The Wetland Intrinsic Potential Tool (WIP)

Mapping wetlands using remote sensing data

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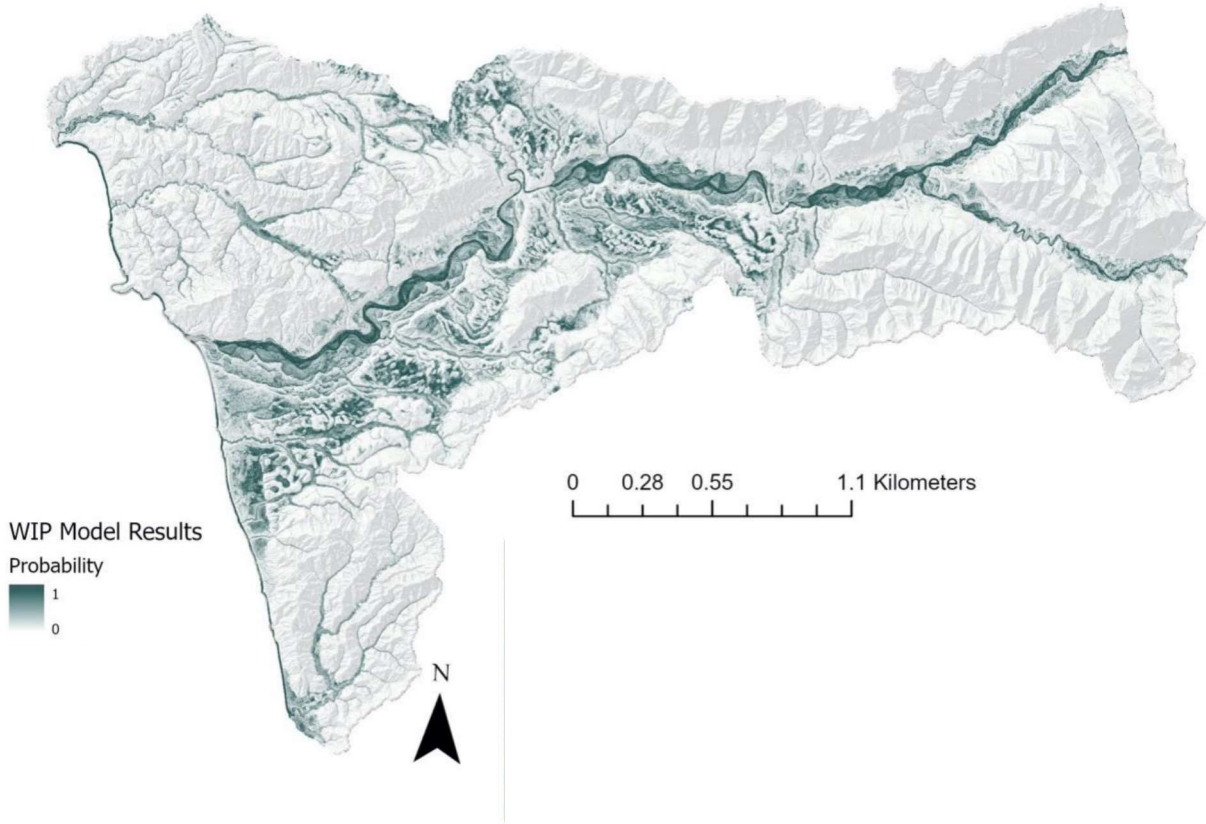
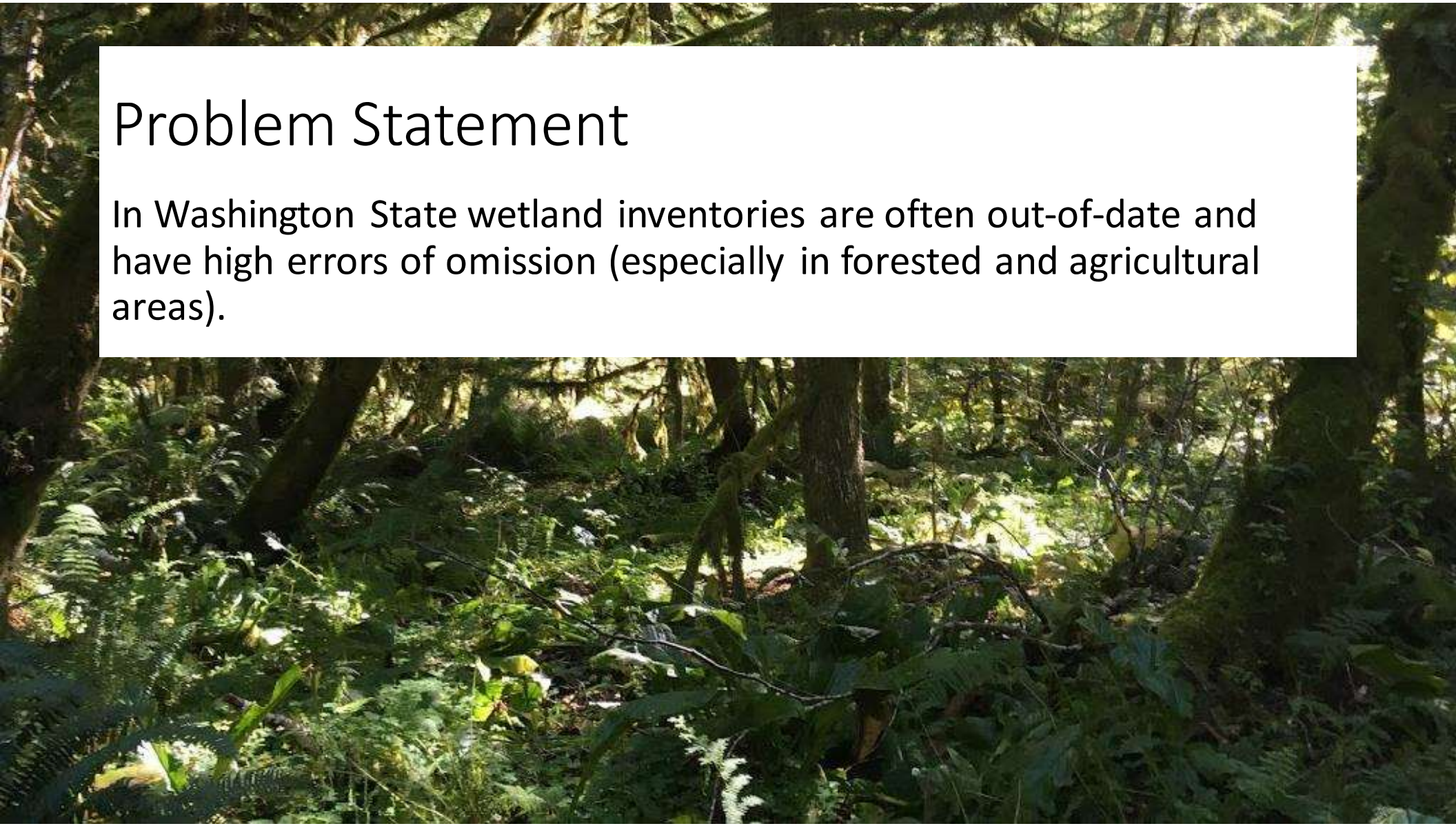


Wetlands are important nature-based solutions to climate change

- Wetlands, which cover only 3% of the earth's land surface, store 30% of all land-based carbon.
- Mitigate impacts of flooding and drought.
- Regulate streamflow, climate refugia, water storage etc..
- WA State has lost ~ 50% of wetlands.

Citation: Convention on Wetlands. (2021). Global Wetland Outlook: Special Edition 2021. Gland, Switzerland: Secretariat of the Convention on Wetlands.

Photo credit: Maria Troitino, Ramsar



Problem Statement

In Washington State wetland inventories are often out-of-date and have high errors of omission (especially in forested and agricultural areas).

<u>Phase 1:</u> Develop semi-automated methods for mapping wetlands.

The 'Wetlands Intrinsic Potential' (WIP) tool uses digital elevation models (LiDAR) and may incorporate other digital data, including soils, geology, and multi-spectral imagery. (Luke Rogers, TerrainWorks)

(Luke Rogers (UW), TerrainWorks)

<u>Phase 2:</u> Improve the WIP tool - Increase field data to evaluate and improve methods developed in Phase 1, and to calibrate statistical models mapping probability of wetland occurrence.

(Meghan Halabisky (UW), TerrainWorks)

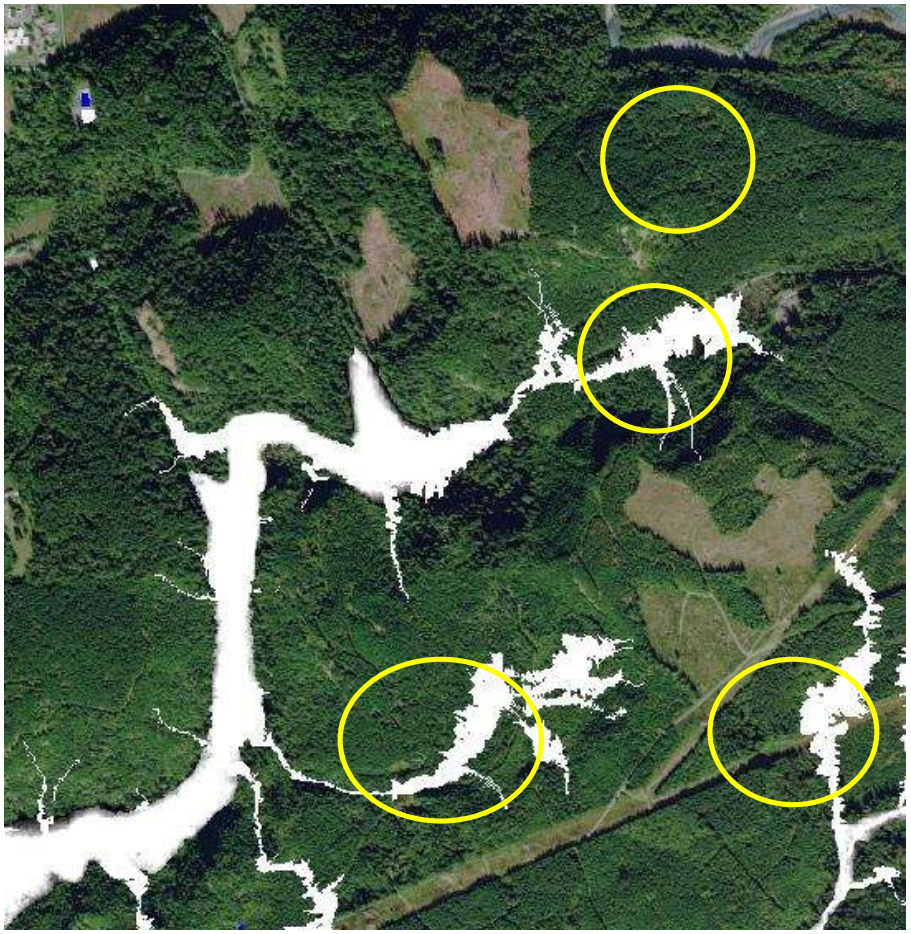
Challenges of mapping wetland ecosystems from a remote sensing point of view

- Wetlands are highly variable
  - Occur under tree canopy
  - Can be small
  - Ephemeral
  - Exist in areas with varied land uses
  - Many different drivers
  - Occur in highly modified landscapes

WIP Phase 1: Adapt methods to WA state

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



Findings from WIP Phase 1: 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

<u>Phase 1:</u> Develop methods for mapping hydrological and geomorphological controls on wetland occurrence.

(Luke Rogers (UW), TerrainWorks)

<u>Phase 2:</u> Improve the WIP tool - Increase field data to evaluate and improve methods developed in Phase 1, and to calibrate statistical models mapping probability of wetland occurrence.

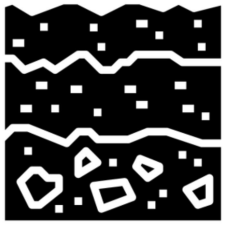
(Meghan Halabisky (UW), TerrainWorks)

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.

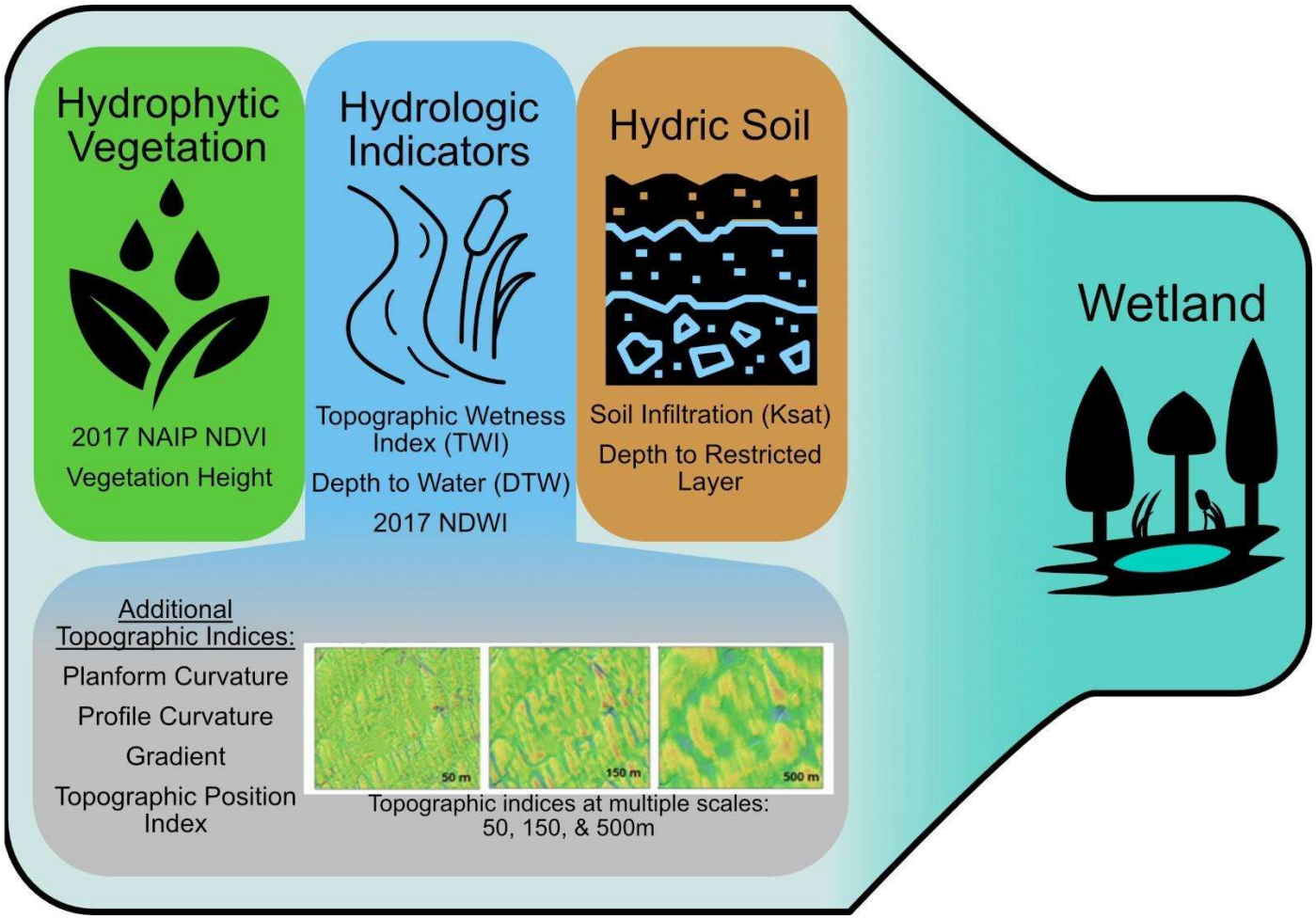
Hydrologic Indicators + Hydric Soil + Hydrophytic Vegetation = Wetland

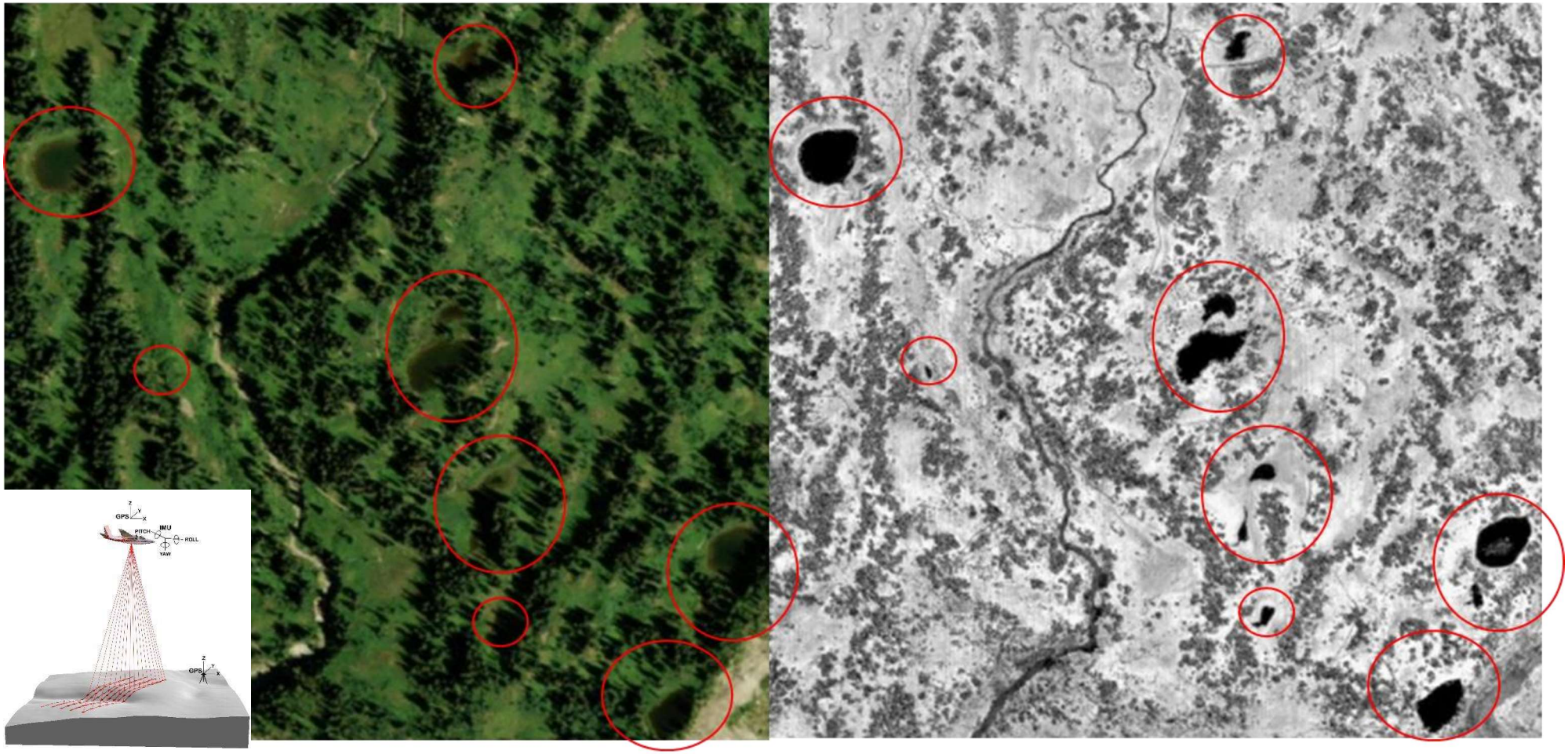


Hydrology

Wetland Indicator Framework

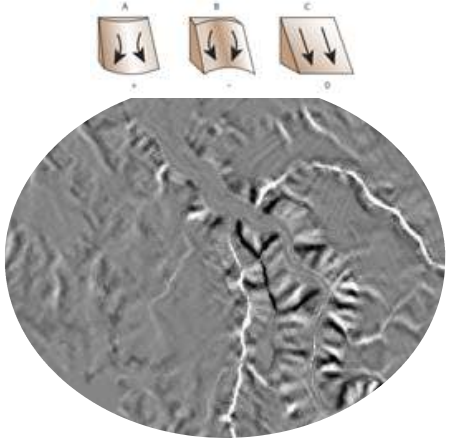
Graphic credit:
Anthony Stewart



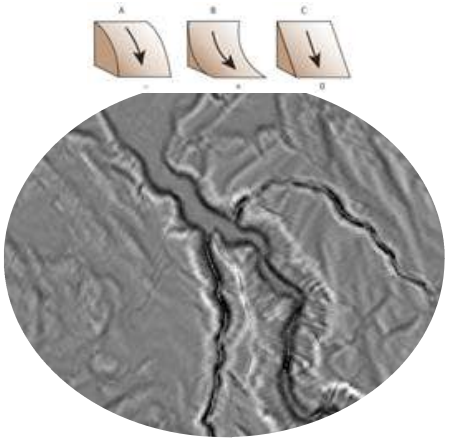

GPS
IMU
PITCH
ROLL
YAW
GPS

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

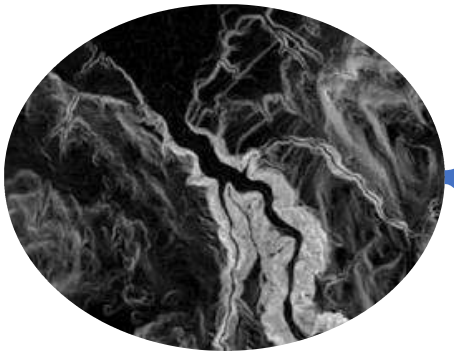
Planform Curvature



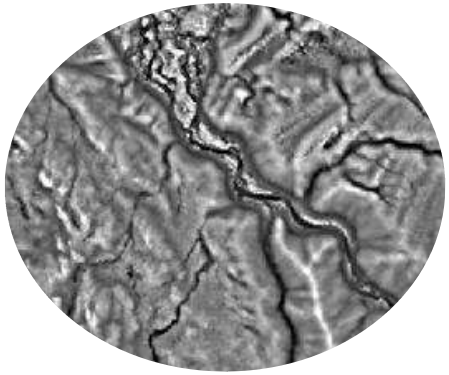
Profile Curvature



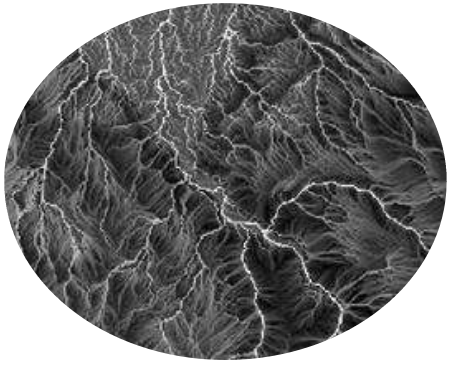
Slope/Gradient



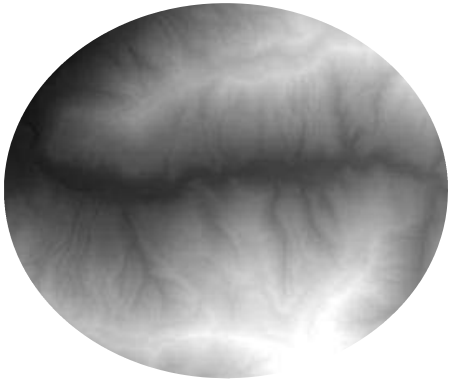
Depression Index



Topographic Wetness Index

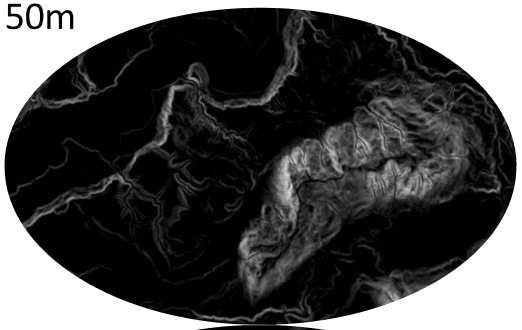


Depth To Water Index

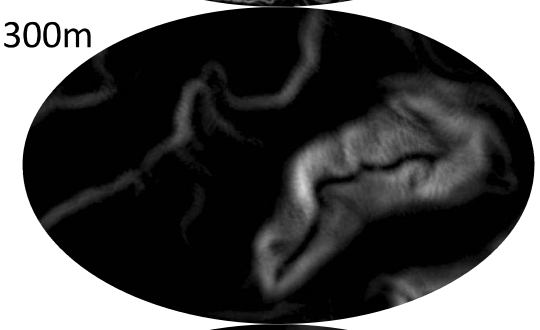


Variable Length Scale of Terrain Metrics

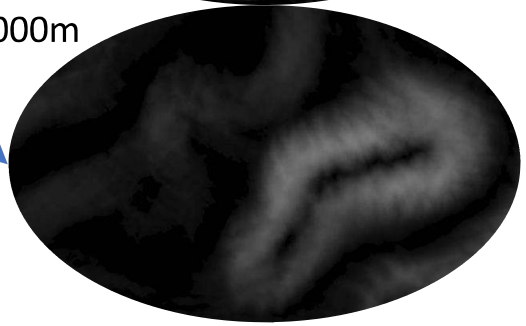
50m



300m



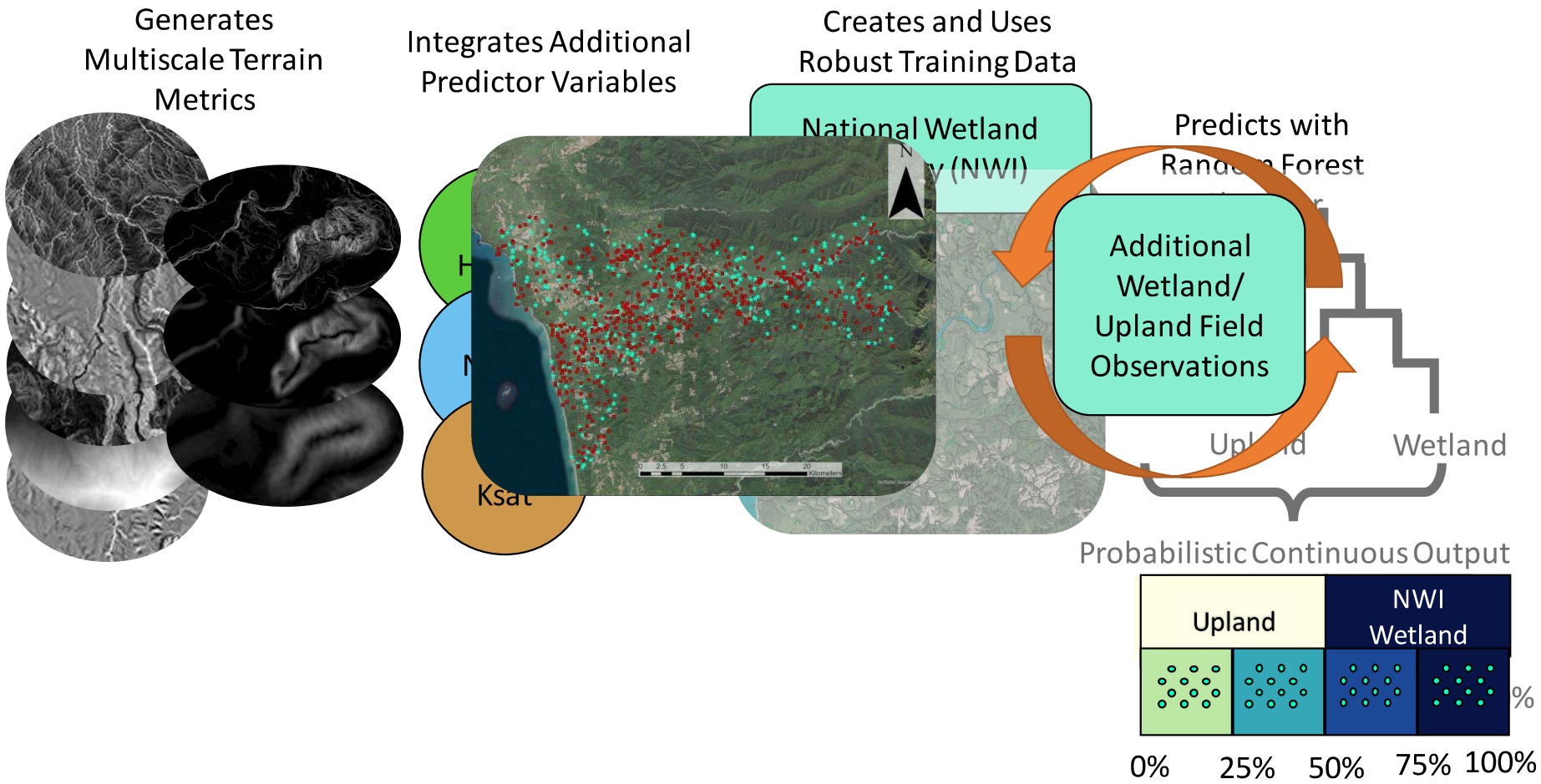
1000m



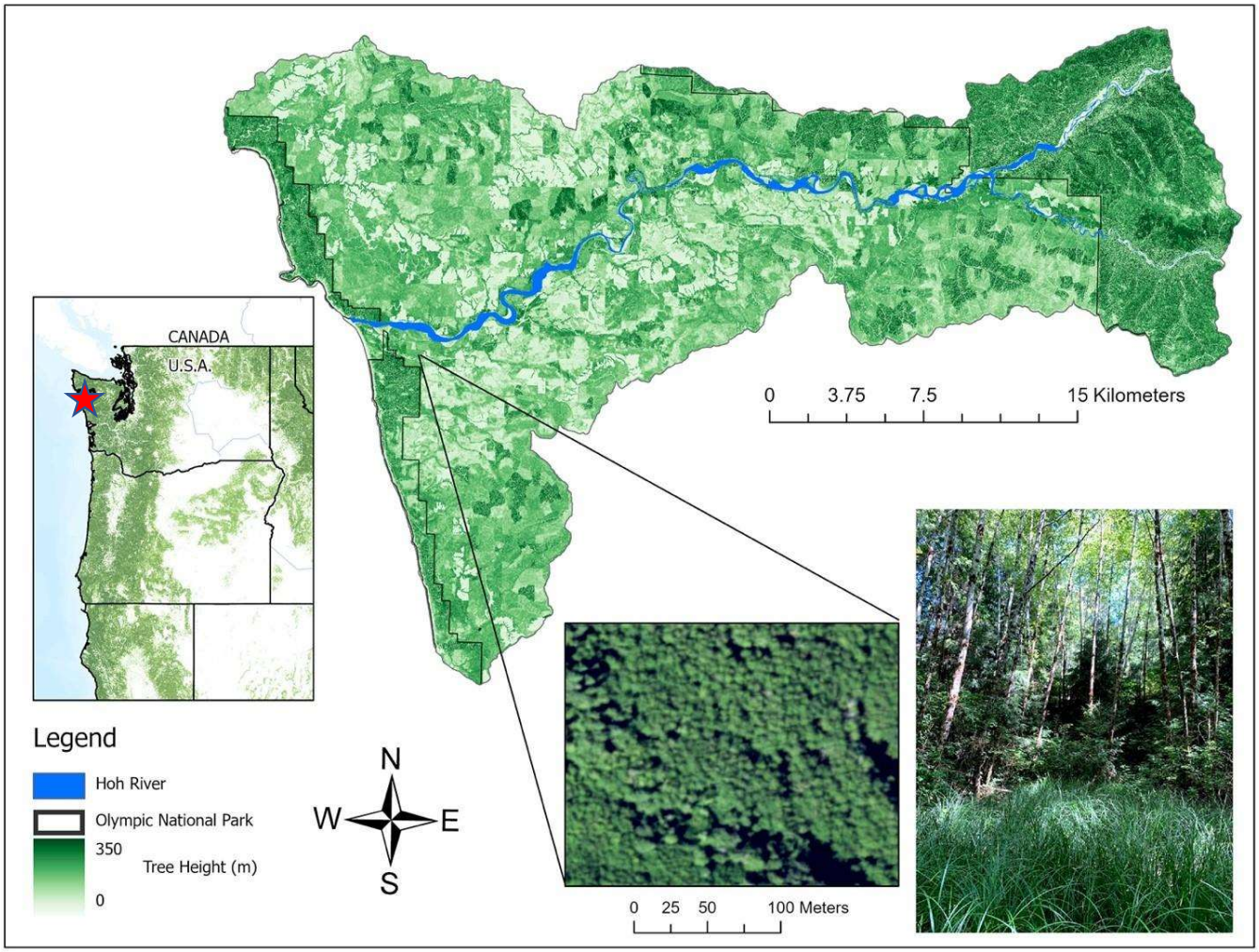
Maxwell et al., 2016

Wetland Intrinsic Potential (WIP) Tool

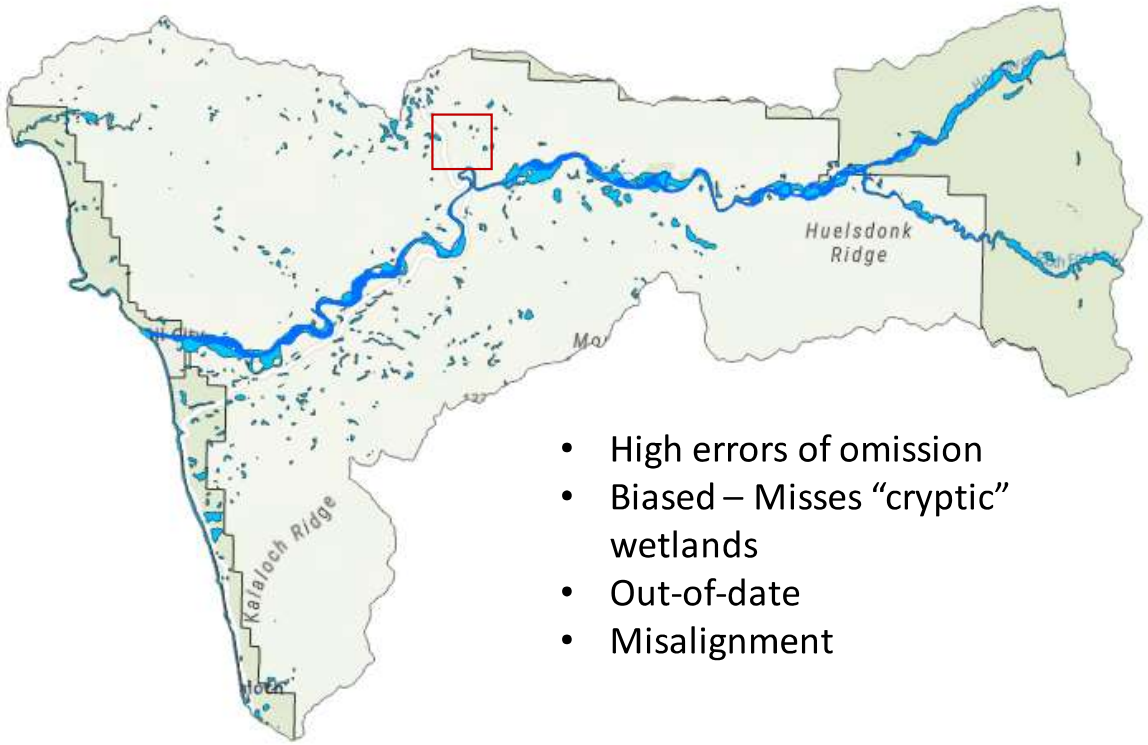
Halabisky et al., 2022 (In Review)



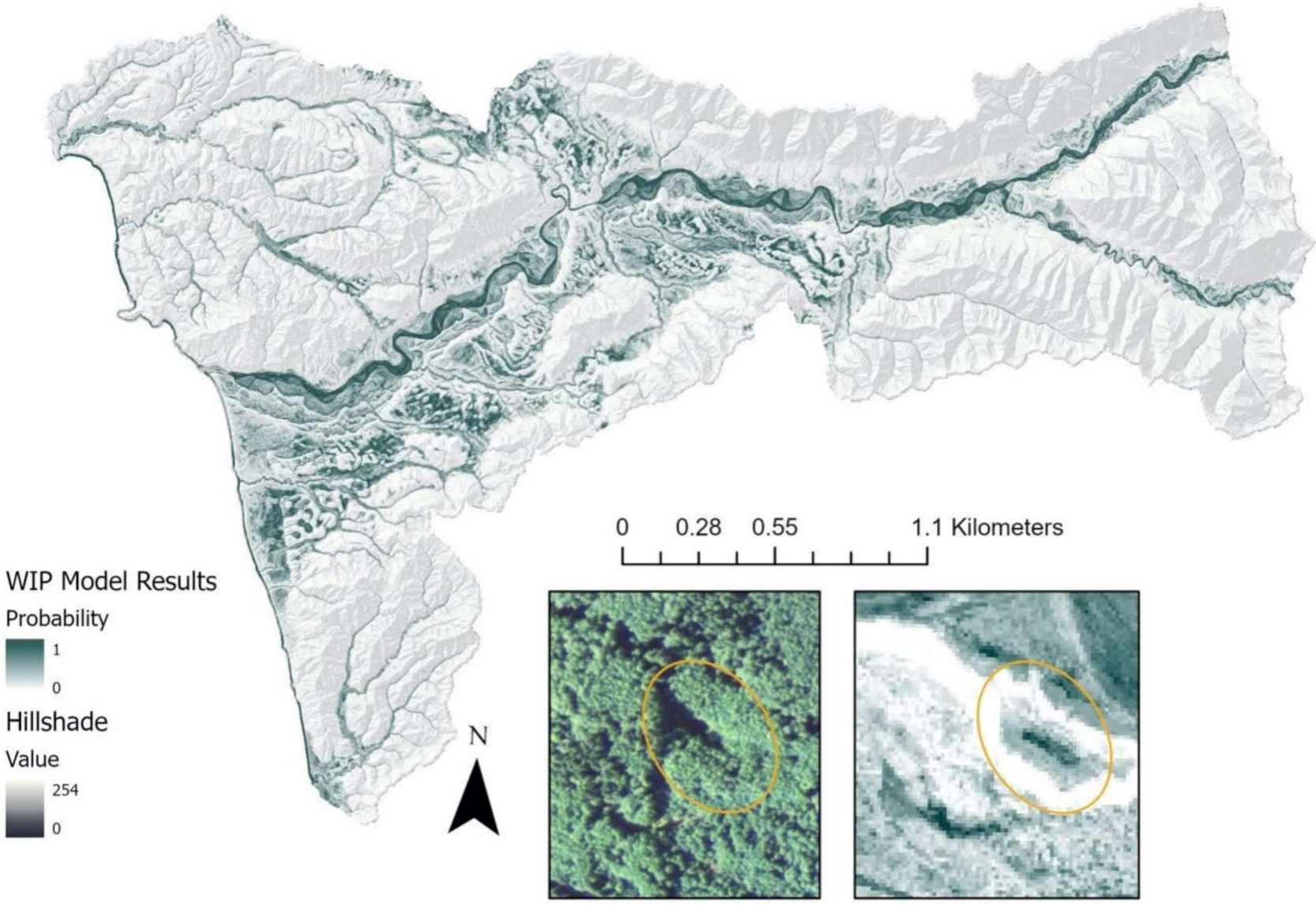
Example: Hoh Watershed

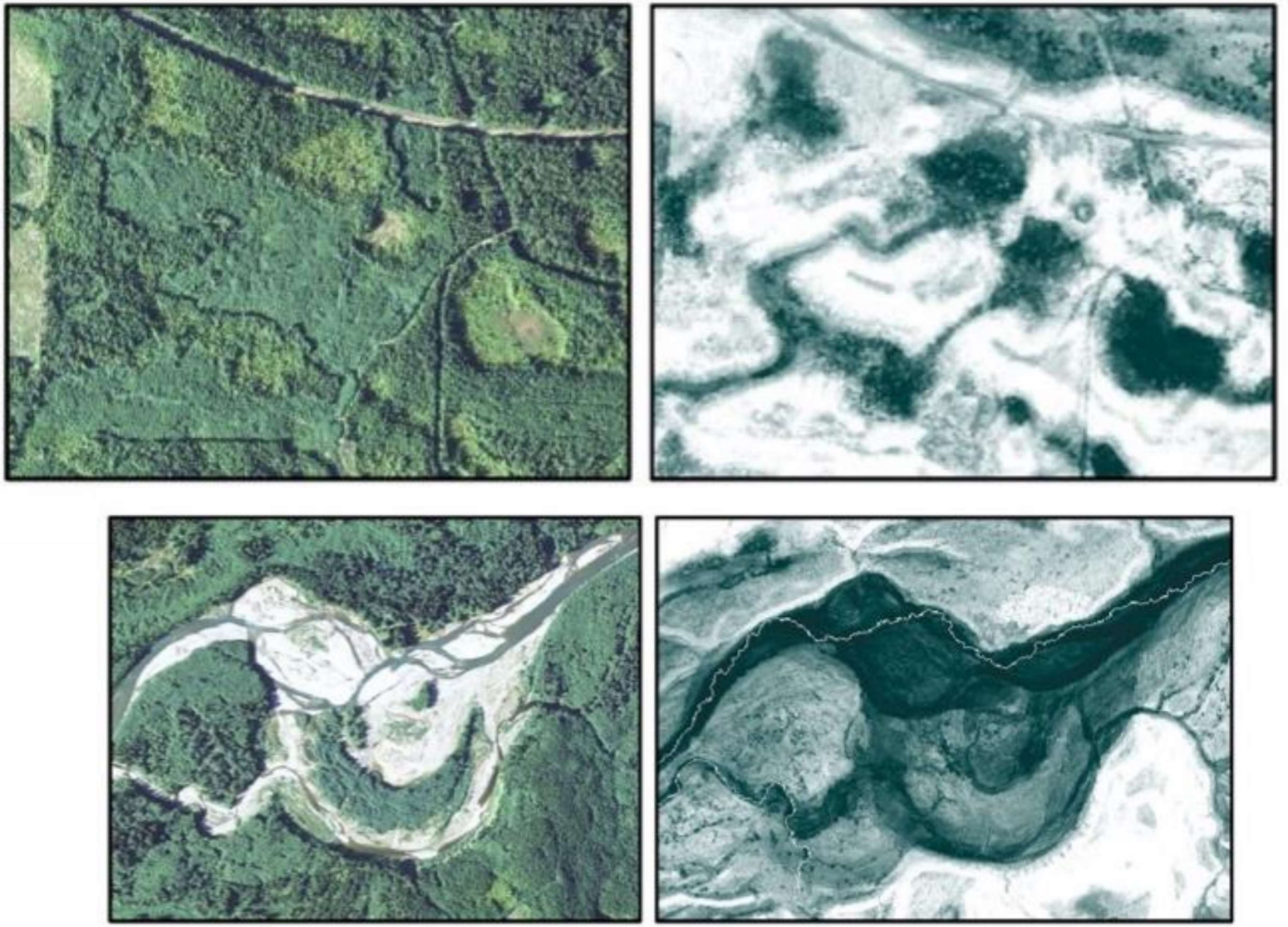


National Wetland Inventory (ex.Hoh River)

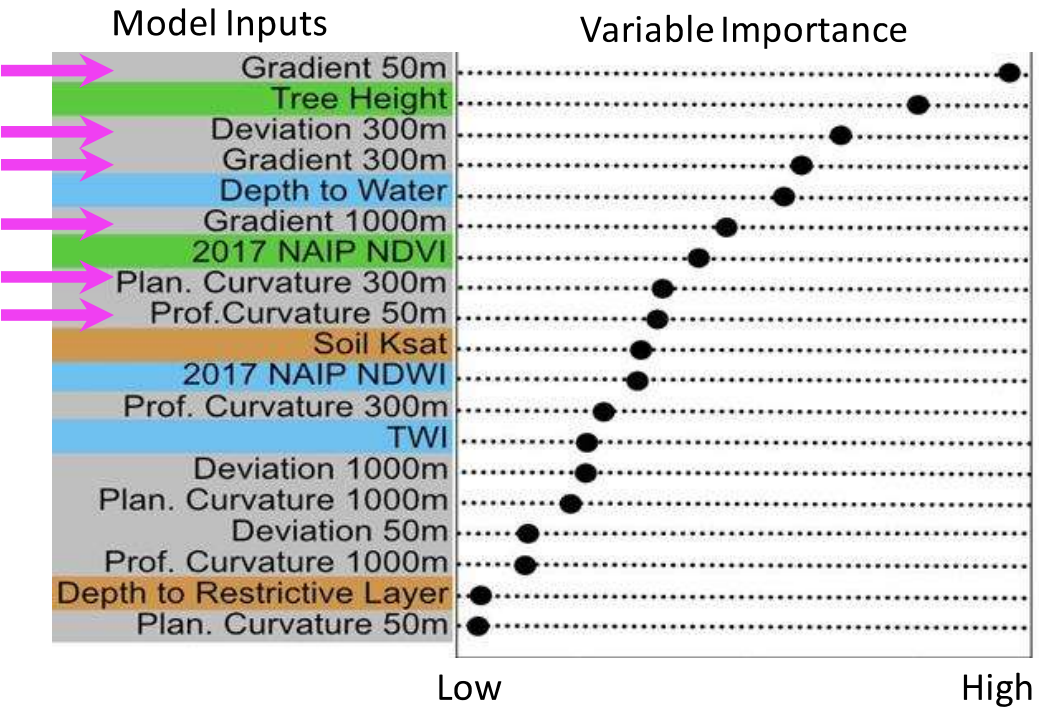


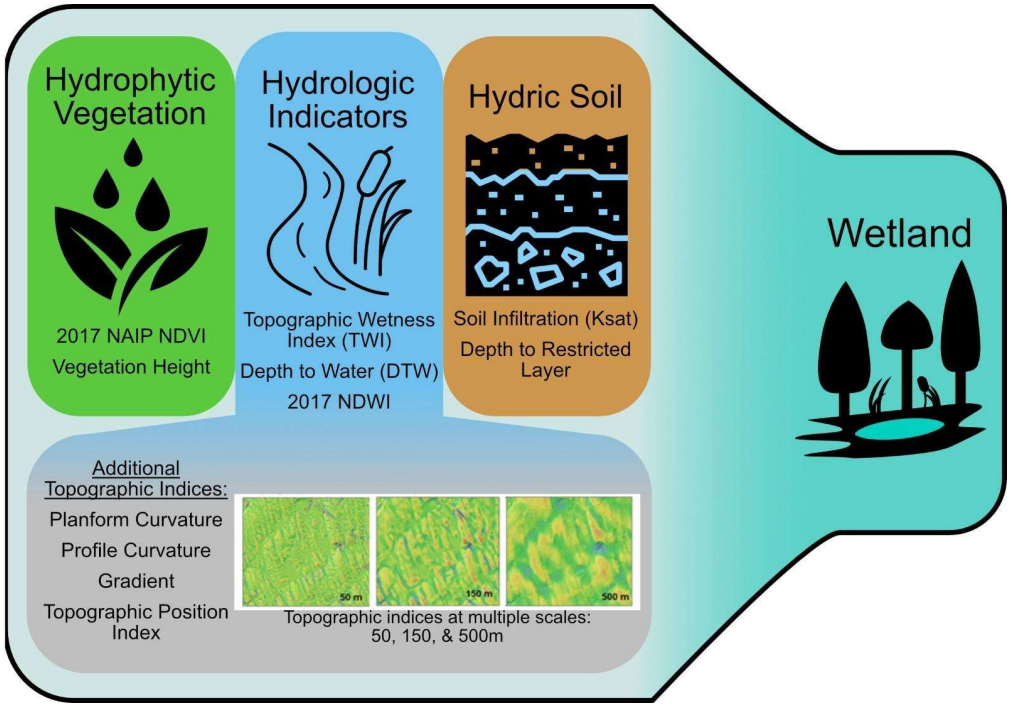
- High errors of omission
- Biased – Misses “cryptic” wetlands
- Out-of-date
- Misalignment


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


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%**

More than 2x increase in wetland area

Conclusion

- The WIP tool identifies wetlands missed in existing wetland inventories.
- Not for jurisdictional wetland delineation. Follow up on-ground is required.
- Flexible tool that can be improved as new input data layers are identified as important.
- Good training data (and lots of it) is key!

The WIP tool – Method & ArcGIS toolbox

WIP Methods:

Currently in review Hydrology and Earth System Sciences (HESS)

https://doi.org/10.5194/egusphere-2022-665
Preprint. Discussion started: 11 October 2022

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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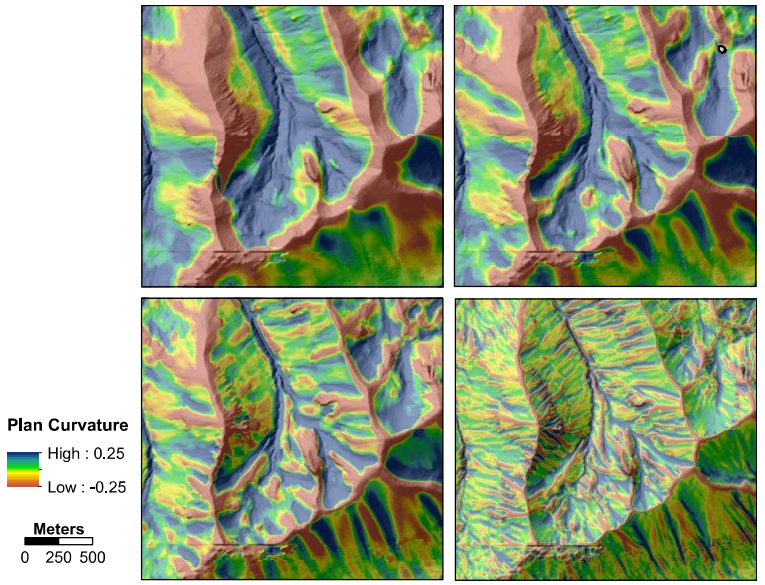
Abstract

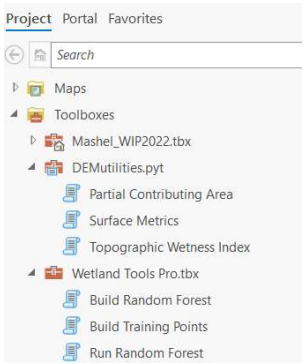
Accurate, un-biased wetland inventories are critical to monitor and protect wetlands from future harm or land conversion. However, most wetland inventories are constructed through manual image interpretation or automated classification of multi-band imagery and are biased towards wetlands that are easy 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



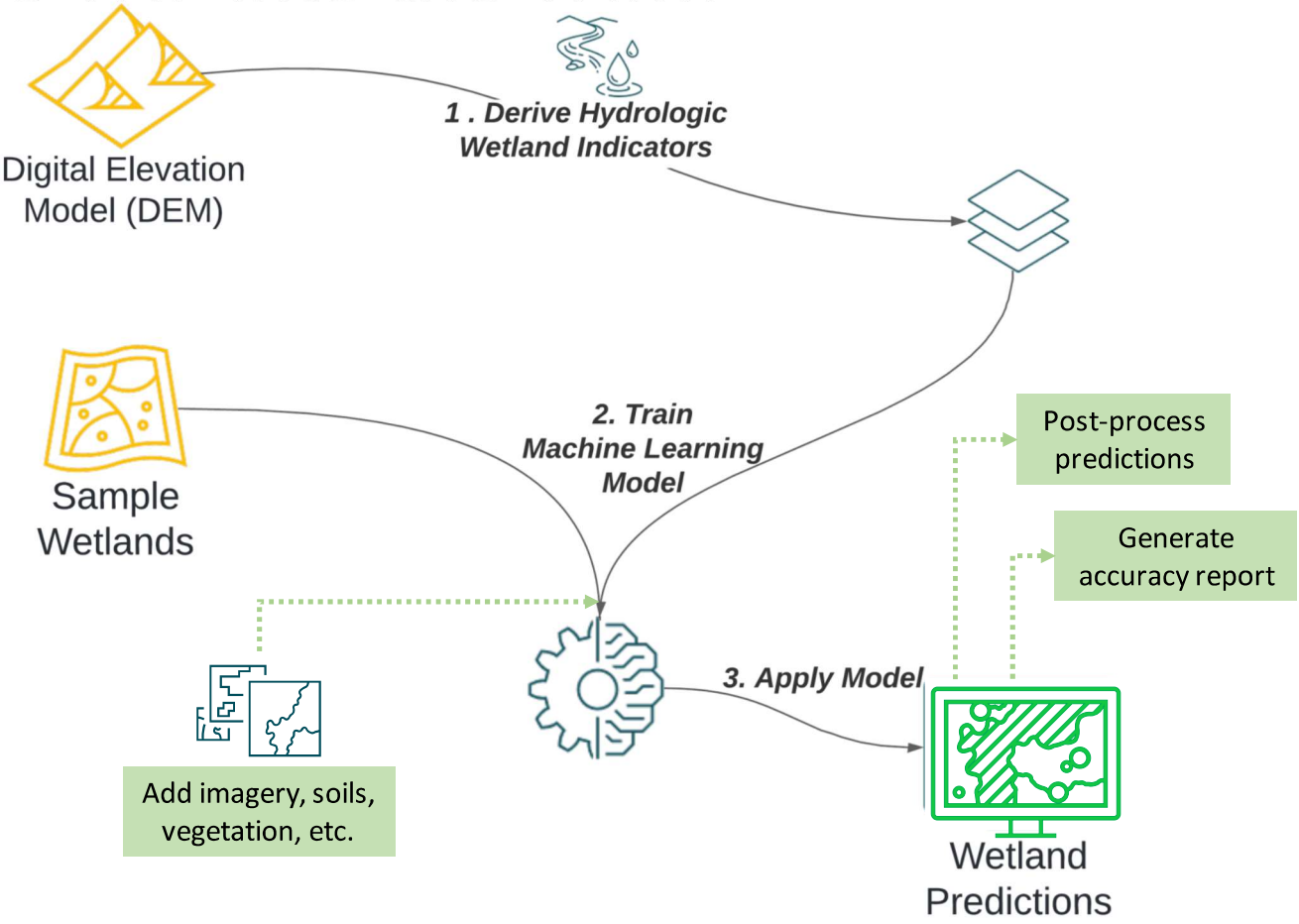
ArcGIS



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



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.

Applications (that I know about)

- Olympic Peninsula – Screening tool. Forested wetland sampling long-term monitoring
- Kitsap County – Improved wetland inventory
- King County – Improved wetland inventory
- Olympic & MT Rainier NPS – Improved wetland inventory
- E. WA - Modification for ag. lands, conservation restoration
- WA State Department of Ecology – Run statewide (EPA funding)
- Tulalip Tribe – Improved forested wetland inventory. Identifying restoration opportunities. Nature-based solutions to holding water longer in the upper and middle watershed to increase summer baseflows for salmon. Flood mitigation, fire management – wet areas may be good areas for breaks).

Other Applications (out of state)

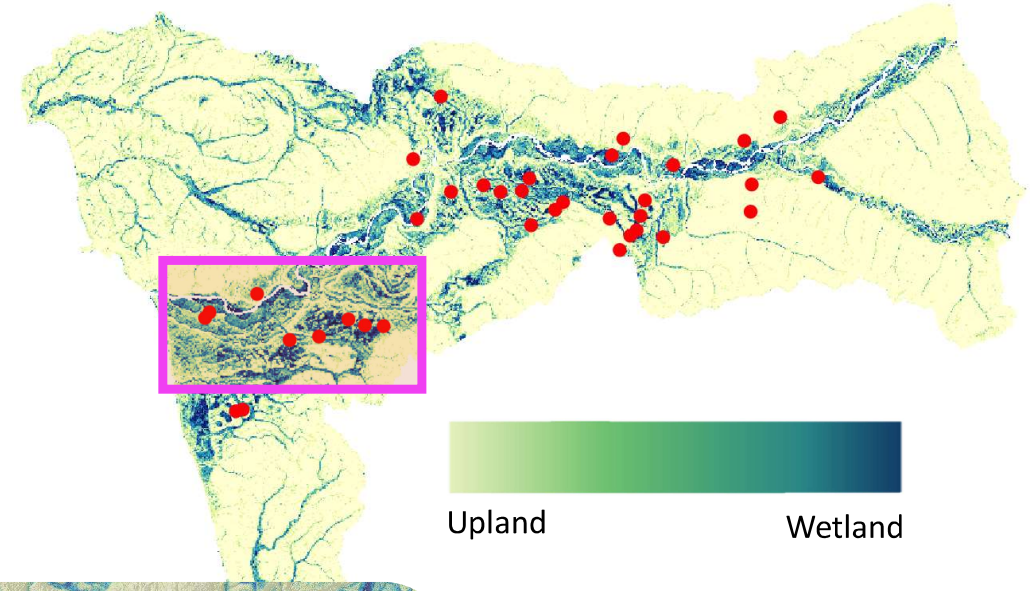
- S.E. Alaska – US Forest Service. – Improved wetland inventory
- Big Island of Hawaii – Improved wetland inventory
- BCIT (Canada) Experimental Forest – improved wetland inventory
- SE Oregon – Understanding the relationship between wetlands and stream temperatures.
- Klamath Tribe – Identifying historic meadows and wetlands for restoration and first foods.
- Digital Earth Africa – Improved wetland inventory for the continent.

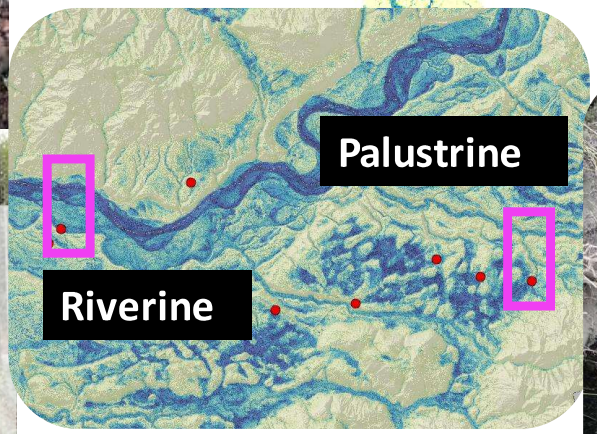
Fieldwork for Cryptic Carbon Sampling
Lead by Anthony Stewart

36 Soil Pits in 22 Workdays

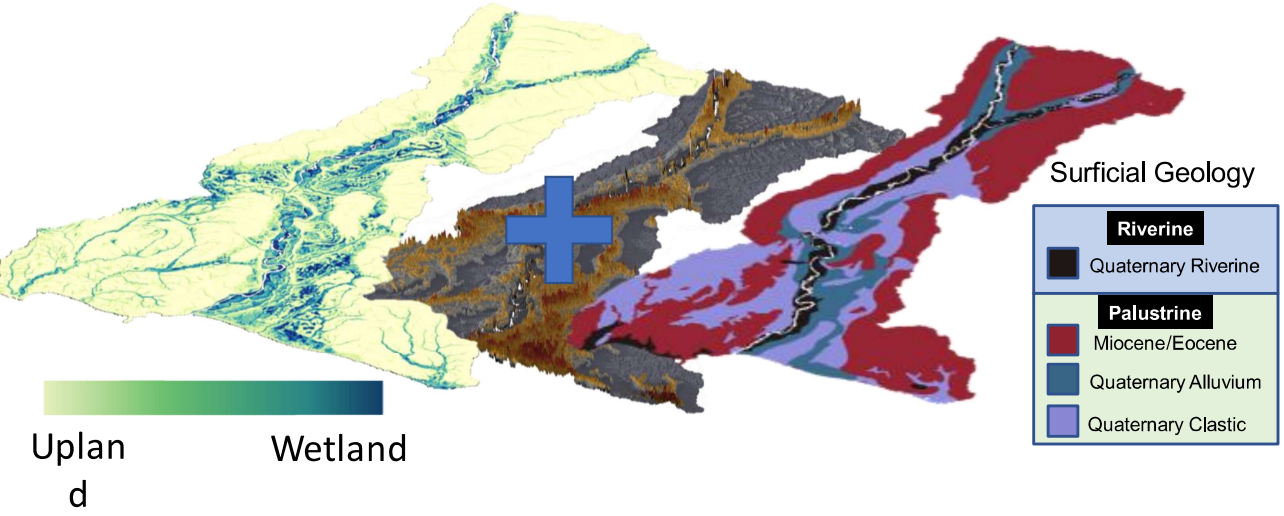
Soil pit characterization

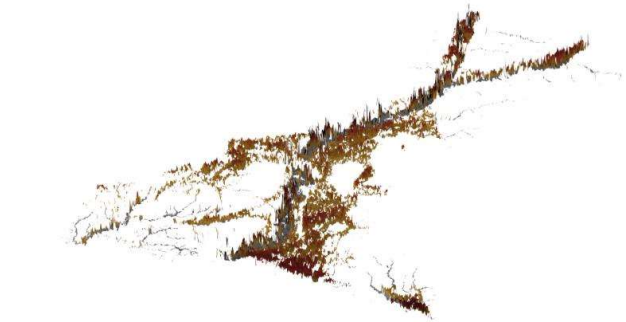
- 1m Depth or more
- Soil survey (horizons, color, texture)
- Vegetation survey (hydrophytic)
- Top level HGM and Cowardin classification
- Bulk Density and Total Carbon sampling





Cryptic Carbon Mapping Results





	Total Landscape	WIP Wetlands	WIP Outside NWI
Surface Area (ha)	68,135	6,114 (9%)	**4,401** (+181%)
Total Soil Carbon (TgC)	9.6	1.8 (19%)	**1.4** (+246%)
Average Soil Carbon Density ($MgC\ ha^{-1}$)	140.4	296.8 (+111%)	**309.0** (+79%)

Thank you !

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Huge Thank you to all that helped out with this project.

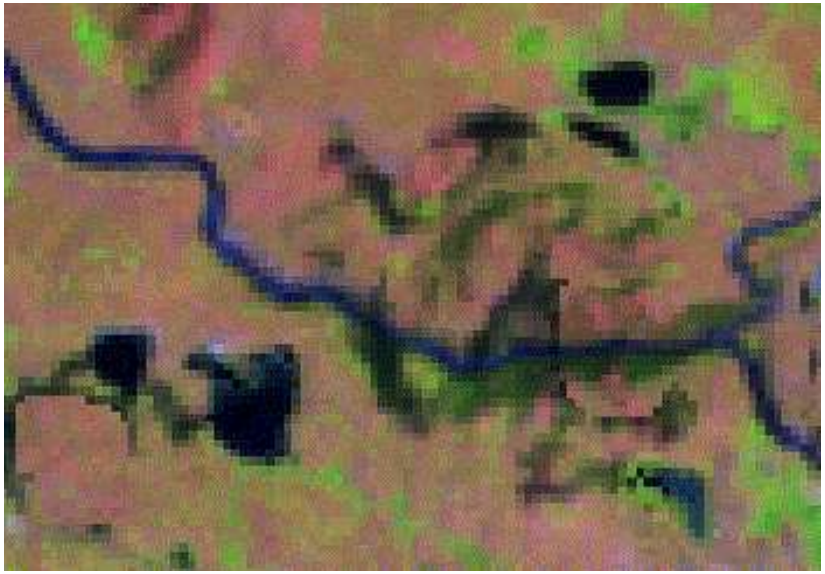
WetSAG for field work and advice – especially Debbie Kay, Doug Martin
WA State Wetland and Monitoring Group
Maureen Duane, UW SEFS RSGAL Lab
Dr. Amy Yahnke, WA Dept. of Ecology
Joe Rocchio, WA DNR WA Natural Heritage
Conor Racette, WA Dept. of Ecology
Astrid Sanna, UW SEFS RSGAL Lab

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