Tools & Databases for Understanding & Predicting Local Effects of Climate Change on Anadromous Fishes & Habitats in the Columbia Basin

Dan Isaak, US Forest Service Research
There’s a Lot on the Line...

2014 & 2015 Set New Records

Tribal & Recreational Fisheries

Land Use & Water Development

ESA Listed Species
Many Things Can be Done to Improve Habitat & Population Resilience

- Maintaining/restoring flow...
- Maintaining/restoring riparian...
- Restoring channel form/function...
- Prescribed burns limit wildfire risks...
- Non-native species control...
- Improve/impede fish passage...

a) Where to do them?
b) Is there a grand strategy?
c) How to maximize bang for the
Need: High-Resolution Stream Scenarios

Global climate models
Resolution: 1000s of kilometers

Regional patterns
Resolution: 10s kilometers

River network temperature & flow

Stream reach

VIC

NorWeST Stream Temp

NorWeST
Precise Information Across Broad Scales

Rangewide

See both the Forest AND the Trees!

Local

Habitat quality

- > 0.90
- > 0.75 to < 0.90
- > 0.50 to < 0.75
- > 0.25 to < 0.50
- < 0.25

Slope = 10% to 15%
Precise Information Across Broad Scales
Empowers Local Decision Makers & Agency Planning

Habitat quality

Highest priority investment!
A Wetter or Drier Future?

Forecasts are uncertain...
BUT... Summer Low Flows Have Been Decreasing for Decades (1948-2006)

VIC Hydrologic Model - All Stream Reaches

Ecologically Relevant Flow Metrics
- Summer flow
- Mean flow
- Winter flood frequency
- Median flow date


Website: Western U.S. Streamflow Metrics

- ArcGIS shapefiles
- A1B climate scenarios

Reach-scale resolution

Google “Stream flow Metrics” or go here...

Temperature is Destiny for Cold-Blooded Stream Critters

Temperature

Stream Temperature (°C)

Time

TMDL limit

Too Hot!

Growth

Temperature

Too Hot!

Sympathy

bull = 0.0085T - 0.0004T² - 0.0121, r² = 0.87
brook = 0.0125T - 0.0004T² - 0.0238, r² = 0.64

Graph showing stream temperature over time with a TMDL limit set at 14°C.
Huge Amounts of Stream Temperature Monitoring...

>200,000,000 hourly records
>20,000 unique stream sites

>100 agencies

NorWeST Stream Temp
### Covariate Predictors

1. Elevation (m)
2. Canopy (%)
3. Stream slope (%)
4. Ave Precipitation (mm)
5. Latitude (km)
6. Lakes upstream (%)
7. Baseflow Index
8. Watershed size (km$^2$)
9. Glacier (%)
10. Discharge (m$^3$/s)
11. Air Temperature (°C)

**USGS gage data**
**RegCM3 NCEP reanalysis**
**Hostetler et al. 2011**

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### Mean August Temperature

**Non-spatial Model**
- $r^2 = 0.90; \text{RMSPE} = 1.0$°C

**Spatial Model**
- $r^2 = 0.60; \text{RMSE} = 2.26$°C

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*Ecological Applications* 20:1350-1370.
High-Resolution Stream & River Scenarios

1-km resolution
1,000,000 stream kilometers
# 30 NorWeST Climate Scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1_93_11</td>
<td>Historical scenario representing 19 year average August mean stream temperatures for 1993-2011</td>
</tr>
<tr>
<td>S2_02_11</td>
<td>Historical scenario representing 10 year average August mean stream temperatures for 2002-2011</td>
</tr>
<tr>
<td>S3_1993</td>
<td>Historical scenario representing August mean stream temperatures for 1993</td>
</tr>
<tr>
<td>S4_1994</td>
<td>Historical scenario representing August mean stream temperatures for 1994</td>
</tr>
<tr>
<td>Etc…</td>
<td></td>
</tr>
<tr>
<td>S23-33</td>
<td>10 Future scenarios…</td>
</tr>
</tbody>
</table>

*Extensive metadata on website*
Future Increases Relative to 2000s Baseline

CIG 10 GCM ensemble for A1B trajectory

*Variation within basins +/-50% from sensitivity adjustment
Website: Temperature Scenarios & Data in User-Friendly Formats

1) GIS shapefiles of stream temperature scenarios

2) GIS shapefiles of stream temperature model prediction precision

3) Temperature data summaries

Google “NorWeST” or go here...

http://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST.shtml
Websurf from your Desktop

☆ Dynamic Online Map Viewer
Temperature Applications

- Coordinated Interagency monitoring
- Species distribution models & climate assessments
- Regulatory temperature standards
- Data access accelerates temperature R&D

Too Hot! Too cold!
Summer River Temp Trends (1968-2011)
245 sites with >10 year monitoring records

+0.11°C/decade

Species Distribution Models for Native Trout Climate Refugia

Trout Unlimited: Water Transactions Tool

Kurt Fesenmeyer & Sean McFall

Dynamic queries of bull trout & cutthroat refuge habitats

https://public.tableau.com/profile/sean.mcfall#!/vizhome/ClimateShieldIdaho/Story1
Trout Unlimited: Water Transactions Tool

Kurt Fesenmeyer & Sean McFall

Idaho Dept. of Water Resources – Water Rights & Diversion Database

Habitat quality

Climate-smart microtargeting of water rights acquisition or fish screening
NorWeST Temperature & Prespawn Mortality in Salmon

Bowerman, Keefer, & Caudill (U. Idaho)
NorWeST Temperature & Prespawn Mortality in Salmon

Proportion PSM

NorWeST predicted mean Aug Temp °C

- Willamette
- MidCol
- Snake
- Clearwater
- Salmon
NorWeST Temperature & Prespawn Mortality in Salmon
NorWeST Temperature & Salmon Hatchery Straying Rates 1993-2011

Environmental Predictors

E.T. Go Home
Not in Hot Years

Inter-Agency Monitoring Coordination
Data Acquisition Rate is Overwhelming

>3,000 annual sites in Pacific Northwest
>200 new sites last year

~30,000,000 hourly records every year!

How to Capture These Data?
Additional Significant Uses

- EPA/OR-DEQ salmon climate refuge project in PNW
- NorWeST north of the border – Canadians replicating in BC & NWT
- USFWS bull trout recovery plan
- FS Climate Adaptation Partnerships (BMAP, NRAP, SCOAP, SWAP, IAP...)
- FS Forest Plan revisions (~80 national forests)
- NOAA Pacific Coast salmon climate vulnerability assessment
Key Points...

- Warming likely to continue for decades
- Summer low flows likely to trend lower
- Precise information about when & where climate factors cause significant stress for anadromous fishes is needed for planning

- Response options include:
  a) habitat restoration,
  b) assisted evolution & migration,
  c) decrease stocking densities,
  d) do nothing

- Strategic prioritization is required