

US EPA ARCHIVE DOCUMENT

Harnessing the hydrologic disturbance regime: **Sustaining multiple benefits in large river** **floodplains in the Pacific Northwest**

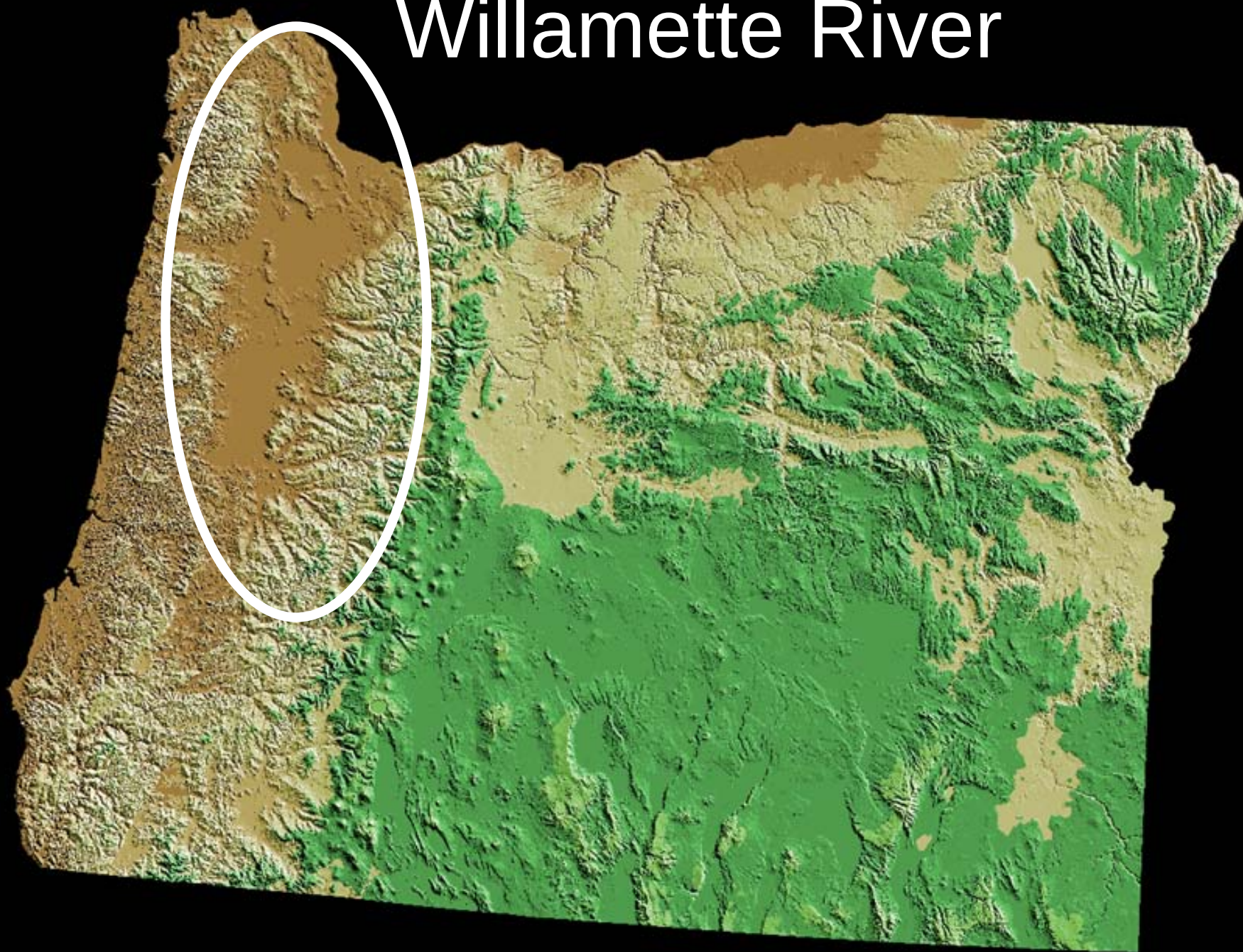
Dr. Stan Gregory, Oregon State University

Prof. Dave Hulse, University of Oregon

Dr. Roy Haggerty, Oregon State University

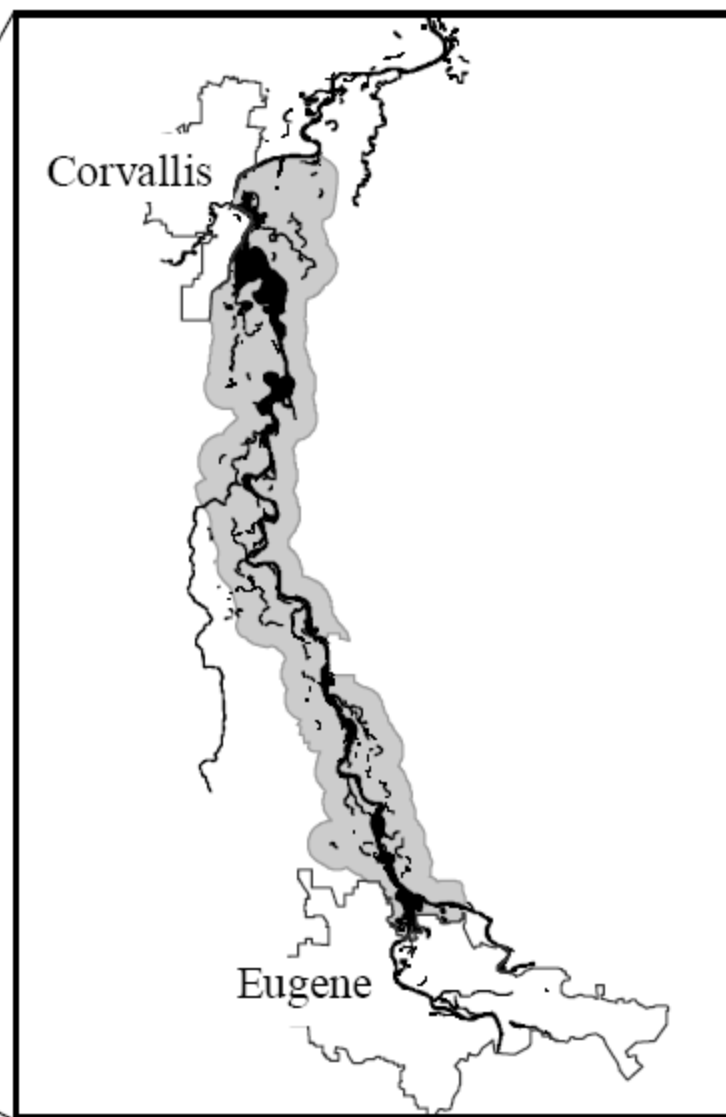


Willamette River





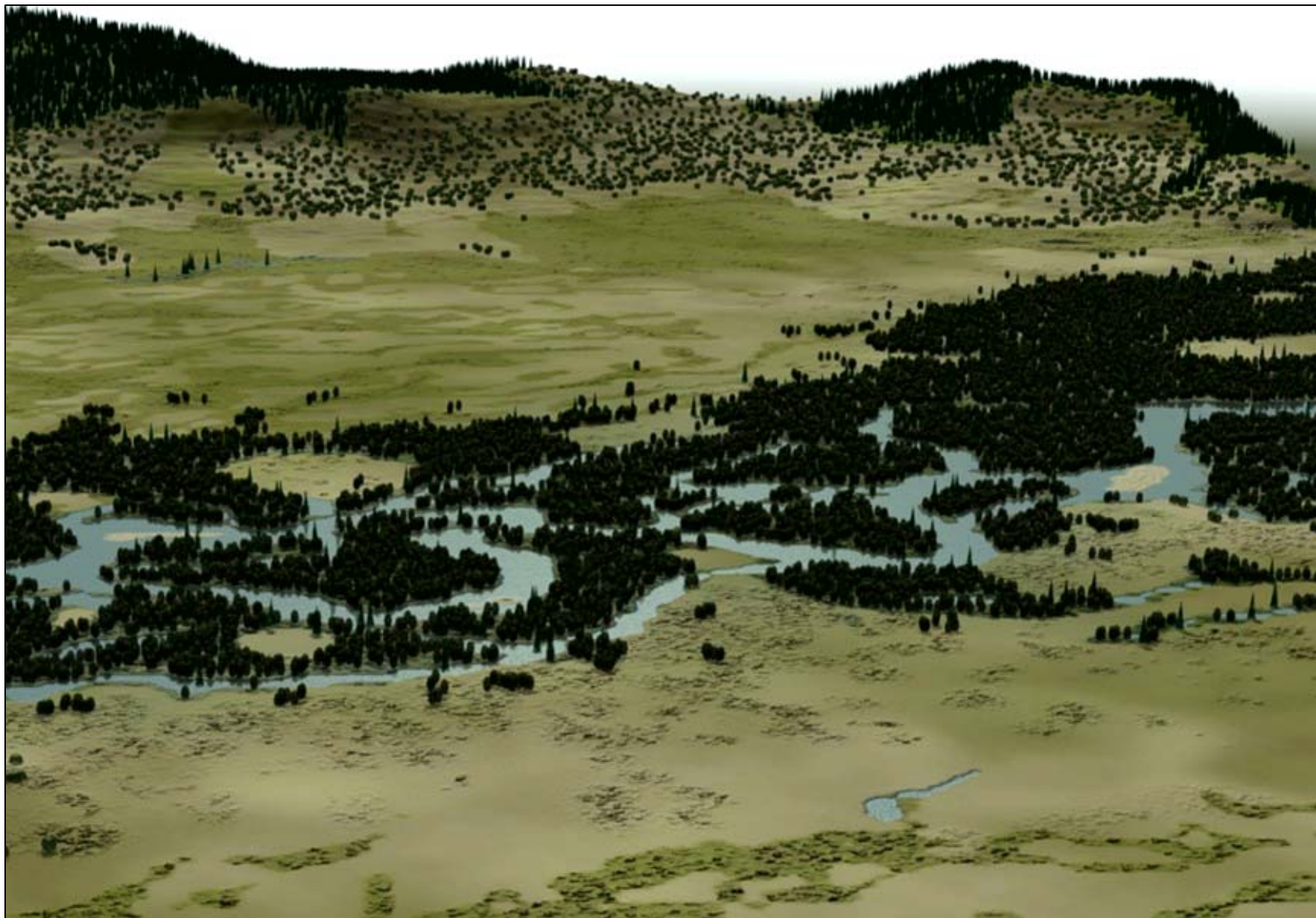
Willamette
River
Basin
(WRB)





Baker et al. 2004
Ecological Applications

1995



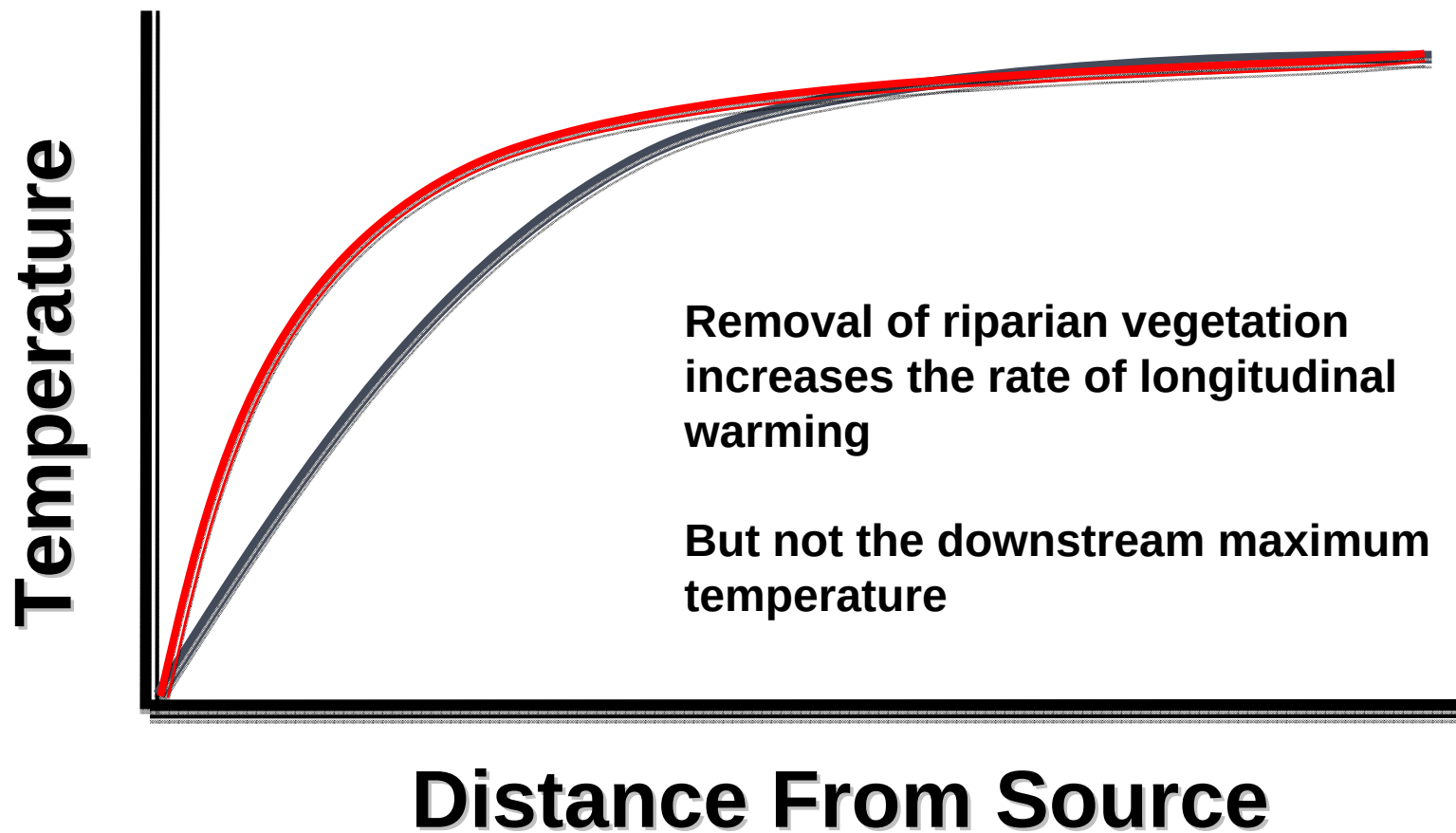
Baker et al. 2004
Ecological Applications

1850

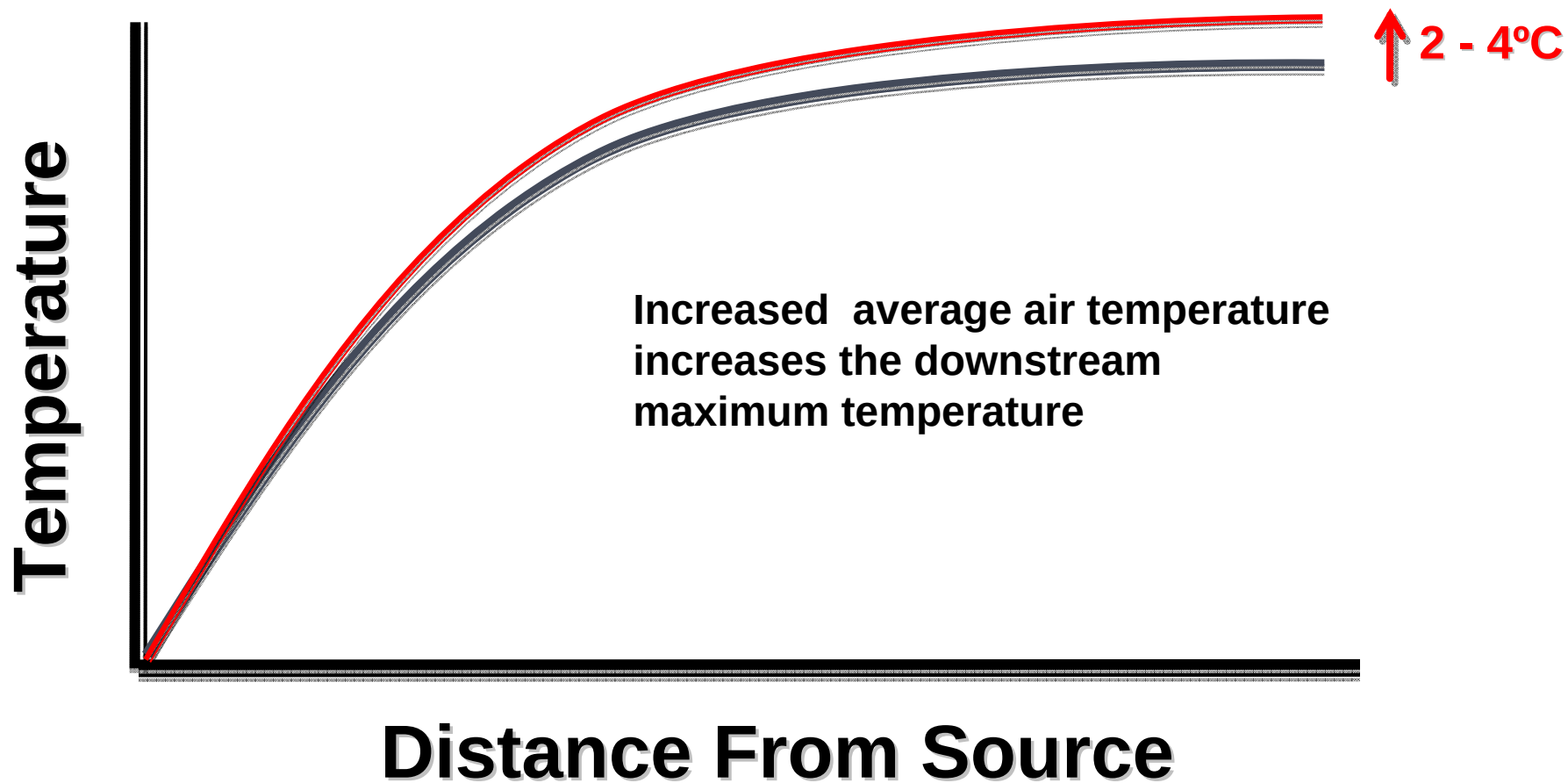
Climate Changes in Pacific Northwest

- Warmer climate
- Decreased summer precipitation
- Changes in temperature appear more certain than changes in precipitation.

Longitudinal Warming



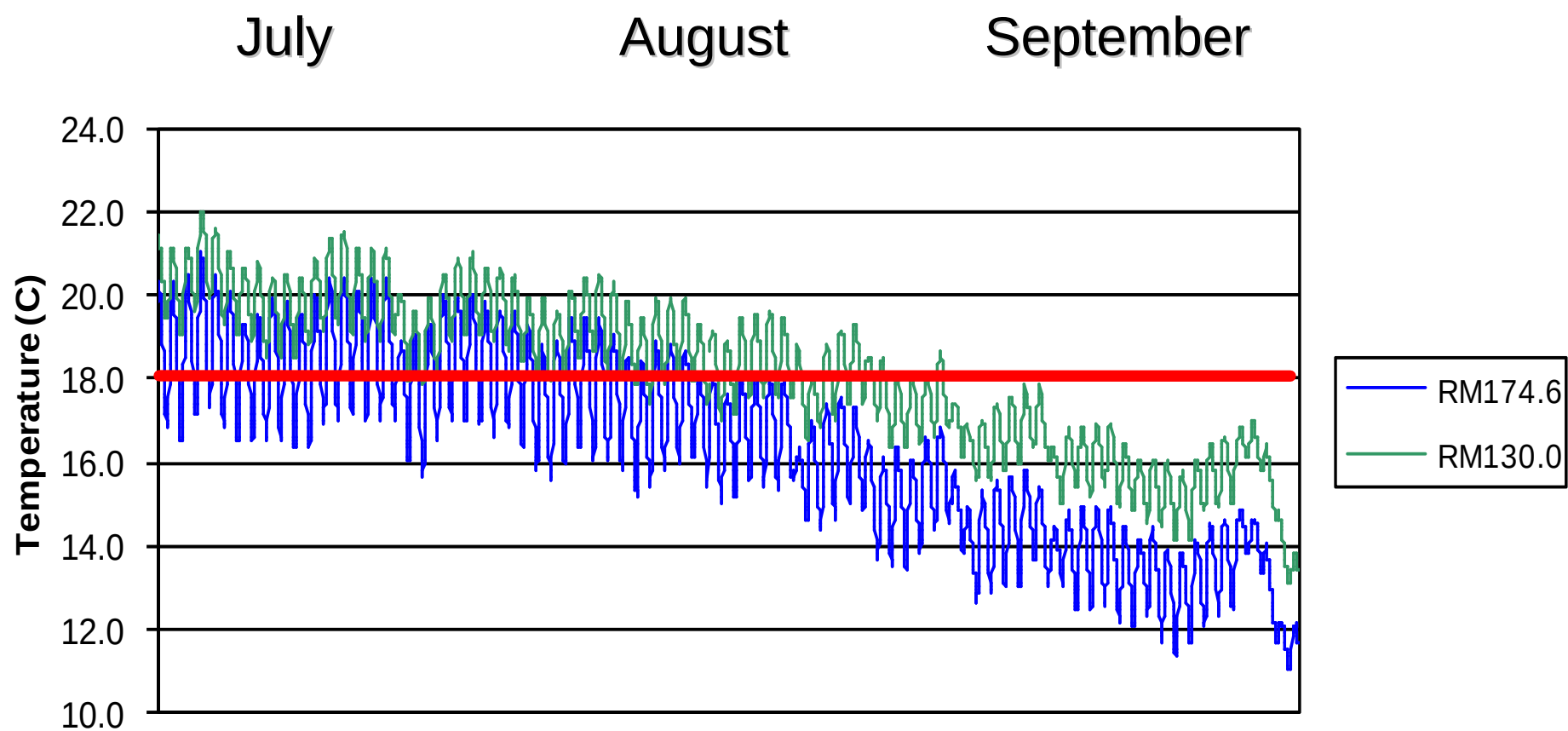
Longitudinal Warming







Longitudinal Profile



Approaches being considered to meet TMDL requirements:

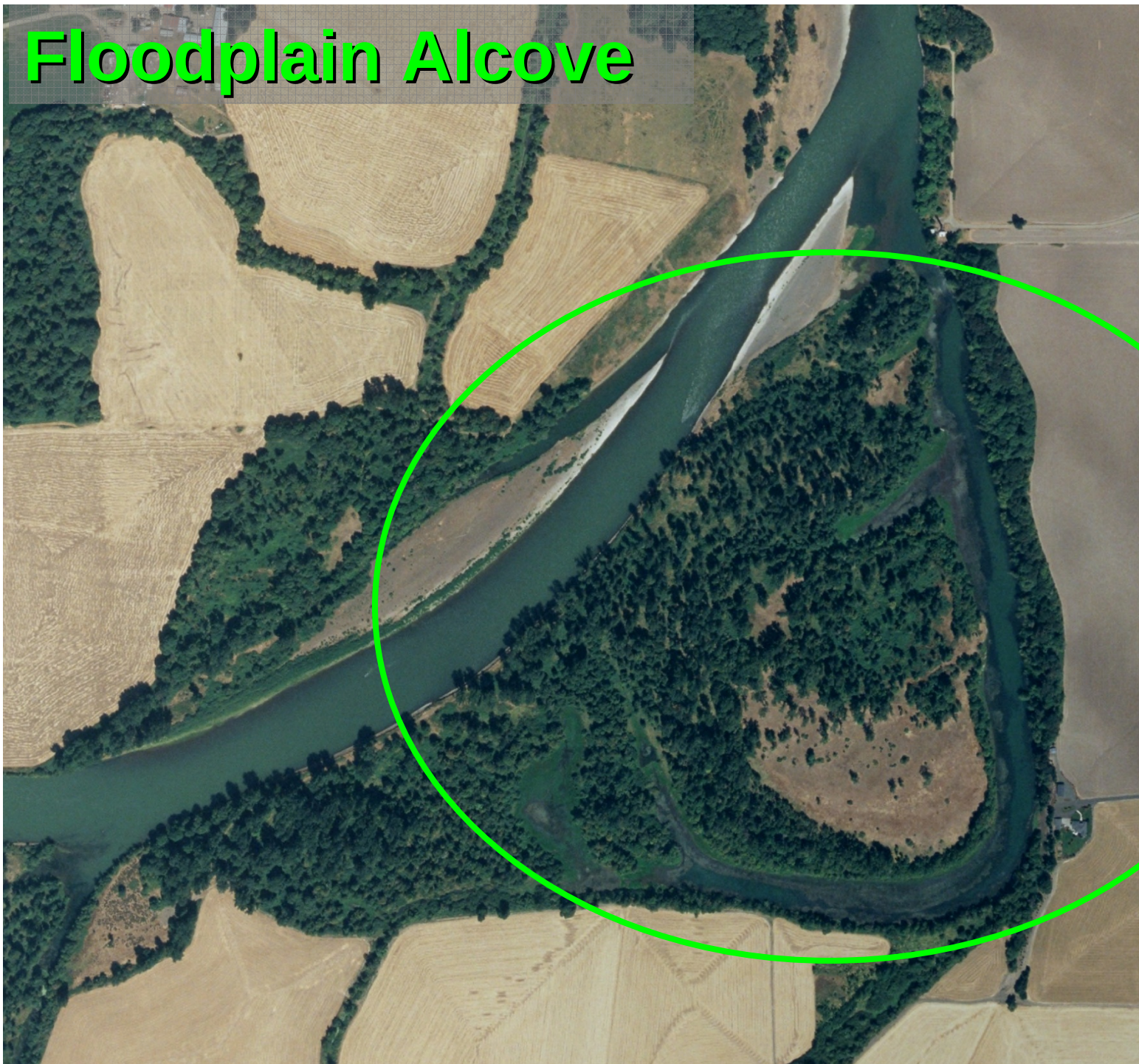
- Refrigeration higher certainty
- Shade ●
- Flow augmentation ●
- Floodplain restoration greater benefits

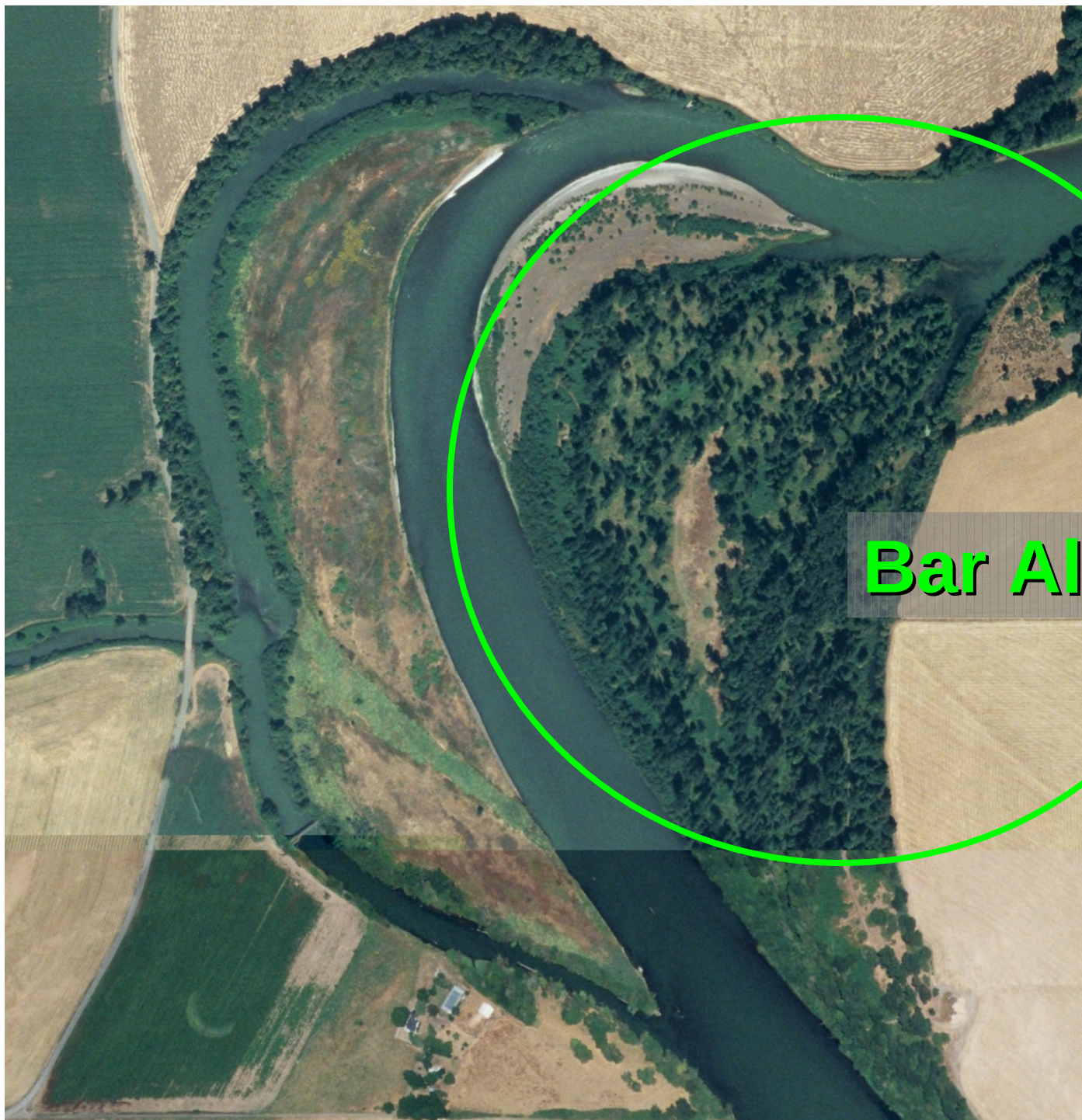






Floodplain Alcove



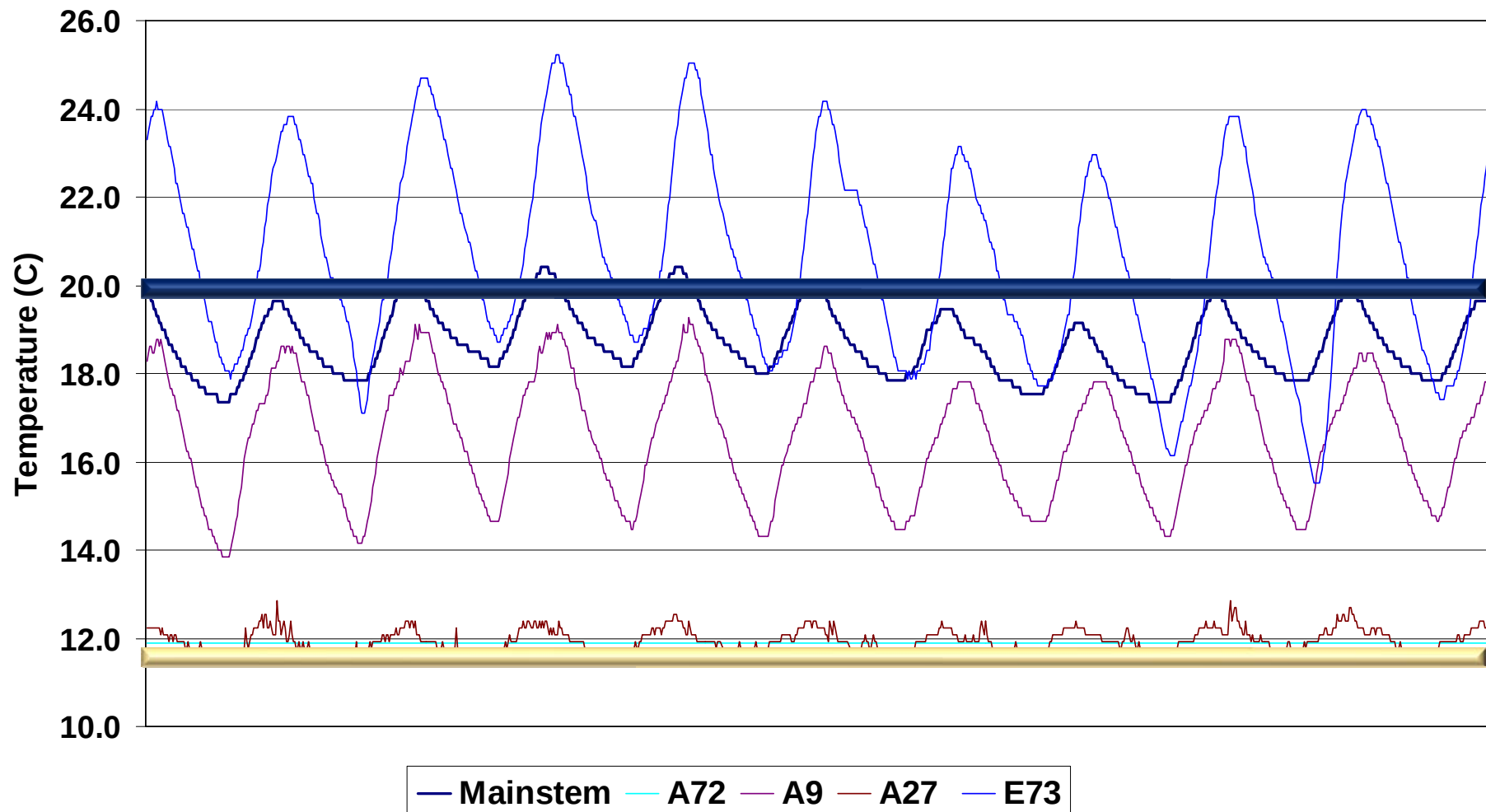


Bar Alcove



Side Channel

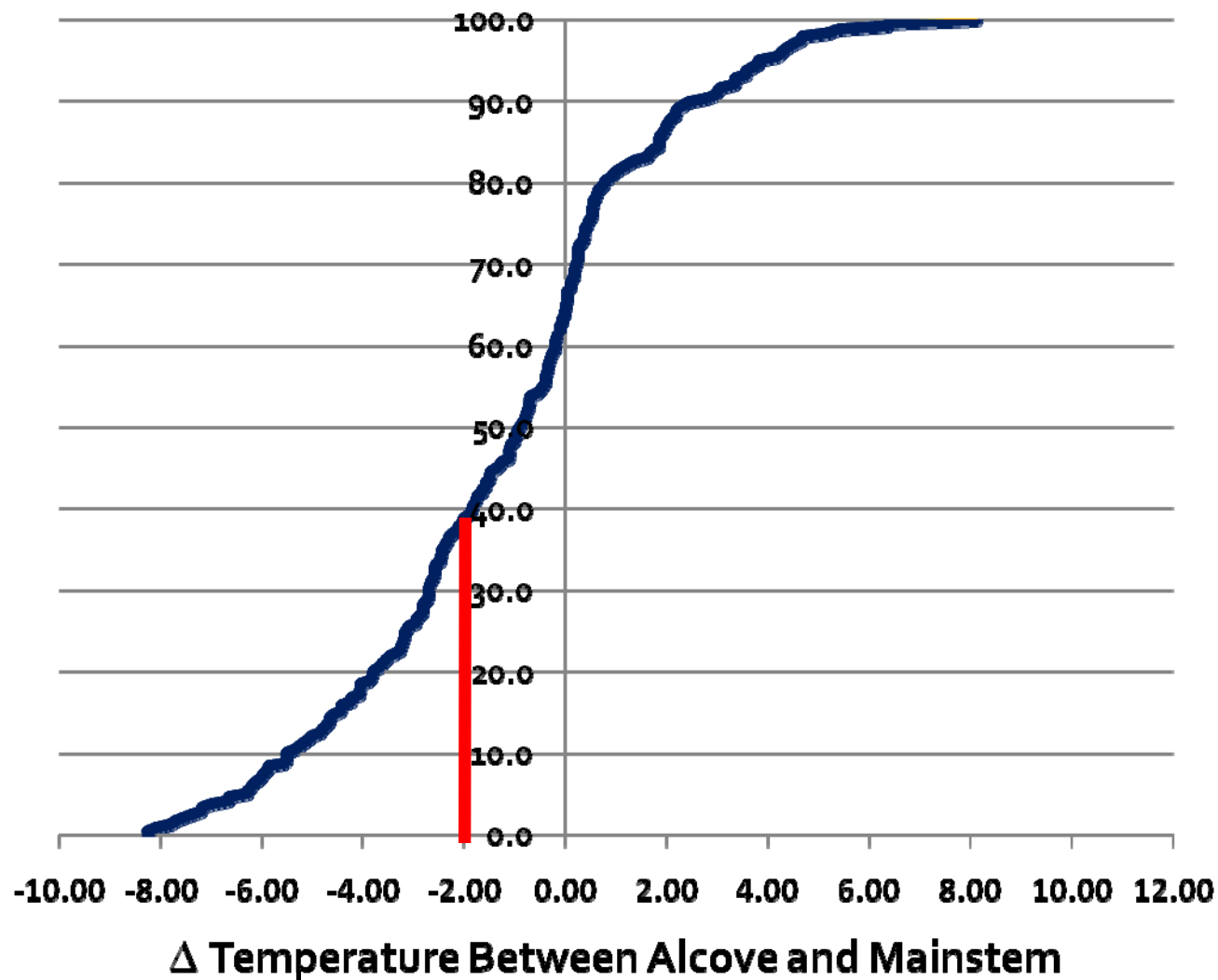
Norwood Island Slough (Aug 11 - 21)



Floodplain Alcoves

65% of sites colder than mainstem

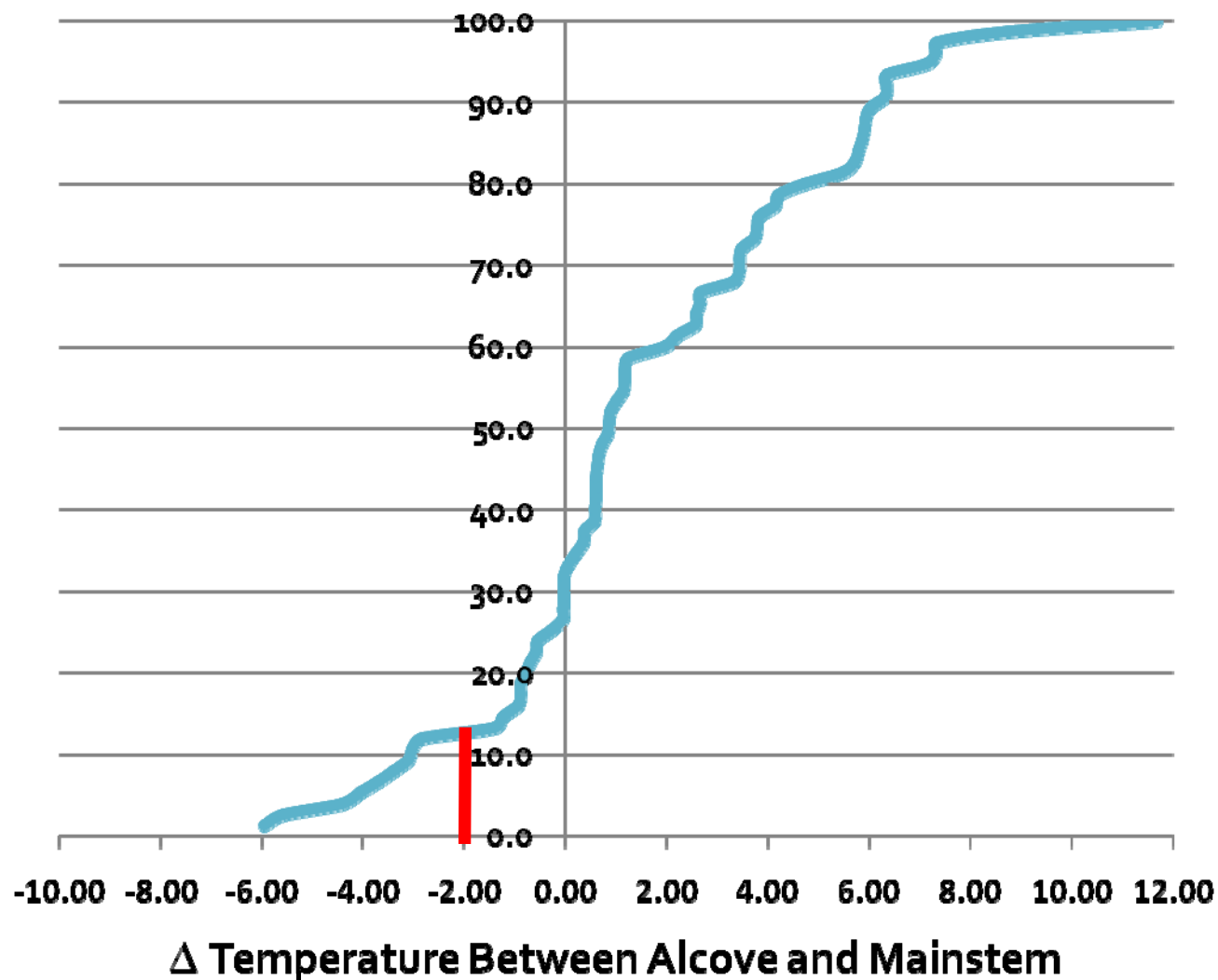
39% more than 2°C colder than mainstem



Alcoves on Gravel Bars

27% of sites colder than mainstem

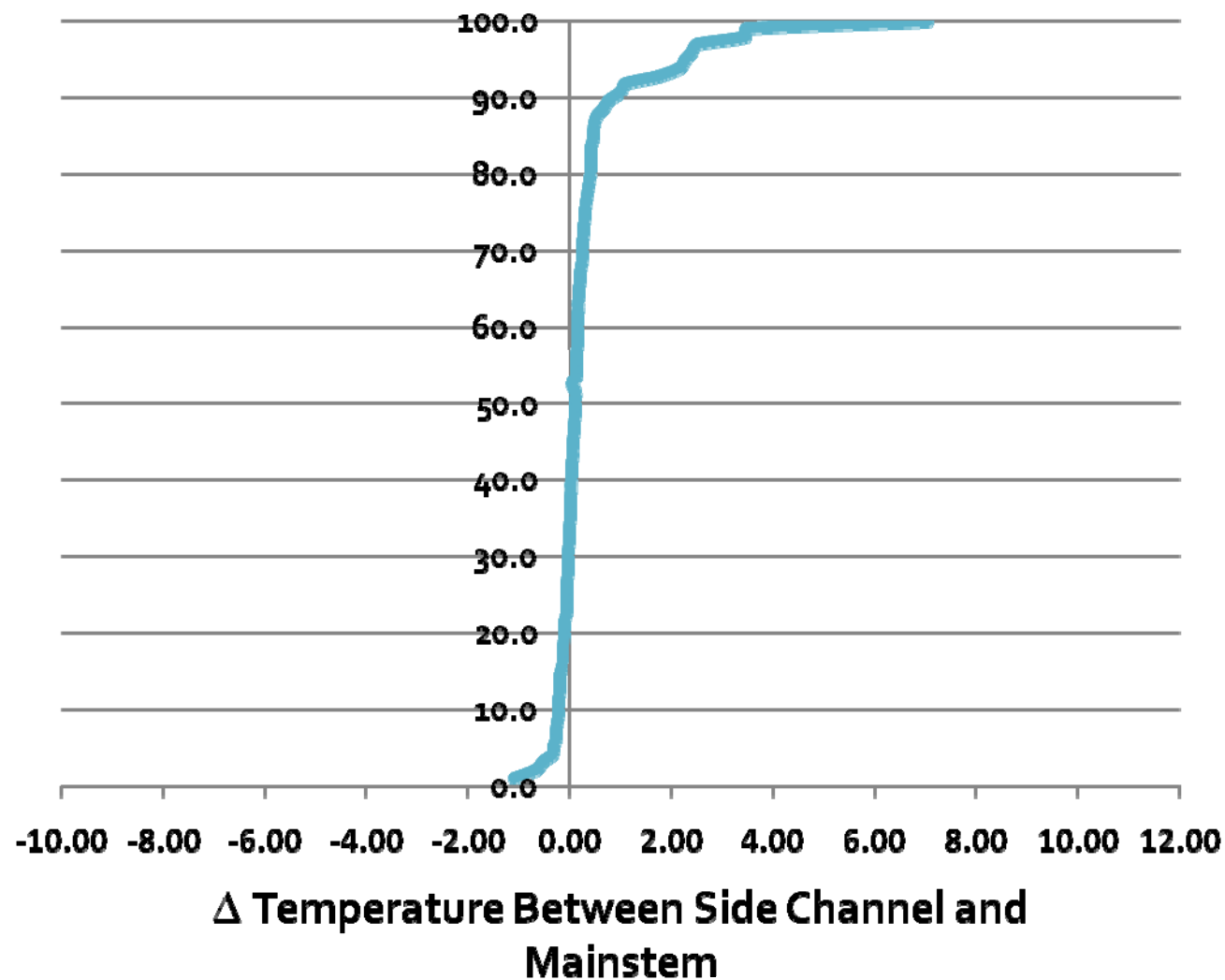
13% more than 2°C colder than mainstem



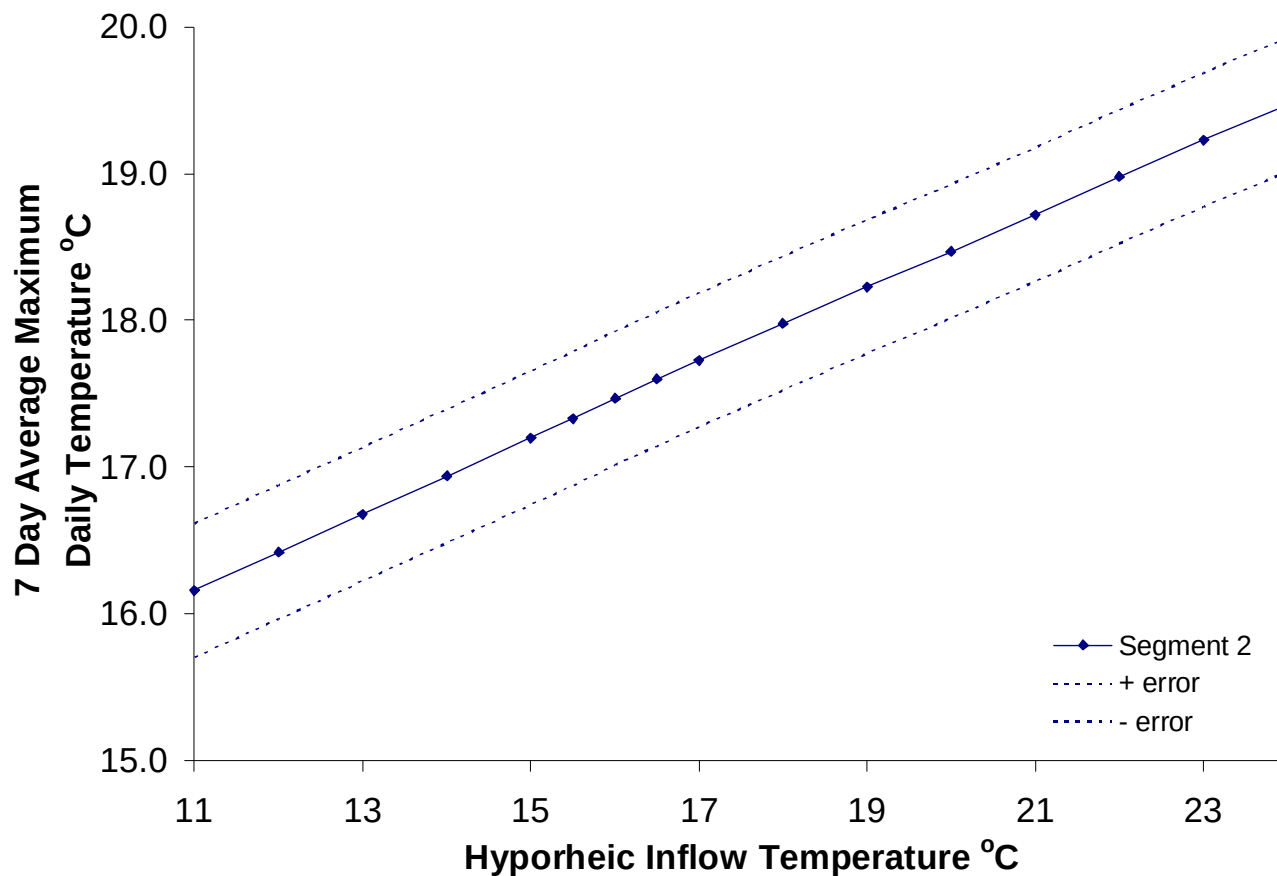
Side Channels

25% of side channel sites were colder than mainstem

None of the side channels were $>2^{\circ}\text{C}$ colder than mainstem

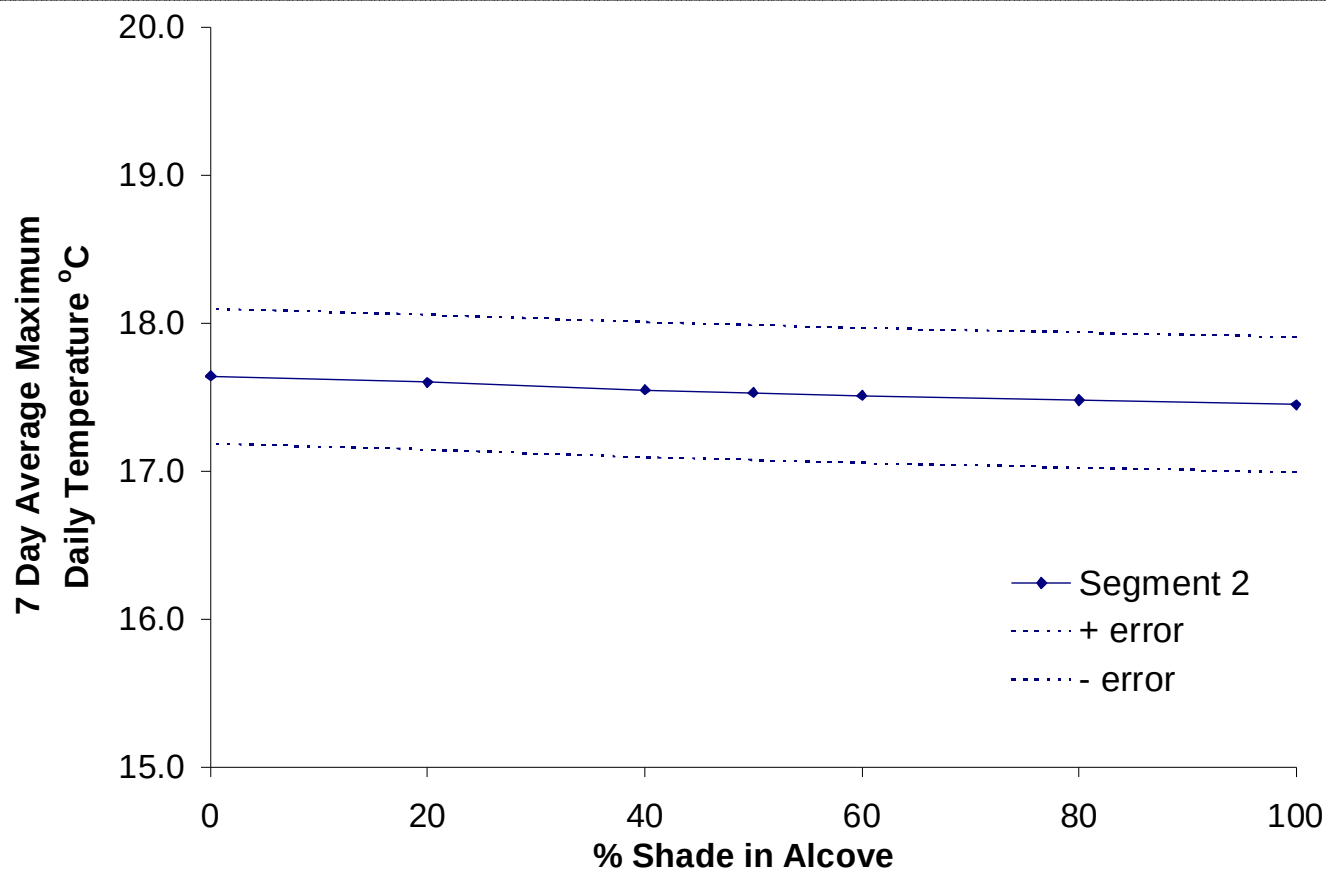


Influence of Hyporheic Inflow on Temperature



Changes in 7 Day Average Maximum Daily Temperatures in a small alcove for range of possible hyporheic inflow temperatures

Influence of Shade on Temperature



Changes in 7 Day Average Maximum Daily Temperatures in a small alcove for range of possible shade cover

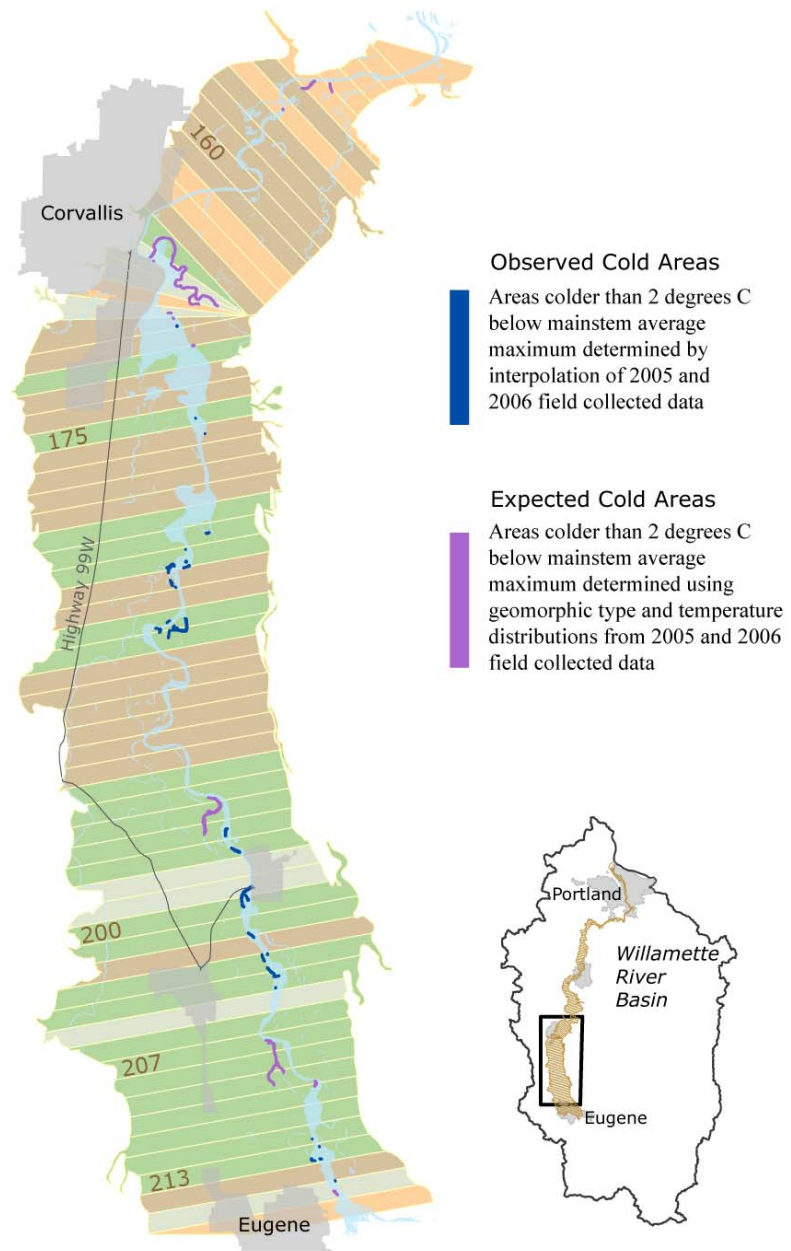
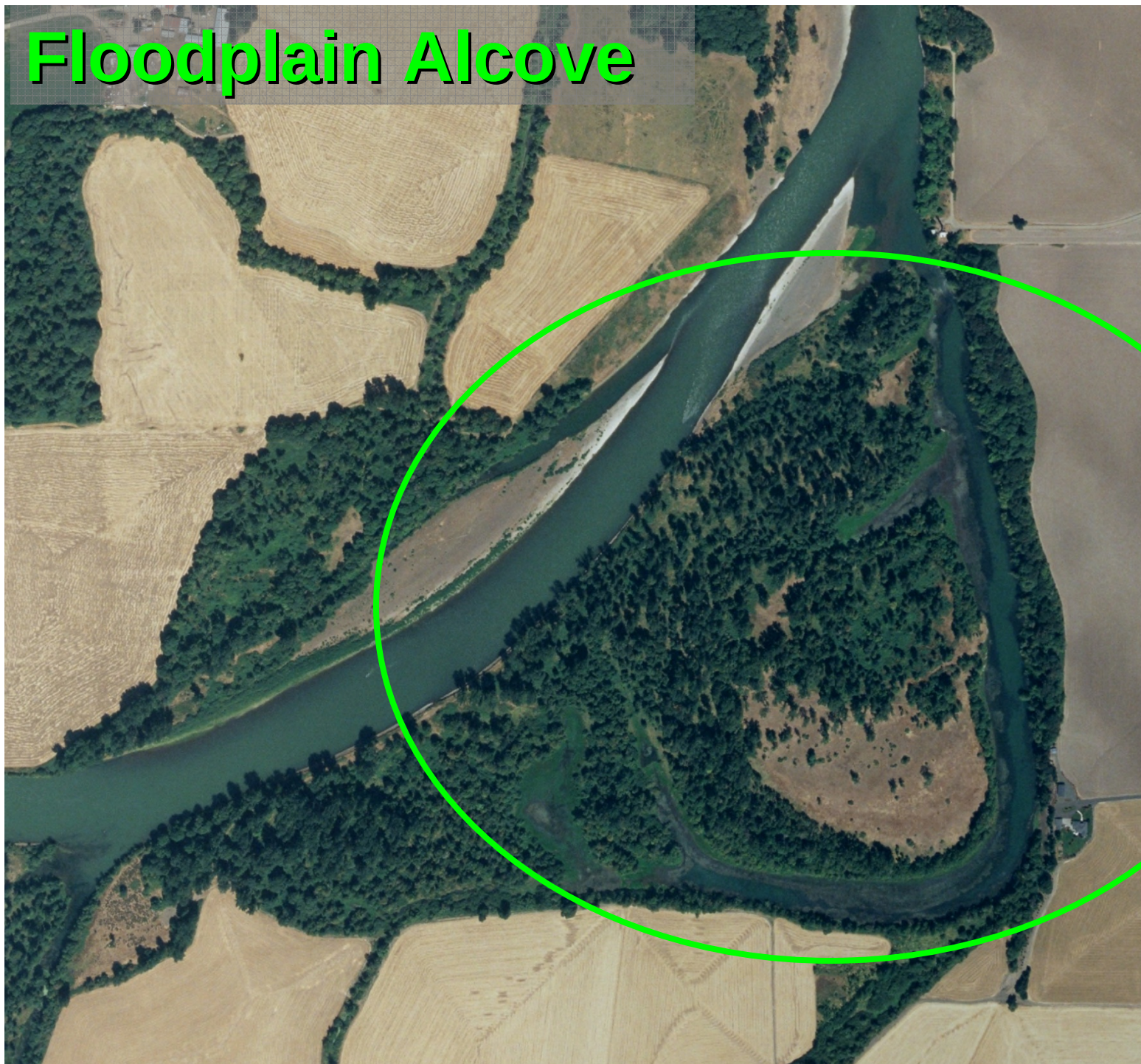
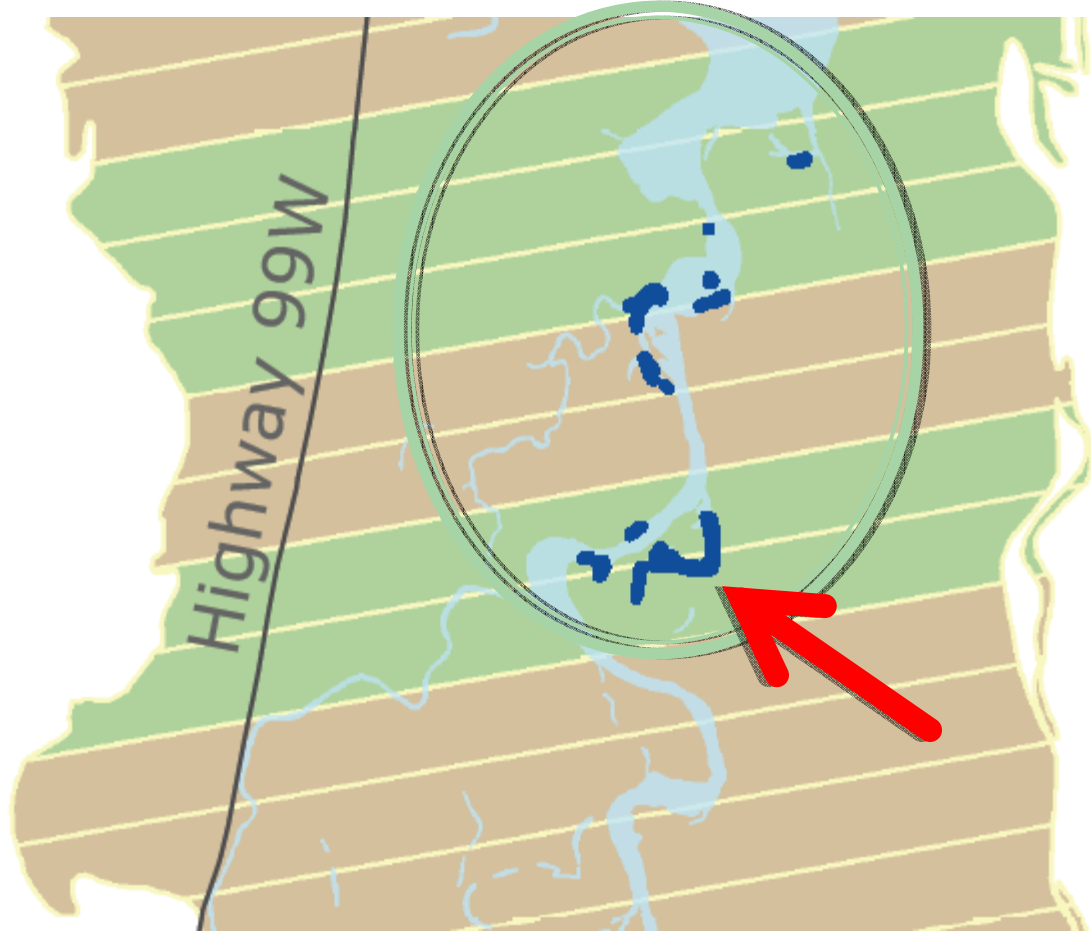


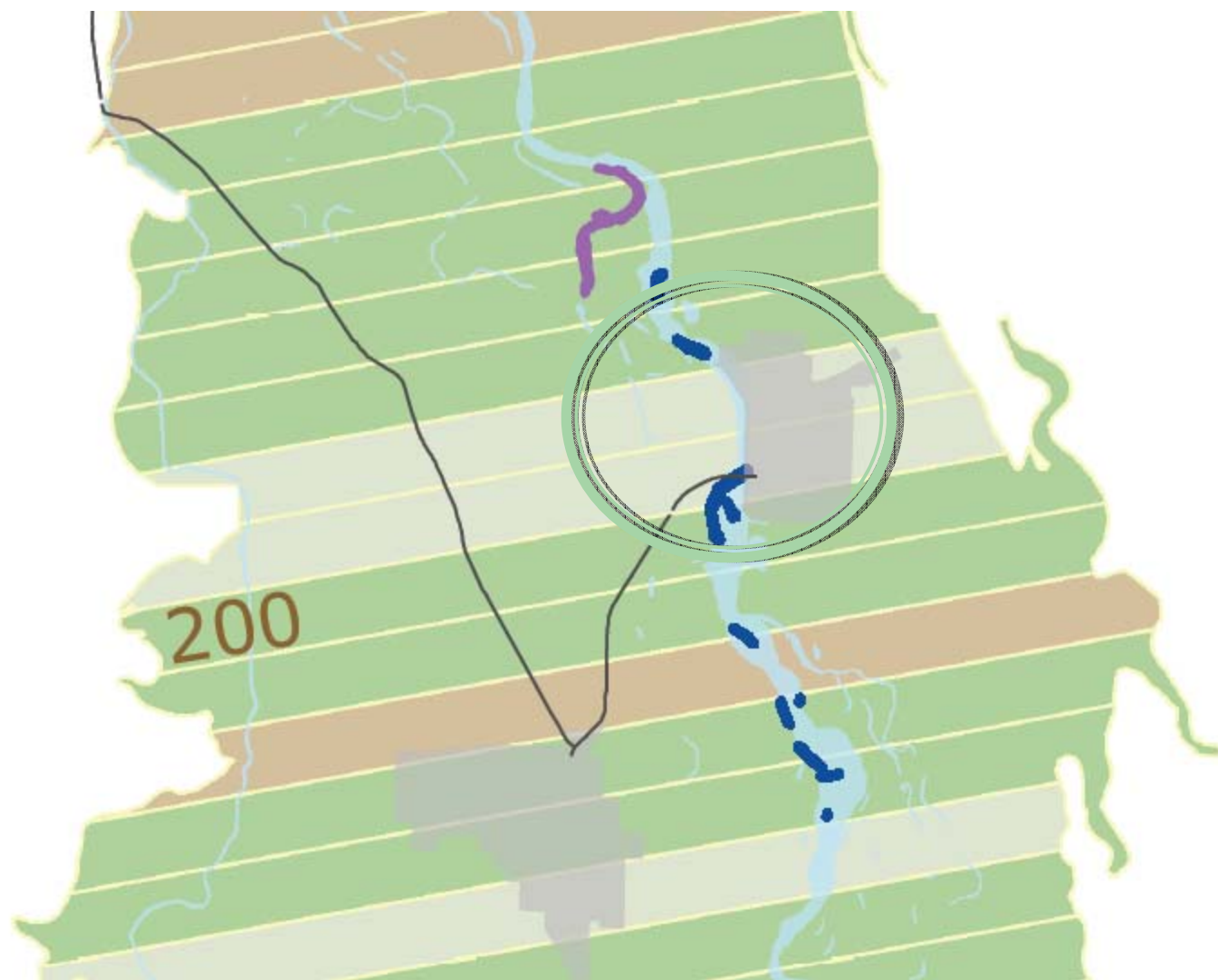
Figure 5
 DRAFT May 16, 2007

Floodplain Alcove

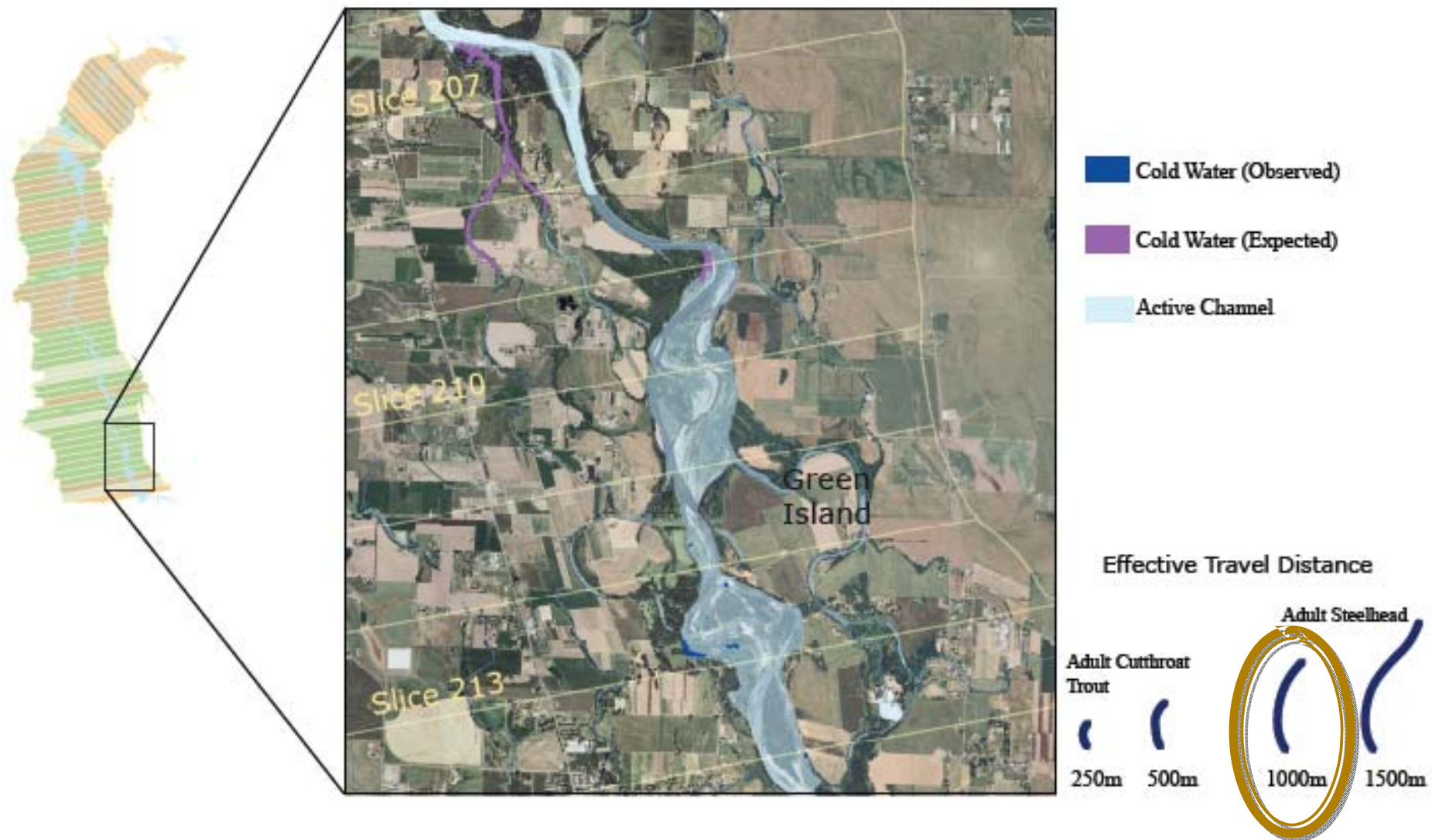


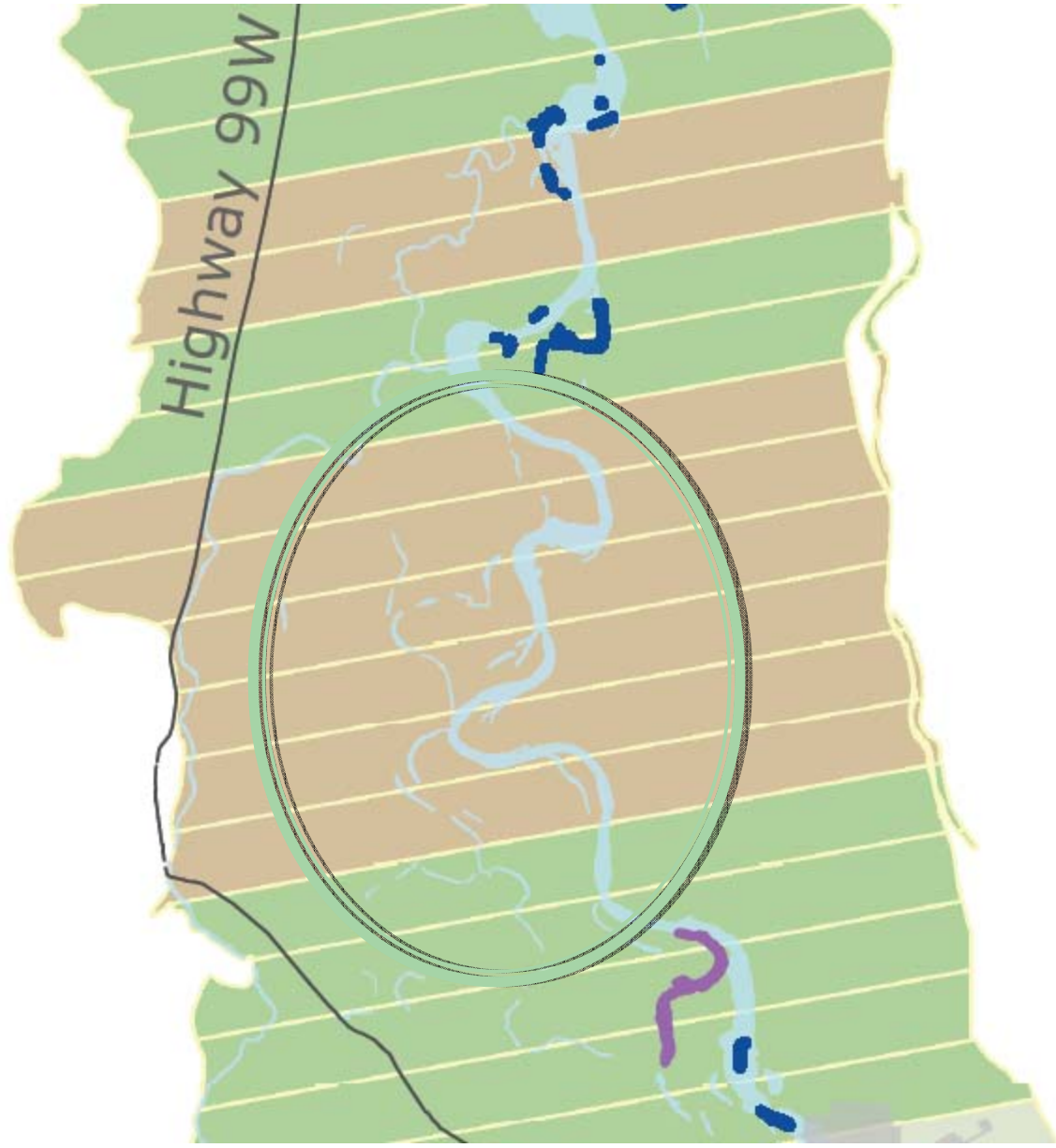


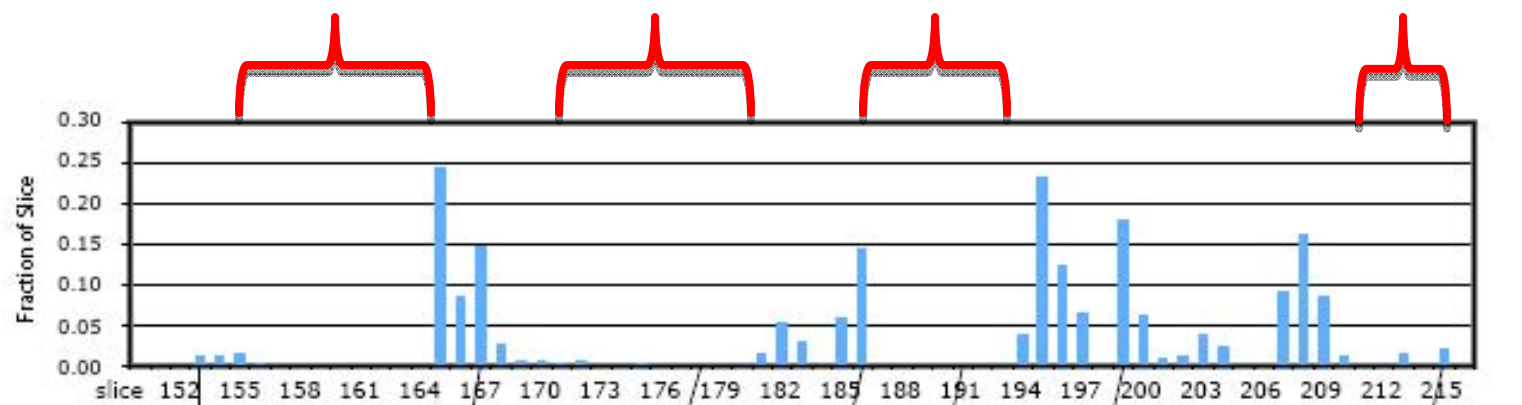




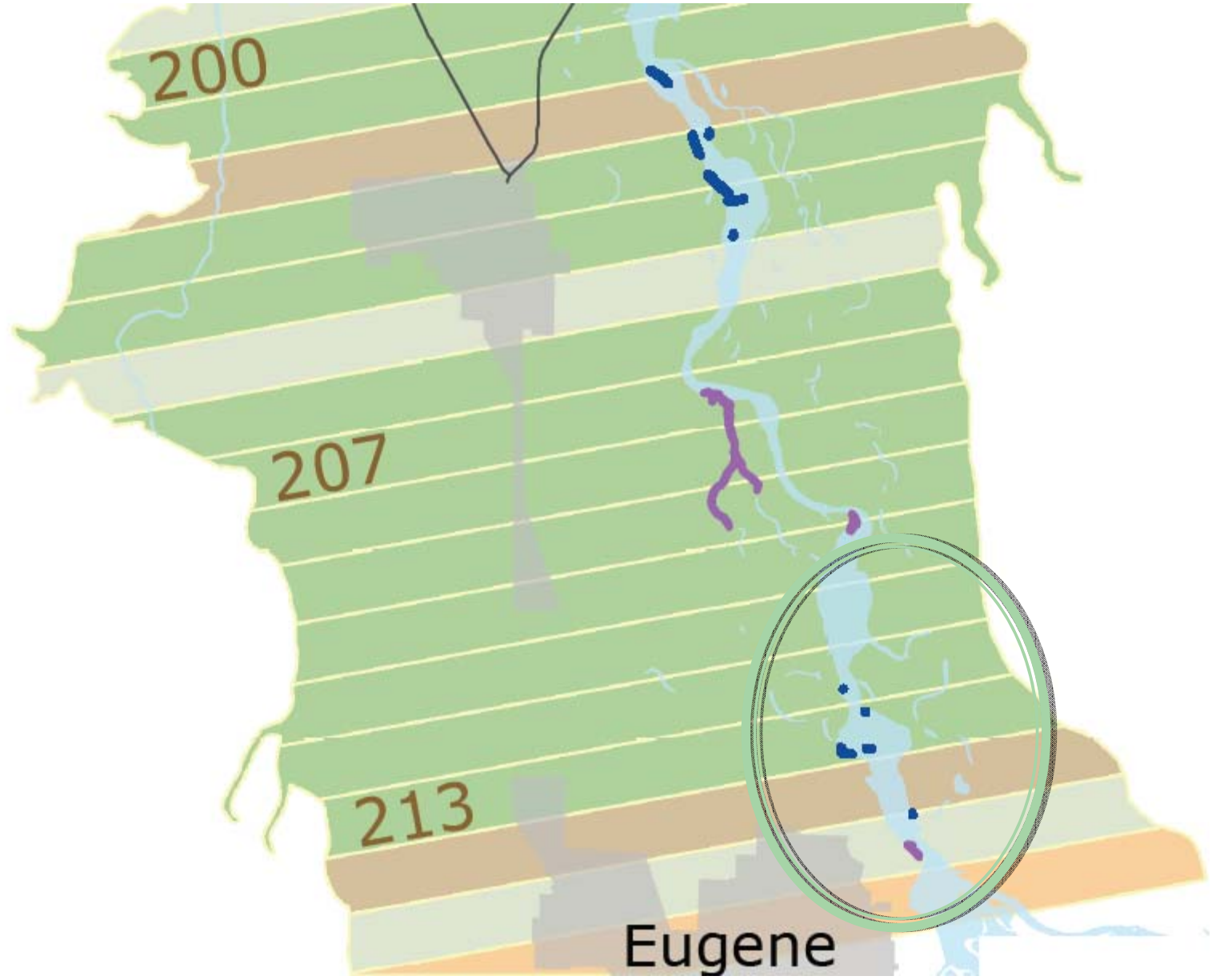












Green Island





Assessment Tools for Past, Present, and Future Ecological Trajectories

- Dynamic visualizations of trajectories of ecological change and demonstration of hyporheic processes
- Prioritization system for river conservation and restoration

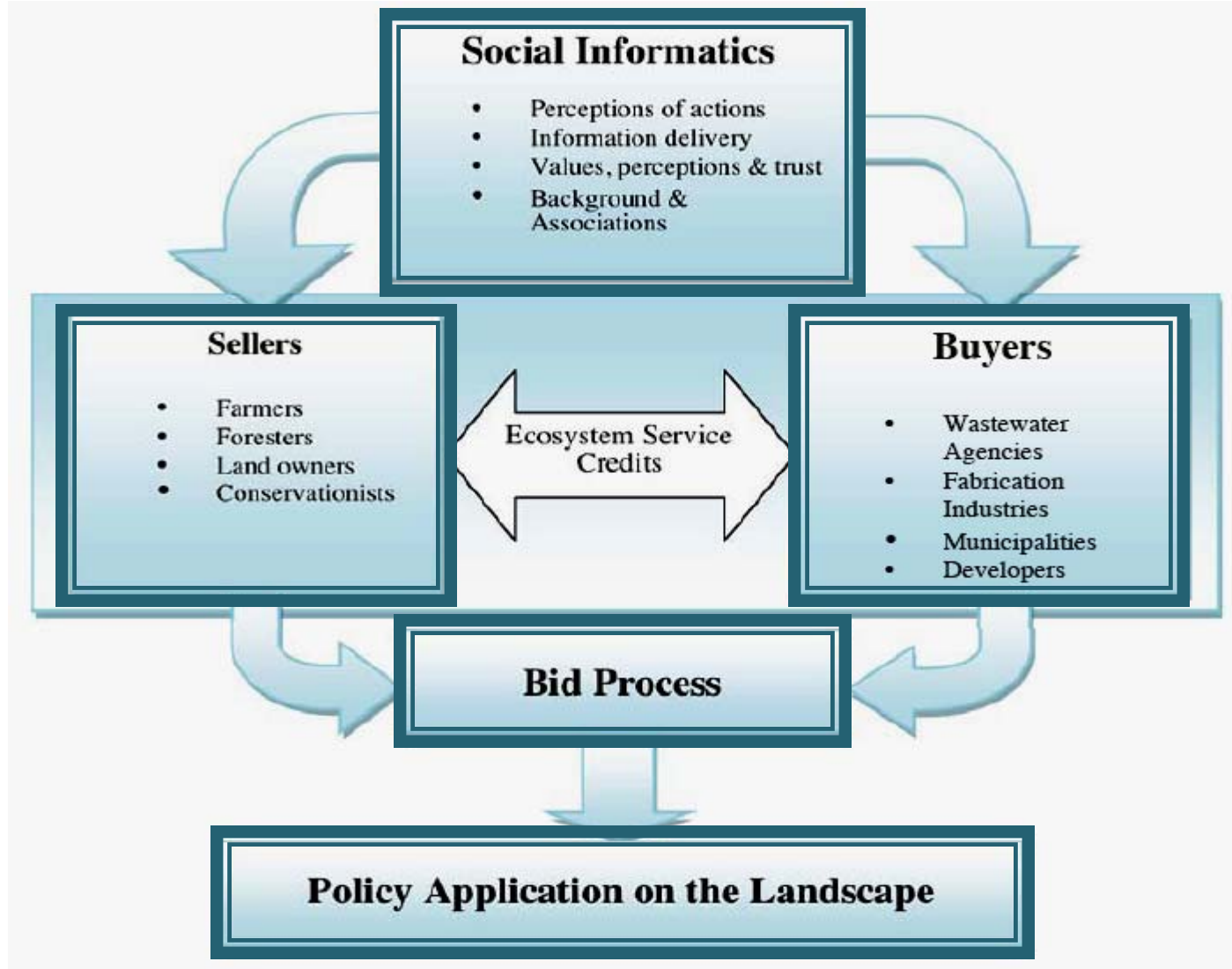
Assessment Tools for Past, Present, and Future Ecological Trajectories

- Assessment of thermal patterns and strategies for restoration of cold water refuges
- Development of an ecological credit trading system

Trading Credits in Willamette Exchange

- Thermal credits
- Wetlands credits
- Carbon credits

Market-Based Trading System



Future Directions

- Oregon Watershed Enhancement Board has funded a 3-yr study of fish use of cold water refuges to determine whether the restoration of cold water habitats would have a positive effect on designated beneficial uses under the Clean Water Act.



Future Directions

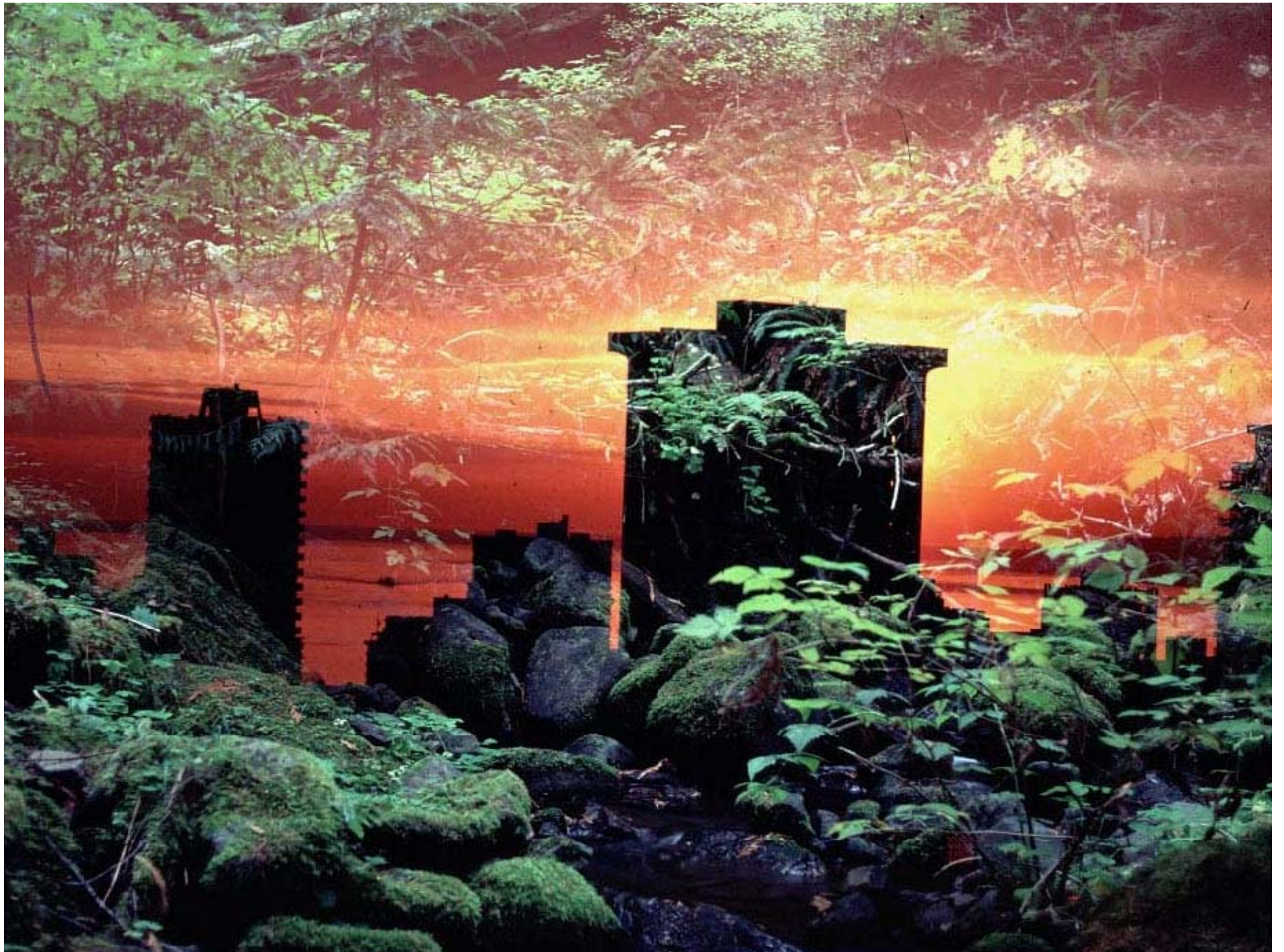
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Future Directions

- Measure composition of fish assemblages in habitats colder and warmer than mainstem river
- Implant temperature loggers and radios in cold water species
- Determine movement rates between cold water refuges





Credit Trading Sequence

Willamette Partnership

- Technical assistance provided by cooperators
 - Agencies, NGOs, Extension agents
- Evaluate site potential
- Plan restoration actions
- Identify regulatory requirements
- Register credits with Willamette Exchange
- Sell to credit buyer or aggregators
- Seller tracks and reports performance

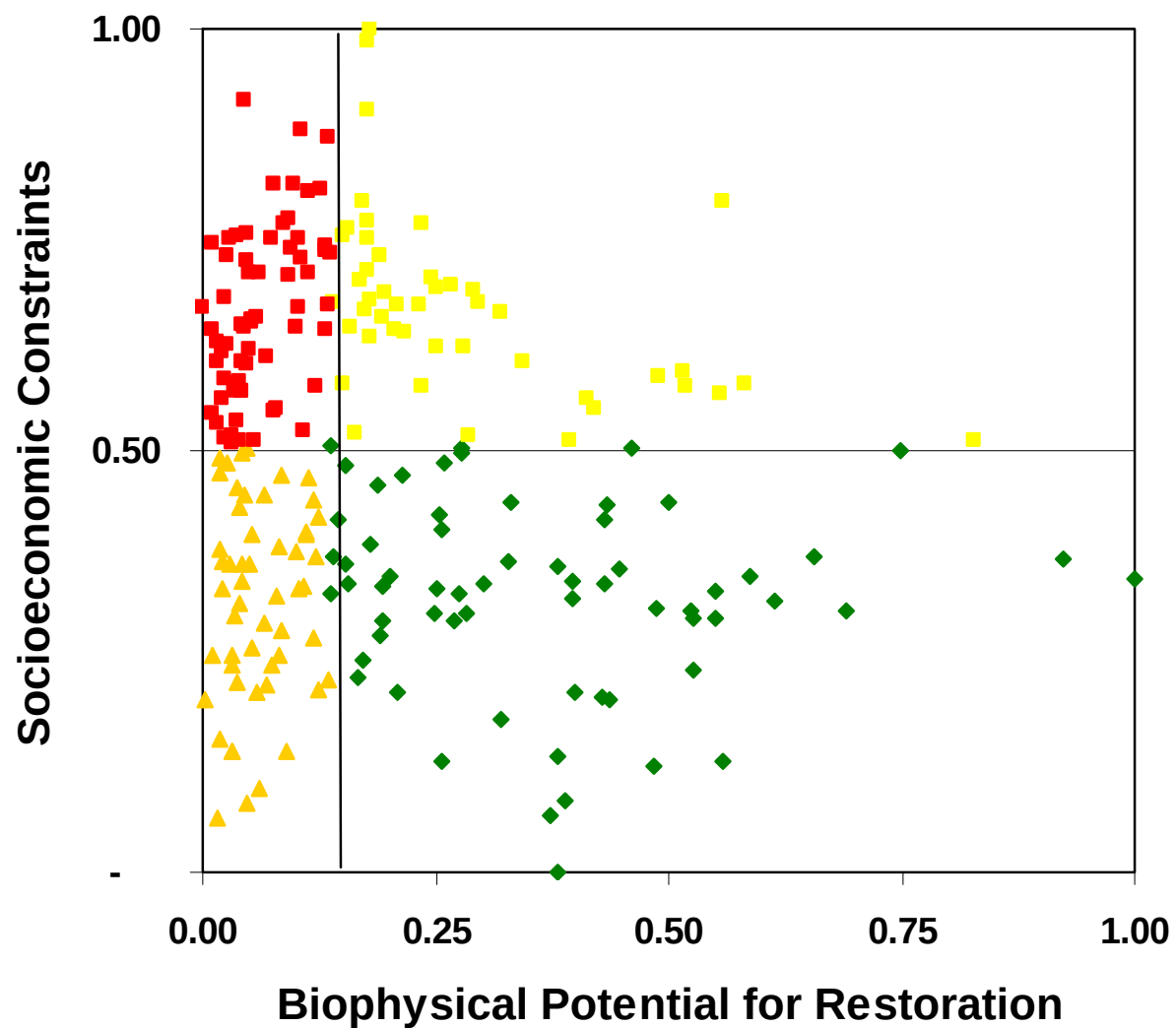
Application of Research

- Willamette Explorer Website for public, watershed councils, and students
- Conservation and restoration opportunities template adopted by state of Oregon
- Southern Willamette basin communities developed Region 2050 Plan for water resources based on alternative futures

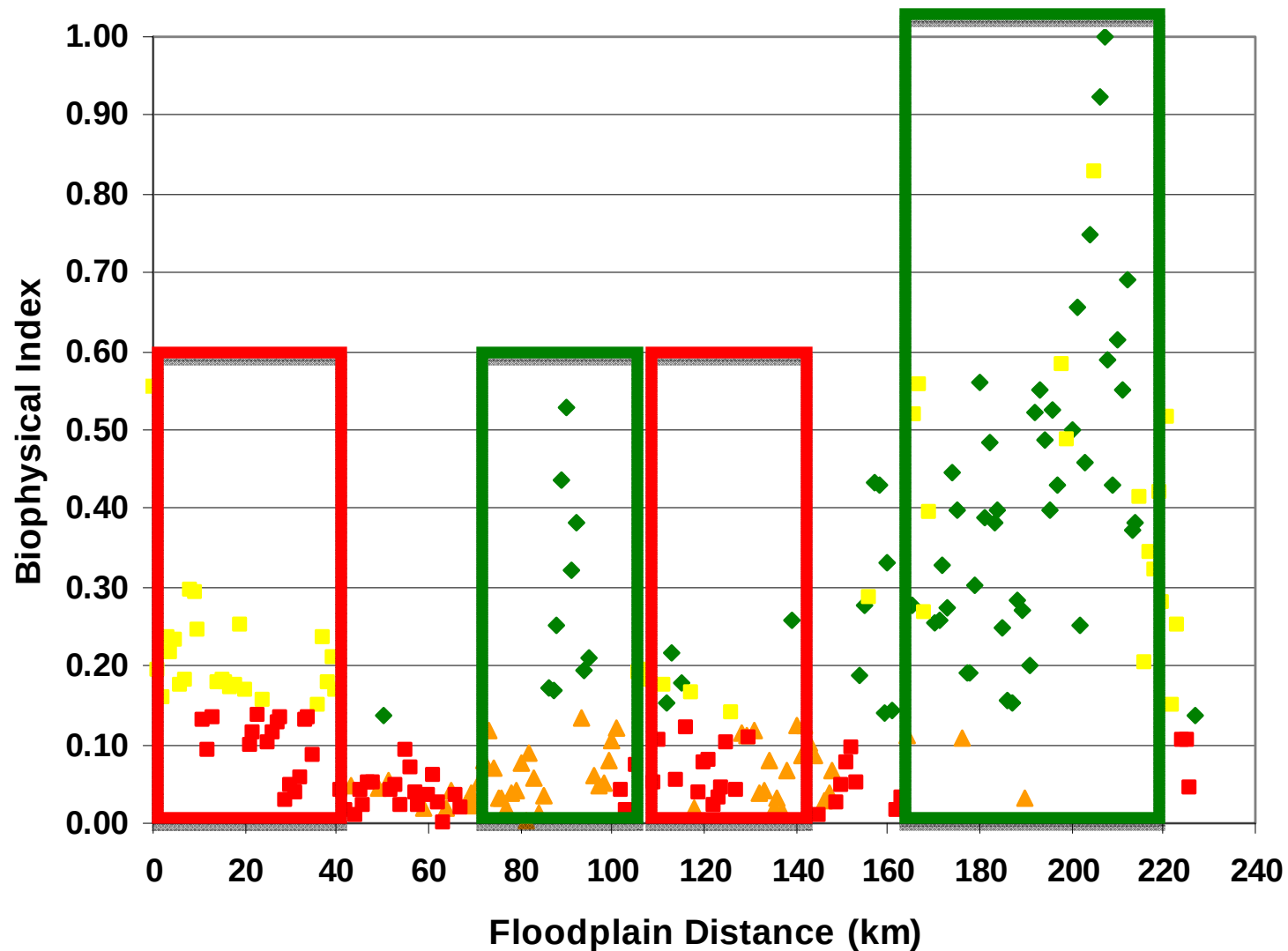
Application of Research

- Green Island Restoration Project incorporates research and concepts in designing and monitoring restoration
- Willamette Exchange credit trading system based on thermal research
- Oregon Sustainability Investments Program will use Willamette River prioritization approach to locate and design major restoration efforts

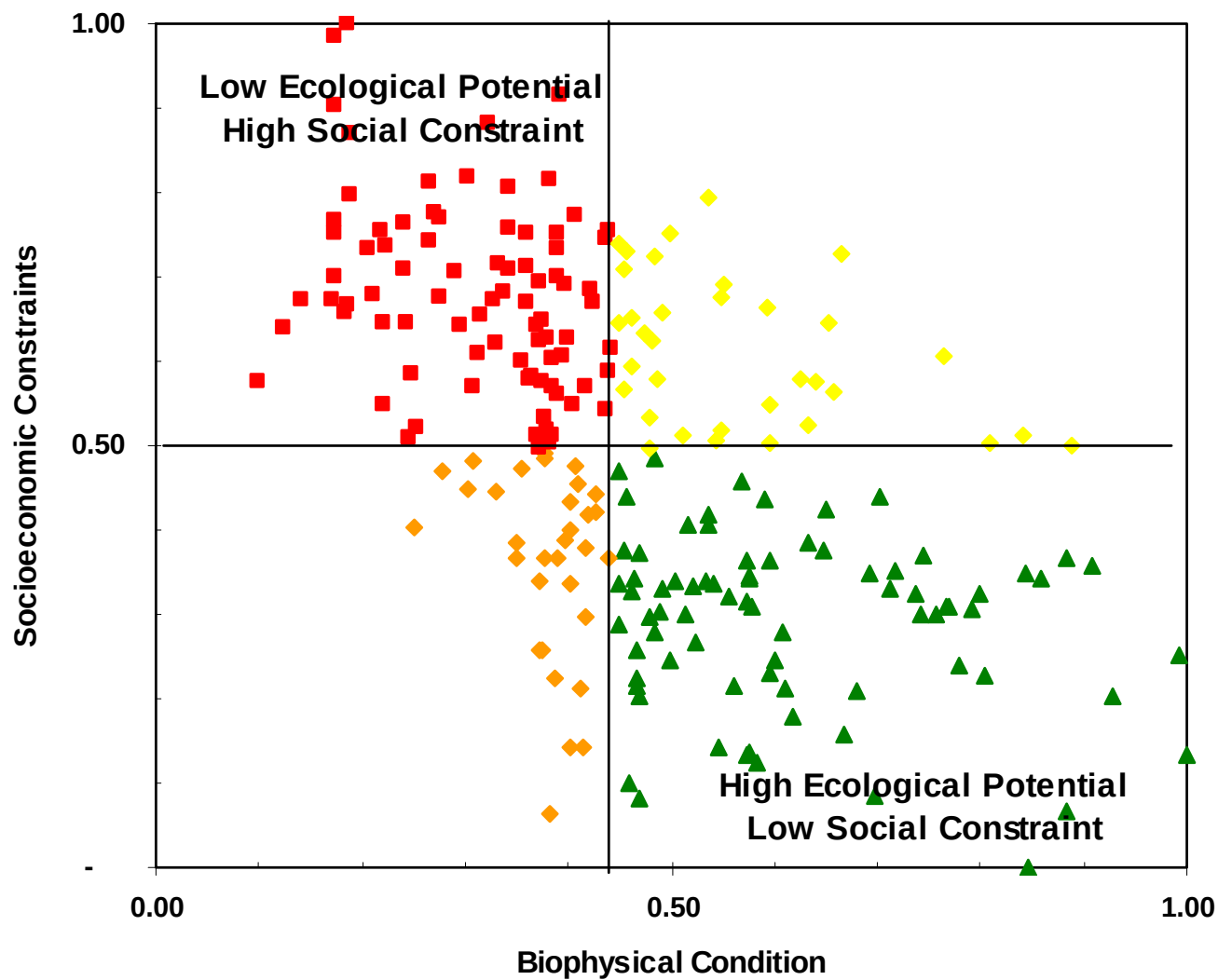
Restoration Priorities



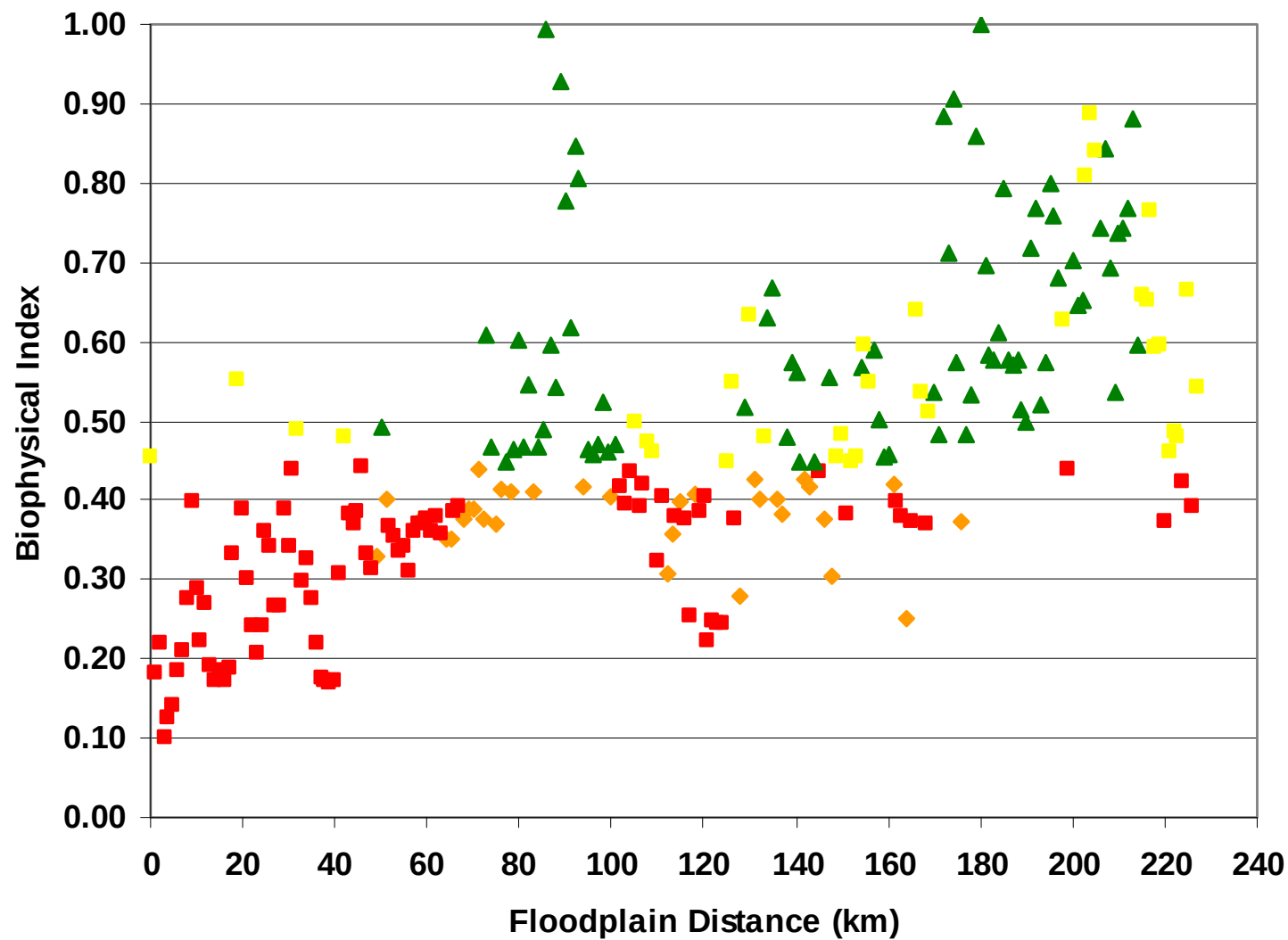
Restoration Priorities



Conservation Priorities



Conservation Priorities

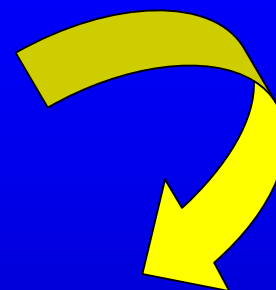


Relative Potential for Restoration

Demographic and Economic
Constraints

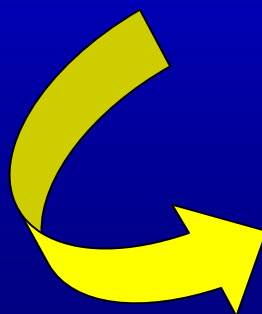
Low Ecological
Potential

High
Demographic &
Economic
Constraints



High Ecological
Potential

Low Demographic &
Economic
Constraints



Ecological Benefit

Hulse and
Gregory 2004

Max $\Delta T_{\max}$

EXH₂O=Light Extinction from Water

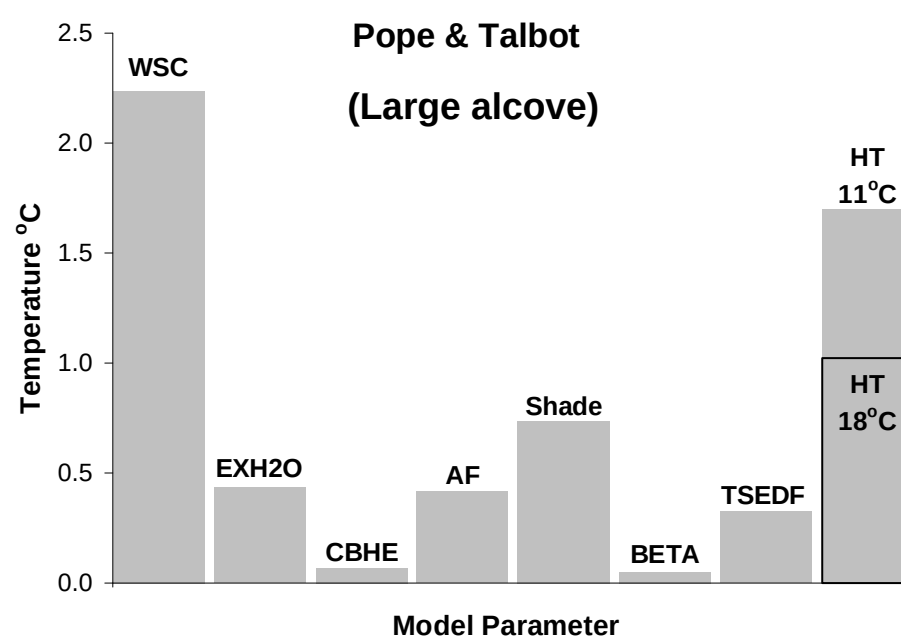
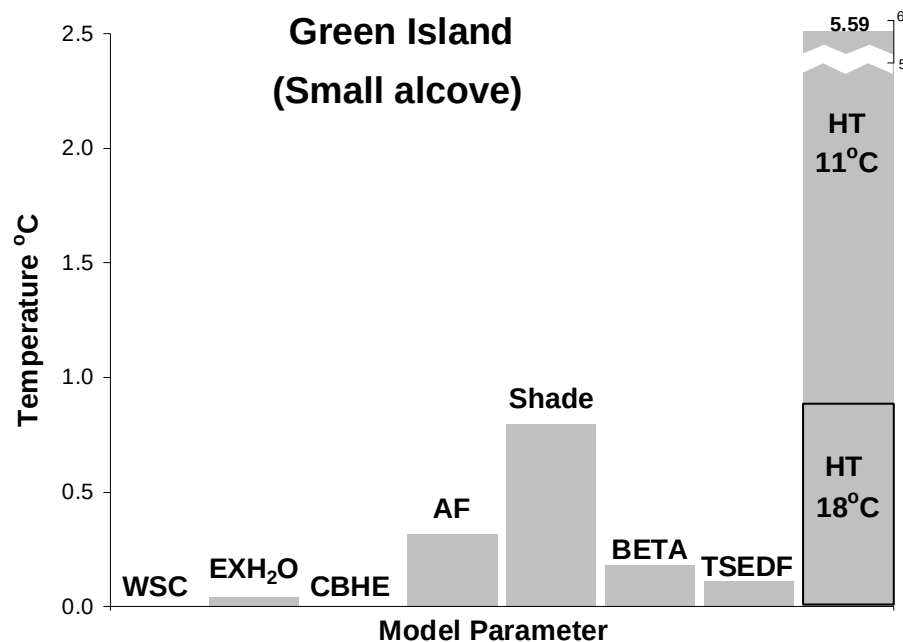
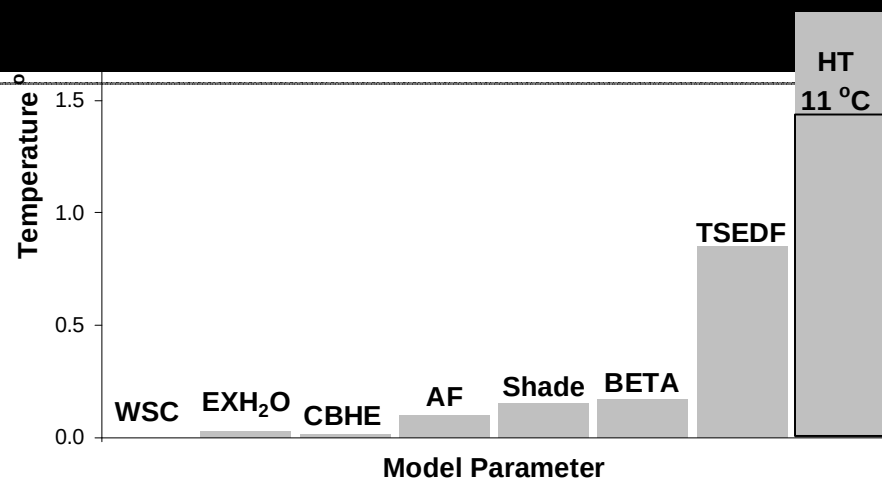
CBHE=Coefficient of Bottom Heat Exchange

AF=Alcove Flux

Shade=Topographic and Vegetative Shading

BETA=Solar Radiation Absorbed at Surface

TSEDF=Sediment Reflection of Solar Radiation



Conclusions

- Alcove size and flux largely determines meteorological impact
 - Large alcoves more affected by meteorological conditions (shade, wind, etc.) because of large surface area and long residence times
 - Small alcoves more affected by advection and residence time (and therefore by hyporheic processes) because of small surface area and short residence times

Conclusions – Small Alcoves

- Hyporheic temperature (or the temperature of any subsurface inflow) is the main driver of small alcove temperature
- Lag time of hyporheic flow determines its temperature
 - Lag time of hours to days can produce water that is out of phase with mainstem but with the same avg. temperature
 - Lag time of months or longer will have lower avg. temp than mainstem. However, long lag times are also associated with low hydraulic conductivity and therefore low total flow.

Conclusion – Restoration

- Features conducive to subsurface flow (i.e., gravel bars) must be continuously formed and maintained
- This process is impaired by altered flow regimes and bank hardening

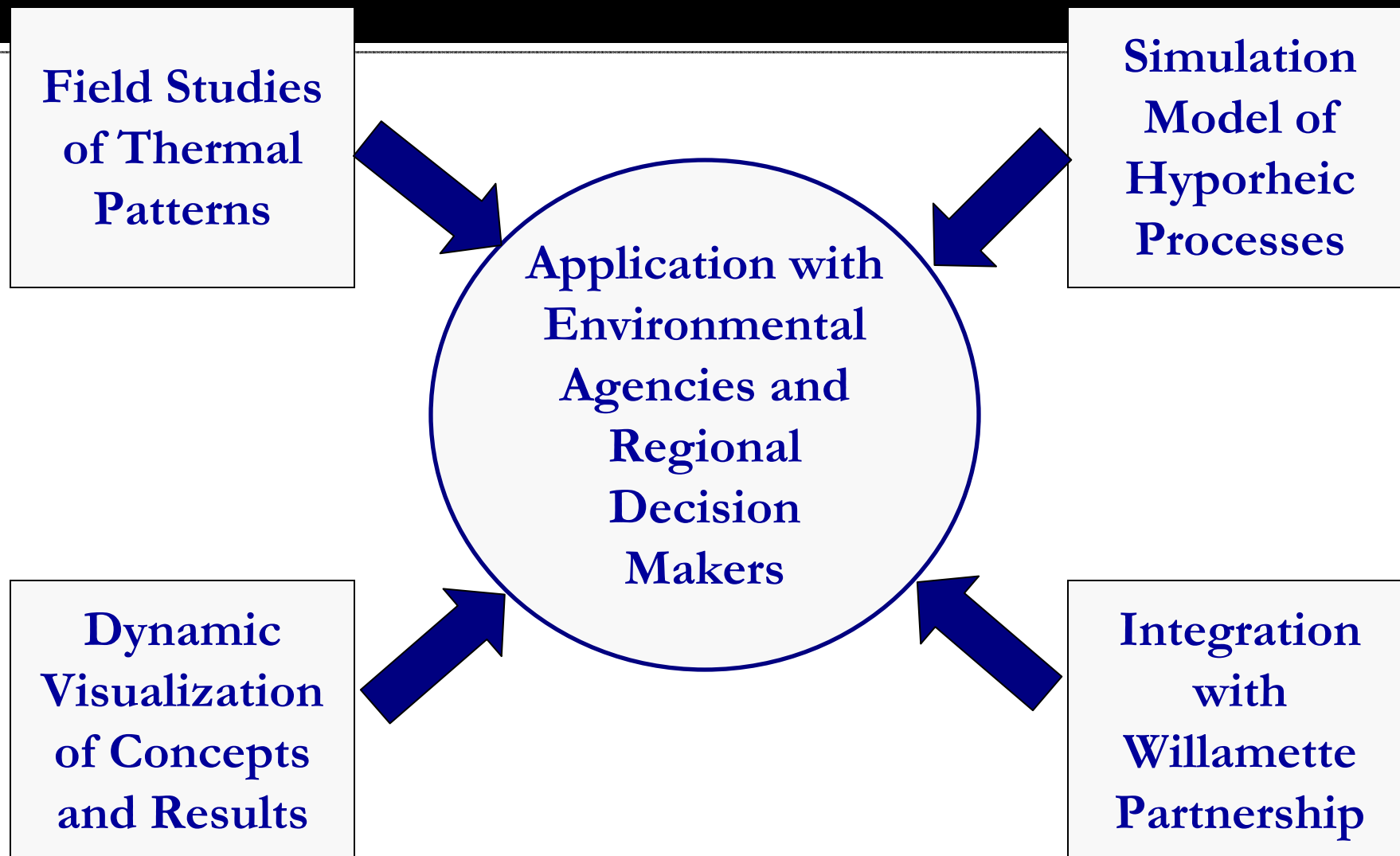
Contribution to Sustainability

- Provides the scientific basis for meeting thermal TMDL goals by restoring coldwater refuges in a large river through a market-based collaborative system.
 - Identifies locations of coldwater refuges
 - Models hyporheic influence on temperature
 - Creates dynamic visualization of complex information for stakeholders
 - Provides spatial framework for decision makers
 - Works directly with stakeholders and environmental agencies to solve environmental challenges

Contribution to Sustainability

- Restoration projects that have been initiated by this research will provide multiple ecosystem services:
 - Cold water
 - Nutrient uptake
 - Floodplain function
 - Riparian forest restoration
 - Channel and habitat complexity
 - Wildlife habitat
 - Recreation and aesthetic values for communities

Project Organization



Surprising Results

- Coldwater refuges (3-8°C lower than mainstem) were found in all study reaches.
- Alcoves on floodplains exhibited the coldest thermal environments.
- Alcoves on gravel bars exhibited temperature both colder and warmer than the mainstem.
- State environmental agencies have officially accepted floodplain restoration to create coldwater habitats as part of TMDL permits.
- Willamette Partnership used the project results and dynamic visualizations to develop a market-based system for restoration of the Willamette River corridor.

Collaborators and Partners

- Oregon State University
- University of Oregon
- Willamette Partnership
- EPA Corvallis NHEERL, Western Ecology Division
- Oregon Department of Environmental Quality
- Metropolitan Wastewater Management Commission
- City of Eugene, Oregon
- McKenzie River Trust
- Oregon Department of Fisheries & Wildlife
- US Department of Agriculture
- US Fish & Wildlife Service
- National Marine Fisheries Service