An applications of GIS , LiDAR and stream survey data for assessing streams for potential woody debris restoration

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So, What is Large Woody Debris?

- Pieces of wood in streams
- Chemical, biological and physical parameters of stream
- More common in smaller streams
- Bankfull zone
- 3 year flood event
- Highest energy
- Varying in size and placement
- .1m x 10cm in bankfull (Murphy et al 1989)
- 2ft at 25ft in bankfull (Northwest Forest Plan)
- .5m x 1.5m – somewhere? (Roni 2001)
- Connects terrestrial and aquatic environments
- Humans have great impact

My Interest...

Examples

What does LWD do?

- Creates pools
- Cools water
- Bank formation
- Anchor for smaller debris
- Shade
- Refuge from higher velocity flow
- Sediment retention
- Hyporheic flow
- Visual isolation for fish
- Nutrients for streams

Pools and Shade

Creation of pools

Plunge pools

Bank formation and stability

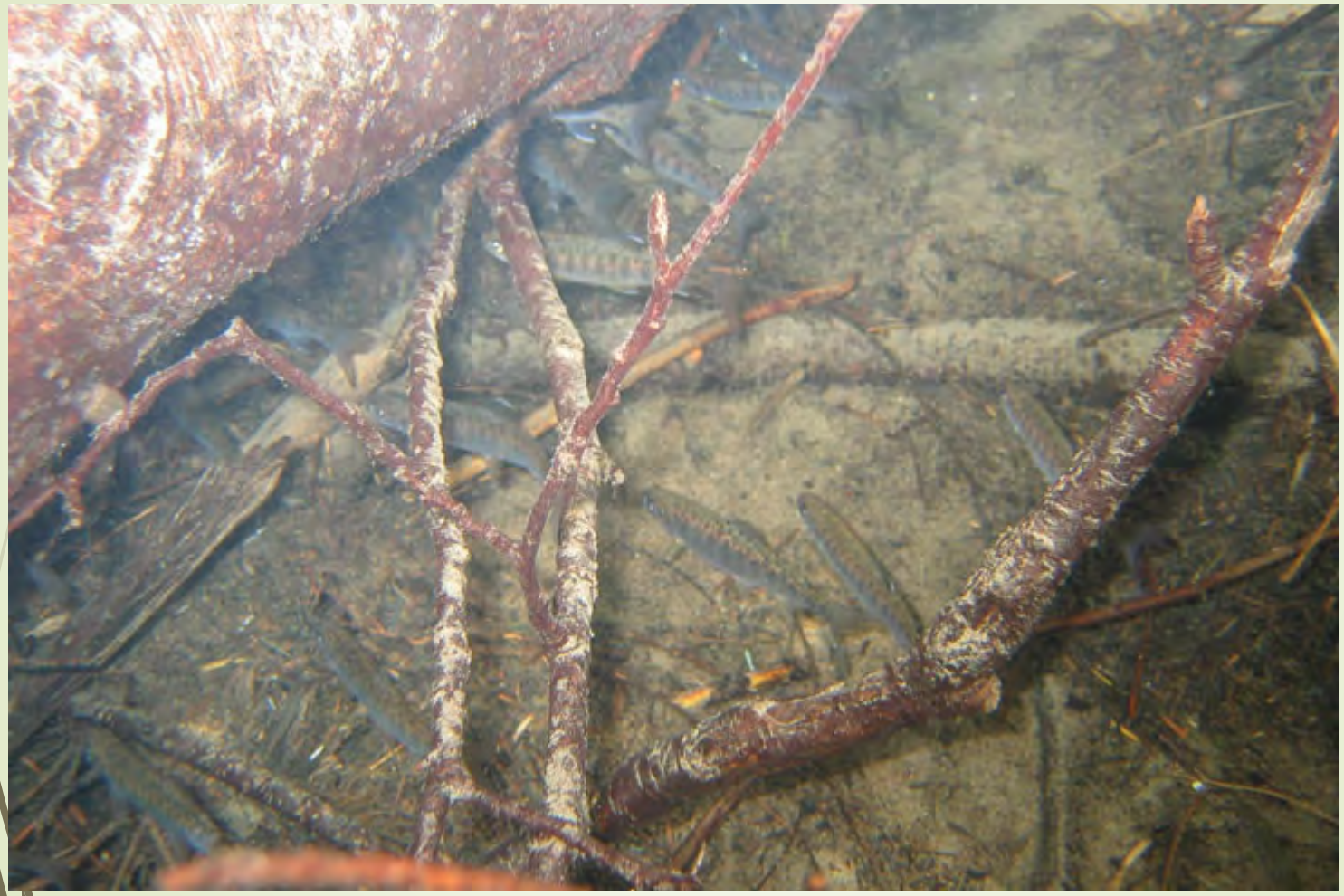
Nutrients for streams

Sediment Retention

Importance

Sediment Retention

Visual isolation for territorial fish



Visual isolation for territorial fish

Visual isolation for territorial fish

Anchors for smaller debris

Anchors for smaller debris

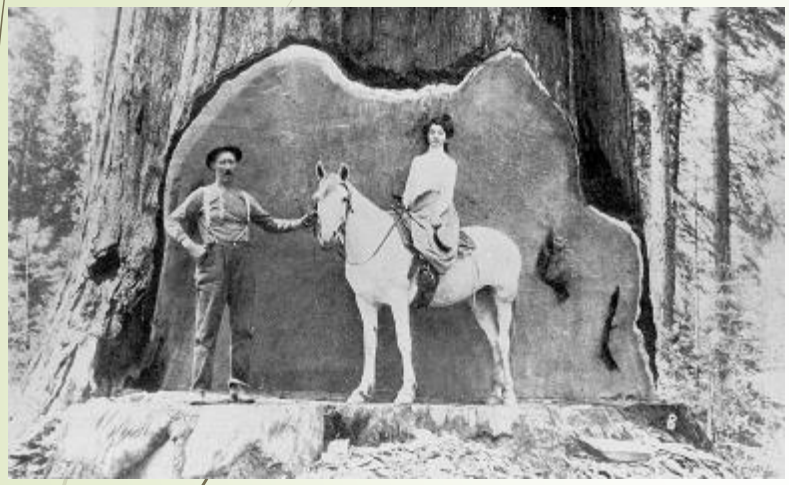
Reduction of velocity/flow rates

Reduction of velocity/flow rates

(scouring and habitat)

Cooling and hyporehic flow

Back in the day...



Landscape alteration

Removal of LWD for ecological reasons

Fish Passage

Intuitive?

Research - Sources of LWD

- **“ Dynamics of large woody debris in streams in old-growth Douglas-fir forests”** (Lienkaimper et al 1987)

-Attempts to identify main source of LWD.

- 9 year study

- How it gets into stream and what is major force

-Found that it in Pacific NW, wind is most important

-Erosion from water not so much

-Also found that streams with most LWD (660 Mg/ha) are in smaller watersheds (~1000 ha) in coastal forests.

- Guide for concentration of efforts

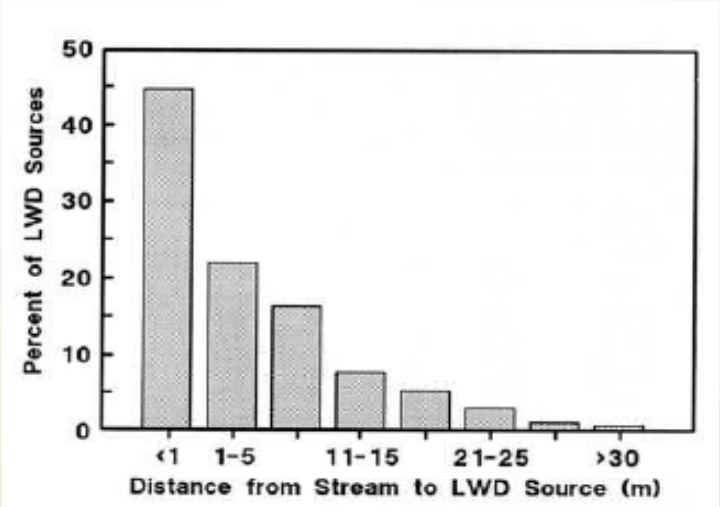
Research - Sources of LWD

- **. "Input and depletion of woody debris in Alaska streams and implications for streamside management" (Murphy et al 1989)**

- Attempts to identify area that contributes LWD to stream
- Looks at resonance time of different sizes of LWD
- Establish standards for riparian buffers

Research

- Found that “Input and depletion rates were inversely proportional to LWD diameter”
- Found that it would take 250 years for stream to get back to back to natural state after logging.
- 10 cm logs max 110 years. >60cm 256 years.
- In this study, area of contribution to be within 30 meters of stream



- From this, establish buffers

Research – Sources of LWD

- **"A Lidar-Derived Evaluation Of Watershed-Scale Large Woody Debris Sources And Recruitment Mechanisms: Coastal Maine, USA.“ (Kasprak et al 2012)**

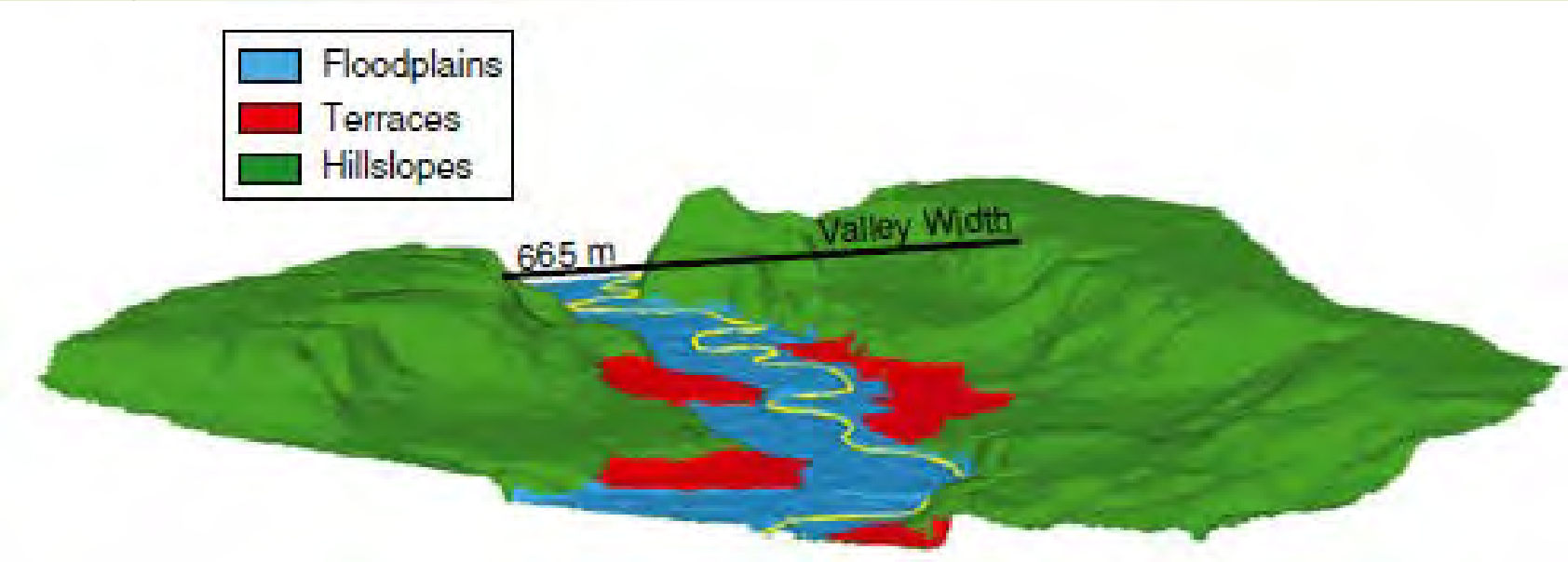
- Used Lidar to quantify potential sources of LWD

- The examined the 588 km^2 watershed that fed a 78km section of the Narraguasgus river.

Research – Sources of LWD

- **"A Lidar-Derived Evaluation Of Watershed-Scale Large Woody Debris Sources And Recruitment Mechanisms: Coastal Maine, USA.“ (Kasprak et al 2011)**
- Found that 6% of wood in watershed could be LWD
- 83% on slopes
- Direct measurement
- Tool for management

Research – Sources of LWD



Area of recruitment for LWD (Kasparak et al 2012)

Research - Aquatic Habitat

- **“Density and size of juvenile salmonids in response to placement of large woody debris in western Oregon and Washington streams” (Roni et al 2001)**
- Aimed to understand impact of LWD on salmonids
- 30 streams with matched reference sites
- Constructed LWD
- Measured salmonid density, pool depth and wood quantity in the summer and winter (1996 -1999)

Research - Aquatic Habitat

Study area and sites

Research - Aquatic Habitat

- **Results**
- that LWD and pool density was higher in the treatment areas
- The researchers found that juvenile coho salmon were found to be 1.8 – 3.2 more dense in treated areas
- Cutthroat and Steelhead trout populations were not any more dense in the summer, but were 1.7 times more dense in treated sections during the winter survey
- Short study?

Research - Aquatic Habitat

- **Other studies**
- "**Woody debris, channel features, and macroinvertebrates of streams with logged and undisturbed riparian timber in northeastern Oregon, USA**" (Carlson et al 2001)

- Examined the impacts on macroinvertebrates in stream in logging units.
- Found populations more dense in logged areas
- More short term nutrients?
- Connection to fish?

Methods and Data

- **Stream Surveys**
- Data from Willamette NF on north and south sides of Lookout Reservoir.
- **Seral stage –** the categorical level of succession of a patch of forest.
- **Bankfull width of stream** – the width of flow at streams peak energy. Final value taken as average of 3 measurements
- **Wet width** – the width of stream during the summer's minimum flow. Final value taken as average of 3 measurements
- **Stream gradient** – the change of stream's height parallel to its flow. Final value taken from average of 3 measurements over 100 feet.
- **Substrate** – the substrate composition percentages based upon measurements of bedrock, fines, gravel, cobble and boulders.
- **Pools per mile** – number of pools observed per unit distance.
- **Total length of stream reach** – measured with hip chain during surveying.

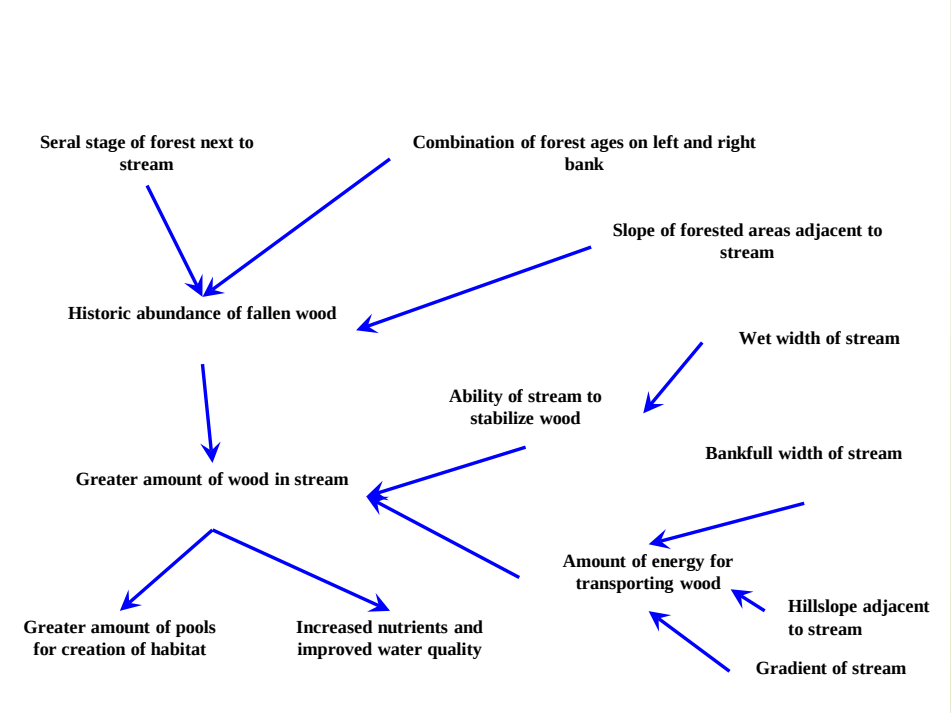
Methods and Data

- **Hillslope** – the average slope of the banks along the stream within 100 feet. Values calculated from DEM/LiDAR model.
- **Canopy height** – the height of canopy in the the forest
- **Canopy closure –** a measure of the percent "openness" of the canopy that determines how much light can get through to the ground. This can also serve as a proxy for the density of the stand.
- **Contributing area buffer** – the area around a surveyed reach that is within a defined buffer.
- **Aspect** – the direction that a surface is facing.

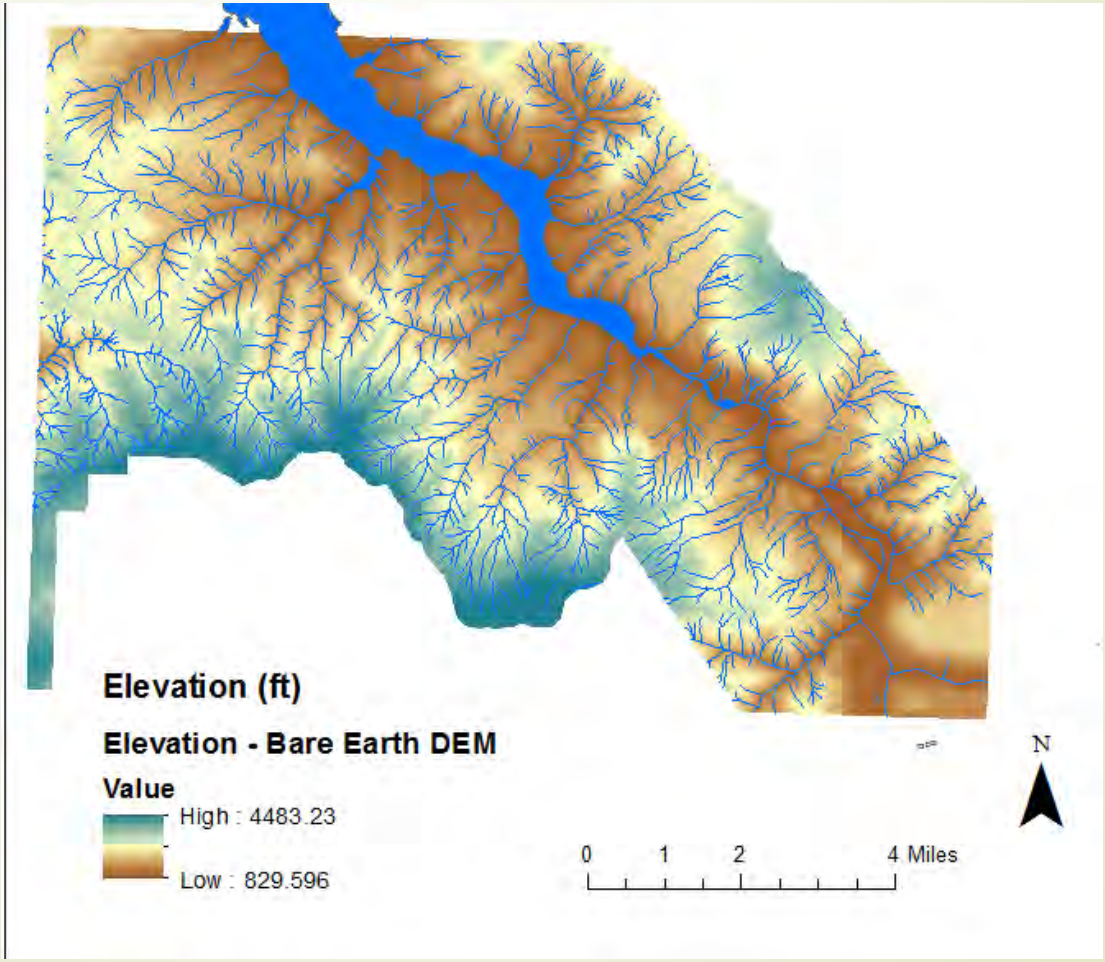
Methods and Data

- 1.5 ft resolution Lidar +/-. 17 ft.
- Used to derive other products
- Collected Spring 2014 by QS

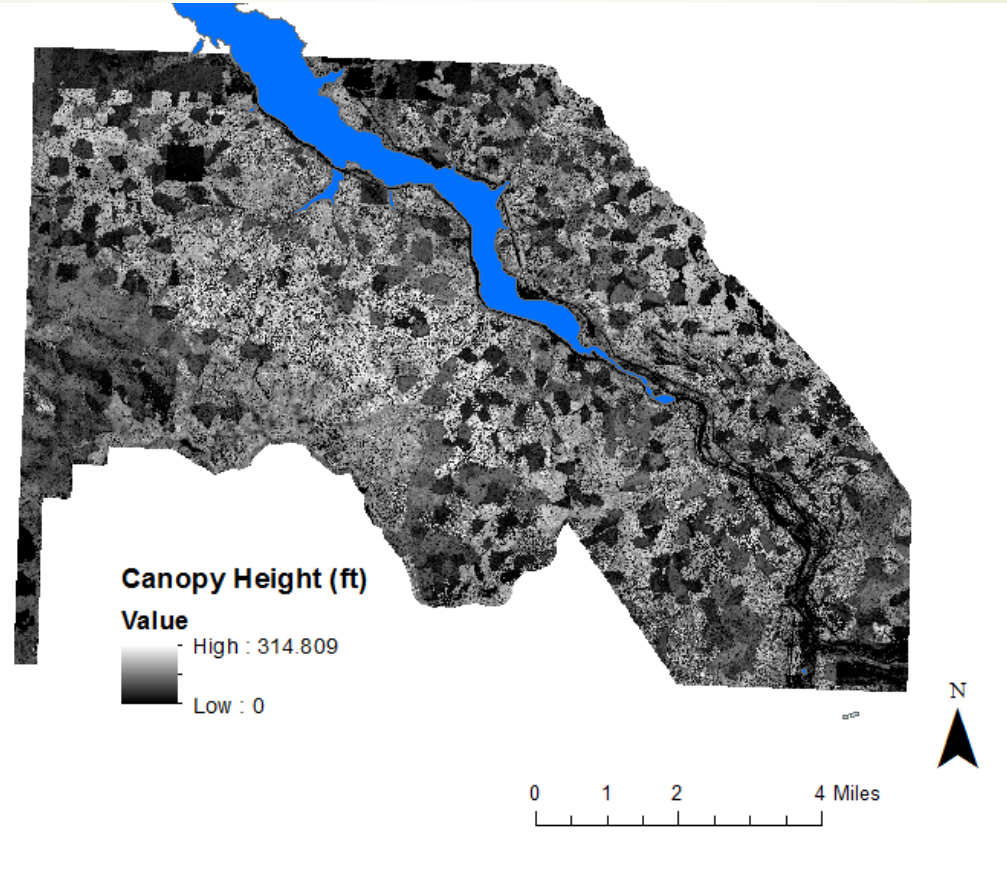
A Conceptual Model



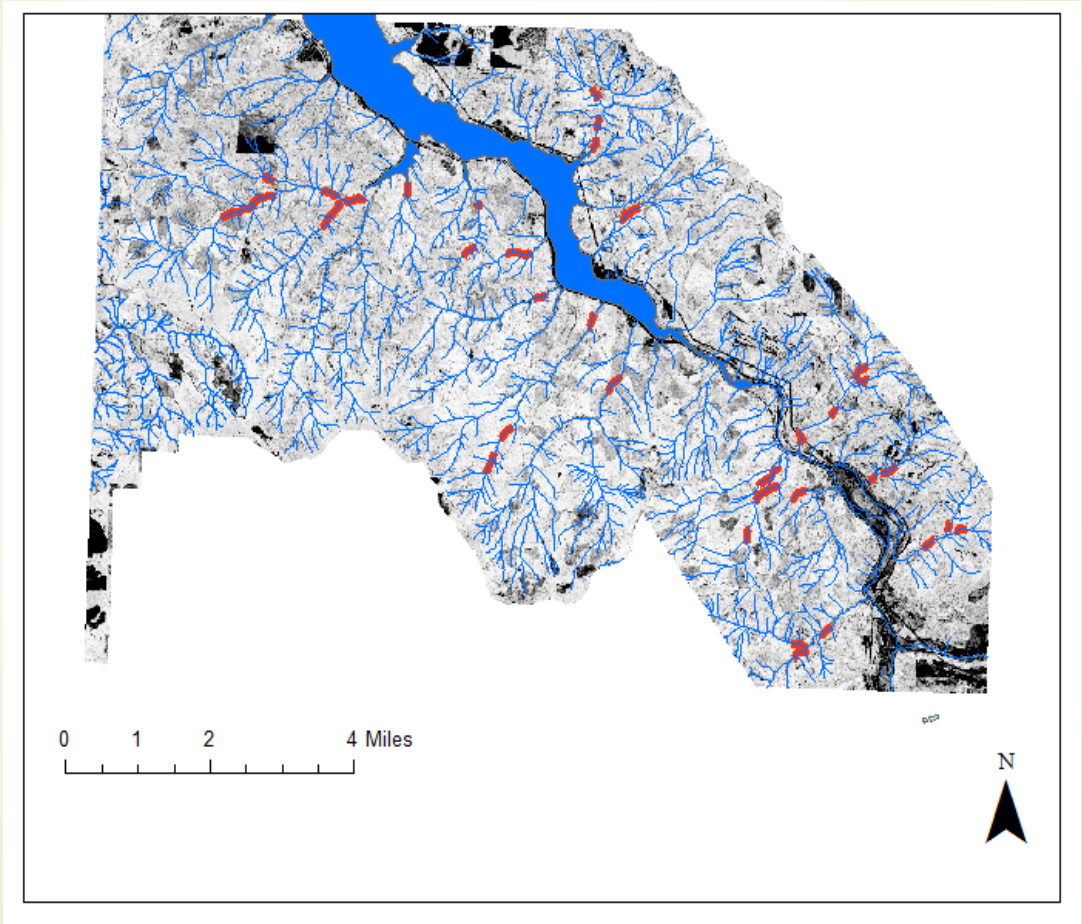
Bare Earth


Elevation (ft)
Elevation - Bare Earth DEM
Value
High : 4483.23
Low : 829.596
N
0
1
2
4 Miles

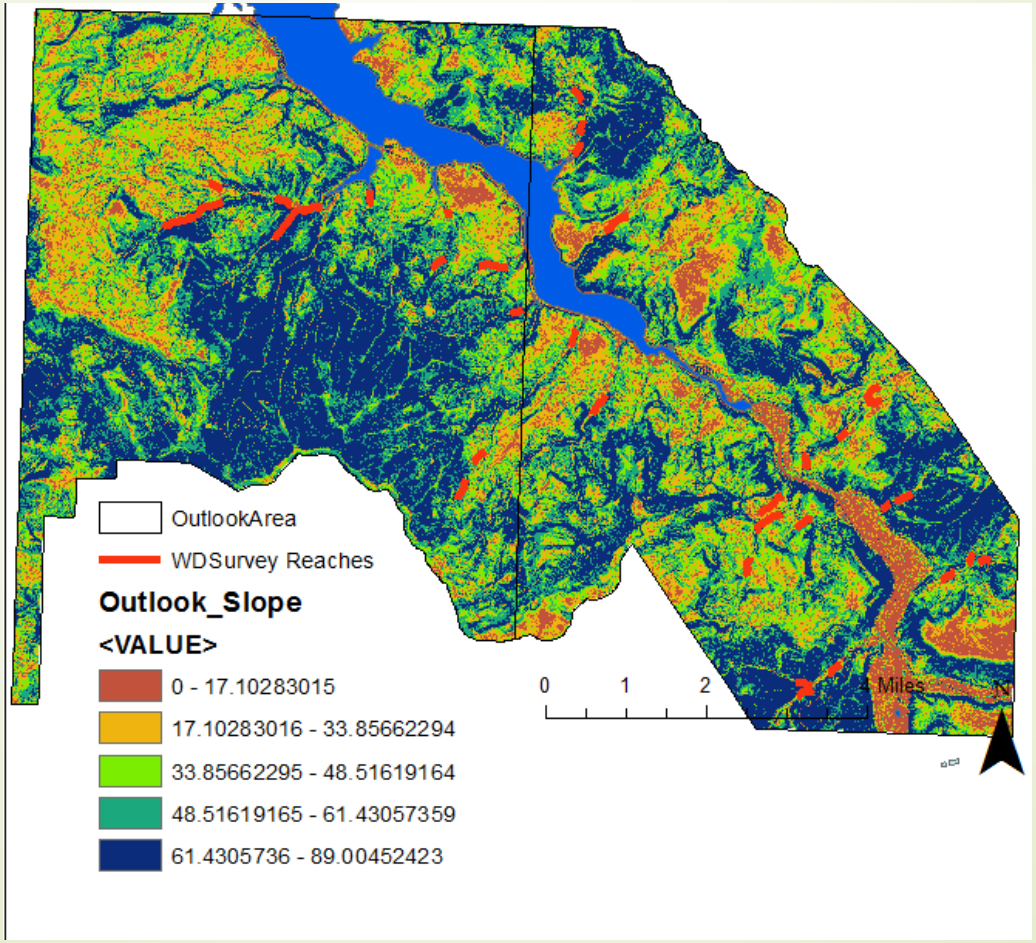
Canopy Height



Canopy Closure



Slope

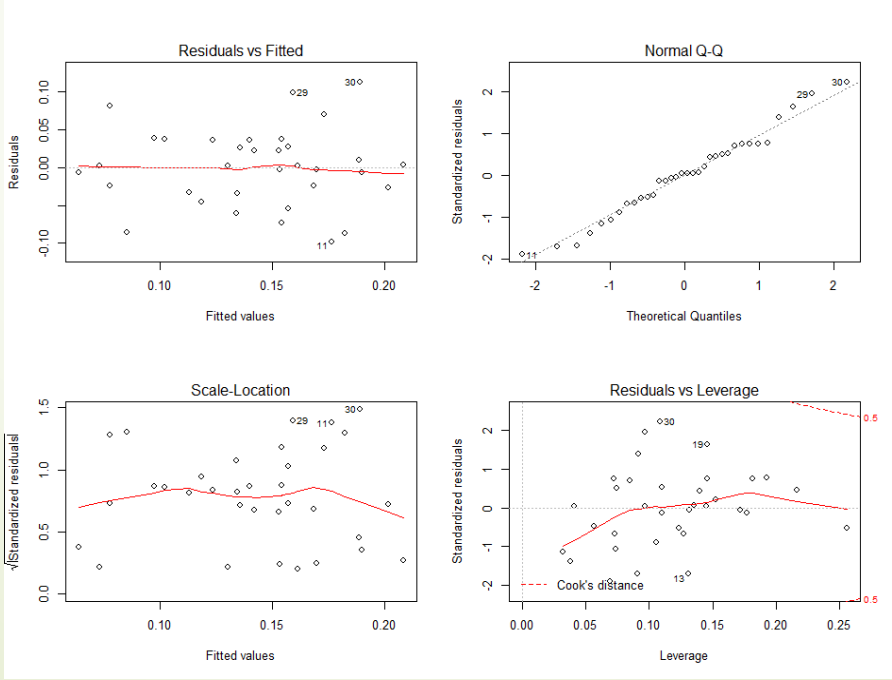

OutlookArea
WDSurvey Reaches
Outlook_Slope
<VALUE>
0 - 17.10283015
17.10283016 - 33.85662294
33.85662295 - 48.51619164
48.51619165 - 61.43057359
61.4305736 - 89.00452423
0
1
2
4 Miles
N

Regression Model

- Collected data from LiiDAR products
- Collated data from stream surveys
- Output table to R
- Created multiple linear regression to find best predictors of LWD/ft
- Fix the data – normality, variance etc…

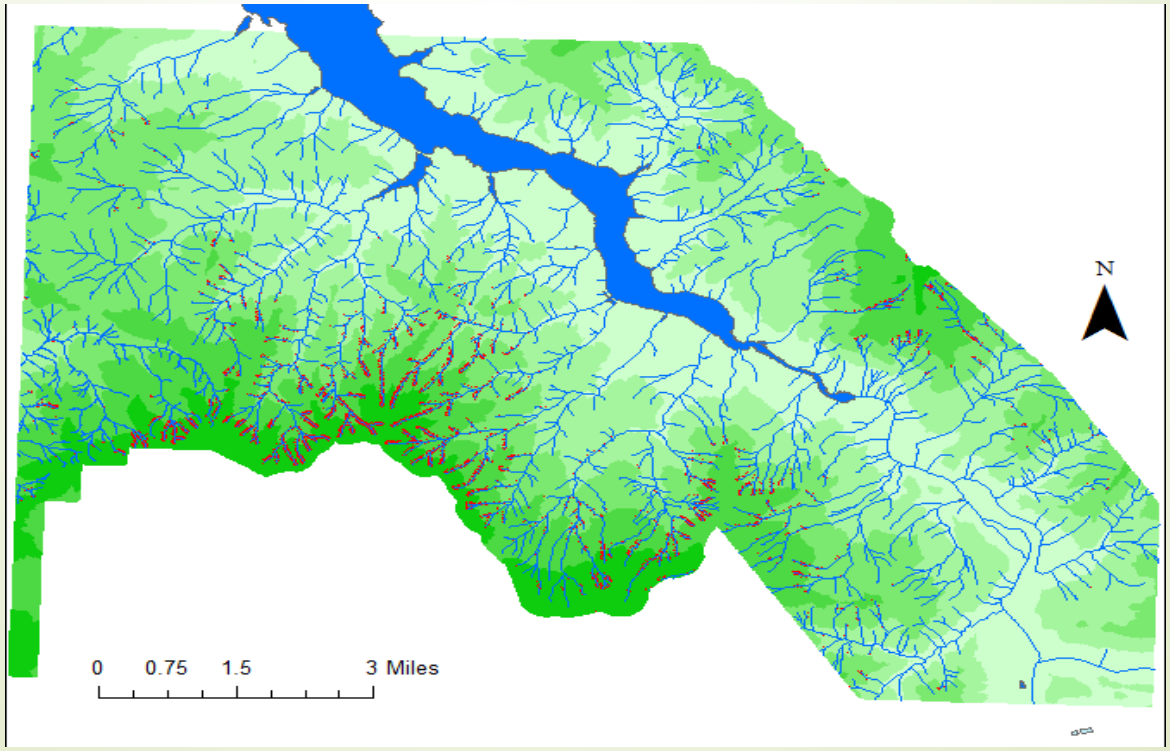
Linear Regression Model

- (Effective Wood Tota)l ^(1/2) ~ .04529 * sqrt(average slope) - .07310 * log(elevation) + 01755 * sqrt(canopy height) + .19476



Raster Calculations!

- Use the regression model to build new raster layer



Conclusions

- A learning process..
- Is this data useful? Does it make sense?
- Most locations found in headwaters. Why?
- Domain of data?
- Sample size?
- Future study?

Works Cited

Carlson, J. Y., C. W. Andrus, and H. A. Froehlich. "Woody debris, channel features, and macroinvertebrates of streams with logged and undisturbed riparian timber in northeastern Oregon, USA." *Canadian Journal of Fisheries and Aquatic Sciences* 47.6 (1990): 1103-1111.

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- White, Shannon L., et al. "Response of trout populations in five Colorado streams two decades after habitat manipulation." *Canadian journal of fisheries and aquatic sciences* 68.12 (2011): 2057-2063.