The Wetland Intrinsic Potential Tool (WIP)

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TerrainWorks
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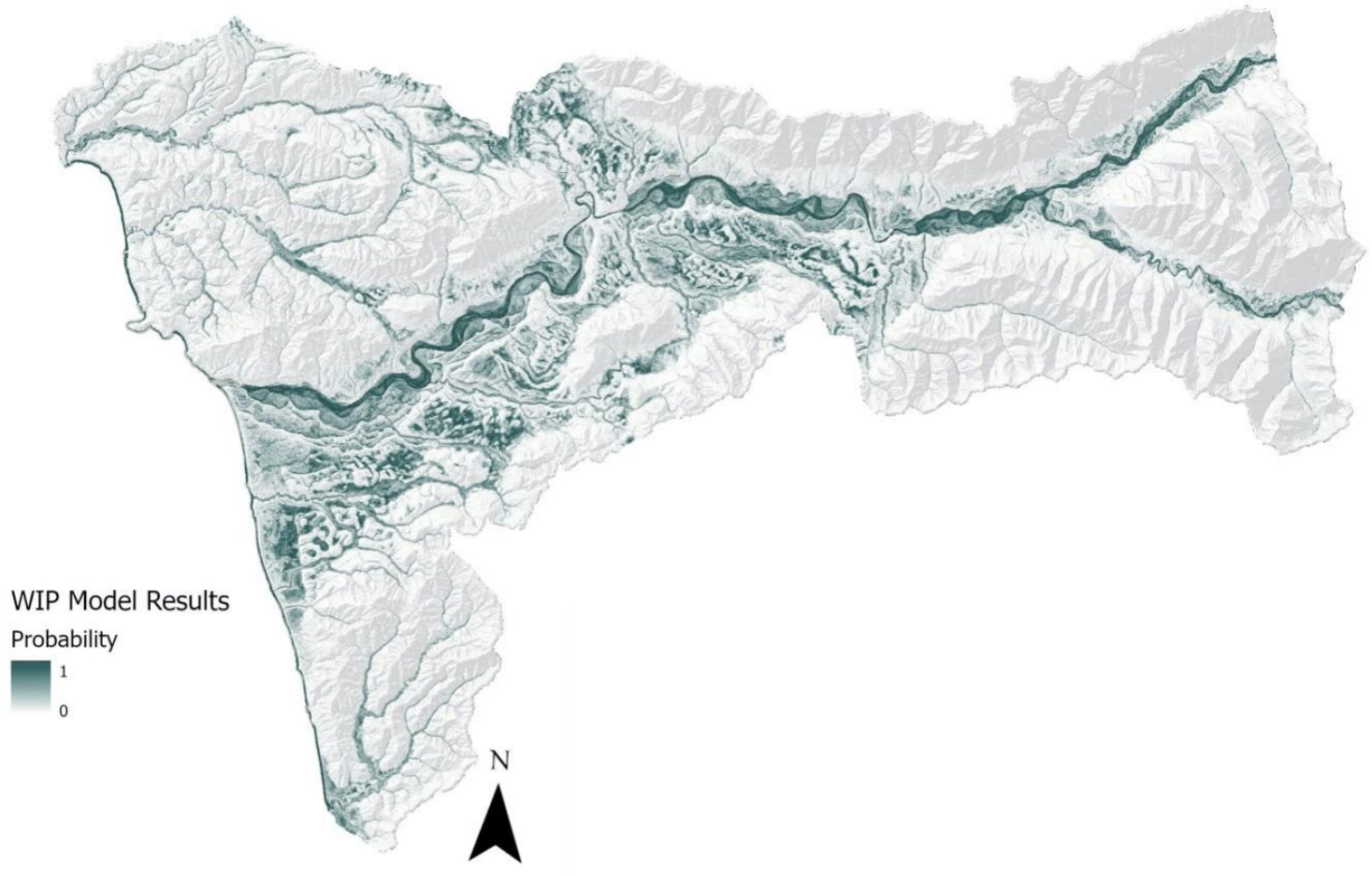

The WIP tool – Method & ArcGIS toolbox

WIP Methods:

Currently in review Hydrology and Earth System Sciences (HESS)

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The Wetland Intrinsic Potential tool: Mapping wetland intrinsic potential through machine learning of multi-scale remote sensing proxies of wetland indicators

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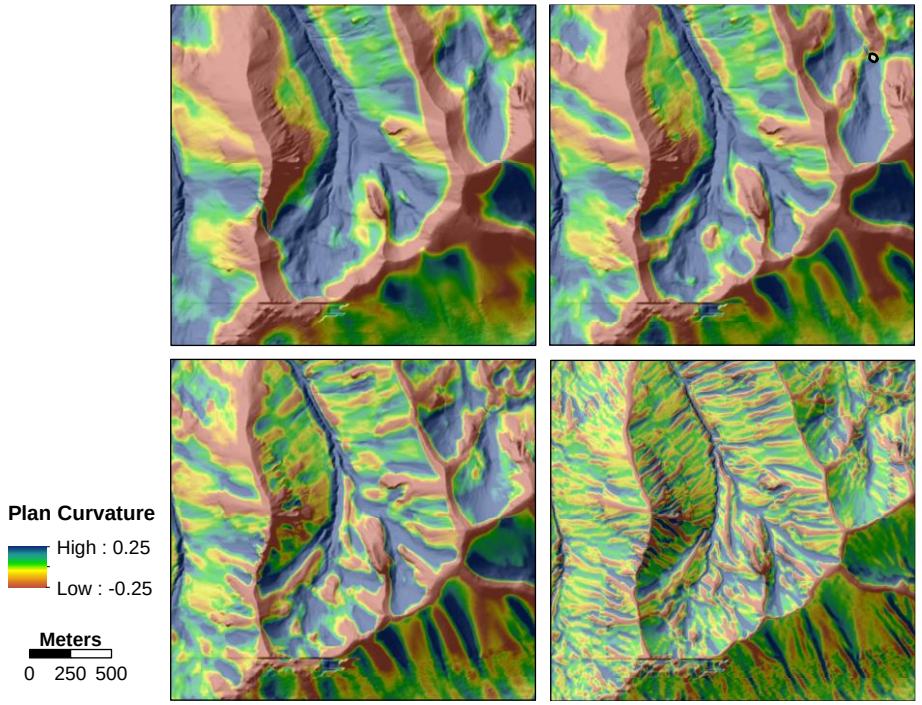
Abstract

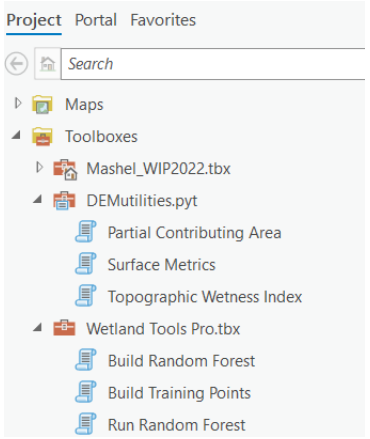
Accurate, un-biased wetland inventories are critical to monitor and protect wetlands from future harm or land conversion. However, most wetland inventories are constructed through manual image interpretation or automated classification of multi-band imagery and are biased towards wetlands that are easy to detect directly in aerial and satellite imagery. Wetlands that are obscured by forest canopy, occur ephemerally, and those without visible standing water are, therefore, often missing from wetland maps. To aid in detection of these cryptic wetlands, we developed the Wetland Intrinsic Potential tool, based on a wetland indicator framework commonly used on the ground to detect wetlands through the presence of hydrophytic vegetation, hydrology, and hydric soils. Our tool uses a random forest model with spatially explicit input variables that represent all three wetland indicators, including novel multi-scale topographic indicators that represent the processes that drive wetland formation, to derive a map of wetland probability. With the ability to include multi-scale topographic indicators, the WIP tool can identify areas conducive to wetland formation and provides a flexible approach that can be adapted to diverse landscapes

WIP Tool:

ArcGIS toolbox



ArcGIS

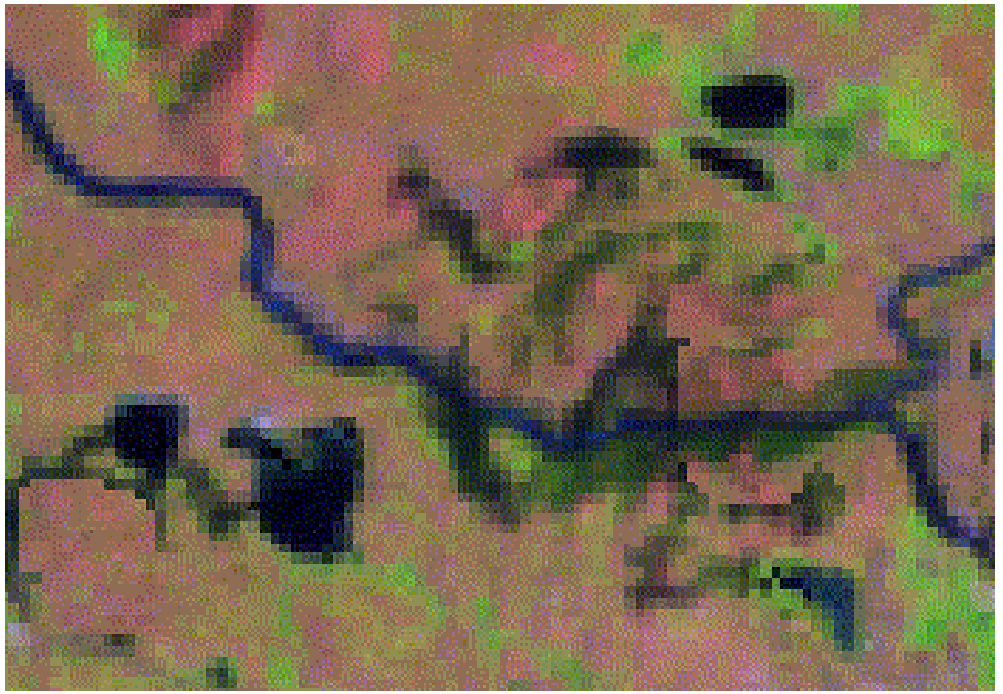


Problem Statement: Identifying wetlands

In [Washington State] available wetland inventories are often out-of-date and have high errors of omission - especially in forested areas.

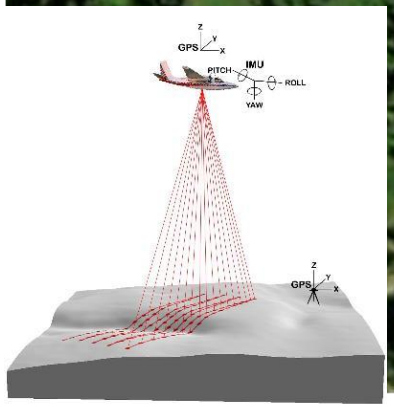
Wetlands are diverse

Wetlands are dynamic



Wetlands have different hydrologic drivers

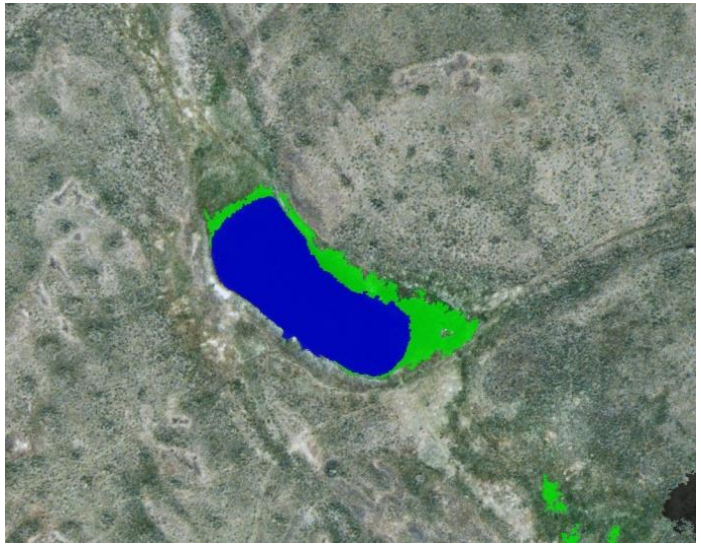
Wetlands may be disturbed - Different land cover / land uses


GPS
IMU
PITCH
ROLL
YAW
GPS

High-resolution Remote Sensing of Wetlands

Remote Sensing of Wetlands has come a long way - East coast, Midwest, & E. WA have had success mapping wetlands:

- Satellite imagery
- High-resolution aerial imagery
- Leaf-off imagery
- Topographic wetness index
- Lidar intensity
- Depth-to-water index
- Radar
- OBIA

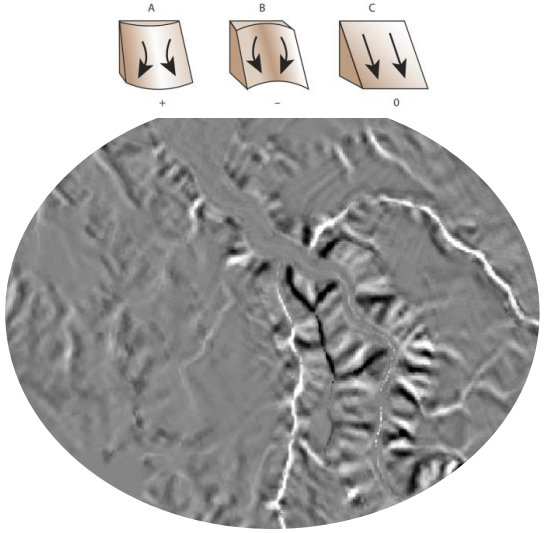


Forested Wetlands

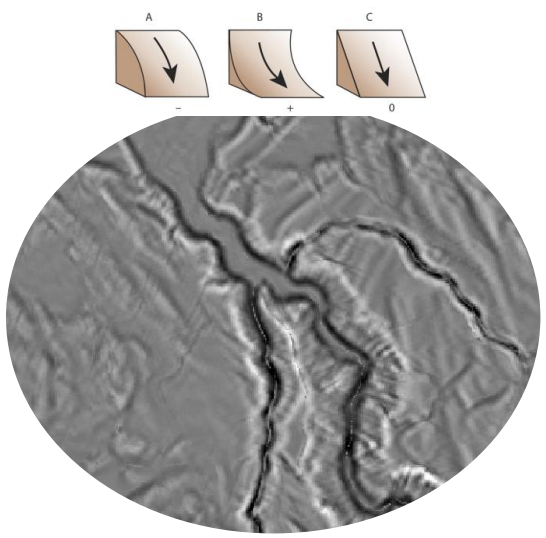
- Lack of training data of omitted wetlands (forested wetlands).
- Develop a sampling strategy for efficient data collection
- Not capturing these hummocky, multi-scale wetland features.
- Develop multi-scale terrain indices

Identifying Forested Wetland Predictors: Terrain Metrics From Digital Elevation Models (DEMs)

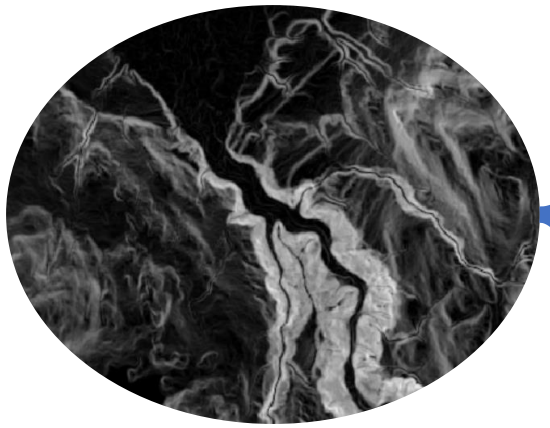
Planform Curvature



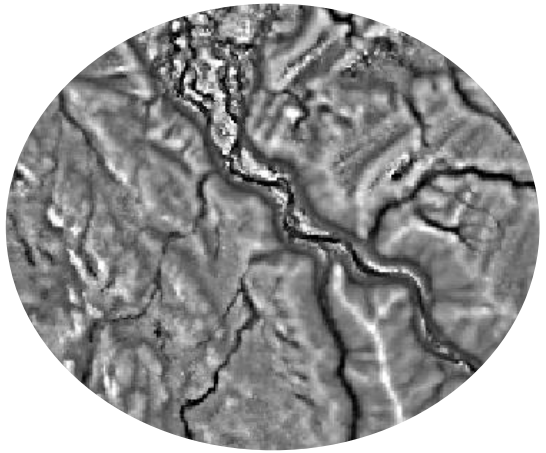
Profile Curvature



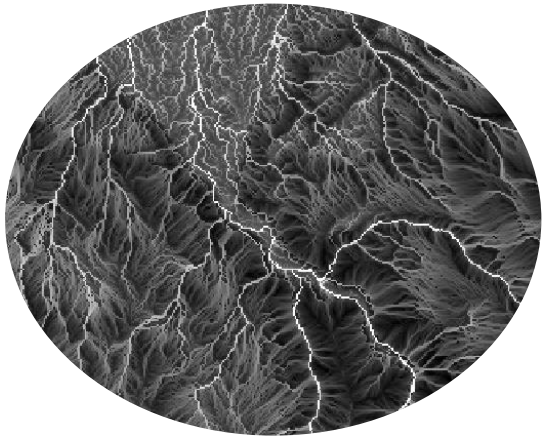
Slope/Gradient



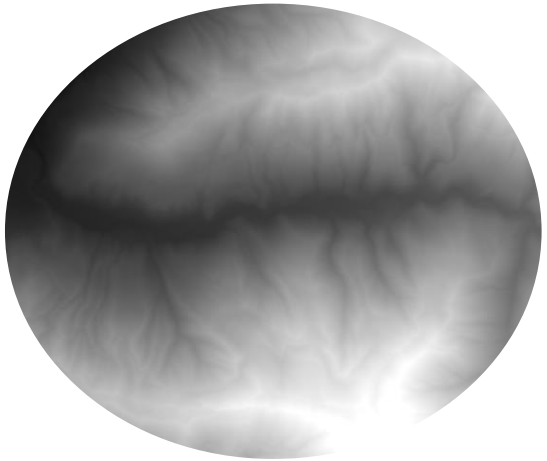
Depression Index



Topographic Wetness Index

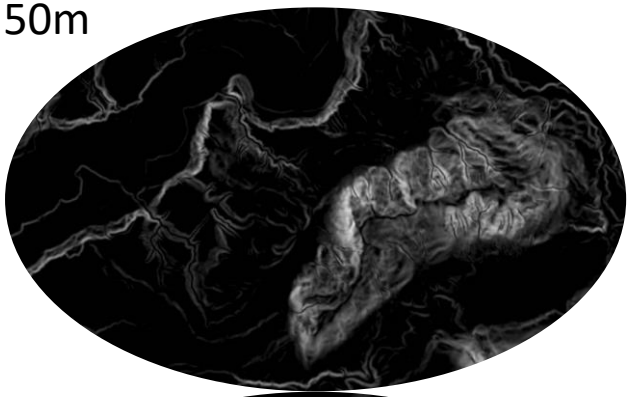


Depth To Water Index

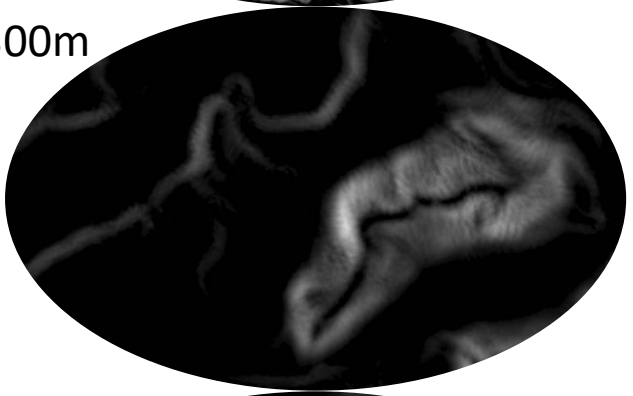


Variable Length Scale of Terrain Metrics

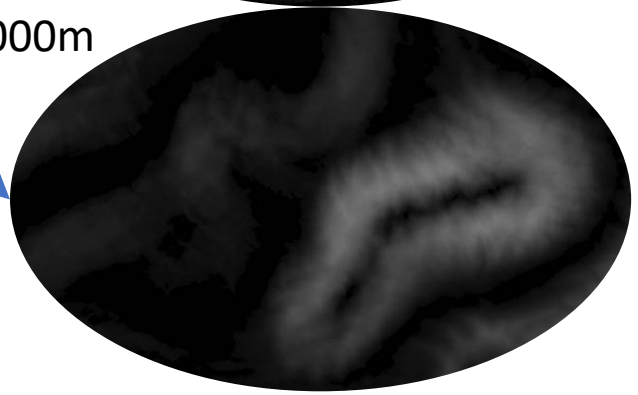
50m



300m



1000m



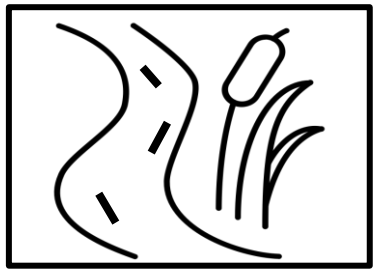
Maxwell et al., 2016

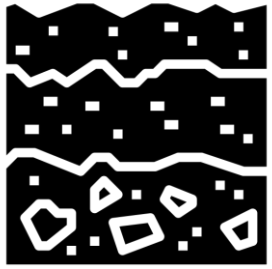
What are Wetlands?

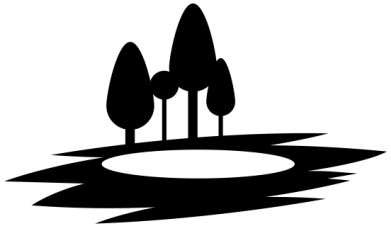
"Wetlands are areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions."

- Definition of wetlands as used by the U.S. Army Corps of Engineers (Corps) and the U.S. Environmental Protection Agency (EPA) since the 1970s for regulatory purposes.

Hydrologic Indicators + Hydric Soil + Hydrophytic Vegetation = Wetland



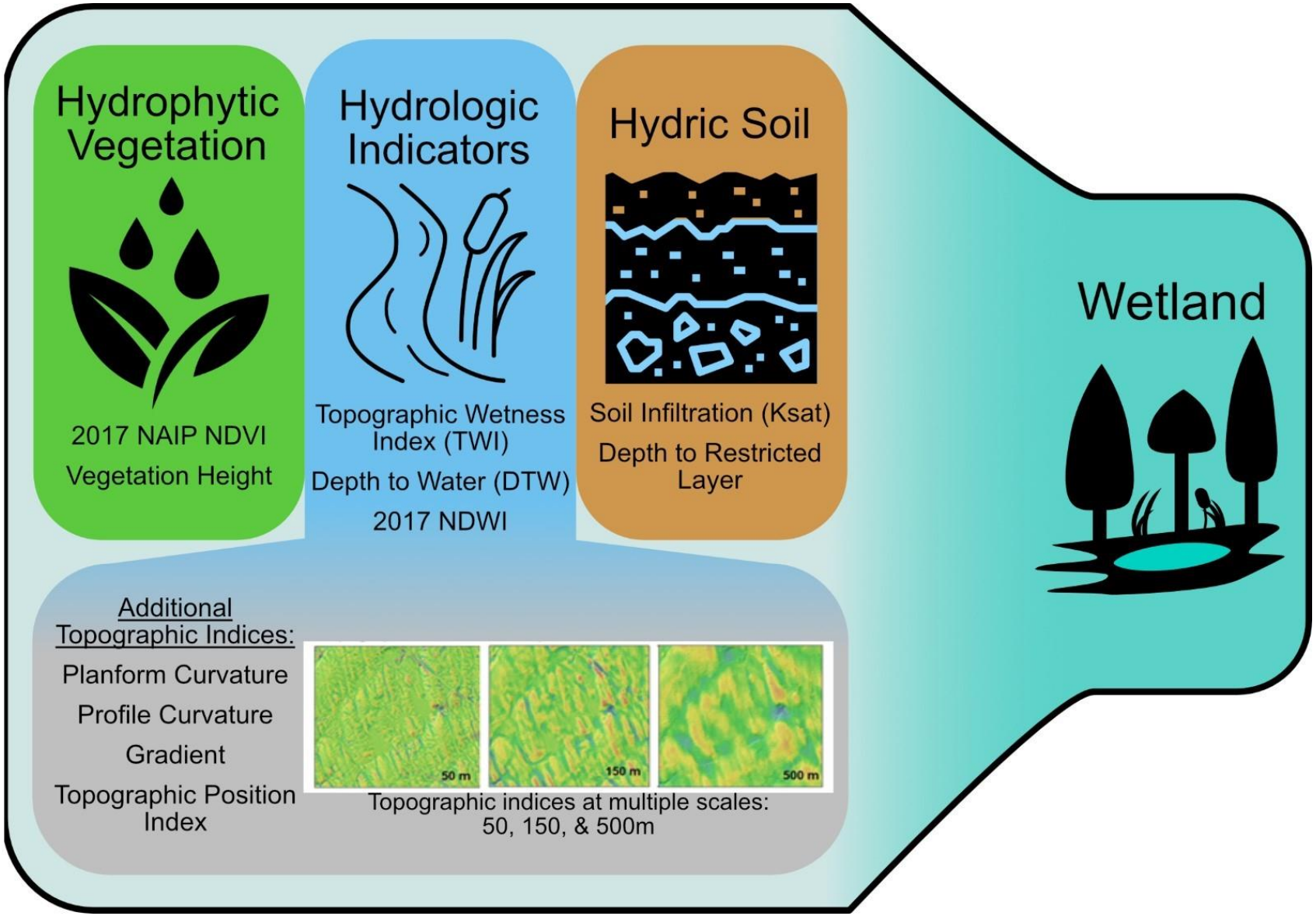




Hydrology

Wetland Indicator Framework

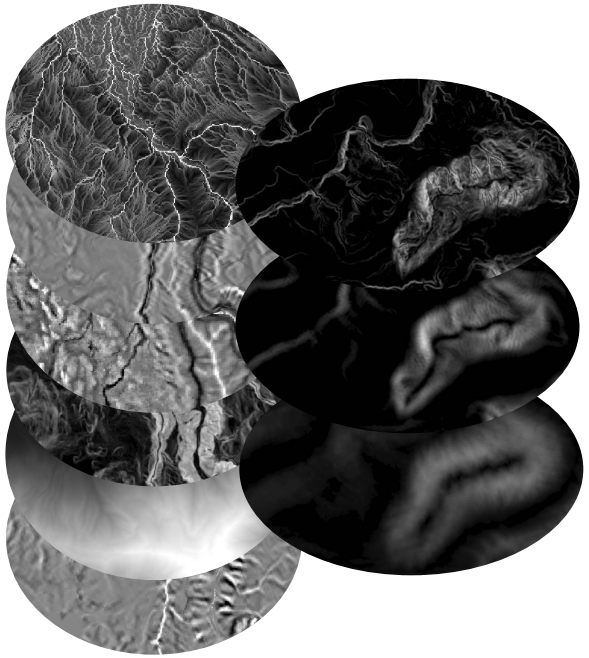
Graphic credit:
Anthony Stewart



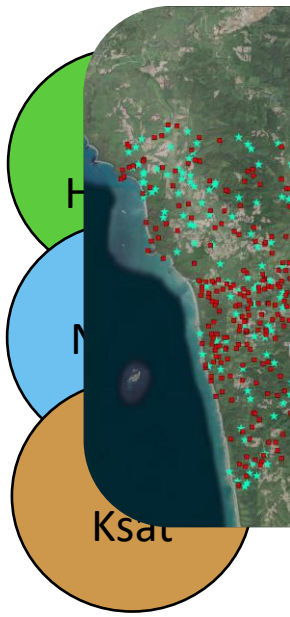
Wetland Intrinsic Potential (WIP) Tool

Halabisky et al., 2022 (In Review)

Generates Multiscale Terrain Metrics



Integrates Additional Predictor Variables



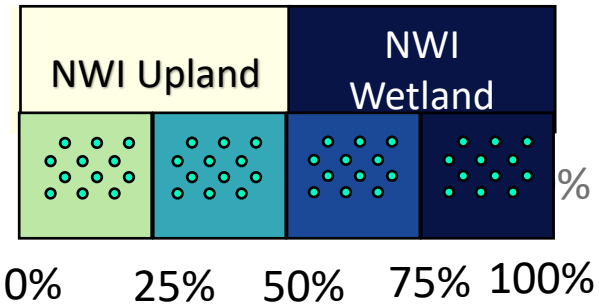
Creates and Uses Robust Training Data

Predicts with Rand Forest

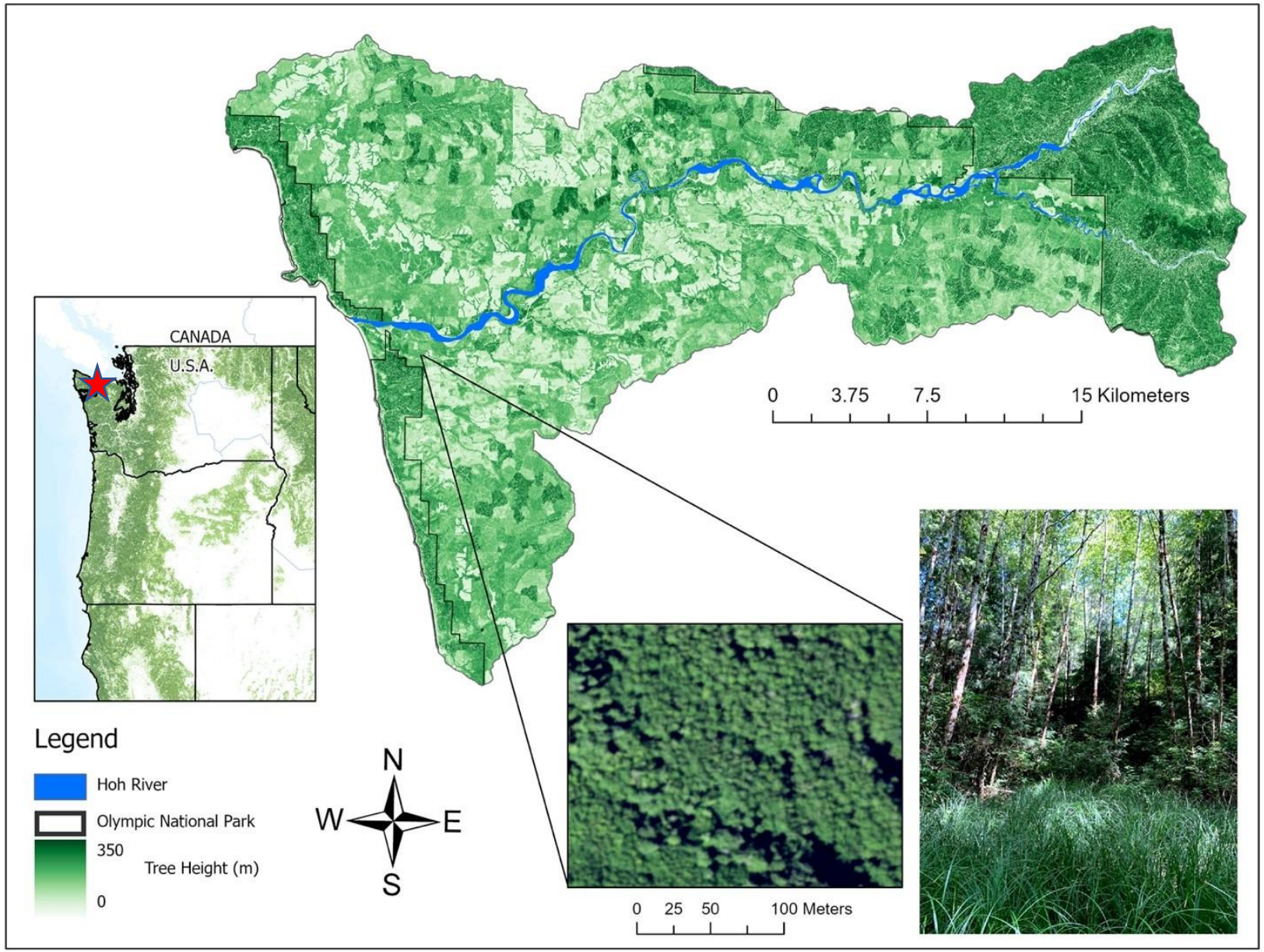
Additional Wetland/ Upland Field Observations

Upland Wetland

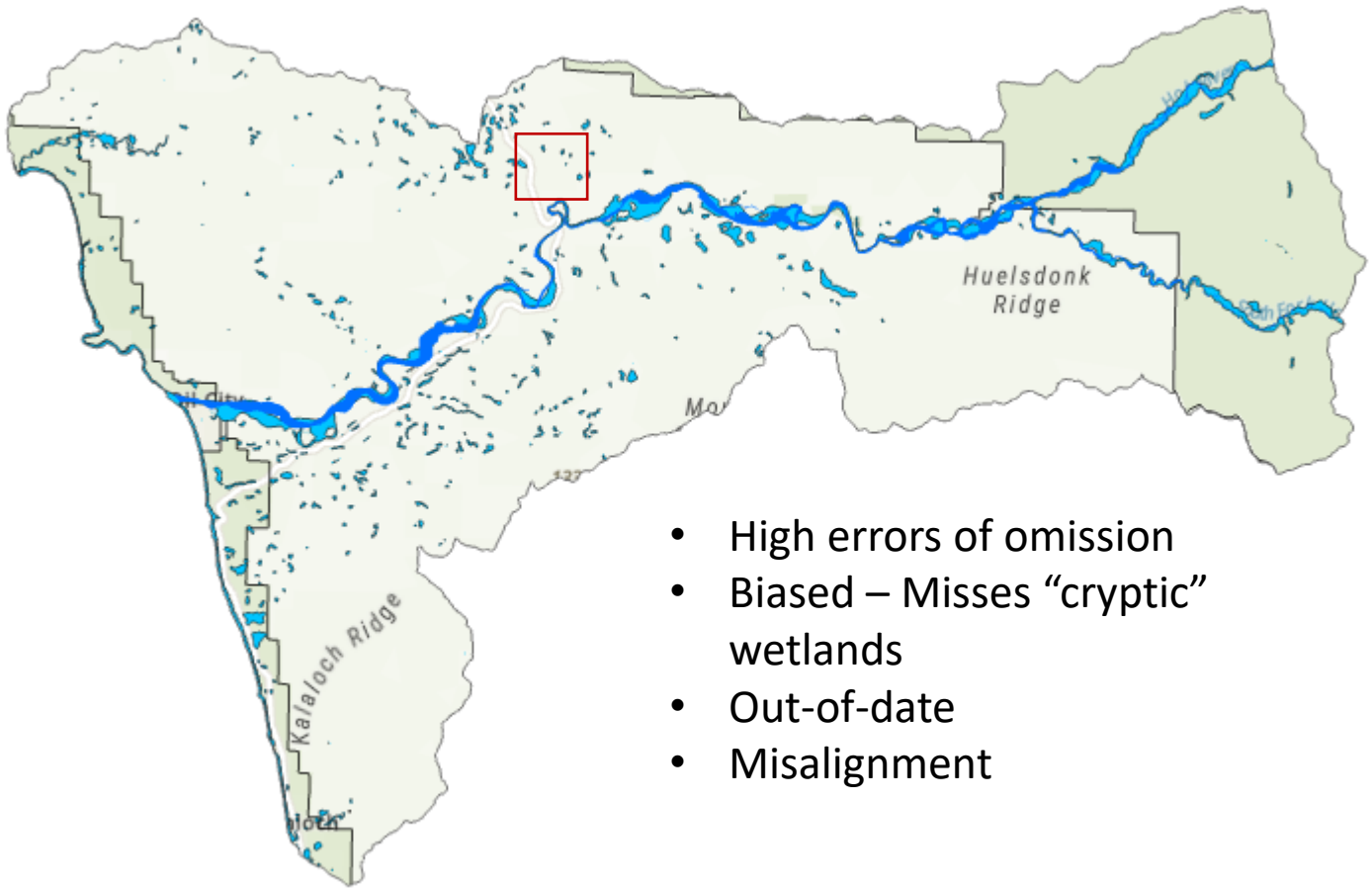
Probabilistic Continuous Output



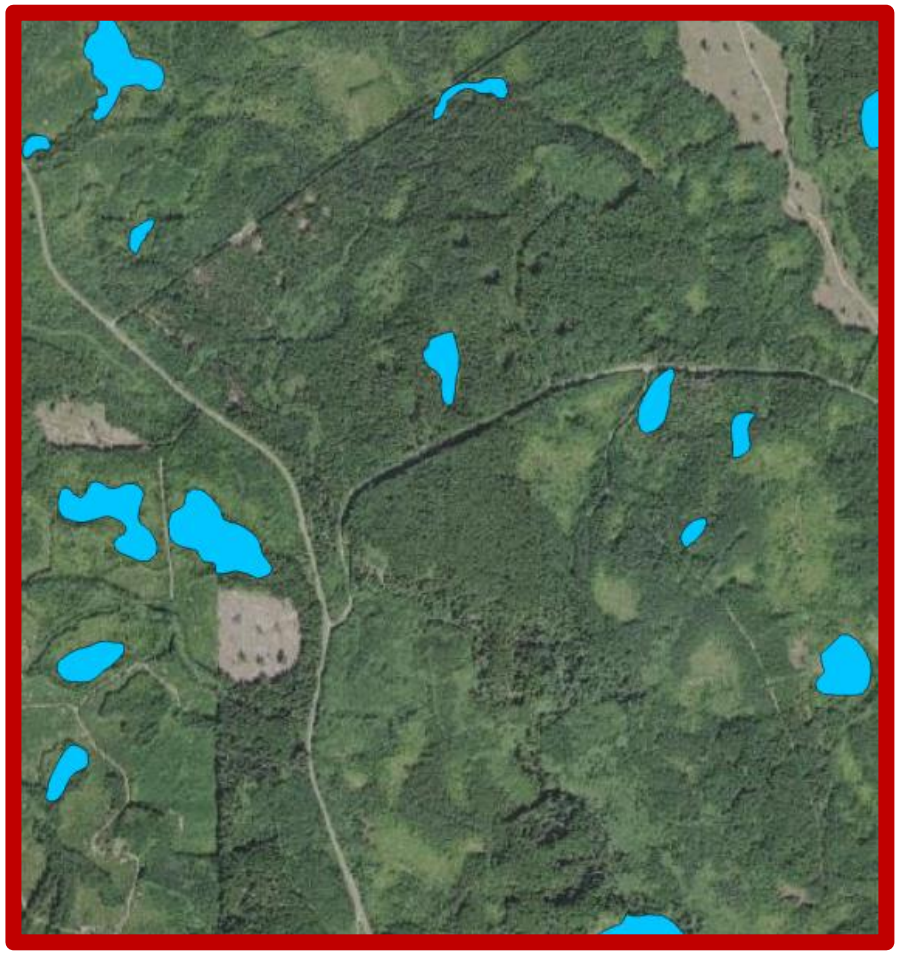
Study Area: Hoh Watershed

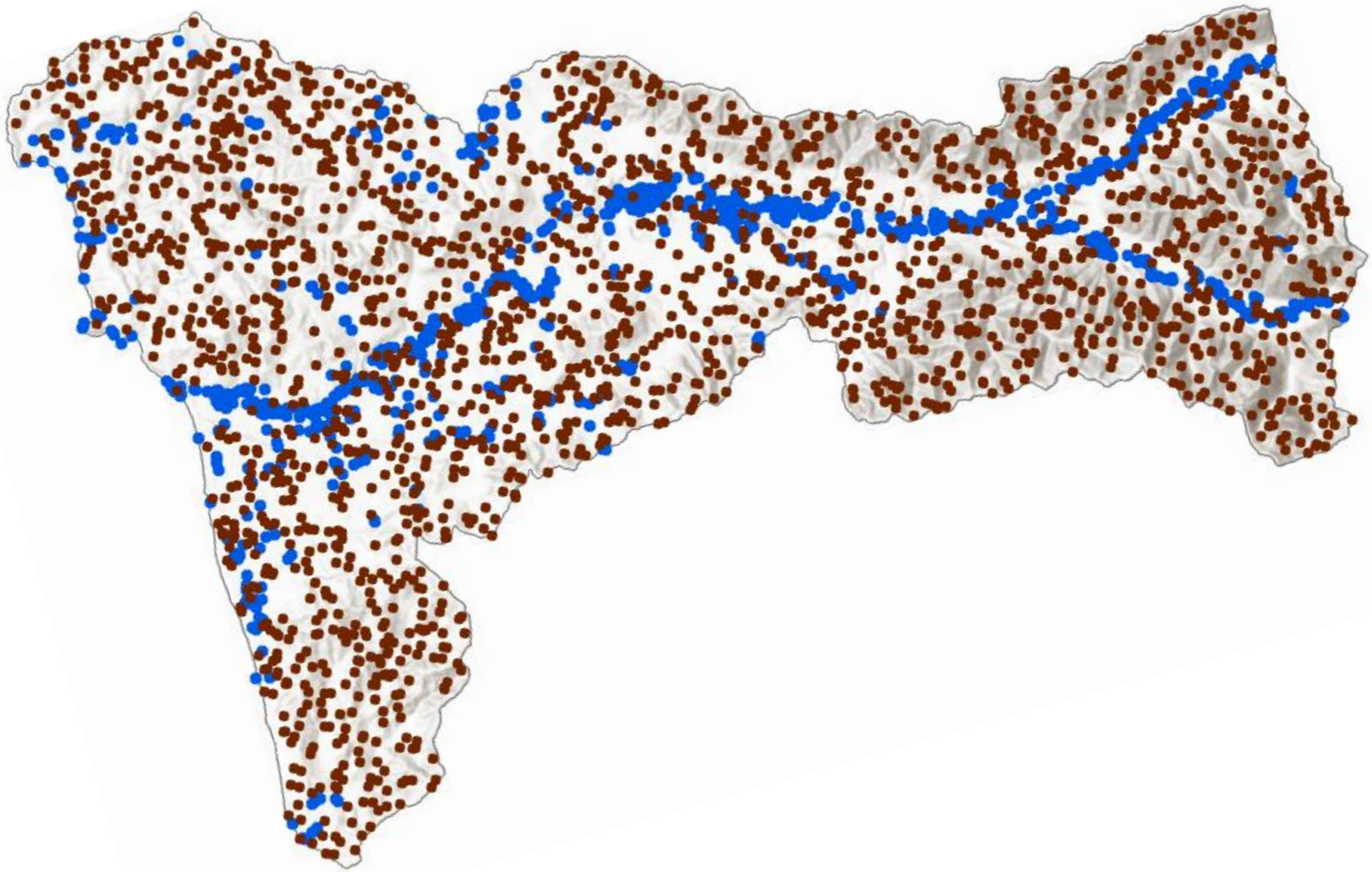


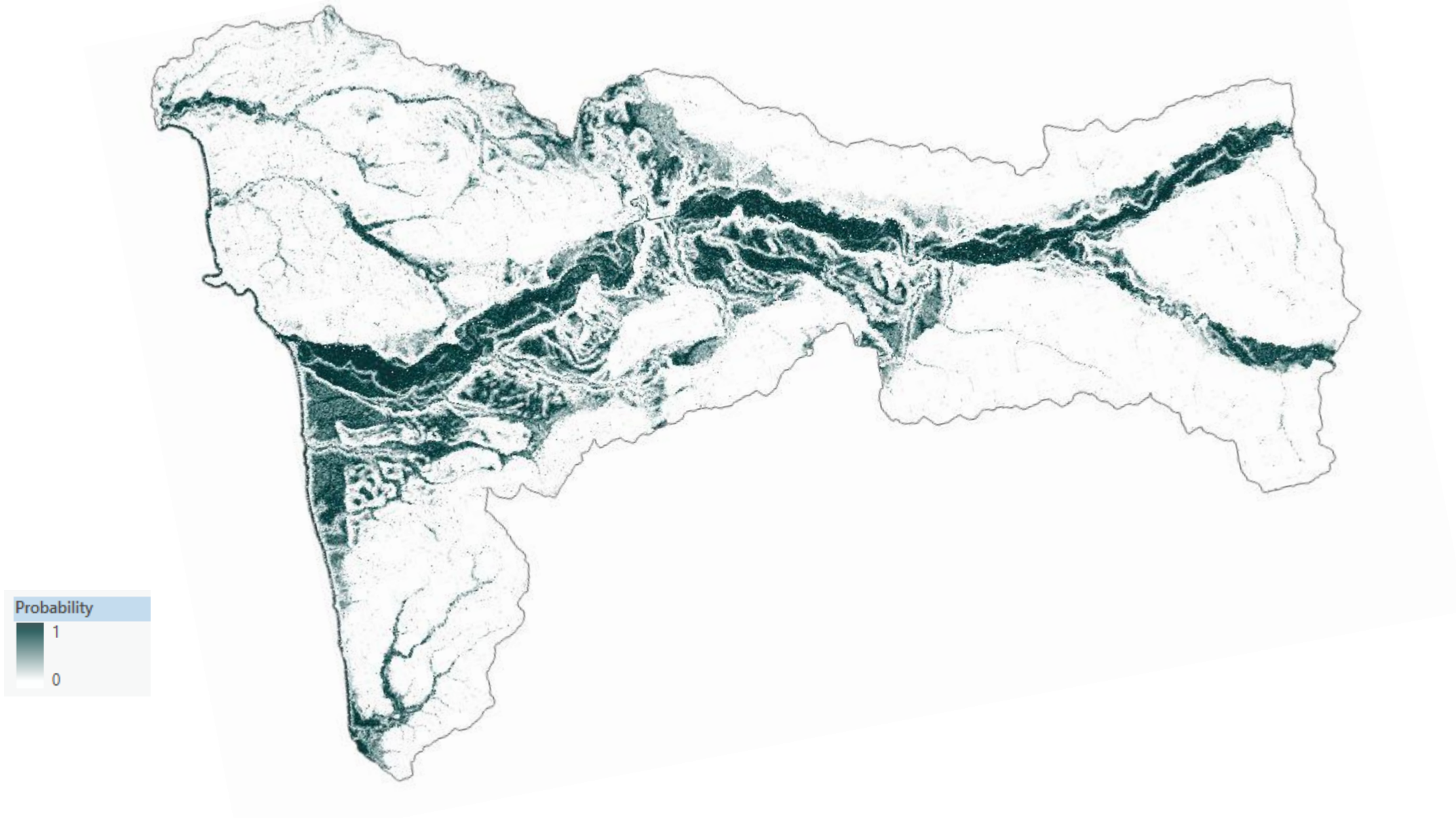
National Wetland Inventory (ex.Hoh River)



- High errors of omission
- Biased – Misses “cryptic” wetlands
- Out-of-date
- Misalignment

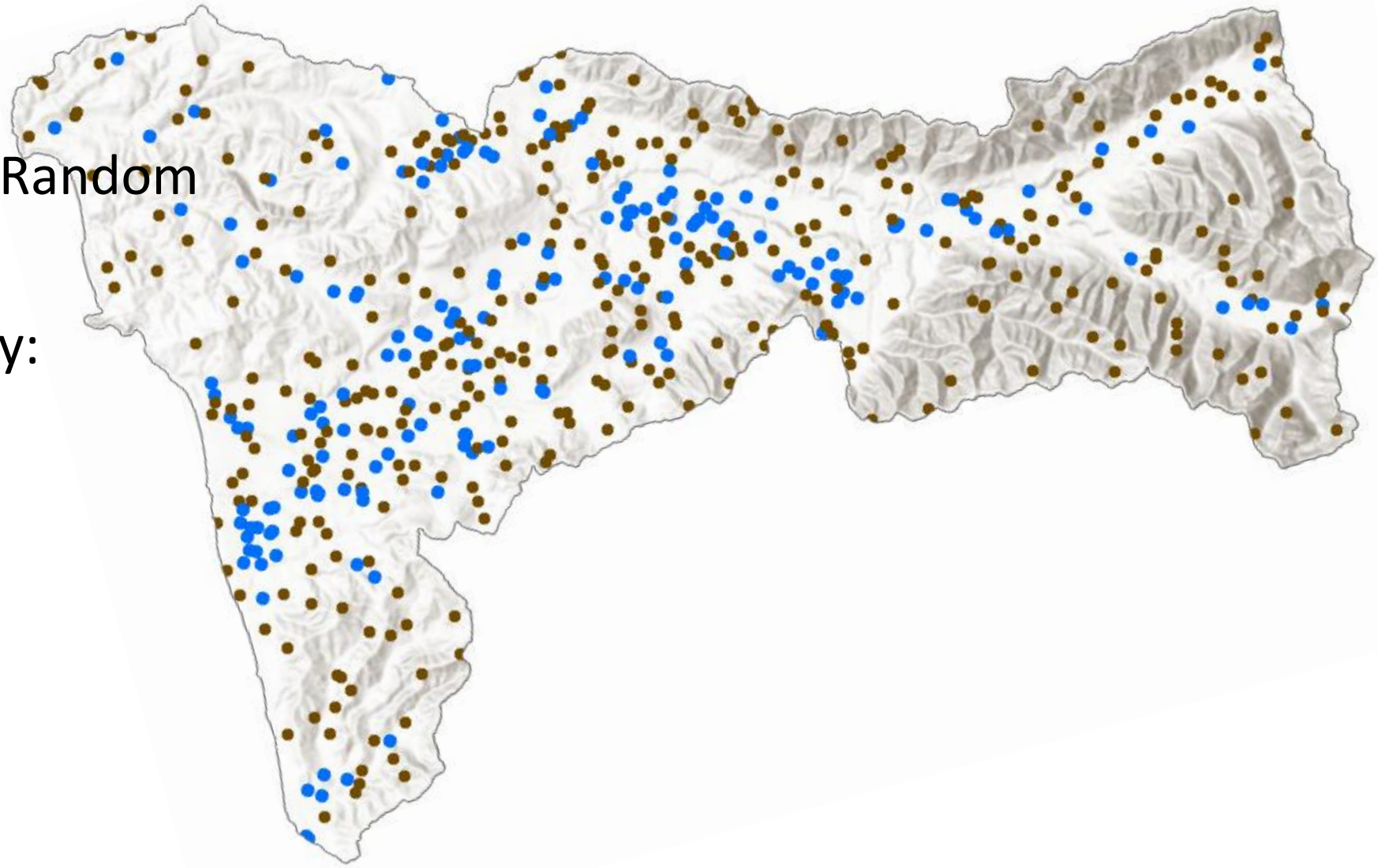


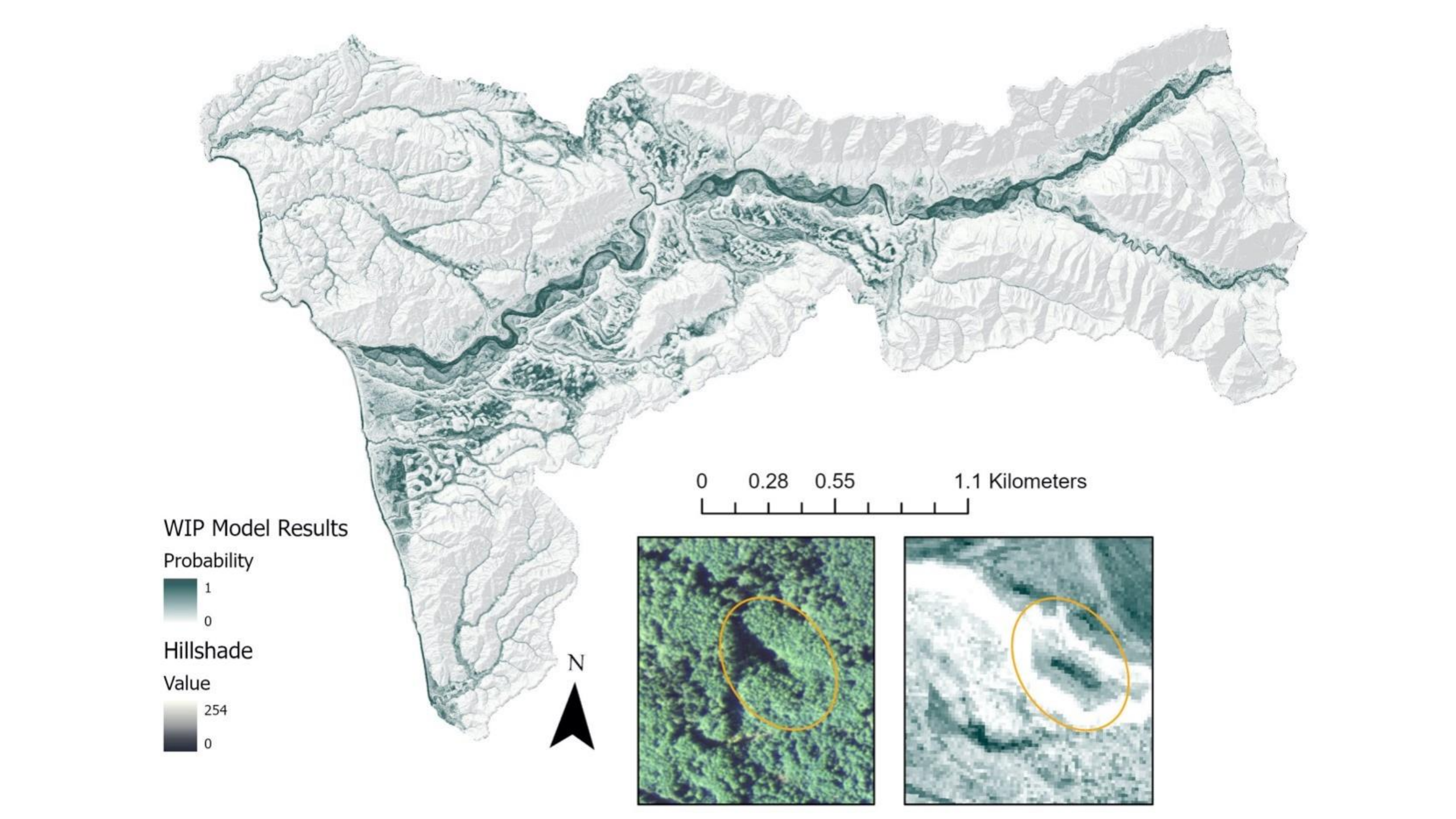


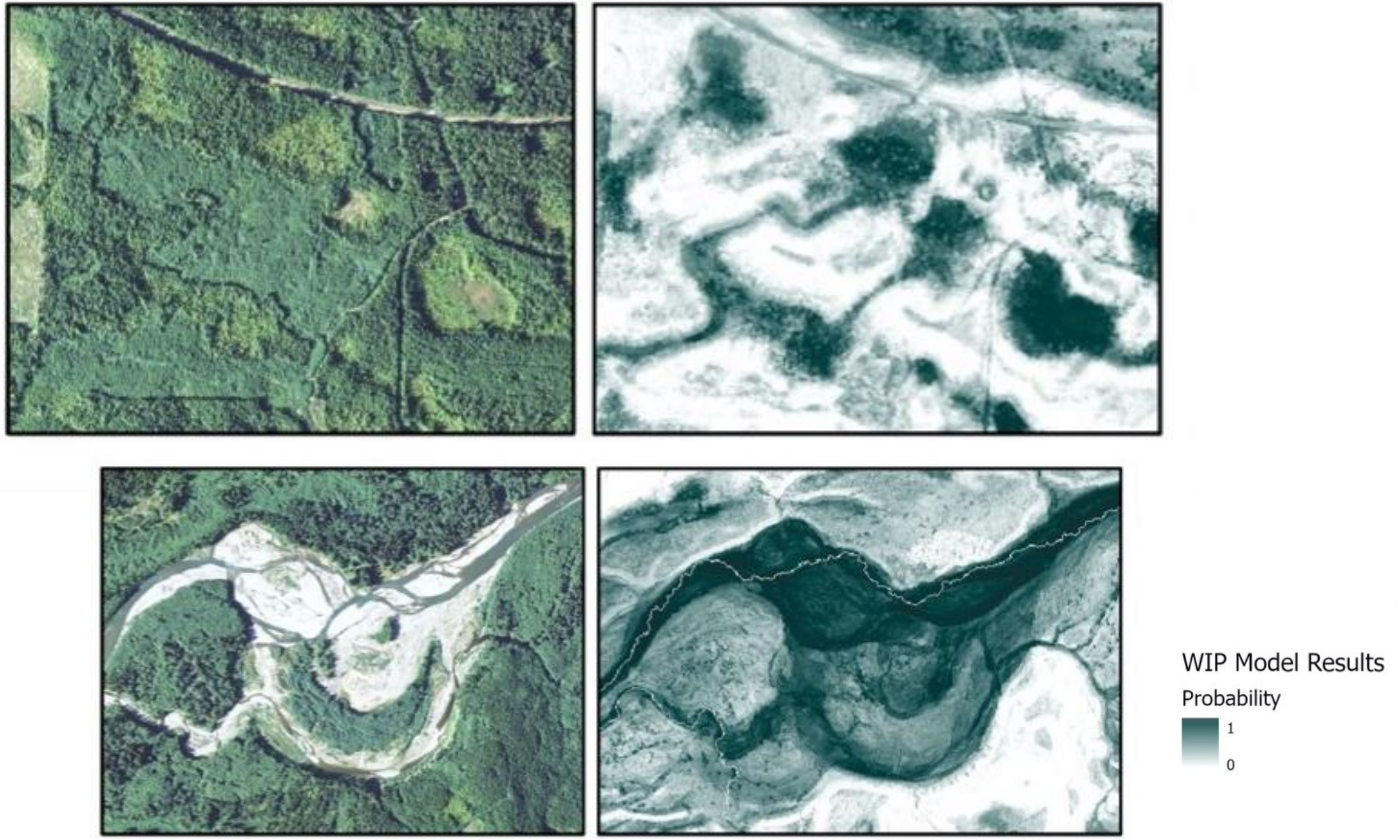

Probability
1
0

Stratified Random Sampling Probability:

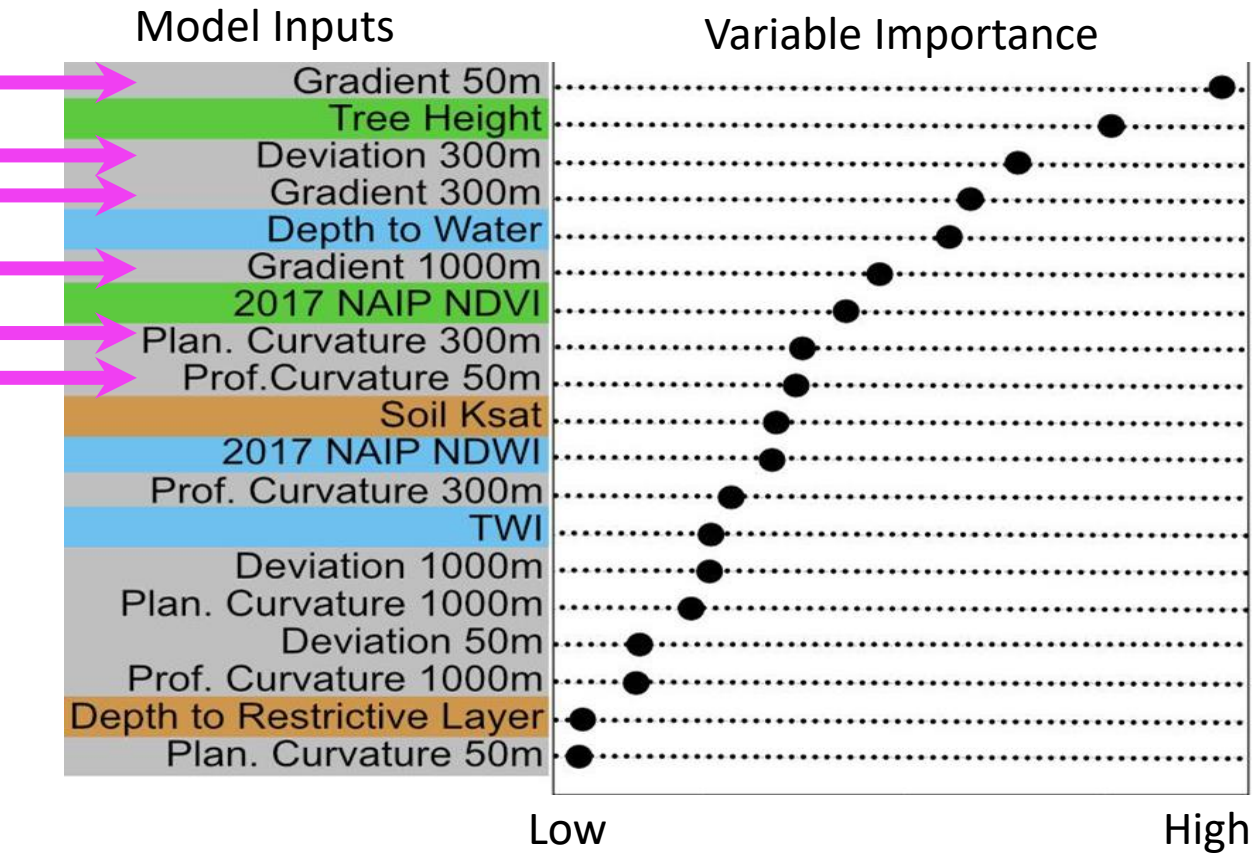
- 0-.25
- .25-.50
- .50-.75
- .75-1.00

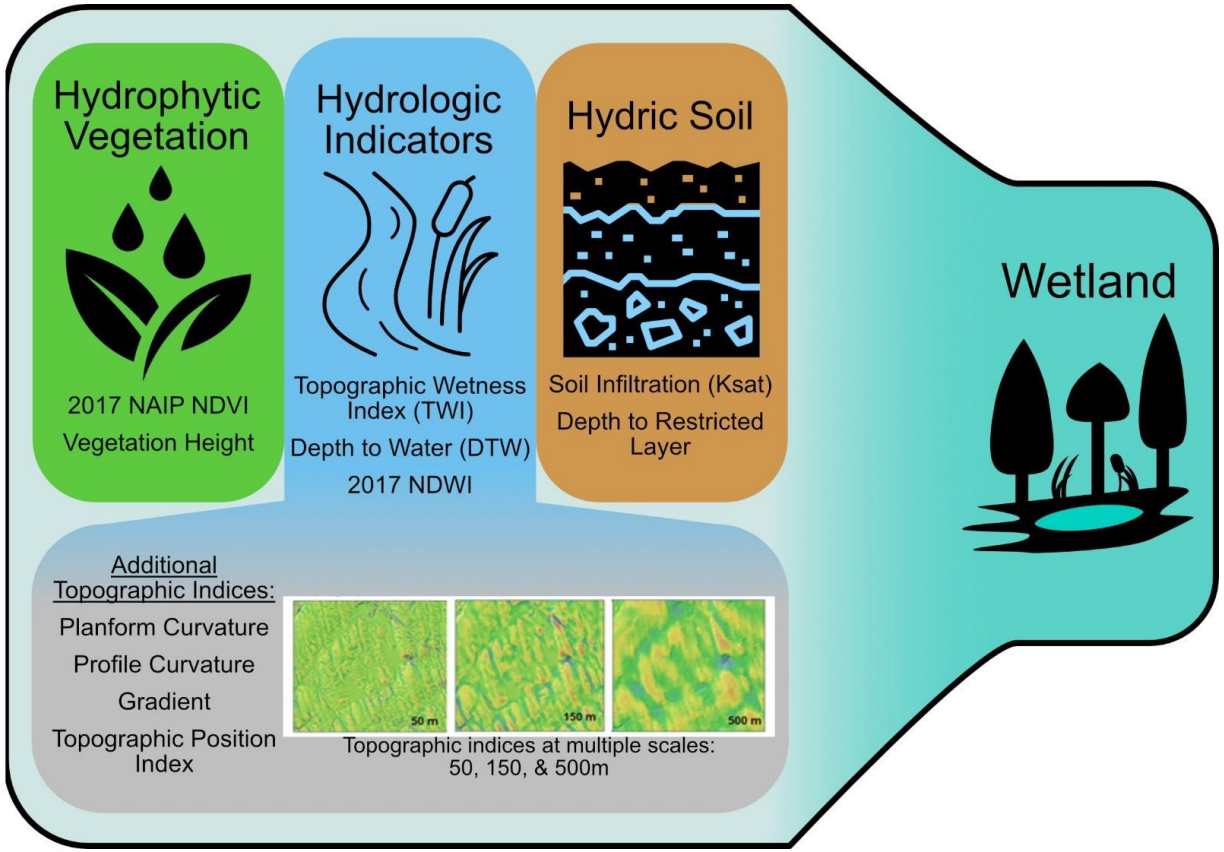



0 0.28 0.55 1.1 Kilometers
WIP Model Results
Probability
1
0
Hillshade
Value
254
0
N


WIP Model Results
Probability
1
0

Wetland Indicators – Variable Importance



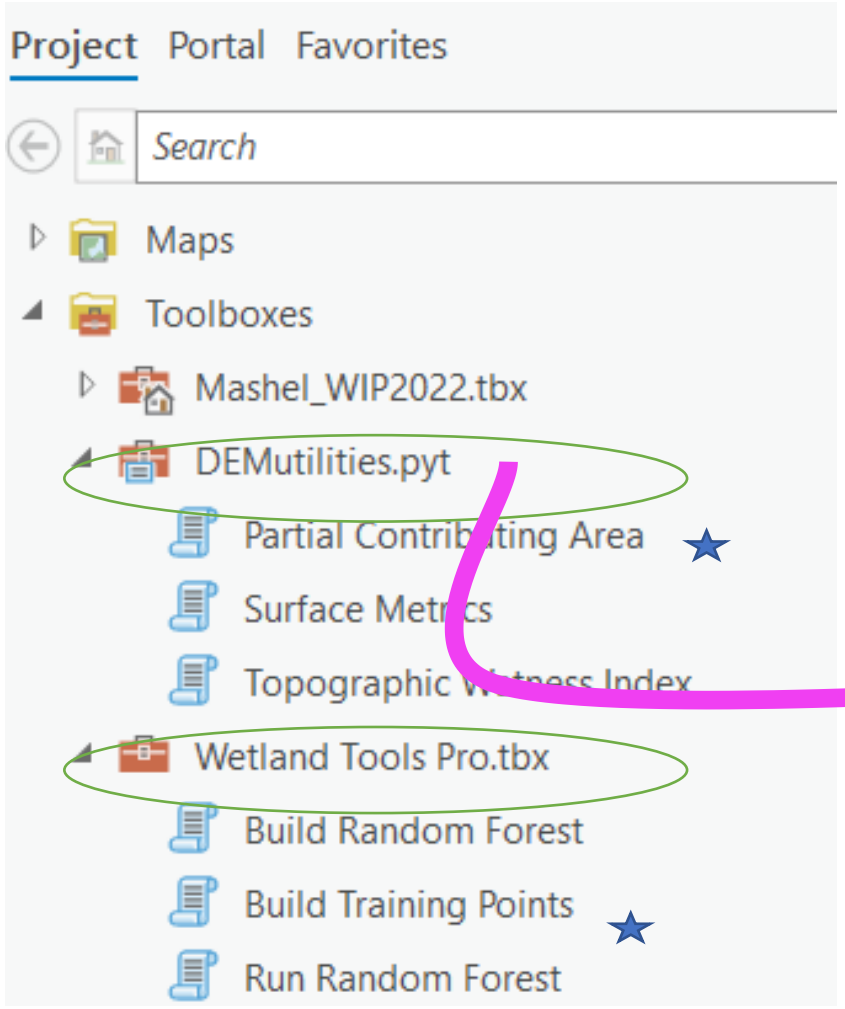


Wetlands Identified with Multi-scale Terrain Metric Approach with High Overall Accuracy

	WIP Tool	**NWI**
Overall Accuracy	**91.97%**	83.95%
Omission Error	**14.14%**	47.47%
Commission Error	10.53%	**1.83%**

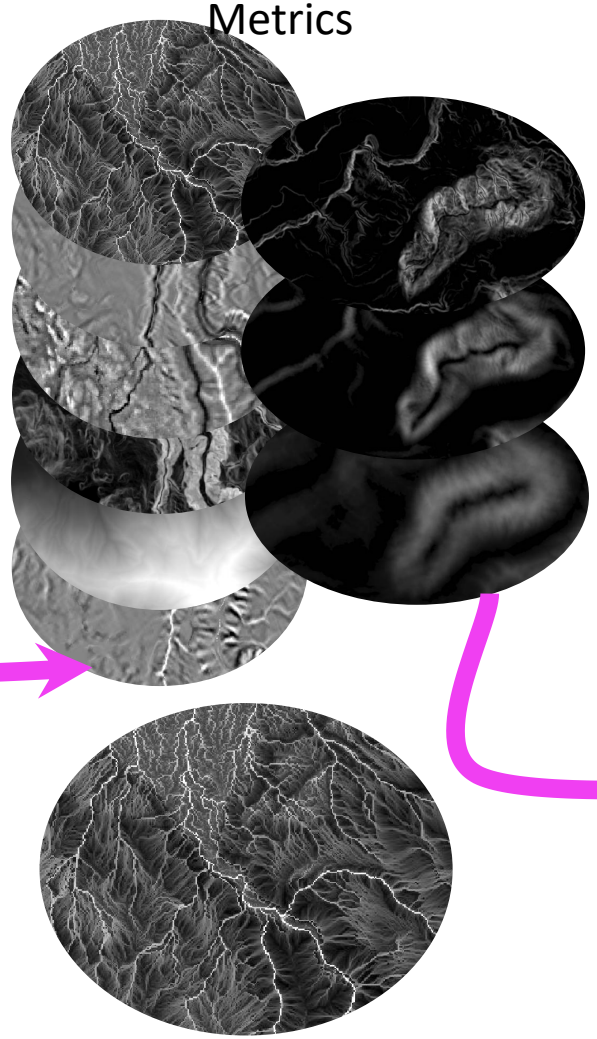
181% increase in wetland area

ArcGIS Toolbox – DEM utilities & Random Forest model

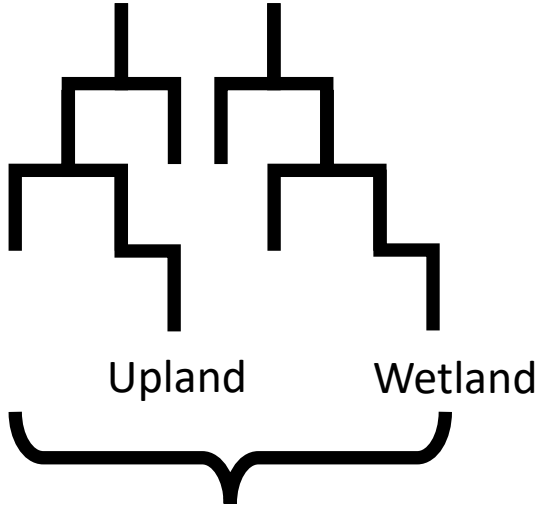


★ Still under development

Generates Multiscale Terrain Metrics



Predicts with Random Forest Classifier



Probabilistic Continuous Output

Conclusion

- The WIP tool identifies wetlands missed in existing wetland inventories. Error of omission and commission – mostly for marginal wetlands.
- Lidar helps identify wetlands that are hard to see because of trees and shadows. Lidar is not required.
- Flexible tool that can be improved as new input data layers are identified as important.
- Can be used to screen for potential wetlands – can lower the cutoff or raise the cutoff.
- WIP model performs better when field data is used, but works very well with NWI training data (available everywhere).

Limitations of the WIP Tool:

The WIP tool provides an improvement on identifying wetland locations in forested areas, but does not delineate wetland borders or classify wetland types. For any policy or management application, the WIP tool is best used as an initial screening for follow-up on the ground.

There are several limitations of the WIP tool:
1.) We did not use a jurisdictional wetland definition.

2.) The WIP tool depends on the training data and input data layers. If training data is missing for a wetland

Limitations of the WIP Tool (Cont…) :

3.) The WIP tool is based on topographic features and surface water flow models. It does not account for well-drained soils. Certain areas may identify strongly as wetlands, but in fact be false positives due to underlying geology and soil types.

4.) The WIP tool may not produce useful results for areas with constructed human modification of water flows (i.e. drains, ditches) as these are not mapped as part of the lidar-derived hydrologic flow models used as inputs to the WIP tool.

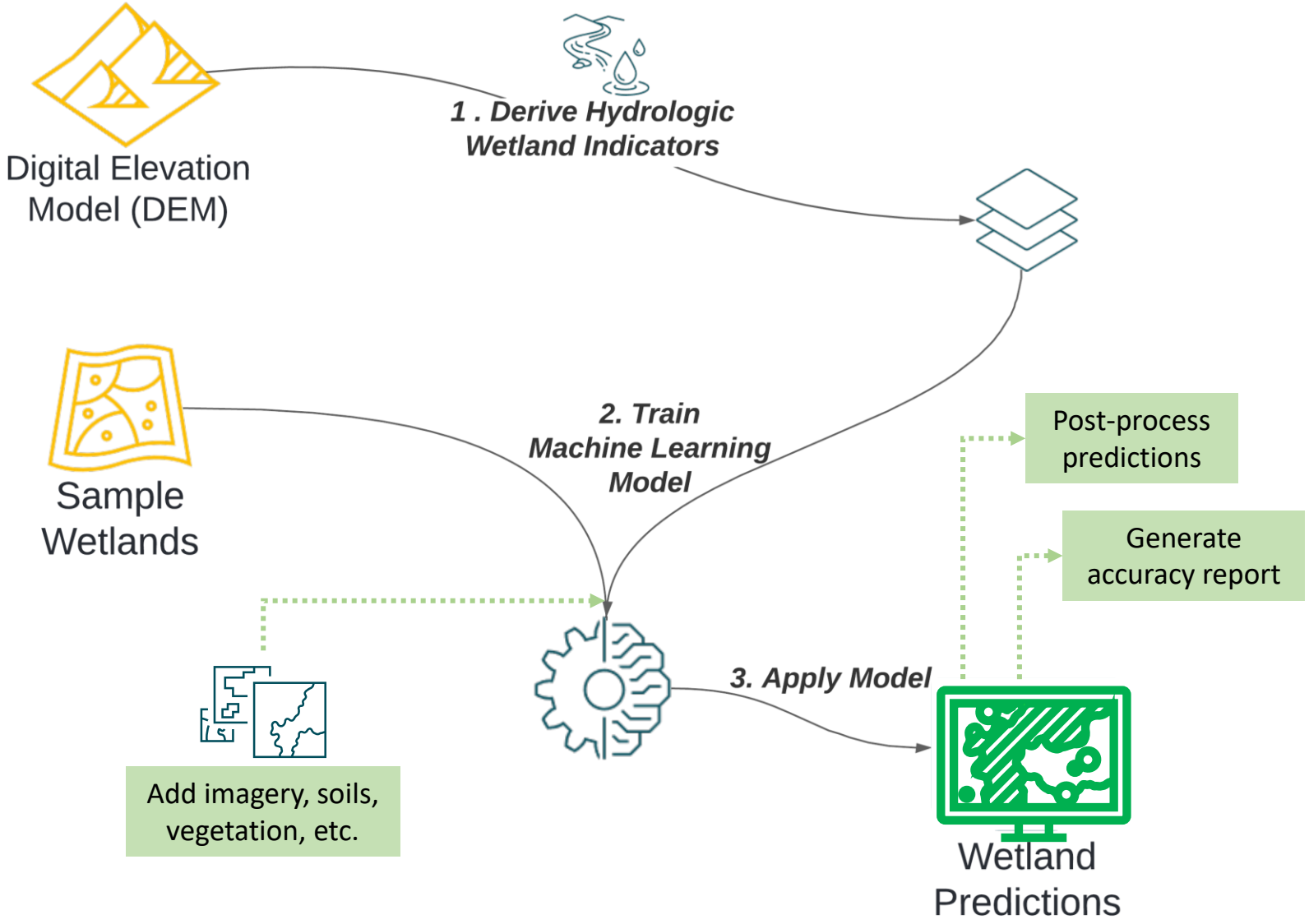
Next Steps

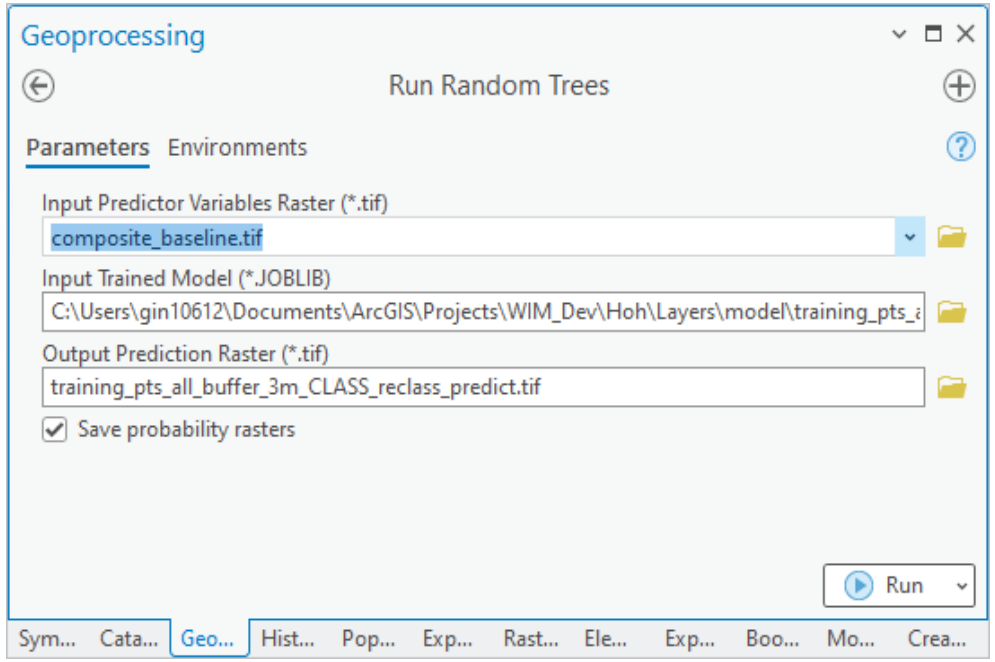
1. Developing an end-to-end workflow on the Digital Earth Africa platform (python based).
2. Expanding on WIP tool to characterize and classify wetlands.
3. Develop an open-source r or python package.

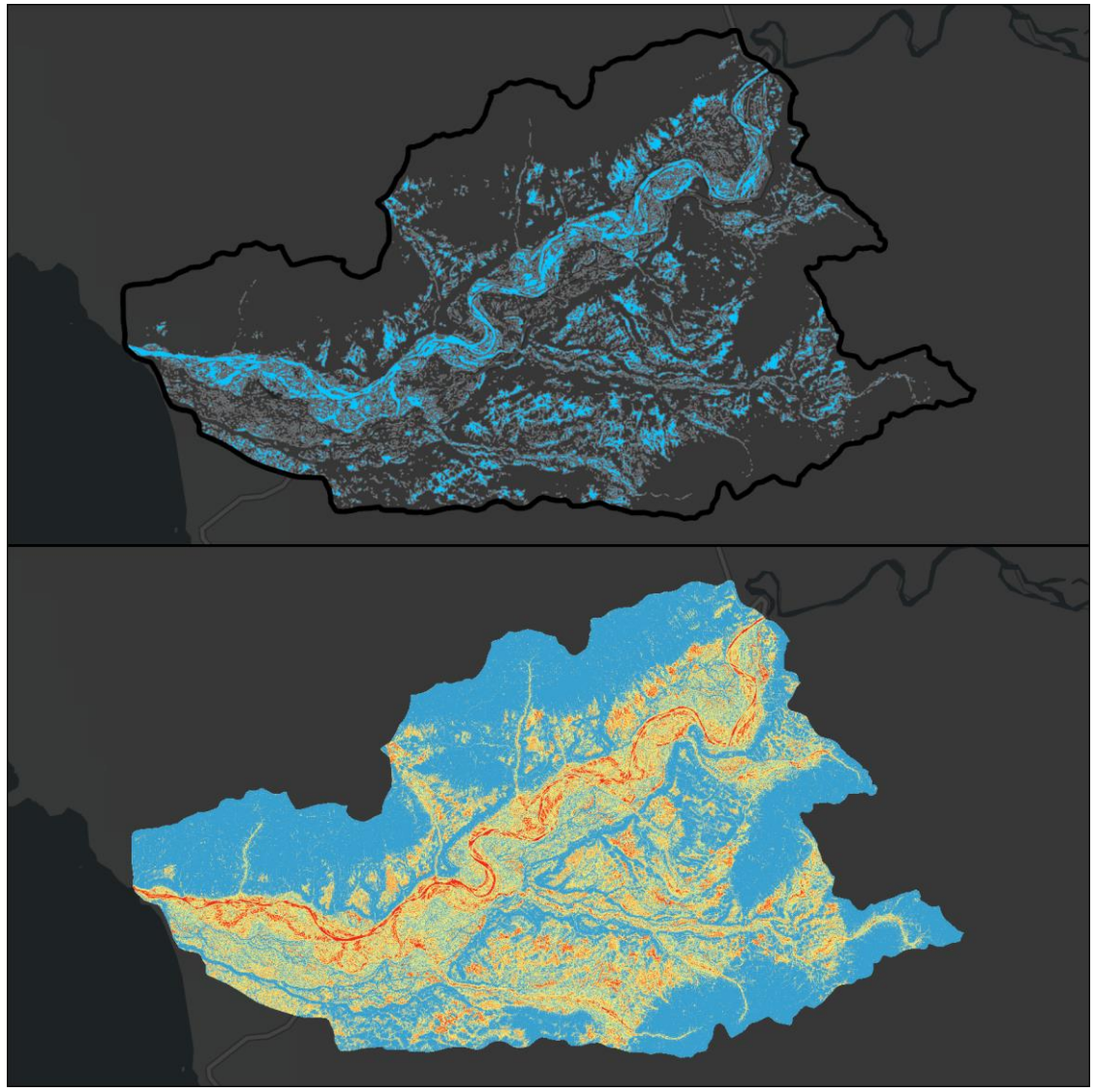
Collaborating with ESRI - Gina O'Neil to include components of the WIP into the WIM!

Arc Hydro for ArcGIS Pro

- Wetland Identification.tbx
  - Assess Accuracy
  - Calculate Curvature
  - Calculate Curvature using Surface Parameters
  - Calculate Depth to Water Index (DTW)
  - Calculate Depth to Water Index (DTW) using Surface Parameters
  - Calculate Topographic Wetness Index (TWI)
  - Calculate Topographic Wetness Index (TWI) using Surface Parameters
  - Hydrocondition High Resolution DEM
  - Post-Process Wetland Predictions
  - Preprocess Ground Truth Data
  - Run Random Trees
  - Smooth High Resolution DEM
  - Train Random Trees
  - Train Test Split







Wetland classification cleaned up with *Post-Process Wetland Predictions*

Probability of each raster cell being a wetland

Thank you !

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