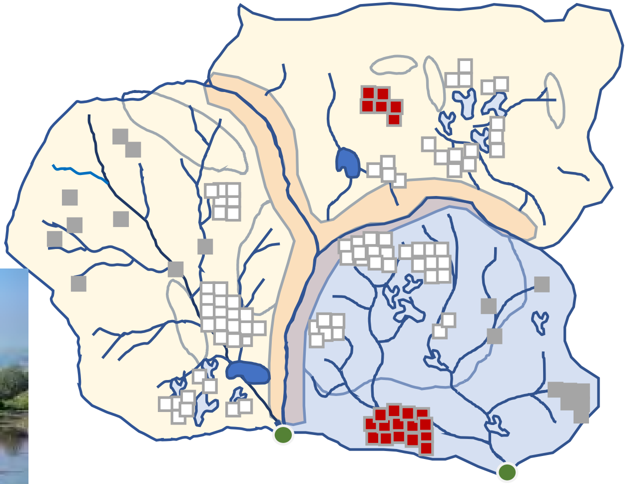
Aerial Imagery and Remotely Sensed Data to Support Watershed Monitoring and Restoration

Levi Keesecker, Washington State Conservation Commission
Jacob Taylor, Spokane Conservation District
Matt Stevenson, CORE GIS
Abby Gleason, WA Department of Natural Resources

Monitoring habitat quantity & quality at watershed scales

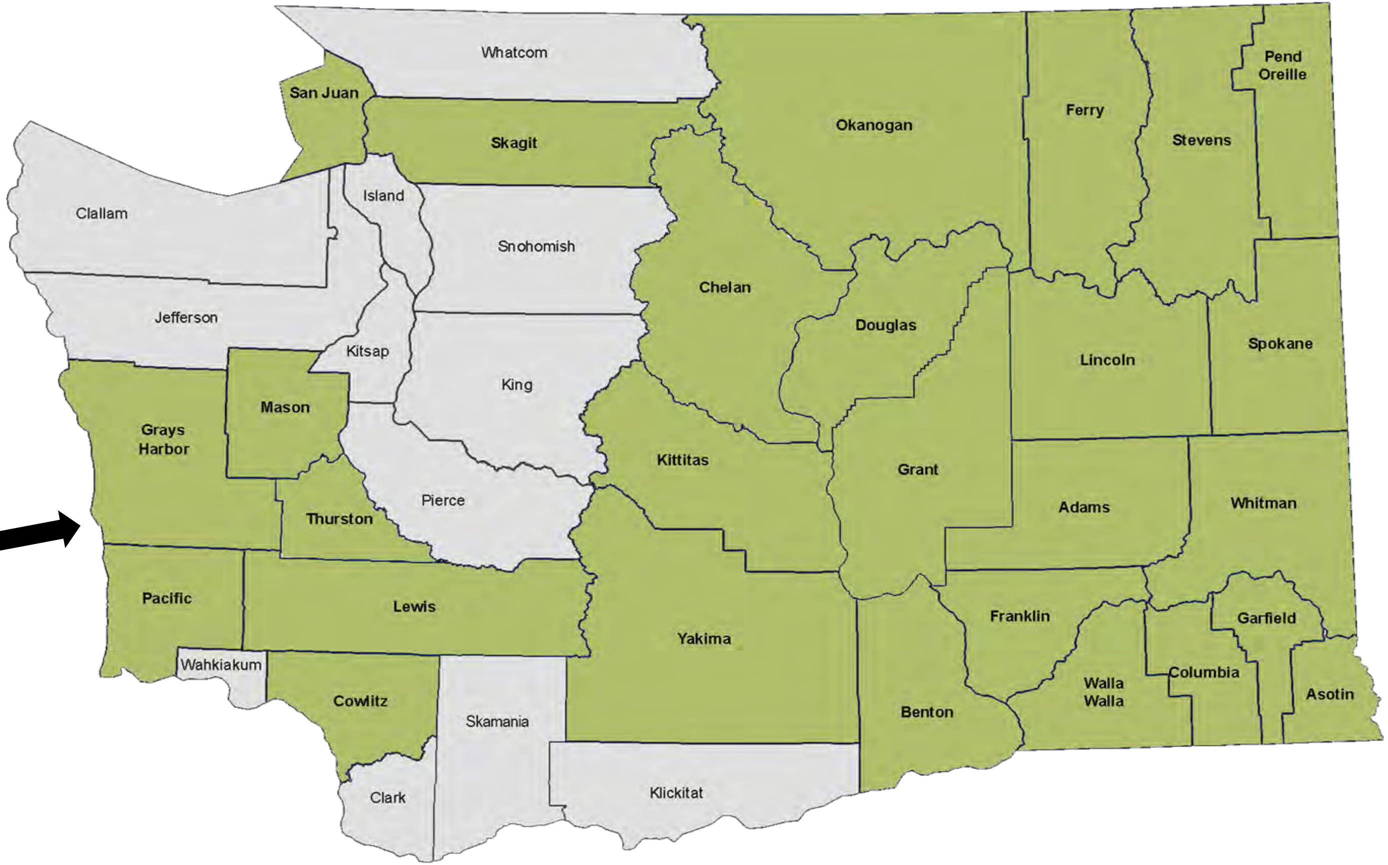


Levi Keesecker, PhD
Natural Resource Scientist
Washington State Conservation Commission

What is the Voluntary Stewardship Program?

Not currently enrolled in VSP (grey color)

Currently enrolled in VSP (green color)



What is the Voluntary Stewardship Program?

Vv is for Voluntary

<u>VSP</u> is an option for counties to manage *critical areas* where agricultural activities are conducted while maintaining the viability of agriculture

What is the Voluntary Stewardship Program?

“…all cities and counties in Washington are also required to adopt critical areas regulations."

Critical Area Types

- Wetlands
- Frequently flooded areas
- Aquifer recharge areas
- Geologically hazardous areas
- Fish and wildlife habitats

http://mrsc.org/Home/Explore-Topics/Planning/General-Planning-and-Growth-Management/Comprehensive-Planning-Growth-Management.aspx

What is the Voluntary Stewardship Program?

Vs

Parcel	Protection scale	Watershed
One-size/negotiated	Actions	Site specific
Presumptive	Effectiveness model	Demonstrative
Regulatory	Participation model	Voluntary
Not required	Monitoring	Required

How does monitoring fit within VSP?

Themes for monitoring

Participation

Agricultural Viability

Effectiveness

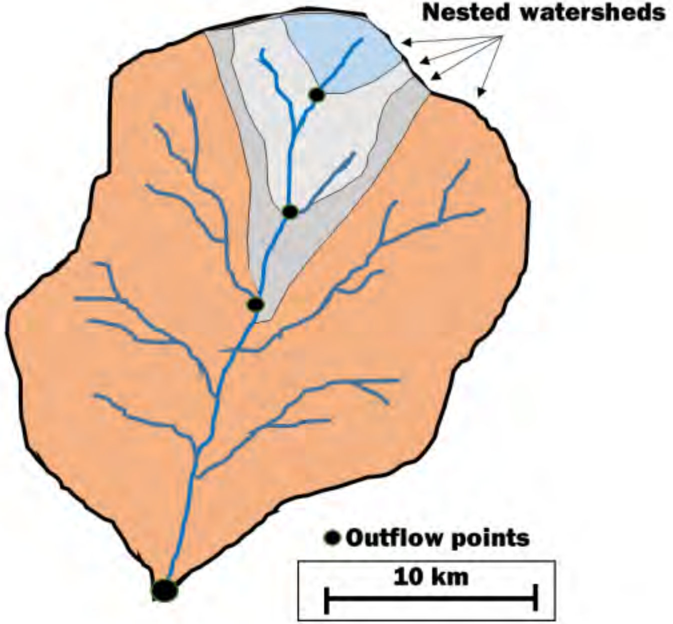
Implementation

How does monitoring fit within VSP?

Monitoring within VSP is required

VSP counties must demonstrate that critical area *functions and values* are protected or enhanced – *at the watershed scale* - relative to July 2011

Effectiveness

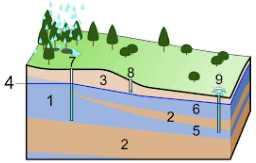


What are "Functions & Values"?

Critical Area Types

Wetlands

Critical Aquifer Recharge Areas



Fish & Wildlife Conservation Areas

Frequently Flooded Areas

Geologically Hazardous Areas

Functions*

Flood Storage – Water Quality Improvement – Shoreline & Erosion Control – Natural Products – Habitat for F & W

Water Quality Improvement – Drinking Water Provisioning – Hyporheic Input for Streams & Rivers

Migration Corridors – Vegetative Cover – Food/Habitat for Fish & Wildlife – Pollination of Wild/Cultivated Plants

Flood Storage – Reduced Erosion/Sedimentation – Groundwater Recharge – Hydrologic Connectivity – Nutrient/Sediment Distribution

Erosion Prevention – Landslide Prevention – Habitat for F & W – Sediment Input in Streams/Rivers

**Not an exhaustive list*

VSP considerations for monitoring

VSP counties must demonstrate that critical area *functions and values* are protected or enhanced – *at the watershed scale* - relative to July 2011

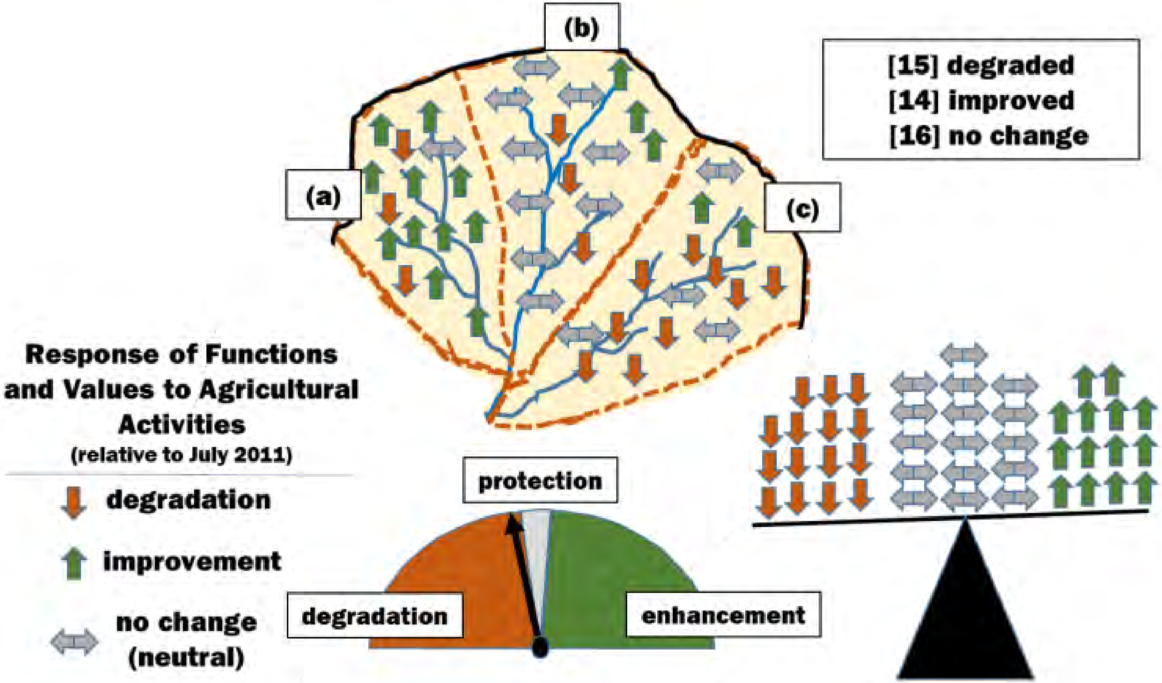
Flood Storage – Water Quality Improvement
Shoreline & Erosion Control

Water Quality Improvement – Drinking Water Provisioning

Migration Corridors – Vegetative Cover – Food/Habitat for Fish & Wildlife

Flood Storage – Reduced Erosion/Sedimentation – Groundwater Recharge

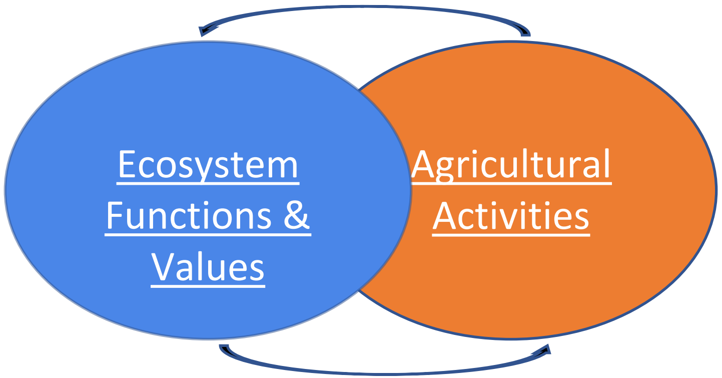
Erosion Prevention – Landslide Prevention

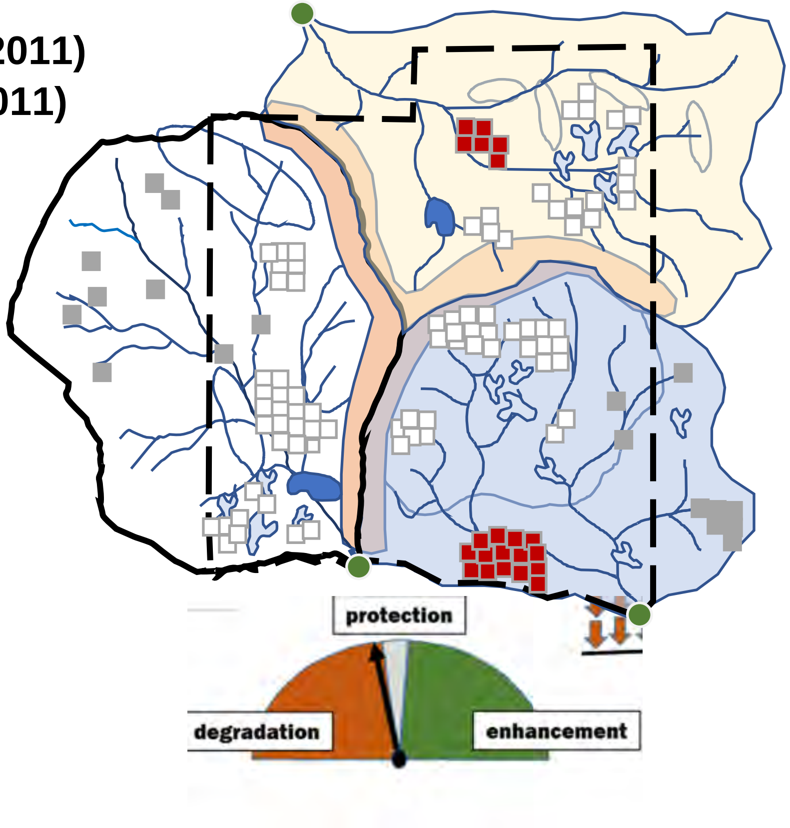


VSP considerations for monitoring

Results of monitoring efforts used to evaluate habitat within a county's watersheds

- change in *quantity* (relative to 2011)
-change in *quality* (relative to 2011)

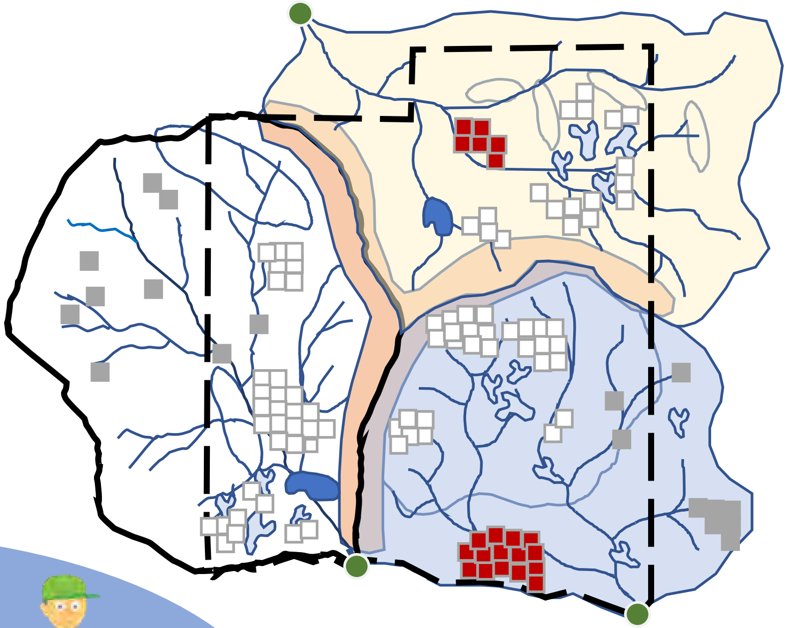




- *Riparian areas*
- *Shrub steppe*
- *Wetlands*
- *More*

VSP considerations for monitoring

Results of monitoring efforts help support VSP decisions within each county (and watershed)

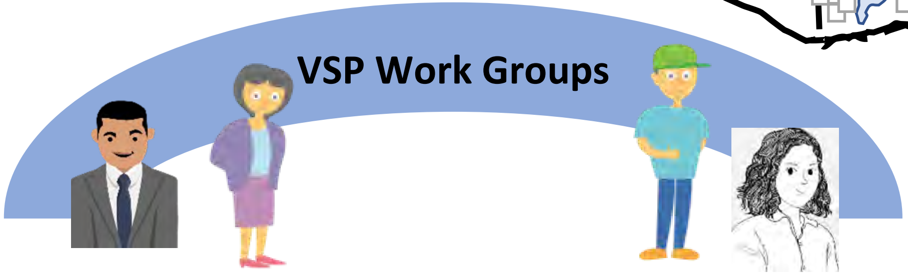


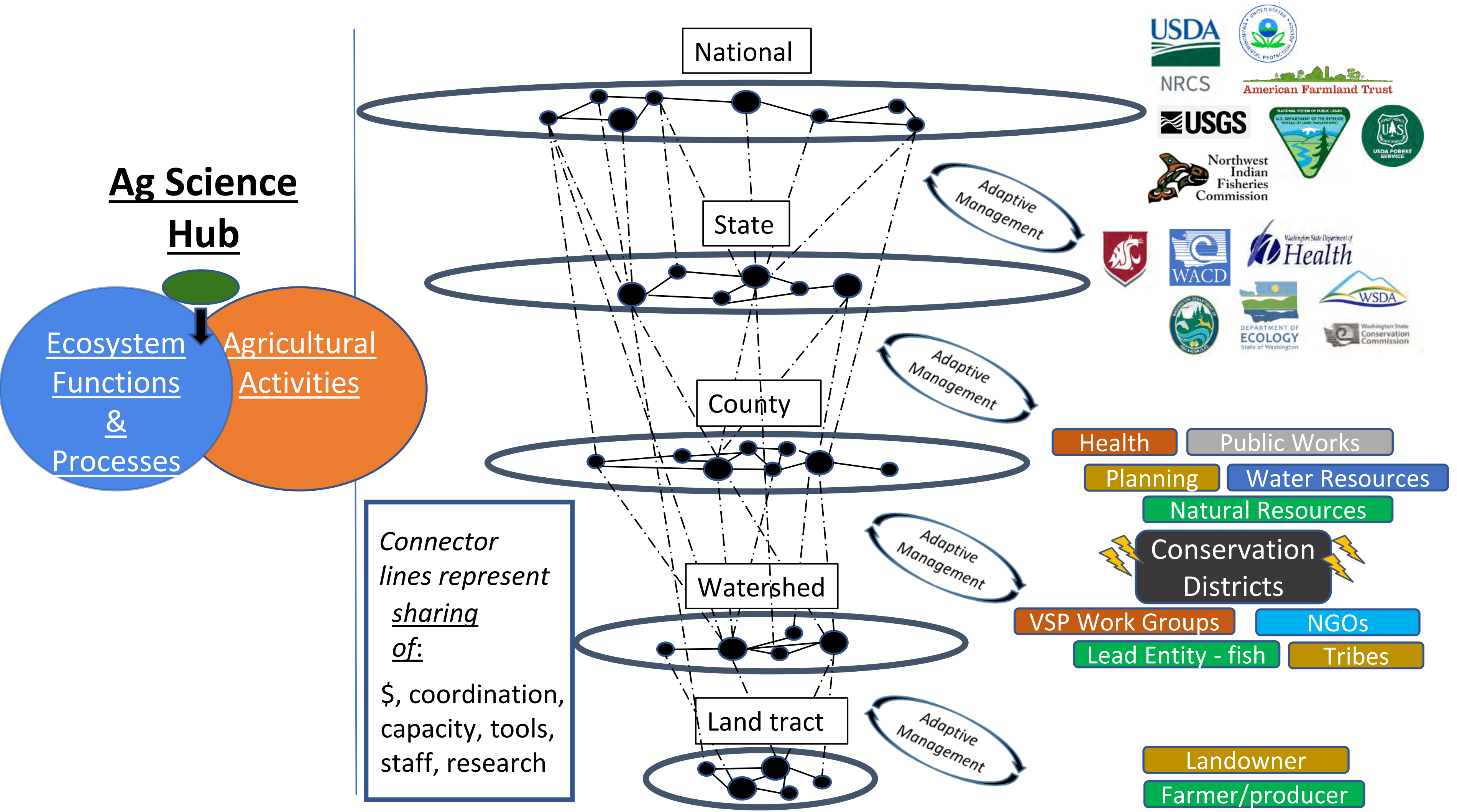
Example:

Where to prioritize specific agricultural conservation practices?

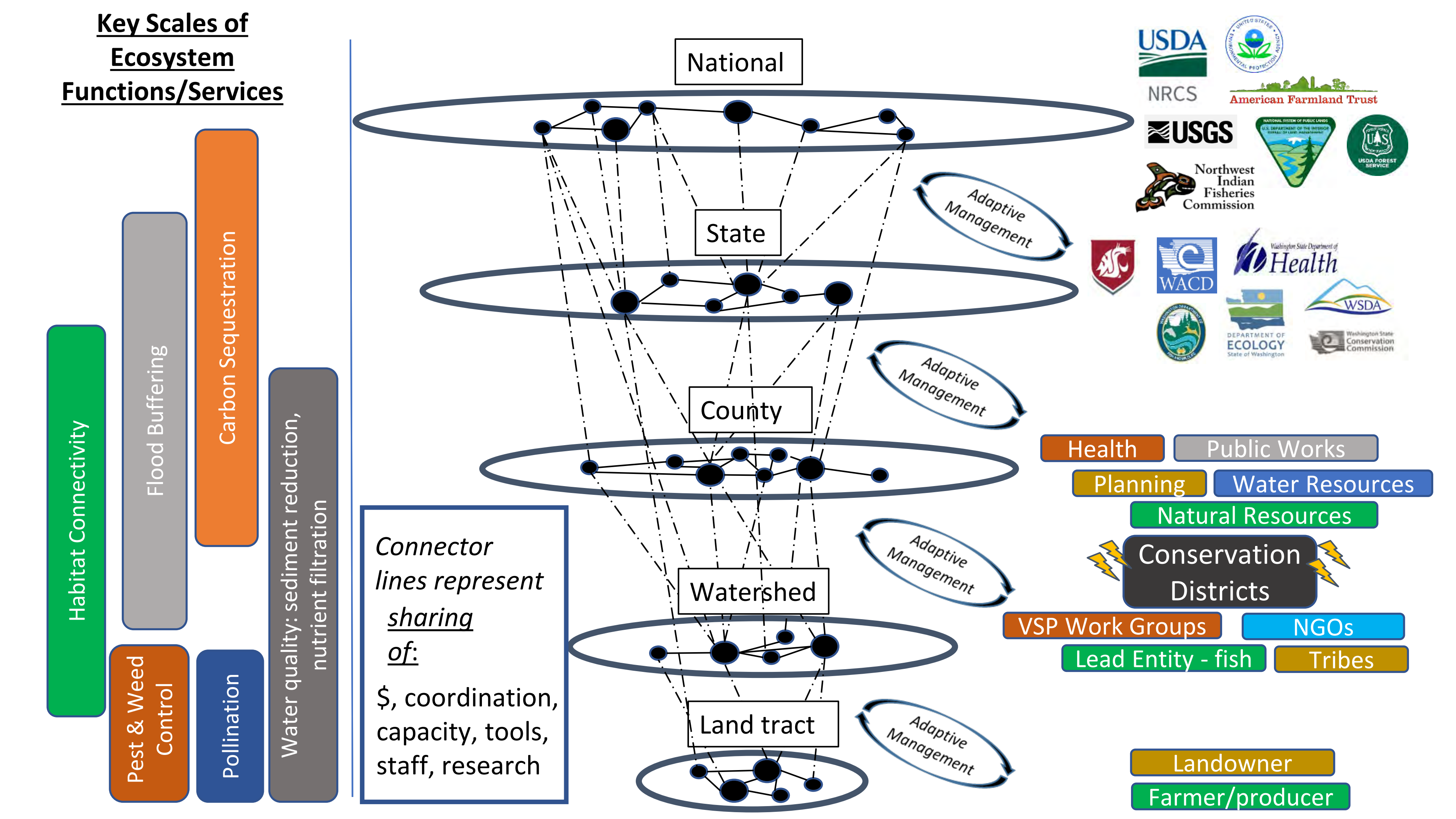
- *Prescribed grazing*
- *Wetland restoration*
- *Riparian planting*

- *Nutrient management*
- *Cover cropping*
- *Livestock rotations*
- *More*





Ag Science Hub
Ecosystem Functions & Processes
Agricultural Activities
National
State
County
Watershed
Land tract
Adaptive Management
Adaptive Management
Adaptive Management
Adaptive Management
Connector lines represent sharing of:
$, coordination, capacity, tools, staff, research
USDA
NRCS
American Farmland Trust
USGS
Northwest Indian Fisheries Commission
WACD
Washington State Department of Health
WSDA
DEPARTMENT OF ECOLOGY State of Washington
Washington State Conservation Commission
USDA FOREST SERVICE
Health
Public Works
Planning
Water Resources
Natural Resources
Conservation Districts
VSP Work Groups
NGOs
Lead Entity - fish
Tribes
Landowner
Farmer/producer



Key Scales of Ecosystem Functions/Services
Habitat Connectivity
Flood Buffering
Carbon Sequestration
Water quality: sediment reduction, nutrient filtration
Pest & Weed Control
Pollination
National
State
County
Watershed
Land tract
Adaptive Management
Adaptive Management
Adaptive Management
Adaptive Management
Connector lines represent sharing of:
$, coordination, capacity, tools, staff, research
USDA
NRCS
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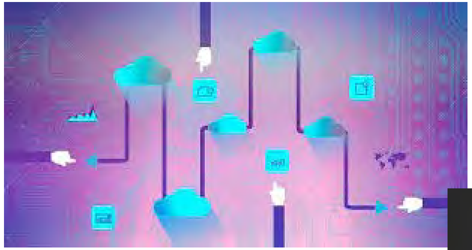
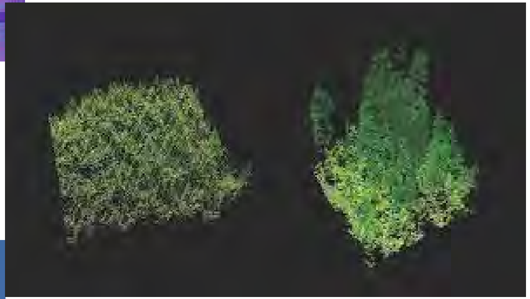
Health
Public Works
Planning
Water Resources
Natural Resources
Conservation Districts
VSP Work Groups
NGOs
Lead Entity - fish
Tribes
Landowner
Farmer/producer

Advances in science, technology, and statistics

Cloud computing

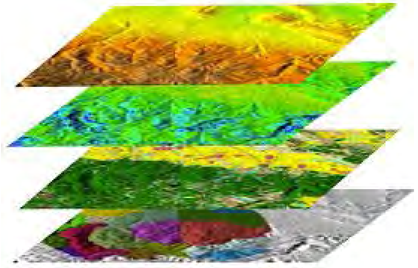


LiDAR

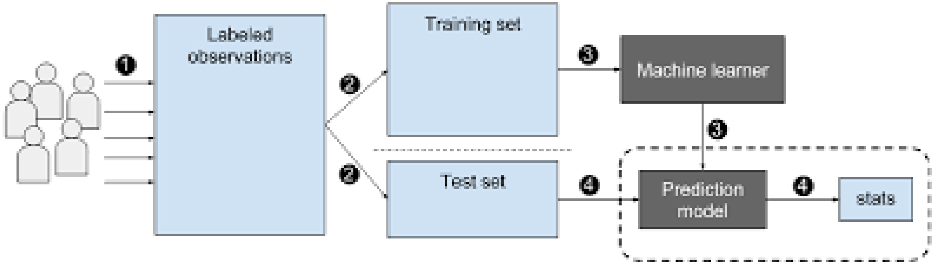


Drones

Satellite imagery – ↑ temporal scale



“big data” & machine learning



Examples from partners and colleagues

Cloud computing

Satellite imagery – ↑ temporal scale

Cloud-Based Environmental Monitoring to Streamline Remote Sensing Analysis for Biologists

AMANDA T. STAHL, ALEXANDER K. FREMIER, AND LAURA HEINSE

Drones

River Research and Applications

RESEARCH ARTICLE | Open Access

Identification of salmon redds using RPV-based imagery produces comparable estimates to ground counts with high inter-observer variability

Daniel S Auerbach, Alexander K Fremier

WASHINGTON STATE UNIVERSITY

Examples from partners and colleagues

USDA NRCS
United States Department of Agriculture
Natural Resources Conservation Service

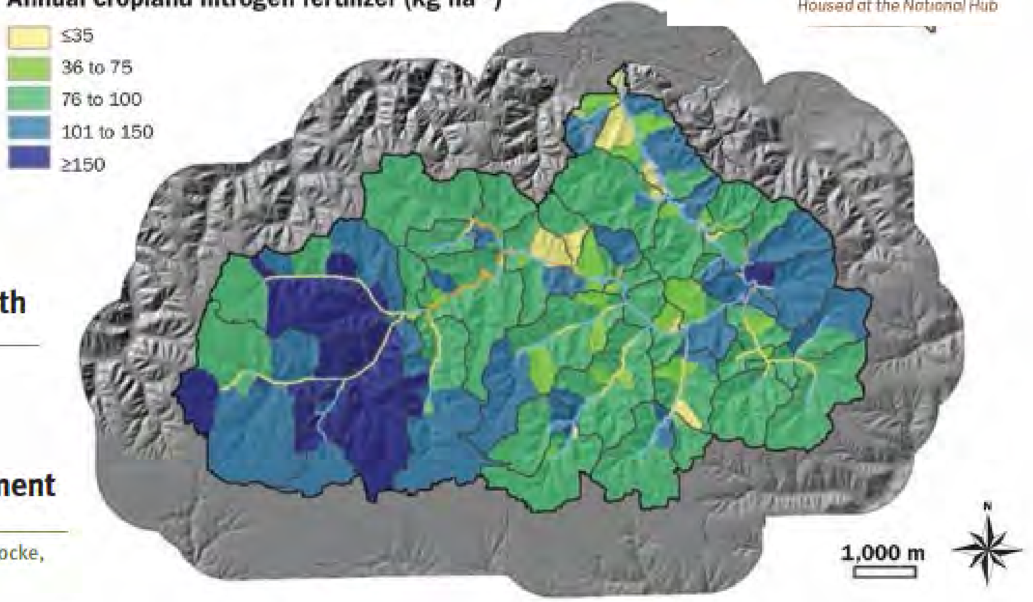
Agricultural Conservation
PLANNING FRAMEWORK
Housed at the National Hub

SOIL AND WATER CONSERVATION SOCIETY

JOURNAL OF SOIL AND WATER
CONSERVATION
The science and art of natural resource management for sustainability

Conservation Effects Assessment Project

Annual cropland nitrogen fertilizer (kg ha^{-1})



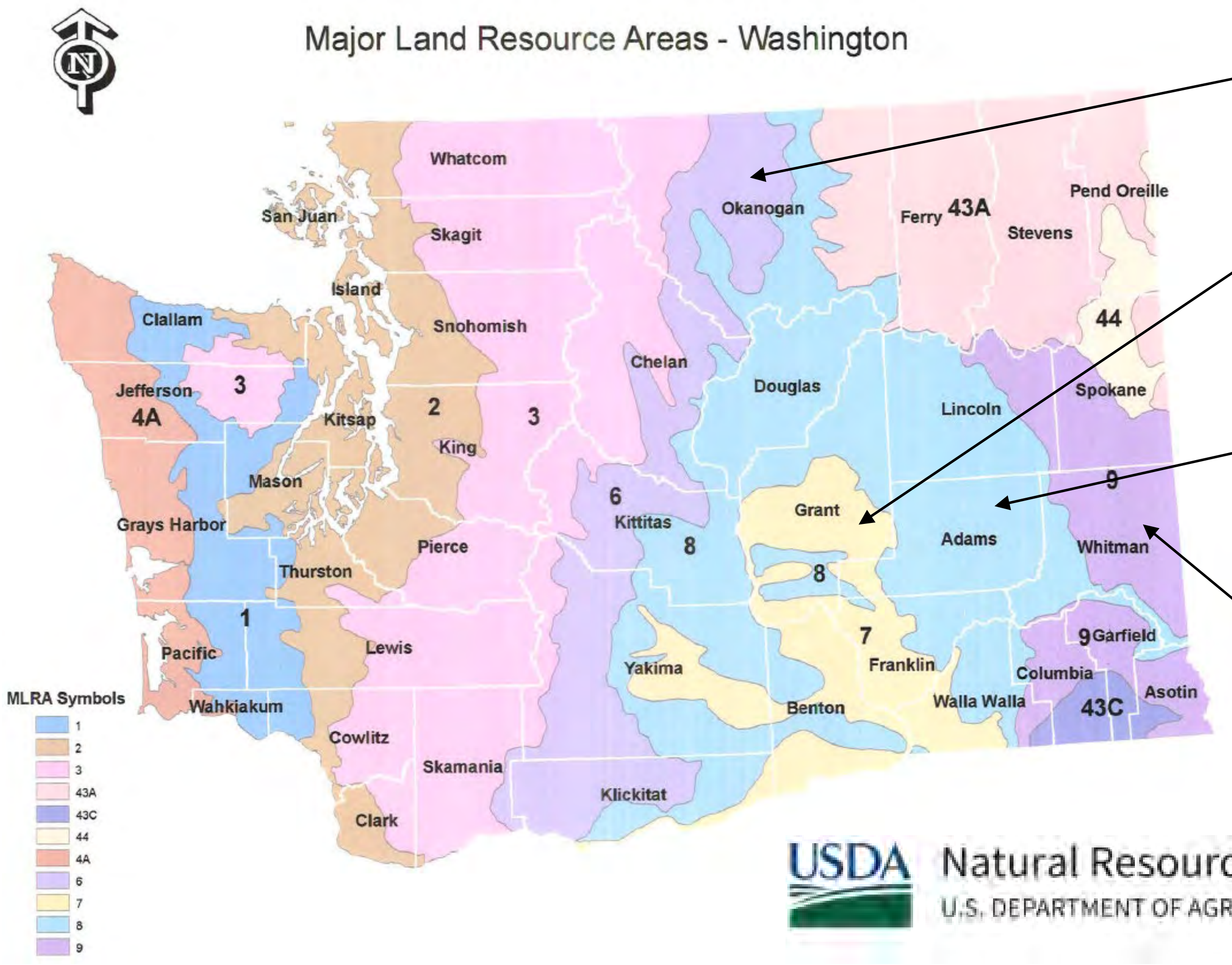
Riparian catchments: A landscape approach to link uplands with riparian zones for agricultural and ecosystem conservation

Mark D. Tomer, Sarah A. Porter, David E. James, and Jessica D. Van Horn

Quantifying the impacts of the Conservation Effects Assessment Project watershed assessments: The first fifteen years

Daniel N. Moriasi, Lisa F. Duriancik, E. John Sadler, Teferi Tsegaye, Jean L. Steiner, Martin A. Locke, Timothy C. Strickland, and Deanna L. Osmond

Example application to shrub steppe habitat



MLRA 6

11 sub-types

-- shallow, north aspect prairie, bitterbrush southern aspect, etc

MLRA 7

15 sub-types

-- loamy, riparian complex, cool loamy, sands, etc

MLRA 8

21 sub-types

-- stony sagebrush, alkali terrace, wetland complex, etc

MLRA 9

12 sub-types

-- north aspect dwarf shrub, north aspect bunchgrass, loamy bottom, etc

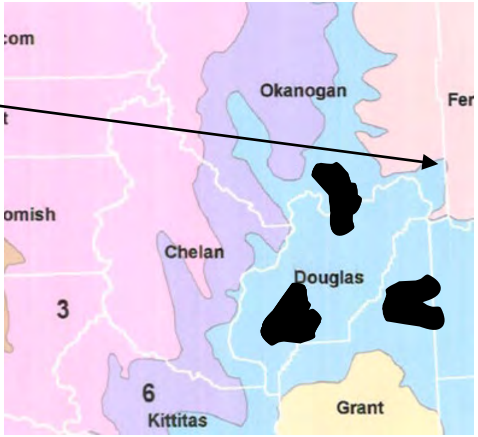
USDA Natural Resources Conservation Service

U.S. DEPARTMENT OF AGRICULTURE

MLRA 8

21 sub-types

-- **stony, sagebrush;** loamy bottom; loamy grassland; etc



Unique description of:

- Soils/geology, climate/precipitation, vegetation, hydrology
- Reference state condition
- State transition model
- Biomass production

Without Cheatgrass

alternative states

Reference condition

Stony, sagebrush –

- 70% wheatgrass
- 10% sagebrush

Bunchgrass community

- 90% wheatgrass
- 0-2% sagebrush

Heavy Sage community

- 30% wheatgrass
- 50% sagebrush

Depauperate community

- 60% sagebrush
- 30% bluegrass

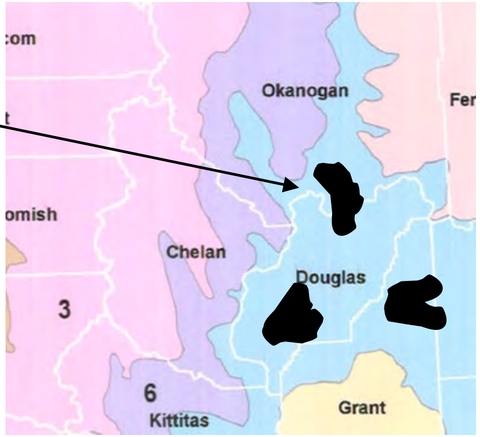
MLRA 8

21 sub-types

-- **<u>stony, sagebrush;</u>** loamy bottom; loamy grassland; etc

<u>Unique description of:</u>

- Soils/geology, climate/precipitation, vegetation, hydrology
- Reference state condition
- State transition model
- Biomass production



With Cheatgrass

<u>alternative states</u>

<u>Reference condition</u>

<u>Stony, sagebrush –</u>

- 70% wheatgrass
- 10% sagebrush
- *1 % cheatgrass*

<u>Bunchgrass community</u>

- 90% wheatgrass
- 0-2% sagebrush
- *1% cheatgrass*

<u>Heavy Sage community</u>

- 30% wheatgrass
- 50% sagebrush
- *5% cheatgrass*

<u>Depauperate community</u>

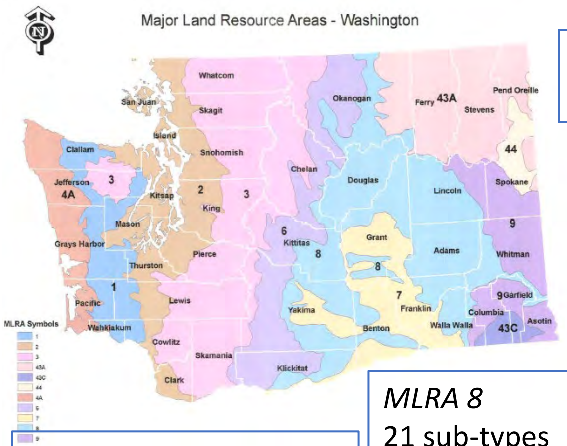
- 55% sagebrush
- 25% bluegrass
- *20% Cheatgrass*

<u>Shrub Cheatgrass</u>

- 40% shrub
- *50% Cheatgrass*

<u>Production (biomass)</u>

- 300- 750 lbs/acre per year



MLRA 7
15 sub-types

MLRA 6
11 sub-types

MLRA 8
21 sub-types

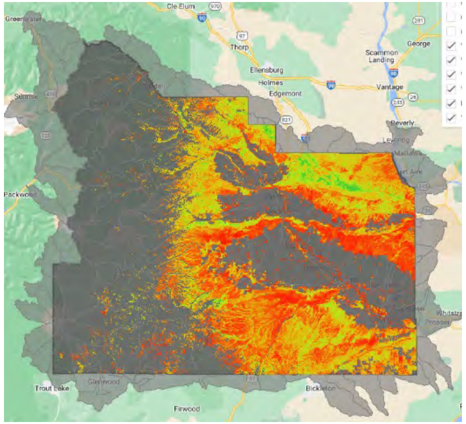
MLRA 9
12 sub-types

Rangeland Analysis Platform

Attributes include:

% Litter
% Shrub
% Perennial forb/grass
% Annual forb/grass
% Tree cover
% Bare ground

Biomass (lbs/acre per year)
% Cheatgrass (annual herbaceous cover)



Reference

Stony, sagebrush –

- 70% wheatgrass
- 10% sagebrush
- *1 % cheatgrass*

Production (biomass)

- 300- 750 lbs/acre per year

alternative state

Depauperate community

- 55% sagebrush
- 25% bluegrass
- *20% Cheatgrass*

Rangeland Analysis Platform

Can we link the RAP variables to the MLRA types?

<u>Attributes include:</u>

% Litter
% Shrub
% Perennial forb/grass
% Annual forb/grass
% Tree cover
% Bare ground

Biomass (lbs/acre per year)
% Cheatgrass (annual herbaceous cover)

Use as basis for “poor”, “moderate”, “good” classifications?

<u>Reference</u>
...diti...

<u>Stony, sagebrush –</u>

- 70% wheatgrass
- 10% sagebrush
- *1 % cheatgrass*

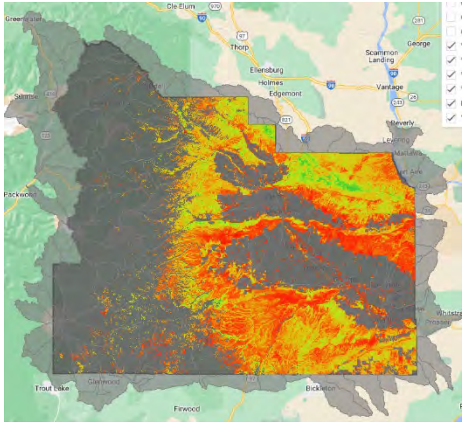
<u>alternative state</u>

<u>Depauperate community</u>

- 55% sagebrush
- 25% bluegrass
- *20% Cheatgrass*

<u>Production (biomass)</u>

- 300- 750 lbs/acre per year



Rangeland Analysis Platform

Can we link the RAP variables to the MLRA types?

<u>**Attributes include:**</u>

% Litter
% Shrub
% Perennial forb/grass
% Annual forb/grass
% Tree cover
% Bare ground

Biomass (lbs/acre per year)
% Cheatgrass (annual herbaceous cover)

Use as basis for "poor", "moderate", "good" classifications?

<u>Reference</u>

<u>Stony, sagebrush –</u>

- 70% wheatgrass
- 10% sagebrush
- *1 % cheatgrass*

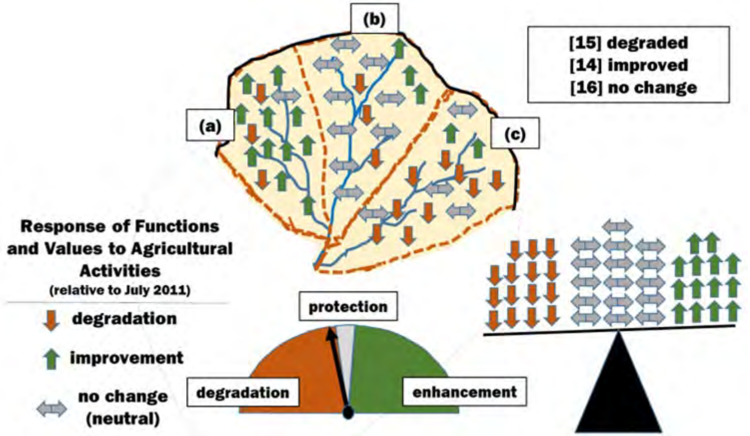
<u>Production (biomass)</u>

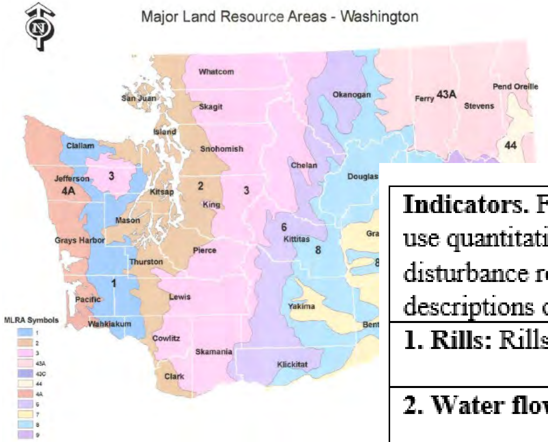
- 300- 750 lbs/acre per year

<u>alternative state</u>

<u>Depauperate community</u>

- 55% sagebrush
- 25% bluegrass
- *20% Cheatgrass*





There are forthcoming field assessments linked to the MRLA sub types

Indicators. For each indicator, describe the potential for the site using the reference sheet checklist. Where possible, (1) use quantitative measurements; (2) include expected range of values for above- and below-average years and natural disturbance regimes for each community phase within the reference state, when appropriate; and (3) cite data. Continue descriptions on separate sheet.
1. Rills: Rills are not present in the reference state.
2. Water flow patterns: Water flow patterns are not present in the reference state.
3. Pedestals and/or terracettes: Pedestals are not present in the reference state.
4. Bare ground: Bare ground refers to exposed mineral soil not covered by litter, rock, basal cover, plant cover, standing dead, lichen and/or moss. Bare ground consists of small, randomly scattered patches (less than 5-inch diameter) and averages 5% and never exceeds 10% in the reference state. Bare patches are usually associated with rodent activity. Sites average about 25% surface rock.

Reference condition

Stony, sagebrush –

- 70% wheatgrass
- 10% sagebrush
- *1 % cheatgrass*

alternative state

Depauperate community

- 55% sagebrush
- 25% bluegrass
- *20% Cheatgrass*

MRLA 6, 7, 8, 9
~60 sub-types
(NRCS)

<u>*Reference condition*</u>

<u>Stony, sagebrush –</u>
- 70% bluebunch wheatgrass
- 10% Wyoming sagebrush
- *1 % cheatgrass*

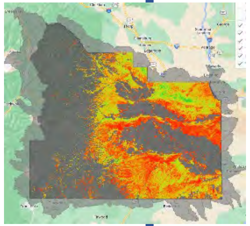
<u>*alternative state*</u>

<u>Depauperate community</u>
- 55% Wyoming sagebrush
- 25% Sandberg bluegrass
- *20% Cheatgrass*

- 300- 750 lbs/acre per year

Rangeland Analysis Platform

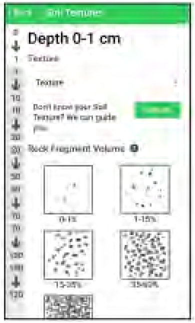
% Litter
% Shrub
% Perennial forb/grass
% Annual forb/grass
% Tree cover
% Bare ground

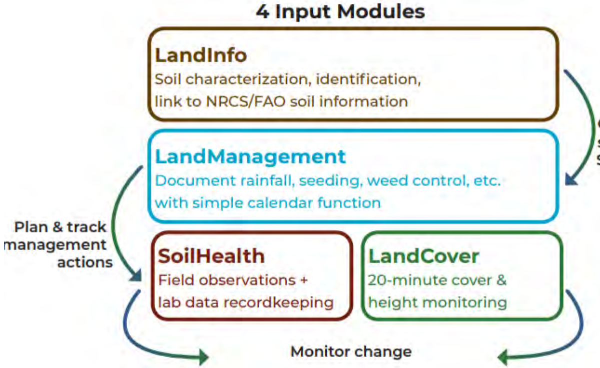


Biomass (lbs/acre per year)
% Cheatgrass (annual herbaceous cover)

Link the MRLAs with RAP and LandPKS?

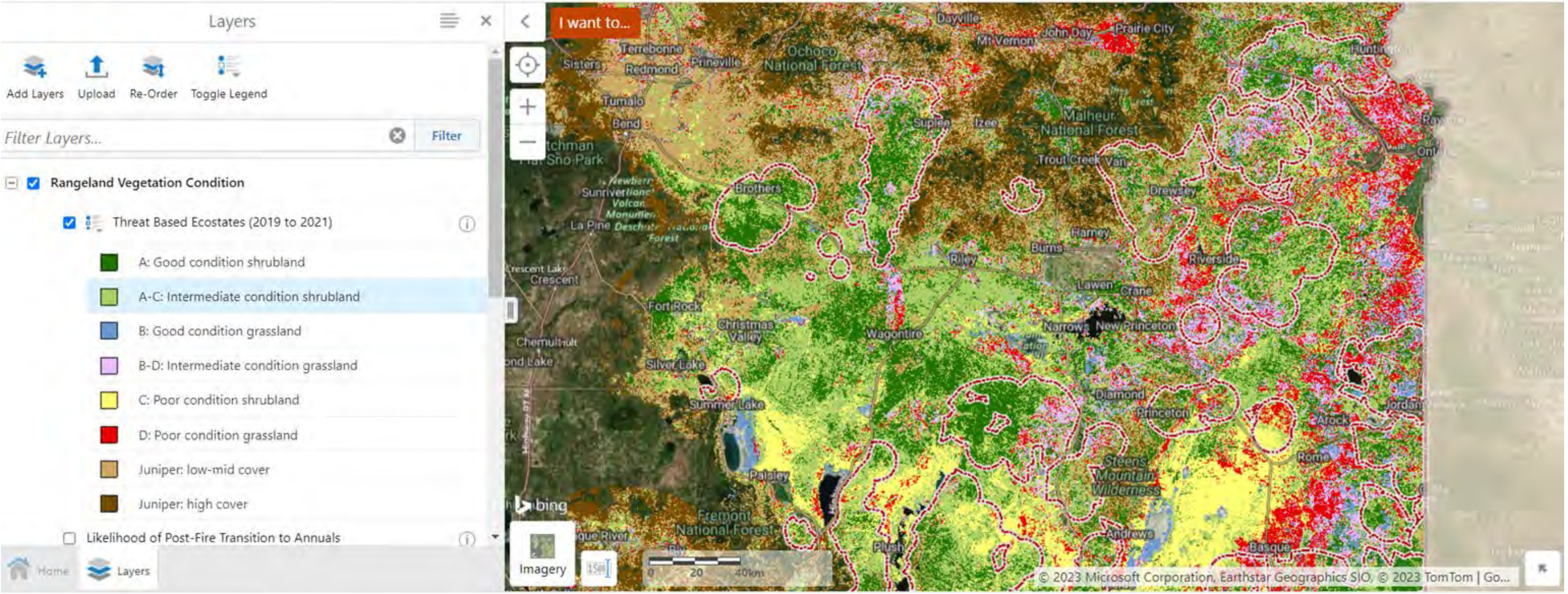
LandPKS





USAID FROM THE AMERICAN PEOPLE · USDA Agricultural Research Service · Jornada · NM State · Sustainability Innovation Lab at Colorado, University of Colorado Boulder

Other approaches & collaborators



Shrubsteppe Fire Preparedness, Response, and Restoration

Washington Department of Fish and Wildlife

OREGON EXPLORER

SageCon Landscape Planning Tool

Least-Conflict Solar Siting

Energy Program
Washington State University

WSU Energy Program
Renewable Energy

Three Separate but Interrelated Projects

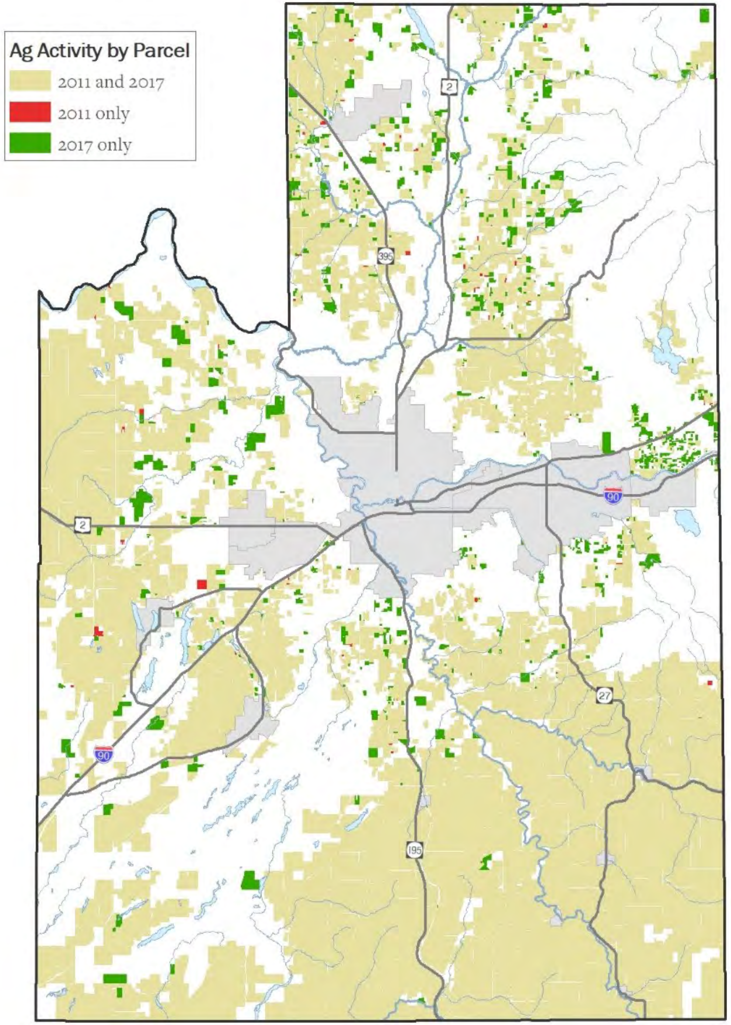
1. **Voluntary Stewardship Program** (VSP) riparian vegetation change monitoring
2. Wetland Monitoring Using **Spectral Unmixing** with Landsat Imagery
3. Creating more accurate wetland maps using the **Wetland Intrinsic Potential** (WIP) tool

Voluntary Stewardship Riparian Vegetation Change Monitoring

- How we are determining study area extent
  - Mapping agricultural activity in 2011, 2017, 2019 and 2022
  - Estimating the extent of potential riparian vegetation using DoE data and buffer distances
- How we are using **Google Earth Engine** to detect changes in vegetation
- Using **Digital Surface Models** to improve accuracy of change detection
- Next steps
- Questions

Agricultural Activity by Parcel

Derived from Washington State Department of Agriculture field-level data for 2011 and 2017 (we are currently analyzing 2019 and 2021)

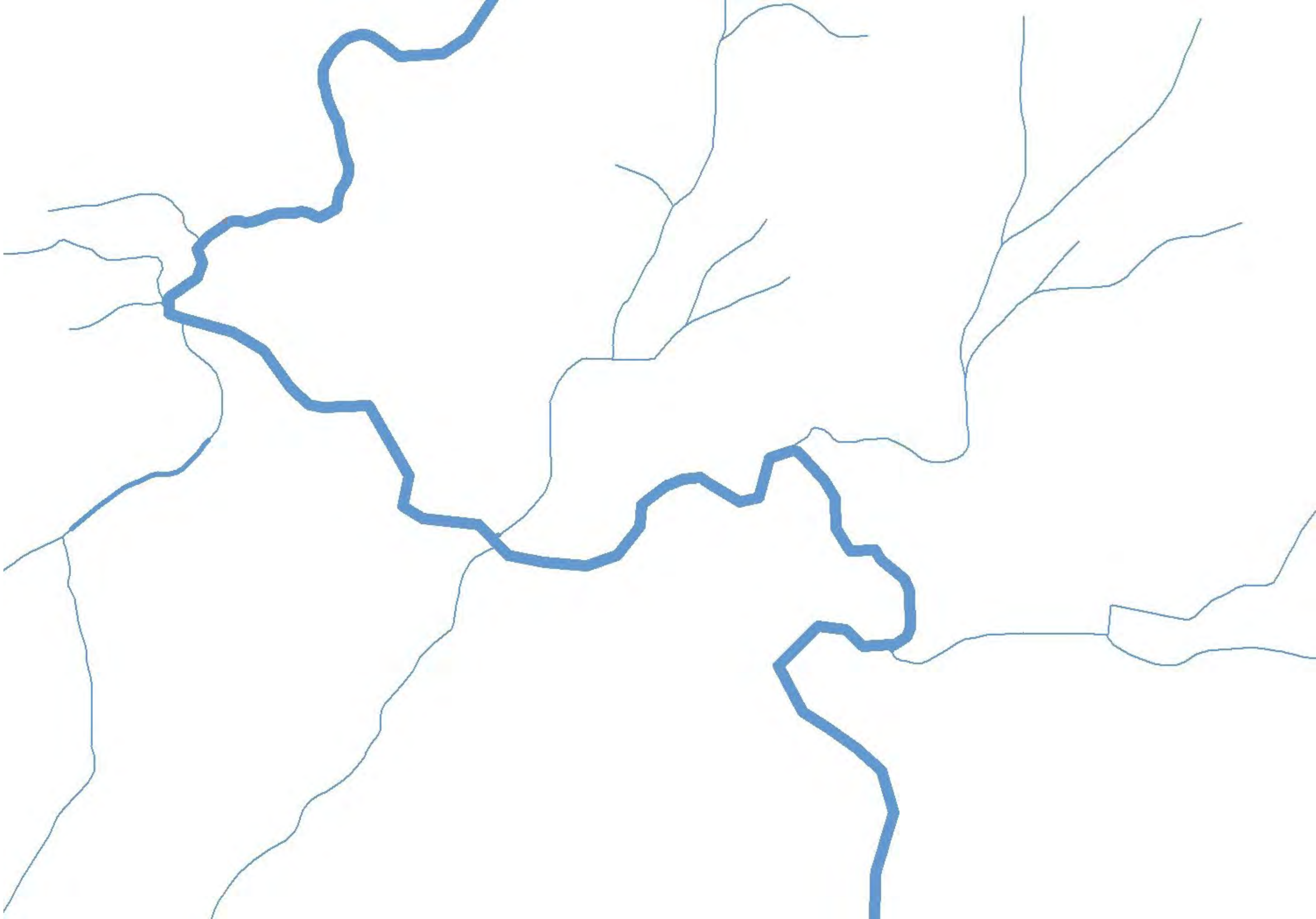


Defining and Mapping Riparian Extent

- The riparian analysis area was determined using **default minimum riparian buffer areas** from WA Department of Ecology in conjunction with floodplain and SMA data
- The initial riparian extent was mapped using five layers:
  - WA DoE 35, 50, and 75 foot stream buffers
  - SMA Lakes 200' buffer
  - SMA Streams 200' buffer
  - NWI Wetlands
  - FEMA DFIRM floodplain
- Riparian extent was refined by removing the following areas:
  - Incorporated cities
  - Publicly owned land
  - Non-agricultural parcels

NAIP Ortho

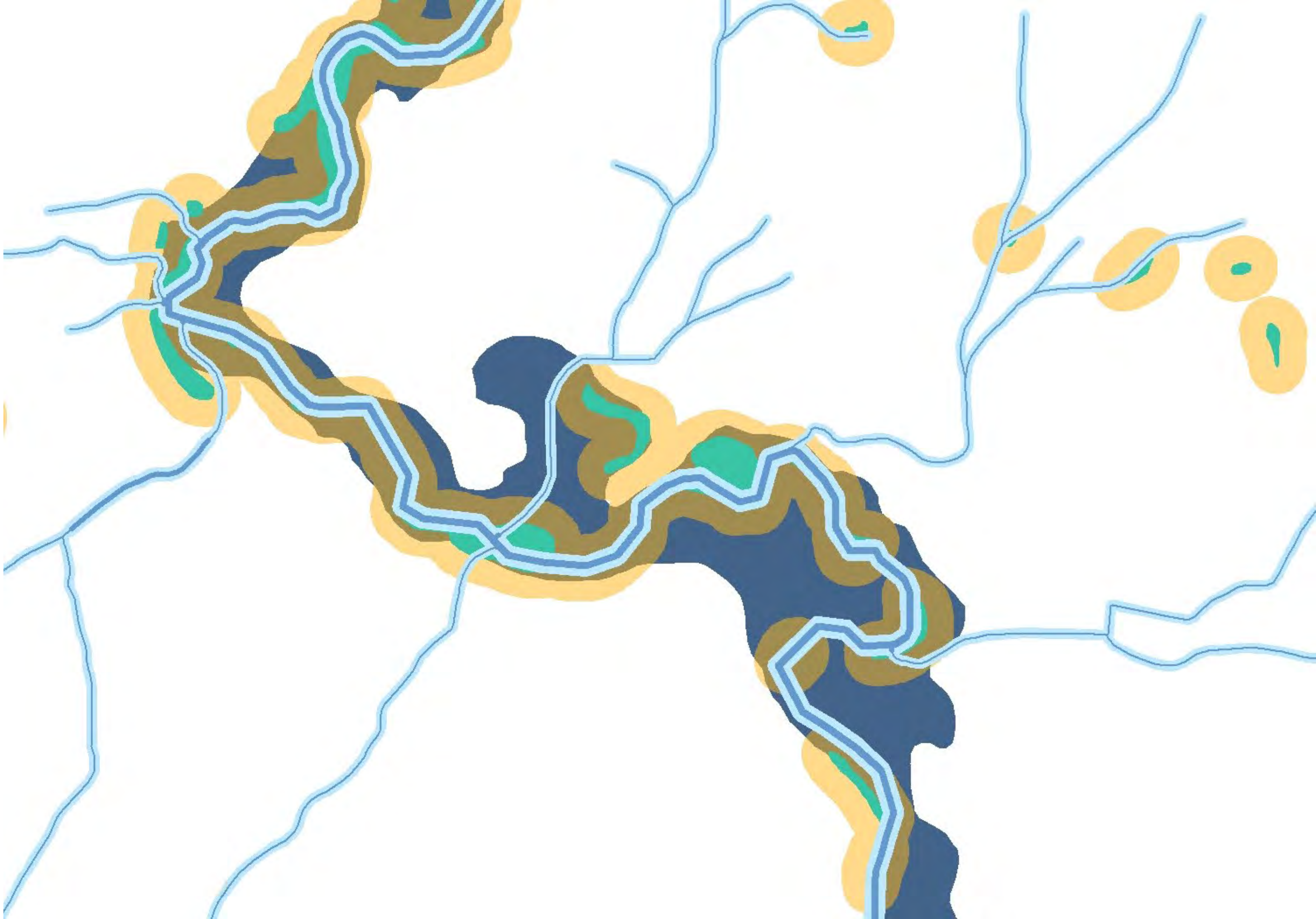
Streams



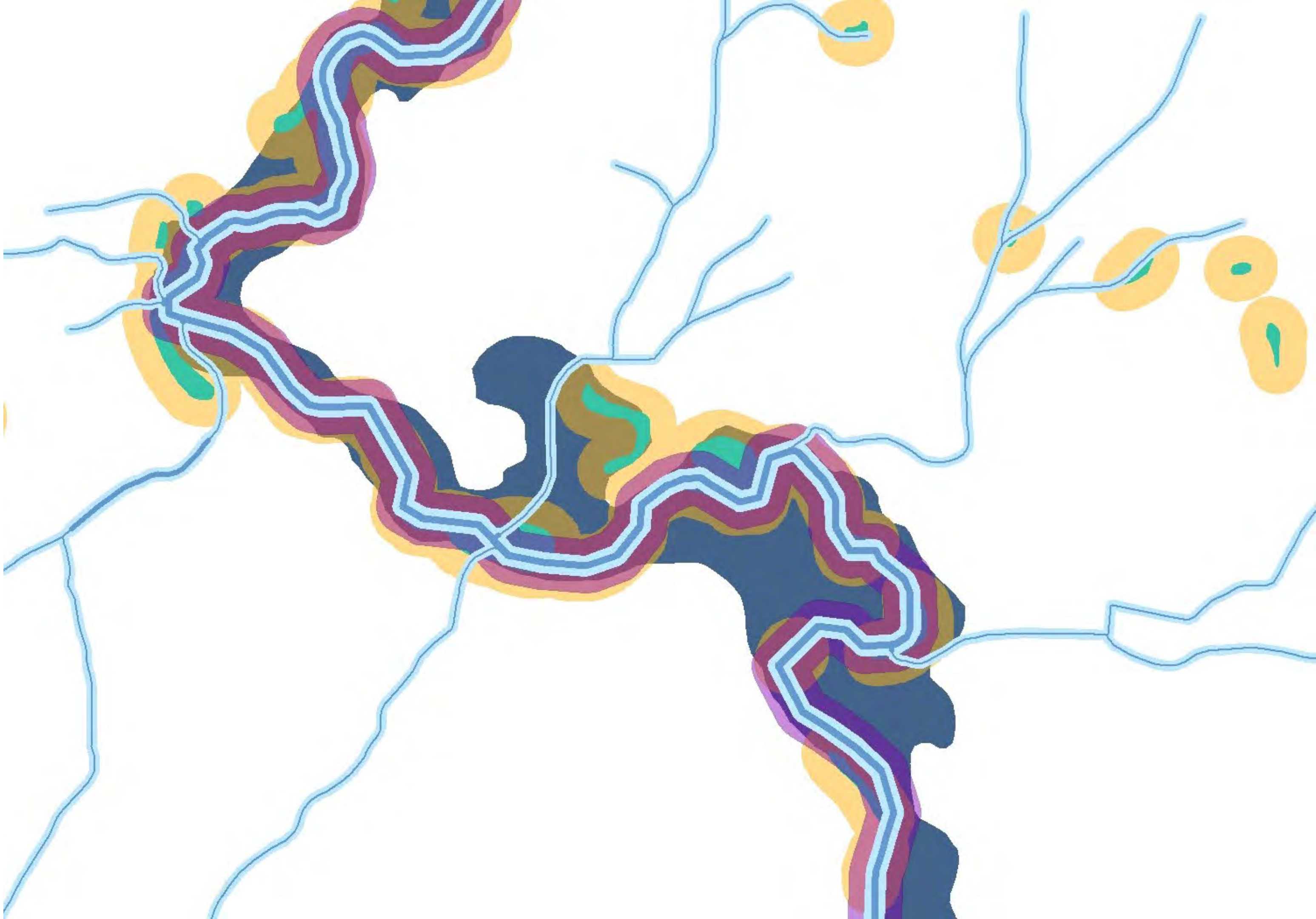
Stream Buffers

FEMA Floodplain

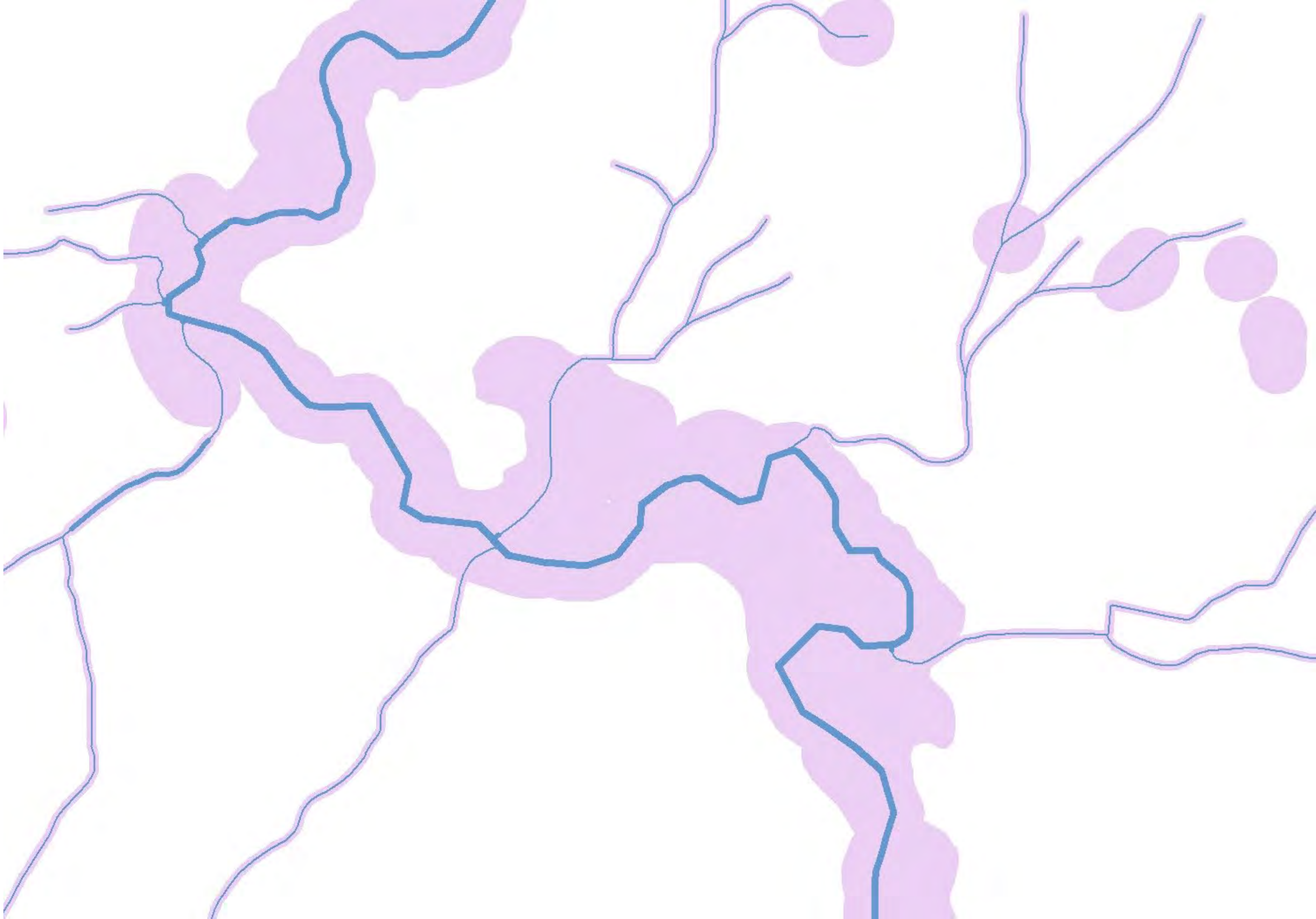
Wetlands & Buffers



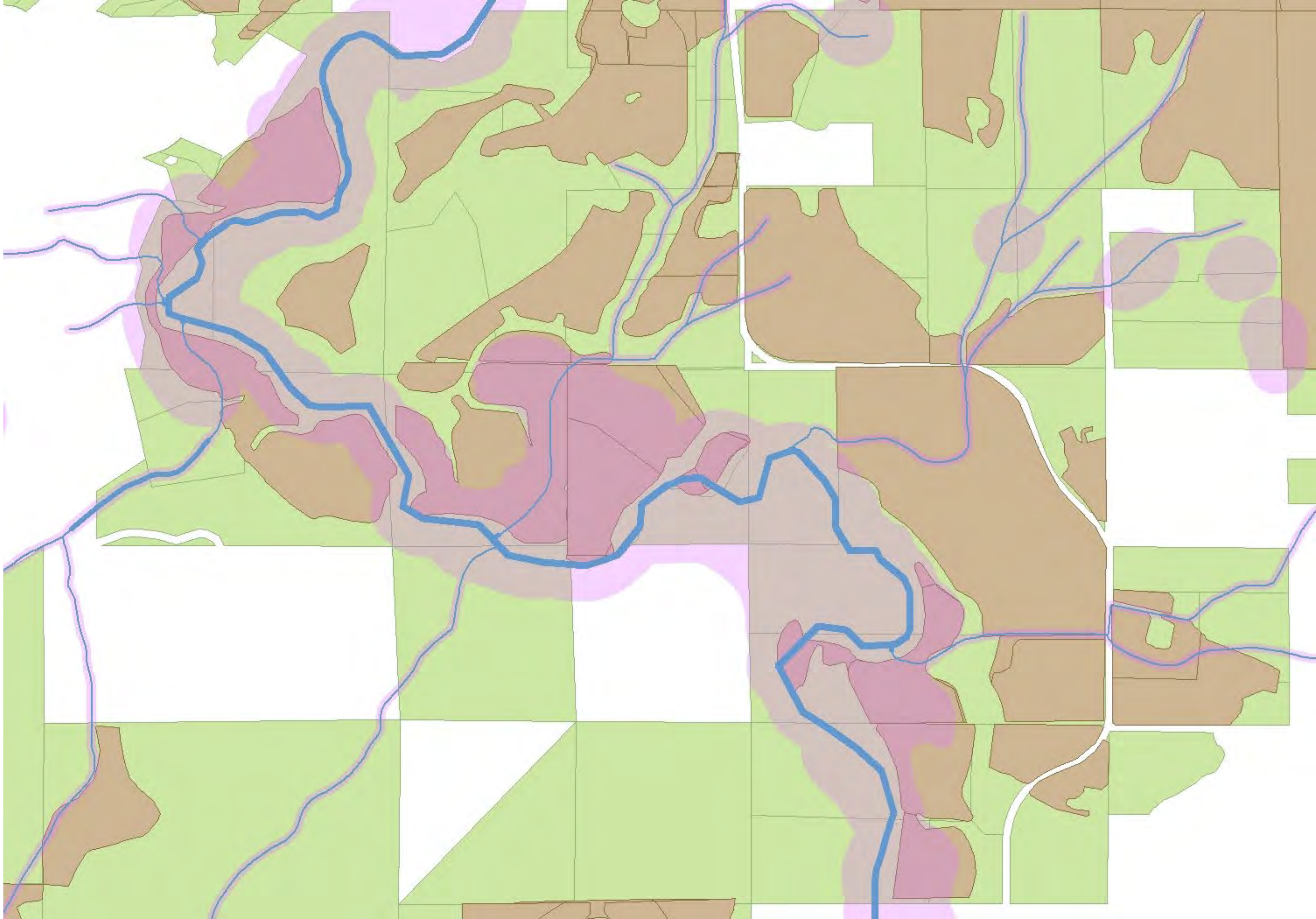
SMA Streams Buffer 200’



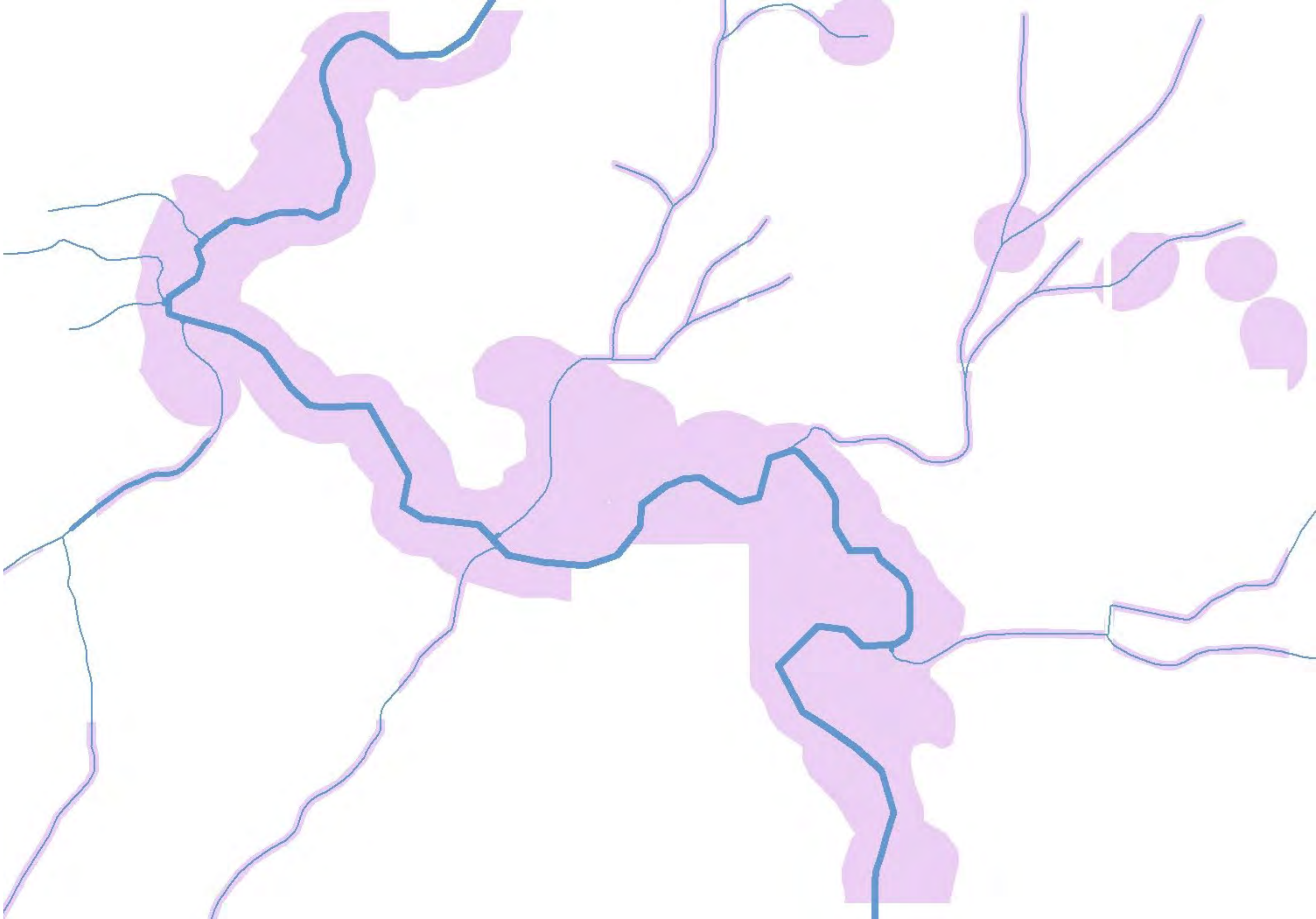
Preliminary Riparian Area



WSDA Field Boundaries and County Parcels



Refined Riparian Area

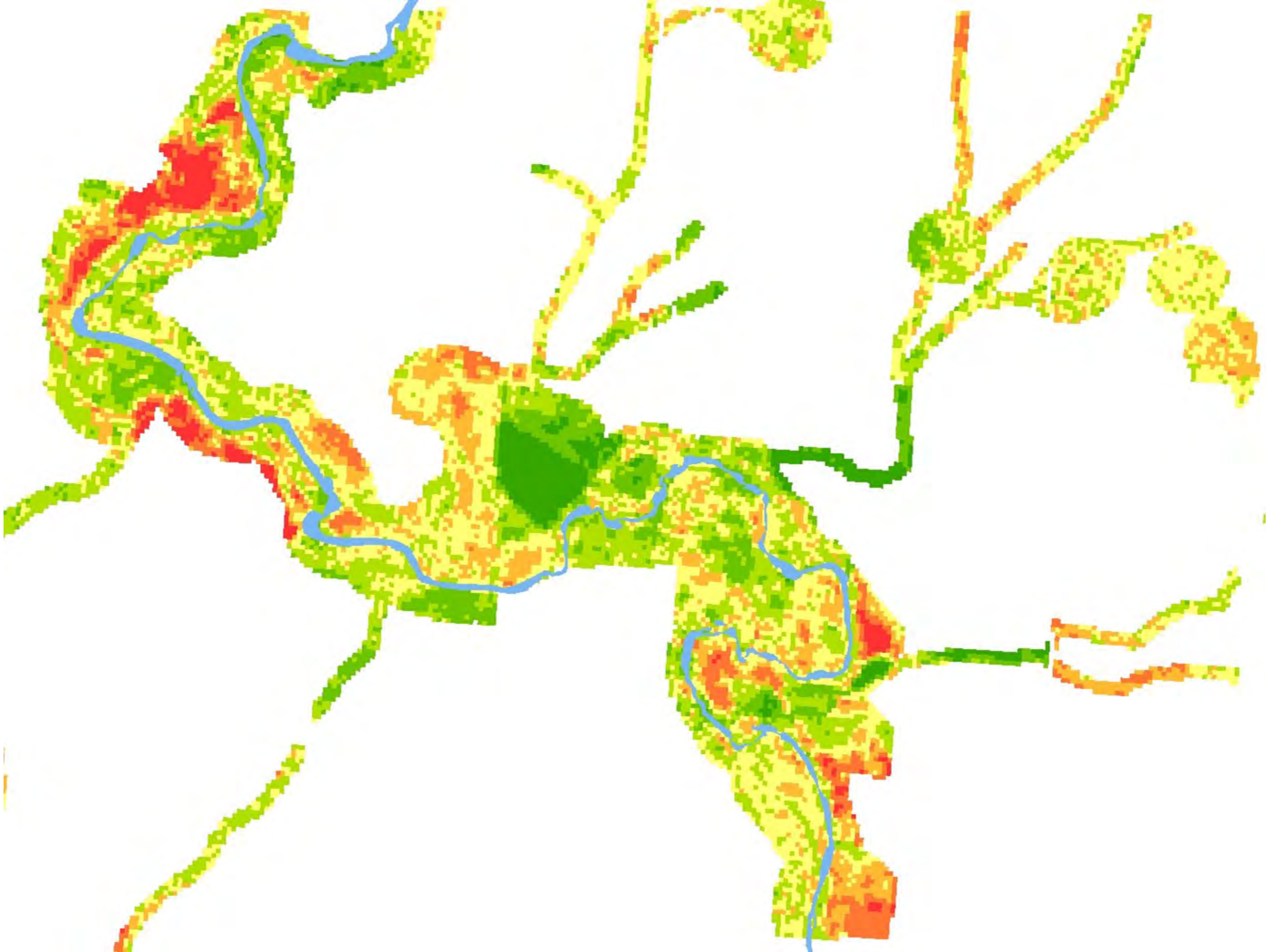


NAIP 2019

NAIP 2021

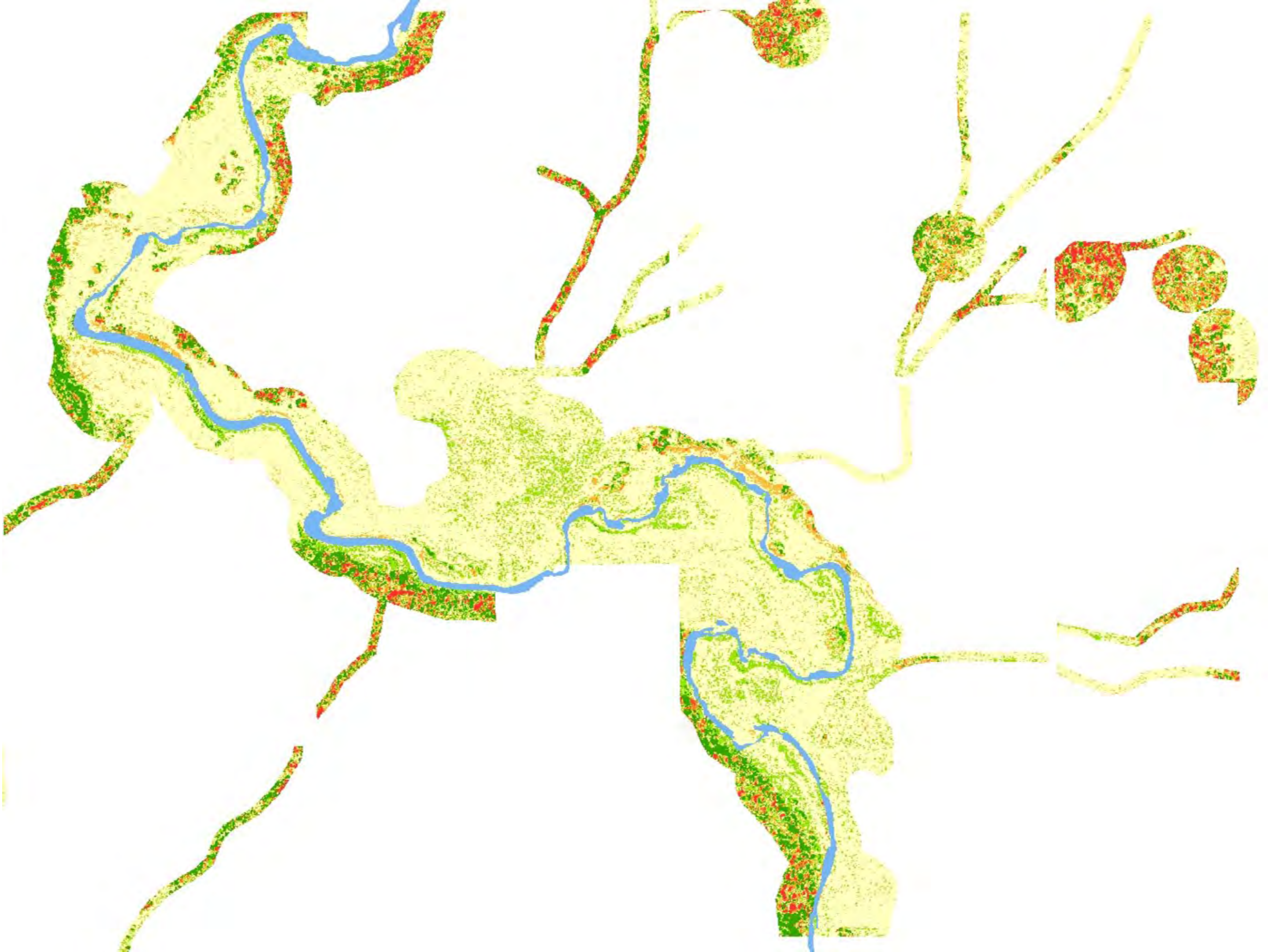
Change in Greenness 2019-2021

Derived from Sentinel 2 imagery for Aug 2019 and 2021 by calculating NDVI, extracting the greenest pixel at the 95th percentile for both years, then calculating the difference between the two



Filtering out Normal Agricultural Activity

Digital surface models derived from point clouds created by WA DNR from source NAIP imagery can be used to differentiate normal agricultural activities from true loss/gain in vegetation within the riparian/agricultural intersect

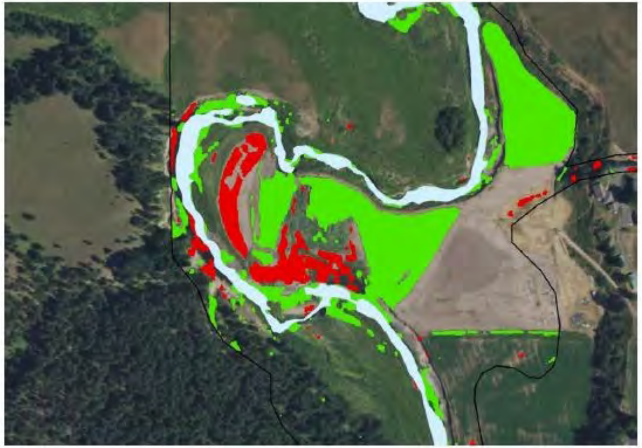


Next Steps

- Complete draft analysis of 2019-2021 data and review results with Spokane CD staff
- Refine, revise, and iterate
- Assess error
- Further rounds of revisions
- Generate statistics, maps, and methods document

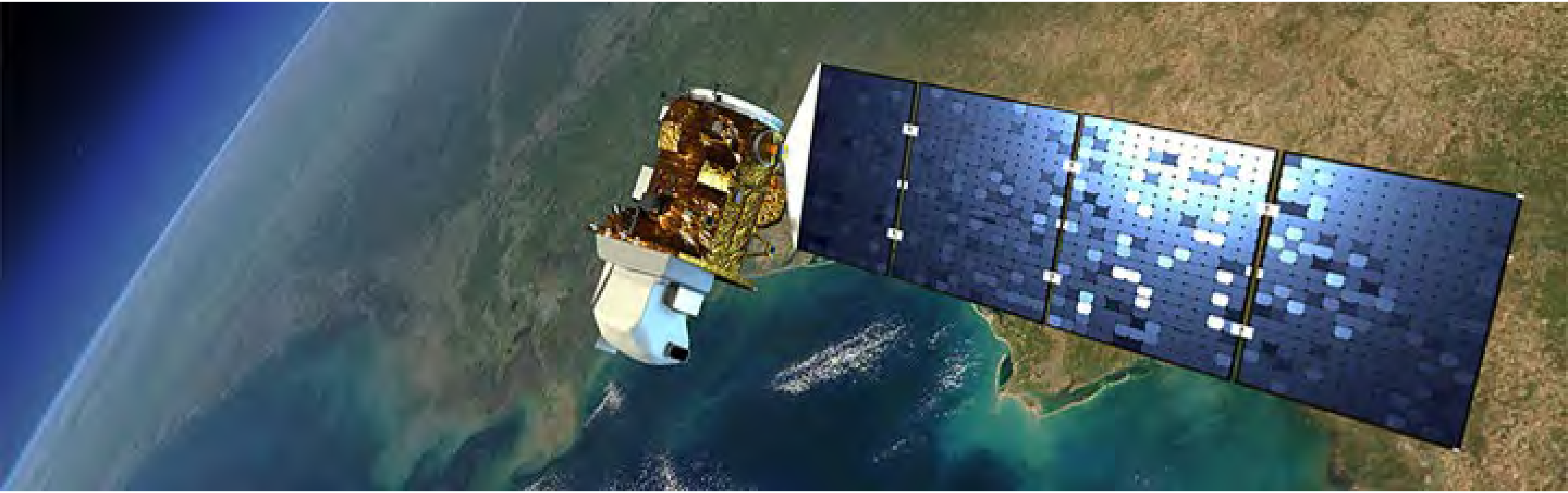
VSP

- Functions and values - habitat, water quality
- 2021 analysis showed no significant changes



Sample area highlighting vegetation gains and losses in riparian area as part of a multi-tiered monitoring approach

Wetland Monitoring Using Spectral Unmixing with Landsat Imagery



Wetland Monitoring Using Spectral Unmixing with Landsat Imagery

Spectral Unmixing is a useful method for tracking changes to individual wetlands and provides the temporal detail to monitor both seasonal and long-term changes in wetland hydrology

Wetland Monitoring Using Spectral Unmixing with Landsat Imagery

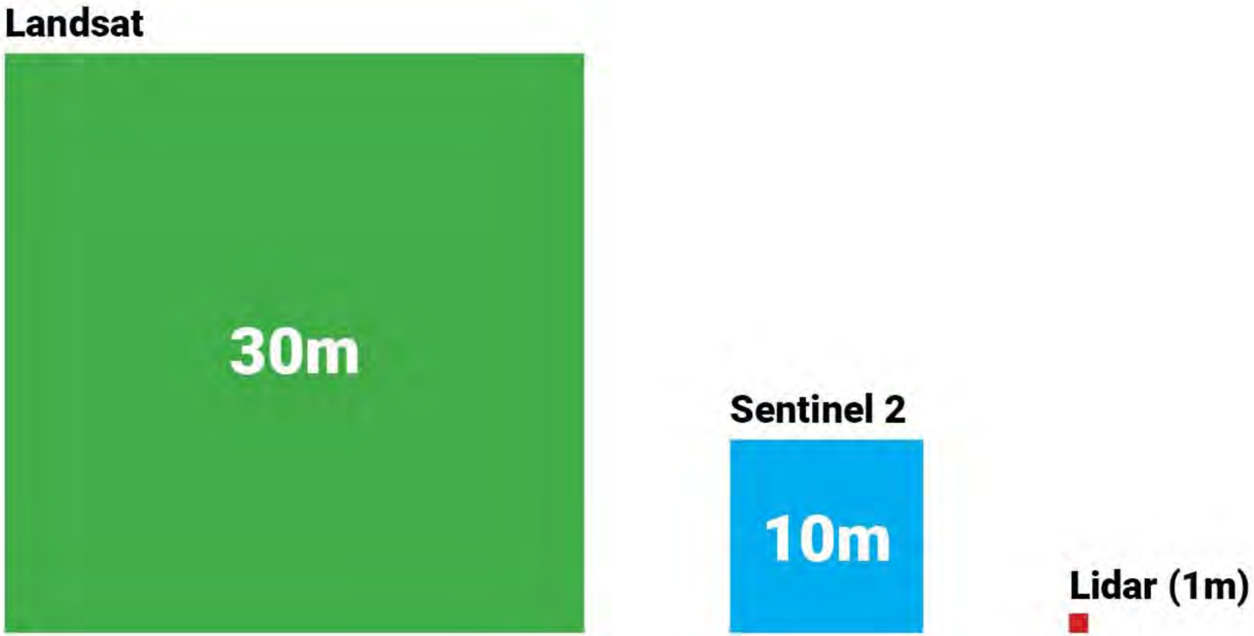
“**Spectral mixture analysis** (SMA) is a physically based technique which can be used to estimate the percent cover of surface water without the need for extensive training data. SMA estimates the **fractional abundance of spectra** representing physically meaningful materials, known as spectral endmembers, which comprise a mixed pixel, thus providing **sub-pixel estimates of surface water extent**[1]”

[1]Halabisky et al, *Reconstructing semi-arid wetland surface water dynamics through spectral mixture analysis of a time series of Landsat satellite images (1984–2011)*

Why is this helpful?

- Traditional satellite classifications take an "**all-or-nothing**" approach, meaning pixels are put into mutually exclusive categories (eg, forest, grass, water, developed)
- Landsat pixels are 30m in resolution, and due to their size, many are **composed of a variety of cover types**, and have various levels of saturation
- Wetlands in particular are frequently a **combination** of emergent aquatic vegetarian, shrubs, tree canopies, and open water, often within close proximity
- To illustrate this…

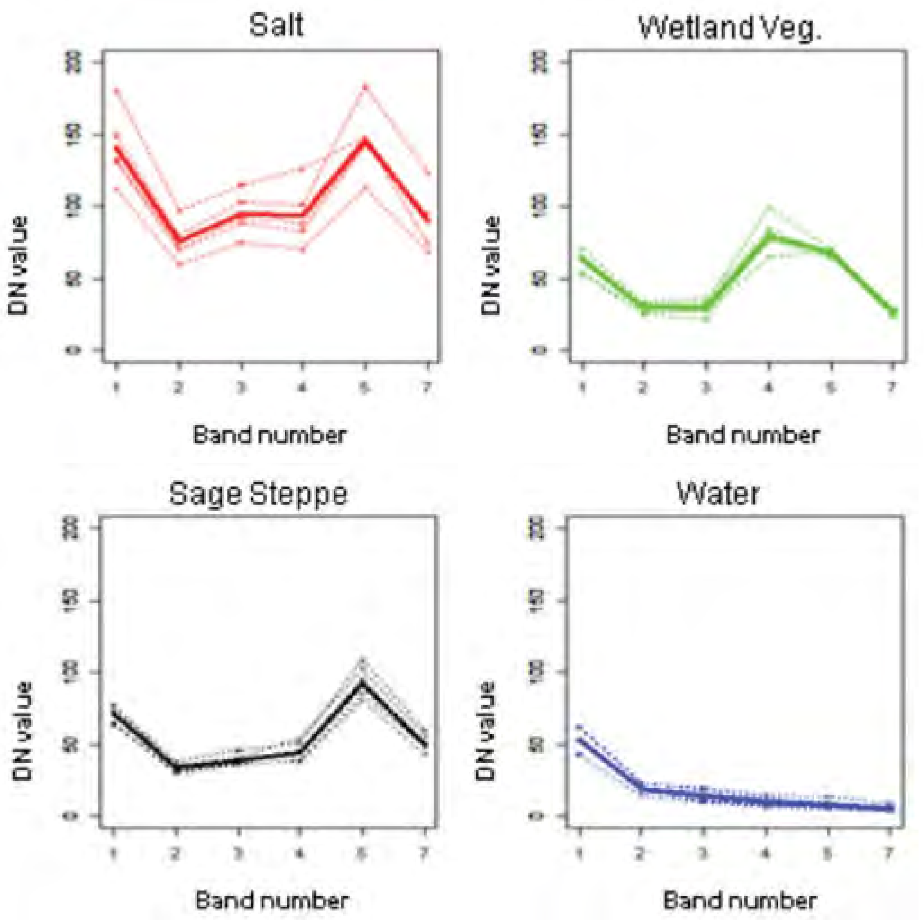
The importance of scale



Endmembers

Endmembers provide spectral ‘profiles’ of different classes

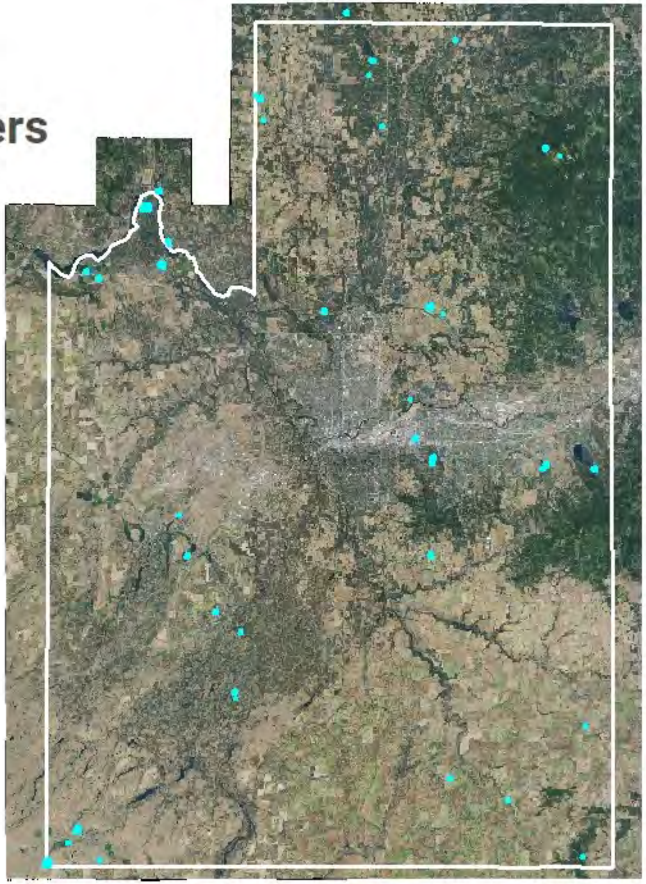
These can be used to provide sub-pixel estimates of surface water extent



Applying the Method

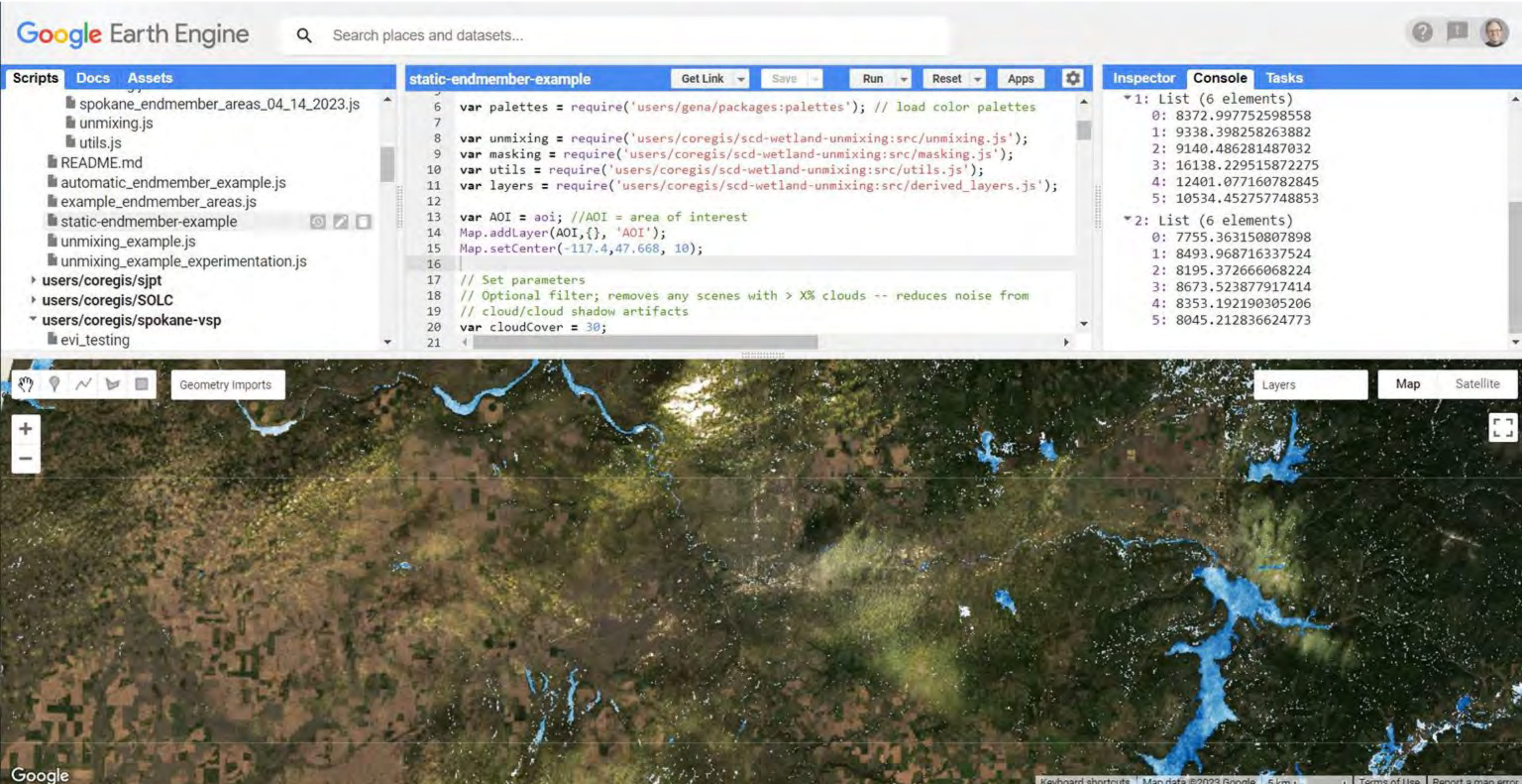
Spokane County Endmembers

- Mud (1)
- VegAg (10)
- VegDry (9)
- VegTree (7)
- VegWet (10)
- Water (5)



Two Examples: Wet Vegetation and Agricultural Vegetation

Adapting the Code in Earth Engine



Outputs

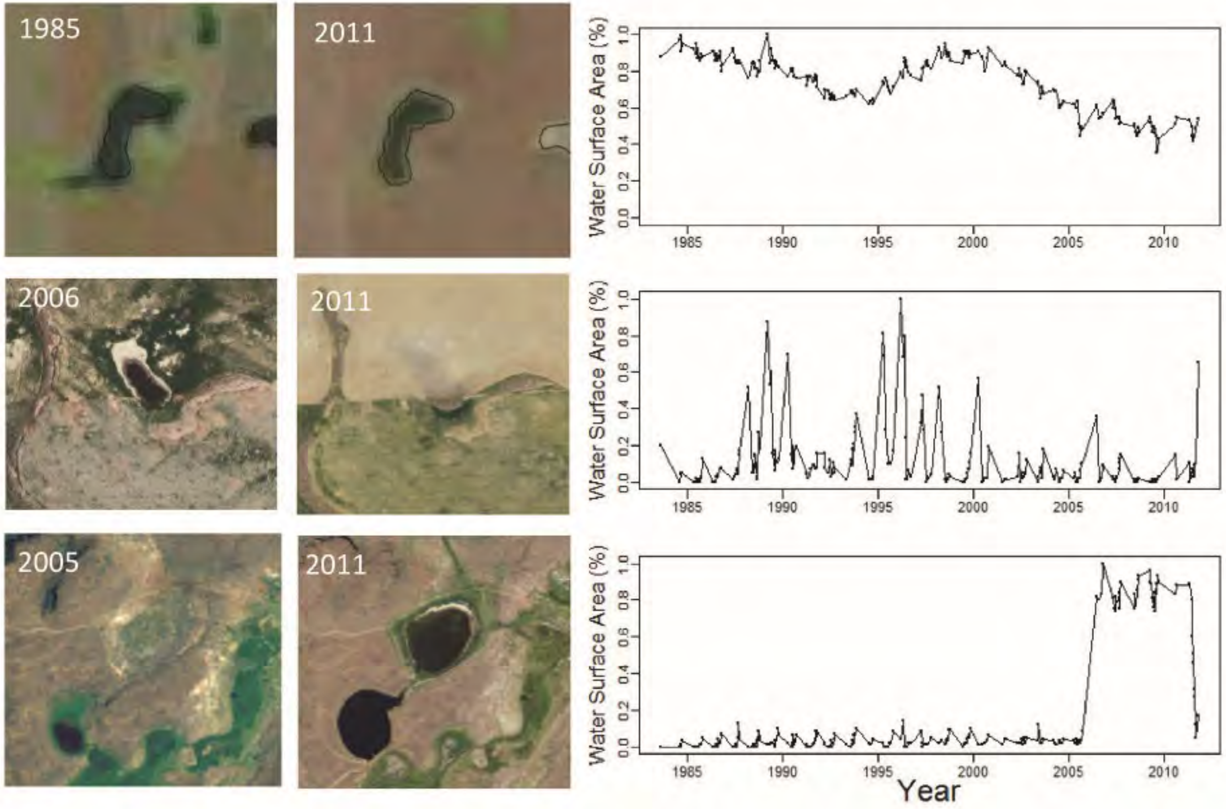
1. Annual = **Length of inundation** (aka % of Landsat obs above 5-10% water in SMA)
2. Across all years = **Avg length of inundation** (“baseline” for comparison)
3. Difference between (1) and (2) = **annual deviation from the norm** (above or below)
4. Annual = **average surface water extent** (%)
5. Annual = **minimum surface water extent** (%)
6. Annual = **maximum/peak surface water extent** (%)
7. **Date of minimum surface water**
8. **Date of maximum/peak surface water**
9. **Date of max/peak NDVI**
10. Difference between (8) and (9) = **length of time between peak water and peak NDVI**

What can you do with the outputs?

Shrinking wetland

Plowed wetland

Created wetland



VSP

Watershed Approach

1. Agricultural Land vs. Watershed
2. Pay close attention to "disturbed" bins

Photo Credit: Scott Fink, Spokane County Saltese Flats Wetland and Trails | Spokane County, WA

The Wetland Intrinsic Potential (WIP) Tool

*Adapted from materials prepared by **Dr. Meghan Halabisky**, University of Washington*

WIP Tool: WA DNR (WetSAG), EPA, WA Dept of Ecology

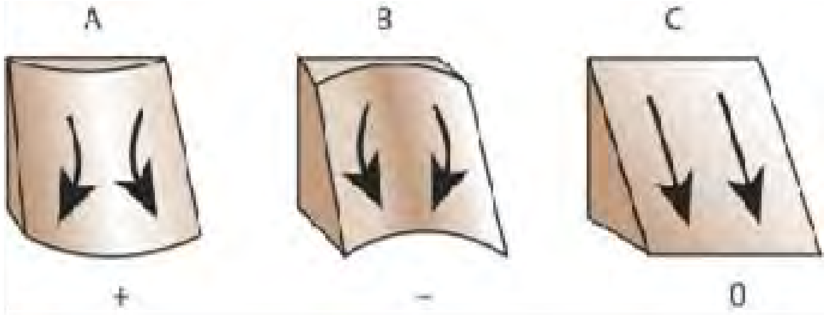
1. Identify key variables used to predict wetlands in the PNW
2. Develop sampling method to collect training and validation data
3. Allow tool to be more flexible and user friendly
4. Use machine learning methods/random forest models
5. Develop an ArcGIS tool

Key Variables Identified

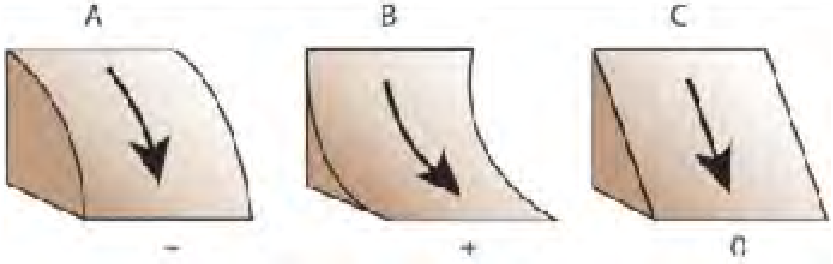
- Topographic wetness index
- Lidar intensity
- Leaf off imagery
- Depth to water index
- Rule based approach v. random forest method

Identify Topographic Features

Plan Curvature (across slope)

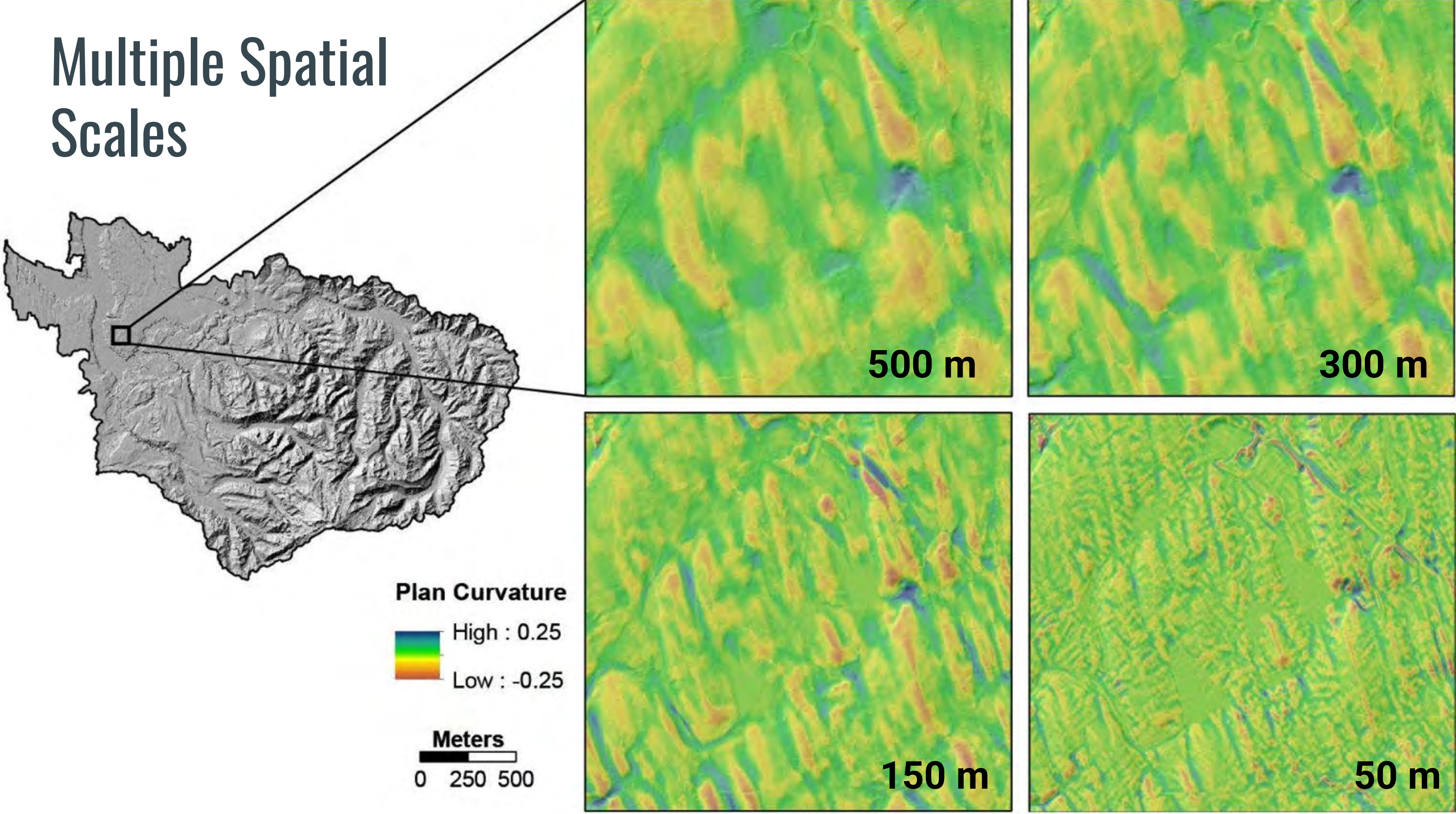


Profile Curvature (along slope)

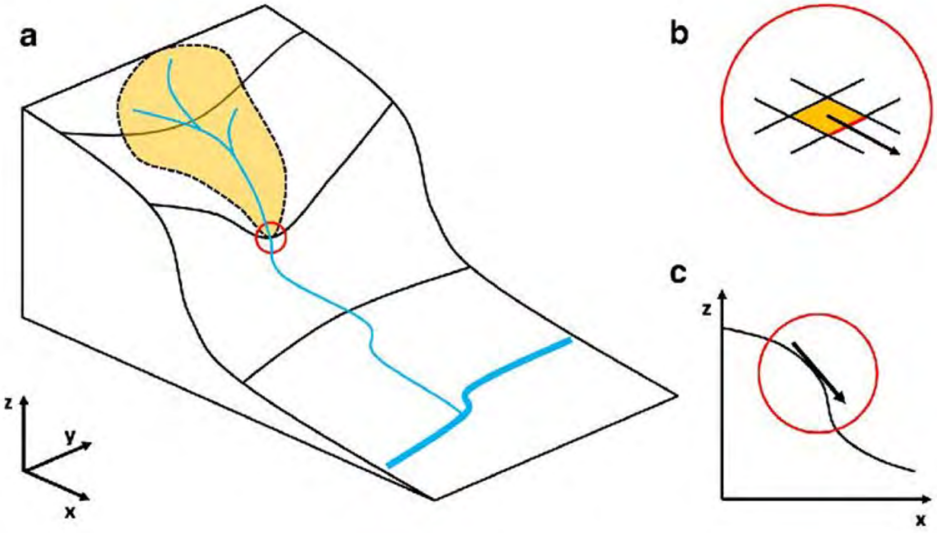


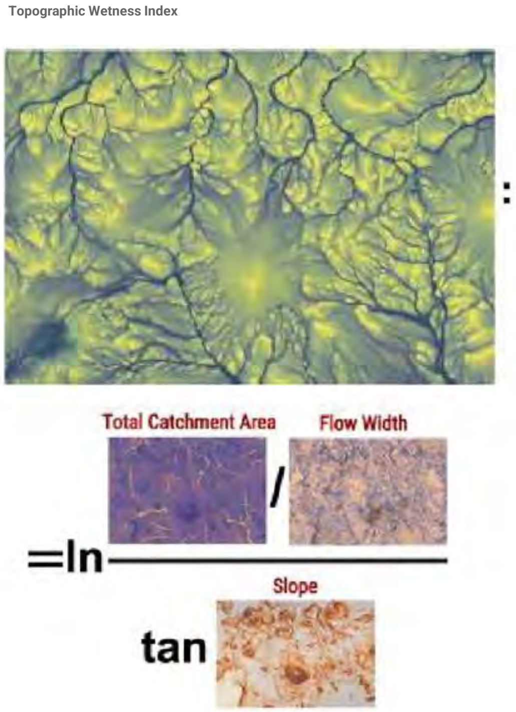
DEV = (elevation - mean elevation/standard deviation elevation)

Multiple Spatial Scales



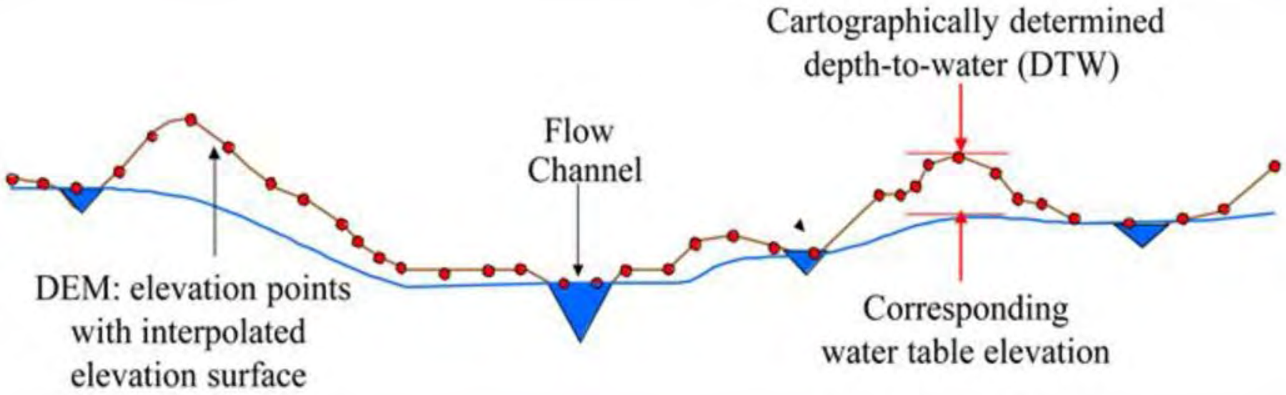
Hydrologic Modeling: Topographic Wetness Index

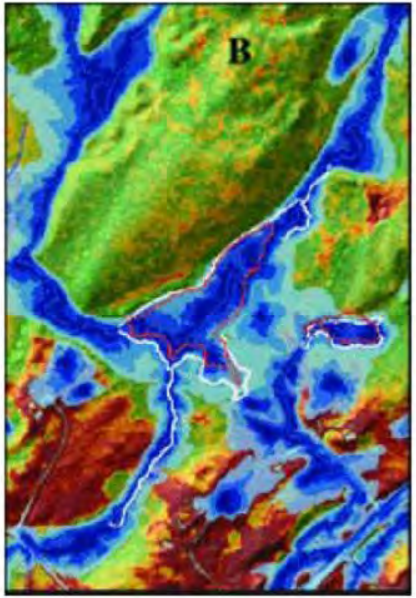




Martin Kopecký , Martin Macek , Jan Wild,
Topographic Wetness Index calculation guidelines based on measured soil moisture and plant species composition, Science of The Total Environment, Volume 757, 2021, https://doi.org/10.1016/j.scitotenv.2020.143785.

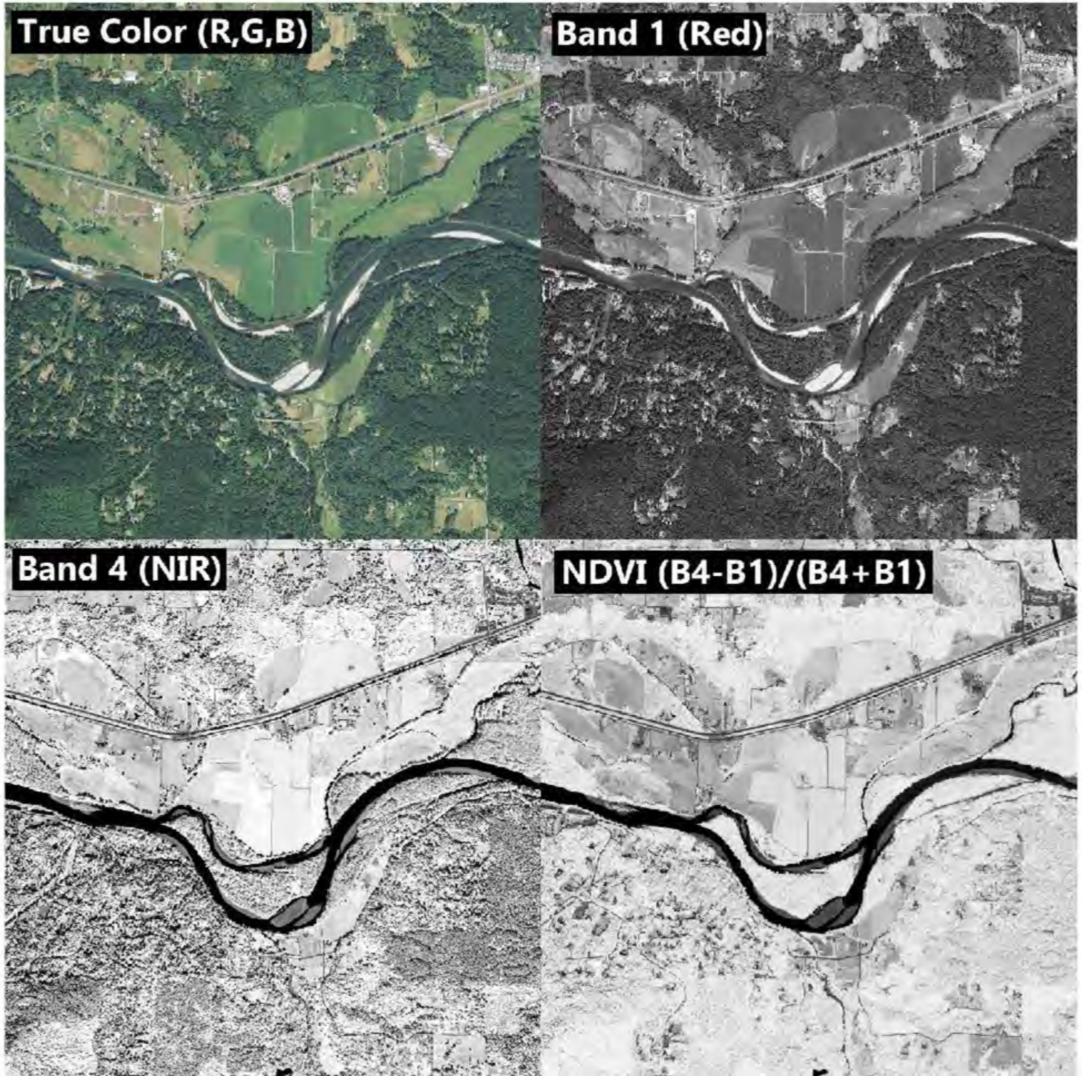
Hydrologic Modelling: Depth-to-Water Index





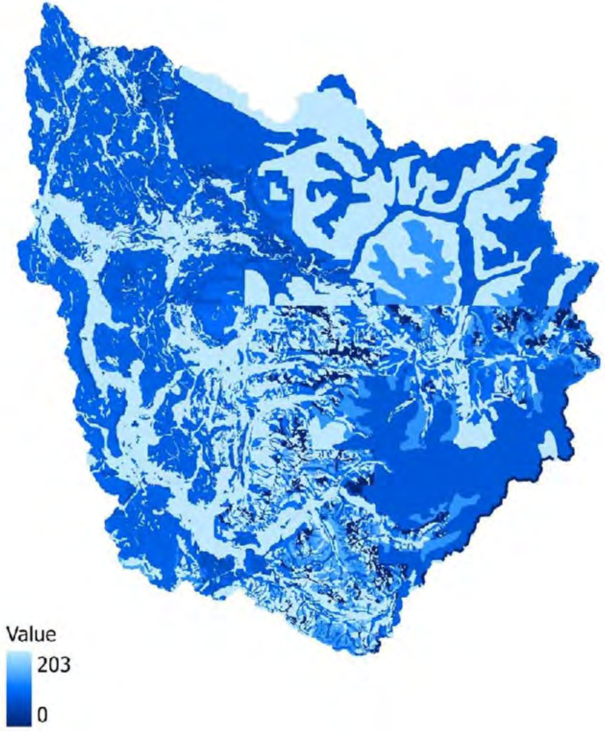
White, Barry & Ogilvie, Jae & Campbell, David & Hiltz, Douglas & Gauthier, Brian & Chisholm, H. & Wen, Hua & Murphy, Paul & Arp, Paul. (2012). Using the Cartographic Depth to Water Index to Locate Small Streams and Associated Wet Areas across Landscapes. Canadian Water Resources Journal. 37. 10.4296/cwrj2011 909.

Spectral Indices: Normalized Difference Vegetation Index

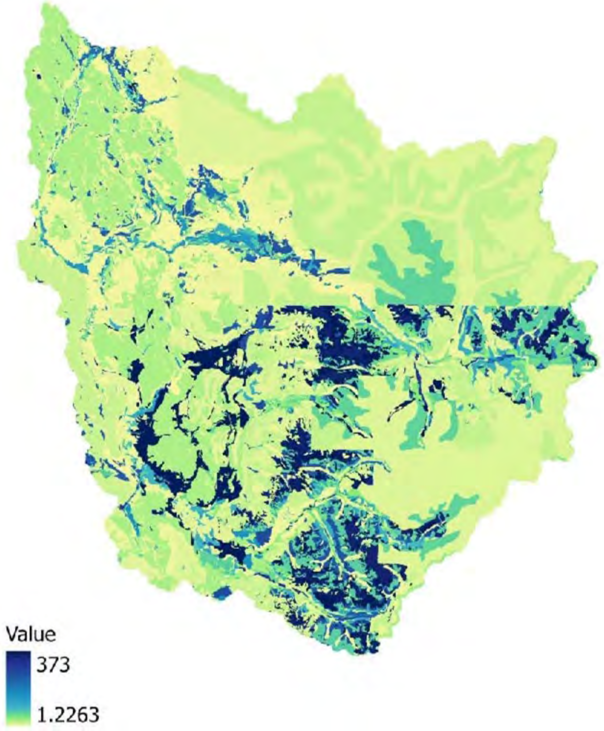


Vector Datasets: Soils, Geology, Other Wetland Inventories

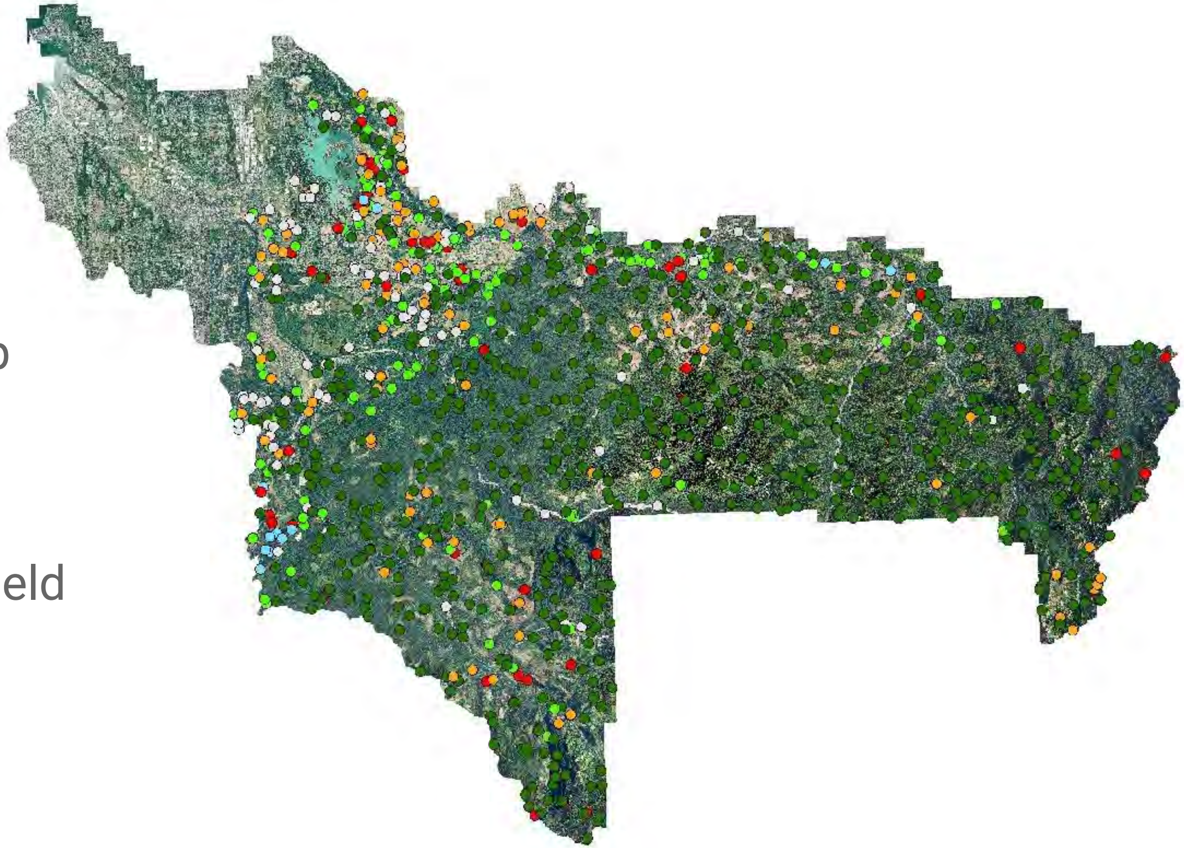
Depth to Any Restrictive Layer (cm)



Saturated Hydraulic Conductivity (KSAT) 0 to 200cm



Collect Training Data

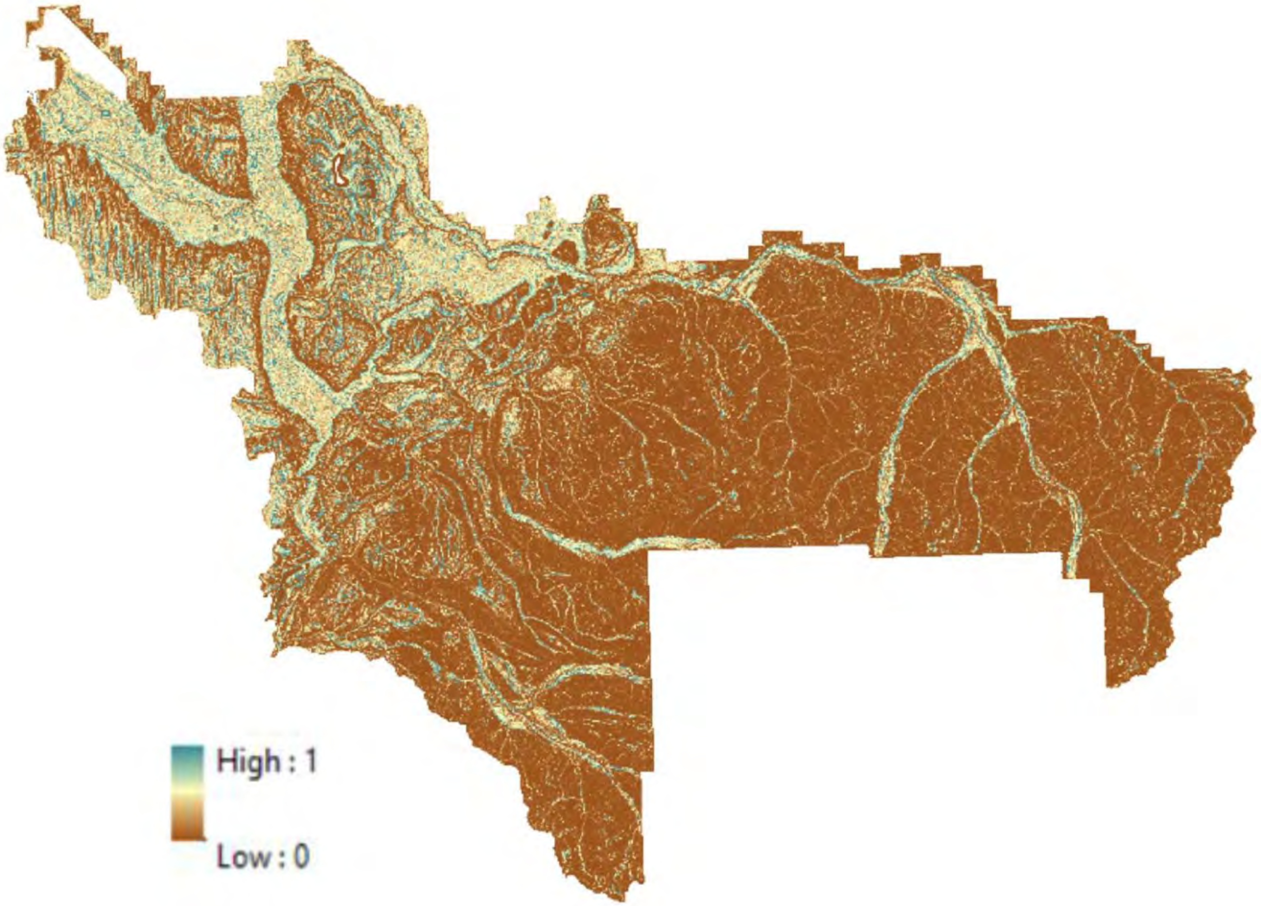


Developed for the Puyallup

- 1,270 points photo interpreted
- 101 assessed in the field

Random Forest Model–Wetland Probability Output

The output is a continuous surface of wetland probability, ranging from a **low of 0** (very unlikely a wetland) to a **high of 1** (very likely to be a wetland)



NWI

Overall accuracy = 88.1%

Error of commission = 2.1%

Error of omission = 41.8%

WIP Model

Overall accuracy = 96.6%

Error of commission = 4.3%

Error of omission = 8.0%

VSP

- Will establish baseline for future comparative analysis
- Replace NWI with something accurate and reliable
- Planning and Regulatory application

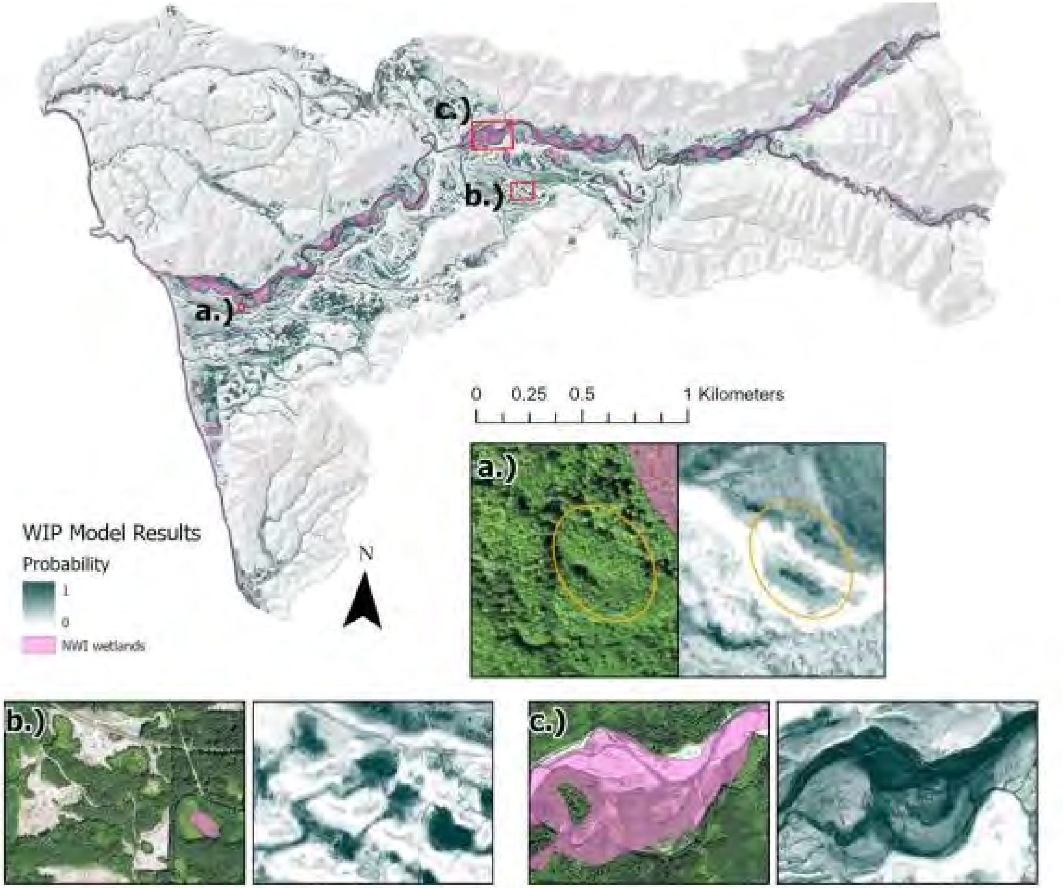


Figure 3. Wetland probability map of the entire study area with three examples: Depressional wetland (a.), peatland (b.), and riverine wetland (c.).

Halabisky 2022

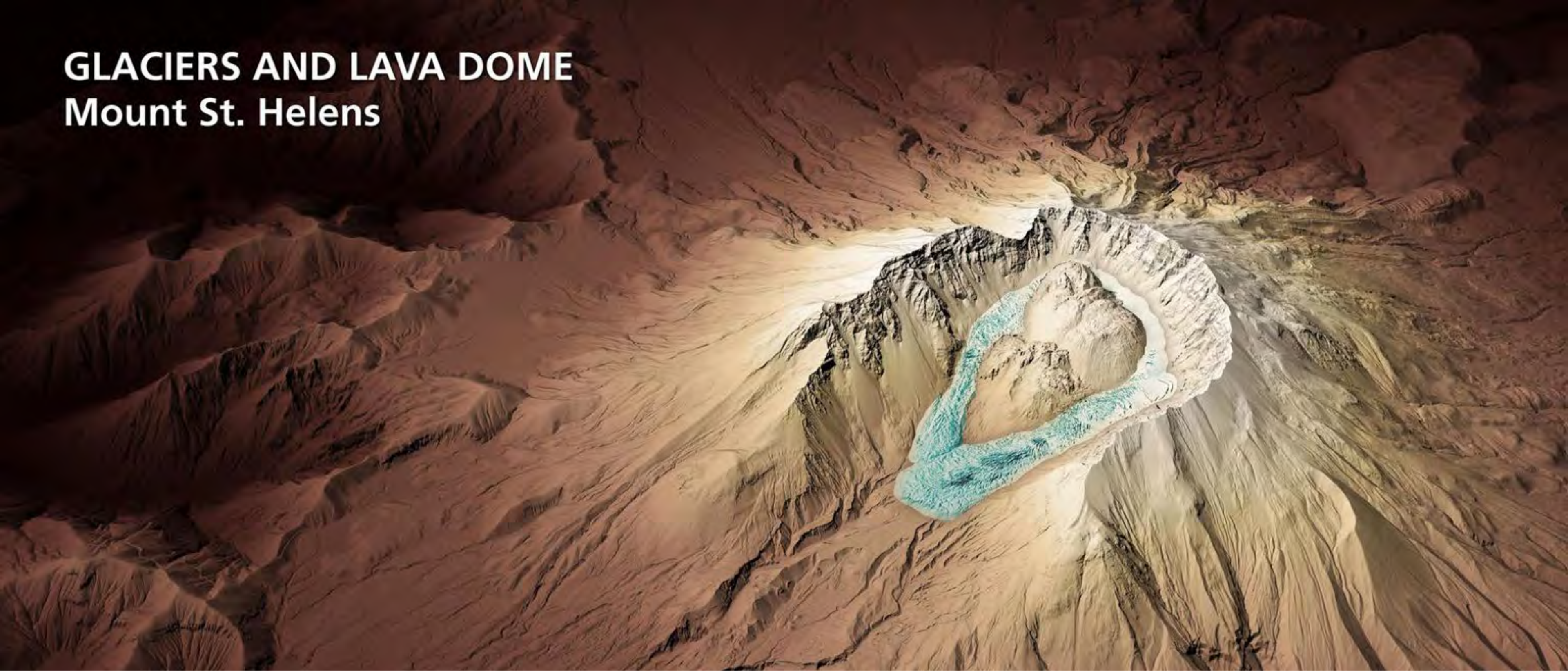
Questions?

Washington Lidar Program

Abby Gleason
Washington Geological Survey
WA Dept. of Natural Resources
Abigail.Gleason@dnr.wa.gov

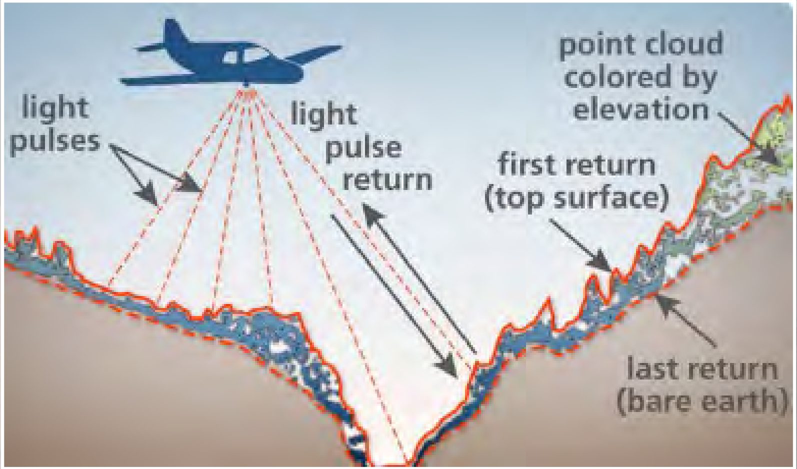
Agenda

- Lidar and Lidar Program Overview
- Bathymetric Lidar
- Lidar-derived Hydrography
- What’s Next



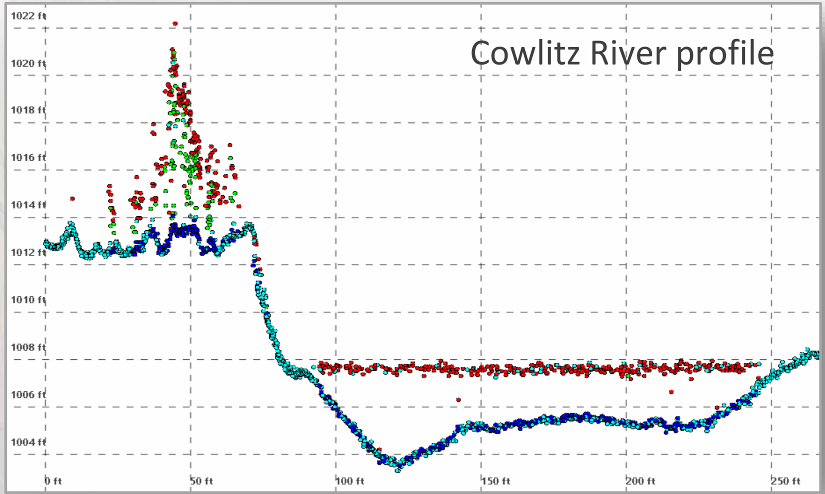
Lidar Program

WASHINGTON STATE DEPARTMENT OF
NATURAL RESOURCES
WASHINGTON GEOLOGICAL SURVEY



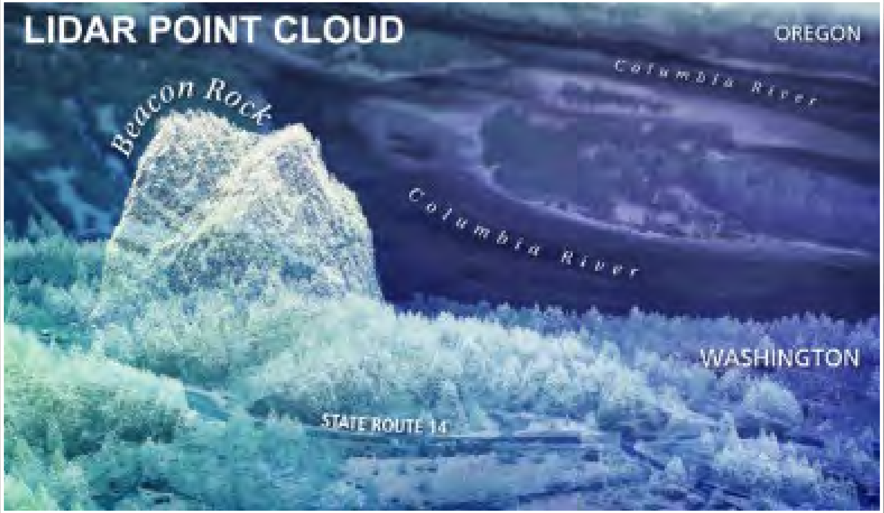
What is Lidar?

- Light Detection and Ranging
- Pulsed laser, NIR or blue/green light



- Collects millions of ‘points’, or returns, throughout tree structure to bare ground
- Highly accurate, typically 10cm accuracy or higher

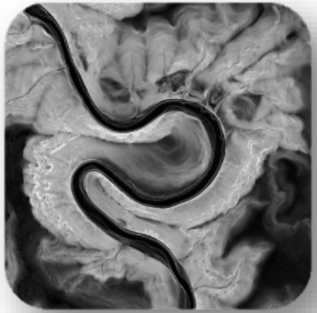
What is Lidar?

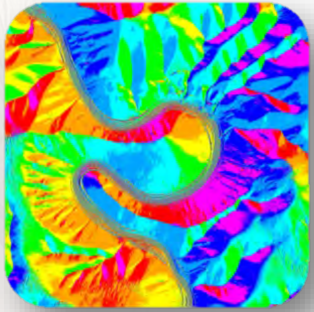



Bare earth DEM


Top surface DEM

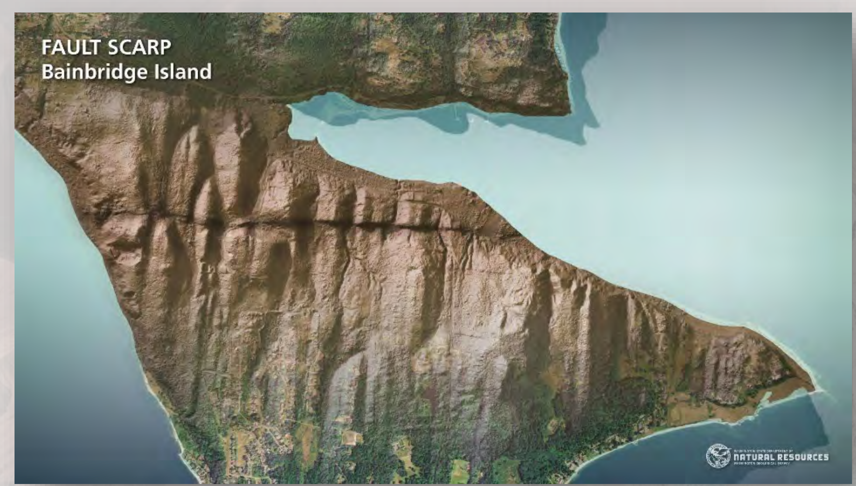

Hillshade (modeled sunlight direction)


Slope

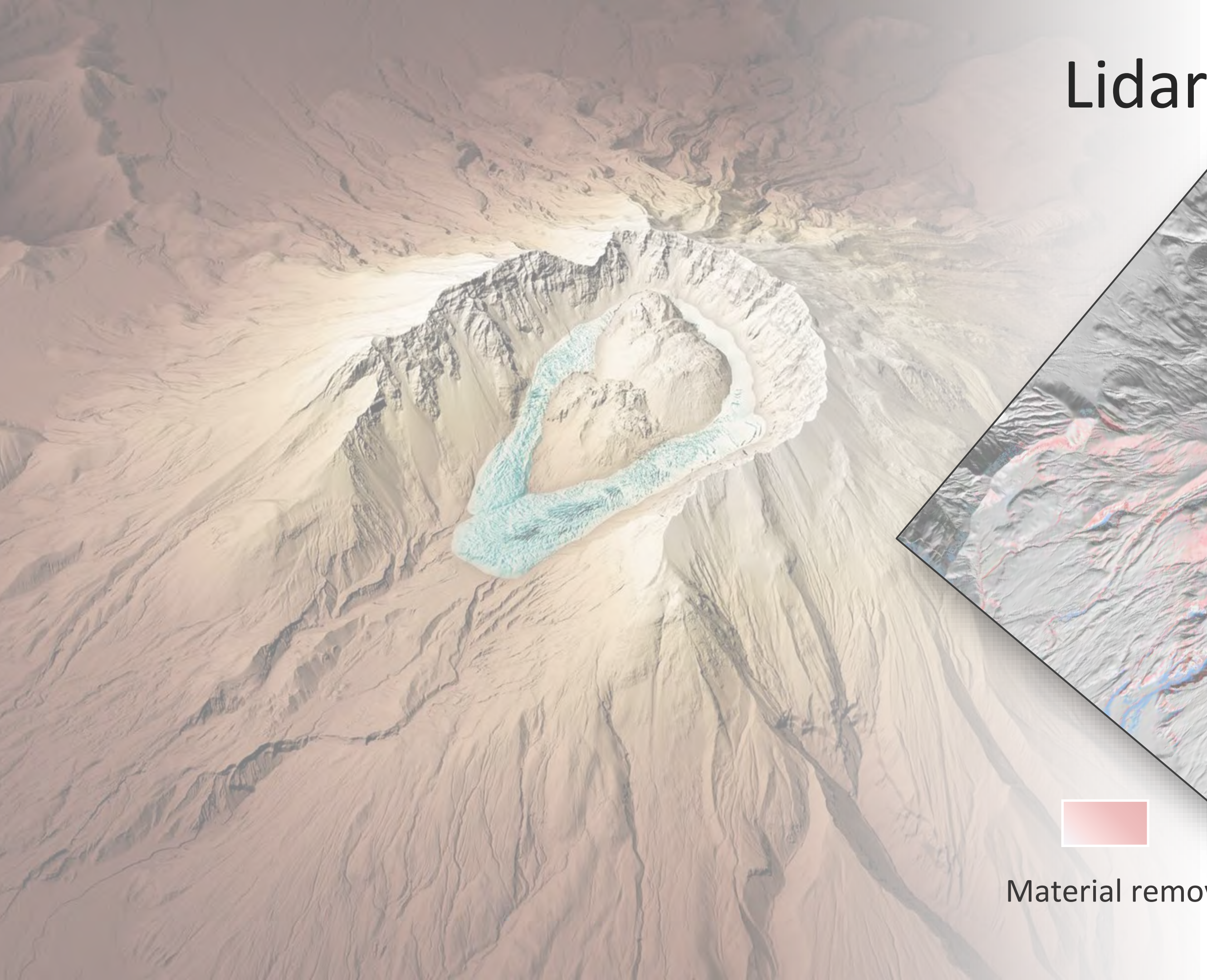

Aspect

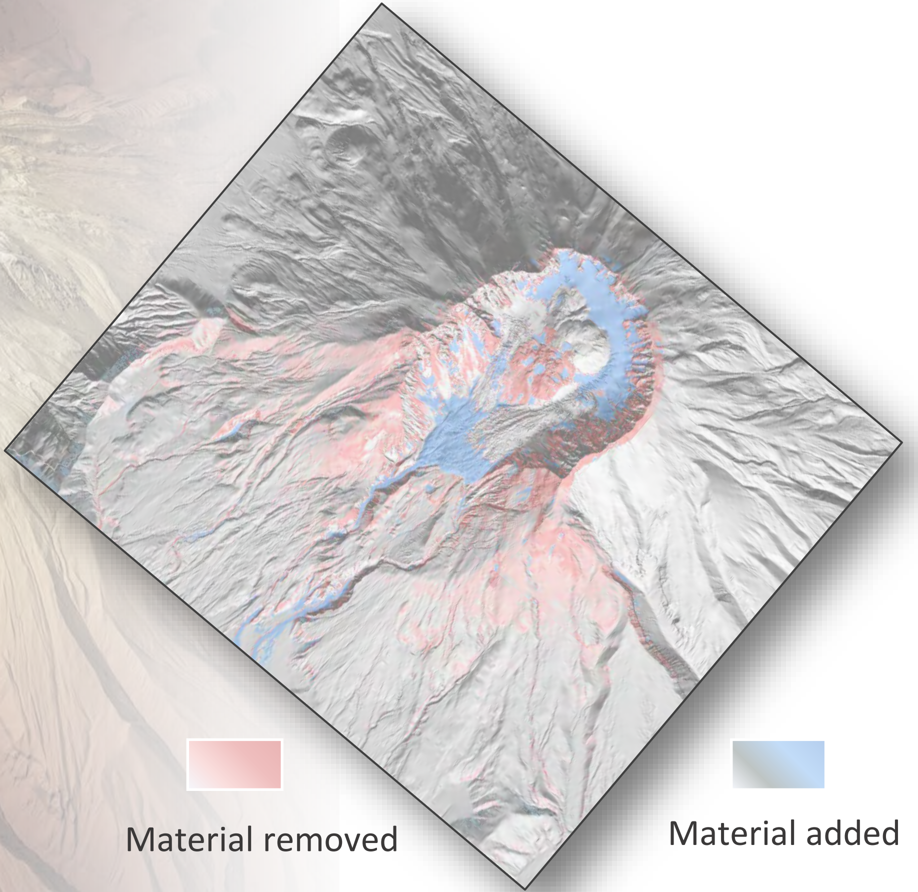

Contours

Lidar in Washington

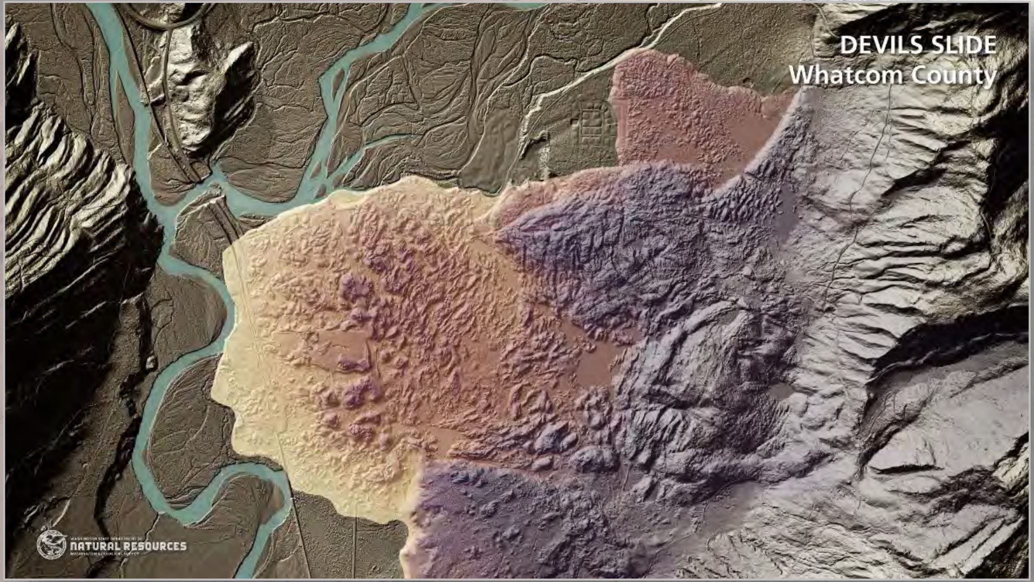


Lidar in Washington



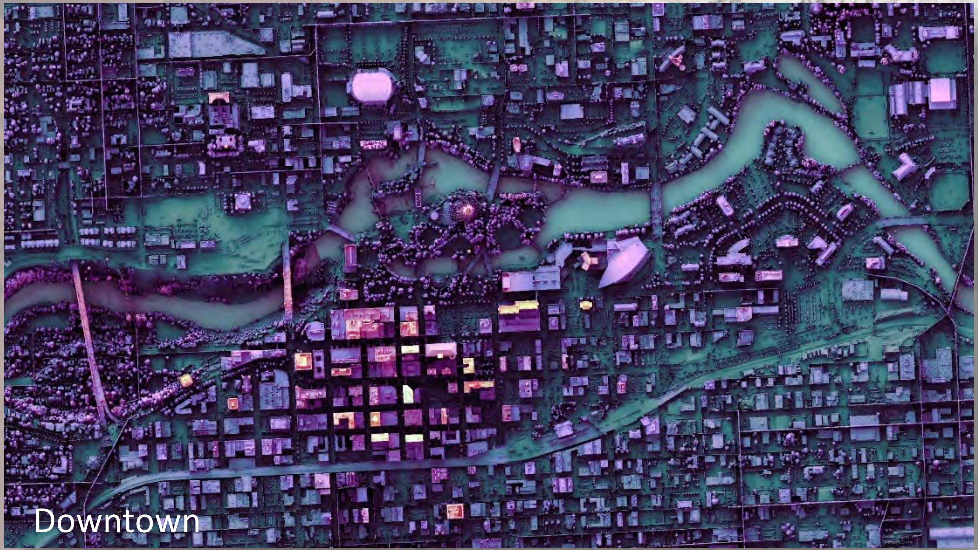


WGS Role and Lidar Program Background



RCW 43.92.025, 2015:
The **Washington Geological Survey** must acquire and process new lidar data or update deficient data and create and maintain an efficient, publicly available database of lidar data

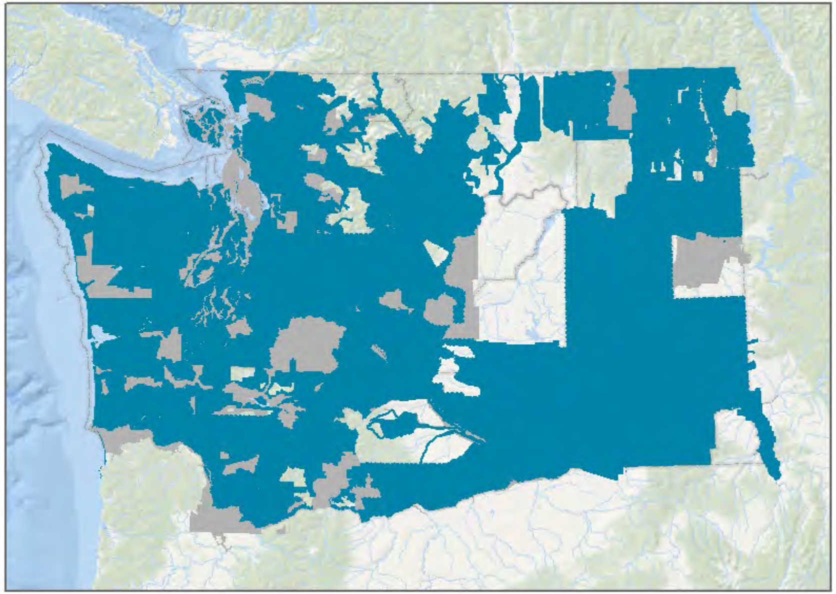
WGS Role and Lidar Program Background



Program goals:

- High-quality, statewide lidar collection to support hazards and all applications
- Collection, coordination with federal, state, local, and tribal stakeholders
- Standardize, QA, and consistent stewardship of the data
- Provide mechanisms for public distribution

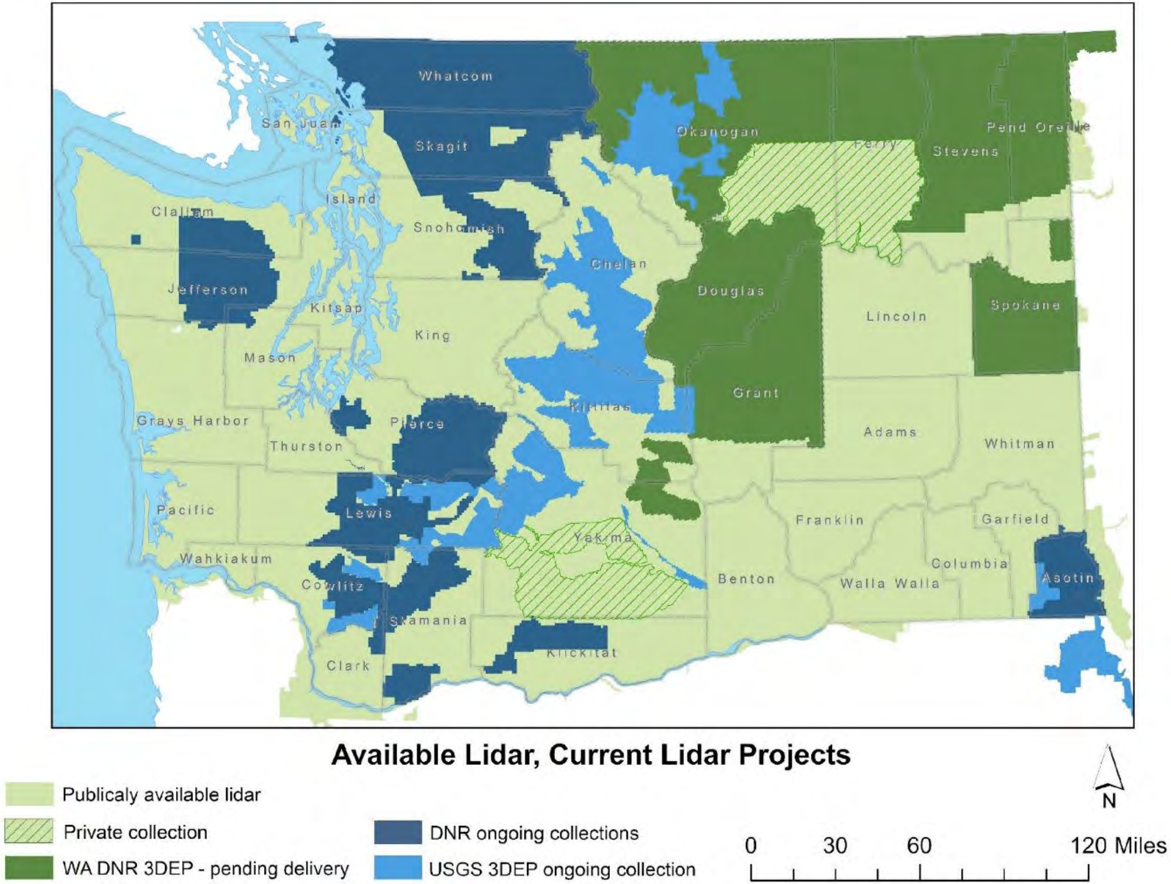
WGS Role and Lidar Program Background



Lidar Coverage of Washington: 2016 - 2022

- 1996-2015: 25,431 square miles
- 2016-2022: 59,729 square miles
- Achieved through:
  - legislative funding
  - Grants – USGS 3DEP and FEMA CTP
  - Partnership/DNR contracts
  - Gathered from other agencies

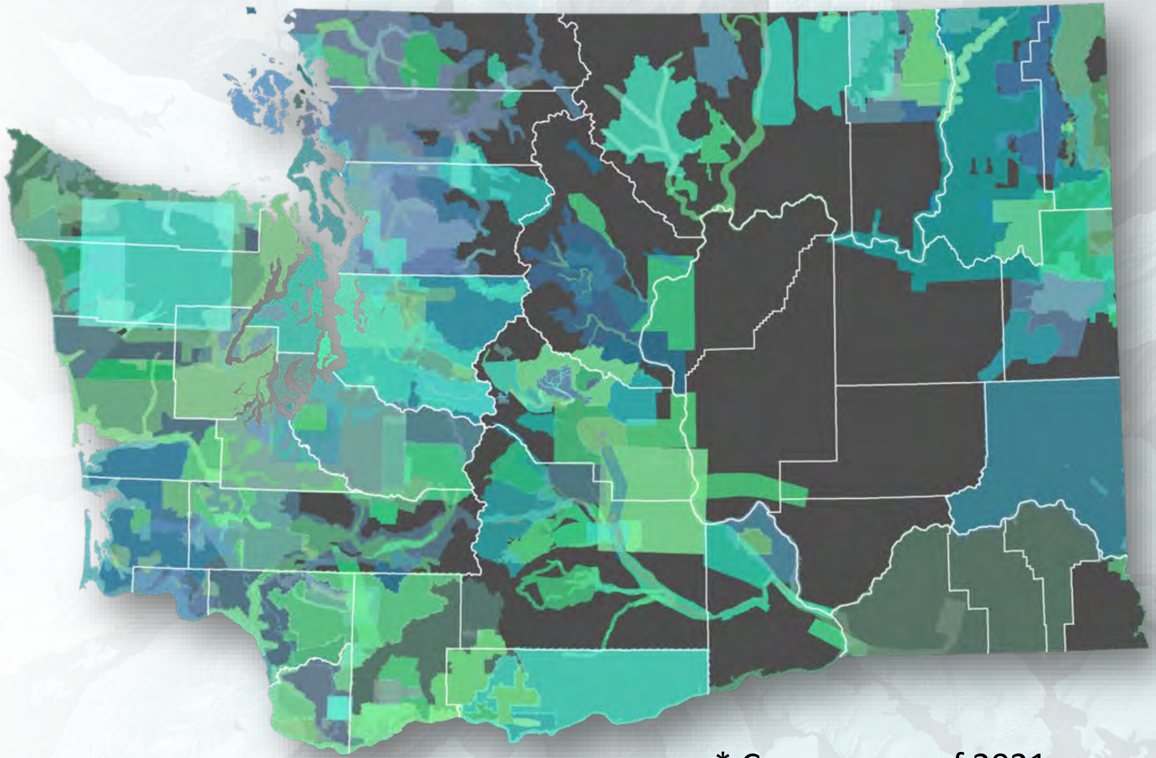
Goal of Statewide Lidar



What's Next: Future Program Goals

Patchy Road So Far…

- Patchwork of quality and time coverage, data inequity across the state
- To be able to plan projects, monitor progress, and measure change, a more consistent, repeatable, widescale approach is needed



* Coverage as of 2021

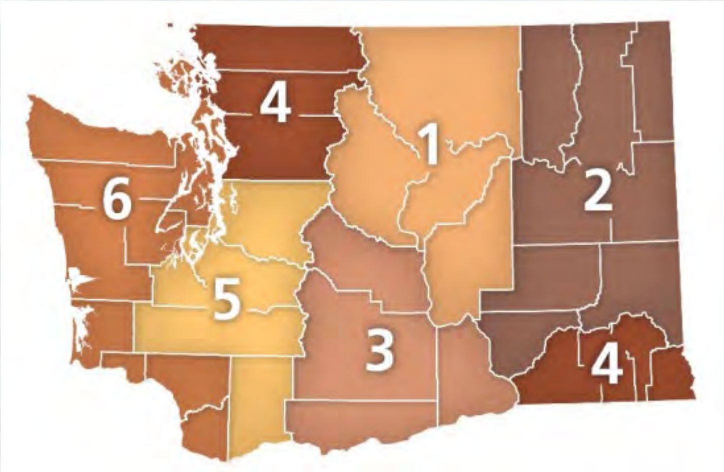
Lidar Refresh Decision Package

- Originally a part of the Puget Sound Action Agenda and Riparian Pathways initiative in 2022
  - Received one year funding to fill in remaining gaps
- Widespread recognition that lidar provides the basis for several current and upcoming state initiatives
  - Including statewide hydrography updates

* Numbers reflect collection regions, not priority

Lidar Refresh Decision Package

- 2023 Legislative cycle: proposed ongoing funding for 10 year collection cycle
  - Streamlines collection in a multi-county, regional approach
  - Balances environmental factors that influence collection
  - Ability to convert plan to 8-year or 6-year plan
- Update: Received one-time funding, start this refresh plan
- Likely try next biennium for on-going funding



3D Nation Study and 3DEP Next Gen

- USGS/NOAA study to document requirements and estimate costs and benefits for National lidar refresh and bathymetry
  - Continuation of 3D Elevation Program
- Study released in September 2022
- Ultimately, some version of a federal program with 4-5 year refresh likely upcoming
- The funding will still rely on state and local partnership

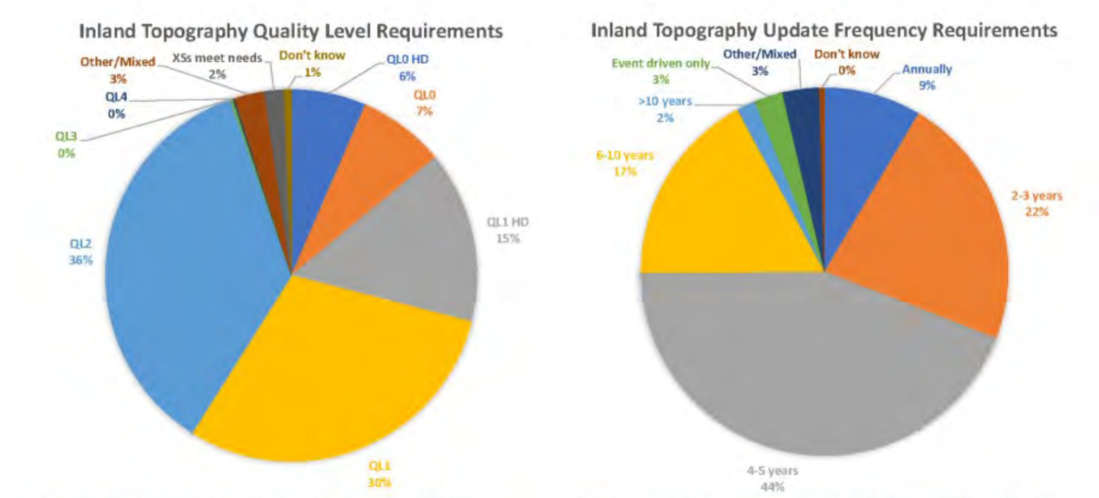


Figure 2. Quality Level requirements for Inland Topography

Figure 3. Update frequency requirements for Inland Topography

* Figure from 3D Nation study

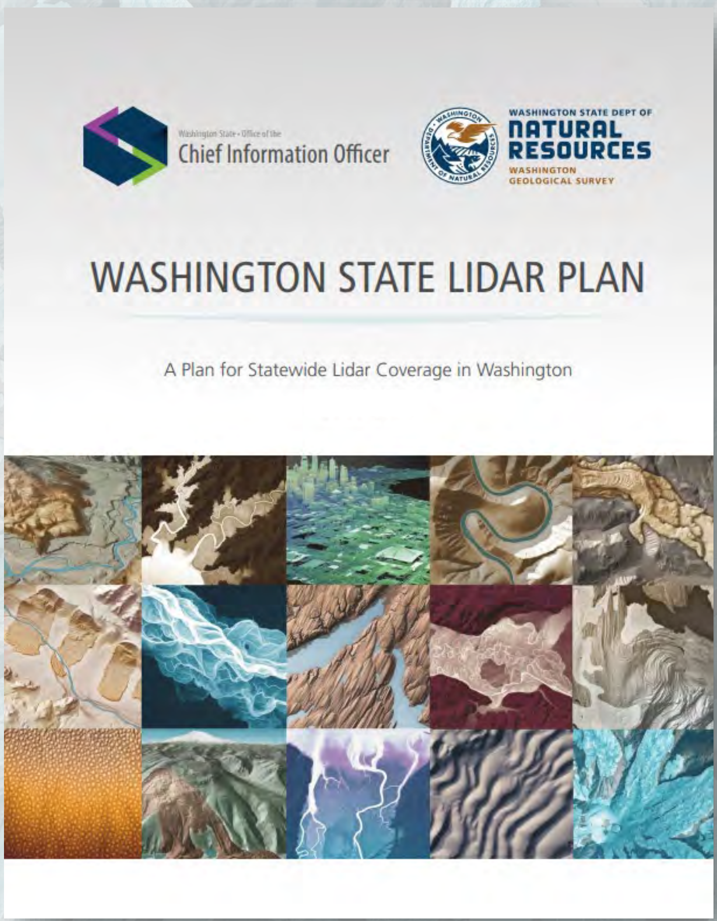
Lidar Program Biannual Meeting

What does this all mean for Washington?

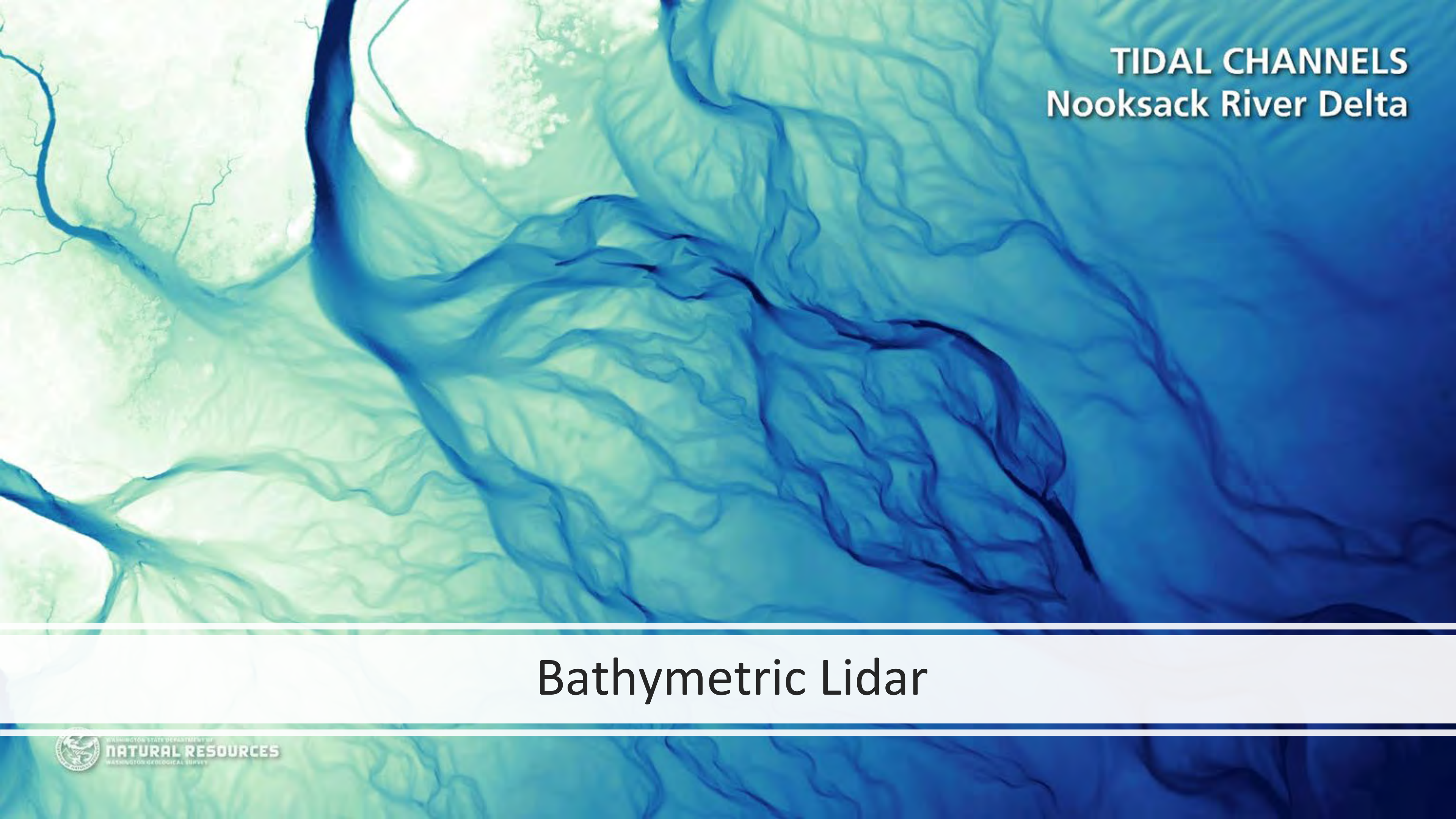
We meet twice a year to figure it out!

- Discuss funding and collaboration
- Collection priorities, update the plan
- Opportunities and new technologies

State, local, tribal, non-profit, federal, public partnership



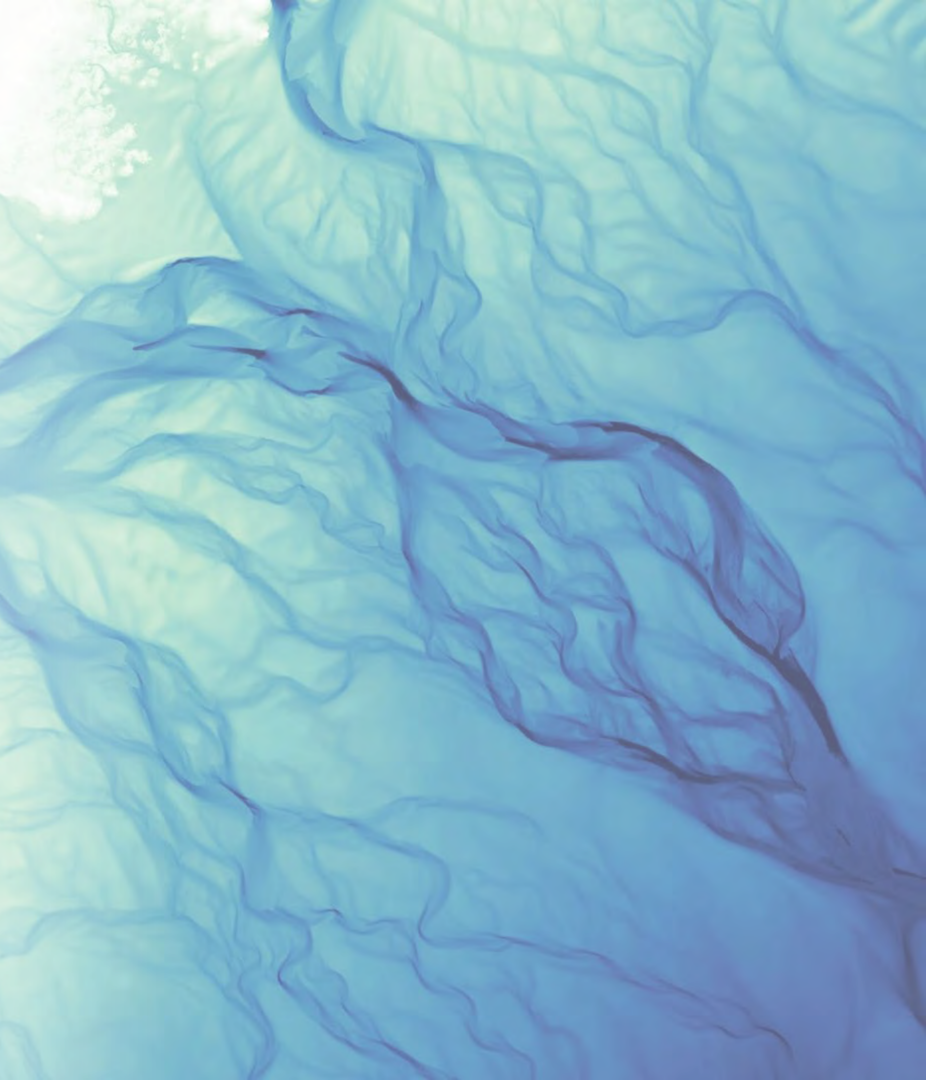
Bathymetric Lidar



NATURAL RESOURCES

Bathymetric Lidar Collection

- Blue/Green wavelength laser
- Penetration depth dependent on flow, turbidity
- Sonar used to supplement deep water
- Planes fly ‘low and slow’ to maximize energy penetration into water column
- Need to be aware of flow rate, runoff events, low tide, glacial sediments…plus regular weather limitations!



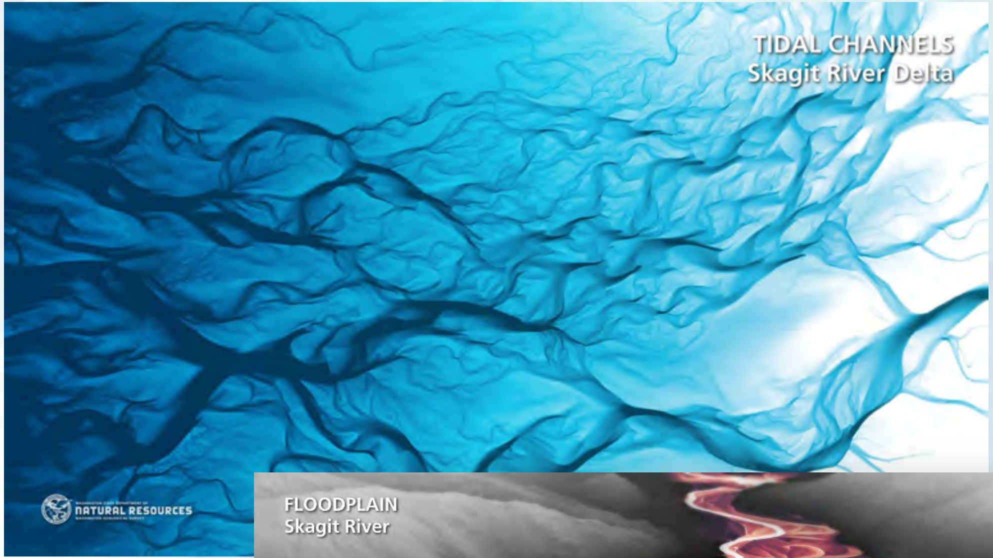
Bathymetric Lidar Applications

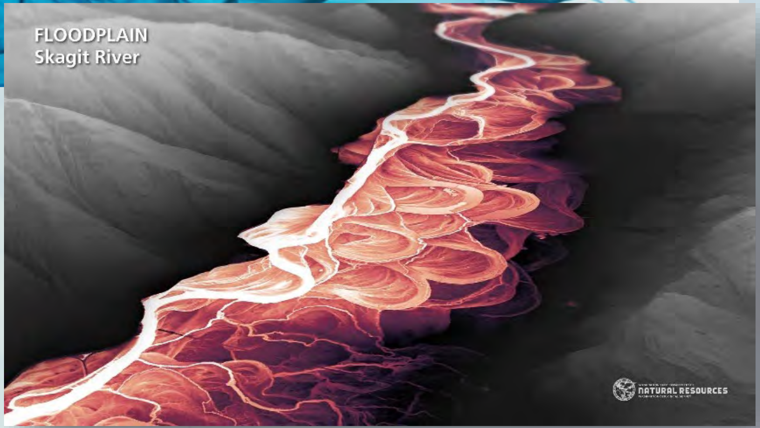
Many applications:

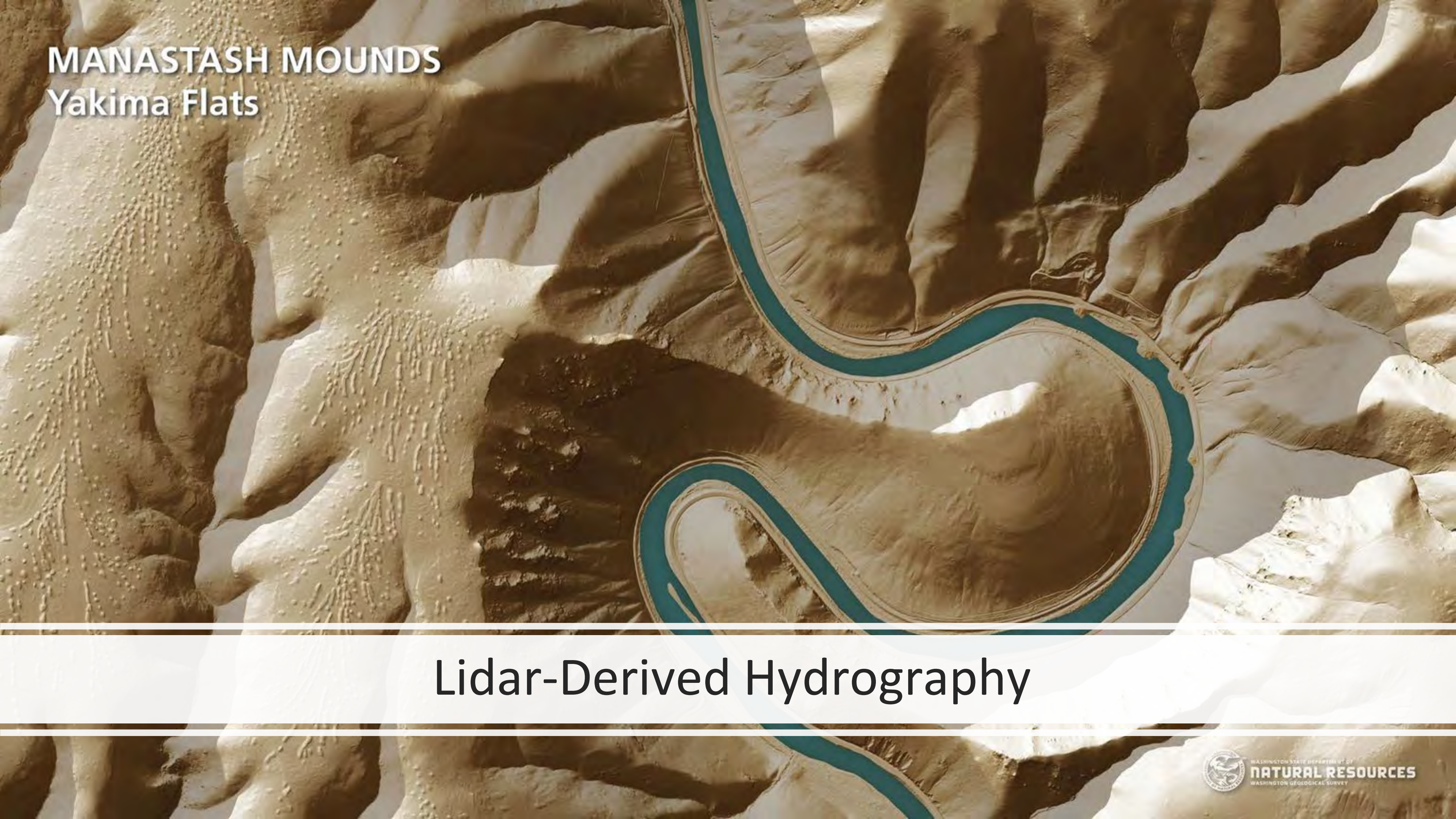
- Flood planning
- Flow modeling
- Channel morphology
- Restoration activities
  - Woody debris placement
  - Environment characteristics
  - Water temperature modeling

Bathymetric Lidar in Washington

- 29 lidar bathymetry projects in archive
- WA DNR contract has worked well for these projects to coordinate with partners
  - Entiat River (2022)
  - Naches River (2022)
  - Nooksack River (2022)
  - Green River (2018)
  - Cowlitz River (2018)
  - Skokomish River (2018)
- Identified as a requirement for USGS





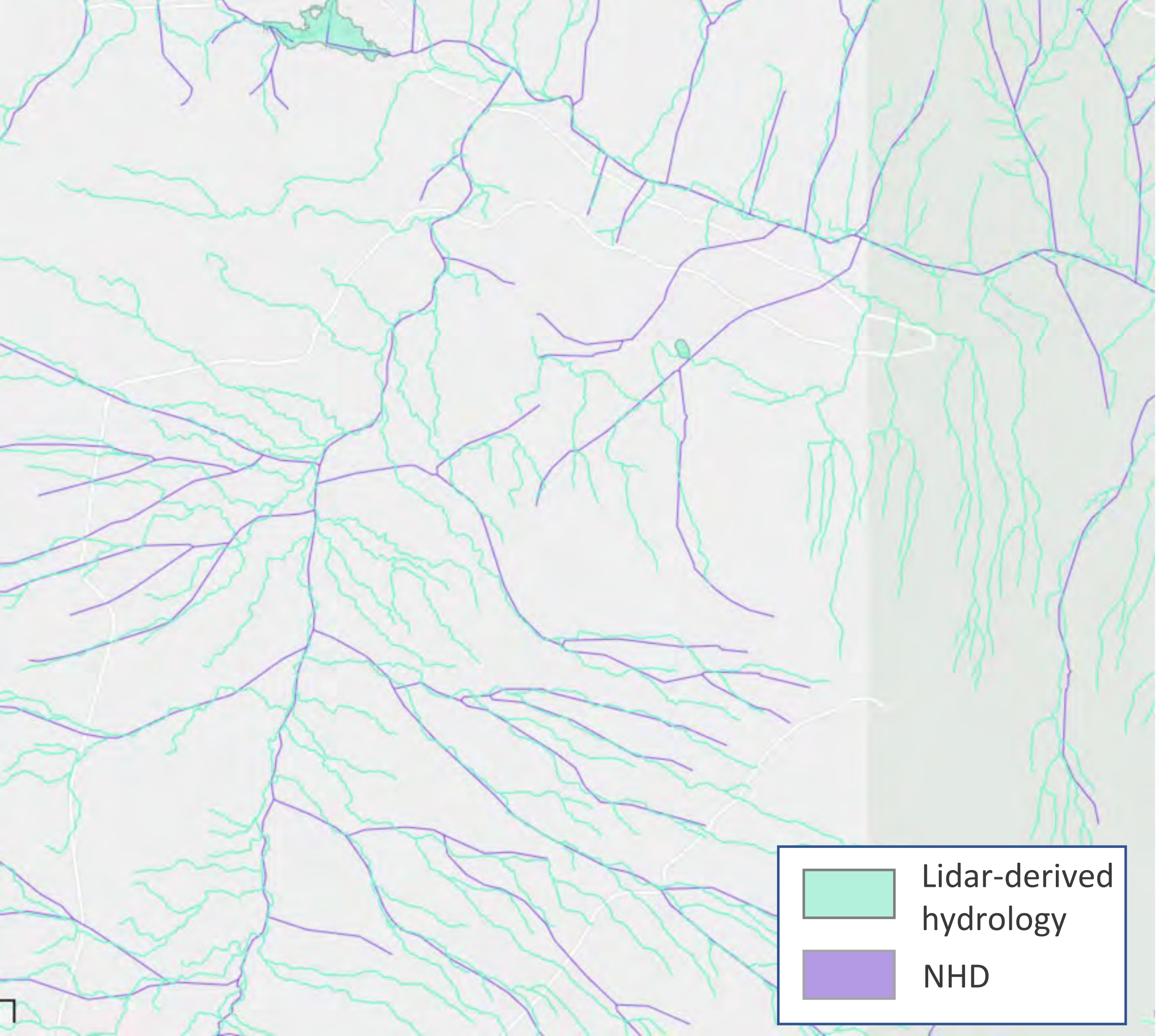


Lidar-Derived Hydrography

WASHINGTON STATE DEPARTMENT OF NATURAL RESOURCES WASHINGTON GEOLOGICAL SURVEY

3D Hydrography Program

- 3DHP - USGS program starting soon!
- Similar to 3D Elevation Program
  - Broad Area Announcement for projects
  - Match model for partners
- Dept. of Ecology has started a pilot to respond to 3DHP



Pilot at Department of Ecology

- Runs through 2023 fiscal year, Stillaguamish Watershed
- Plan for statewide Decision Package FY25
- Plan for contract to allow for broader partnership

Thank you! Questions?

Check out more lidar images and resources at:

- https://www.dnr.wa.gov/lidar
- https://www.flickr.com/photos/wastatednr/
- https://wa100.dnr.wa.gov/