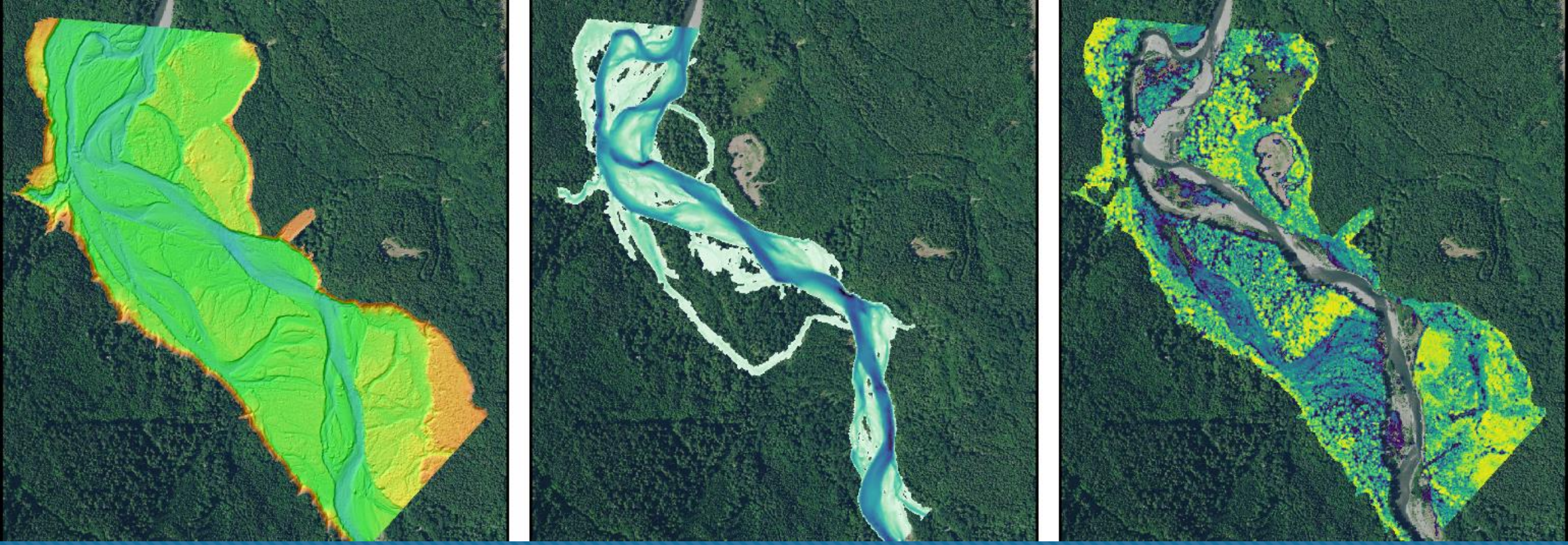


Remote Sensing For Natural Resource Management

A Brief Overview of Options

CRAMER FISH SCIENCES®
An Employee Owned Consulting Company

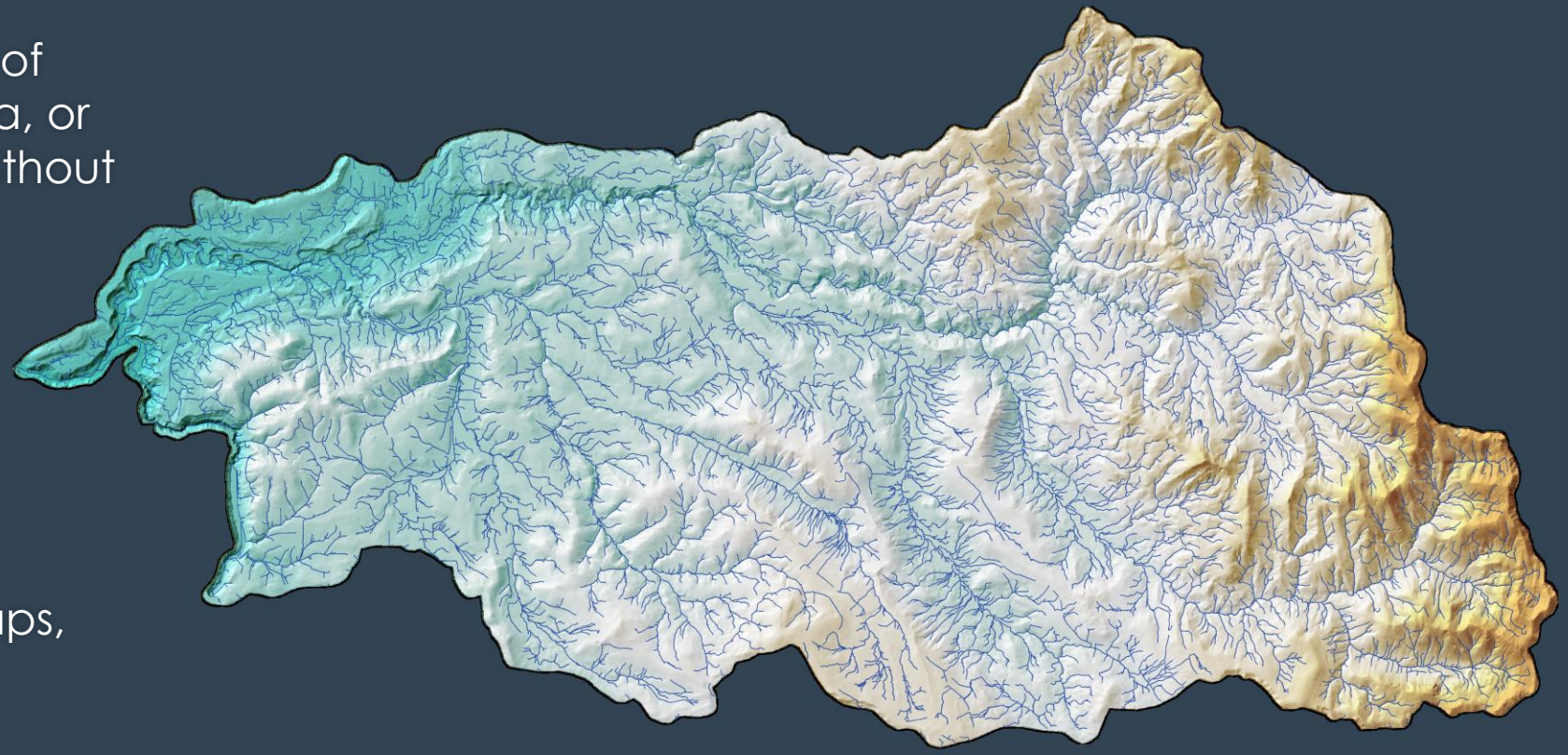
Remote Sensing

The collection and interpretation of information about an object, area, or phenomenon from a distance, without physical contact.

Data from:

- Satellite and Aerial imagery
- RADAR, LiDAR

- Deployed sensors (Camera traps, Temperature loggers, etc.)
- eDNA in streams



Overview

01 Aerial Imagery

02 Digital Elevation Models

03 Point Clouds

04 Spatial Modeling

05 Field Components

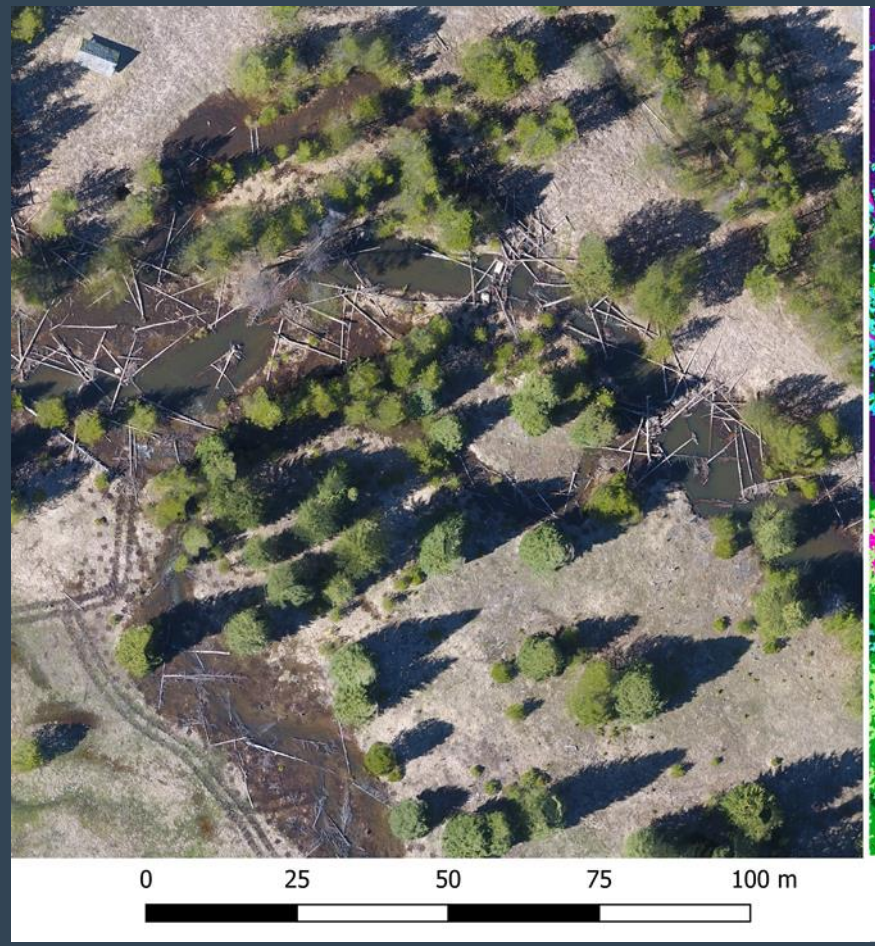
06 Known Issues

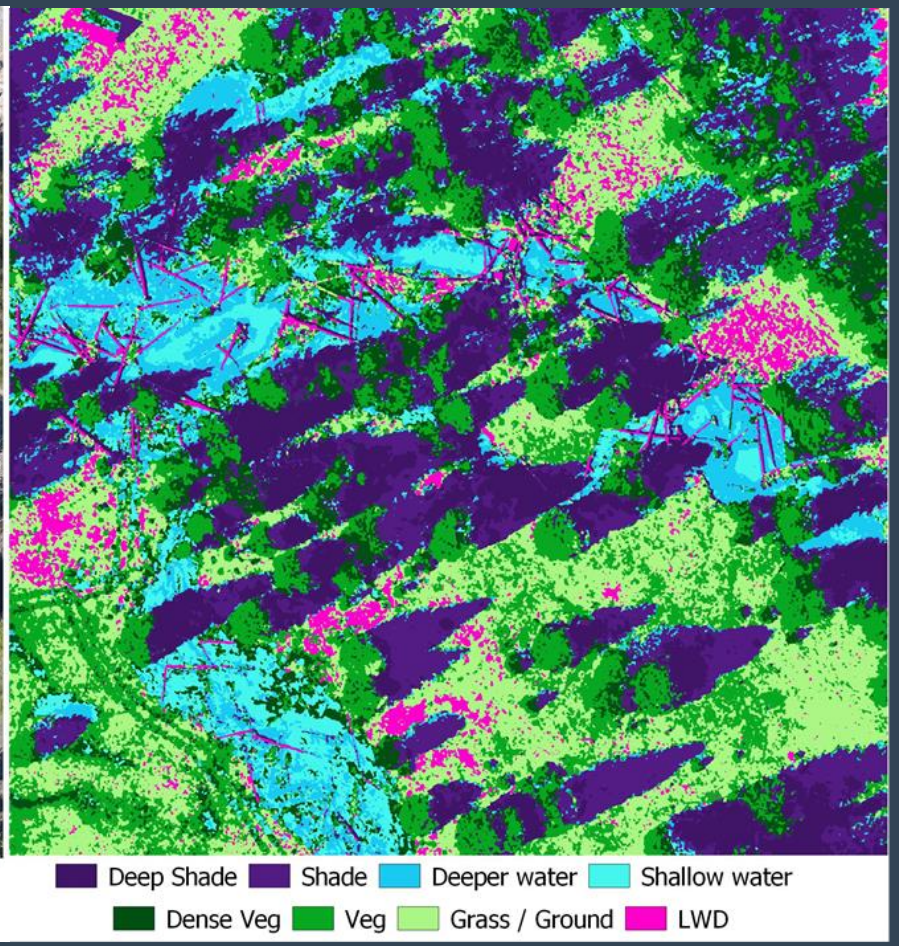
Aerial Imagery

Georeferenced photos from above: kites, UAVs, fixed wing aircrafts, satellites, etc..

Allows for pixel-based classification

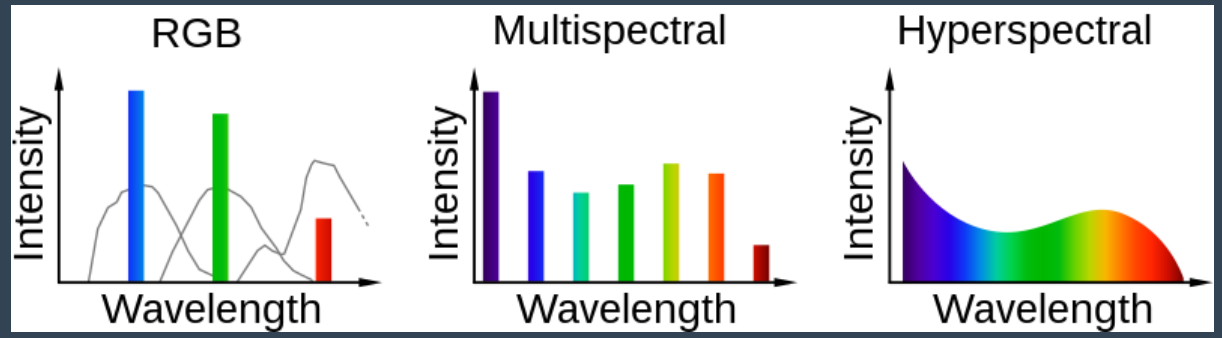
- Land Cover Classification
- Unit Delineation
- LWD Estimates
- Feature identification: Bridges, Landslides, Log Jams

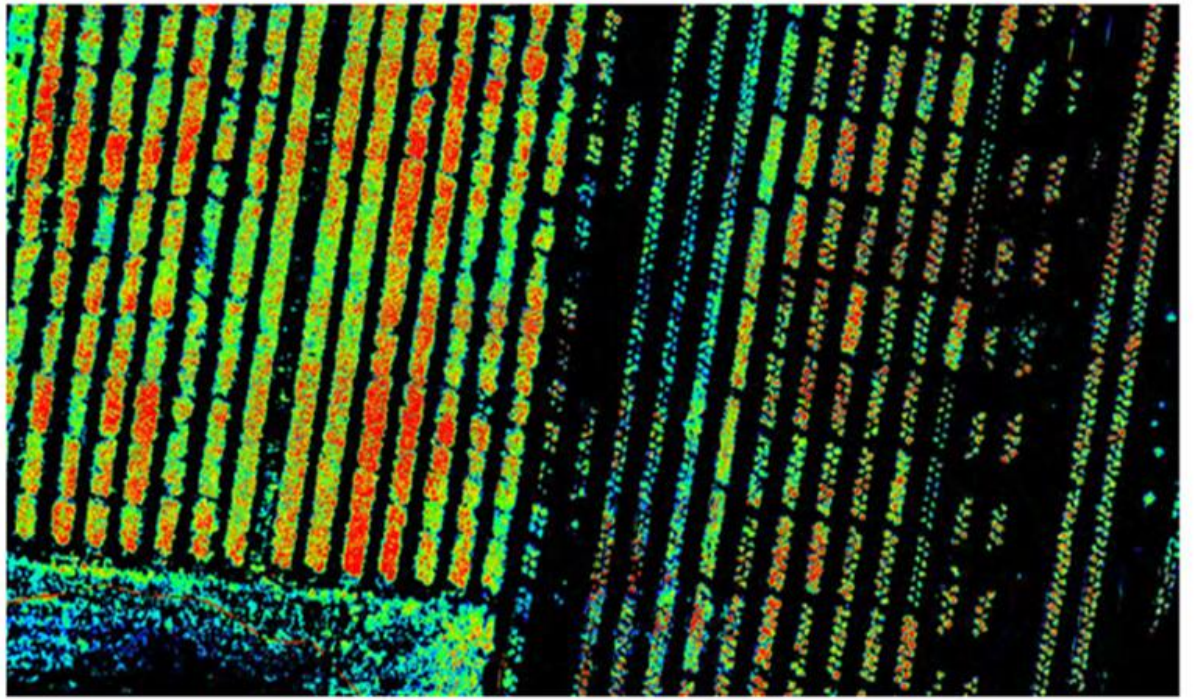




Aerial Imagery

- Standard Imagery is 3-band RGB
- Multispectral allows for more: hardwood vs conifer, forest health, wetland delineation, etc.
- Hyper spectral can potentially go even further: Plant Species / material identification, plant growth and survival





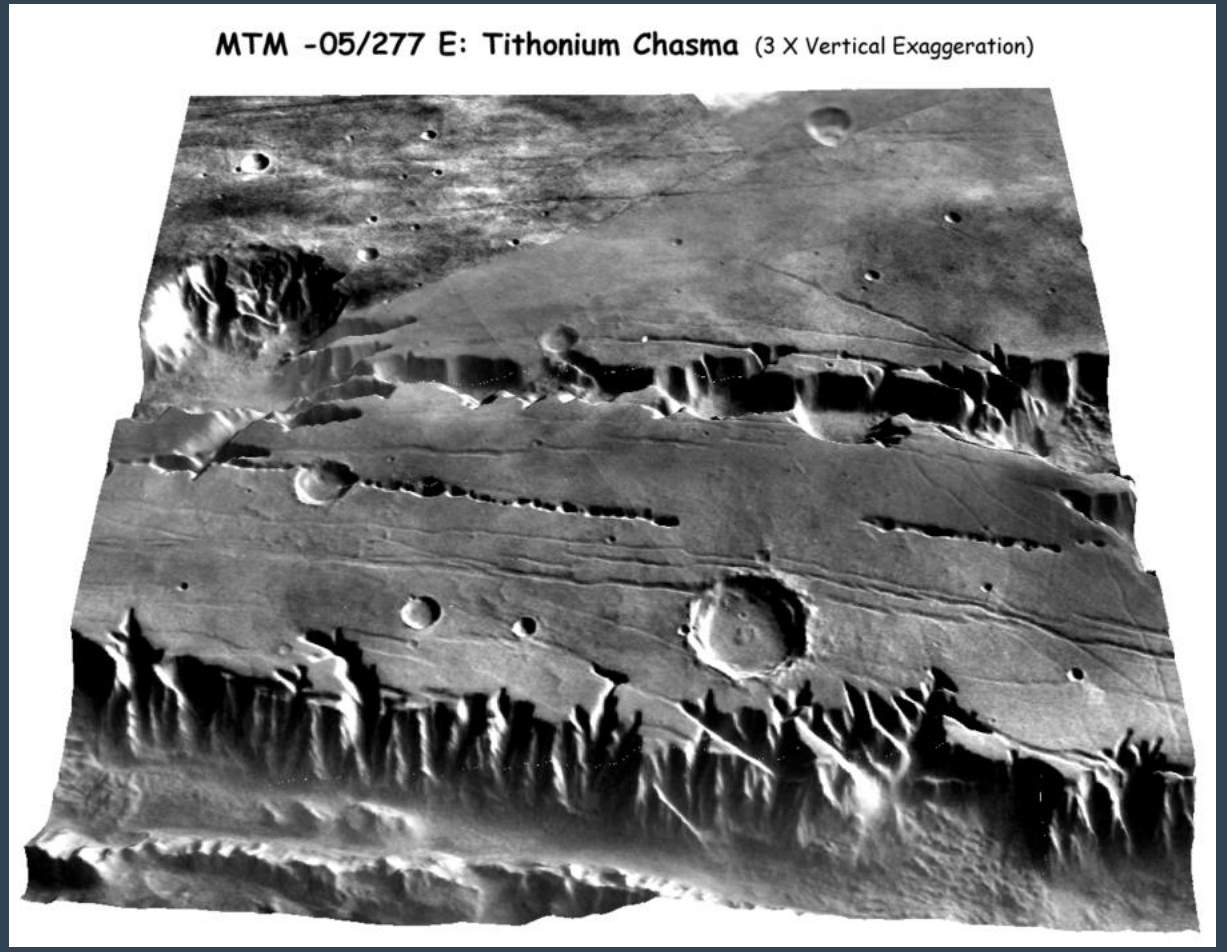
Digital Elevation Models (DEMs)

Continuous digital representation of surface elevation (DTM Vs DSM, Bathymetric Vs Surface water)

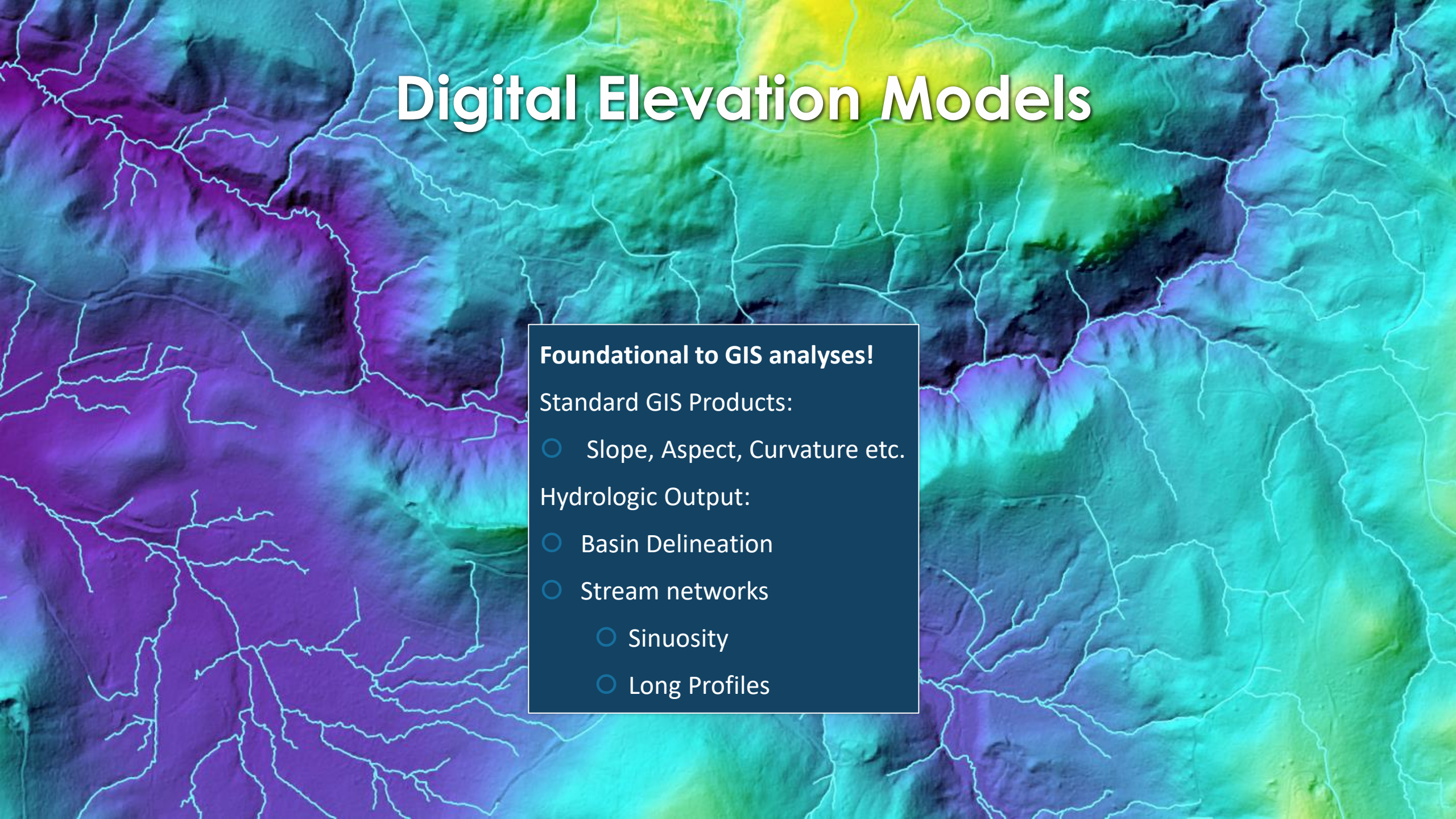
Most common versions are pixel based “grid” approaches, where each cell‘s value represents the average elevation across the area covered by the cell.

Resolution determines available techniques and analysis options.

One cell represents multiple features (30m) VS One feature is represented by multiple cells (0.5m).



Digital Elevation Models



Foundational to GIS analyses!

Standard GIS Products:

- Slope, Aspect, Curvature etc.

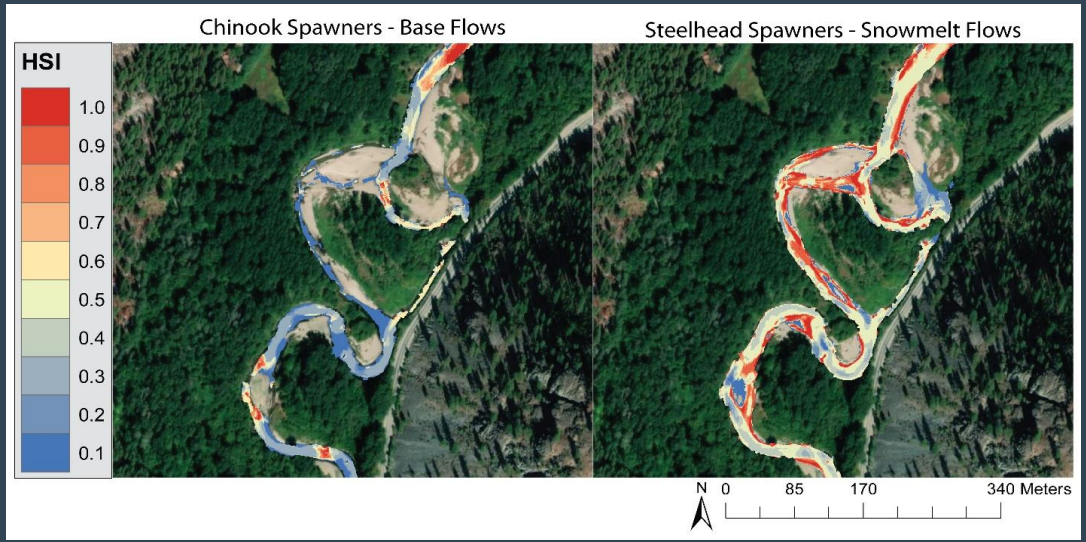
Hydrologic Output:

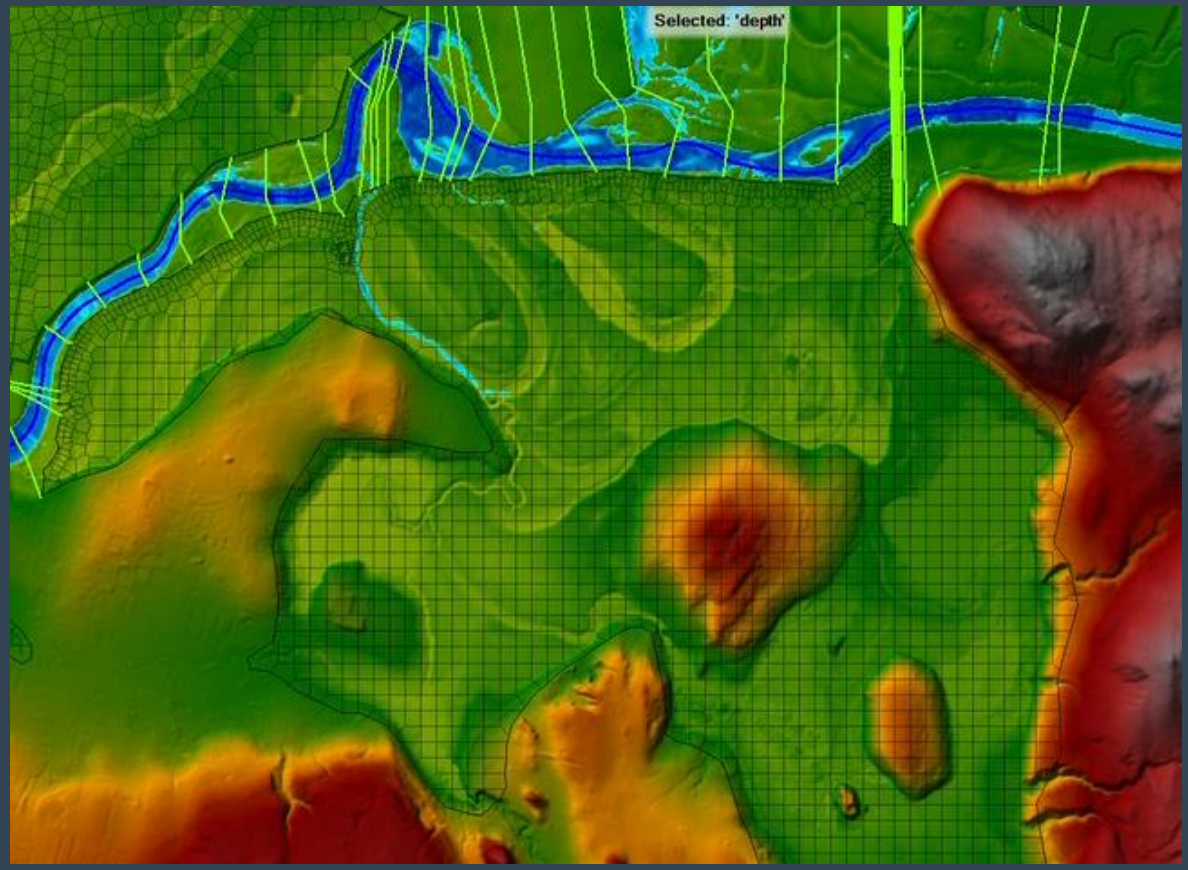
- Basin Delineation
- Stream networks
  - Sinuosity
  - Long Profiles

Hydraulic modeling:

Estimates of Depth and Velocities by flow:

- Wetted areas
- Estimated flooding extents
- Habitat Suitability Indices (HSI)
  - Habitat–by–stage curves





Digital Elevation Model

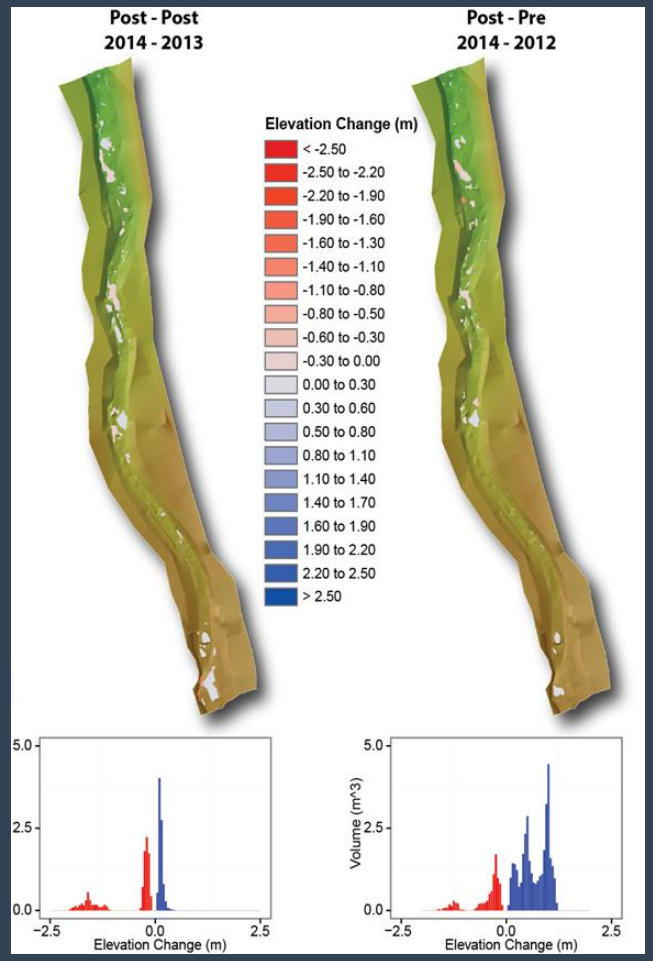
Unit delineation:

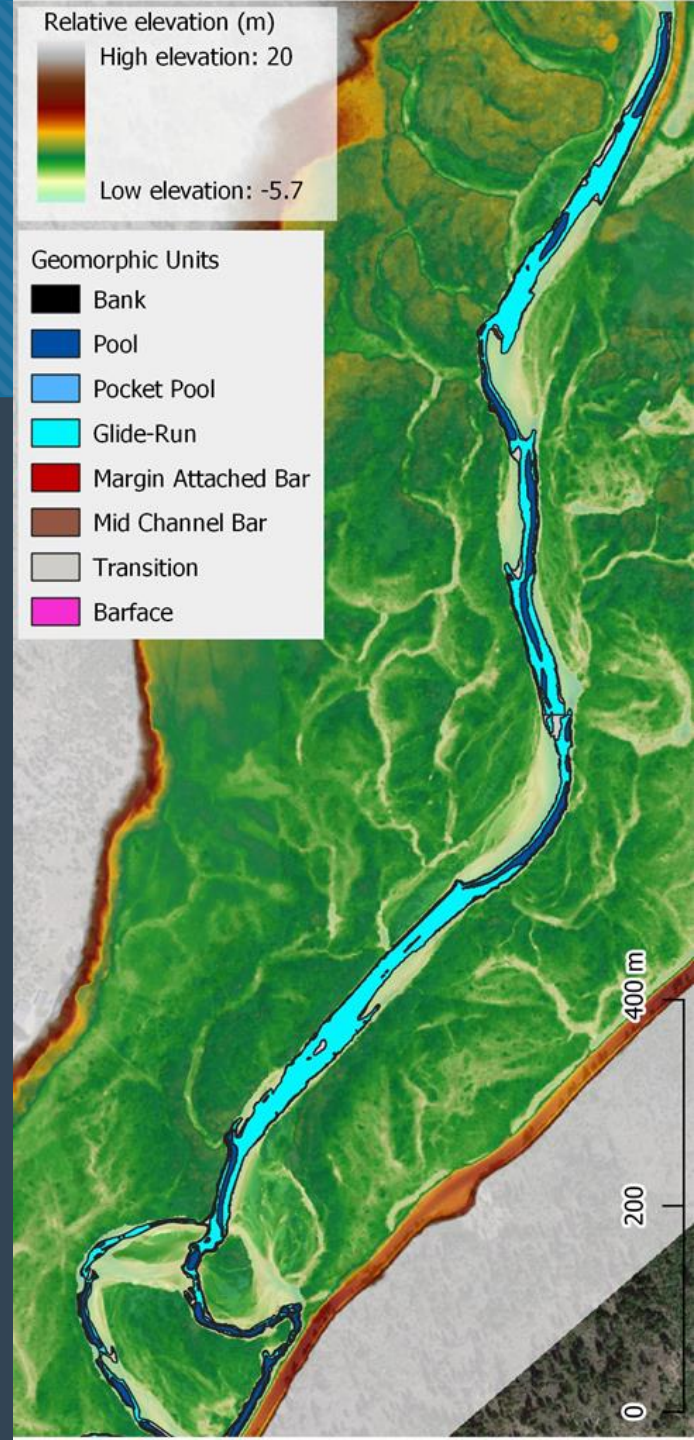
- Pool-Riffle-Glide from long profiles
- Fine scale units form the Geomorphic Unit Tool (GUT)

Change-based metrics:

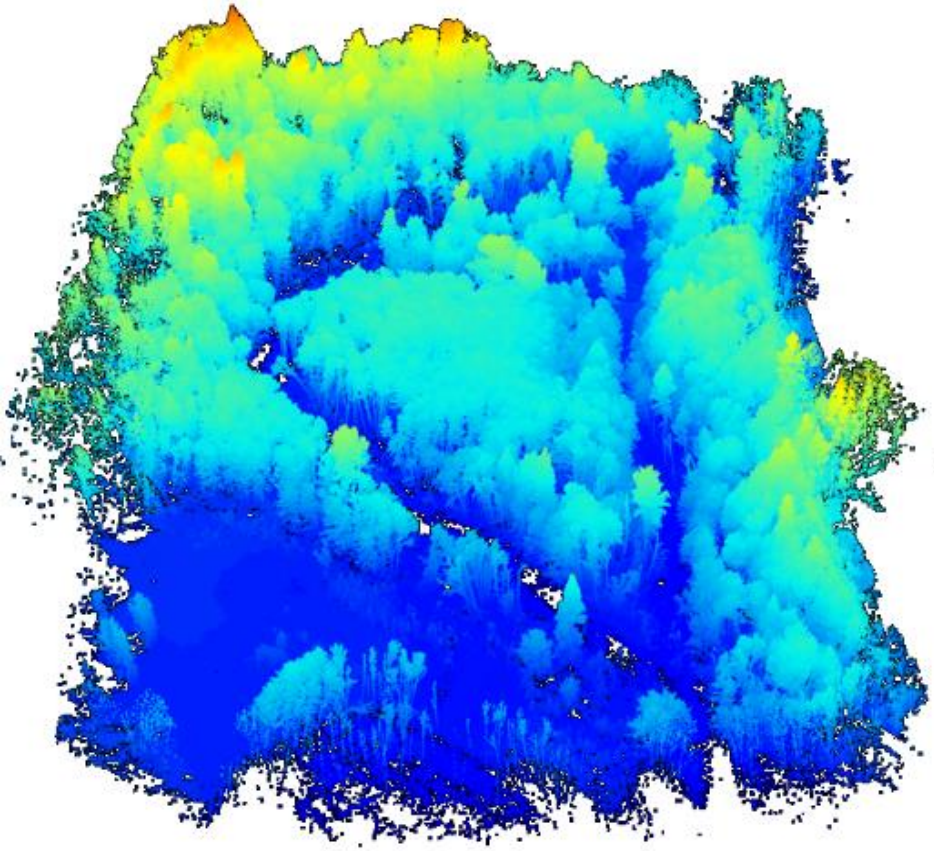
Some metrics cannot be measured directly, but can be compared across time

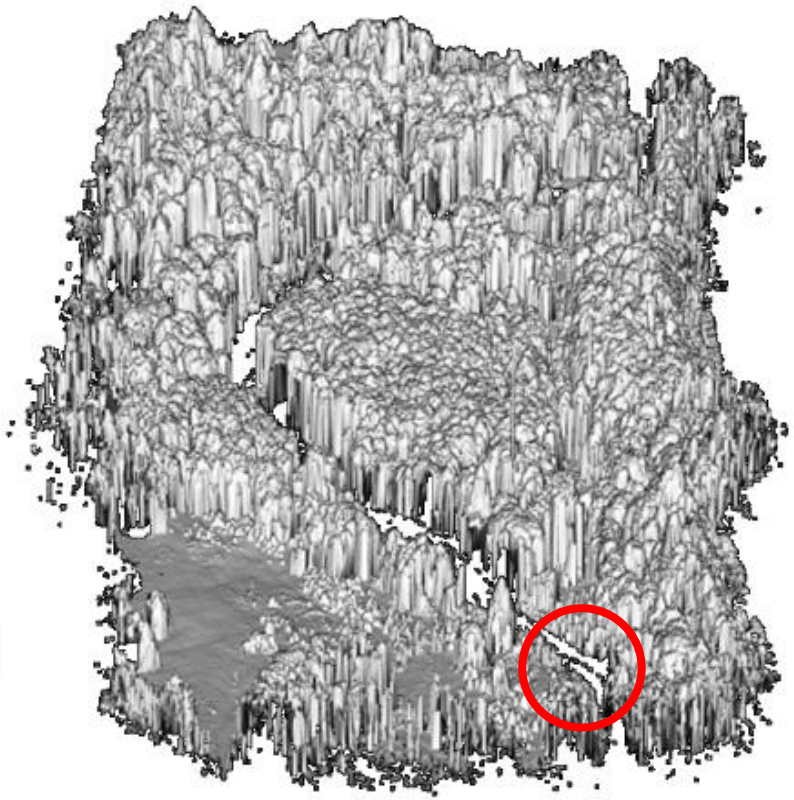
For example: Sediment deposition and storage

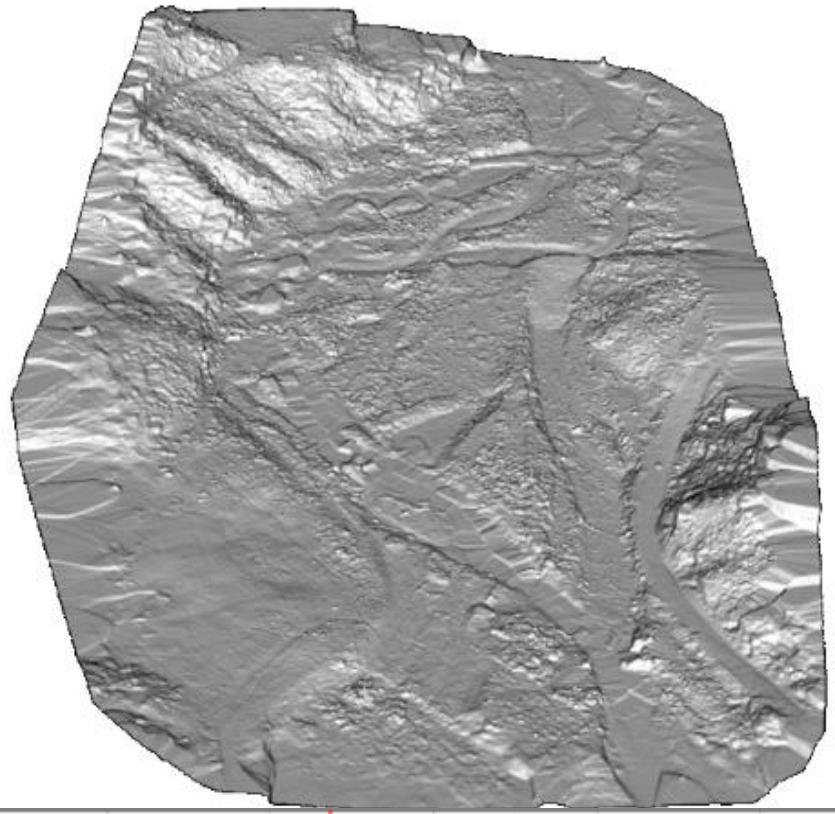




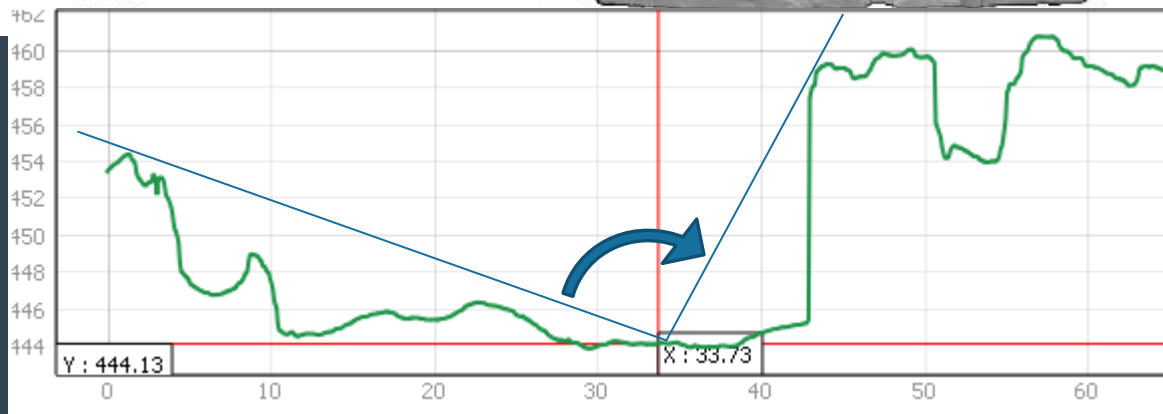
Digital Surface Models







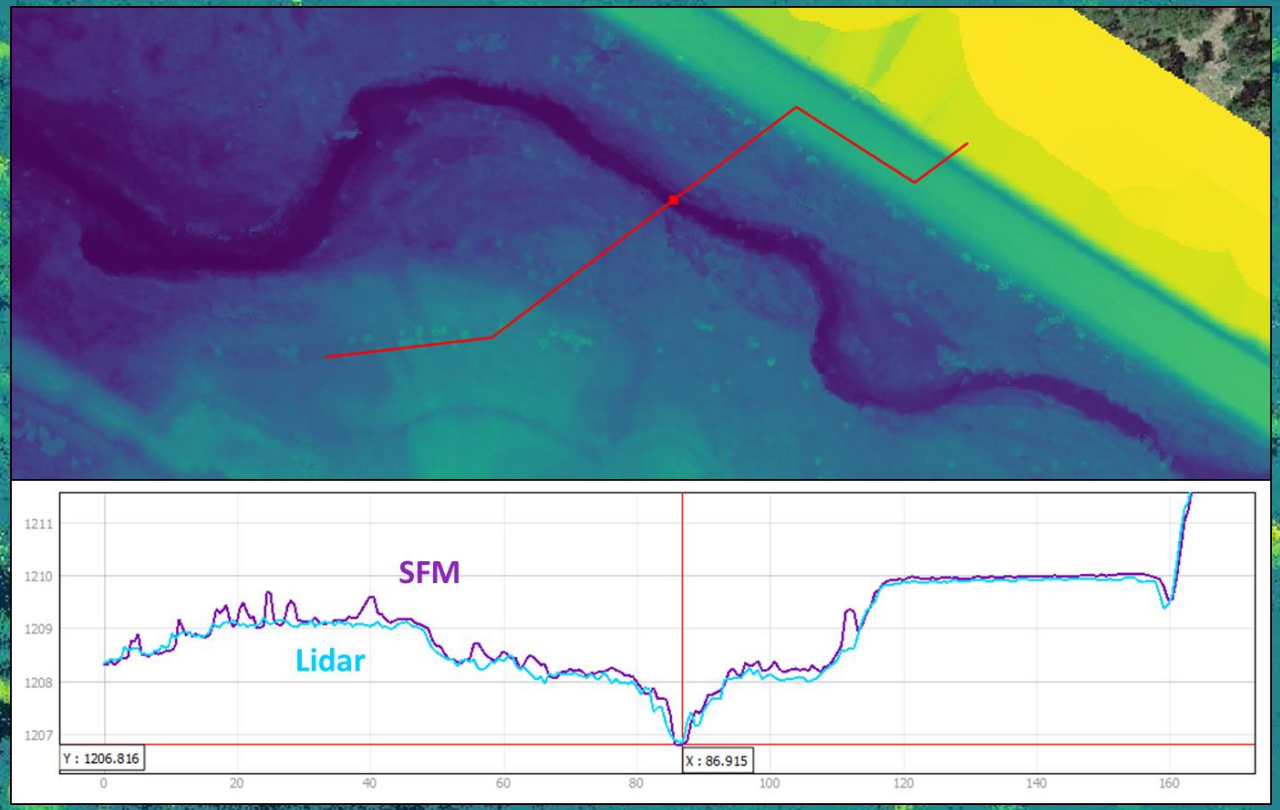
- Nice to look at!
- Useful to verify / troubleshoot.
- Some additional products and analyses.
  E.g., View of sky:



Point Clouds

From pixels to points in space (XYZ)

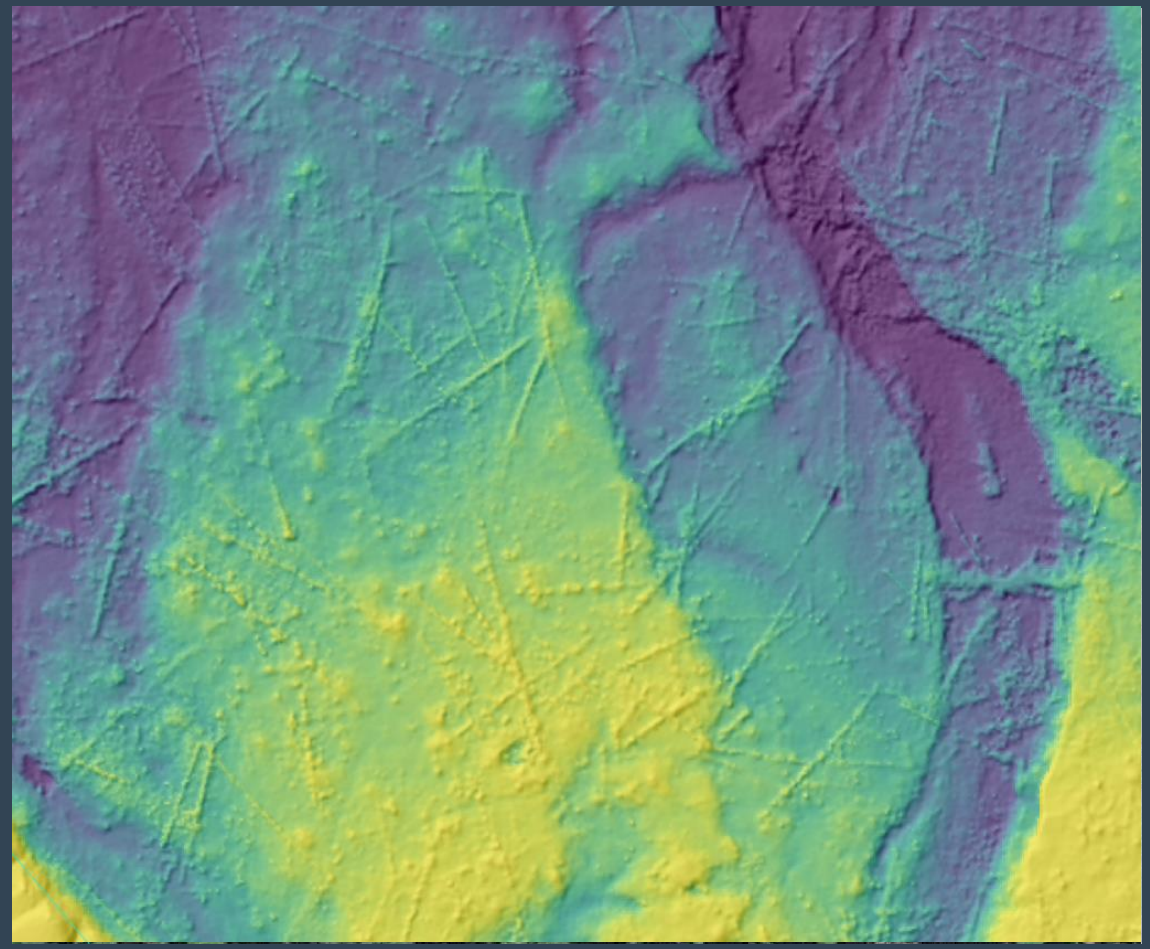
- Point clouds come in many shapes and sizes
- Data from LiDAR, (SFM, NeRFs, Total stations…)
- Not just XYZ: Intensity, point density, RGB etc.
- Not Fully 3D in many in many cases



Point Clouds

LiDAR can penetrate through tree canopies

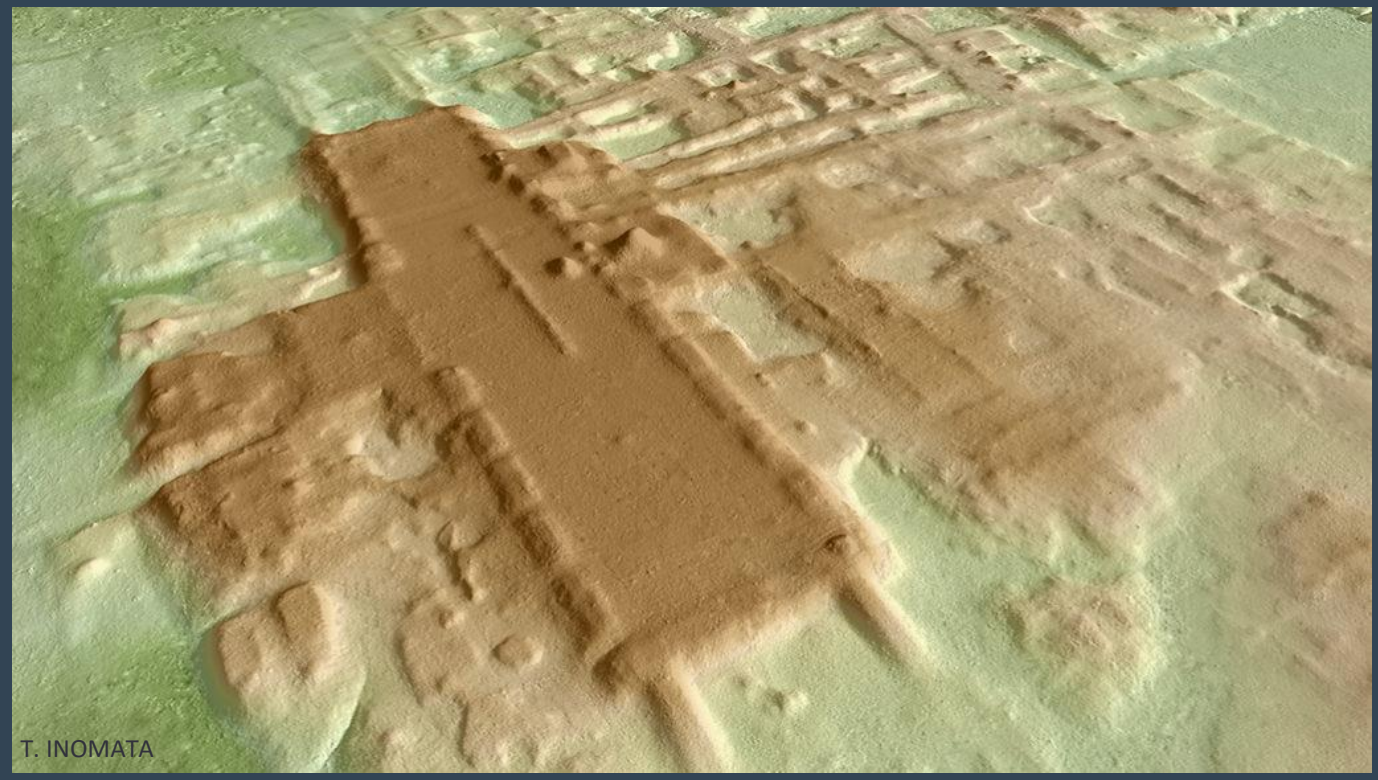
- Light Penetration Index for continuous cover
- Understory and Overstory Cover Class Estimates
- LWD Recruitment
- Great for DEMs!



Point Clouds

Many feature extraction use cases documented:

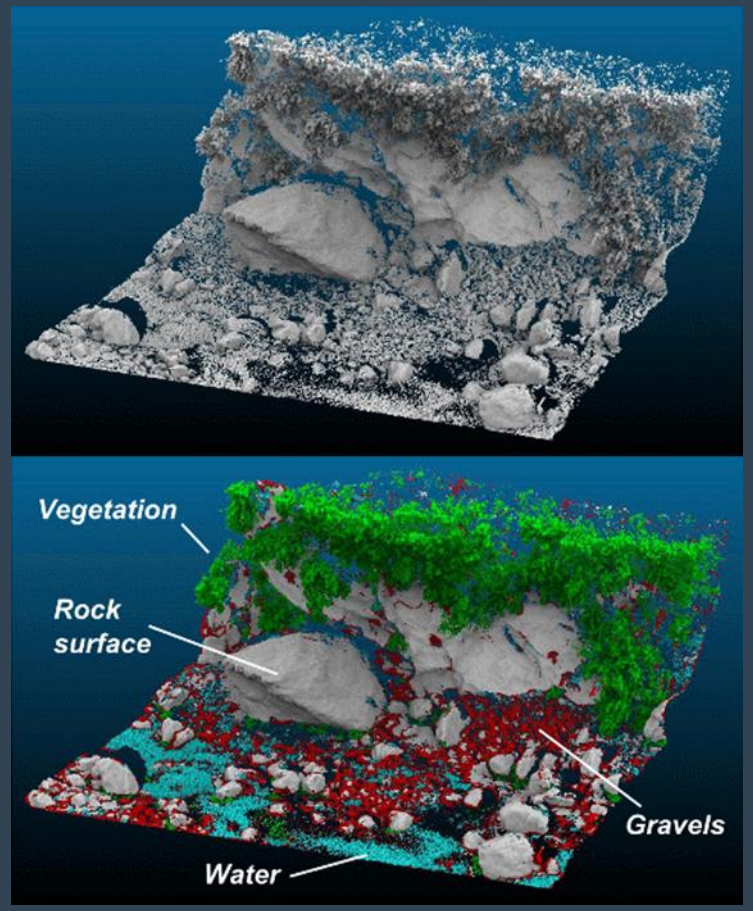
- Water body detection
- Planar surface detection
- Individual tree segmentation
- Phone poles and powerlines
- Ancient Mayan ruins…



Point Clouds

Modeling follows similar paths to pixel- based Classification:

- Preprocess data (elevation thresholds, pixel class evaluation, normalization…)
- Unsupervised Classification (geometry, thresholds)
- Supervised Classification (Training data)
- Postprocessing

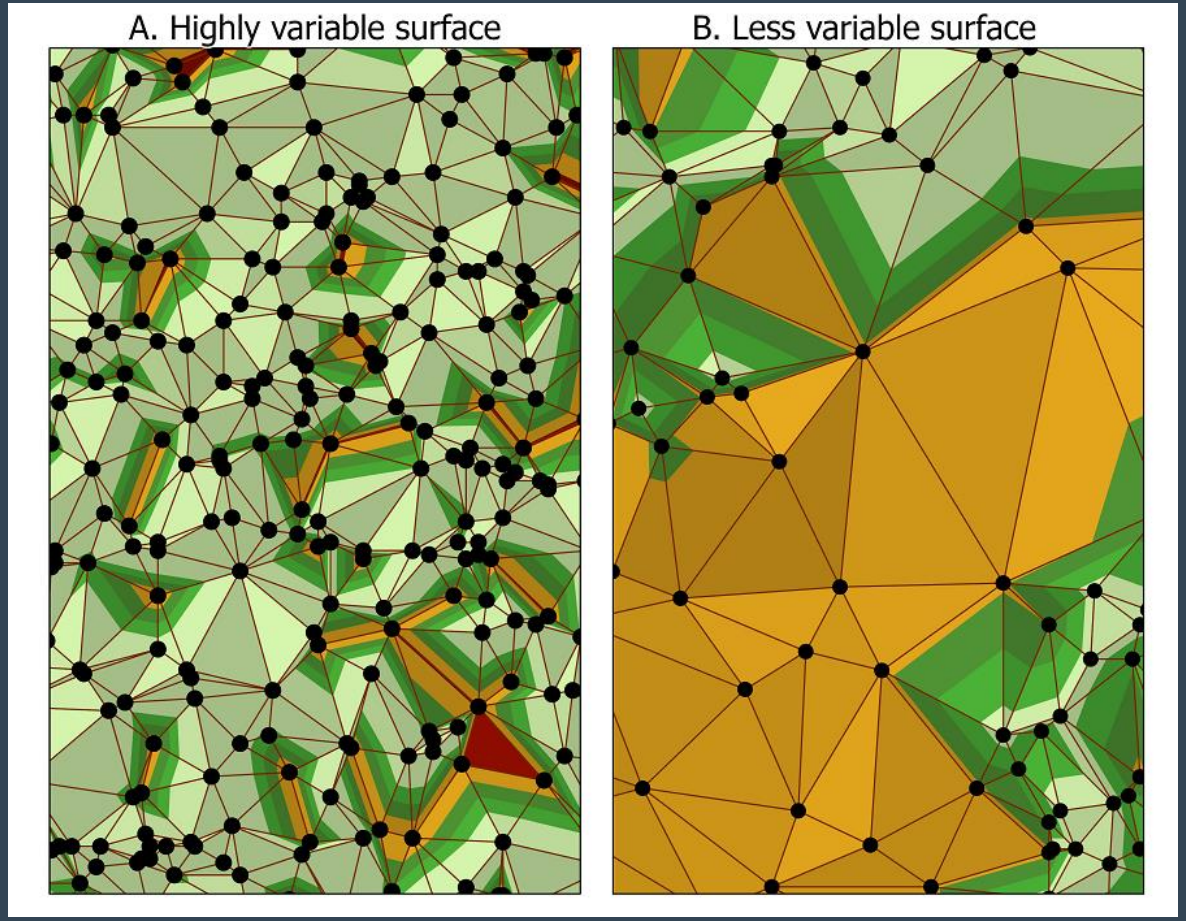


Spatial Modeling:

Extrapolation and interpolation: Connect the dots!

- Kriging
- Delaunay Triangulation
- Inverse Distance weighting
- Neighborhood analyses, etc.

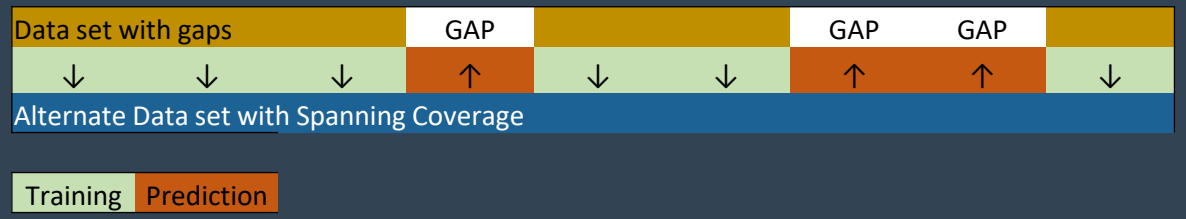
- Cost-path analyses VS “as the crow flies”

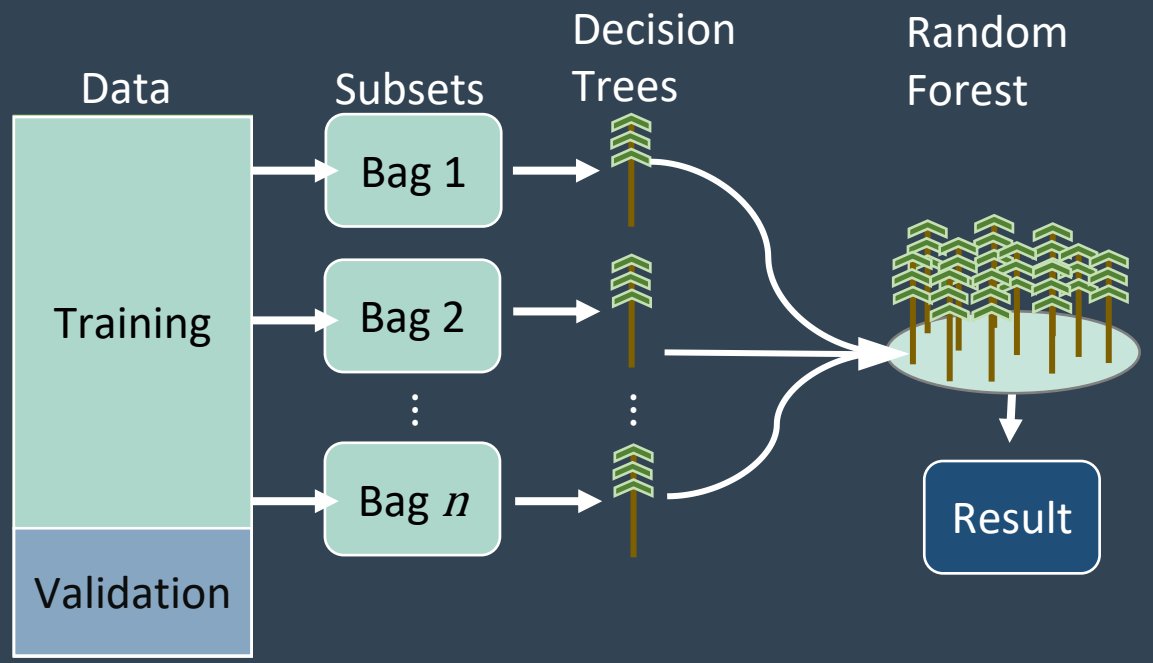


Spatial Modeling:

Machine learning :

- Unsupervised classification / regression (e.g., Clustering, threshold bands etc., Linear models)
- Supervised classification / regression (e.g., Random Forest Classification, Support Vector Machines).
- Crosswalk analysis. Use one Dataset to predict another. Great for filling data gaps!

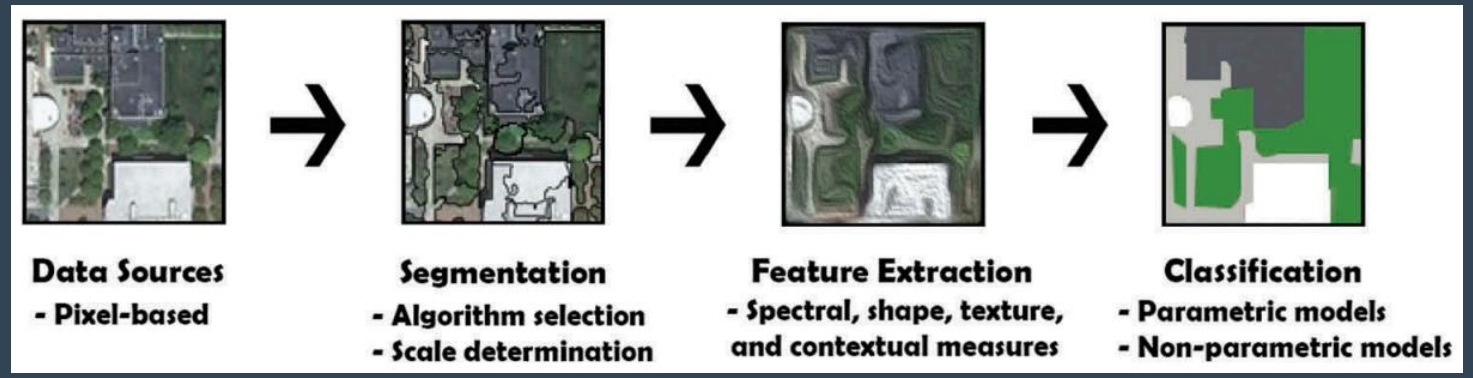


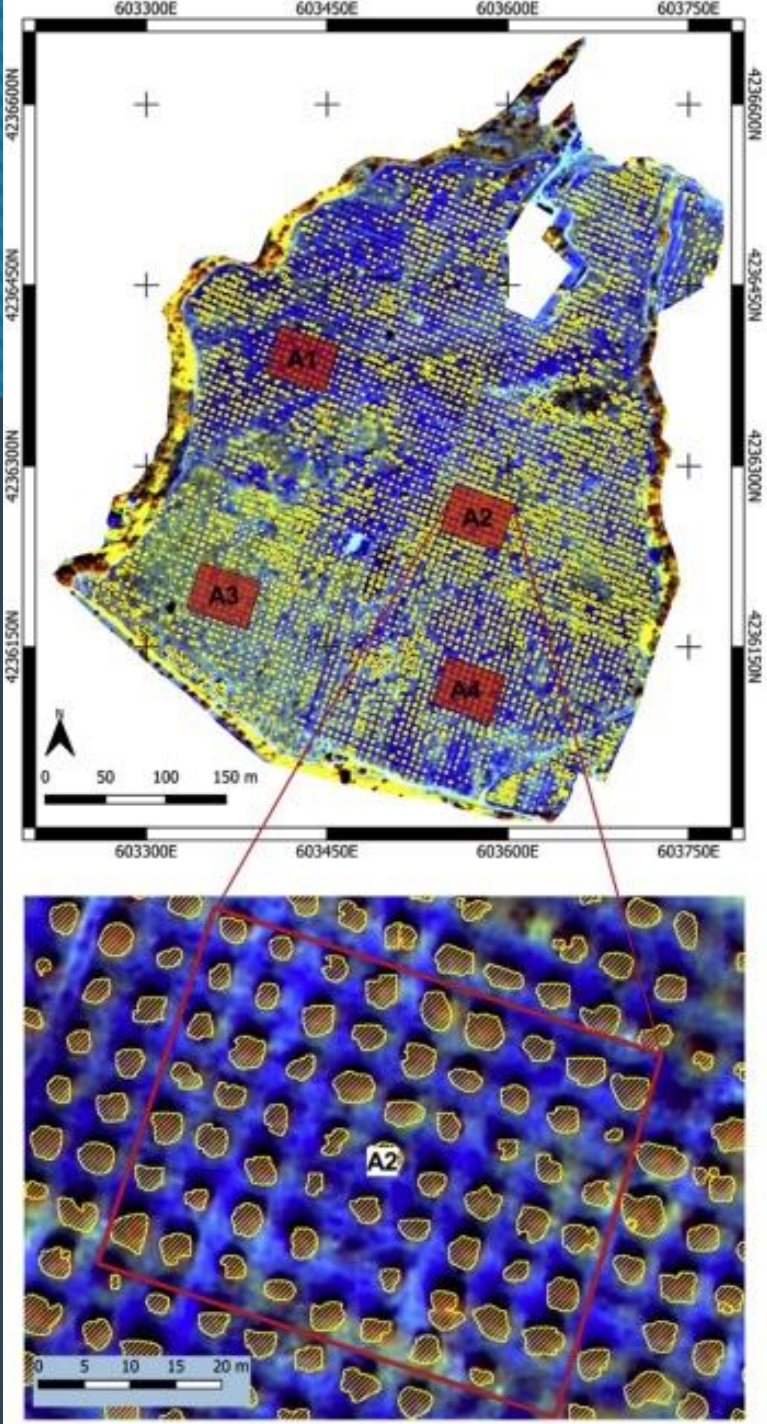


Spatial Modeling:

GEOBIA (Geographic Object-Based Image Analysis)

- Supervised Classification
- E.g., E-cognition



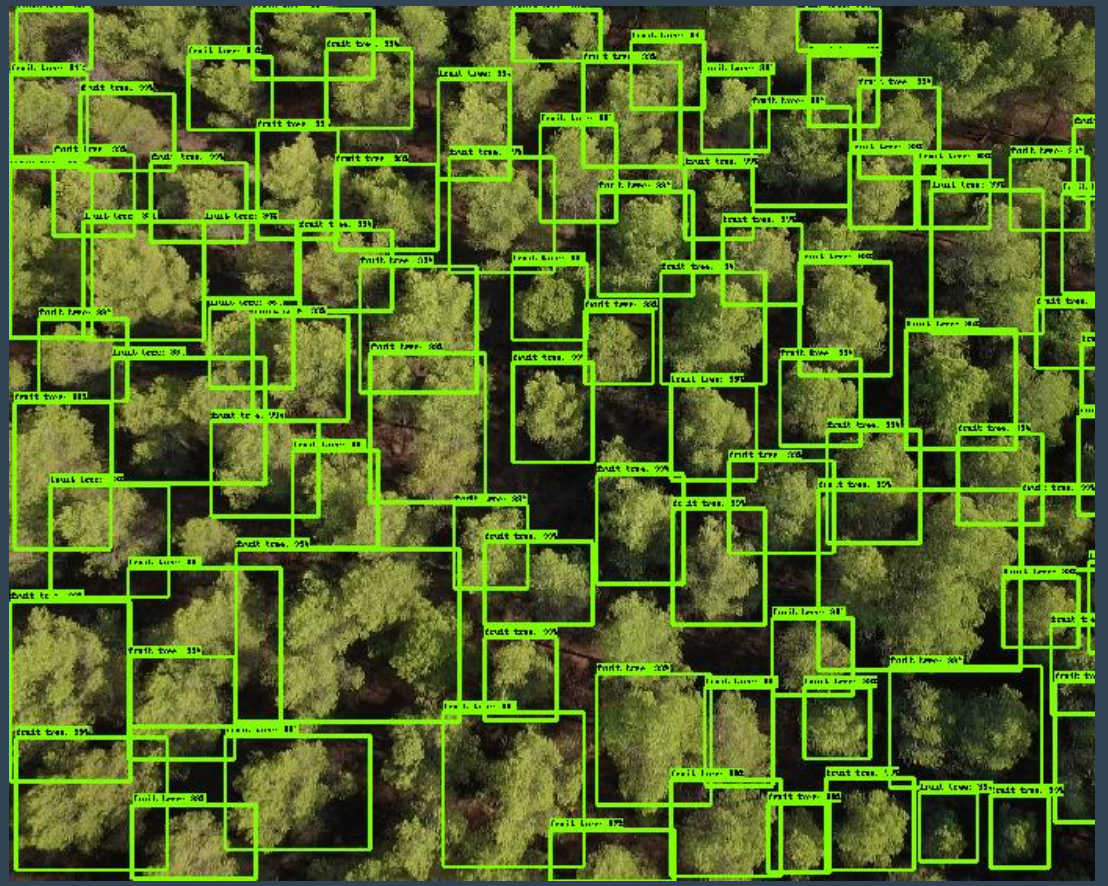


Spatial Modeling:

GEOBIA (Geographic Object-Based Image Analysis)

- Supervised Classification
- E.g., E-cognition

RCNN and other “Deep” methods

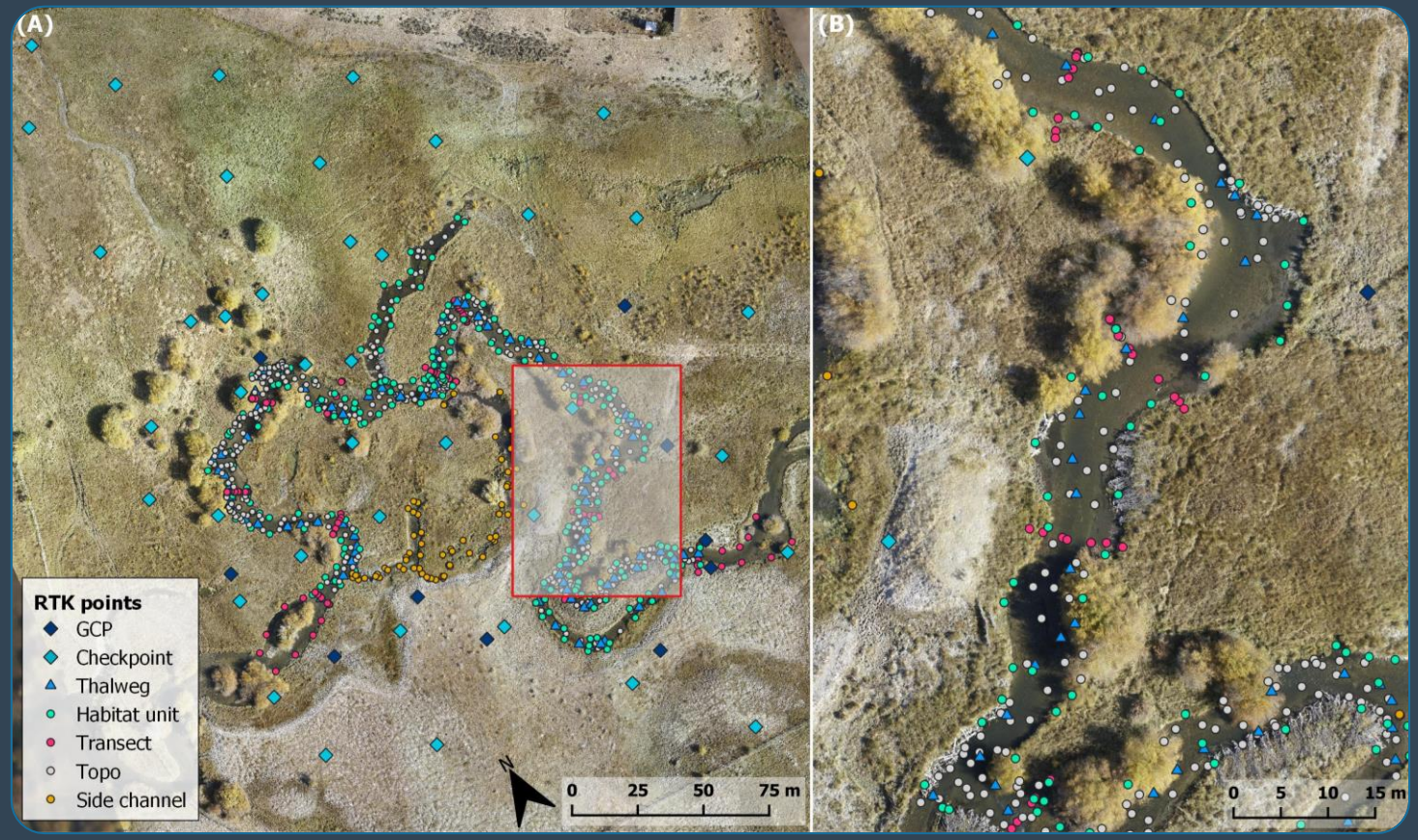


Field Components

Most analyses can be enhanced with field data.

Verification: Data used to test how a modeled process predicts reality

- Field crew estimates or classifications to validate geomorphology
- Fish observations to validate habitat suitability
- Opportunistic data sampling during storm and flood events to validate stage/flow relationships.

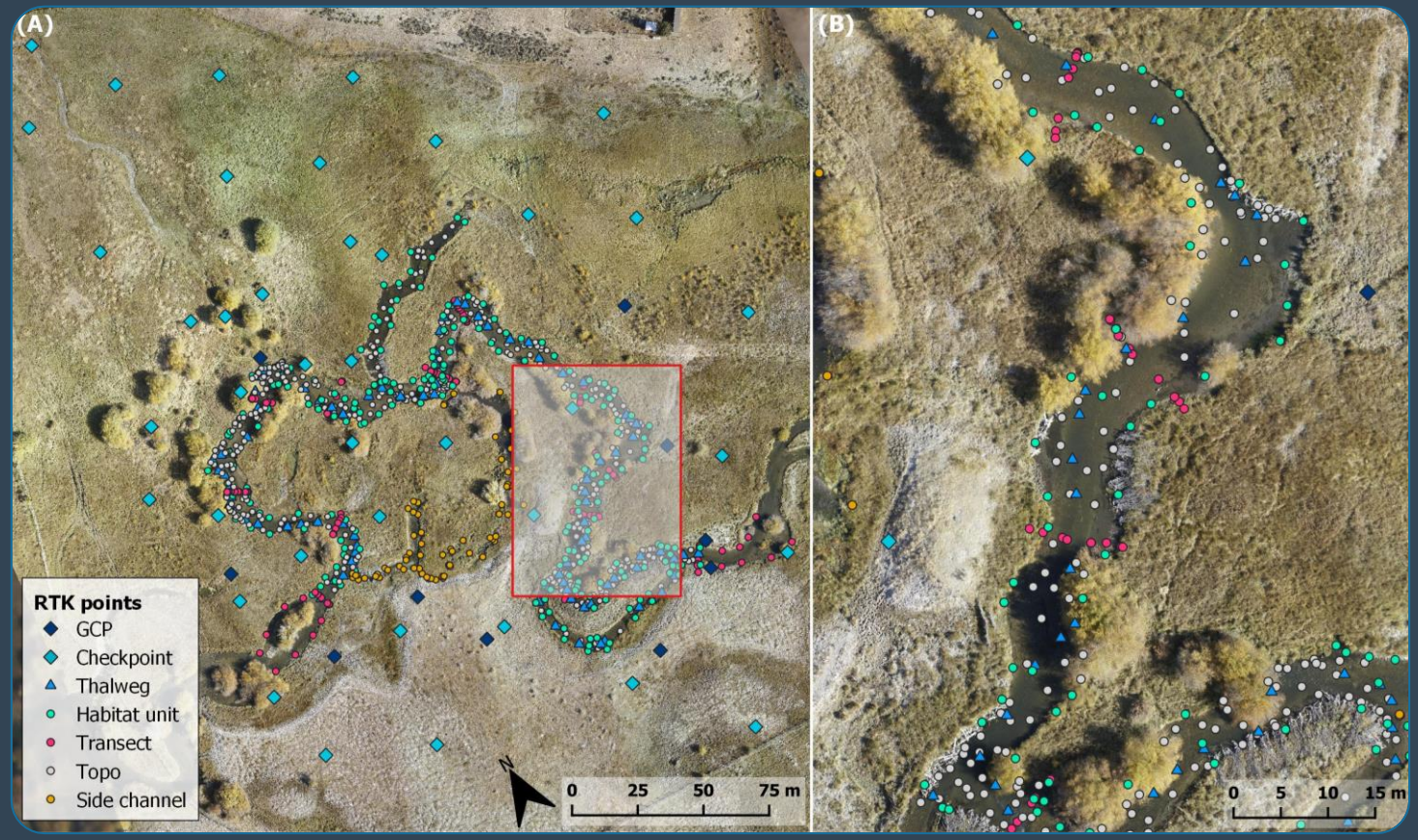


Field Components

Calibration: Data gathered to help build and refine the best model possible

- Ground control points
- BFW points and break lines
- Bathymetric surveys to supplement LiDAR

- Riparian Plant Species Surveys



What Doesn't Work:

Water Chemistry / Quality:

- DO, Alkalinity, Chlorophyl etc.
  - Deployed sensors can do a lot of this though

Biological Use:

- Fish Species, counts, behavior
- Benthic richness
  - eDNA can address some of these issues

Substrate:

- Embeddedness, D50, etc.
  - Some available proxies for specific questions (e.g., Maximum Mobile Grain Size)

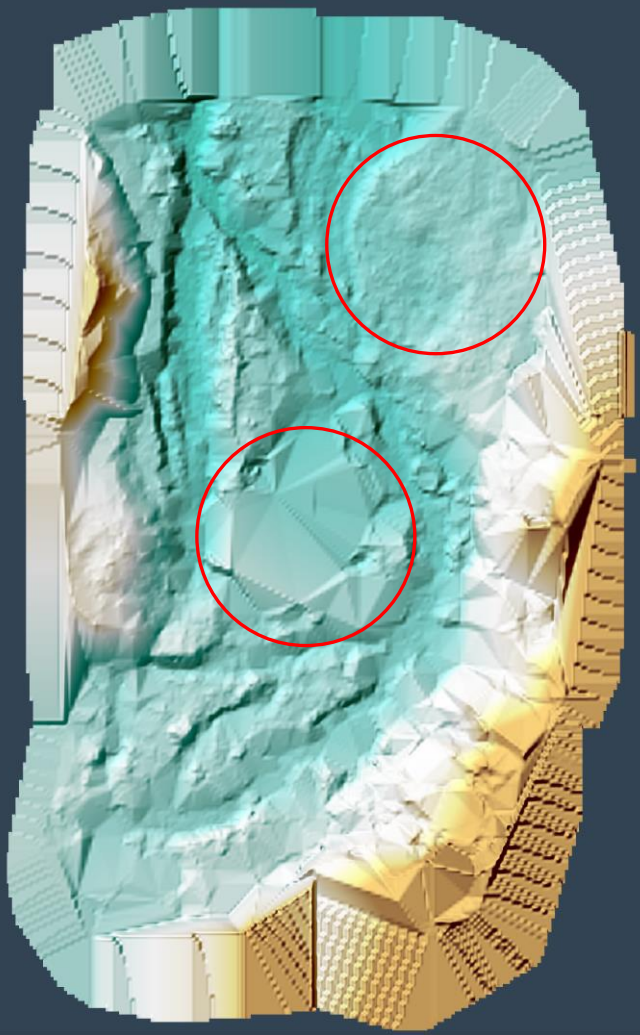
Riparian Composition:

- Composition, Species Diversity
  - Some possibility with multi-band Imagery and nearby field assessments

What Doesn't Work

Certain Conditions

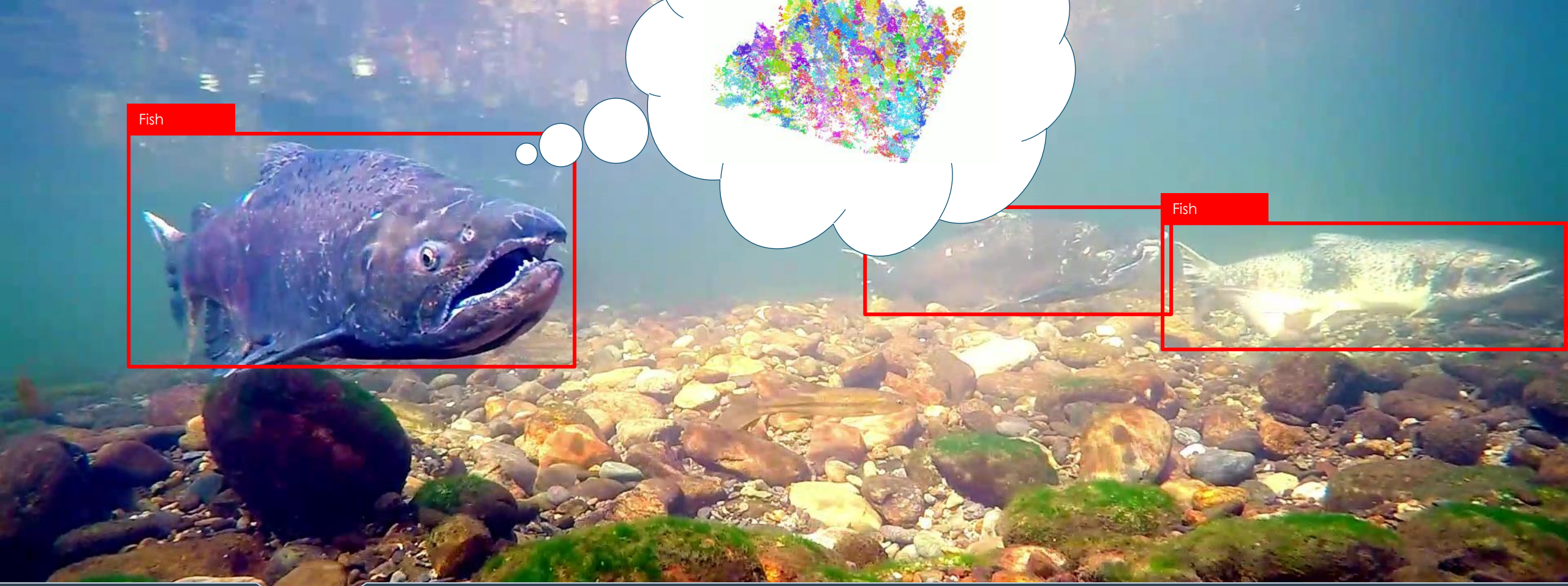
- Dense tree coverage
- Fog
- Snow
- Timing (Leaf on vs Leaf off)
- Shade!
- Water Depth, Turbidity, Turbulence (for Bathymetric LiDAR)



Summary

- A large amount of Geomorphology measures can be estimated remotely. Many habitat measures as well. E.g., Sinuosity and confinement, Reach gradient
- Spatial modeling can help extrapolate spotty data to greater coverages. E.g., Norwest Stream Temperature, Prism Rain Maps, "Heatmaps"
- Some metrics can be estimated using machine learning models to cross walk two datasets To help fill gaps
- Supervised classification can detect, highlight, and enumerate distinct features within a data set, or across a landscape. E.g., Logjams, landslides, etc.

Parameter/metric	LiDAR (Green or w/ bathymetric survey)	LiDAR (near-infrared)	Multispectral imagery	Aerial photography	Satellite imagery	FLIR
Channel morphology	Y	Y	**M**	**M**	**M**	N
Channel pattern	Y	Y	**M**	**M**	**M**	N
Bathymetry	Y	N	N	N	N	N
Topography	Y	**M**	N	N	N	N
Habitat units	Y	**M**	**M**	**M**	N	N
Habitat diversity	Y	**M**	**M**	**M**	N	N
Floodplain inundation	Y	Y	N	N	N	N
Floodplain area	Y	Y	N	N	N	N
Area altered	Y	Y	**M**	**M**	**M**	N
Channel migration zone/Active channel	Y	Y	N	N	N	N
Side channel no., length, & area	Y	Y	**M**	**M**	**M**	N
Pond/wetland number & area	Y	Y	**M**	**M**	**M**	N
Sediment deposition & storage	Y	N	N	N	N	N
Large wood	Y	Y	Y	Y	**M**	N
Surface temperature	N	N	N	N	N	Y[2]
HSI (Habitat suitability index)	Y	N	N	N	N	N
Riparian shade	Y	Y	N	N	N	N
Riparian composition	**M**[1]	**M**[1]	Y	**M**	N	N
Riparian stem density	**M**	**M**	N	N	N	N
Plant survival	N	N	**M**	N	N	N
Growth	Y	Y	**M**	N	N	N
Area vegetation extent by class	Y	Y	N	N	N	N
Bank stability	Y	Y	N	N	N	N
Organic inputs (leaf litter)	Y[3]	Y[3]	N	N	N	N



If you have any questions, I'm happy to go over them!

Email: Kai.Ross@fishsciences.net

GIF:Jean-Romain Roussel