Projecting Effects of Climate Change on River Habitats and Salmonid Fishes:

Integrating Remote Sensing, Genomics, and Demography to Inform Conservation

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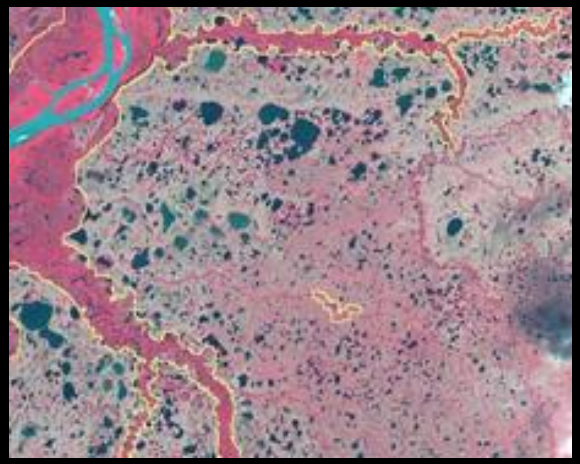
May 2016



UNIVERSITY OF MONTANA Flathead Lake Biological Station

NASA

Partners

With particular thanks to:

- Jen Bayer (PNAMP) and Clint Muhlfeld, USGS
- Jeff Hard and Robin Waples, NOAA
- Nick Gayeski, Wild Fish Conservancy

NASA

Climate Change and Salmonids

Urgent Need

- Recent presidential task force report calls for federal agencies to consider climate change vulnerability in decision-making
- Salmonids are "canaries of climate change"
- Billions $ spent on salmonid conservation; need guidance on the how and the where

Clean, Connected COLD Habitat

Spawning bull trout

Integrating Remote Sensing, Genomics, & Demography

Habitat (Remotely Sensed)

Genomics

Demographics

Abundance

Life History Diversity

Explosion of data

Exciting time for conservation

Capacity

Integrate as key elements of VULNERABILITY

Vulnerability: the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes (IPCC 2001).

Whether a species will be vulnerable to future climate depends on intersection of climate exposure, sensitivity & adaptive capacity.

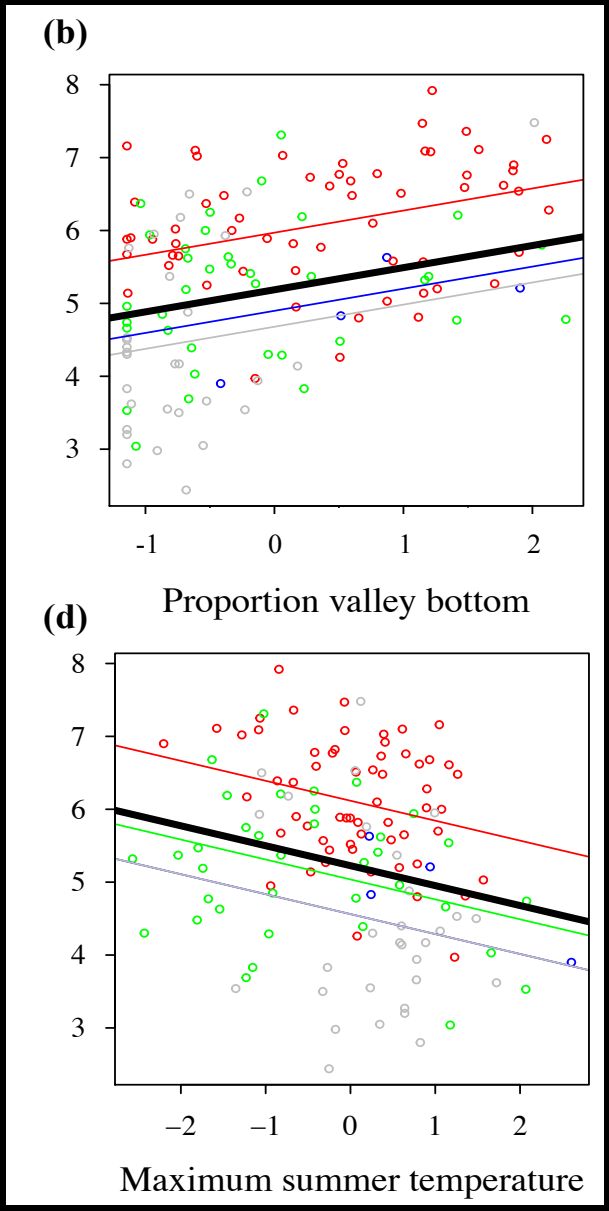
Integrated = Correlated

Kovach et al. 2015
Global Change Biology

New science illustrates **bull trout** genetics correlate with climate & habitat variables

Allelic Richness correlated with:
+ habitat quality & quantity
- summer temperatures & flood frequency

Suggests we can use projections of climate change to predict changes in genetic variation

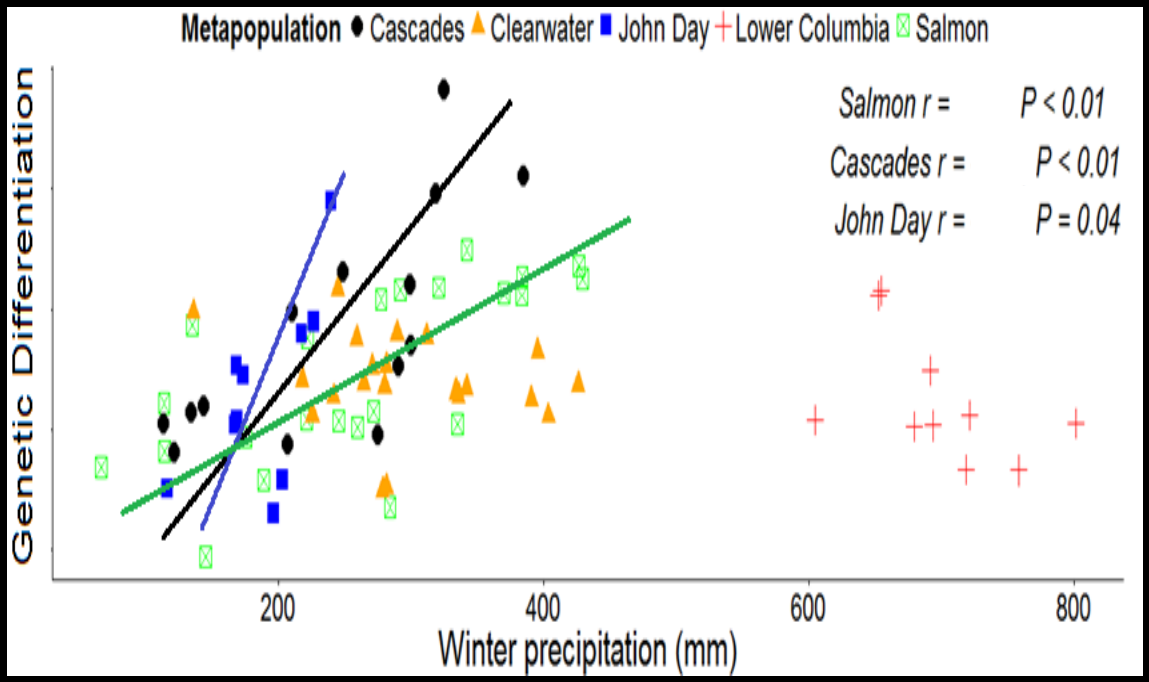


Integrated = Correlated

Hand et al. 2016
Molecular Ecology

New science illustrates **steelhead** genetics correlate with climate variables

Fst correlated with:
- summer temperatures
+ winter precipitation



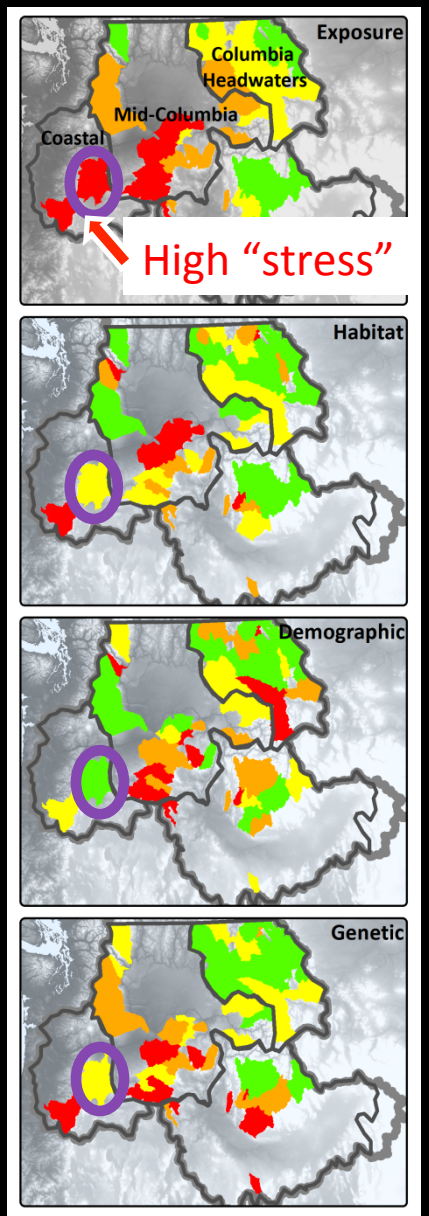
Suggests we can use projections of climate change to predict changes in genetic variation

Integrated = Complex

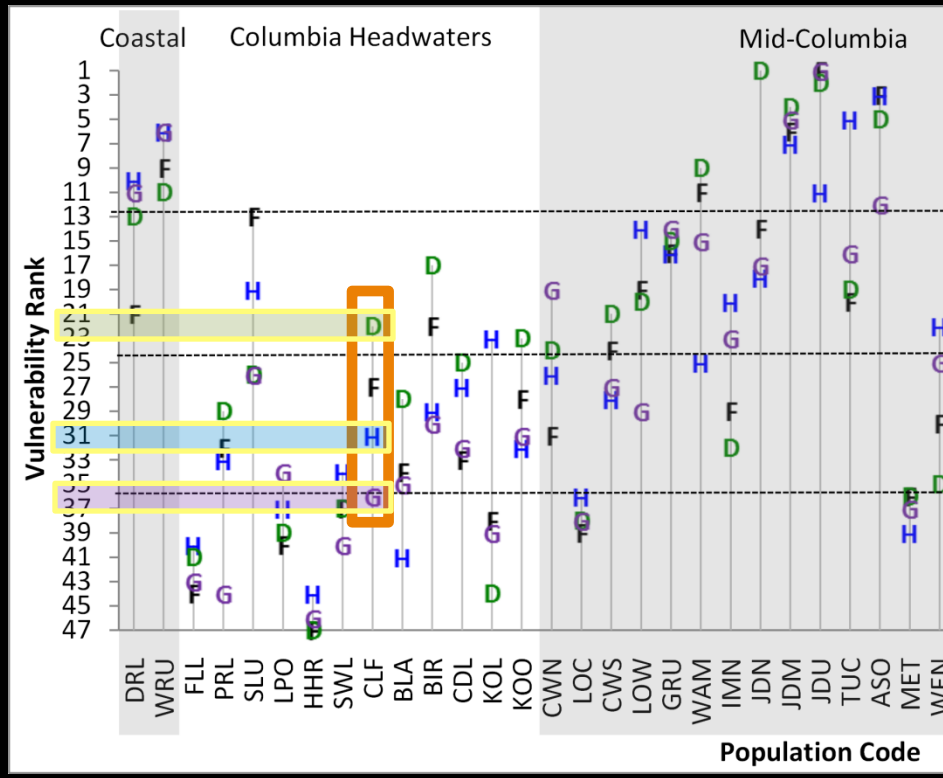
Wade et al. In Review Conservation Biology

New research into how habitat, demography, and genetics interact with climate across populations…

A given population may have very different levels of "stress" depending on stressor type



…and what that may mean for inference from CCVA.

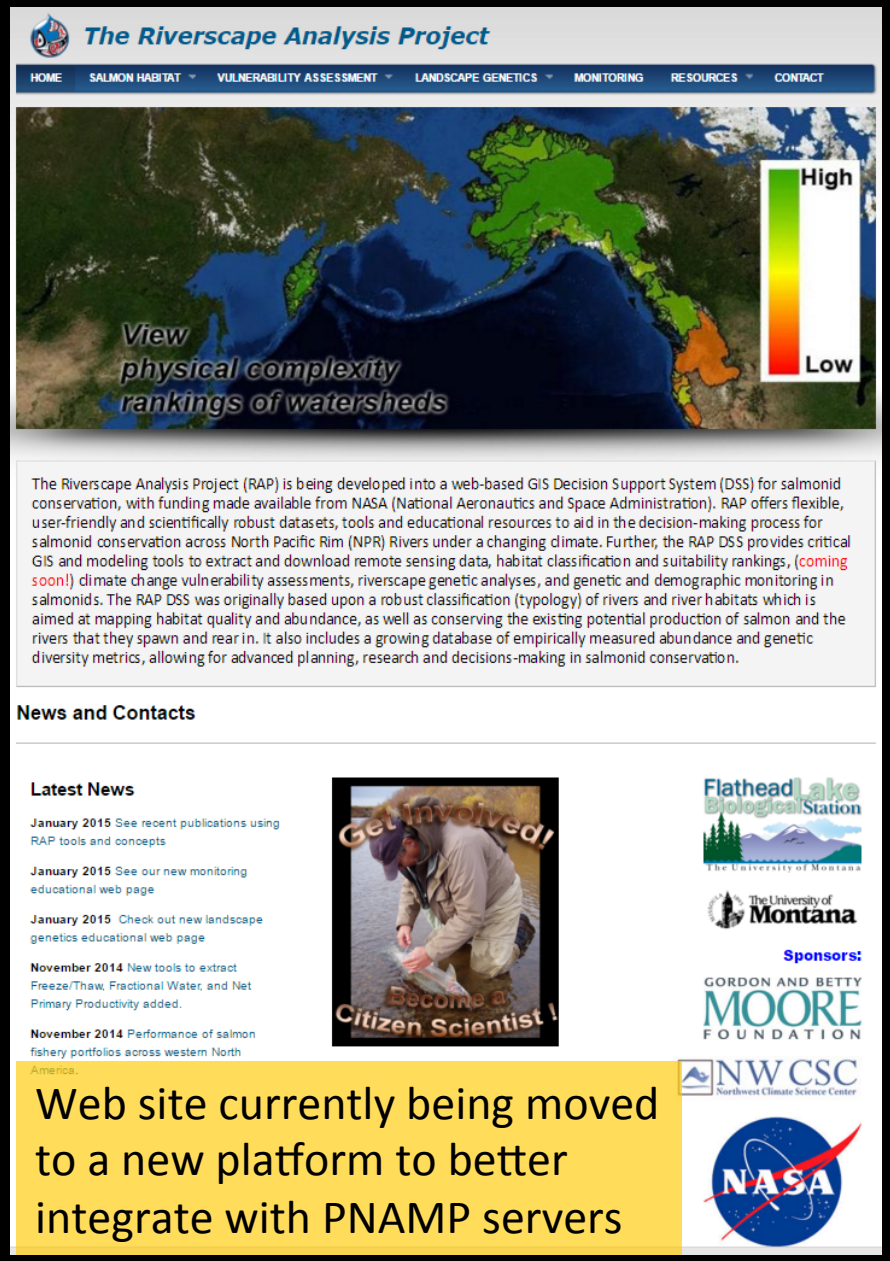


A given population may be considered "relatively vulnerable" solely on the basis of the variables considered

Integrated = Putting it All Together

The Riverscape Analysis Project (RAP)

Web-based DSS for salmonid conservation



Data

- Expanded access to remotely-sensed climate/habitat data
- Crowd-sourcing data

Tools

- CCVA tools
- Landscape genetic tools

Guidance & Examples

- Best practices
- Worked examples

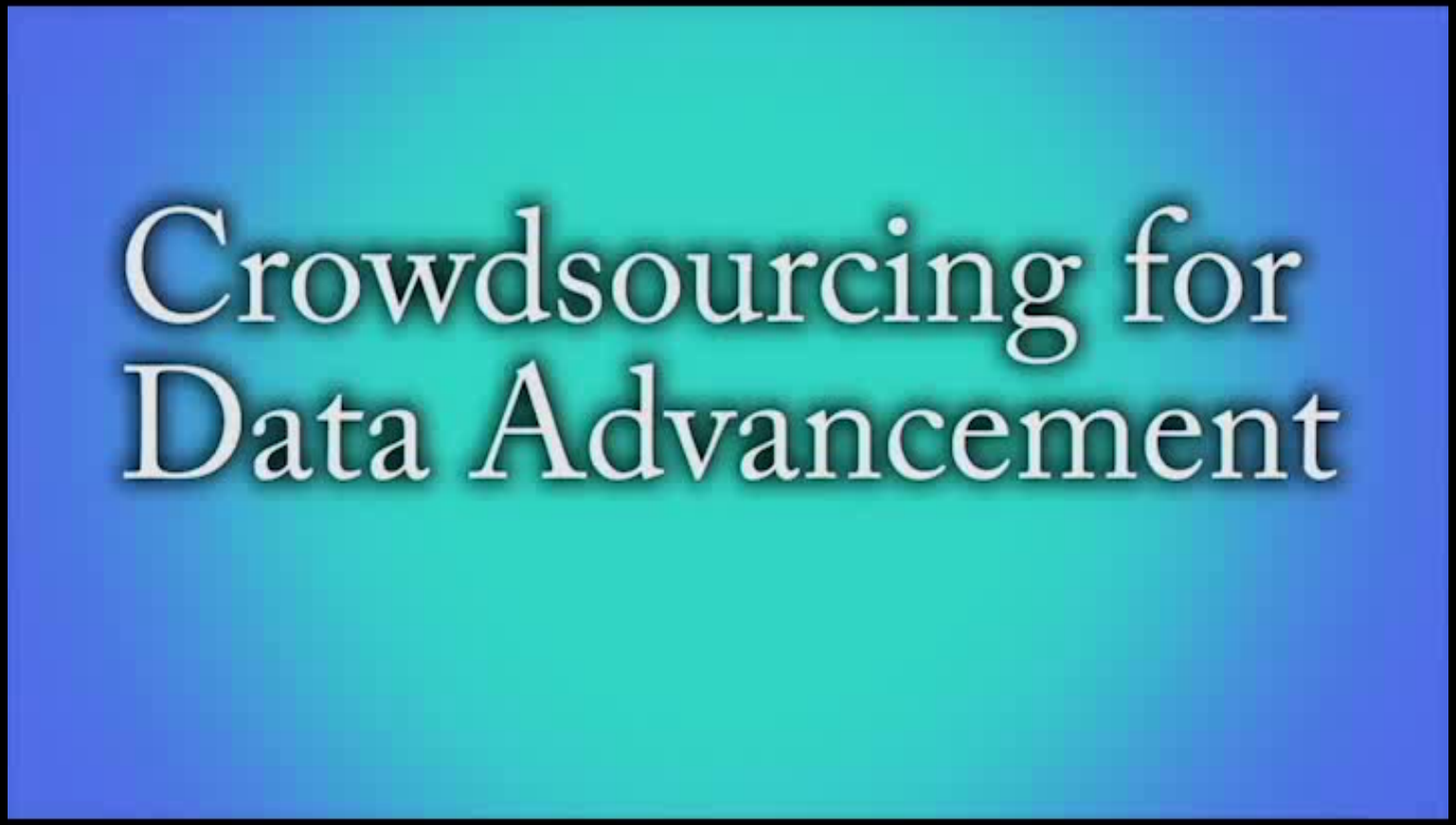
Data: Increased access

One-stop shop for salmonid/aquatic habitat characteristics

Climate Data	RS Mission/ Product
Freeze-Thaw Timing	**NASA SSM/I, AMSR-E, SeaWinds-on-QuickSCAT**
Open Water	**NASA AMSR-E**
Air Temperature, Precipitation, Runoff	**NASA NEX-DCP 30**
NorWeST Stream Temperature	**NASA Landsat TM** & NAIP
USFS Stream Flow	n/a

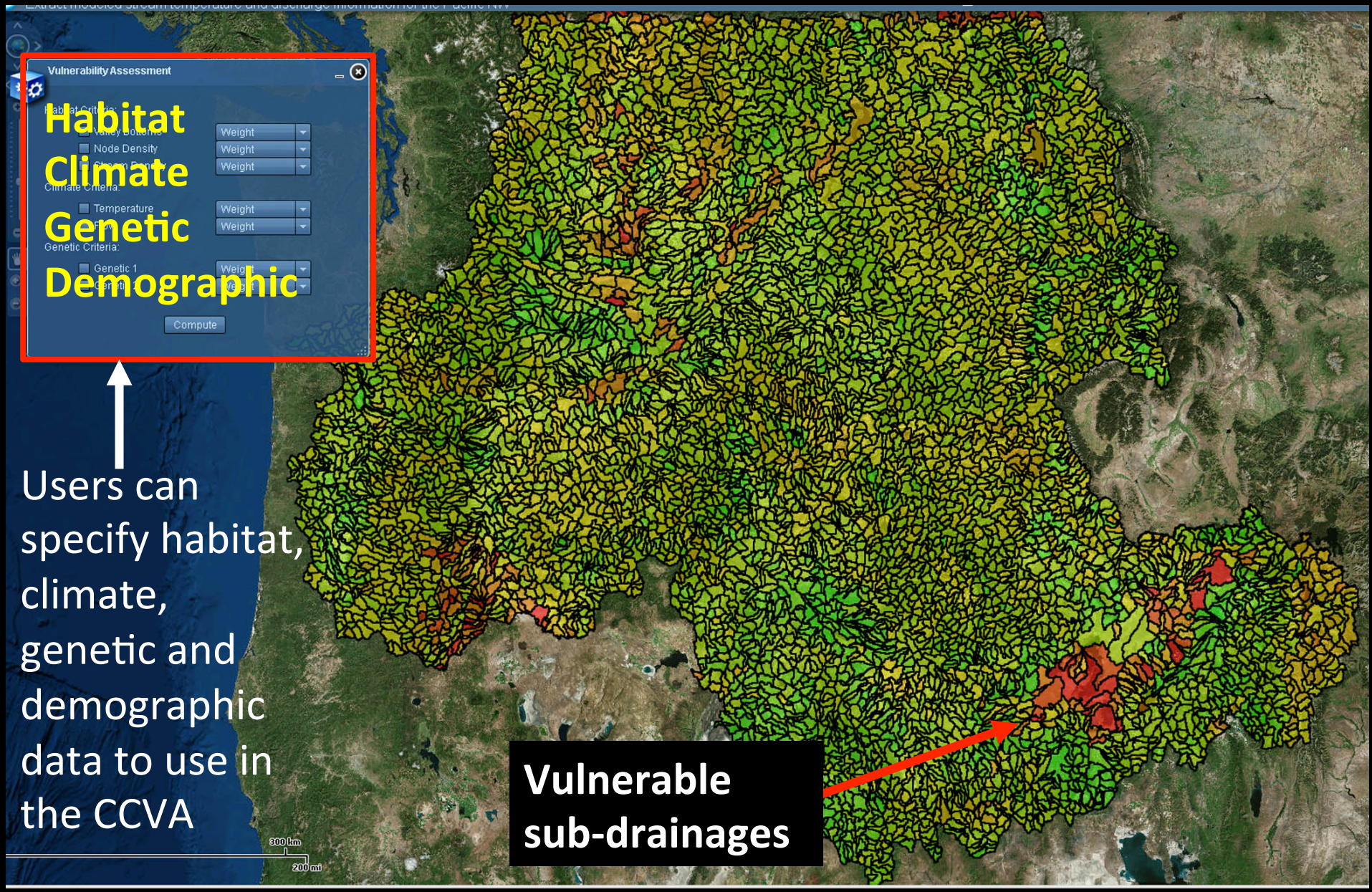
Habitat Data	RS Mission/ Product
Drainage Density, Amount, and Sinuosity	**NASA SRTM** & NHDPlusv2
Floodplain Amount and Nodes (complexity)	**NASA SRTM, Landsat TM, NDVI**
Disturbance: NOAA CHAMP, Human Footprint, and NLCD 2011	**NASA GRUMP, GPWv3, DMSP, Landsat** (NLCD)
Channel and Valley Slope	**NASA SRTM**
Others: Glaciers, Dams, Elevation, Waterbodies	various

Data: Crowd Sourcing



- Network of 7 agencies as data crowd-sourcing partners
- Training biologists and citizens on eDNA sampling for presence/ absence and abundance of native salmonids and invasive aquatic organisms
- Training biologists on DNA fin clipping to minimize effects on fish

Tools: User-Friendly CCVA Tool



Tools: Landscape Genetics Tool

Genetic Tools for Demographic Monitoring

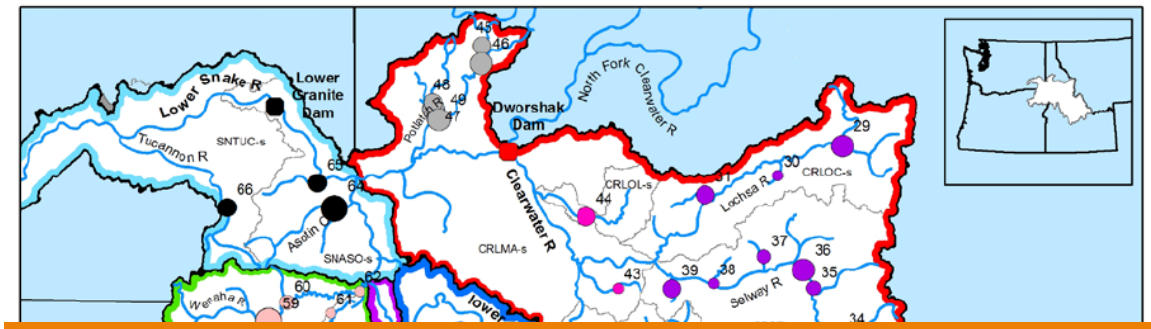
- **Diversity and abundance within**
- **Connectivity between**

1. AgeStructureNe – simulation, power analysis and prediction
2. NbSampler – estimation of Nb and required empirical sample sizes

Tools → Research

Garner et al. in prep.

Impact of environmental factors on the effective number of breeders (Nb) for steelhead trout in the Snake River system



Tools applicable to all species, not just salmon

Allow managers to monitor populations and build predictive models – what is driving vulnerability?

Courtesy of Mike Ackerman and IDFG

Guidance

Worked Examples

Climate change scenarios of steelhead survival in the Puget Sound

Jeff Hard NOAA &
Phil Sandstrom WDFW

- NOAA-developed life cycle model to estimate steelhead abundance
- Two-stages: ocean & **freshwater**
- Freshwater productivity = f(S, α, β)
  - S = number of spawners
  - α = number of recruits per spawner
  - **β = habitat capacity modeled based on "intrinsic potential" of habitat**

β "intrinsic potential" currently on basis of river slope and width

1: Improve β with remotely-sensed data of habitat quality characteristics

2: Compare scenarios of stream temperature change

Best Practices

CCVA Pseudo to Science

Wade et al. in prep

- Improving rigor in species' CCVA
- CCVAs as untested hypotheses
- Accounting for uncertainty
- Methods for validation

Thanks!

Integrating remotely-sensed, demographic, & genomic data

Integrating data, tools, & support for salmon conservation

pacific northwest aquatic monitoring partnership

Columbia River Inter-Tribal Fish Commission

Wild Fish Conservancy NORTHWEST

USGS science for a changing world

Current eDNA sampling sites

Partners

- Clearwater Resource Council
- Flathead Basin Commission
- NPS
- Swan Valley Connections
- USFS
- USGS
- Whitefish Lake Institute