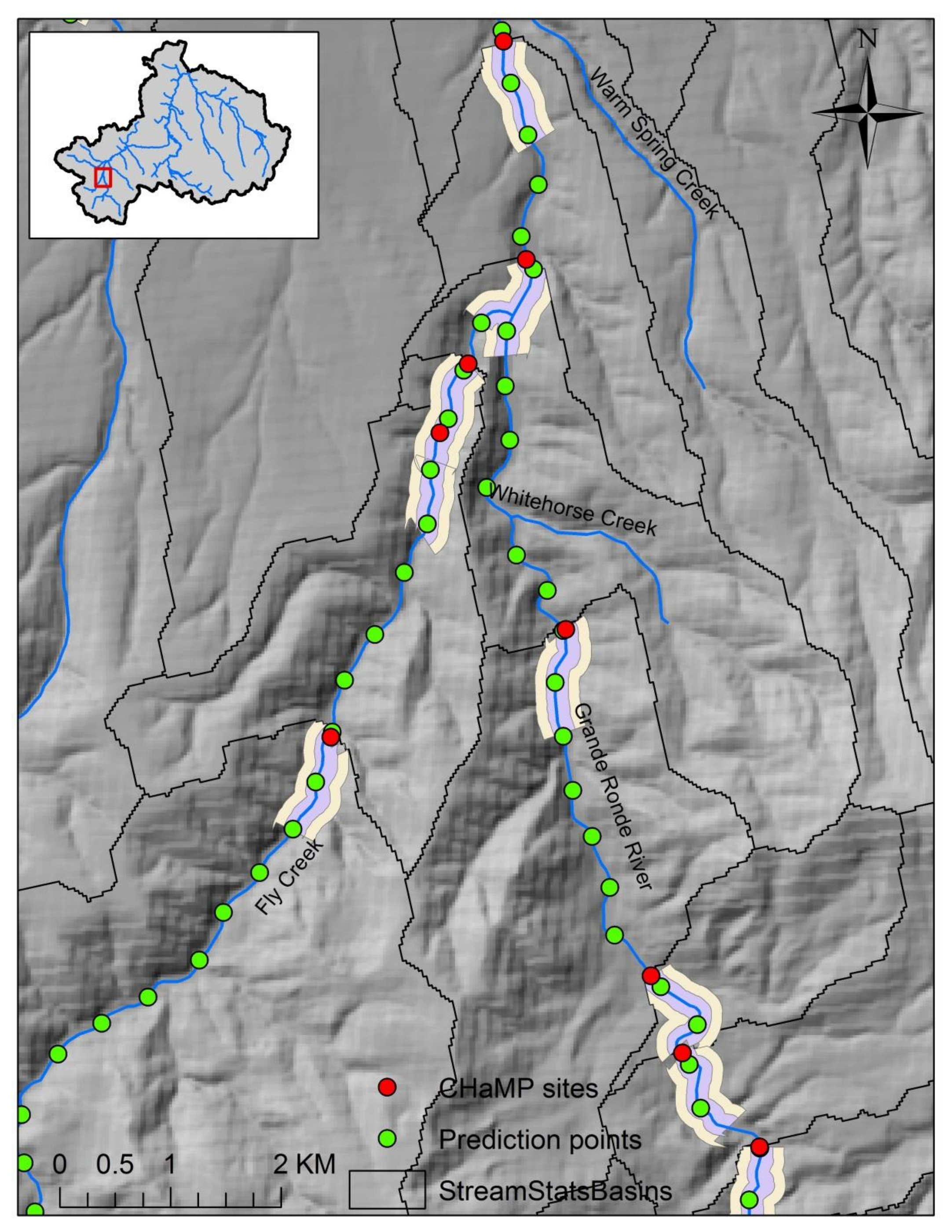
Spatial Tools for the Analysis of River Systems (STARS)



1. Import Hydrology Layer (Reconditioned NHDPlus stream layer from USFS Norwest Project, 1:100K resolution)
2. Ensure stream segments are digitized in the downstream direction
3. Eliminate topological errors such as converging stream nodes or braided channels



Figures from Peterson (2014)



4. Create prediction points (spacing 500 m)

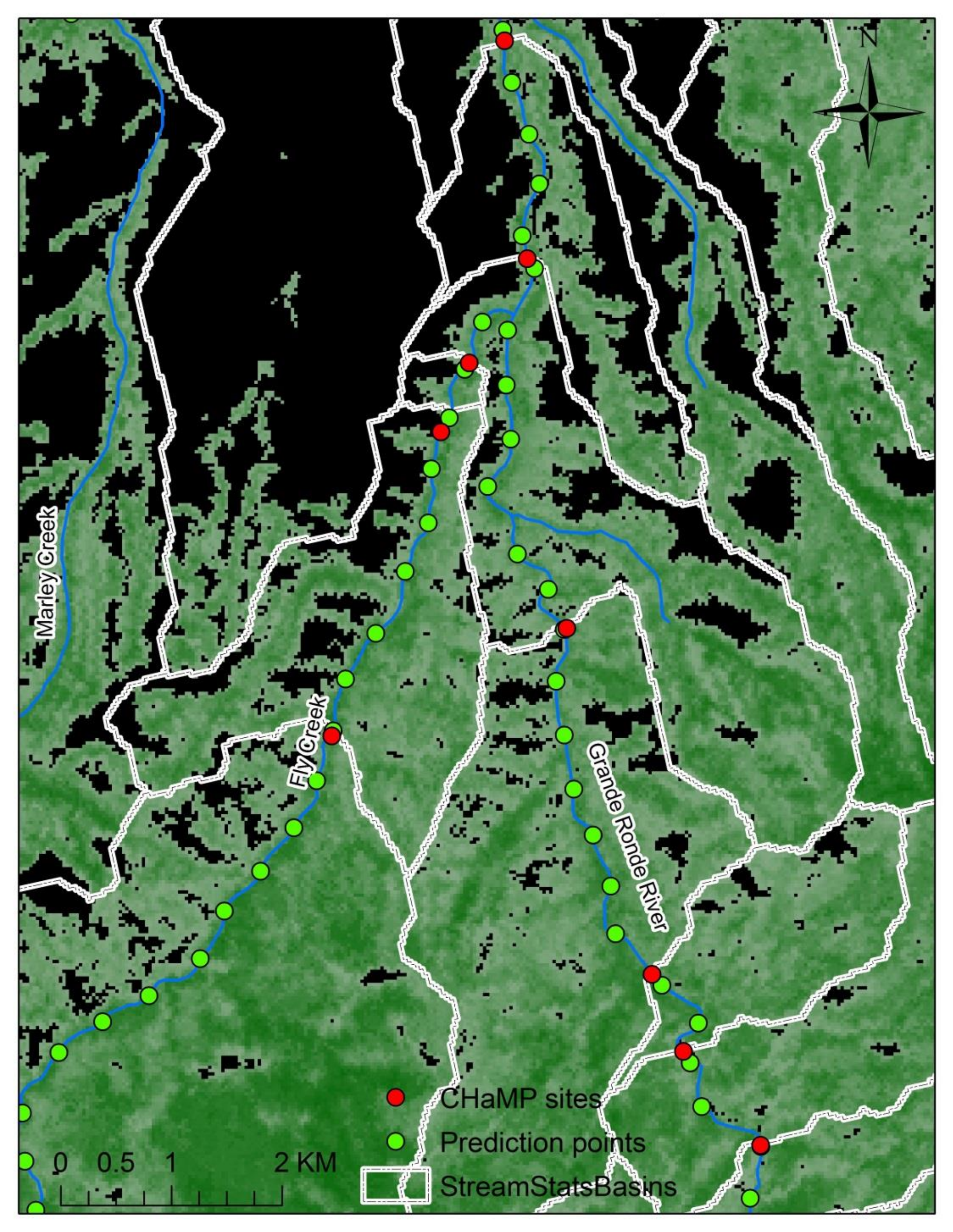
5. Create watershed polygons for CHaMP sites and predicition points
   a) From USGS Streamstats

6. Create riparian buffer polygons
   a) Lengths = 1, 2, 5km
   b) Widths = 30, 100, 200, 500m

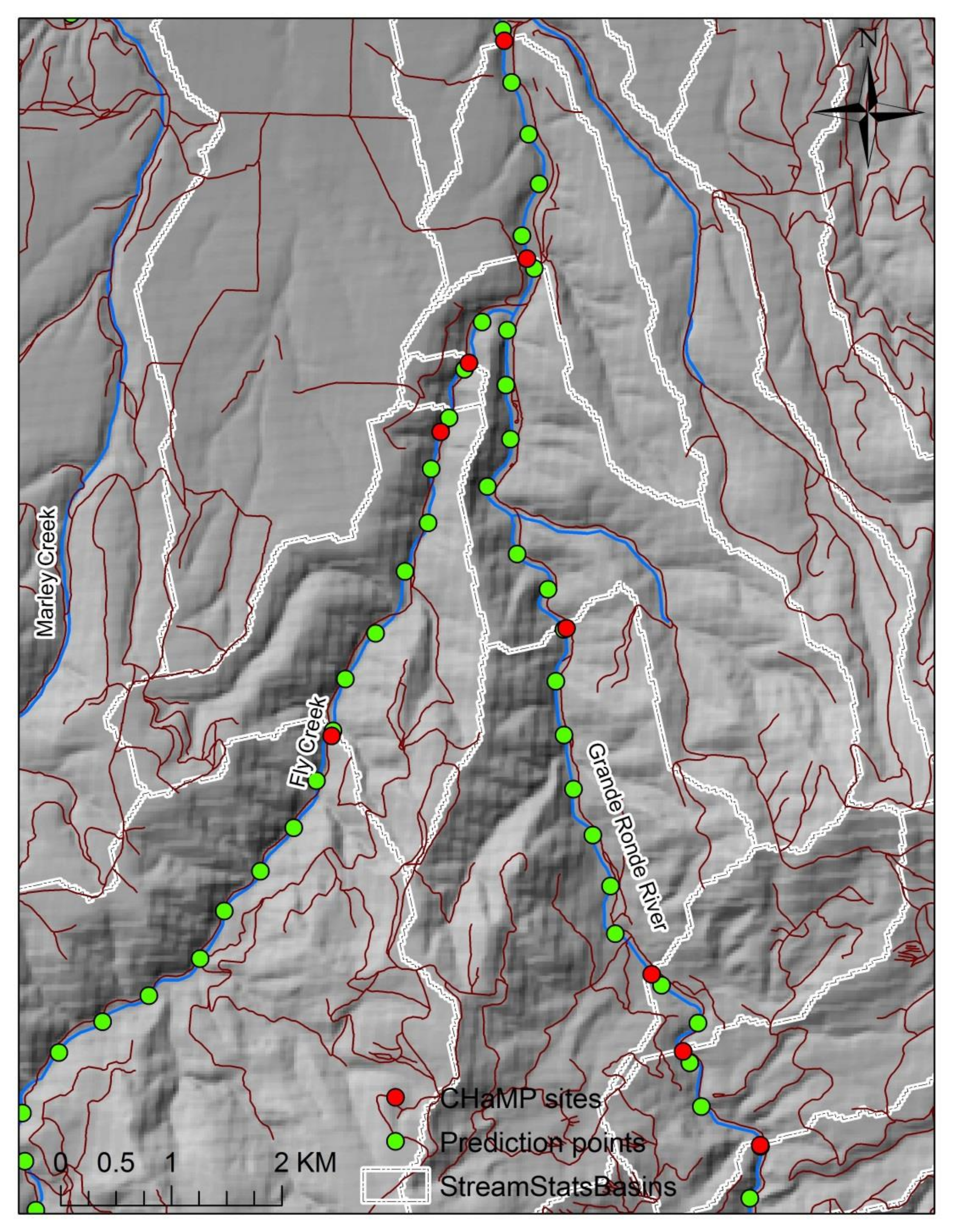
Landscape/Land Use Characteristics

Number	Metric	Category	Description	Source
1	BFQ	Flow	Bankfull Flow (cms)	Netmap
2	MEANANNCMS	Flow	Modeled mean annual streamflow (cms)	Netmap
3	Q0001E_08	Flow	Modeled mean August streamflow (cfs)	NHDPlus
4	Q0001E_MA	Flow	Modeled mean annual streamflow (cfs)	NHDPlus
5	UnitStrPow	Flow	Unit stream power (1000 kg/m^3 * 9.8 m/s^2 * mean annual flow (cms) * channel slope)/bankfull width (m)	Netmap
6	siteid	Random	Site identification number	CHaMP
7	VisitYear	Random	Year the habitat survey was completed	CHaMP
8	AreaKm2Wat	Reach intrinsic	Watershed area (Km^2) calculated from Streamstats watershed polygons	StreamStats
9	ELEV_M	Reach intrinsic	Mean Elevation (m)	Netmap
10	ErodPct	Reach intrinsic	Percentage area with highly erodable geology within the upstream watershed.	CHaMP
11	GRADIENT	Reach intrinsic	Gradient (rise/run) of nearest stream segment	Netmap
12	SLOPEpct	Reach intrinsic	Slope (rise/run) of nearest stream segment * 100	NHDPlus
13	StDen_wat	Reach intrinsic	Stream density (drainage density) in km/km^2 for the upstream watershed	NHDPlus
14	VWI_Floor	Reach intrinsic	Valley width index (bankfull width/valley width)	Netmap
15	WIDTH_M	Reach intrinsic	Modeled bankfull width (m)	Netmap
16	rd1km100m	Roads	Road density (Km/Km^2) in a buffer area of length 1km upstream from the bottom of site and width 100m on either side of the stream.	CRITFC
17	rd1km200m	Roads	Road density (Km/Km^2) in a buffer area of length 1km and width 200m	CRITFC
18	rd2km100m	Roads	Road density (Km/Km^2) in a buffer area of length 2km and width 100m	CRITFC
19	rd2km200m	Roads	Road density (Km/Km^2) in a buffer area of length 2km and width 200m	CRITFC
20	rdwat	Roads	Road density (Km/Km^2) within the upstream watershed	CRITFC
21	tco1km100m	Tree Cover	Percent canopy cover from trees > 5 m tall in a buffer area of length 1km and width 100	NLCD 2011
22	tco1km200m	Tree Cover	Percent canopy cover from trees > 5 m tall in a buffer area of length 1km and width 200	NLCD 2011
23	tco1km30m	Tree Cover	Percent canopy cover from trees > 5 m tall in a buffer area of length 1km and width 30	NLCD 2011
24	tco2km100m	Tree Cover	Percent canopy cover from trees > 5 m tall in a buffer area of length 2km and width 100	NLCD 2011
25	tco2km200m	Tree Cover	Percent canopy cover from trees > 5 m tall in a buffer area of length 2km and width 200	NLCD 2011
26	tco2km30m	Tree Cover	Percent canopy cover from trees > 5 m tall in a buffer area of length 2km and width 30	NLCD 2011
27	tcowat	Tree Cover	Percent canopy cover from trees > 5 m tall within the upstream watershed.	NLCD 2011
28	LWFreq_Bf	Wood	Count of wood pieces >= 1m length and .10m diameter in the bankfull channel per 100m channel length	CHaMP
29	LWVol_Bf	Wood	Total volume of wood pieces >= 1m length and .10m diameter in the bankfull channel (m^3)	CHaMP
30	LWVol_Wet	Wood	Total volume of wood pieces >= 1m length and .10m diameter in the wetted channel (m^3)	CHaMP

Tree Cover (NLCD 2011)



Road Density (TIGER, USFS, CRITFC)

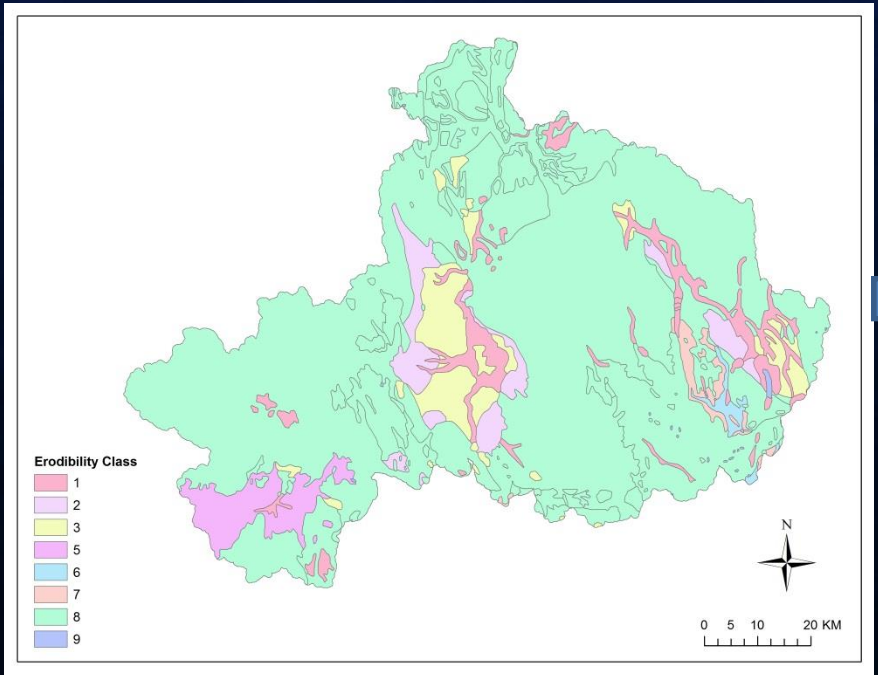


Erosivity (Percent Easily Erodible Geology)

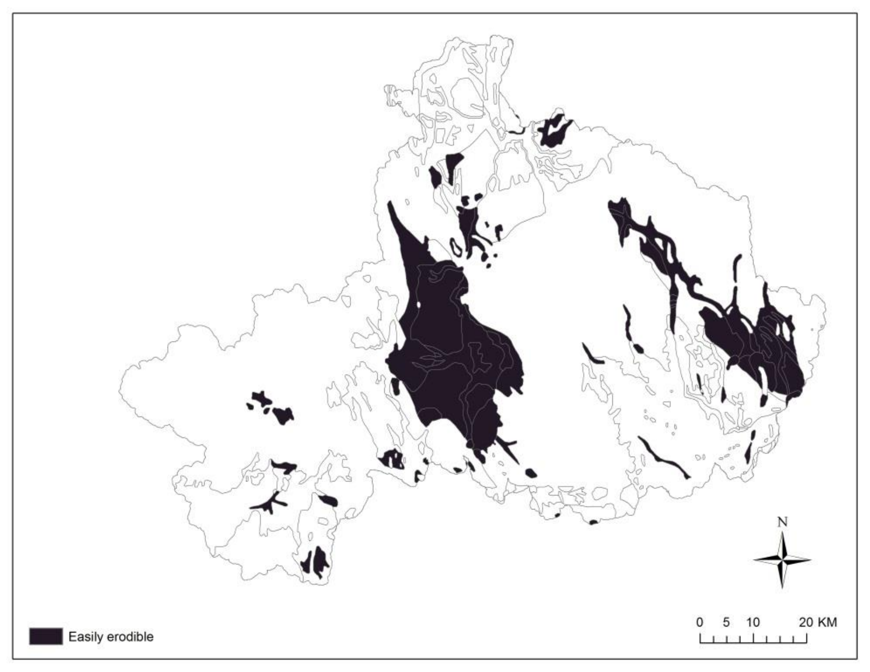
Data from Carol Volk, North Fork Research

Erodibility Class

1: low resistance, fine grain (alluvial, glacial silt)
2: low resistance, medium grain (sand)
3: low resistance, coarse grain (gravel, boulders, colluvial)
4: medium resistance, dissolvable (limestones and dolomites)
5: medium resistance, fine grain (shales, mudstones, clays)
6: medium resistance, medium grain (most sedimentary, a 'catch all' if formation descriptions were vague).
7: medium resistance, coarse grain (conglomerates, pyroclastics)
8: high resistance (consolidated volcanics, metamorphics)
9: open water



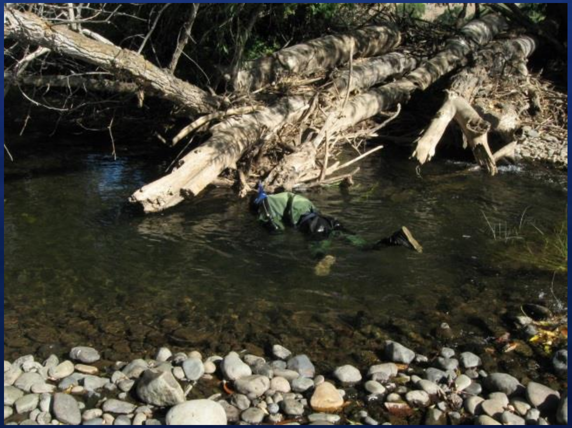
Erodibility Re-classified
Easily erodible area



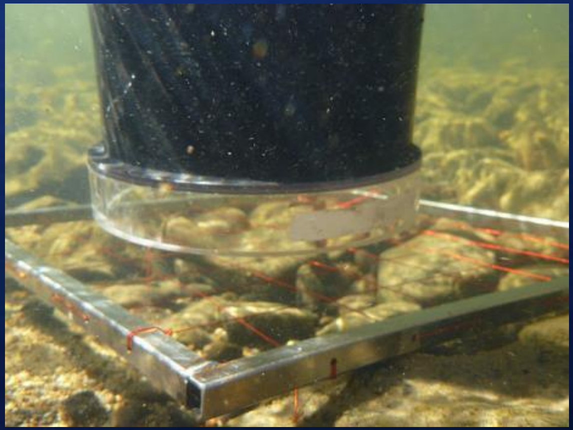
Dependent Variables

Percent Pools

Large Wood Frequency



Pool Tail Fines < 2 mm



Independent Variables (Fixed Effects)

1. Elevation
2. Valley width index
3. Watershed area
4. Slope
5. Tree cover (1km X 200m buffer)
6. Drainage density
7. Large wood frequency (wet)

1. Elevation
2. Valley width index
3. Bankfull width
4. Slope
5. Tree cover (watershed)
6. Drainage density

1. Elevation
2. Valley width index
3. Watershed area
4. Slope
5. Erosivity
6. Tree cover (watershed)
7. Road density (watershed)
8. Drainage density

Random Effects (for all models) = Site and Year

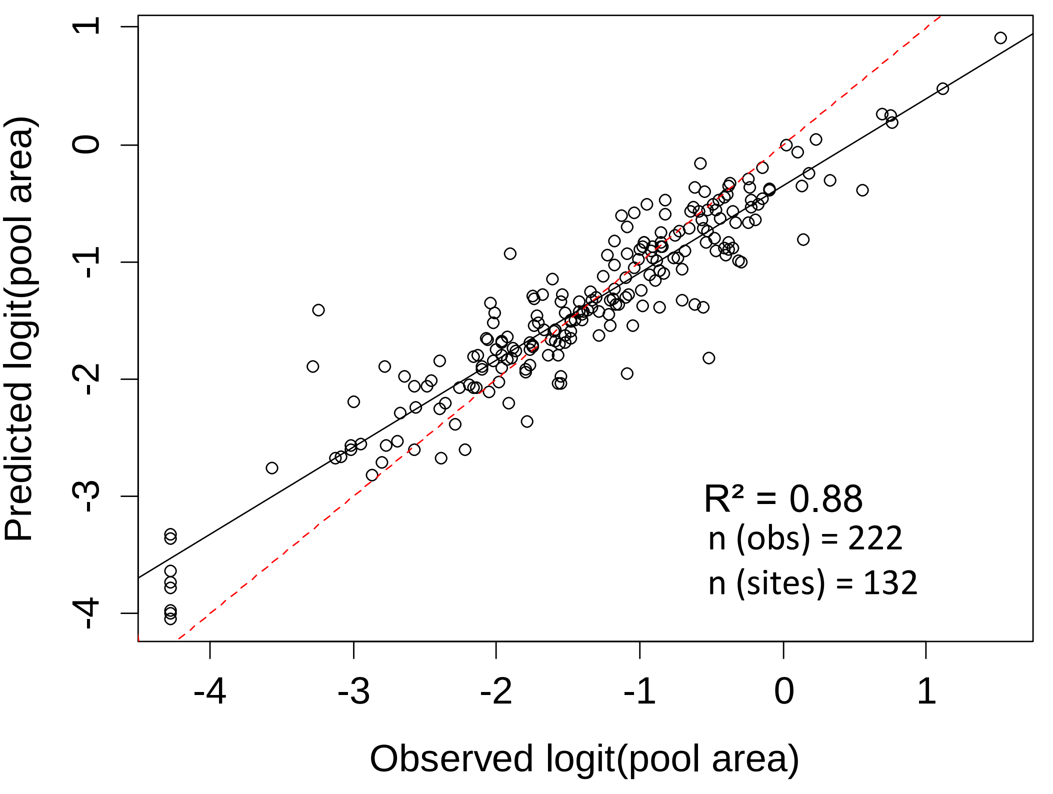
Data Sources: Netmap, NLCD, NHDPlus, USGS StreamStats, CHaMP, TIGER, USFS

Results

Percent Pools

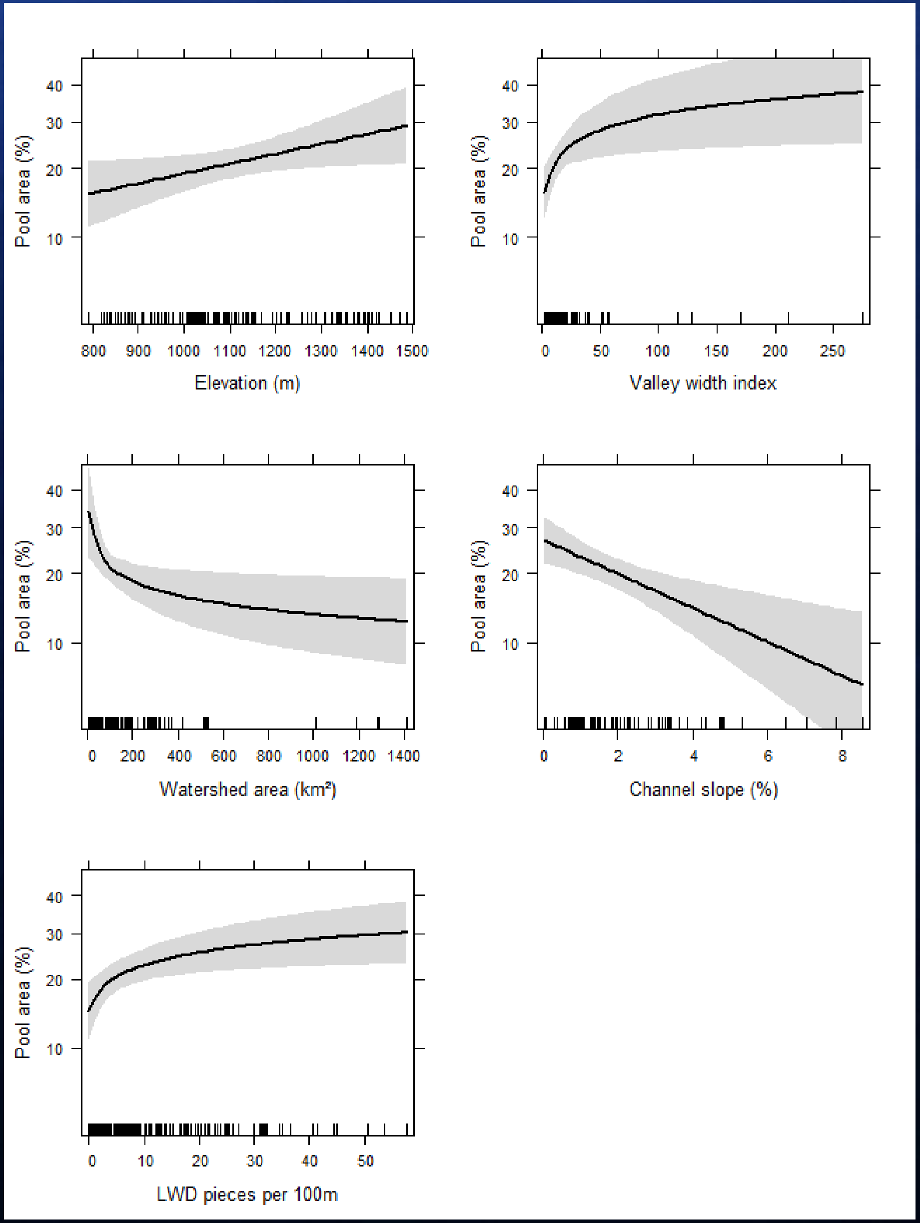
Best Fitting Model:

logit(Percent Pools) = Elevation + log(Valley Width Index) + log(Watershed Area) + Slope + log(Large Wood Frequency); Random effects = site + year



Results

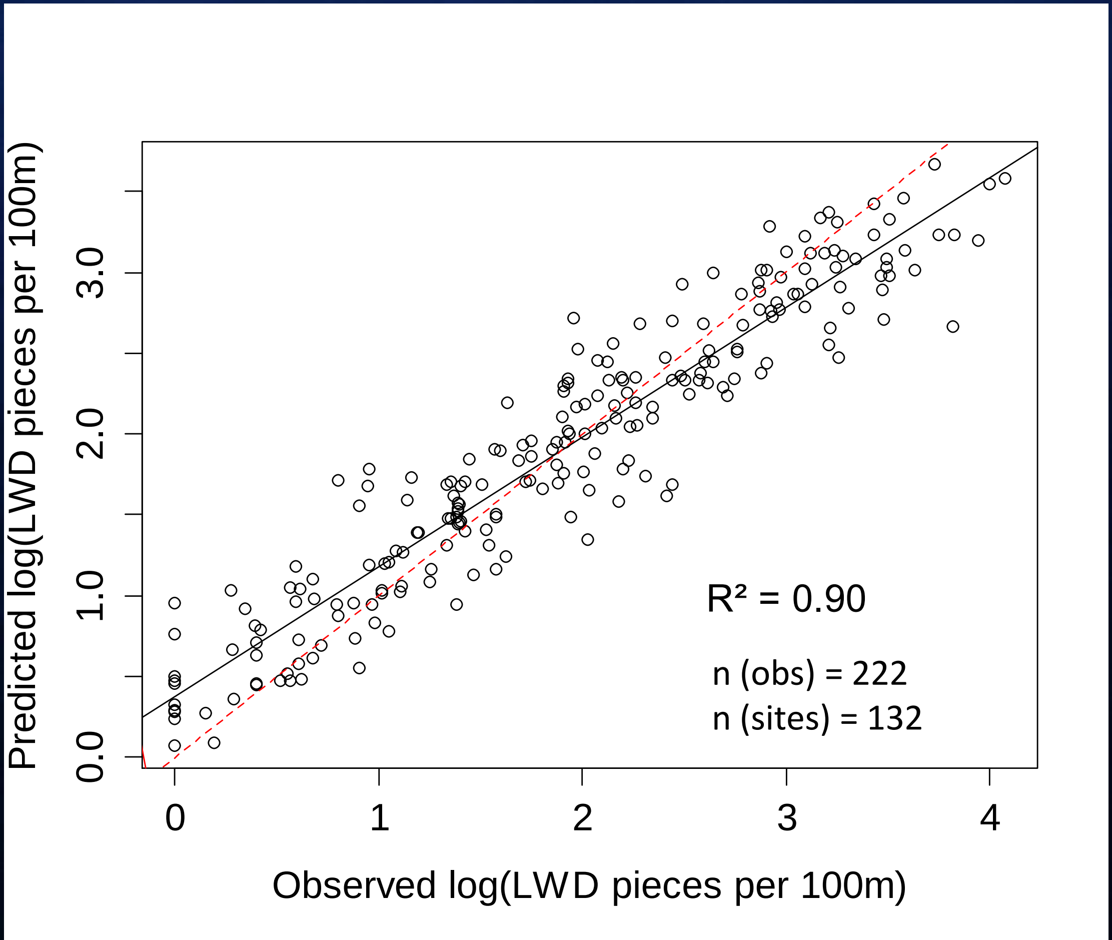
Percent Pools



Results

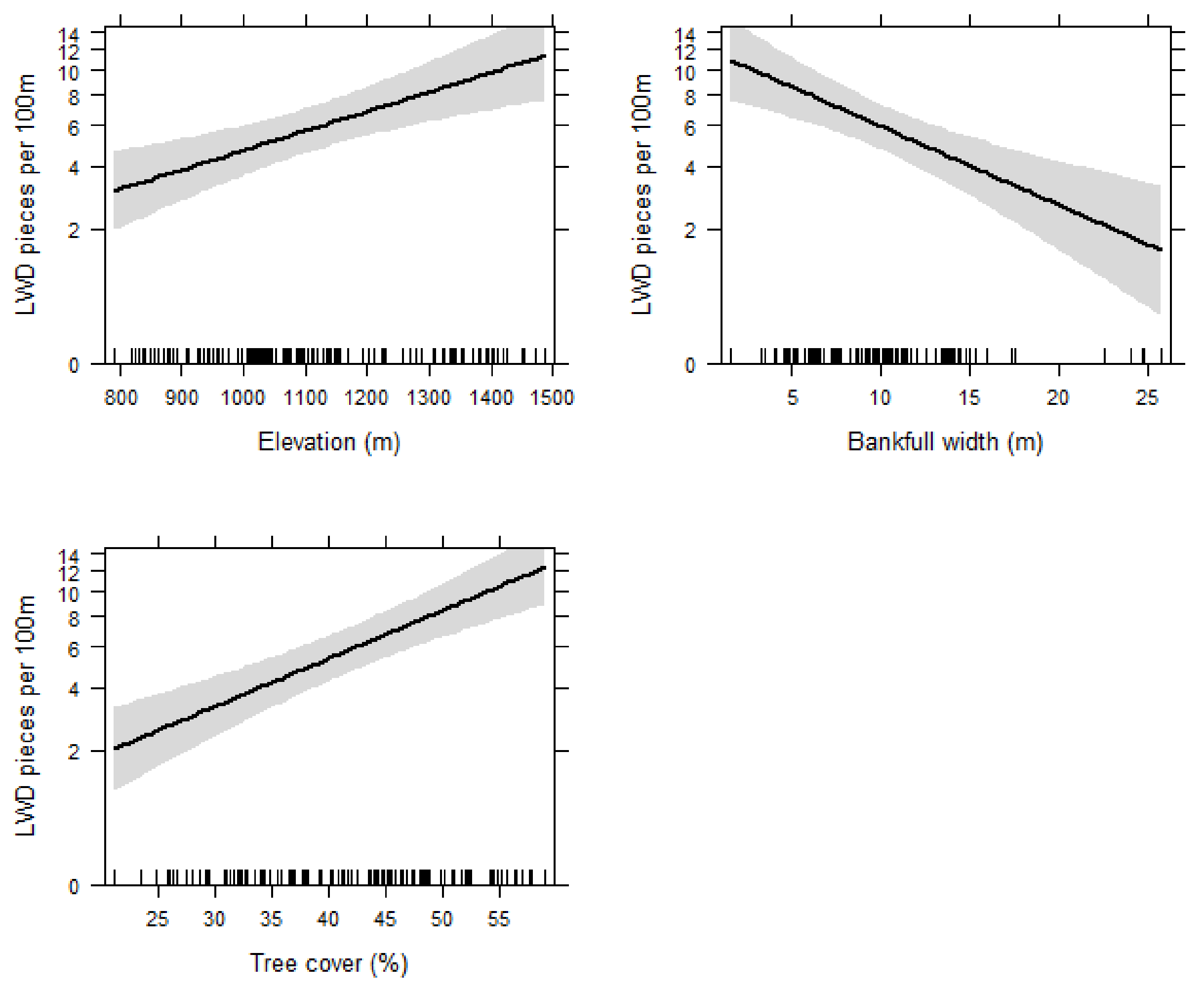
Large Wood Frequency (wet)

Best Fitting Model:
log(Large Wood Frequency) = Elevation + Bankfull Width + Tree Cover (watershed); Random effects = site + year



Results

Large Wood Frequency (wet)

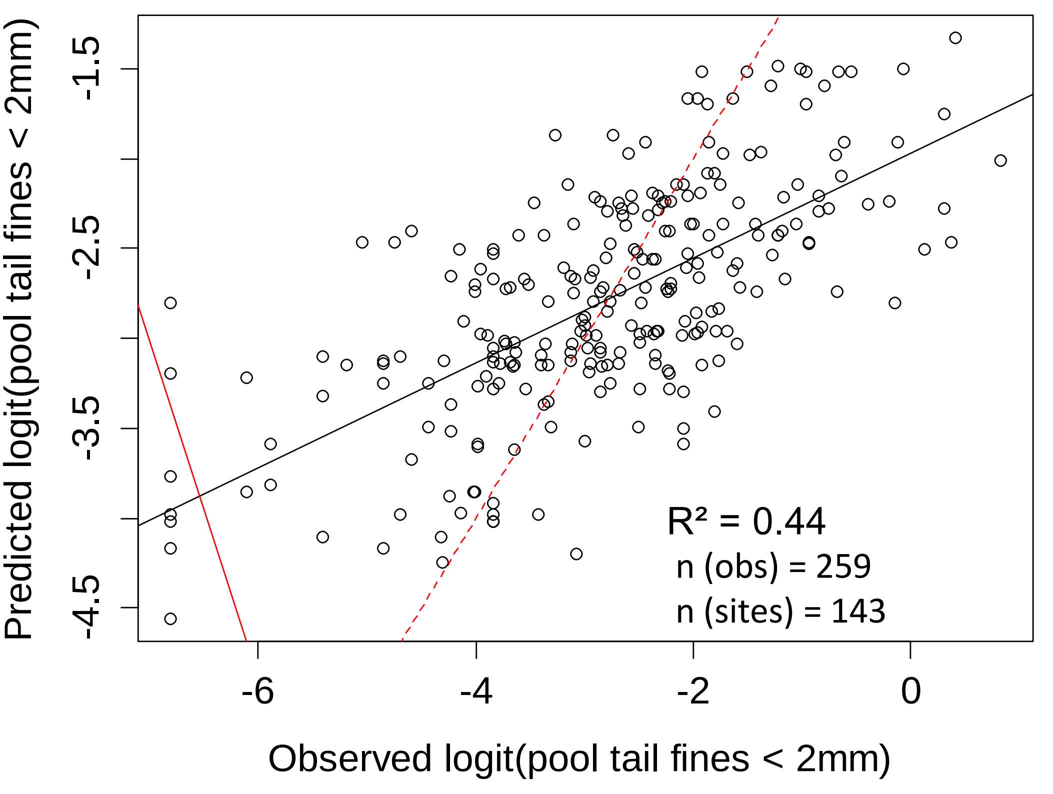


Results

Pool Tail Fines < 2 mm

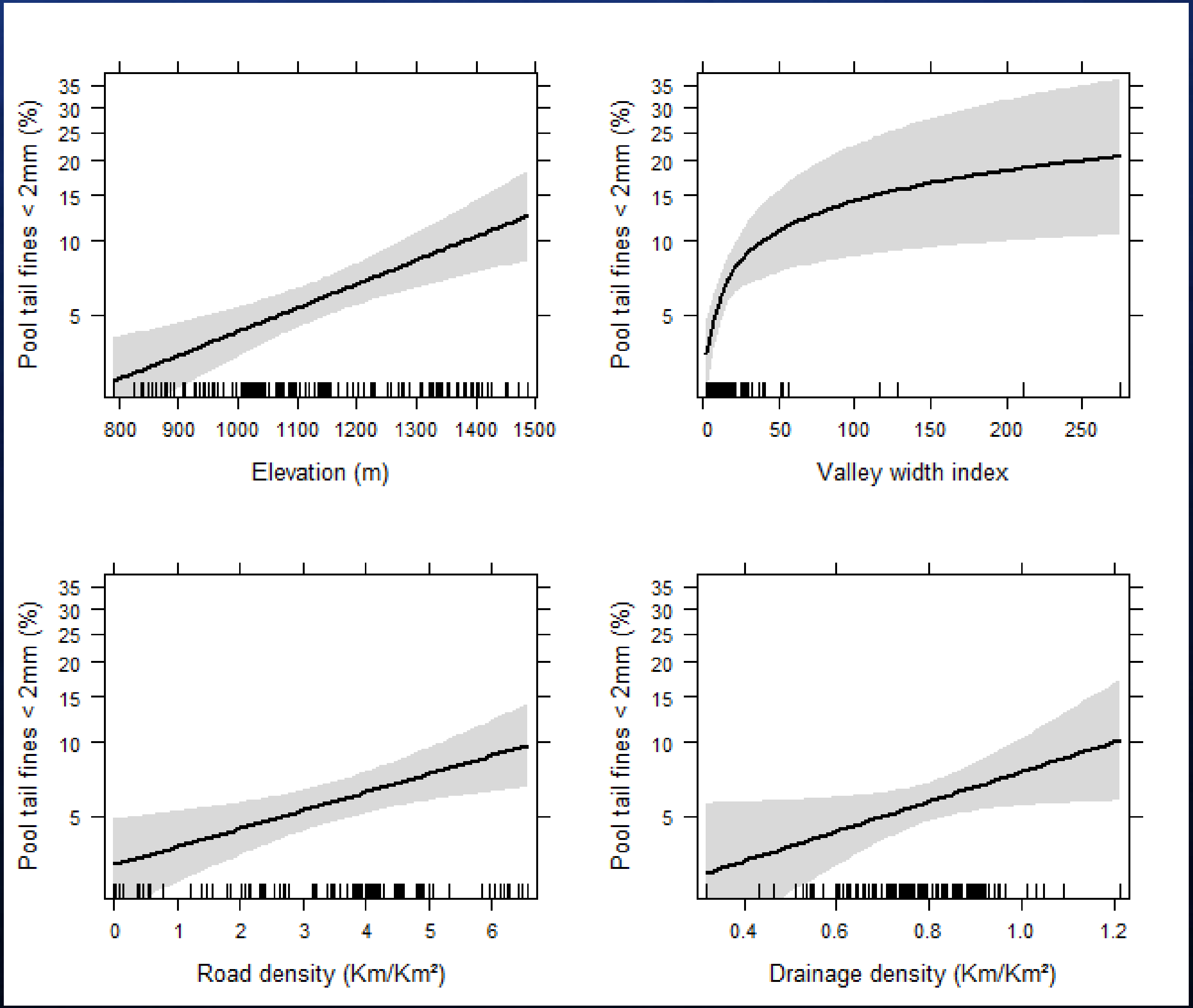
Best Fitting Model:

logit(Pool Tail Fines < 2 mm) = Elevation + log(Valley Width Index) + Road Density (watershed) + Drainage Density; Random effects = Site + Year



Results

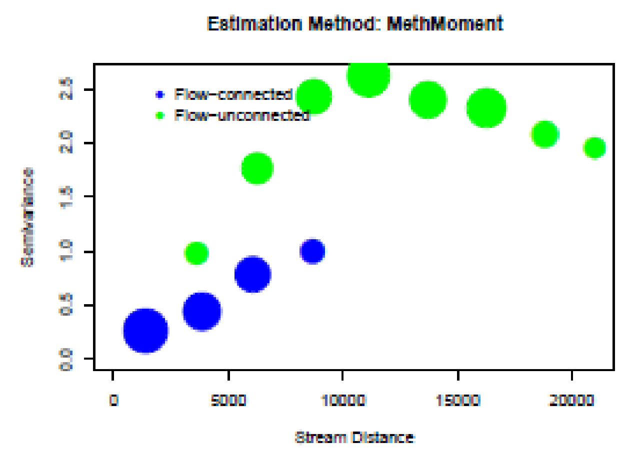
Pool Tail Fines < 2 mm



Exploring Spatial Autocorrelation Among Sites

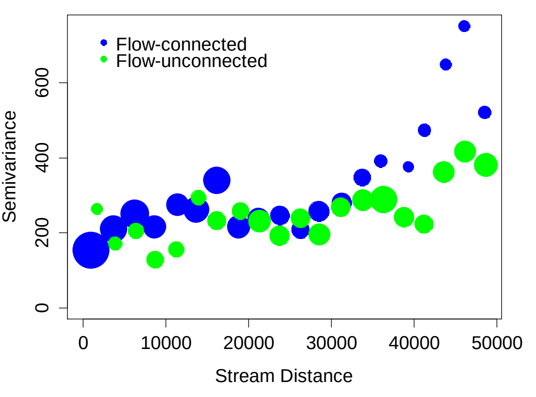
Torgegram Plots

Mean summer temperature (Ver Hoef *et al.* (2014)

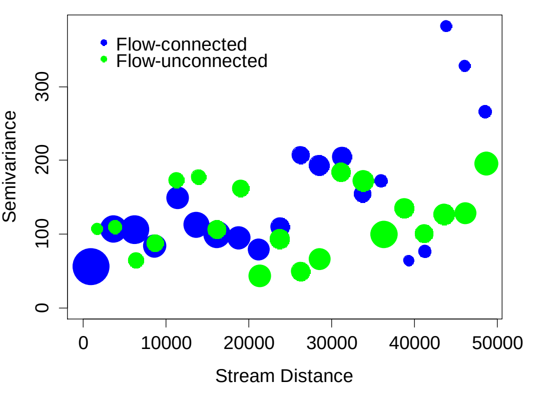


Plots generated using SSN package in R

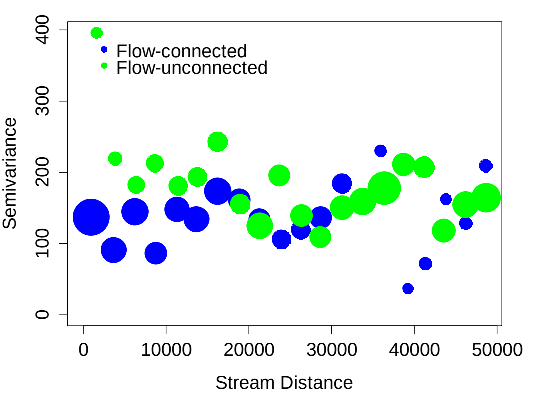
Percent pools



Large wood frequency



Pool Tail Fines < 2 mm



Conclusions

1. Linear mixed-effects models can be used to predict the quantity of large woody debris and pool area as a function of landscape/land-use variables derived from remote sensing data with a fairly high degree of accuracy.

2. The best-fitting model for pool tail fines was relatively weak ($R^2 = 0.44$), and alternative methods will be needed to accurately predict pool tail fines in unsampled locations.

3. The use of spatial statistical network models did not generally improve model fit over the linear mixed-effects models, with the exception of large wood frequency, which was slightly improved by the inclusion of spatial autocorrelation.

Next Steps

1. Add design weights to analysis!

2. Use these models to generate predictions of CHaMP metrics for prediction sites (spaced every 500 m) and calculate mean values for each Biologically Significant Reach

3. Expand modeling effort to include other key CHaMP metrics (e.g., Water Temperature, Weighted Usable Area from HSI models, NREI estimates of Capacity) as well as fish density.

4. Compare different methods of rolling-up CHaMP data (i.e., GRTS, rapid assessment, linear mixed-effects models, spatial statistical network models)

5. Apply best estimates of mean habitat conditions at each BSR to life cycle model and restoration planning

Questions?