

US EPA ARCHIVE DOCUMENT

# **Sustaining Multiple Benefits in Large River Floodplains in the Pacific Northwest**



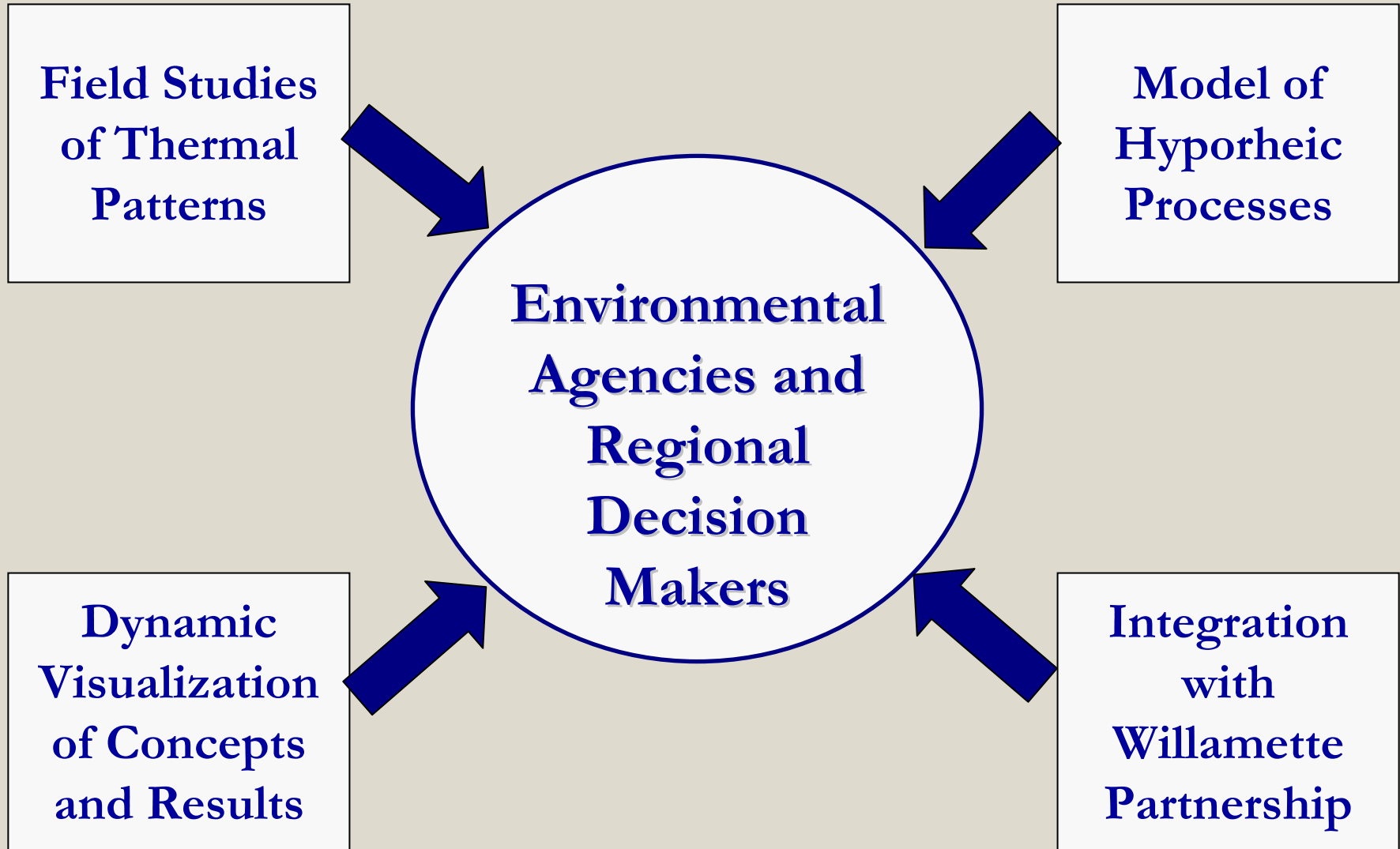
**Stan Gregory, David Hulse, Roy Haggerty**  
**Oregon State University**  
**University of Oregon**



# Sustaining Multiple Benefits in Large River Floodplains in the Pacific Northwest



# Project Organization







# Typology of Thermal Habitats

- Geomorphic
- Hydraulic
- Hyporheic
  - Dynamics not demonstrated empirically





**Bar Alcoves**



# Embayment



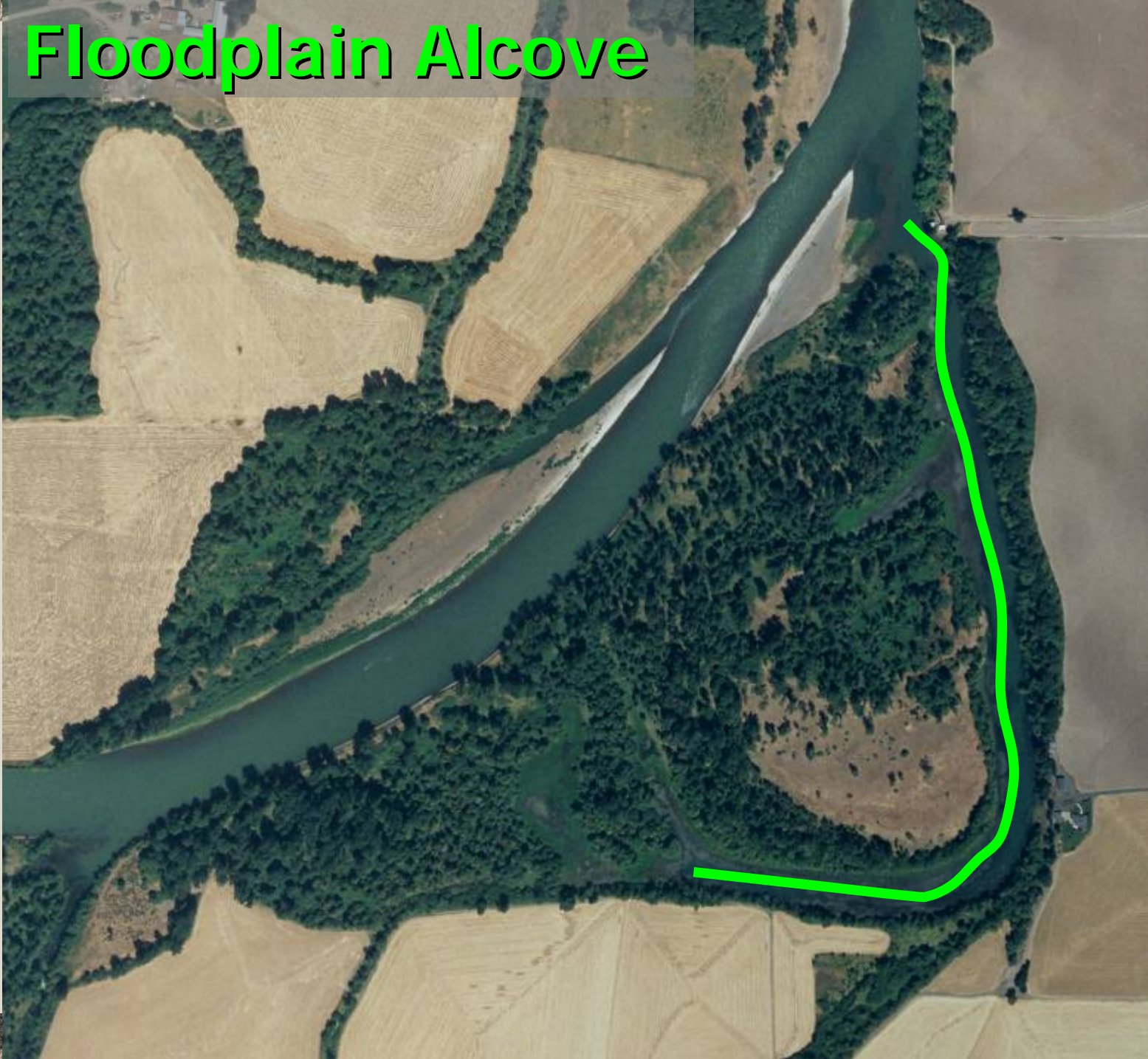


An aerial photograph of a river system. A main river flows from the top right towards the bottom center. A side channel branches off to the left, highlighted by a thick red line. The side channel flows through a mix of green forest and brownish, possibly marshy or agricultural, land. The main river has a large, light-colored sandbar in its upper section. The surrounding landscape includes large, rectangular agricultural fields in shades of tan and yellow, and dense green forested areas.

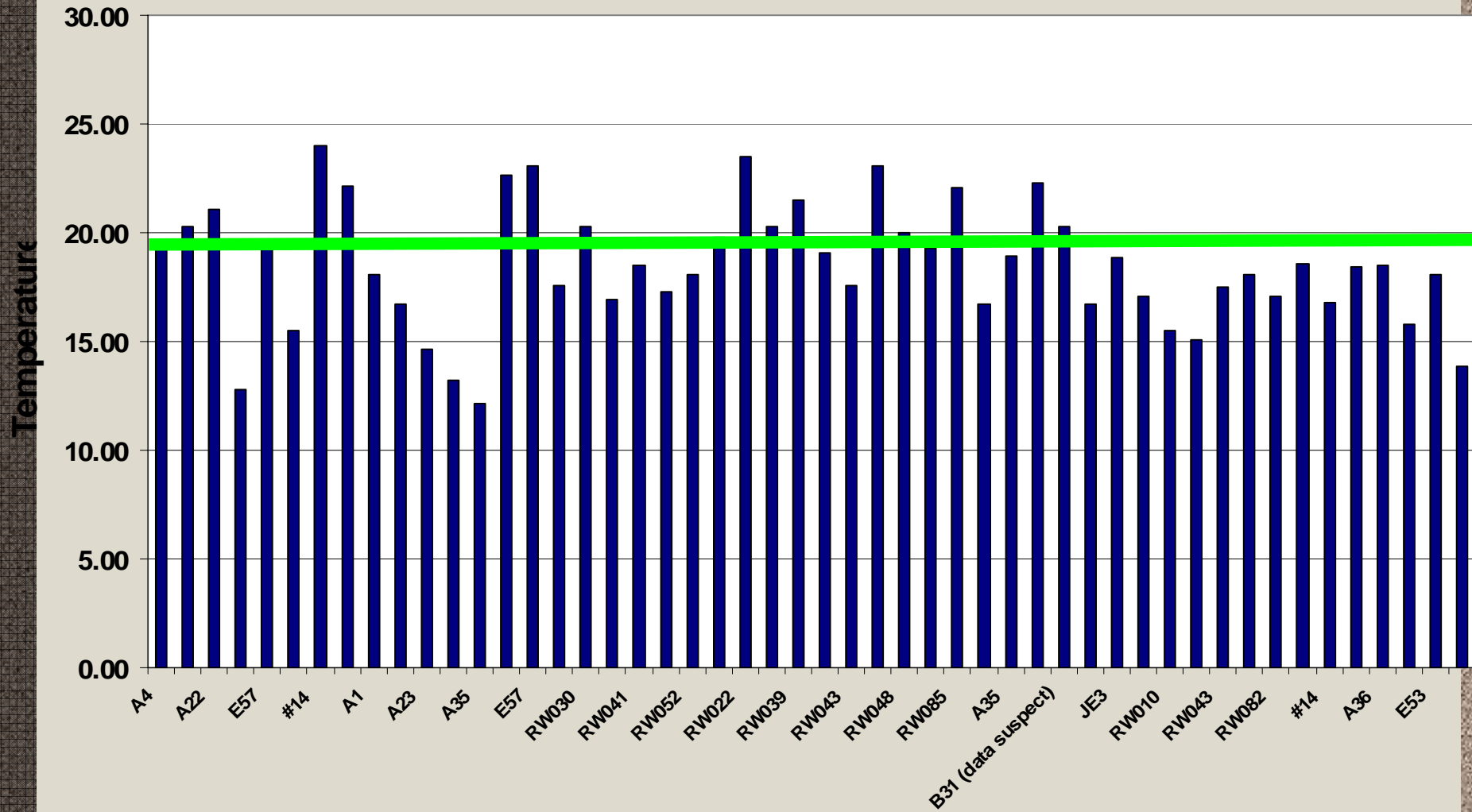
**Side Channel**



# Floodplain Alcove

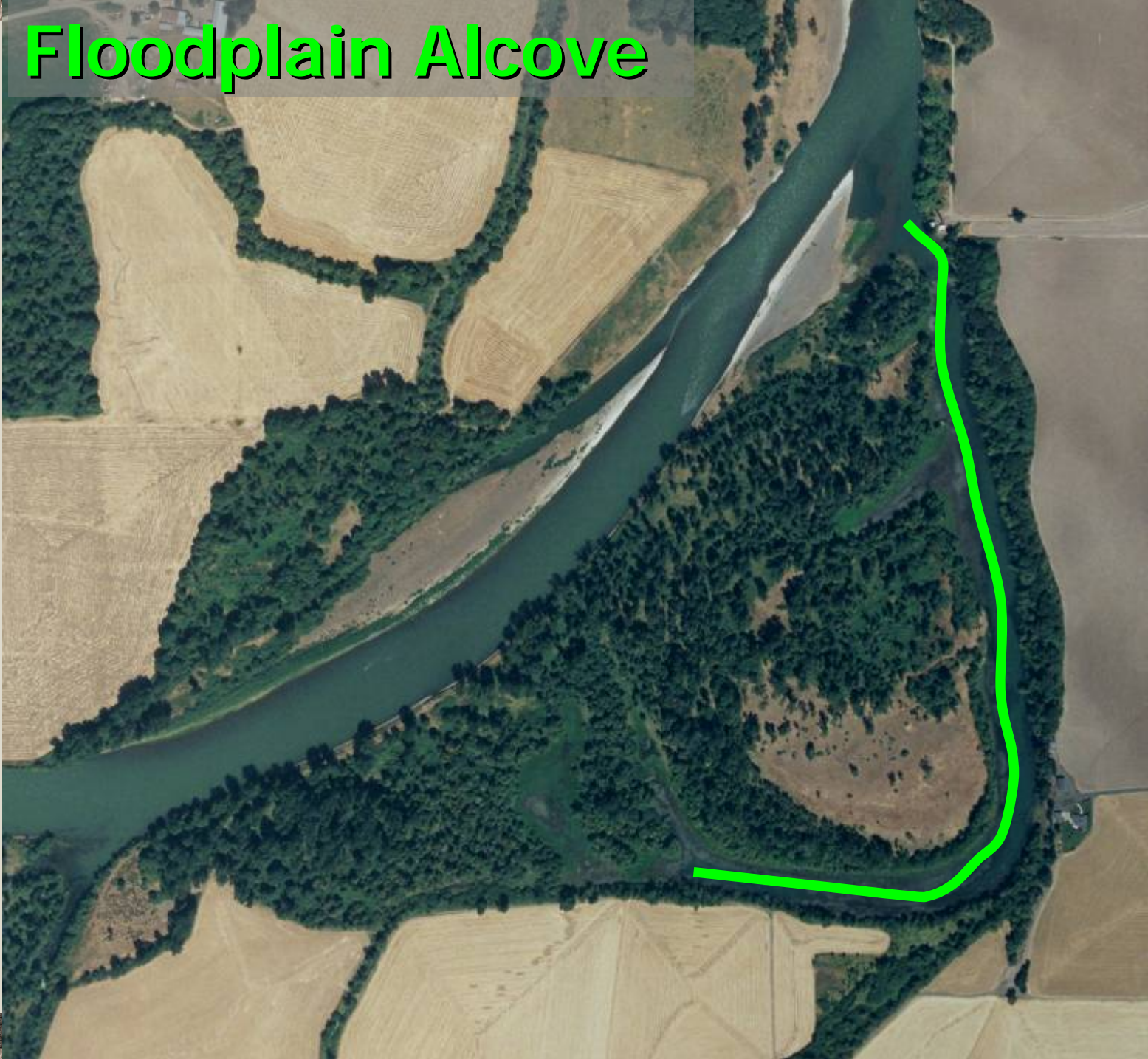






Small Alcove on Floodplain

# Floodplain Alcove







# Temperature

4.9 above mainstem average max,  
warmest Norwood temperature

10

6

4

2

1

0

-1

-2

-4

-6

-7

-8.5

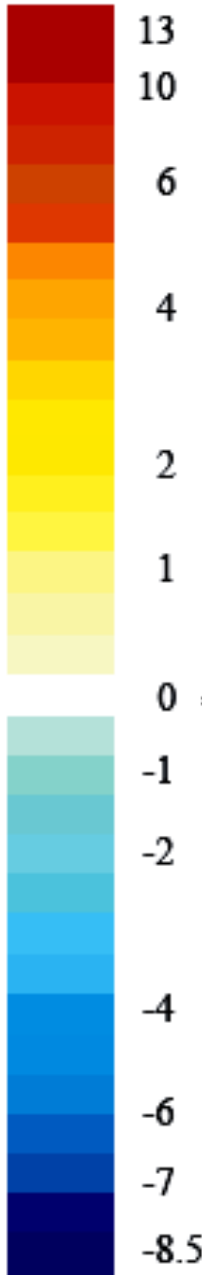
0 = 20.3°C mainstem average max  
for Norwood Island

-8.4 below mainstem average max,  
coolest Norwood temperature





# Temperature



# Temperature





# MODELING

Estimate HE



CE-QUAL-W2

$$t = \frac{Ln_e}{Ki}$$

Where:

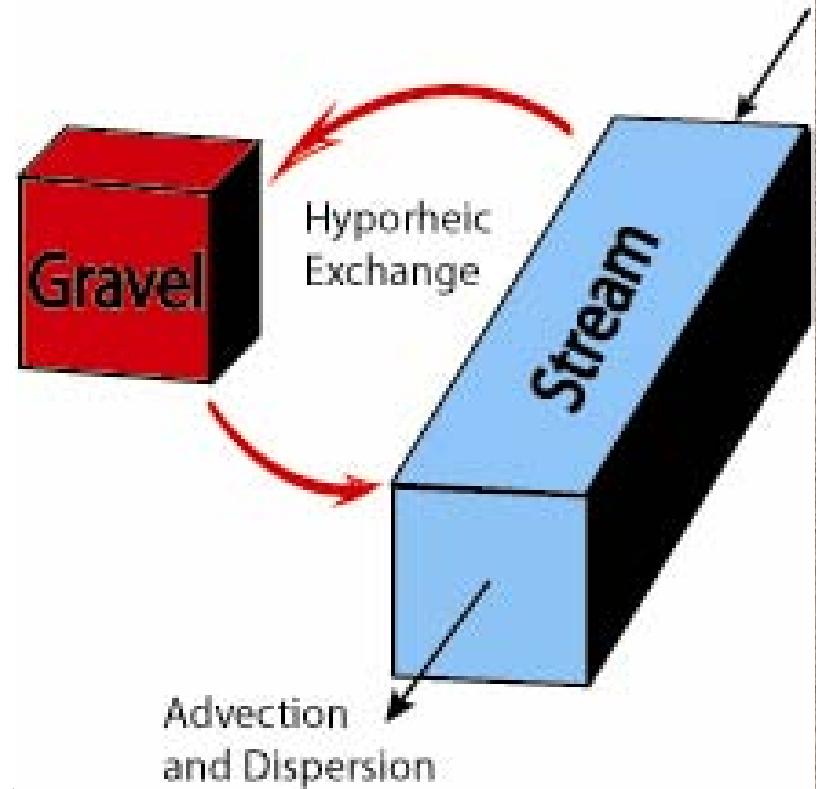
$t$  = time of travel

$L$  = flow path length

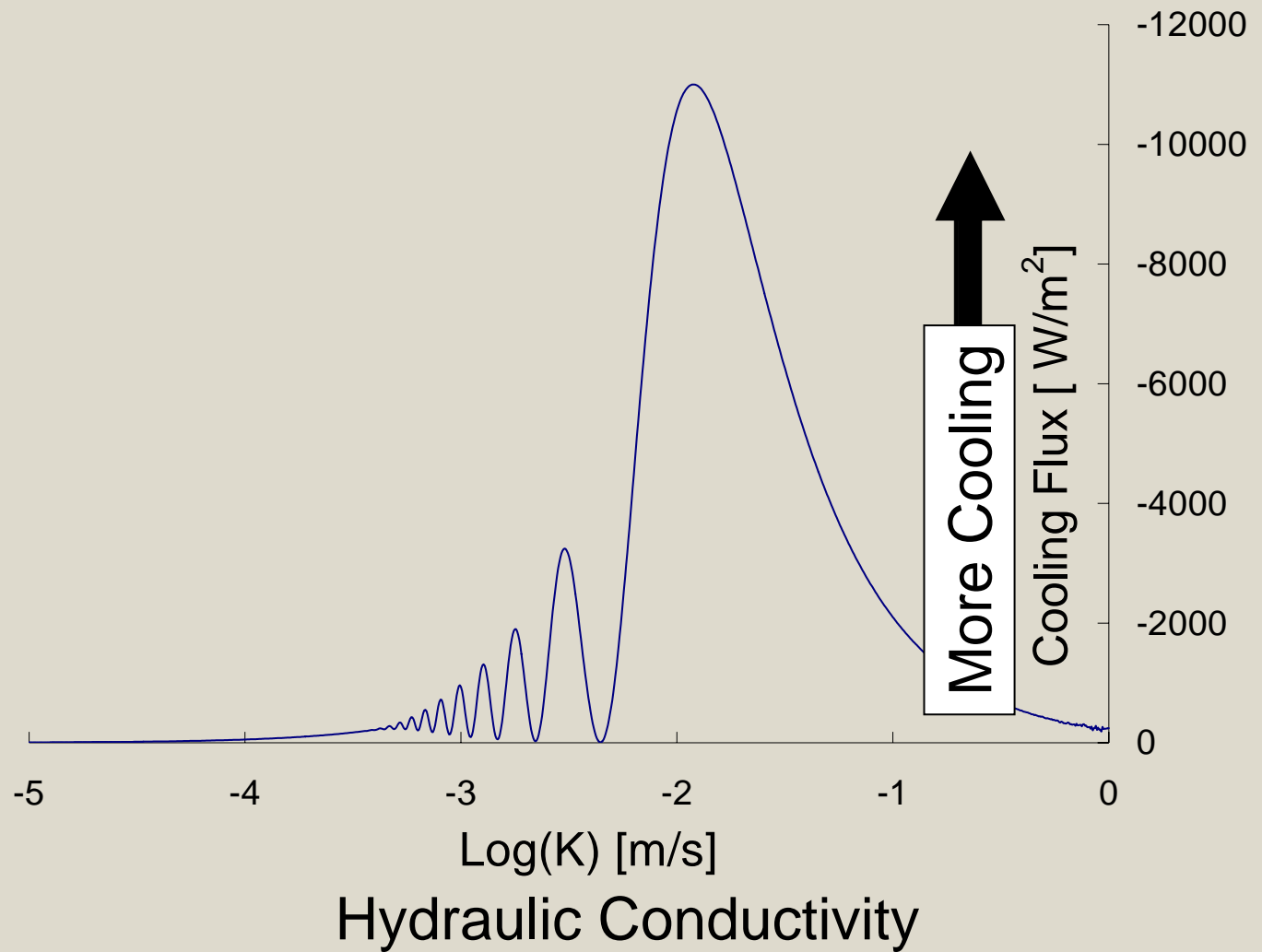
$n_e$  = porosity

$K$  = hydraulic conductivity

$i$  = stream gradient



# Hyporheic Cooling vs Hydraulic Conductivity



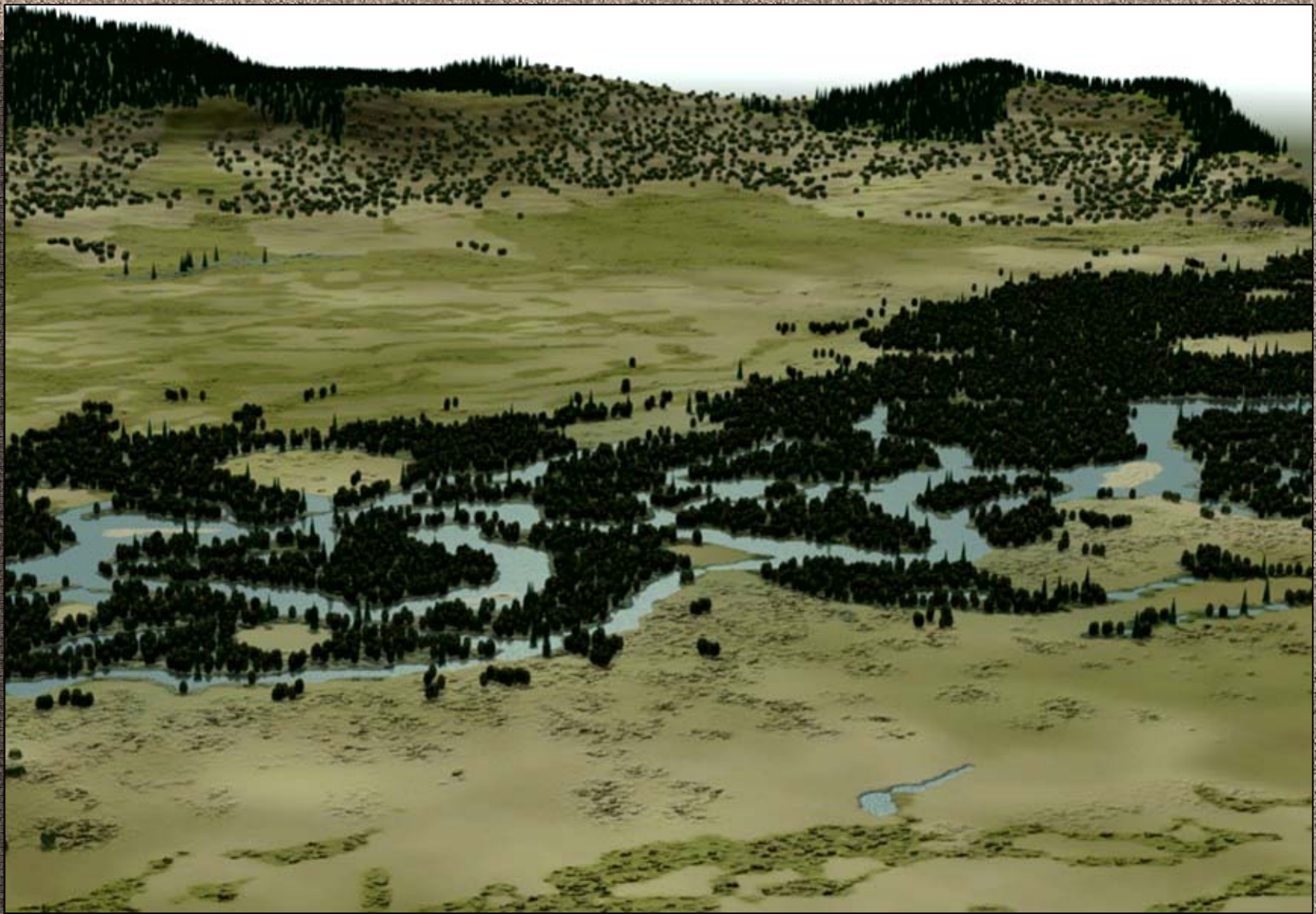




**1995**

Baker et al. 2004  
Ecological Applications

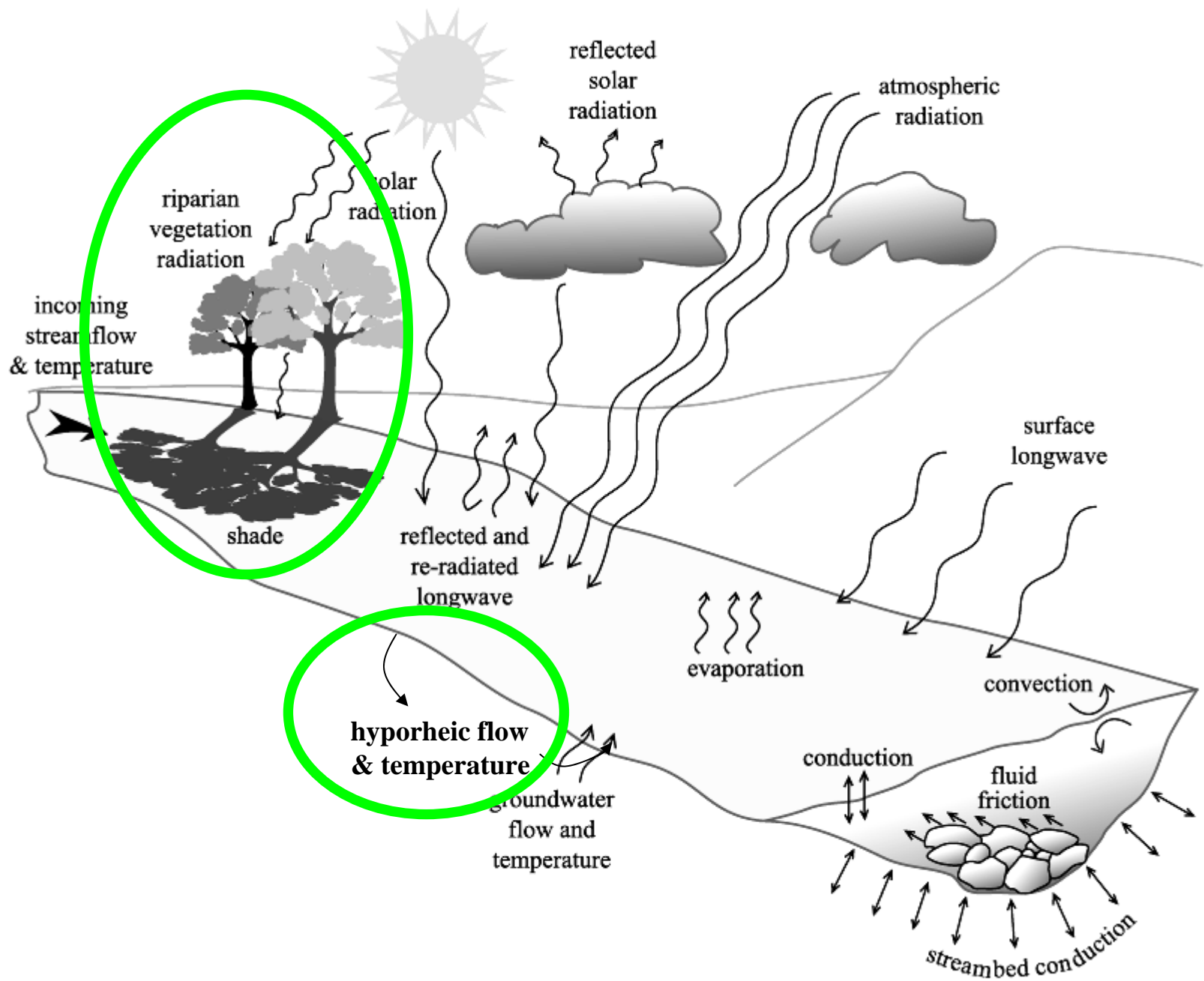


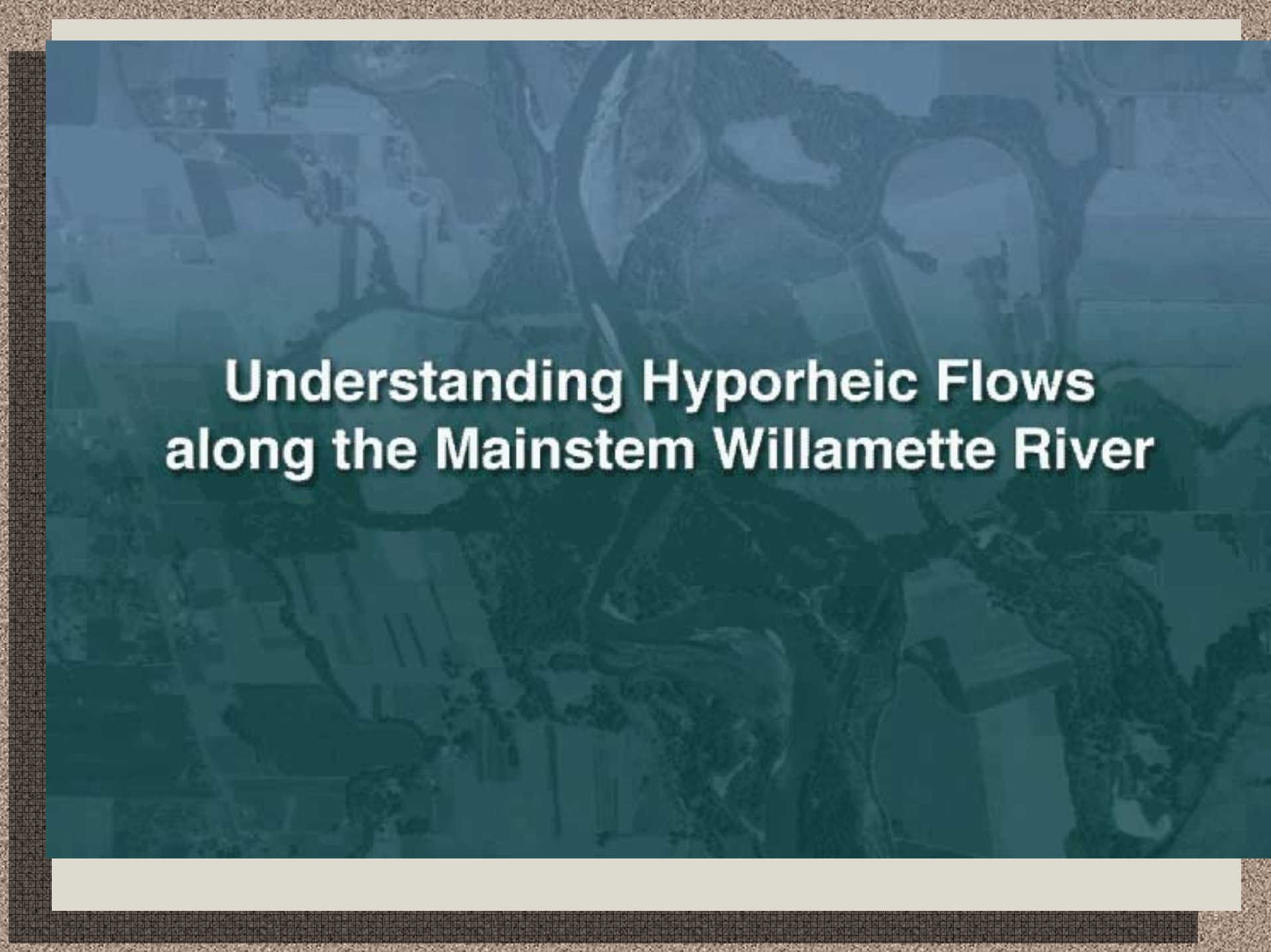


**1850**

Baker et al. 2004  
Ecological Applications





An aerial photograph of a river system, likely the Willamette River, is shown with a semi-transparent blue overlay. The river winds through a landscape of fields and some developed areas. The text is centered over the middle of the image.

# **Understanding Hyporheic Flows along the Mainstem Willamette River**









## 2050 Conservation Scenario

Baker et al. 2004  
Ecological Applications







An aerial photograph of a river system. A large, light-colored, crescent-shaped oxbow lake is on the left, separated from the main river channel by a narrow strip of land. The river channel is dark and winding, with several smaller, similar features branching off. The surrounding landscape is a mix of green forest and light-colored agricultural fields. The text "Dynamic Channel Features" is overlaid in a semi-transparent grey box on the right side of the image.

# Dynamic Channel Features





# **Multiple Benefits of Floodplain and Channel Restoration**

- **Coldwater refuges**
- **Nutrient uptake**
- **Sediment storage**
- **Flood detention**
- **Habitat complexity**
- **Large wood**
- **Shade**
- **Fish and invertebrate communities**
- **Wildlife communities**
- **Riparian forests**
- **Visual acceptance**
- **Recreation**
- **Alternatives for communities**



**Can agencies  
and  
stakeholders  
work together?**

**When citizen  
values and legal  
requirements  
are consistent**



# Market-based Solutions

- **Restoration goals**
- **Social benefits**
- **Legal requirements**
- **Landowner incentives**
- **Compensation for flood damage**
- **Community perception**





# CNS Assistance

- **Provided funding for first field survey of river temperatures in Willamette River.**
- **Provided working relationship with EPA-funded Willamette partnership**
- **Provided funding for developing dynamic visualizations of concepts and river data**



# Contribution to Sustainability

- A scientific basis for meeting thermal TMDL goals by restoring coldwater refuges in a large river through a market-based collaborative framework.
  - Locations of coldwater refuges
  - Model of hyporheic influence on temperature
  - Dynamic visualization of complex information for stakeholders
  - Spatial framework for decision makers
  - Working directly with stakeholders and environmental agencies to solve environmental challenges



# Contribution to Sustainability

- Restoration efforts also provide multiple ecosystem services and social benefits
  - Cold water refuges
  - Floodplain function
  - Riparian forest restoration
  - Channel and habitat complexity
  - Hyporheic processes
  - Wildlife habitat
  - Recreation
  - Aesthetic values for communities along the river

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

# Requested Feedback

- *Do you have any information on use of coldwater refuges by aquatic organisms?*



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- *Can fish or other aquatic organisms use coldwater refuges as “stepping stones” during periods of thermal stress?*

# Requested Feedback

- Do you have any information on use of coldwater refuges by aquatic organisms?
- Can fish or other aquatic organisms use coldwater refuges as “stepping stones” during periods of thermal stress?
- *Can market systems be used to create “compensation banks” to compensate land owners for property loss in a floodplain corridor?*



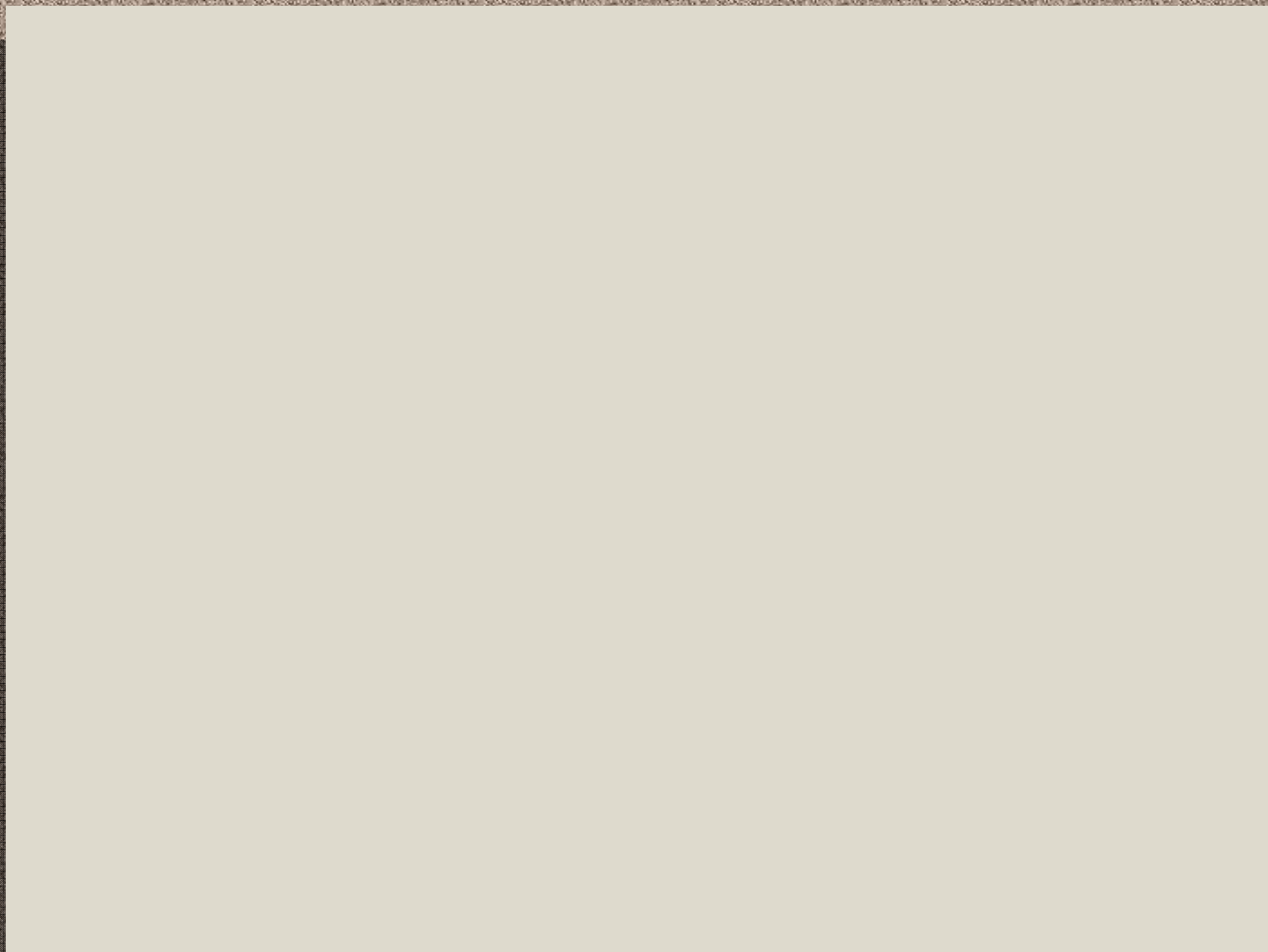
# Requested Feedback

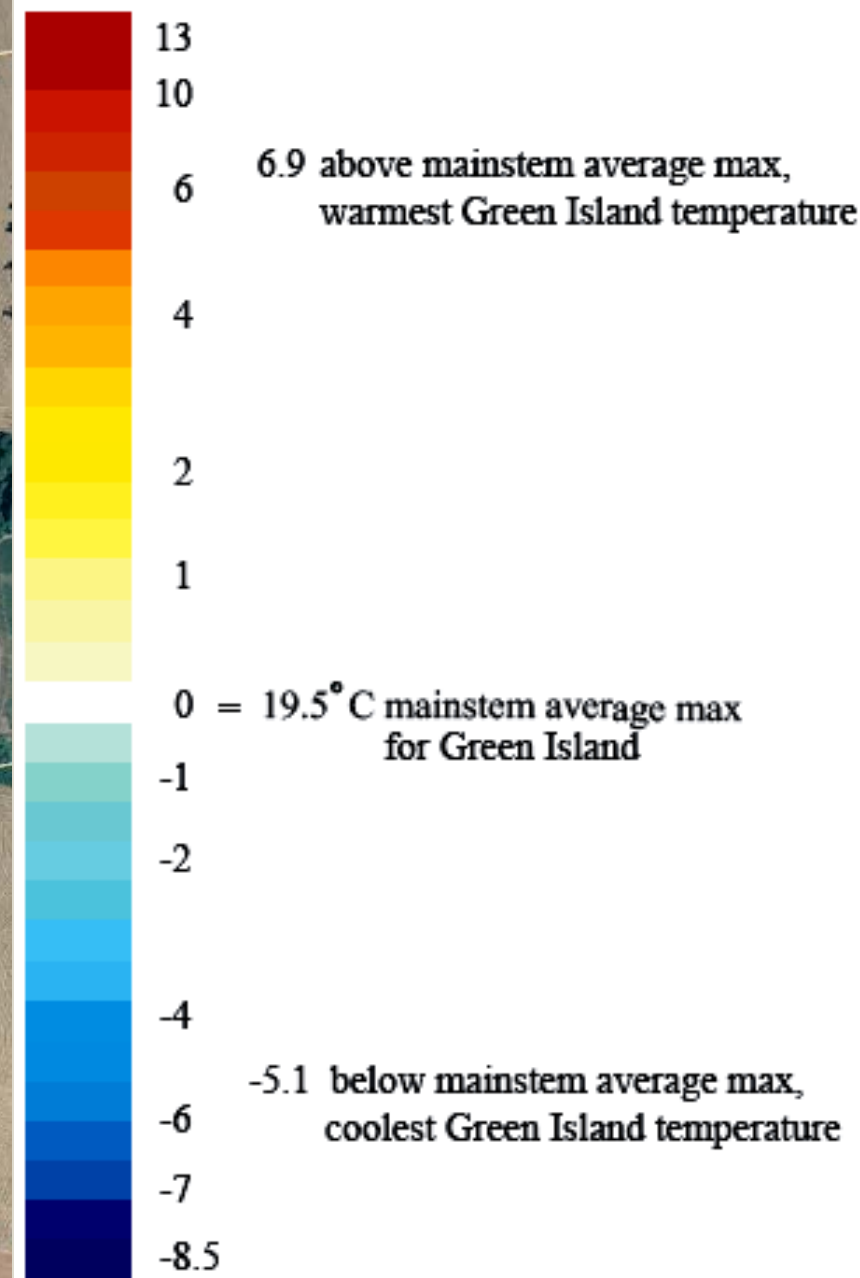
- *Do legal restrictions on participation in mitigation create barriers for collaboration with federal or state agencies?*

# Requested Feedback

- Do legal restrictions on participation in mitigation create barriers for collaboration with federal or state agencies?
- *Do you have other examples of landscape studies of ecosystem services linked to analysis of alternative future scenarios?*











13

10

6

4

2

1

0

-1

-2

-4

-6

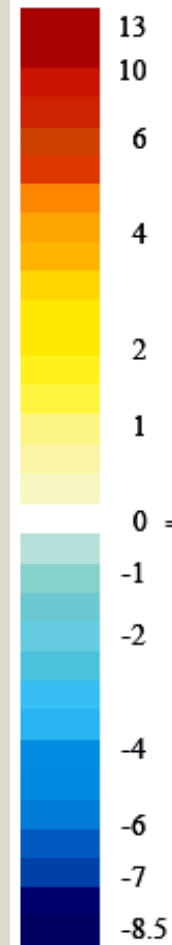
-7

-8.5

2.4 above mainstem average max,  
warmest Sam Daws temperature

0 = 20.4° C mainstem average max  
for Sam Daws Bend

-5.9 below mainstem average max,  
coolest Sam Daws temperature

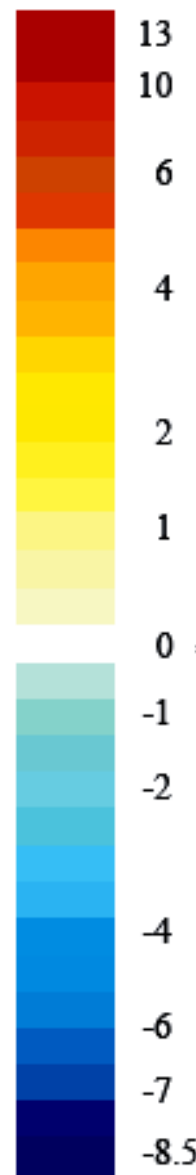


9.0 above mainstem average max,  
warmest Snag Boat temperature

0 = 19.6°C mainstem average max  
for Snag Boat Bend

-2.8 below mainstem average max,  
coolest Snag Boat temperature





5.7 above mainstem average max,  
warmest Kiger\* temperature

0 = 17.8° C mainstem average max  
for Kieger Island\*

-3.9 below mainstem average max,  
coolest Kiger\* temperature



# Green Island





Blue Ruin





# Snagboat Bend





Sam Daws



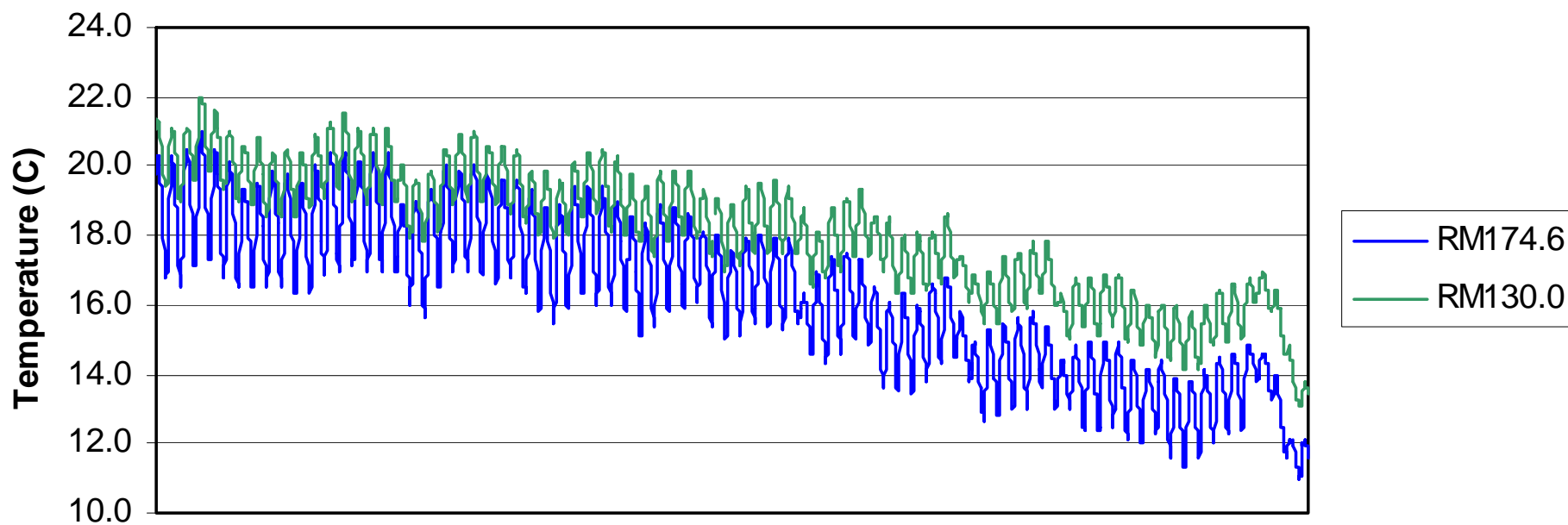


# Norwood Island





## Willamette River Longitudinal Temperature Profile (July 15 - October 3, 2005)



# Effect of Hyporheic Exchange on River Temperature

