The effect of LiDAR digital elevation model resolution on stream network prediction and computational requirements

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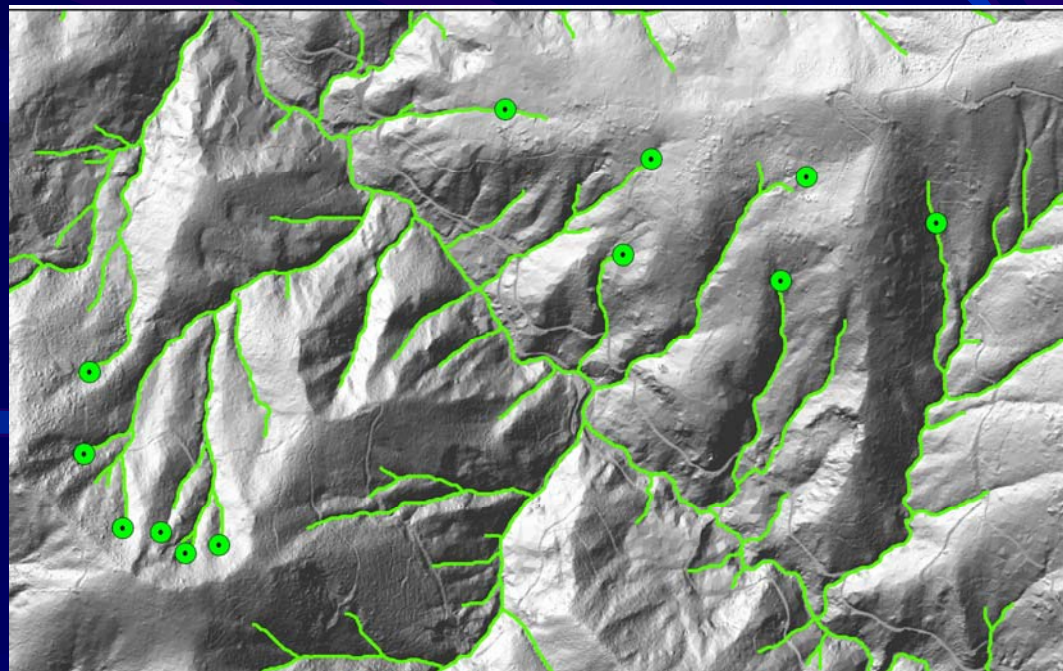
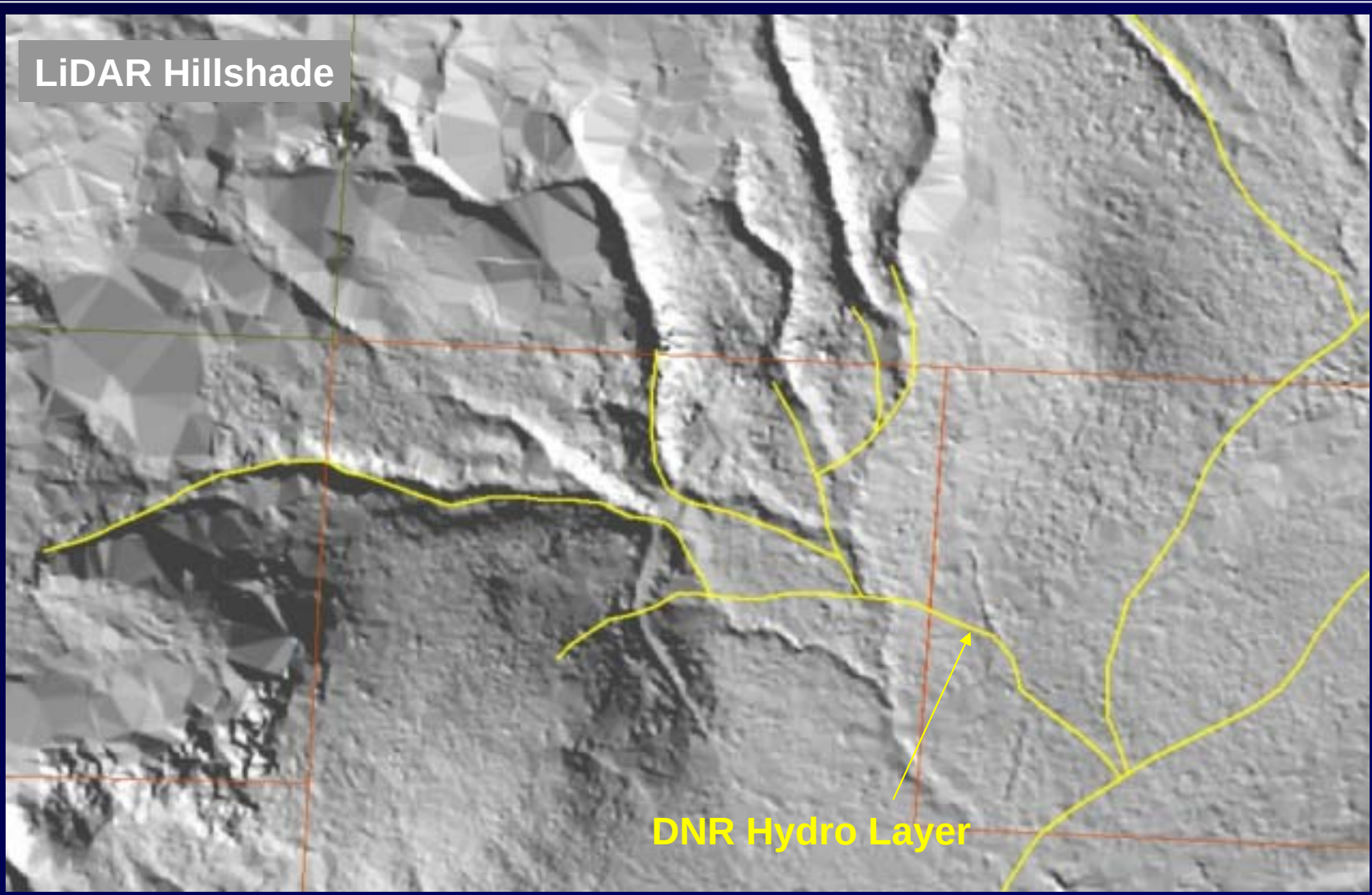


Current Stream Layer Inaccuracy



Problem

Increased protection afforded to stream networks

No clear information about geographic extent for streams

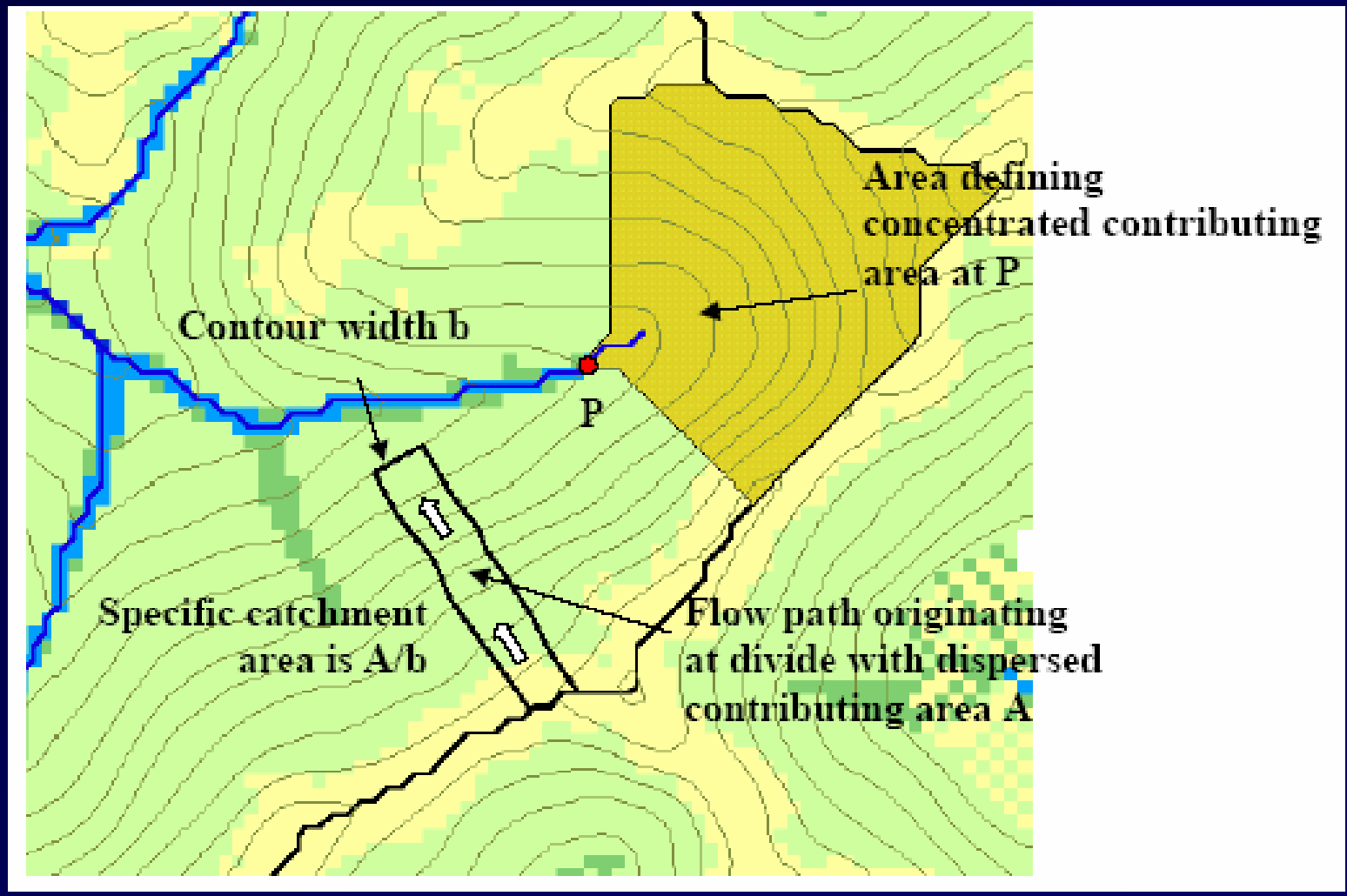
Data quality does not support the necessary detail for:

- strategic planning
- operational planning
- etc.

Stream Definition

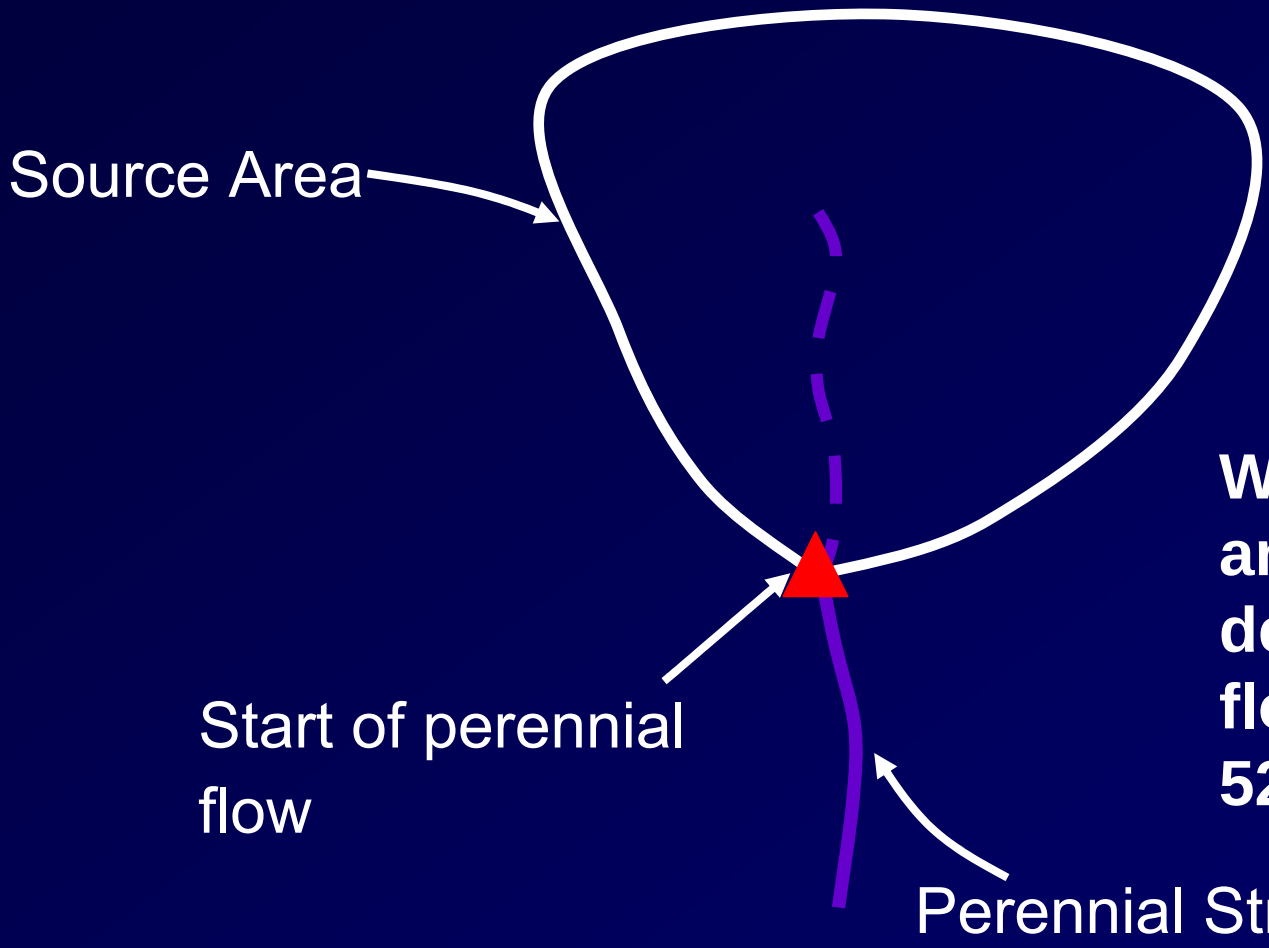
All segments of natural waters within the bankfull widths of defined channels which are either **perennial streams** (waters that do not go dry any time of a year of normal rainfall) or are physically connected by an **above-ground channel system** to downstream waters

Where Streams Begin



(Tarboton 2003)

Where Streams Begin



WAC 222-16-030 and 222-16-031 defines perennial flow for our site at 52 acre source area

Questions

- Does an increase in resolution improve stream channel determination?
- Can stream types be determined more accurately using LiDAR datasets?
- Should a new algorithm be developed for identifying perennial streams?

Research Topics

- Flow Directions Utilized
- Effects of Resolution on Flow Direction
- Flow Direction Comparison
- Perennial Stream Classification

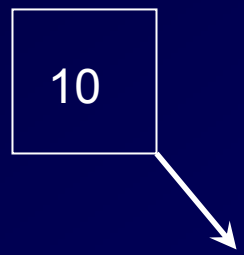
Flow Direction Algorithms

Block Centered

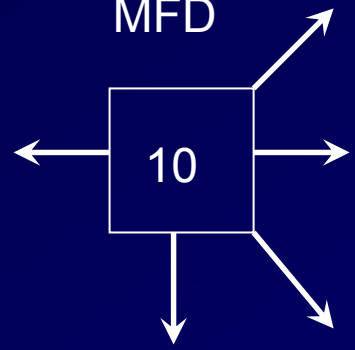
12	11	9
9	10	8
11	7	5

Edge Centered

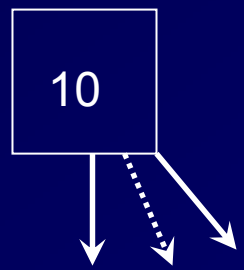
D8



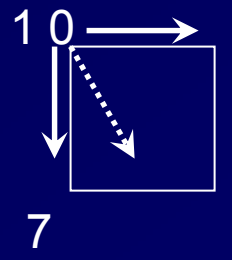
MFD



Dinf 304 degrees



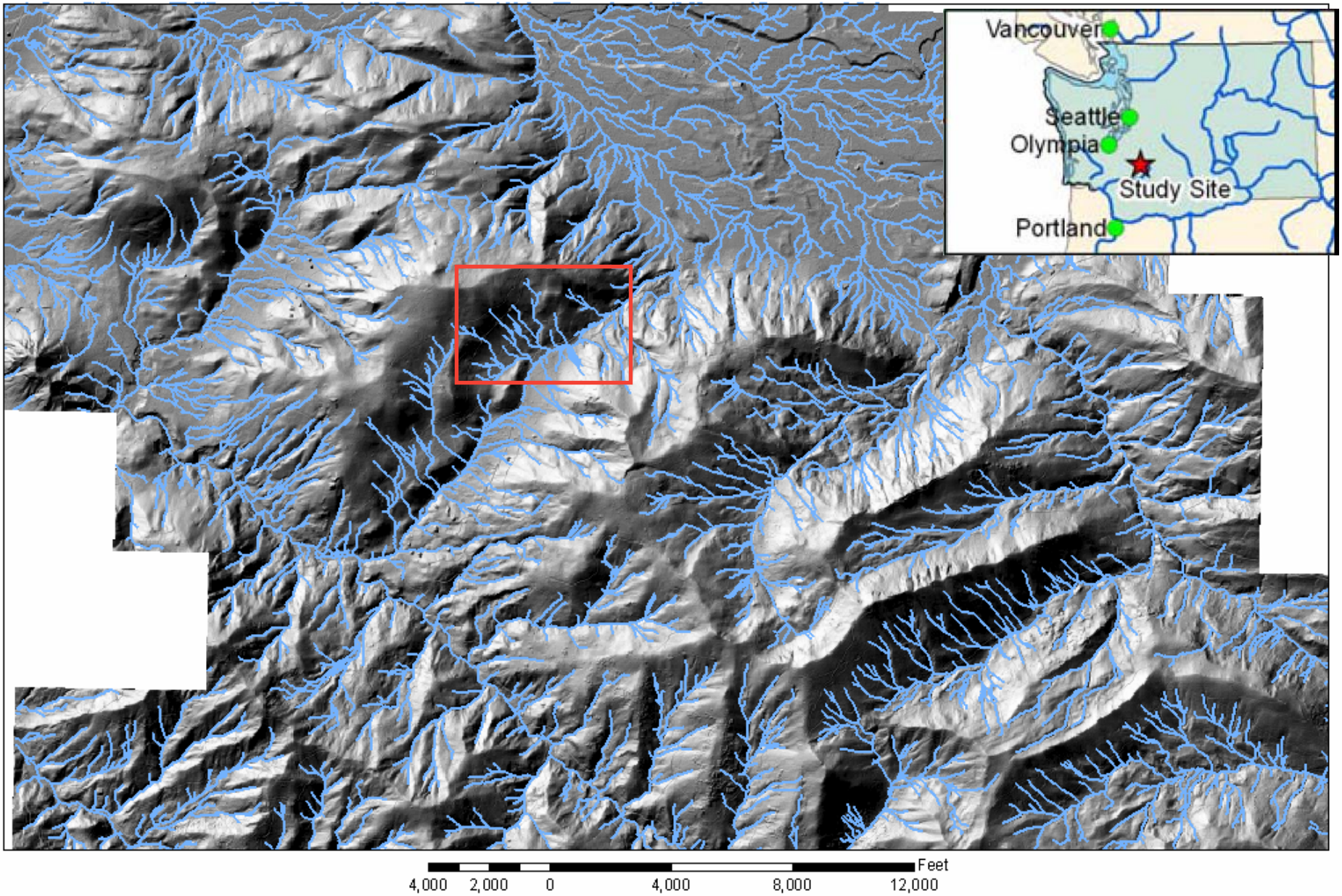
DEMON 304 degrees



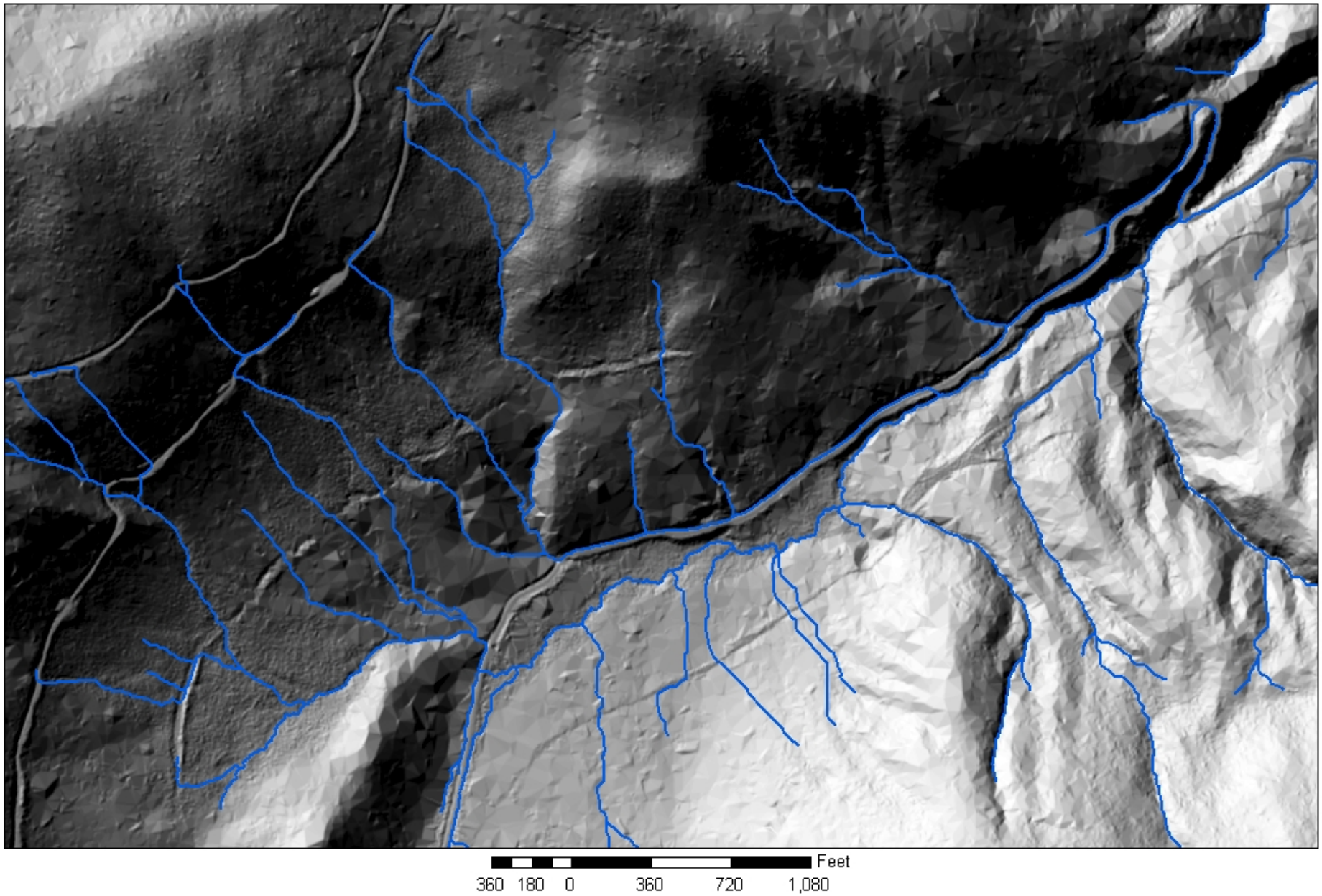
Topography Sources

- The Flow Direction Algorithm is tested on:
  - 2m Pixel Size LiDAR Grid
  - 6m Pixel Size LiDAR Grid
  - 10m Pixel Size LiDAR Grid
  - 10m USGS DEM Grid

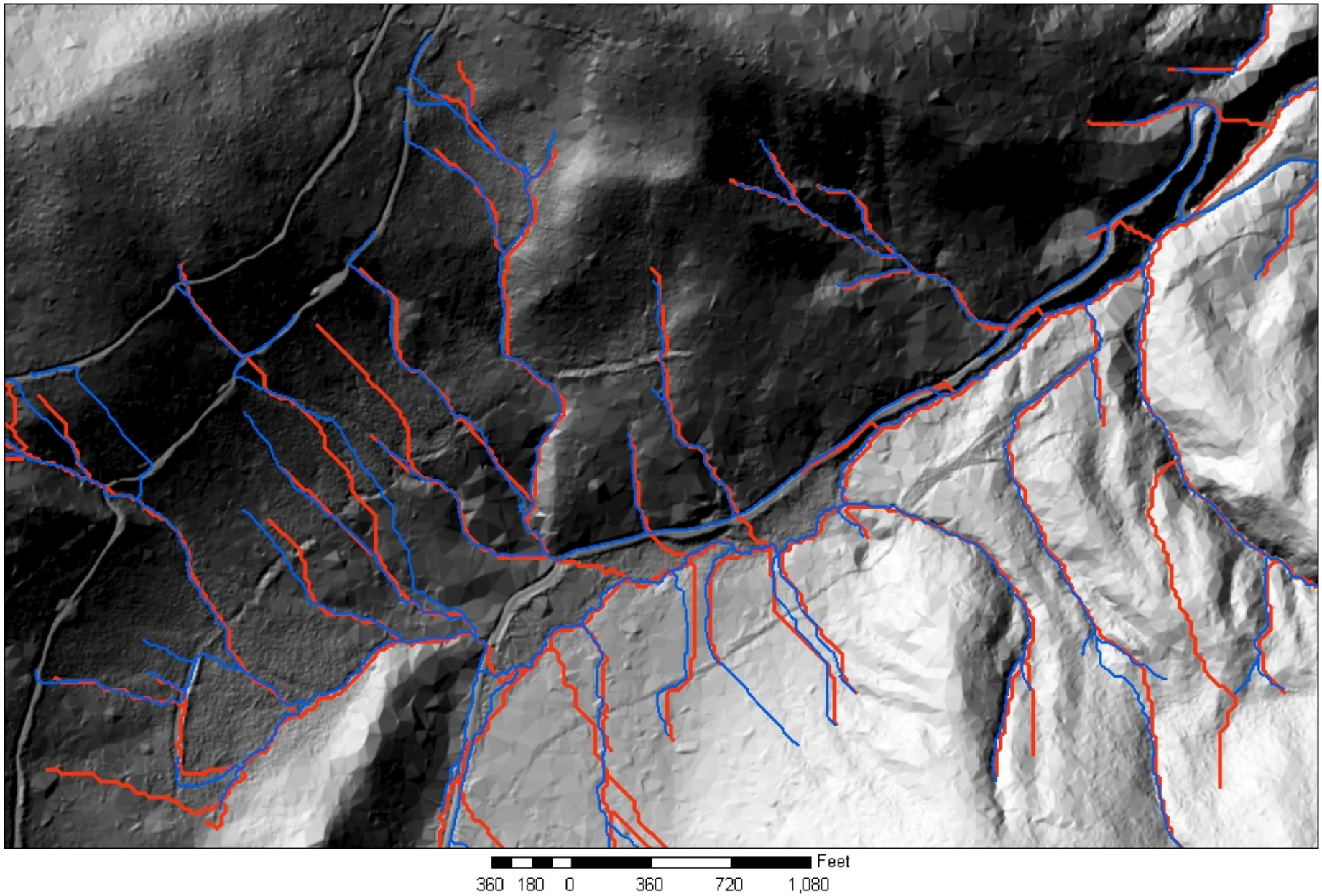
Site of Interest in Red



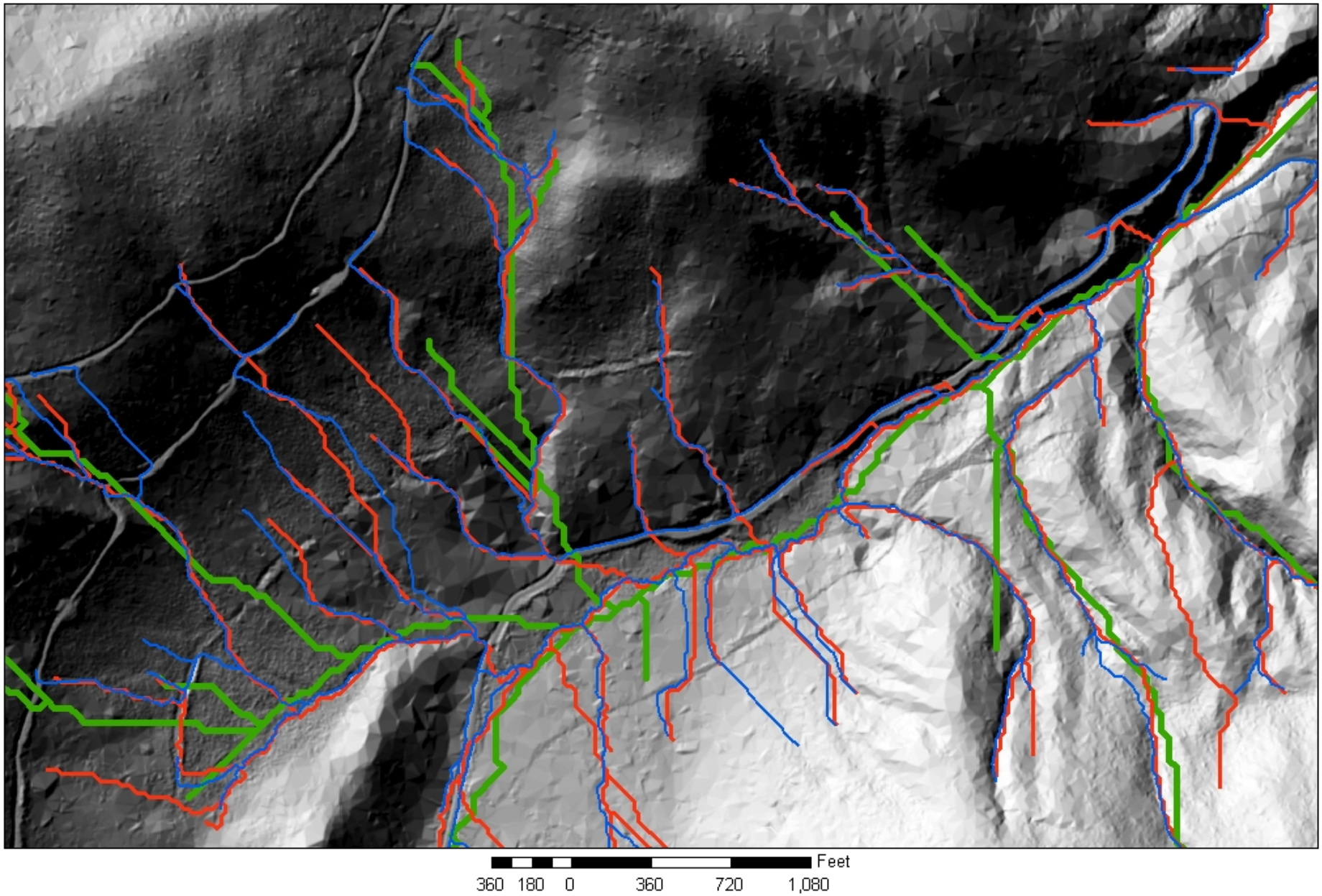
D8 on DEM (2 m)



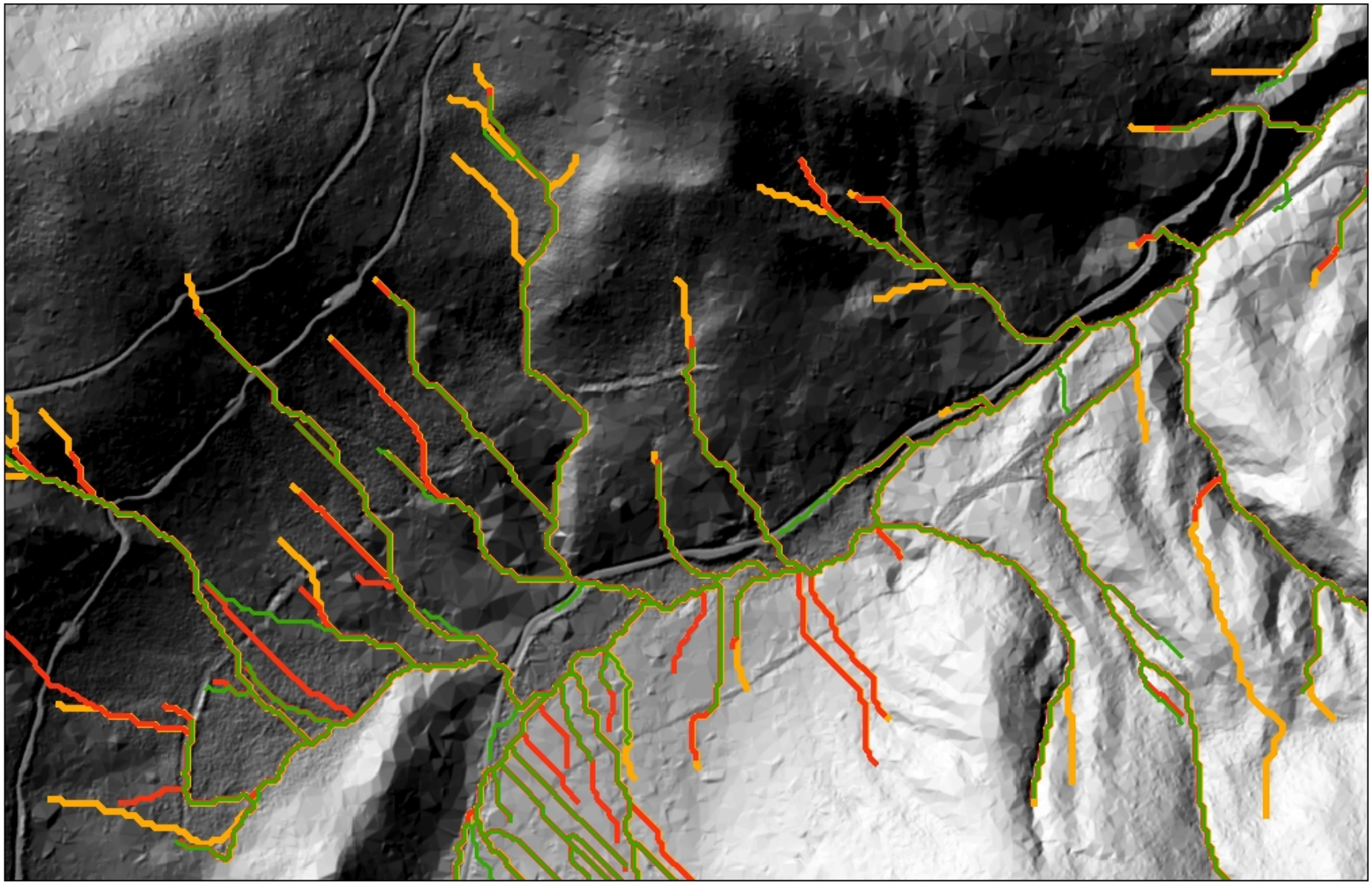
D8 on DEMs (2m – blue, 6m – red)



D8 on DEMs (2m -- blue, 6m -- red, 10m -- green)



Streams on the 6m LiDAR DEM



Orange - D8, Red - Dinf

Green - MFD

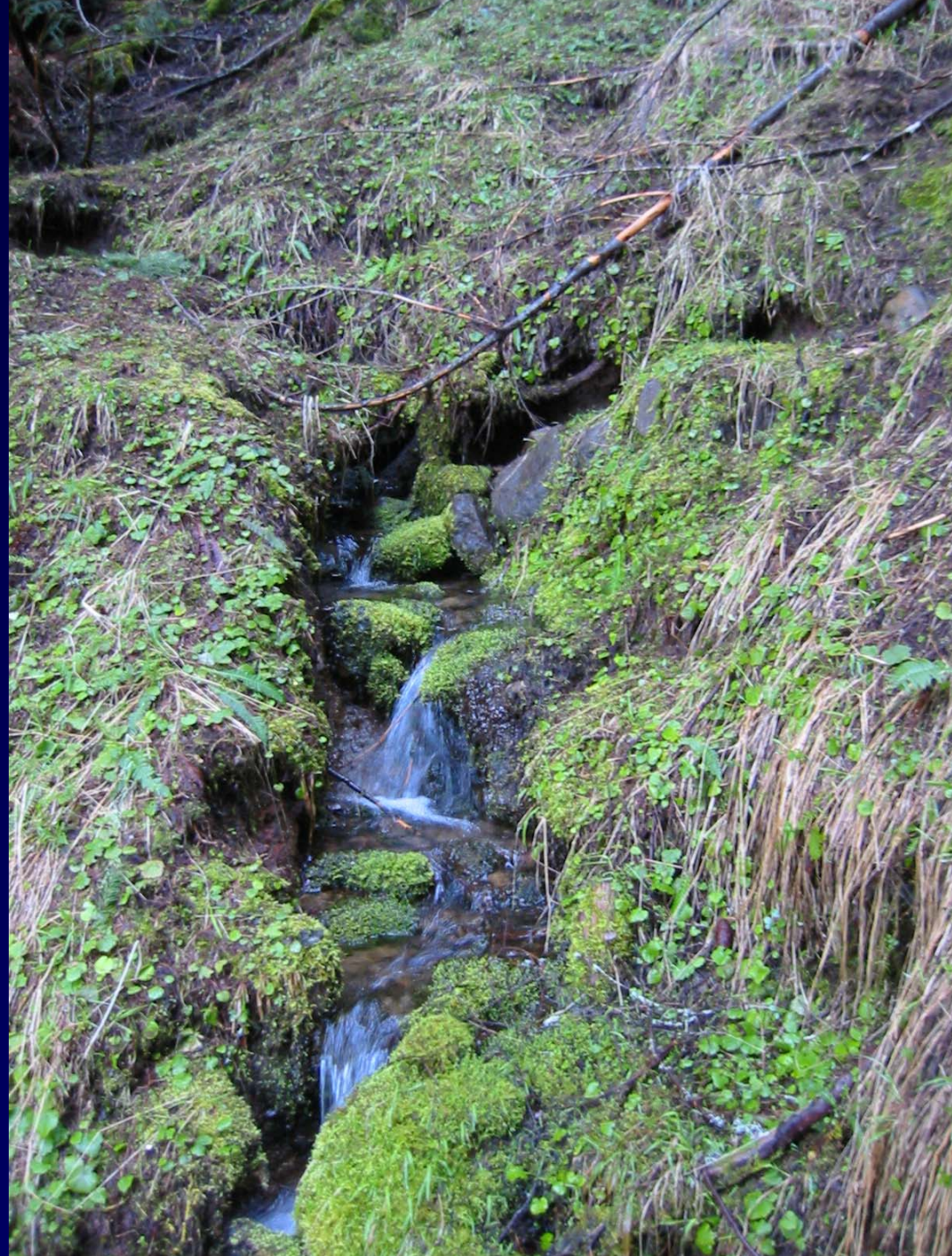
Flow Direction Convergence

- D8 and Demon Converge with increasing resolutions

Basin Convergence (ha)	Demon vs D8
2-m LiDAR DEM	5.0
6-m LiDAR DEM	6.8
10-m LiDAR DEM	9.1
10-m USGS DEM	30.4

- Dinf and MFD do not converge with each other or D8 and Demon

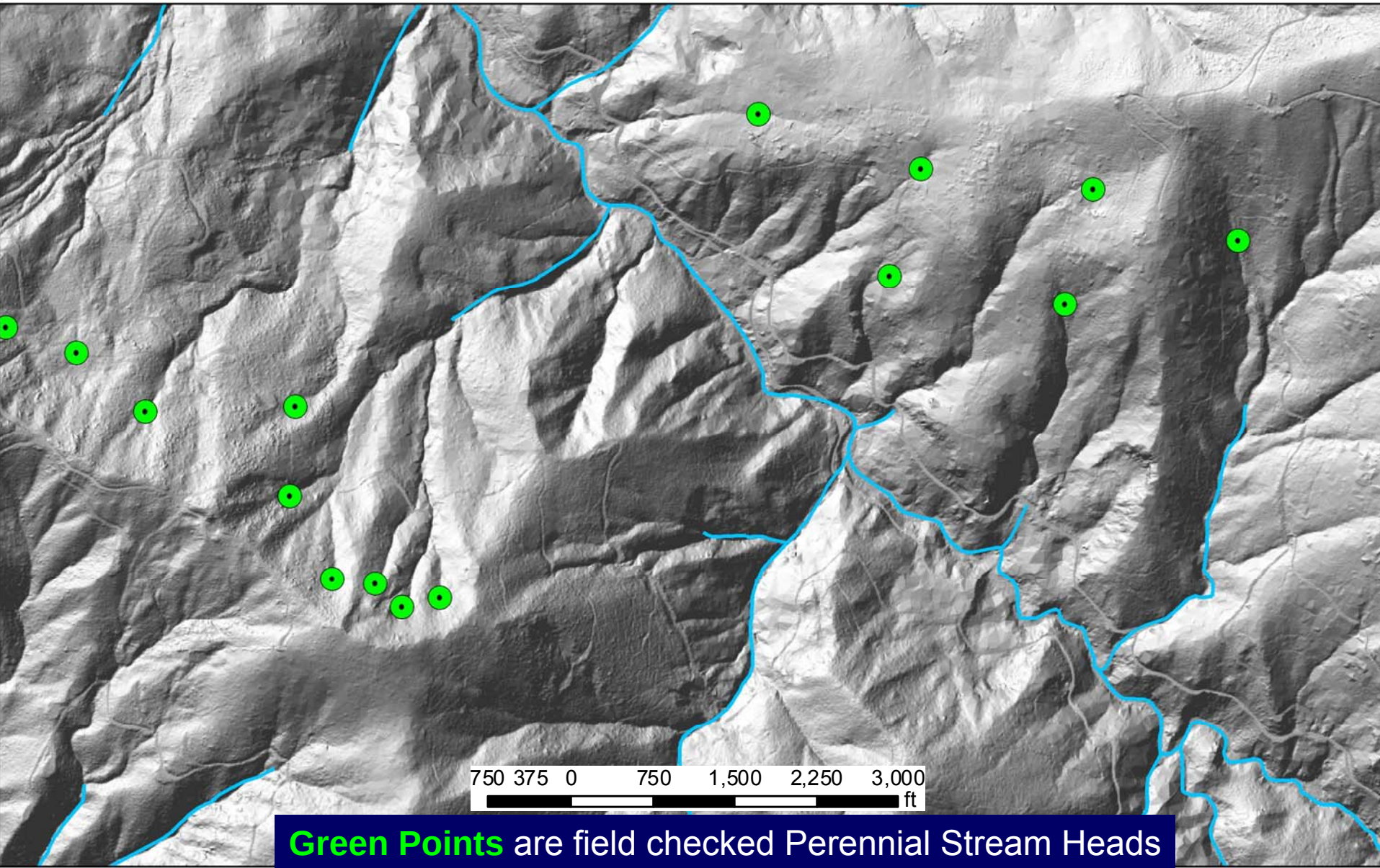
Perrenial Stream Classification



Model Development
Perennial Heads

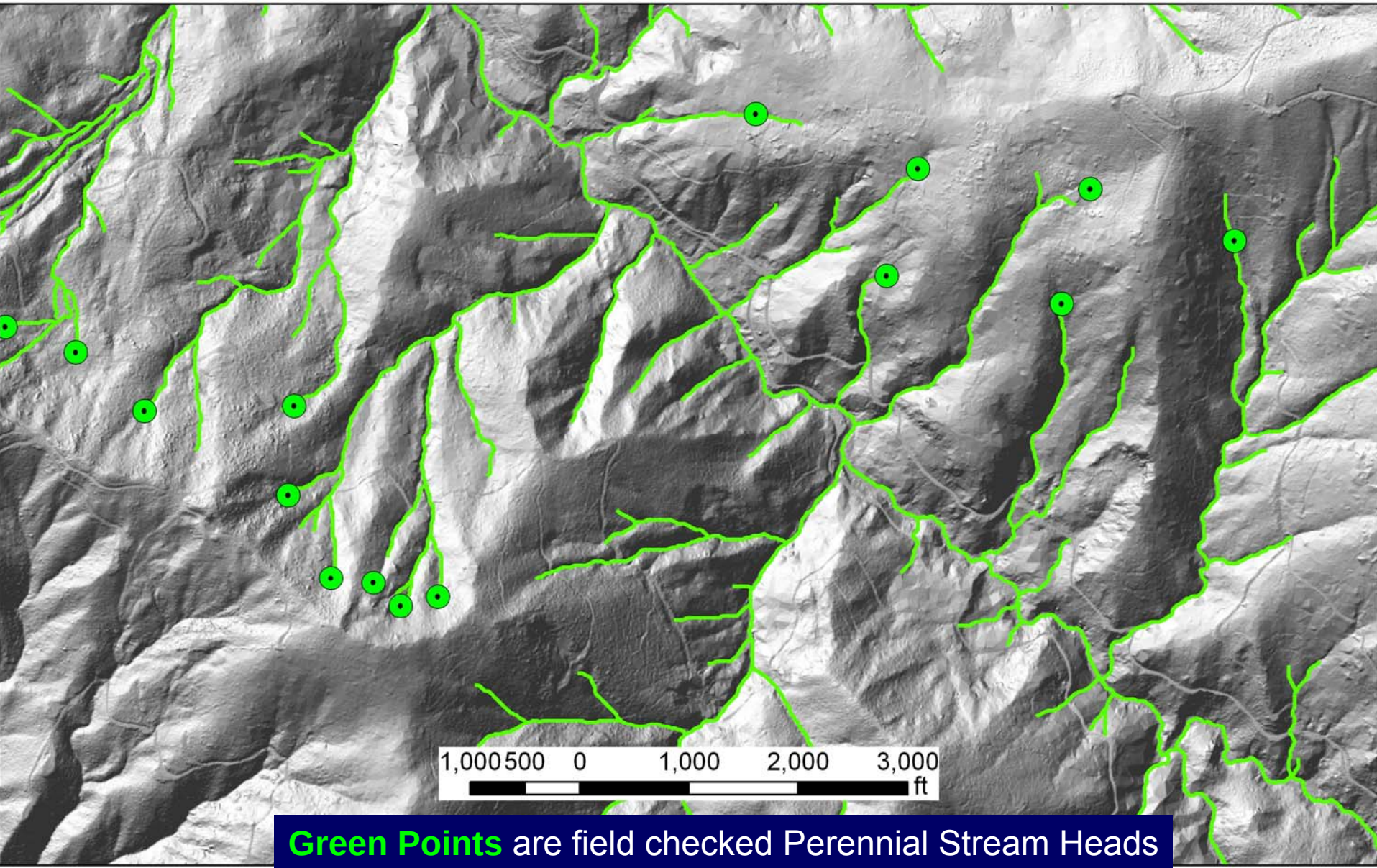
- Field Locate Perennial Initiation Points (PIP)
- Uses D-8 raster flow direction processes
- Binomial Linear Regression (50 ft spread)
- Algorithm uses:
  - Basin Size
  - Percent Slope
  - Precipitation
- Algorithm could not use:
  - Downstream Gradient, Site Class, Forest Density

DNR Hydro Layer vs. … Perrenial, Class 1-44'



Green Points are field checked Perennial Stream Heads

LiDAR DEM (D8 – 6m)
'Perennial, Class 1-44'



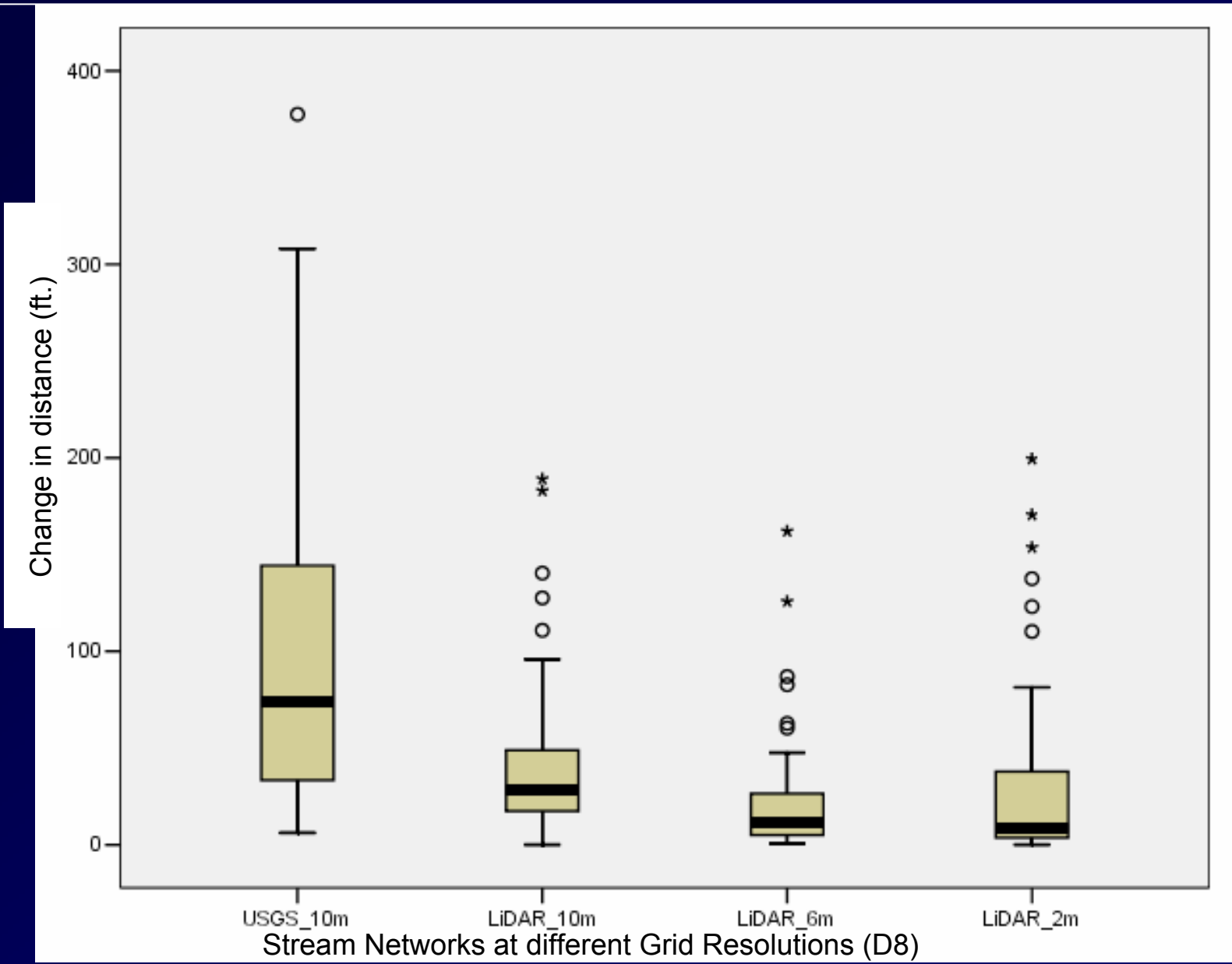
Green Points are field checked Perennial Stream Heads

Potential errors in calculated stream lengths and buffer areas based on DNR and LiDAR-derived stream data

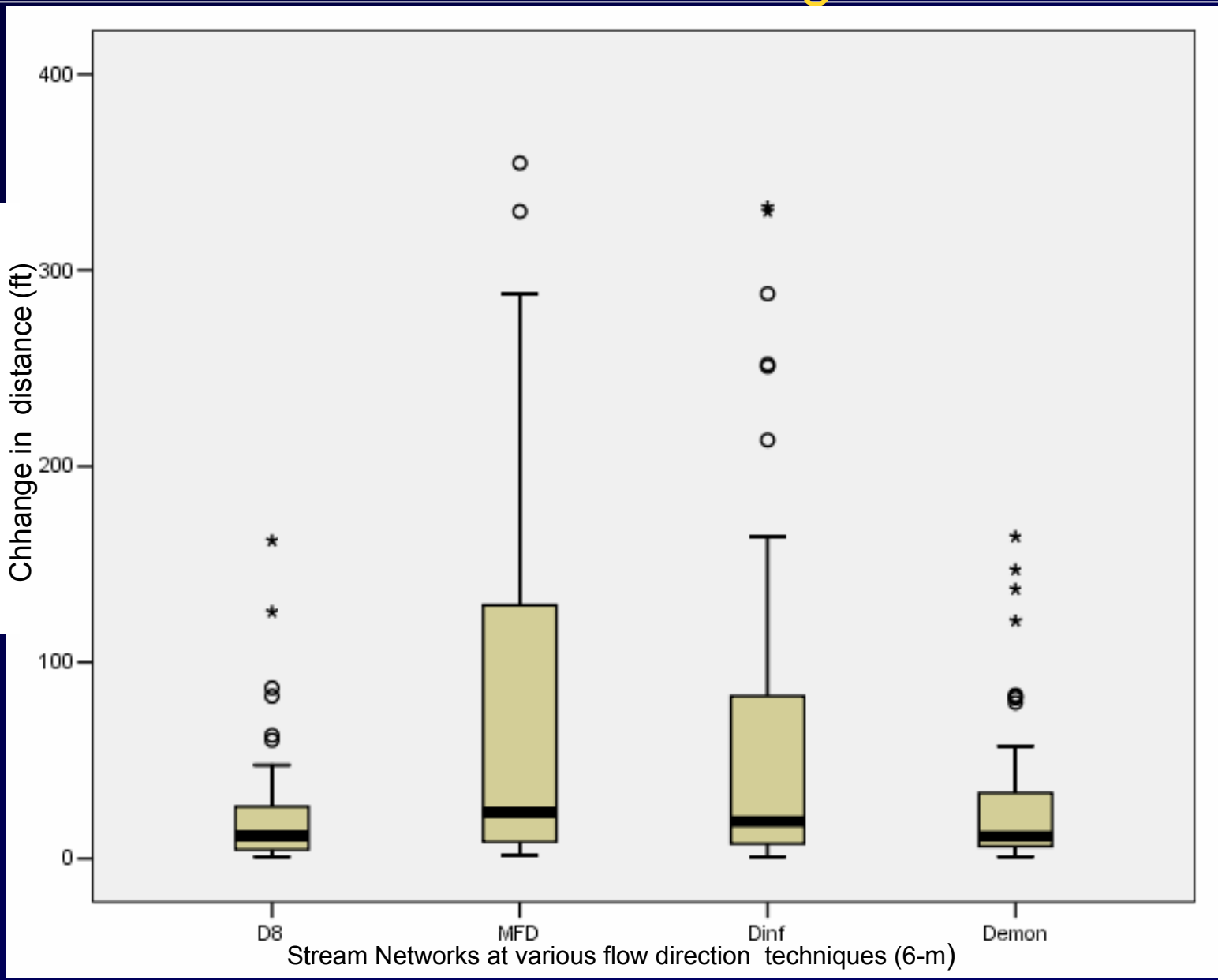
Dataset	Length (km)	Buffer Area (ha)*
DNR Hydro Layer based in part using USGS 7.5'	68	240
LiDAR Streams (6-m)	362	860

* Uniform 30-m buffer for both datasets for Perennial flow

The change in distance between modeled and field-verified stream head location at a given resolution



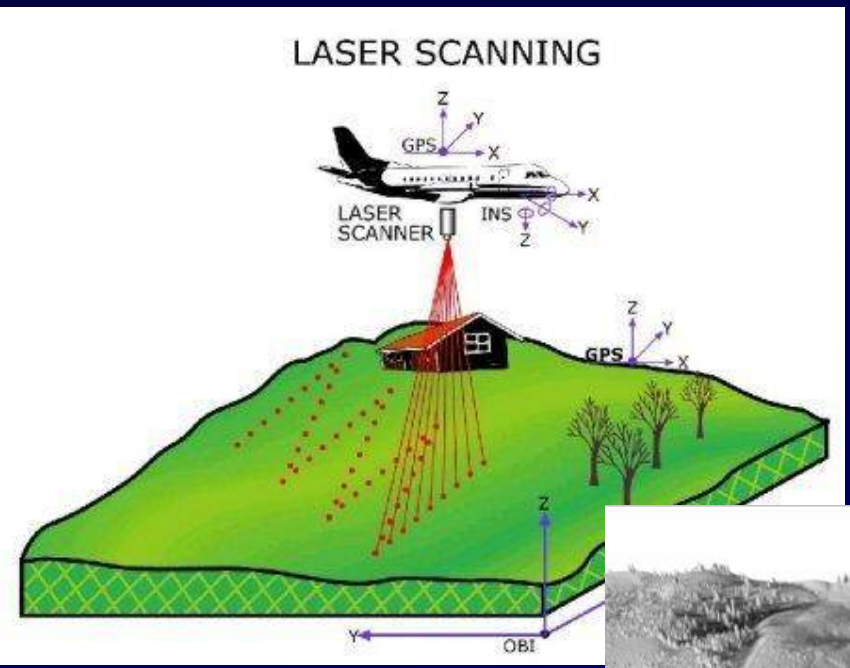
The range in distance between modeled and field-verified stream head location using different models

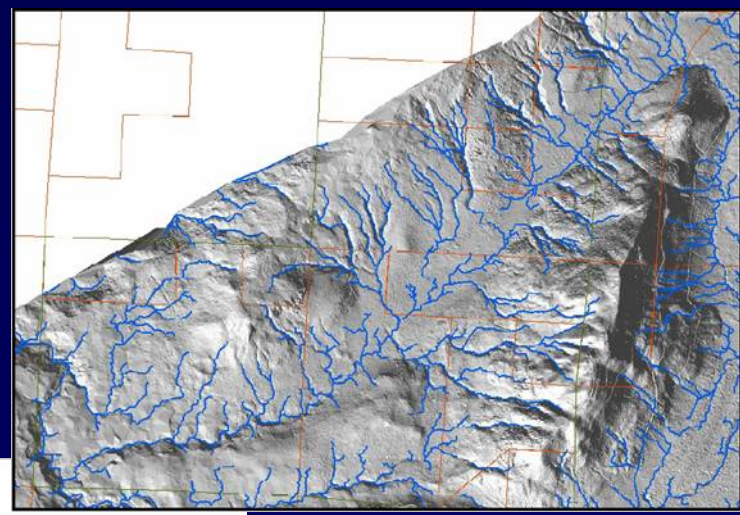


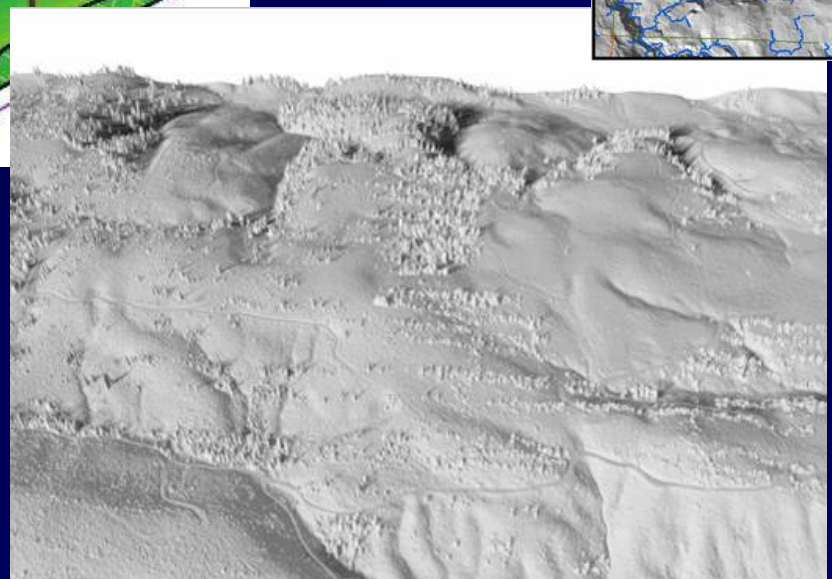
Conclusion

- An increase in resolution improved stream channel determination
- Stream types can be determined more accurately using LiDAR datasets
- A new algorithm does not need to be developed for identifying perennial streams because computationally demanding flow algorithms (DEMON) don't vary from simple flow algorithms (D8)

Questions?

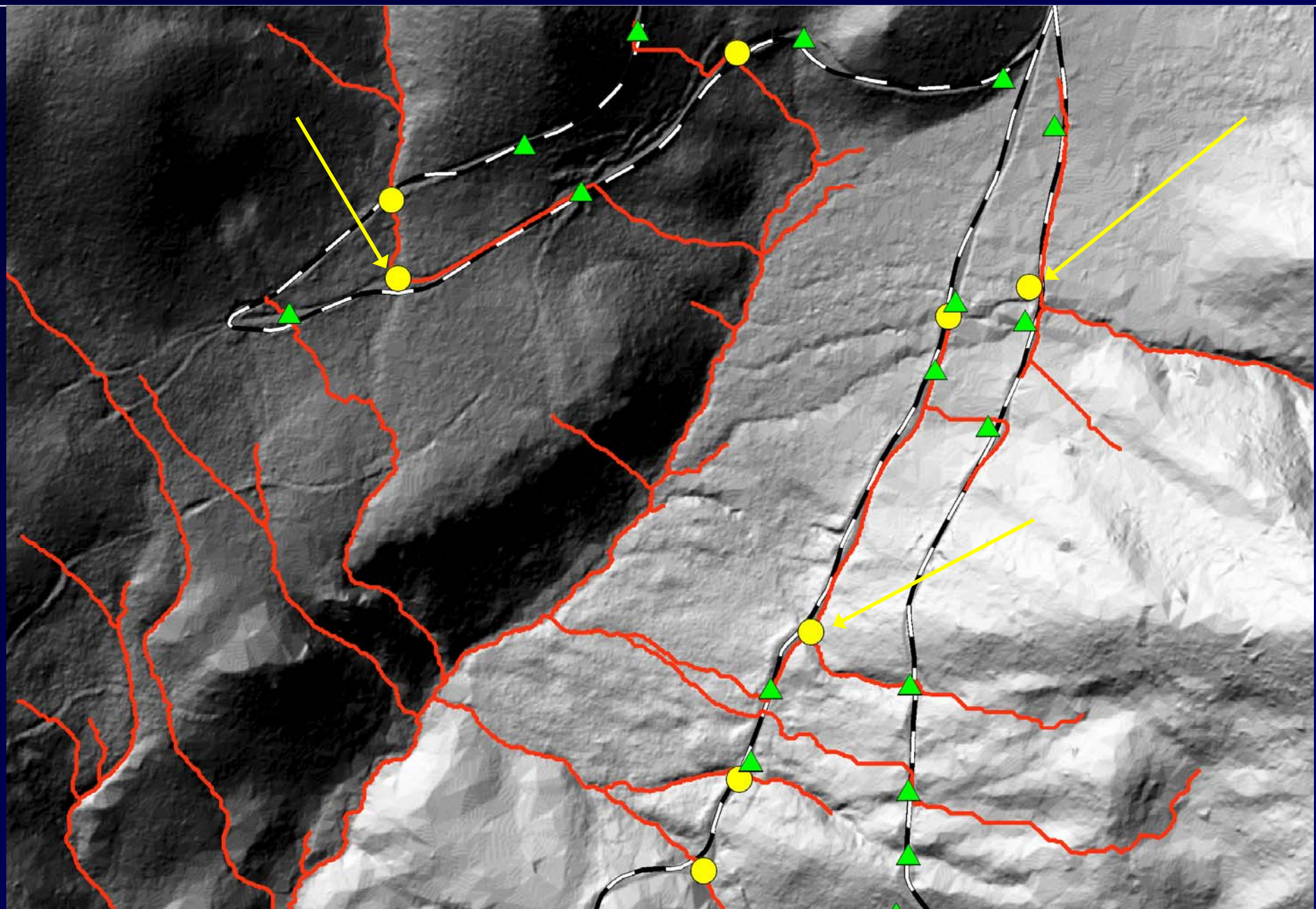




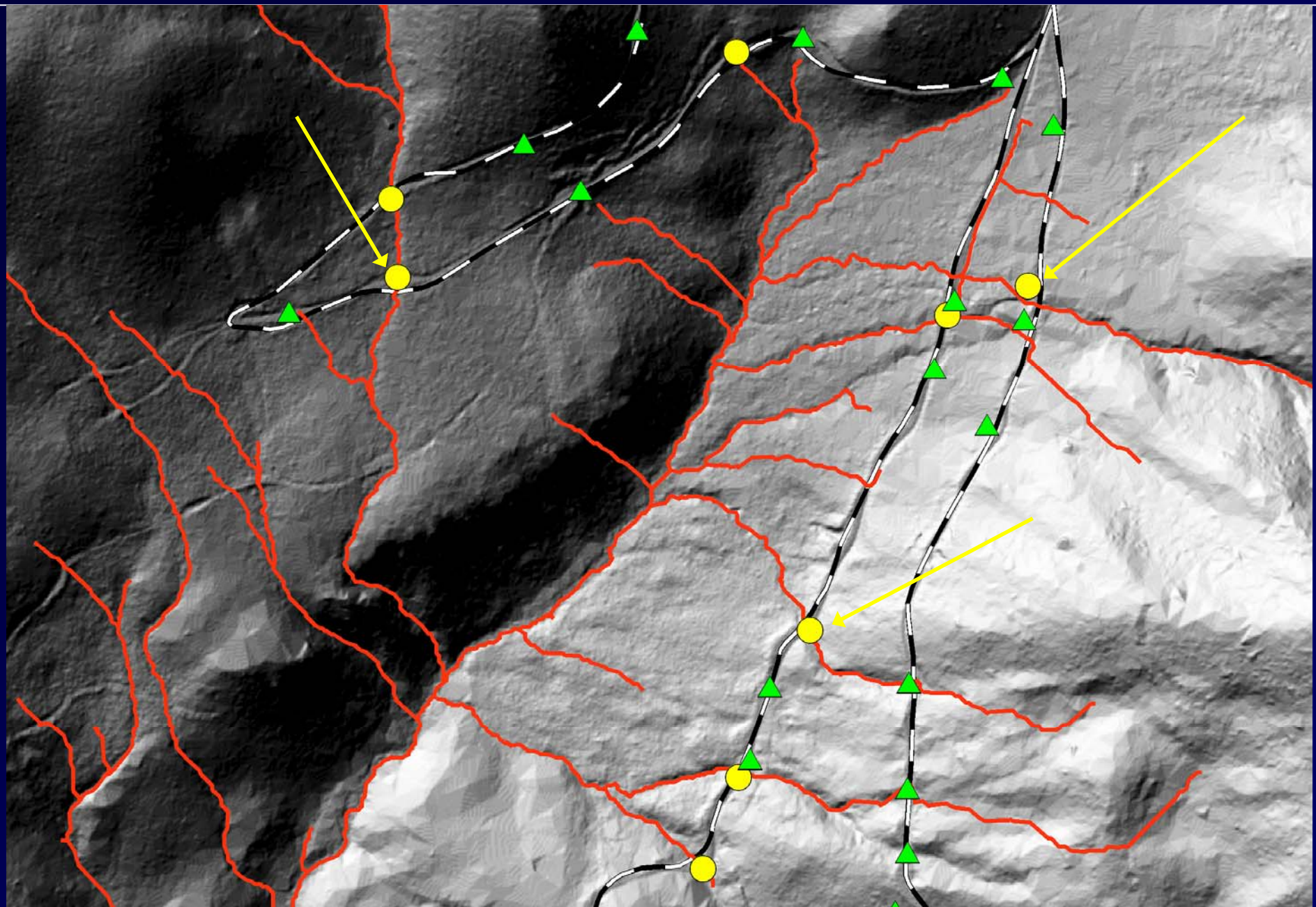


Road Influence with Increased Resolution

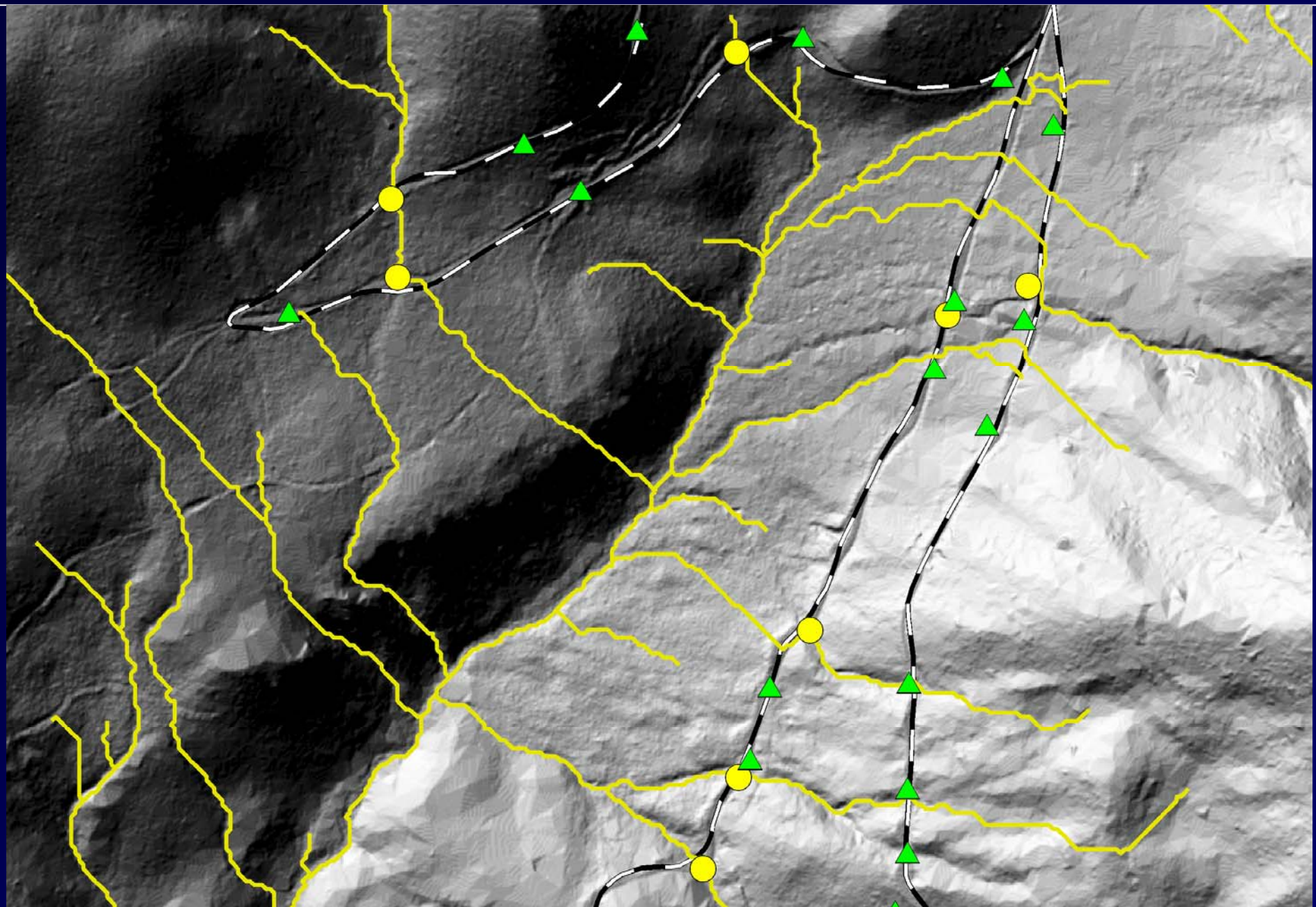
Road Effects -- 2-m Uncorrected



Road Effects -- 2m LiDAR Corrected



Road Effects -- 6-m LiDAR



Fish Stream Determination

Model Development
Fish Location

Cooperative Monitoring, Evaluation, and Research Group (CMER)

Determines End of Fish Points (EOFP)

- D-8 raster flow direction processes
- Algorithm uses:
  - Elevation
  - Down slope gradient
  - Basin Size
  - Precipitation

Model Development
Fish Location

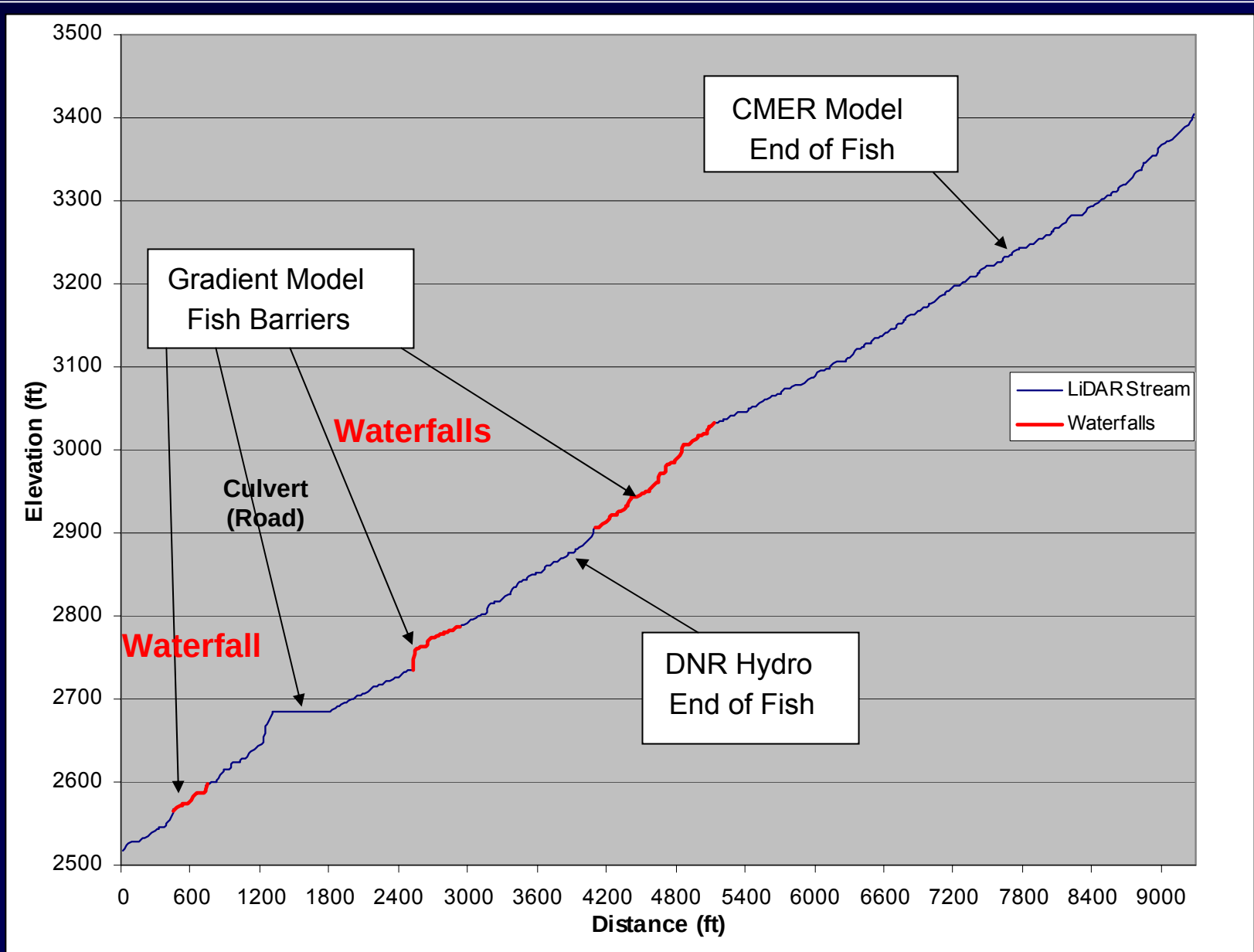
Physical Constraints on trout distribution in the Cascade Mountains (2003)

Determines fish habitat location

- Based on physical constraints
- Algorithm uses:
  - Downstream Gradient
- Grade > 13% = fish barrier (100 meters mean)

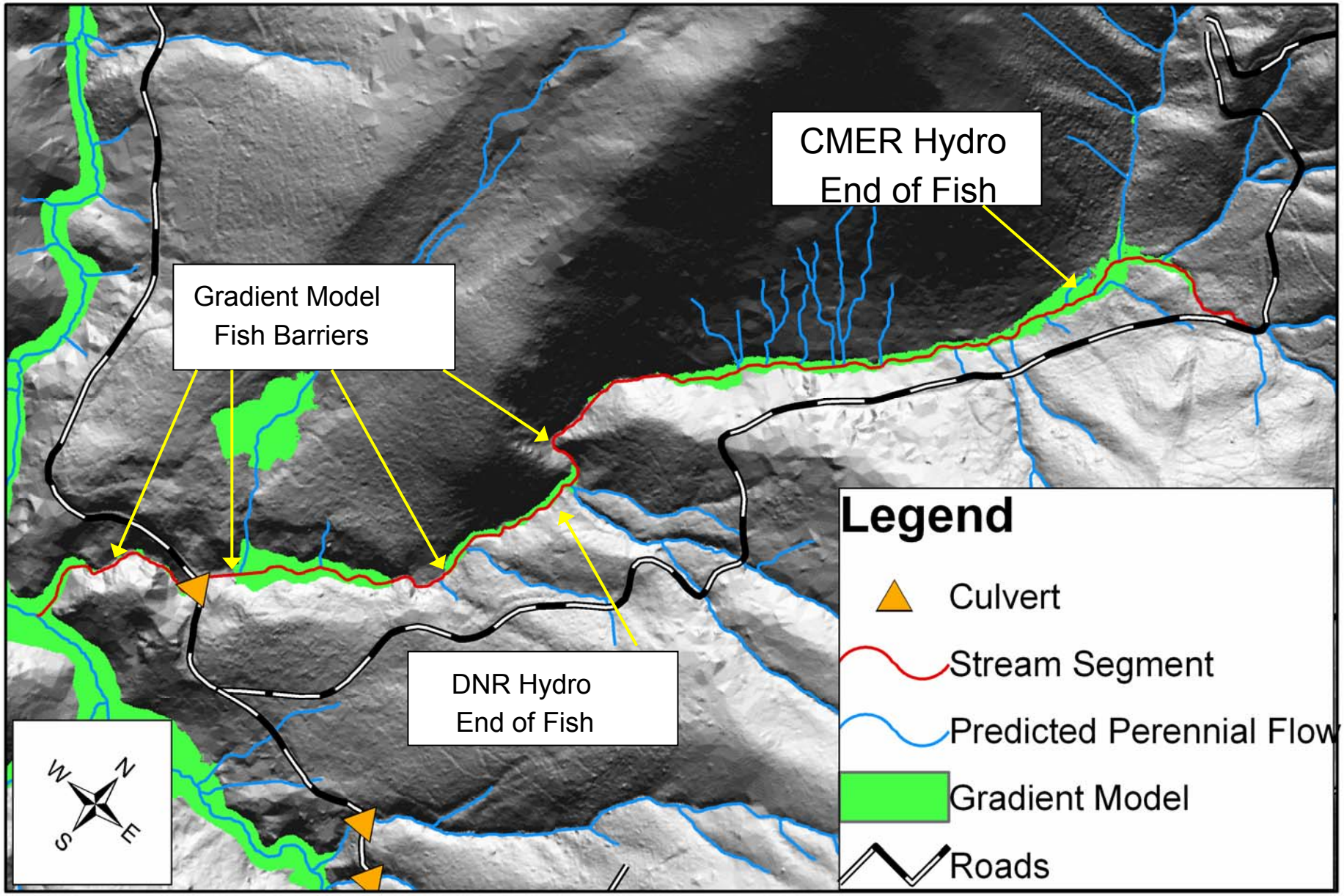
Predicted Fish Habitat

Barriers define in the field



Predicted Fish Habitat Gradient

Barriers define in the field



Predicted Fish-Bearing Streams using different techniques

Dataset for Fish-Bearing	Length (km)
DNR Hydro Layer	18.0
CMER Model	22.4
Gradient Model	14.5

- Using the Gradient Model, fish-bearing streams decrease 24% from the DNR Hydro layer.
- The CMER Model potentially overestimates fish-bearing streams by 54% when compared to the Gradient Model.

Acknowledgement

I am grateful to Peter Schiess for giving me the opportunity to take on this project and truck through it as desired and Finn Krogstad for his ability to handle a bombardment of questions. Thank you to David Montgomery and Steven Burges for advising me on the ways of hydrobiology and then some; Luke Rogers and Phil Hurvitz for early GIS advice; Hans-Erik Anderson for LiDAR pre-processing; Bob McGaughey for various advice; David Tarboton and Theodore Endreny for question regarding resolution and modeling; and Julie Forcier for grammatical help. Can't forget Capstone 2005 which is composed of Adam Baines, Lou Beck, Ben Carlson, Mark Williams, Sara Wilson, Edwin Wong,and Amy Hawk for their assistance during field collection. The Washington State DNR provided the financial support for this study and then some more.

Stats on the PIP Model

The final Linear Regression model for PIP used fewer variables than expected. The final model selected Basin Size using D8, Percent Slope, and Precipitation. Downstream gradient, forest density, elevation, and site class could not be used to create the equation for determining stream head locations based on a 0.05 significance level. The Hosmer-Lemeshow chi-square statistic for this model was 10.262 and the -2 Log likelihood statistic was 80.130. Self-classification accuracies for this model were 77.4% for perennial flow and 88.7% for non-perennial flow.

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