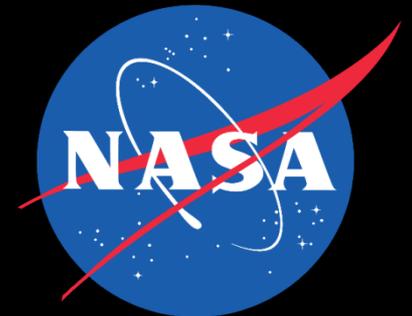
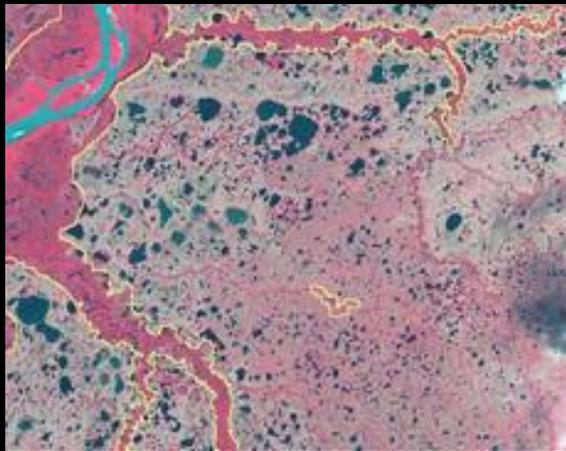


# Projecting Effects of Climate Change on River Habitats and Salmonid Fishes:

Integrating Remote Sensing, Genomics, and Demography  
to Inform Conservation

Alisa Wade, Brian Hand, Brit Garner, Gordon Luikart (PI)

May 2016



# Partners



With particular thanks to:

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



# 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, & Demographics

**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 the intersection of climate exposure, sensitivity & adaptive capacity. Whether a species will be vulnerable to future climate depends on climate variability and extremes (IPCC 2001).

# Integrated = Correlated

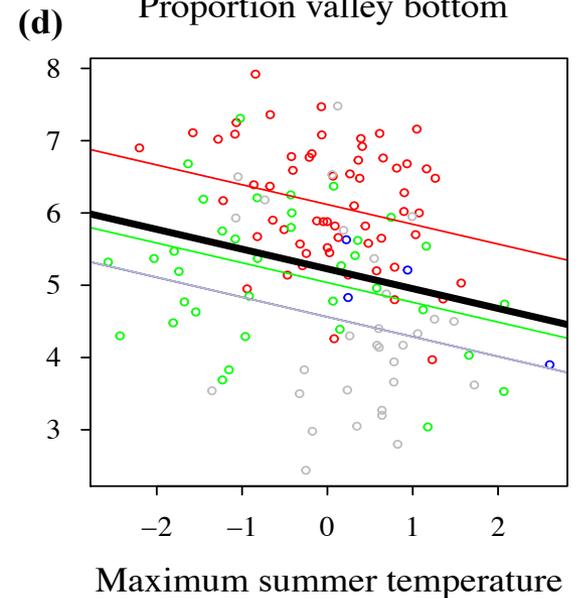
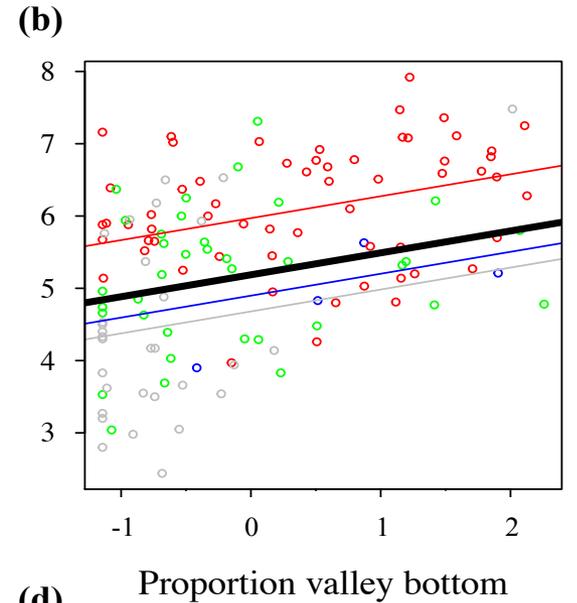
Kovach et al. 2015  
Global Change Biology

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**

Genetic Diversity



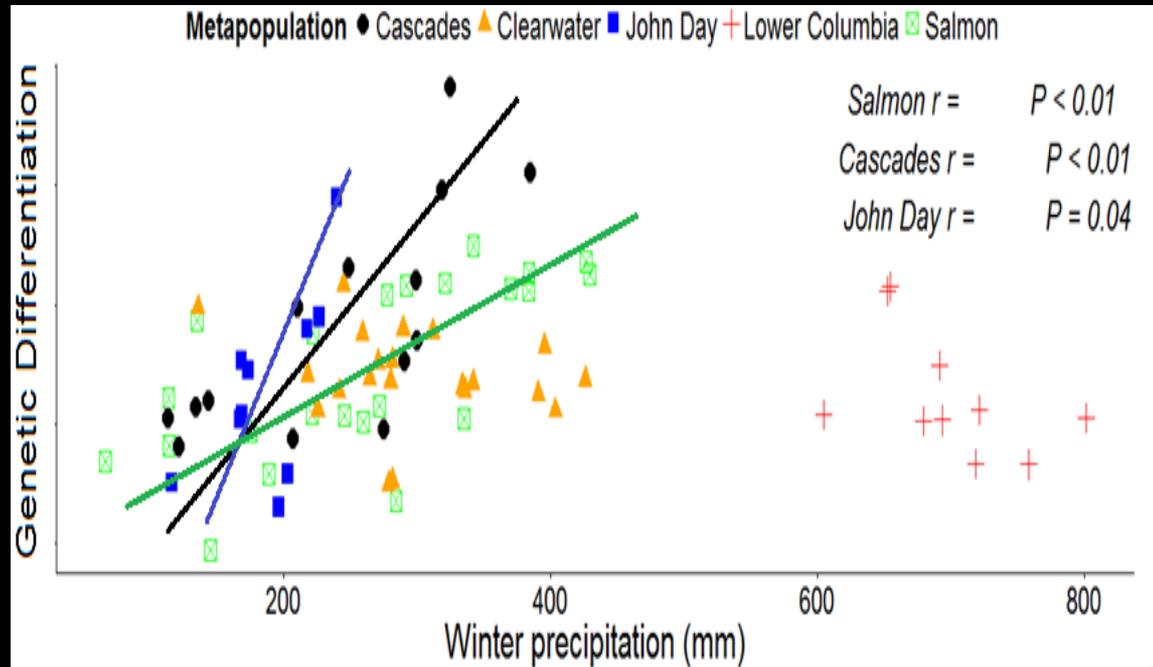
# Integrated = Correlated

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**

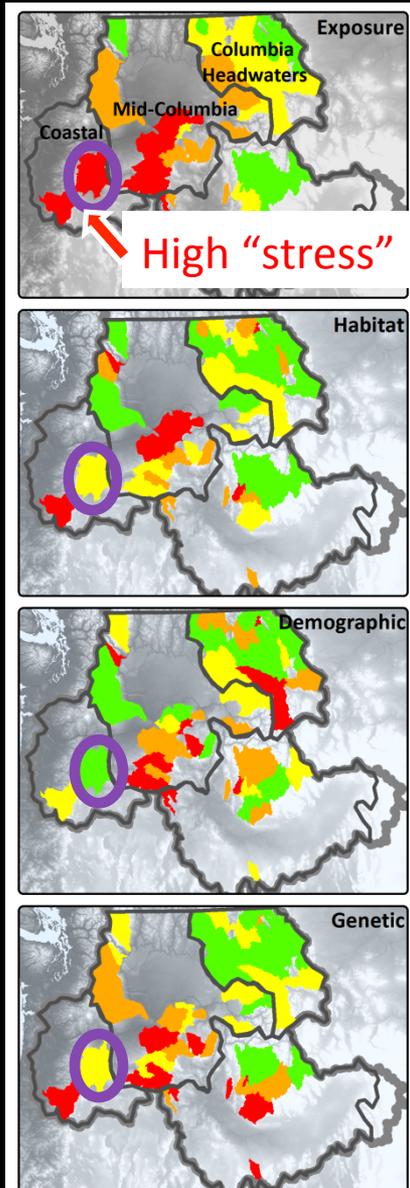


# Integrated = Complex

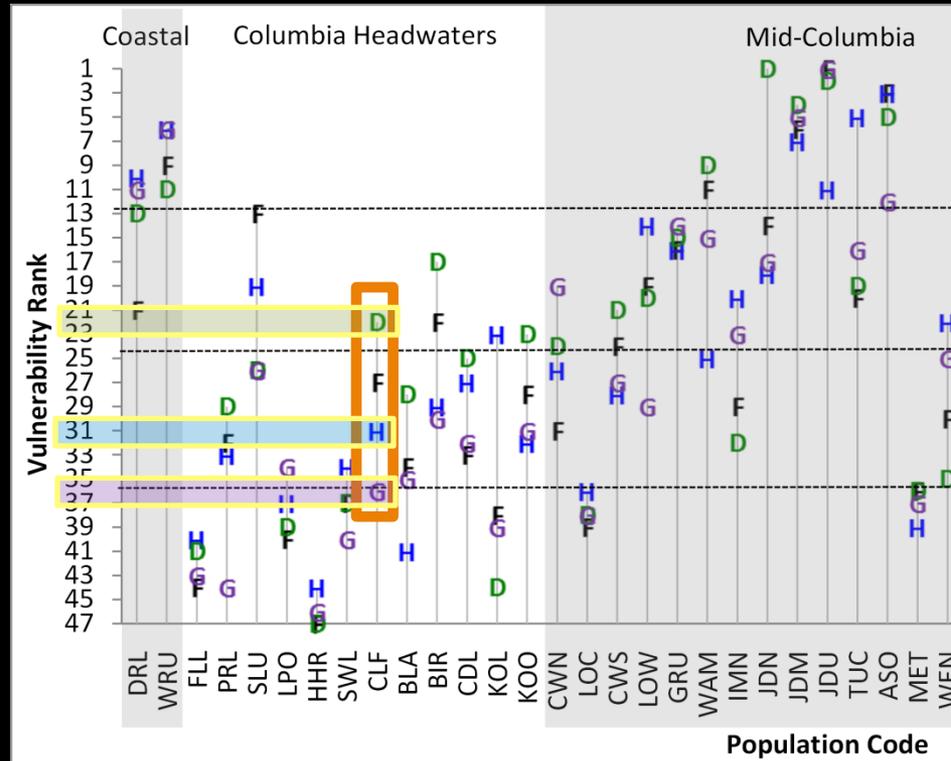
## Wade et al. In Review Conservation Biology

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

**The Riverscape Analysis Project**

HOME SALMON HABITAT VULNERABILITY ASSESSMENT LANDSCAPE GENETICS MONITORING RESOURCES CONTACT

View physical complexity rankings of watersheds

The Riverscape Analysis Project (RAP) is being developed into a web-based GIS Decision Support System (DSS) for salmonid conservation, with funding made available from NASA (National Aeronautics and Space Administration). RAP offers flexible, user-friendly and scientifically robust datasets, tools and educational resources to aid in the decision-making process for salmonid conservation across North Pacific Rim (NPR) Rivers under a changing climate. Further, the RAP DSS provides critical GIS and modeling tools to extract and download remote sensing data, habitat classification and suitability rankings, (coming soon!) climate change vulnerability assessments, riverscape genetic analyses, and genetic and demographic monitoring in salmonids. The RAP DSS was originally based upon a robust classification (typology) of rivers and river habitats which is aimed at mapping habitat quality and abundance, as well as conserving the existing potential production of salmon and the rivers that they spawn and rear in. It also includes a growing database of empirically measured abundance and genetic diversity metrics, allowing for advanced planning, research and decisions-making in salmonid conservation.

**News and Contacts**

**Latest News**

January 2015 See recent publications using RAP tools and concepts

January 2015 See our new monitoring educational web page

January 2015 Check out new landscape genetics educational web page

November 2014 New tools to extract Freeze/Thaw, Fractional Water, and Net Primary Productivity added.

November 2014 Performance of salmon fishery portfolios across western North America.

**Get Involved!**

**Become a Citizen Scientist!**

**Sponsors:**

Flathead Lake Biological Station  
The University of Montana  
GORDON AND BETTY MOORE FOUNDATION  
NW CSC  
Northwest Climate Science Center  
NASA

Web site currently being moved to a new platform to better integrate with PNAMP servers

# Data: Increased access

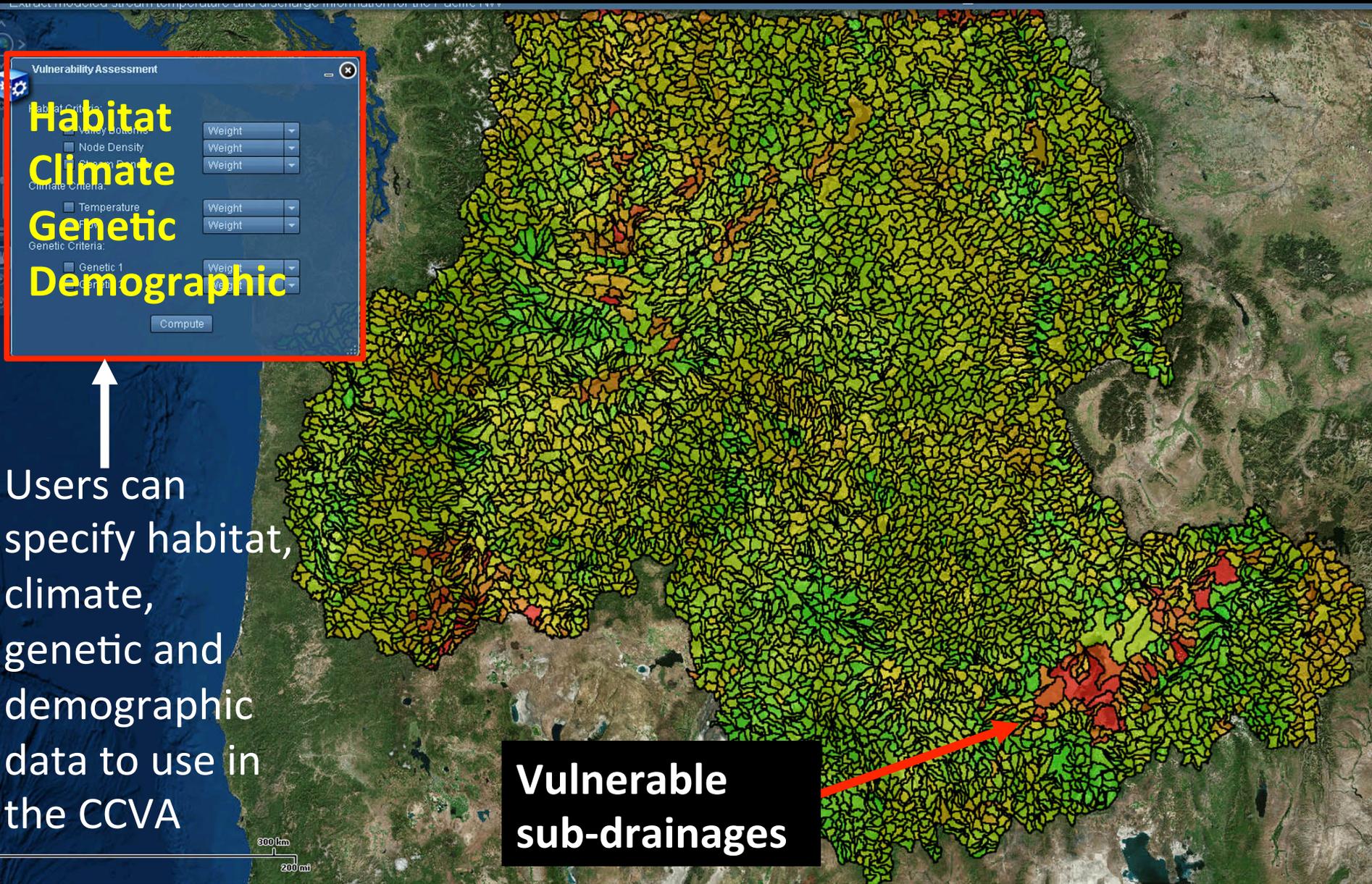
## One-stop shop for salmonid/aquatic habitat characteristics

Climate Data	RS Mission/Product	Habitat Data	RS Mission/Product
Freeze-Thaw Timing	NASA SSM/I, AMSR-E, SeaWinds-on-QuickSCAT	Drainage Density, Amount, and Sinuosity	NASA SRTM & NHDPlusv2
Open Water	NASA AMSR-E	Floodplain Amount and Nodes (complexity)	NASA SRTM, Landsat TM, NDVI
Air Temperature, Precipitation, Runoff	NASA NEX-DCP 30	Disturbance: NOAA CHAMP, Human Footprint, and NLCD 2011	NASA GRUMP, GPWv3, DMSP, Landsat (NLCD)
NorWeST Stream Temperature	NASA Landsat TM & NAIP	Channel and Valley Slope	NASA SRTM
USFS Stream Flow	n/a	Others: Glaciers, Dams, Elevation, Waterbodies	various

# Crowdsourcing for Data Advancement

- 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



**Habitat**  
Habitat Criteria:  
 Valley Bottoms Weight  
 Node Density Weight  
 Stream Power Weight

**Climate**  
Climate Criteria:  
 Temperature Weight

**Genetic**  
Genetic Criteria:  
 Genetic 1 Weight  
 Genetic 2 Weight

Compute

Users can specify habitat, climate, genetic and demographic data to use in the CCVA

**Vulnerable sub-drainages**

800 km  
200 mi

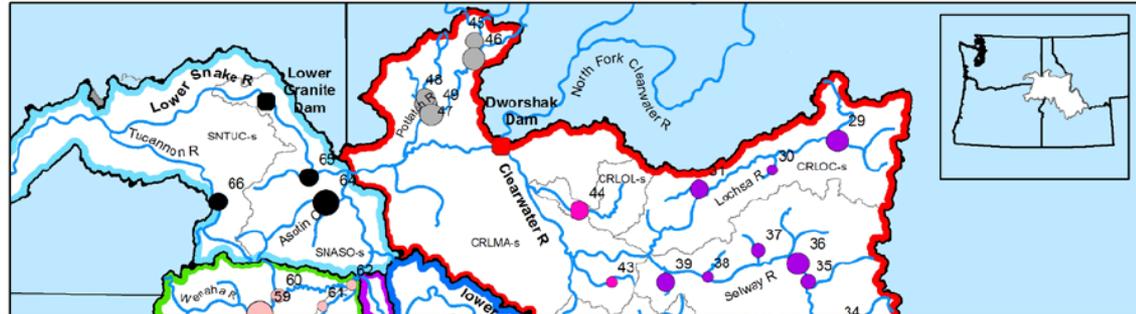
# Tools: Landscape Genetics Tool

## 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** =  $f(S, \alpha, \beta)$ 
  - S = number of spawners
  - $\alpha$  = number of recruits per spawner
  - $\beta$  = **habitat capacity modeled based on “intrinsic potential” of habitat**

$\beta$  “intrinsic potential” currently on basis of river slope and width

1: Improve  $\beta$  with remotely-sensed data of habitat quality characteristics

2: Compare scenarios of stream temperature change

## Best Practices

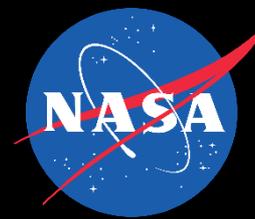
### CCVA Pseudo to Science

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



# Current eDNA sampling sites

## Partners

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

