The Salmonid Population Viability Project

Seth Wenger, University of Georgia
Motivation:
How do we allocate scarce resources for species that occur in multiple isolated populations?
Remote sensing enables borrowing from data rich populations for inferences in data poor populations.

- **New population viability modeling framework** combines remote sensing with field surveys to estimate extinction risks for populations range-wide (including those without biological data).
- **Web tool** for managers to assess extinction risks under future climate and management scenarios: [http://trout.shinyapps.io/lahontan](http://trout.shinyapps.io/lahontan)
- **Decision making support** using all available data
- **Added value** to existing biological datasets

### Spatio-temporal biodata

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**Federally-threatened Lahontan cutthroat trout**

**State & federal imperiled population monitoring**

**Spatio-temporal geodata** (long-term & large-scale) essential for **Stream habitat models**

- Temperature (NorWeST)
- Hydrology (NLDAS/VIC)

**Salmonid Population Viability Project**

Remote sensing enables borrowing from data rich populations for inferences in data poor populations.
Lahontan Cutthroat Trout
(Oncorhynchus clarkii henshawi)

FEDERALLY THREATENED SUB-SPECIES
Lahontan Cutthroat Trout Database
What’s in the Lahontan cutthroat trout database...

- 1985 – 2015 (30 years)
- 232 populations
  - 155 populations with data
  - 69 FWS conservation pops
- 1,806 sampling sites
- 3,980 sampling events
- 196 miles of electrofishing
- 23,499 individual TROUT
- 15,265 individual LCT (Age 1+)
Ruby Mountains, NV
Willow-Whitehorse, OR
Quinn and Little Humboldt, NV drainages
Environmental covariates => Demographics
Normalized Difference Vegetation Index (NDVI)

Landsat, 1985-present

Active photosynthesis and vegetation

1992 – Dry year

2011 – Wet year
NDVI: Population x Year

Dry year

Wet year
Stream Temperature

- Annual estimates of mean August stream temperature for every 1km stream segment
- Derived from weather stations, GIS layers, and remote sensing (AVHRR, Landsat, MODIS, NAIP)
Stream hydrology
Annual high flow (NLDAS)

Climate and Dynamics

The multi-institution North American Land Data Assimilation System (NLDAS): Utilizing multiple GCIP products and partners in a continental distributed hydrological modeling system

1. Estimate extinction risks
2. Use ALL available data (all populations/years in one model)
3. Spatio-temporal covariates (remote sensing & GIS)
4. Forecasting and spatial extrapolation
5. Account for key sources of uncertainty
   • Demographic stochasticity
   • Observation error
   • Sampling error
MPVA: A hierarchical Bayesian model

Observation Model

Site abundance = observed + unobserved animals

Sampling Model

Total population = sampled + unsampled habitat

Process Model

Population change = births - deaths

Population change a function of environmental covariates
Lahontan Cutthroat Trout Population Simulator

Population:

Forecast year:

Future Conditions

Population extent (km):

Non-native trout:
- Use historic densities
- Set a constant density (slider below)

Stream habitat:
- Temperature
- High flow

Detection

Data

Help

About

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Last Update: Tue Apr 25 10:24 54 2017
“I am thrilled with the outputs and their applicability to real time decision making”

“The results have exceeded my expectations”

--Lee Ann Carranza
U.S. Fish & Wildlife Service
“The prospect of using this to make better informed decisions about where to focus restoration and reintroduction efforts is truly game-changing.”

“I can honestly say that in my more than 15 years now with Trout Unlimited that was the most exciting and potentially important presentation I’ve ever heard.”

-- Chris Wood, CEO Trout Unlimited
Bonneville Cutthroat Database

- 1980 – 2016
- 229 Populations (132 pops have data)
  - 207 Conservation Populations
  - 22 Other Populations
- 927 Sample Sites
- 1,763 Sampling Events
- 95,170 Individual Fish
Bonneville Cutthroat Trout Population Simulator (v0.1 beta) **PRELIMINARY RESULTS WITH KNOWN ERRORS**

Population:
BearWF

Forecast year:
3200
2015

Future Conditions

Change in population extent (km):

Non-native trout:
- Use historic densities
- Set a constant density (slider below)

Demographic stochasticity:

Stream Habitat:
Sliders define the range of historical values used for forecasting

Last Update: Sun Nov 12 22 58 22 2017 (Version 0.1 beta)
Bonneville Cutthroat Trout Population Simulator (v0.1 beta) **PRELIMINARY RESULTS WITH KNOWN ERRORS**

Population:
BearWF

Forecast year:
2020 2025

Future Conditions
Change in population extent (km):

Non-native trout:
- Use historic densities
- Set a constant density (slider below)

Demographic stochasticity:
- 0.51

Stream Habitat:
Sliders define the range of historical values used for forecasting

Last Update: Sun Nov 12 22:58:22 2017 (Version 0.1 beta)
Bonneville Cutthroat Trout Population Simulator (v0.1 beta) **PRELIMINARY RESULTS WITH KNOWN ERRORS**

Population: BearWF

Forecast year: 2020

Future Conditions

Change in population extent (km):

Non-native trout:
- Use historic densities
- Set a constant density (slider below)

Demographic stochasticity:
- (slider)

Stream Habitat:
- Sliders define the range of historical values used for forecasting

Population: BearWF
Extinction Risk: 0.8% (0.4 - 1.4%)

Growth Potential (%)

Water Temperature (°C)

High Flow (m³/h)

LCT Carrying Capacity (fish / km)

Non-native Trout (fish / km)

Riparian Vegetation (NDVI)

Last Update: Sun Nov 12 22:22 2017 (Version 0.1 beta)
Covariates for Bonnevilles

Field-based
• Population-level habitat condition
• Detection covariates

Time static
• Road density
• Coverage of surficial geology (water chemistry; e.g. Olson et al.)

*Annual measurements*
• NDVI
  • Separate effects by elevation threshold
  • Proportion above threshold (i.e. coverage of forest)
• Proportion below temperature threshold (i.e. thermal refugia)
• Night-time lights (yearly index of human impact)
Potential issues

- Non-isolated populations
- Adfluvial populations
- Reconnect scenarios
- Lakes as movement corridors
Collaborators

River Basin Center, University of Georgia
    Seth Wenger, Doug Leasure

Trout Unlimited, Boise, ID
    Helen Neville, Dan Dauwalter, Robin Bjork,
    Kurt Fessenmyer, Jean Barney

USGS Aquatic Sciences Lab, Corvallis, OR
    Jason Dunham, Nate Chelgren

University of Nevada—Reno
    Mary Peacock

Rocky Mountain Research Station
    Charlie Luce, Abby Lute

University of Montana
    Erin Landguth

Supported by (thank you):

Lahontan Cutthroat Trout Population Simulator
trout.shinyapps.io/lahontan