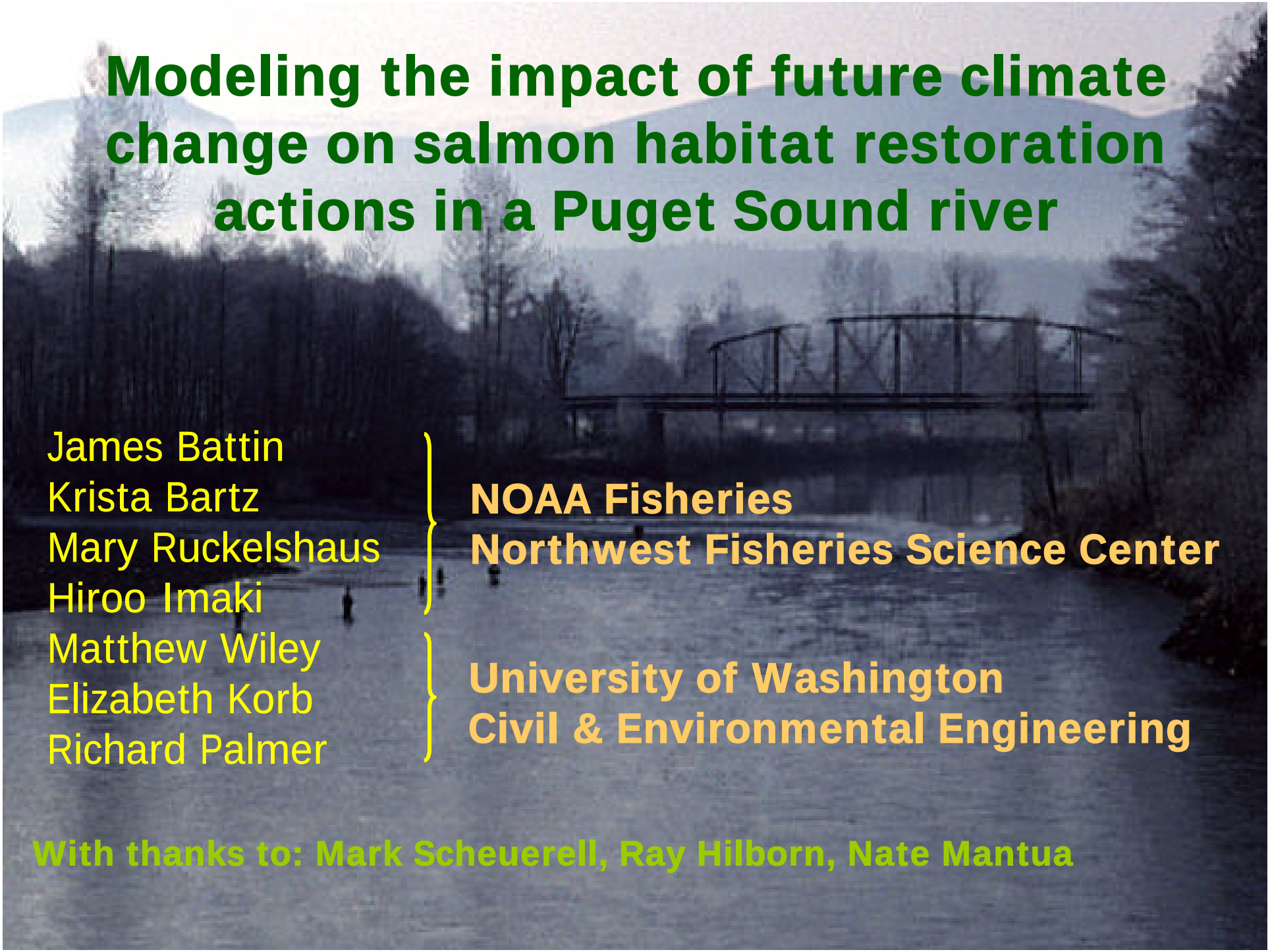

# Modeling the impact of future climate change on salmon habitat restoration actions in a Puget Sound river


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**With thanks to: Mark Scheuerell, Ray Hilborn, Nate Mantua**

# Snohomish River Basin


**Area: 2644 mi²**

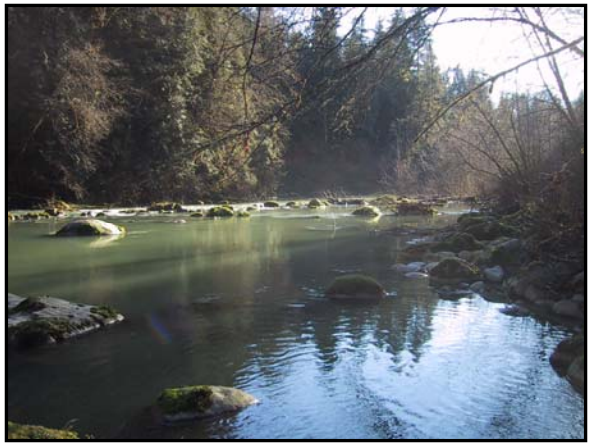
# The Problem

## Chinook salmon in the Puget Sound are threatened

- **Habitat destruction, harvest, hatcheries, dams and other factors have caused large population declines and ESA listing.**
- **Major recovery efforts are being planned.**

## But

- **Climate change effects are largely unknown and unaccounted for.**



# The Question

**How might climate change alter the effectiveness of planned recovery actions?**

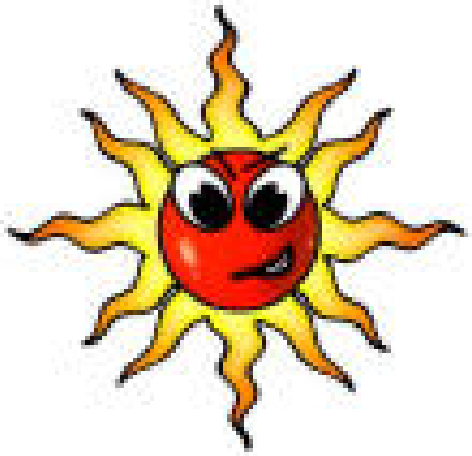
- **How might climate change affect salmon populations?**
- **How might climate effects interact with habitat restoration effects?**

# Proposed Habitat Restoration Actions

- **Restore instream habitat (capacity)**
  - --Riparian restoration
  - --Habitat reconnection
  - --Instream habitat restoration
- **Restore hydrologic processes**
  - --Land use modification
  - --Floodplain restoration
  - --Road removal

# Climate Change Over Next 50 Years in the Northwest

- **Air temp. up 2-4 degrees C → warmer water temps**
- **Earlier snowmelt → more intense winter flooding, lower summer flows**
- **Altered precipitation regime (maybe wetter, esp. in winter) → increased flood magnitude**



# Ocean-type Chinook Salmon Life Cycle

High Water Temp.
Low Flow

High Water Temp.
High Peak Flow

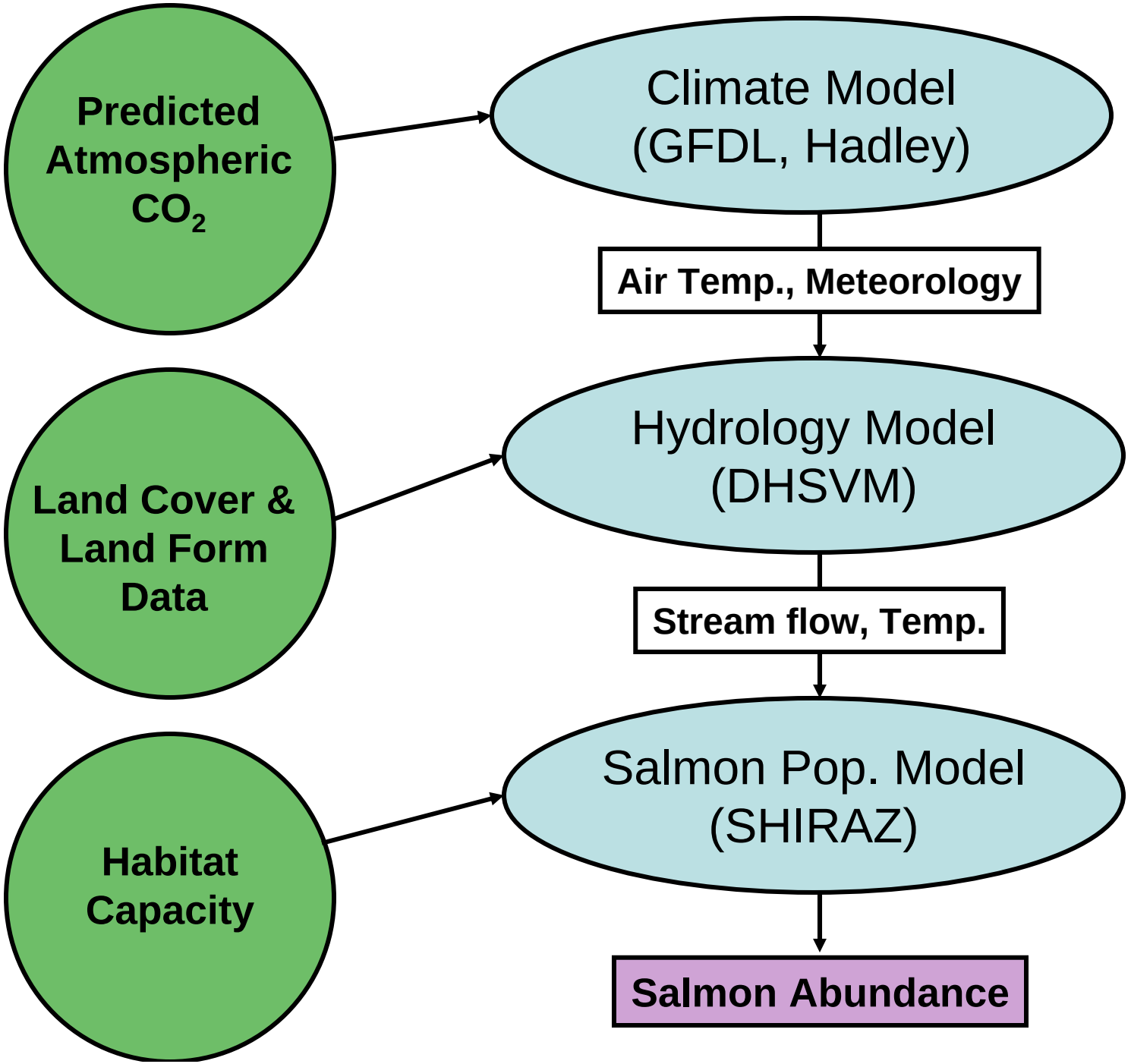
Spawner

Egg

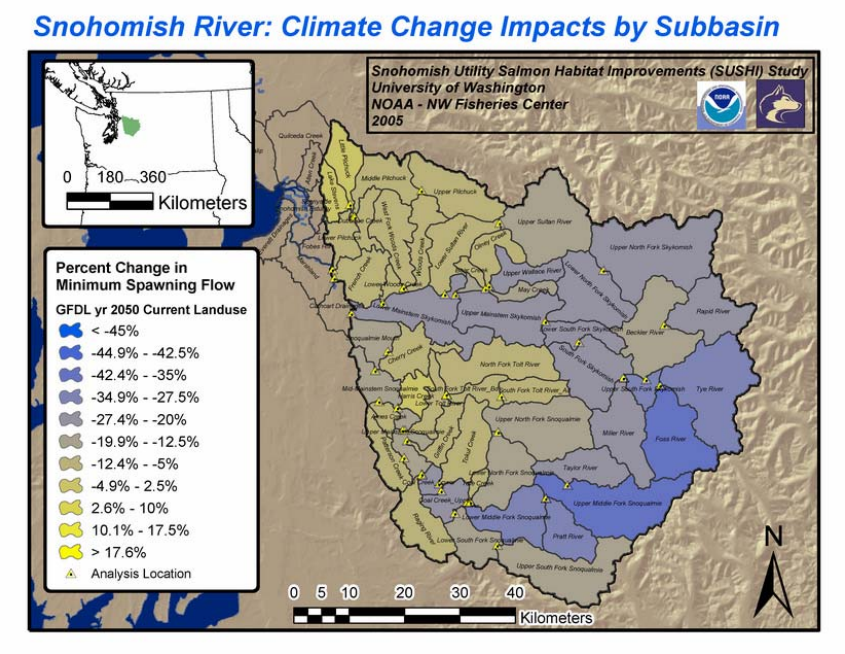
Fry

Smolt

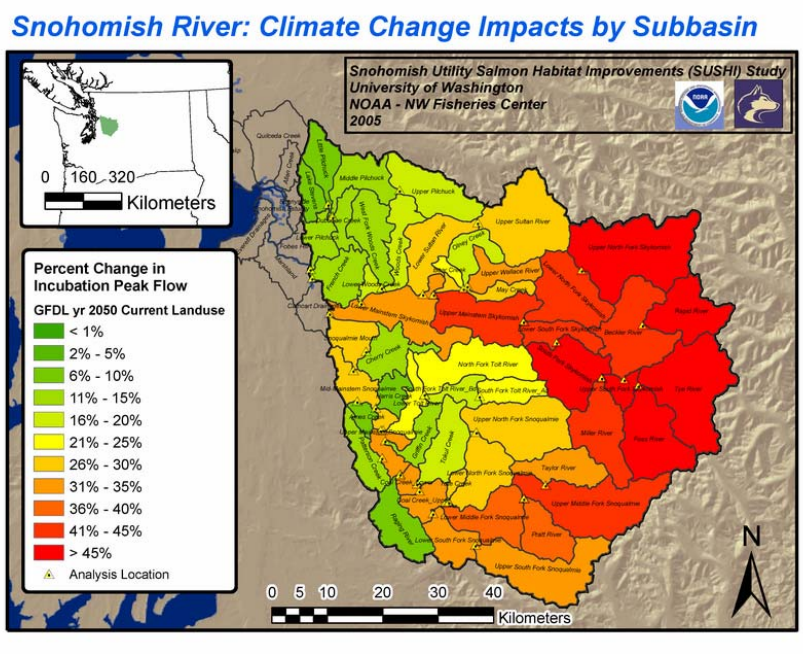
Adult
(Ocean)


Predicted Atmospheric $CO_2$
Climate Model (GFDL, Hadley)
Air Temp., Meteorology
Land Cover & Land Form Data
Hydrology Model (DHSVM)
Stream flow, Temp.
Habitat Capacity
Salmon Pop. Model (SHIRAZ)
Salmon Abundance

# Global climate impacts on stream flows in the Snohomish watershed

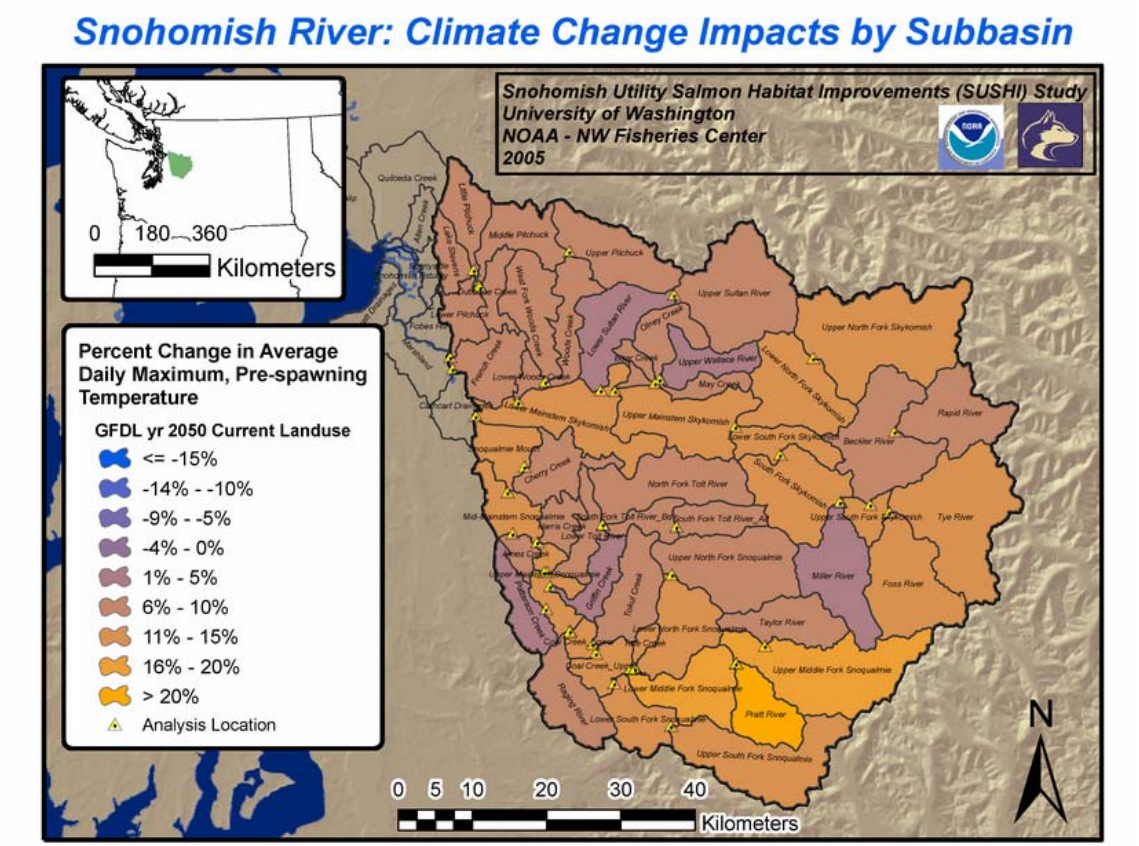



**Reductions in minimum spawning flows up to 40%**



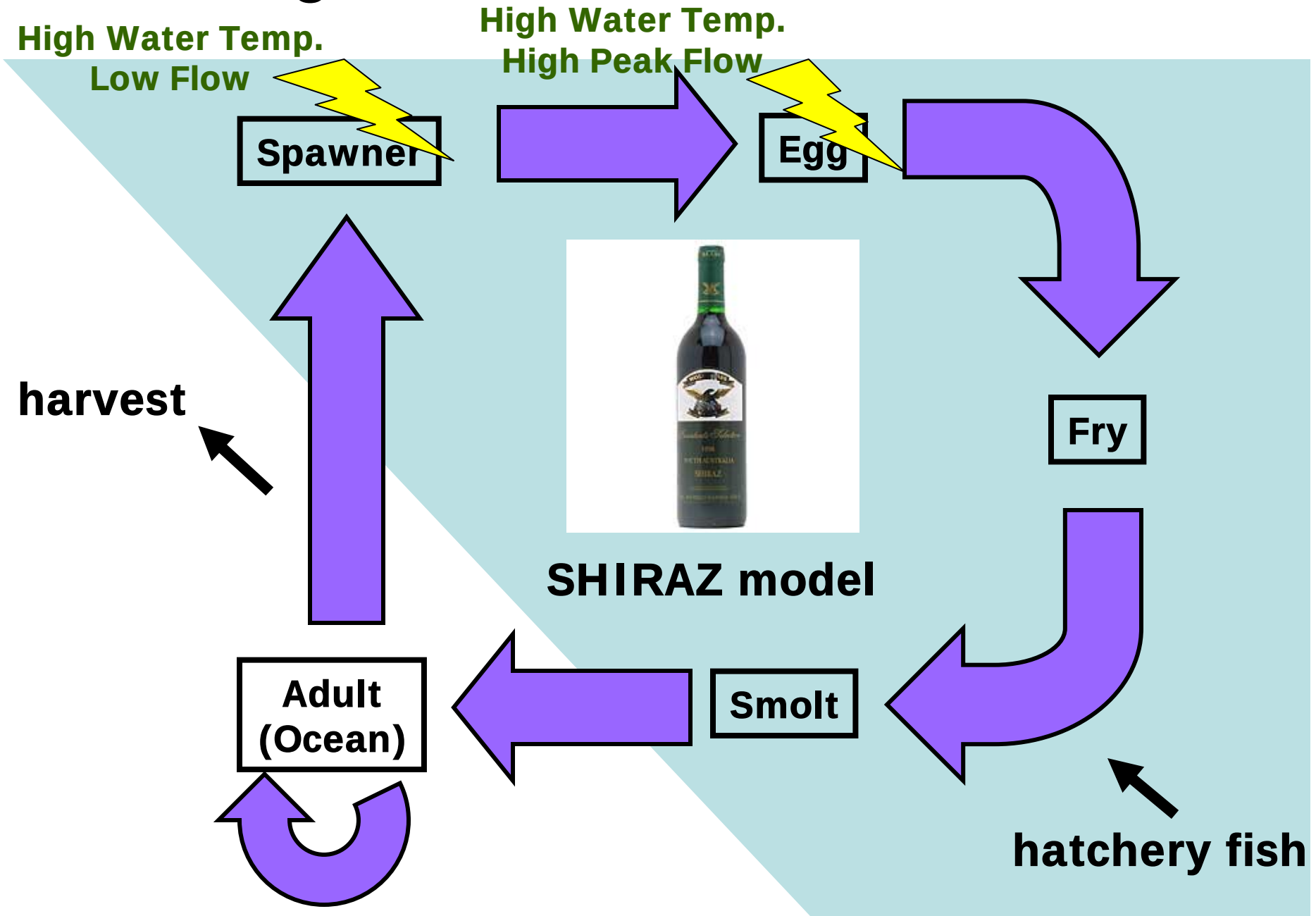

**Increases in peak incubation flows up to 45%**

# Global climate impacts on stream temperature in the Snohomish watershed

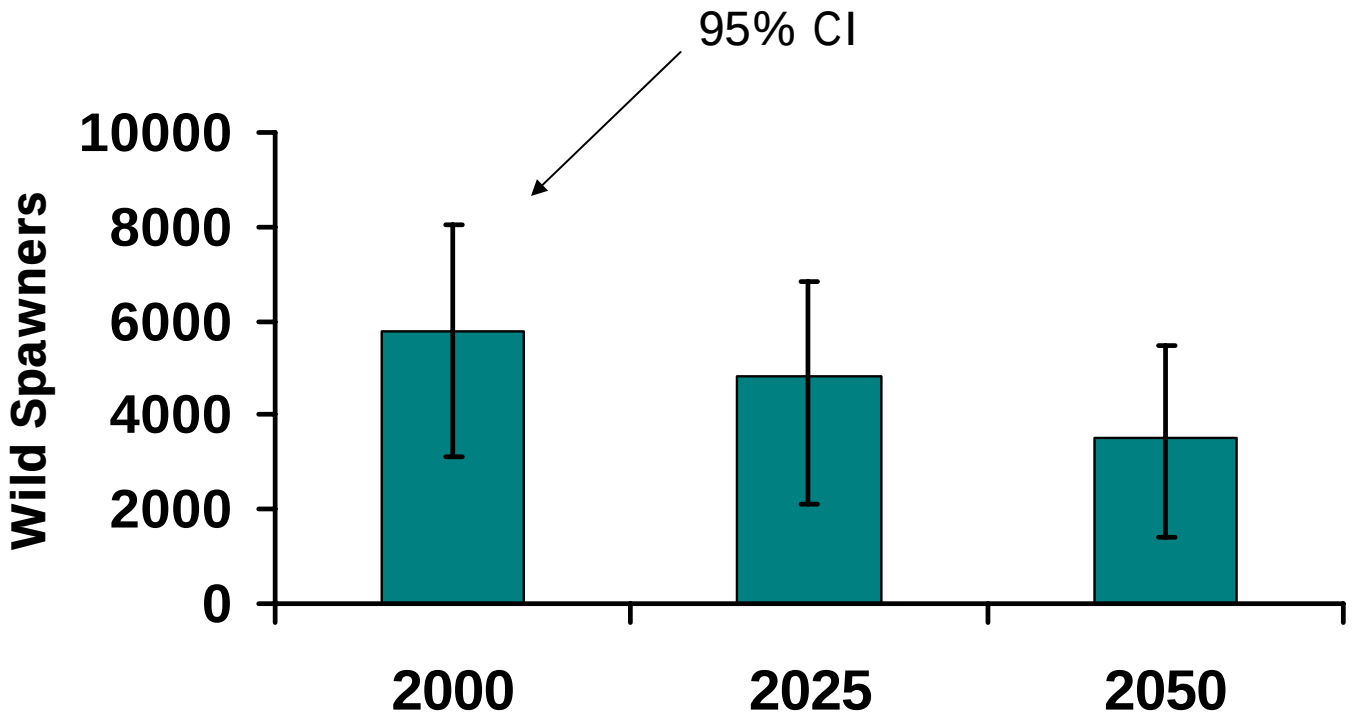



**Increases in pre-spawning temperature up to 20 %**

# Modeling the effects of climate on salmon



# Climate Effects on Wild Spawner Abundance

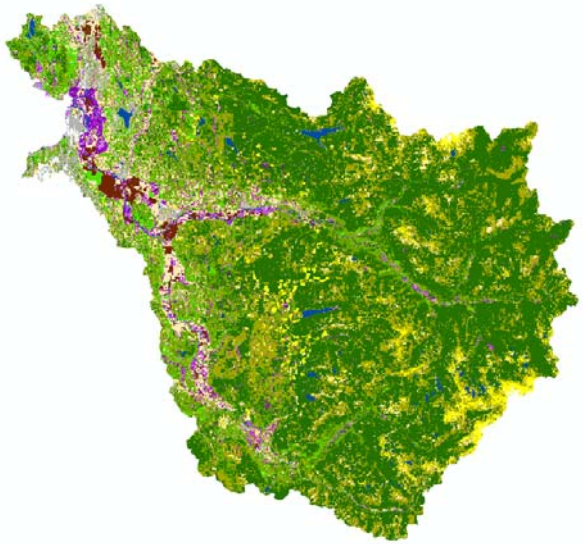



**Salmon population in Snohomish declines by >39% between 2000 and 2050 due to climate impacts alone.**

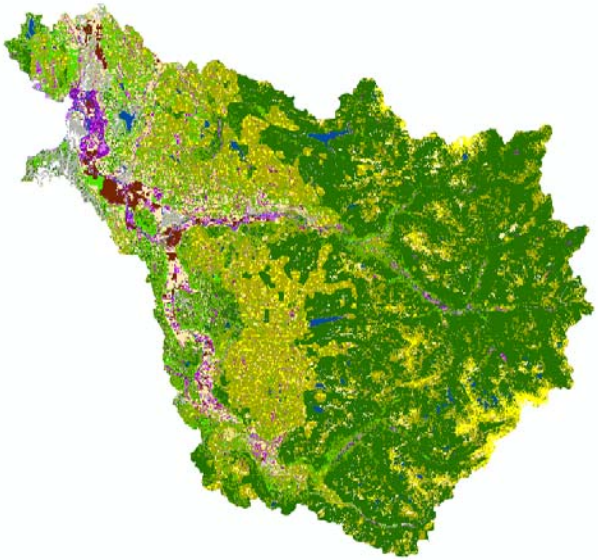
# Alternative Land Use Scenarios: What can restoration do?

Current Path

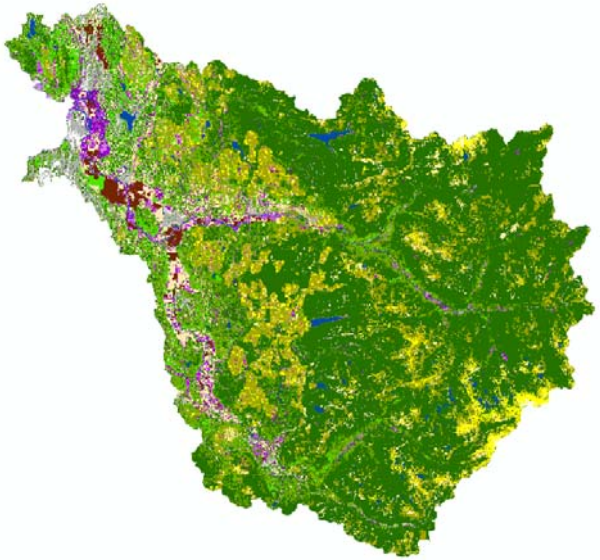
Restoration



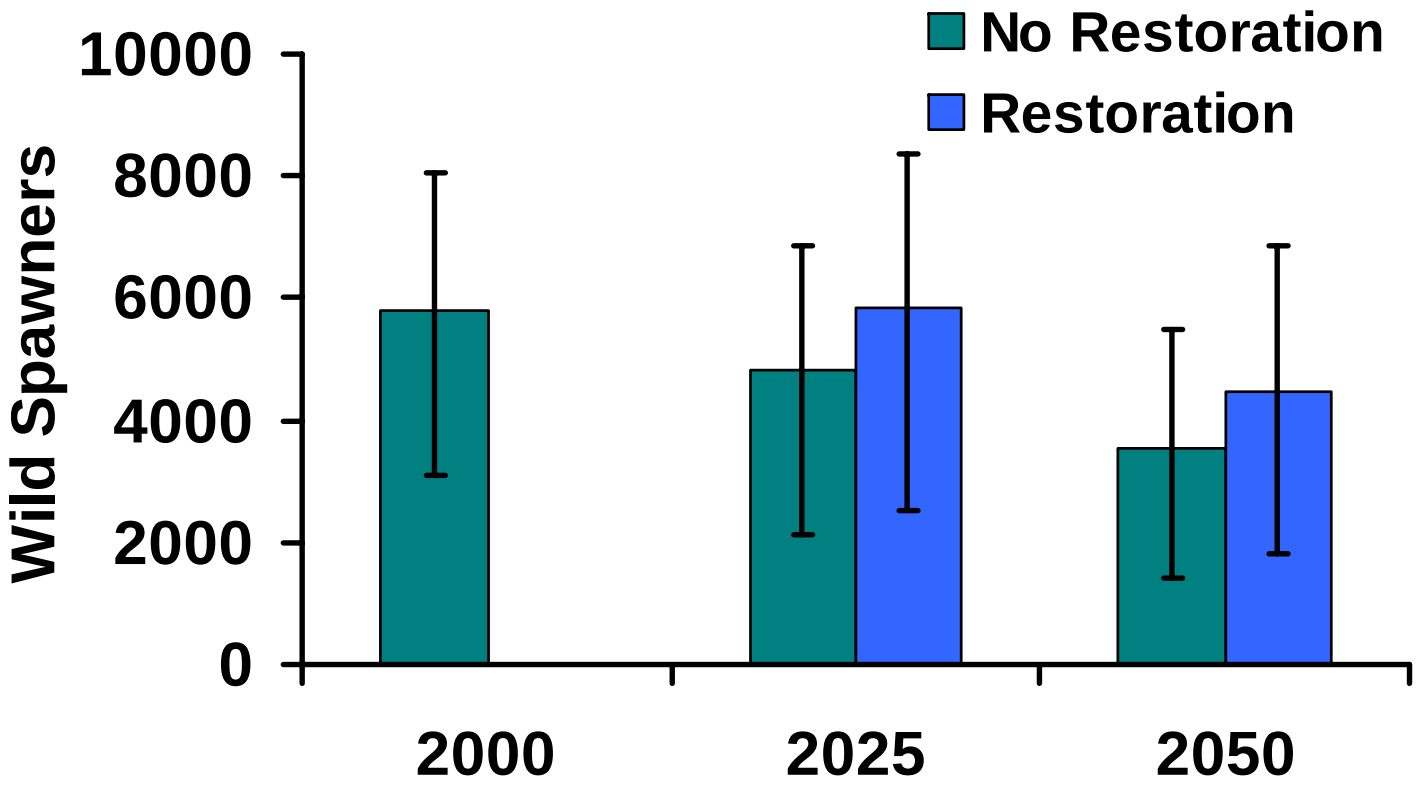
2001



2025



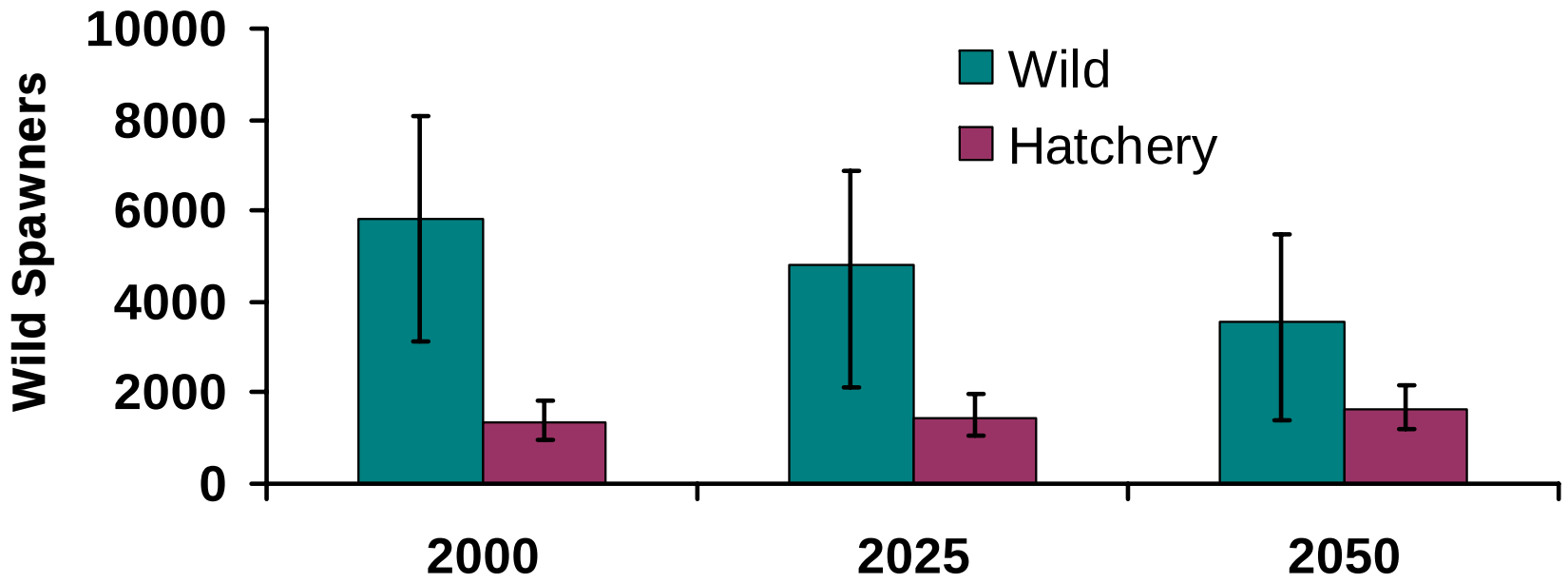
# The Mitigating Effects of Restoration




**2000-2050 decline w/o restoration: 39%**

**2000-2050 decline w/ restoration: 23%**

# Hatchery Fish: A Very Different Response to Climate




**Hatchery returns *increase* by 20% between 2000 and 2050**

**Hatchery fraction increases from 19% to 31% of returning spawners**

# Hypotheses for Further Exploration

- **Climate change signal already evident in freshwater habitat.**

- **Climate change will have a large negative effect on Puget Sound chinook salmon populations.**

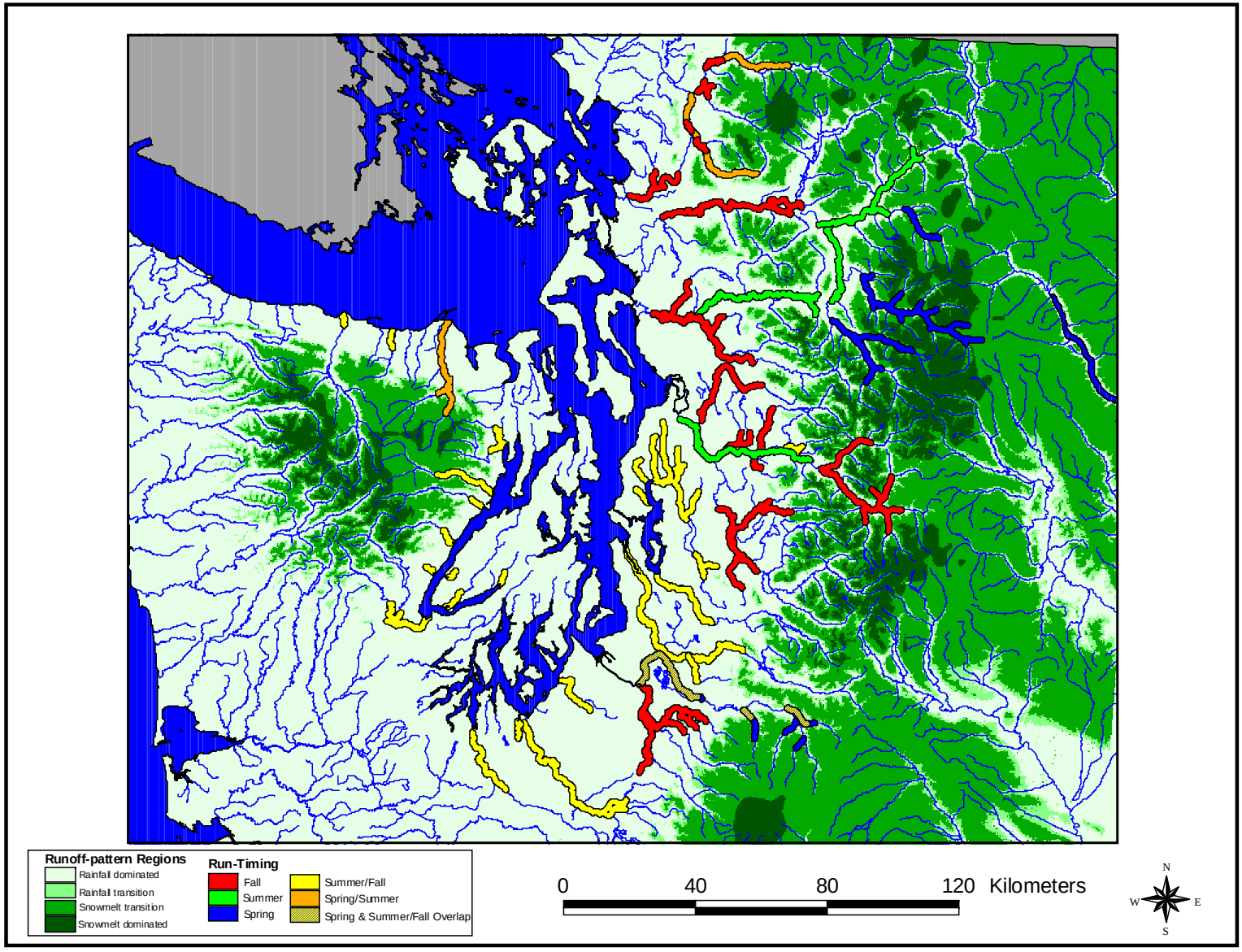
- **Even if restoration plans are fully implemented, chinook populations may decline in some areas.**

- **Hatchery stocks may be poor indicators of climate effects on wild stocks.**

# Now what?

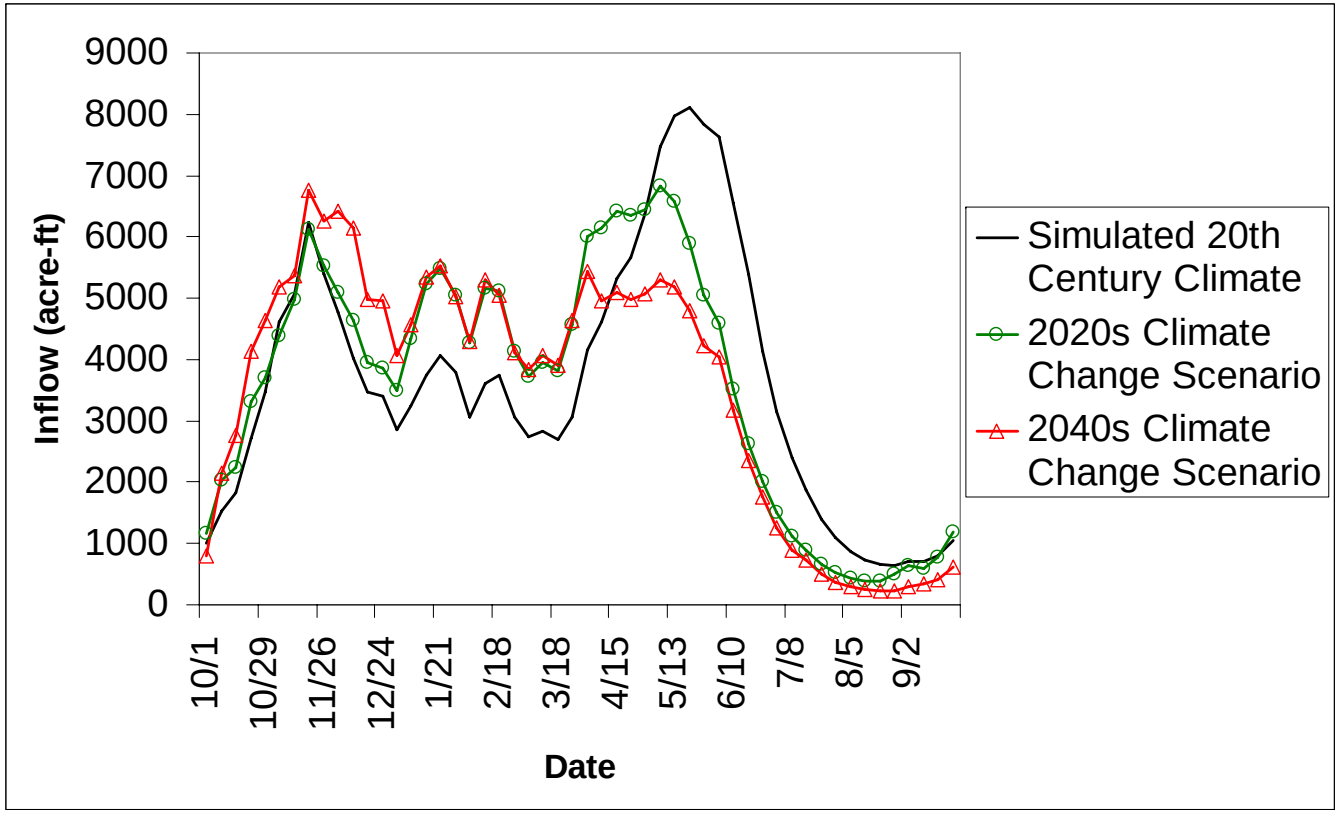
- Explore more general benefits of watershed restoration beyond Chinook: i.e., effects on other salmon species, other plants and animals, water quality and quantity.
- A regional view of recovery for salmon and other species is important

# A regional perspective on salmon recovery strategies



# Spawning Flows: Water Supply Modeling

Effects to the Cedar River (Seattle Water Supply)
for "Middle-of-the-Road" Scenarios




**Spawning flows predicted to be 50-80% lower under "average" warming conditions.**

**Translates to ~45% decline in spawning habitat area.**

# Habitat Destruction & Degradation

## Habitat Destruction (↓ Capacity)

- Riparian forest clearing
- Channelization

## Habitat Degradation (↓ Survival)

- Increased water temperature
- Larger peak flows
- Increased sedimentation

**Restoration aims to reverse these effects**

# Modeled Climate Effects on Salmon