Modeling juvenile salmonid presence in the Tillamook Basin using landscape-level attributes

GIS II, Spring 2008
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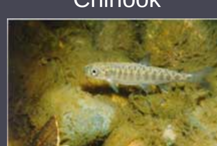
Introduction

- Research Question: Can salmon habitat preference be predicted from GIS-derived spatial features?
  - Develop a multiple logistic regression model
  - Response variable: Parr presence
  - Derive landscape specific data and relate to reach using GIS

Chinook



dnr.metrokc.gov

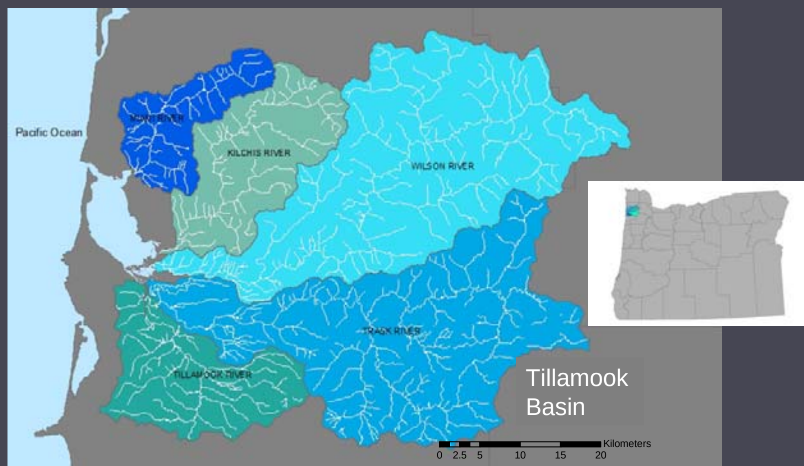
Steelhead

http://currents.ucsc.edu/05-06/02-13/grants.asp

Coho

www.marine.ie

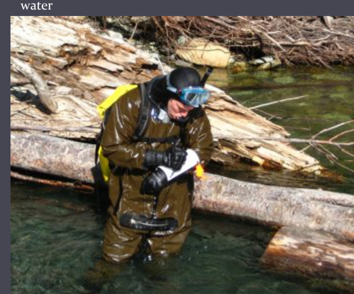
Study Area



Data and Sources

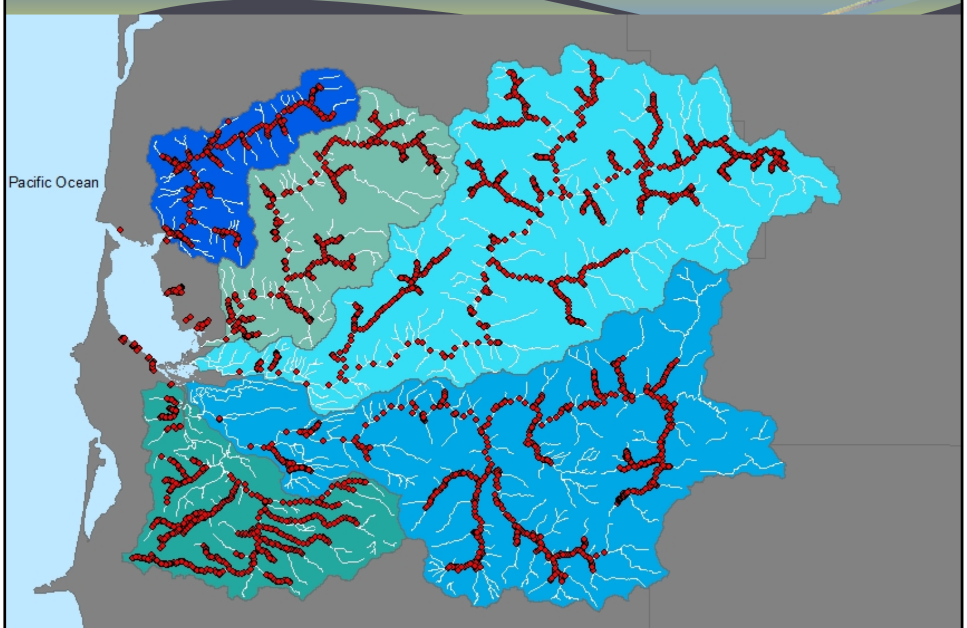
- CLAMS (Coastal Landscape Analysis and Modeling Study)
  - Stream Network
  - Discharge
  - Channel Confinement Index
    CI = ACW / VW
  - Gradient
- TEP (Tillamook Estuaries Partnership)
  - Point Data-Count of Chinook, Steelhead, Coho
- Land cover (NLCD)
- Land ownership (ODF)
- Roads (ESRI)
- Geology (DOGAMI)

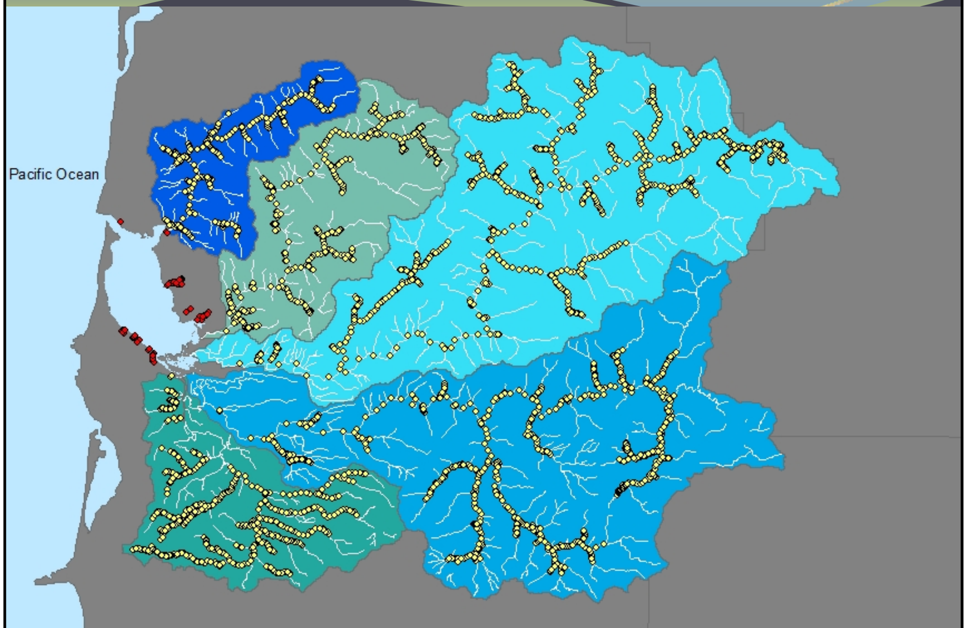
http://www.nationalparkstraveler.com/2007/10/biologists-count-fish-olympic-national-parks-elwha-river-under-water



Methods

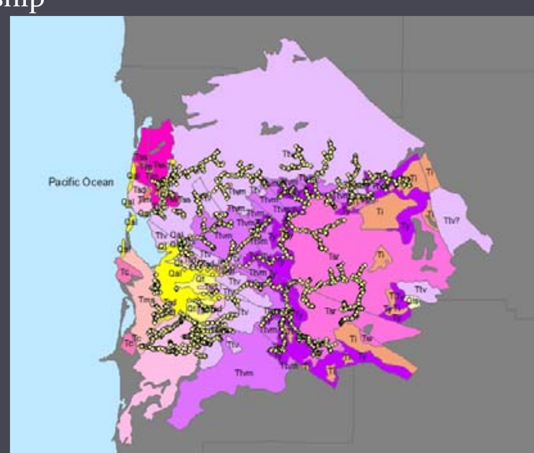
- Reduce TEP point file 2708 to 2623





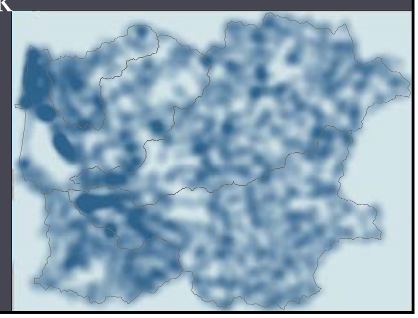
Methods

- Reclassify land ownership (feature to raster)
  - public
  - private
- Reclassify land cover
  - developed
  - agriculture
  - wetland/water
  - forest
- Reclassify geology (feature to raster)
  - erodible
  - resistant



Methods

- Derive road density with Kernel
- Distance to roads
- Sample Base points from all datasets
  - Contained CI, Q, Elevation, Gradient
- Converted TEP stream network to Major points
- Sample Major points from all datasets
- Joined tables back to Base points and exported as .dbf



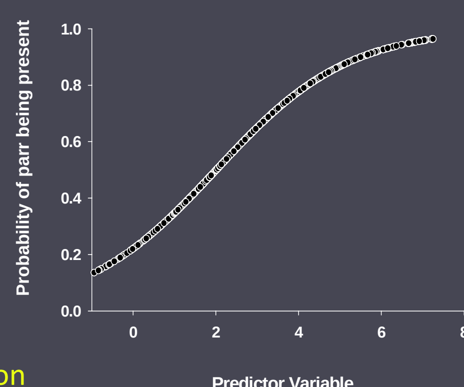
Statistical Modeling

Logistic Regression

Event (1/0) = Presence / Absence of parr

$\theta = b_0 + b_1x_1 + b_2x_2 + \ldots$

$prob = 1 / (1 + \exp(-\theta))$



Variable Selection:

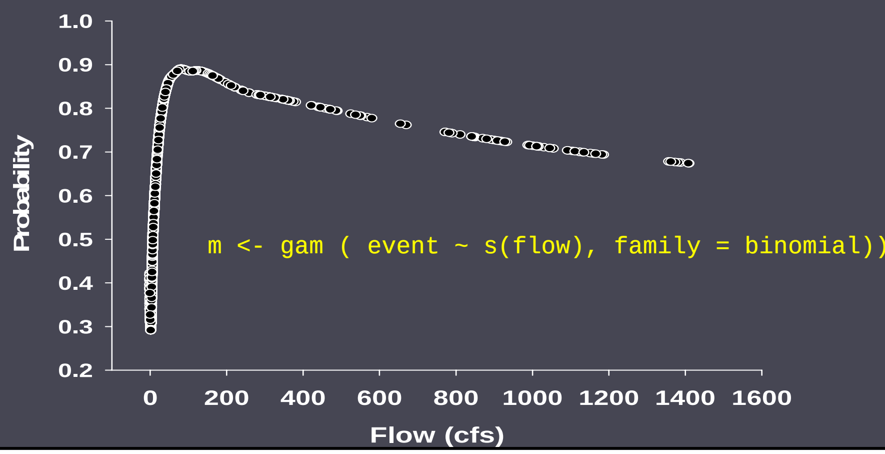
Δ AIC : Akaike Information Criterion

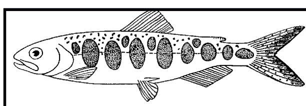
Exploratory Data Analysis

GAM : Generalized Additive Model

A generalized version of GLM (Generalized Linear Model)

$g(x) = b_0 + f_1(x_1) + f_2(x_2) + \ldots$





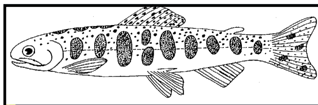
Statistical Model Results: Chinook

Most straightforward – 3 variables

Full Model Results (terms added sequentially):

Variable	Explained Deviance	Residual Deviance	Residual d.f.
NULL		1075.6	2622
Flow (cfs)	641.1	434.5	2621
Elevation	79.5	355.0	2620
Cum. Length	24.0	331.0	2619

θ = 11.0 + 1.64 * log(flow) – 0.000152 * elev – 0.00016 * elev^2 - 0.00045 * length + 2.6E9 * length^2

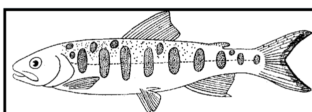


Statistical Model Results: Steelhead

More complex

Full model results (terms added sequentially):

Variable	Explained Deviance	Residual Deviance	Residual d.f.
NULL		2838.8	2622
Flow	675.3	2163.5	2621
Drainage Area	70.1	2093.4	2620
Confinement Index	29.6	2063.8	2619
Precipitation	18.3	2045.5	2618
Gradient	24.1	2021.4	2617
Stream Width	9.1	2012.3	2616



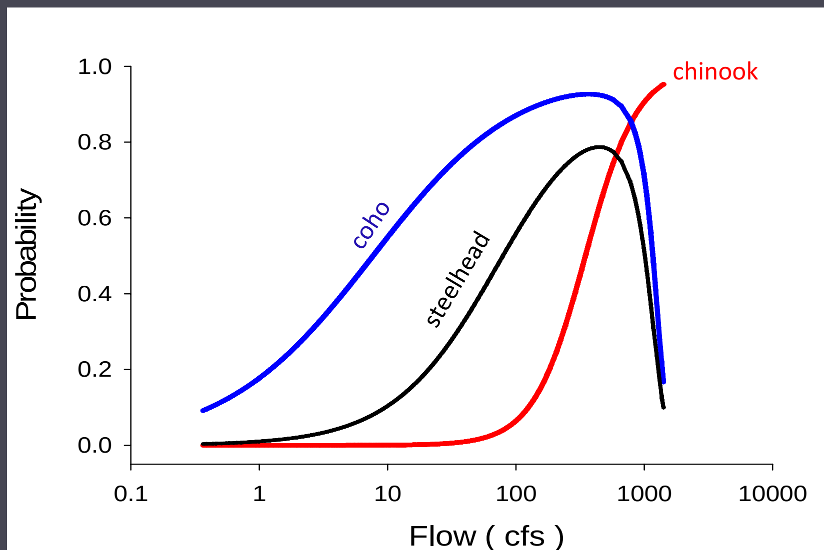
Statistical Model Results: Coho

Most complex – two major variables, many minor variables

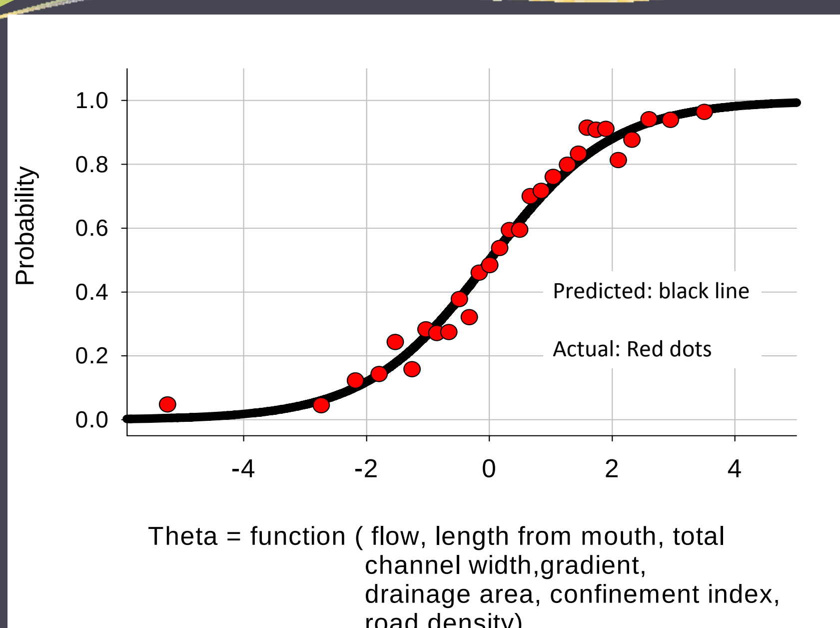
Full model results (terms added sequentially)”

Variable	Explained Deviance	Residual Deviance	Residual d.f.
NULL		3521.3	2622
Flow	493.2	3028.1	2621
Cum. River Length	110.7	2917.4	2620
Stream Width	54.5	2862.9	2619
Gradient	28.9	2834.0	2618
Drainage Area	29.8	2804.2	2617
Road Density	7.4	2796.8	2616
Confinement Index	9.0	2787.9	2615

Flow – dominant variable



Model Performance: Actual versus predicted (coho)



Categorical Variables

- Significant variations:
  - Between the five major watersheds
  - Between public/private lands
  - Geology: Erodable/Resistant
- Land cover: none
- LiDAR-derived "rugosity" (Canopy Height Variation):
  - Steelhead only

LiDAR-DEM-derived watershed variables

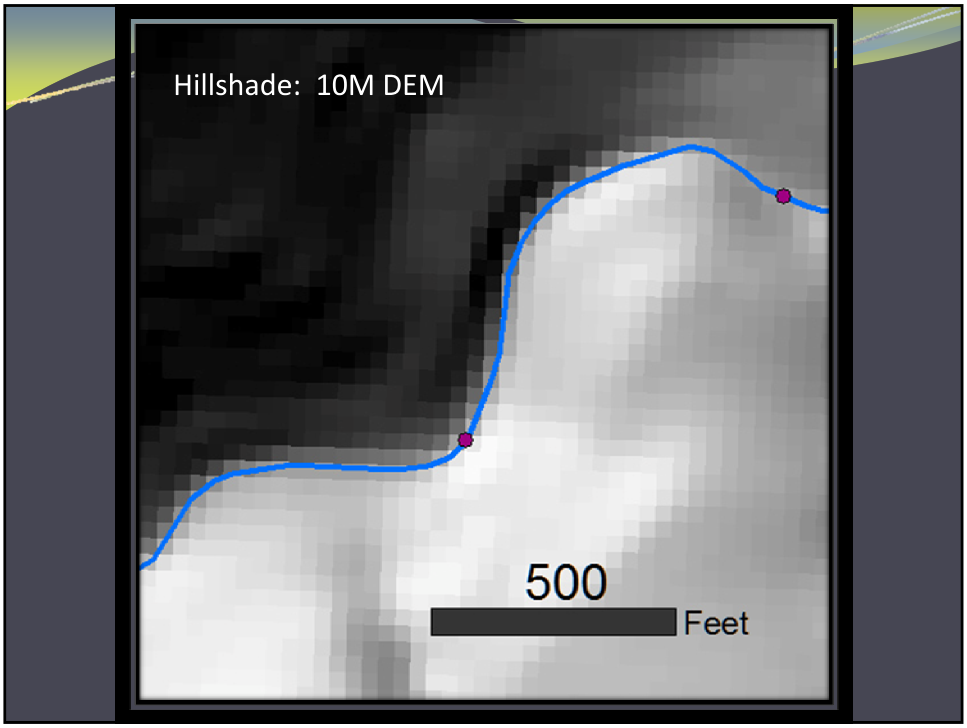
Earth System Institute watershed analysis tools could not handle # of bytes ☹

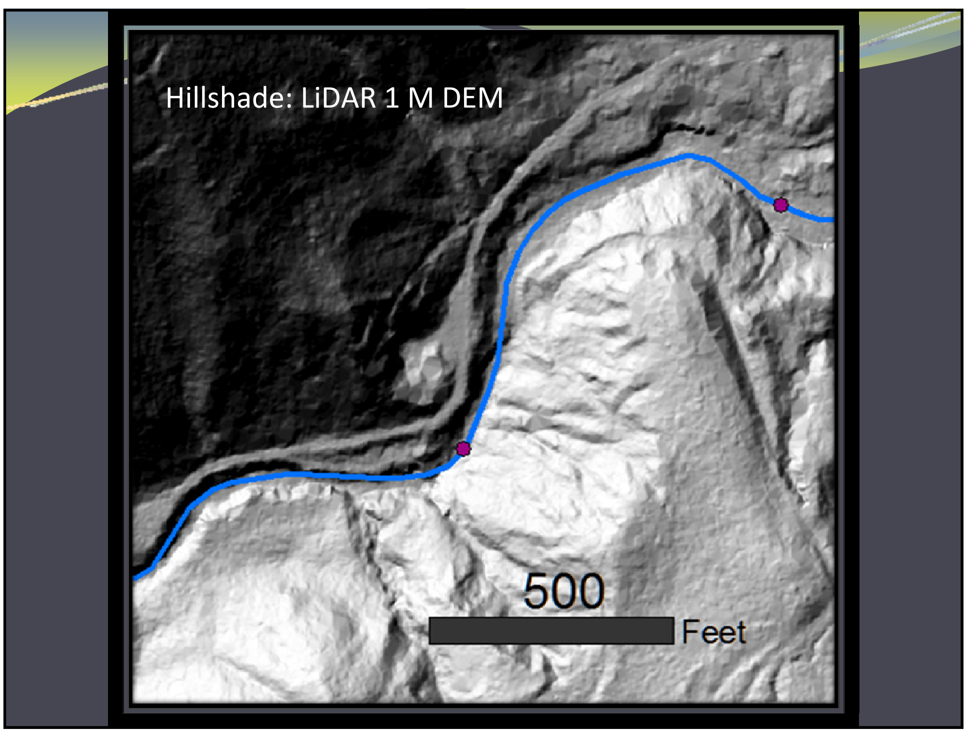
Increased DEM resolution:

- Will not significantly change watershed delineation, flow estimate
- Will enable more ***precise*** stream width calculation

Would LiDAR-based data help?

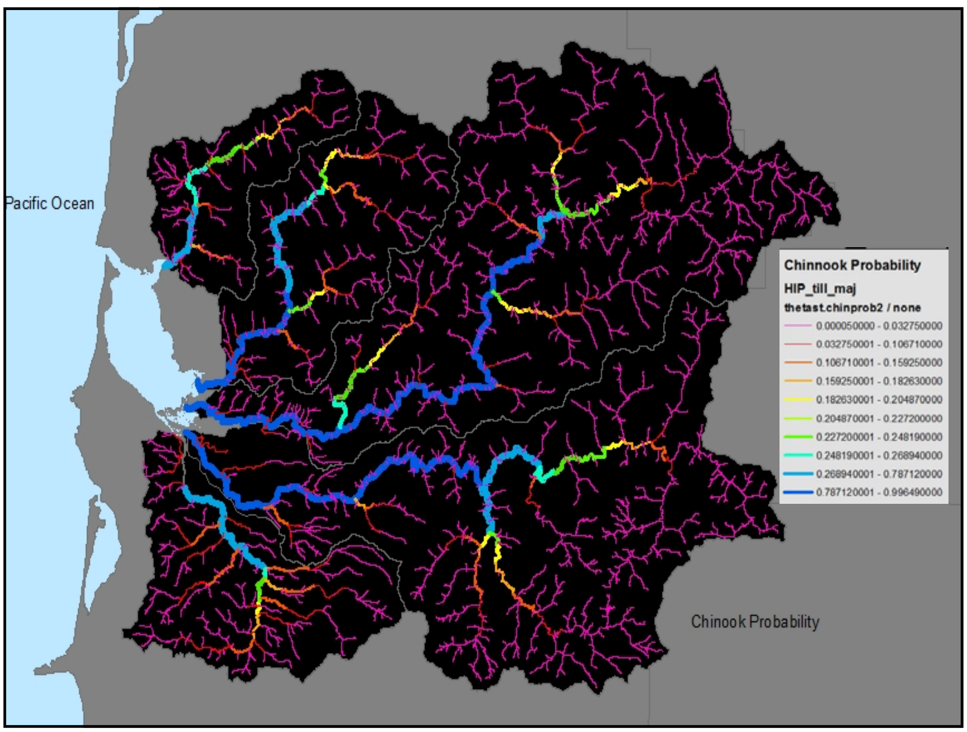
- Chinook: likely not. Flow is dominant factor.
- Coho, steelhead: possibly. Stream width, confinement index are minor contributors

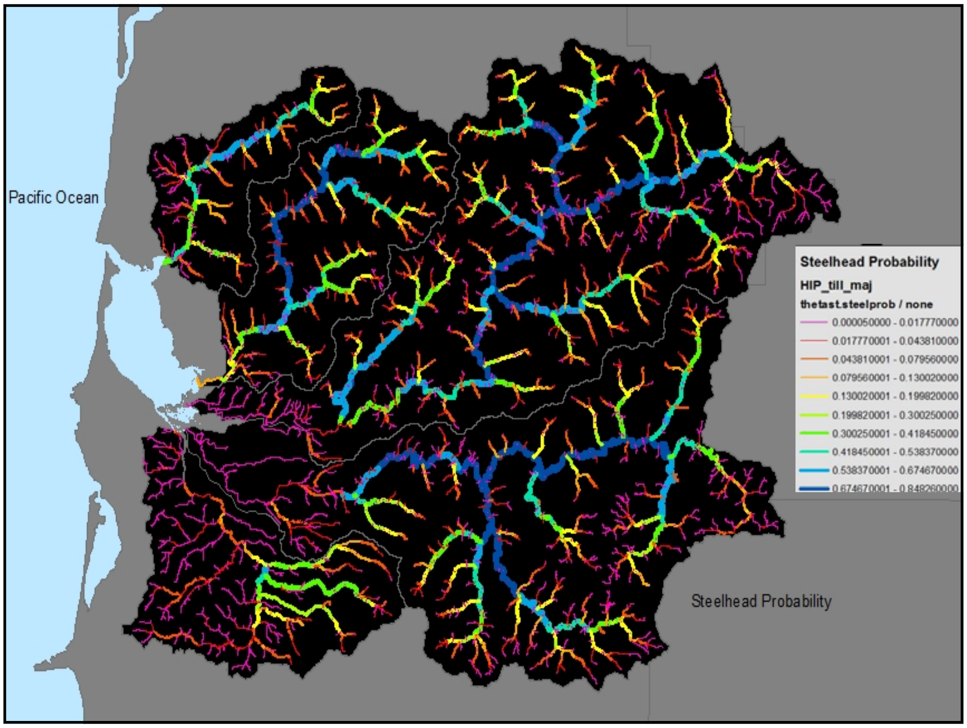

Hillshade: 10M DEM
500
Feet

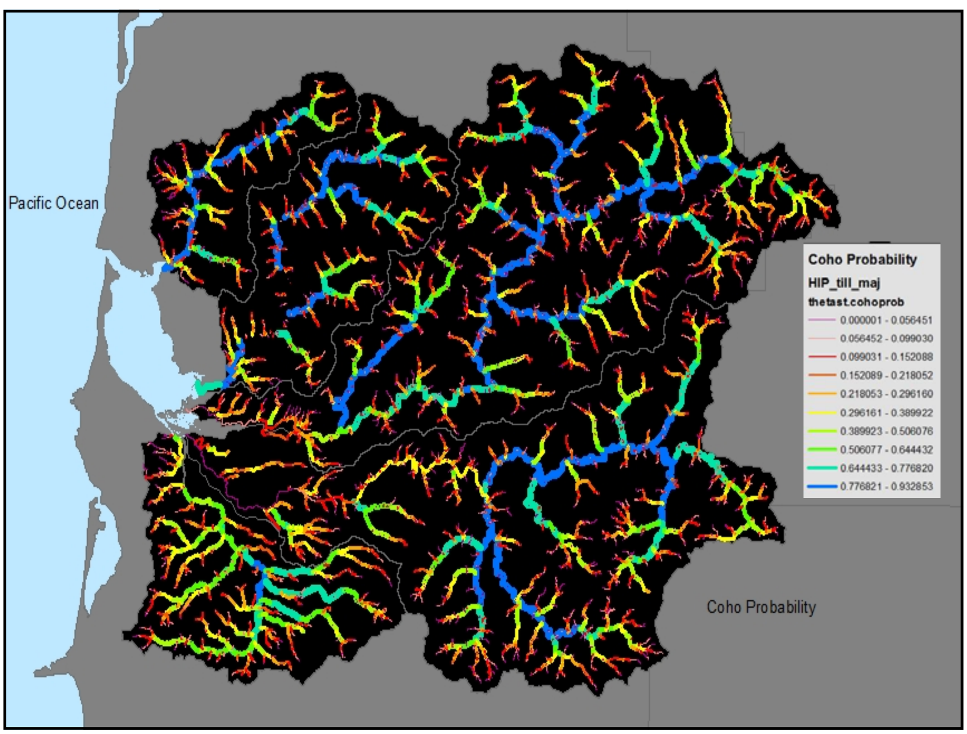

Hillshade: LiDAR 1 M DEM
500
Feet

Methods

- Create new fields
  - Theta
  - Probability
- Create probability maps for all species




Pacific Ocean
Steelhead Probability
HIP_till_maj
thetast.steelprob / none
0.000050000 - 0.017770000
0.017770001 - 0.043810000
0.043810001 - 0.079560000
0.079560001 - 0.130020000
0.130020001 - 0.199820000
0.199820001 - 0.300250000
0.300250001 - 0.418450000
0.418450001 - 0.538370000
0.538370001 - 0.674670000
0.674670001 - 0.848260000
Steelhead Probability


Pacific Ocean
Coho Probability
HIP_till_maj
thetast.cohoprob
0.000001 - 0.056451
0.056452 - 0.099030
0.099031 - 0.152088
0.152089 - 0.218052
0.218053 - 0.296160
0.296161 - 0.389922
0.389923 - 0.506076
0.506077 - 0.644432
0.644433 - 0.776820
0.776821 - 0.932853
Coho Probability

Conclusions

- Variables used to predict parr habitat preference differ among species and watersheds
- GIS, in conjunction with S-Plus, was used effectively to model and predict

Limitations…..

- Time and Availability of Data
  - Try using difference in LiDAR HH – BE for rugosity
  - Derive our own stream network from LiDAR
- Keeping the model simple
- Model for whole basin, not individual watershed

References

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