Climate Change Effects on Aquatic Ecosystems in the Crown of the Continent: Implications for Adaptive Management

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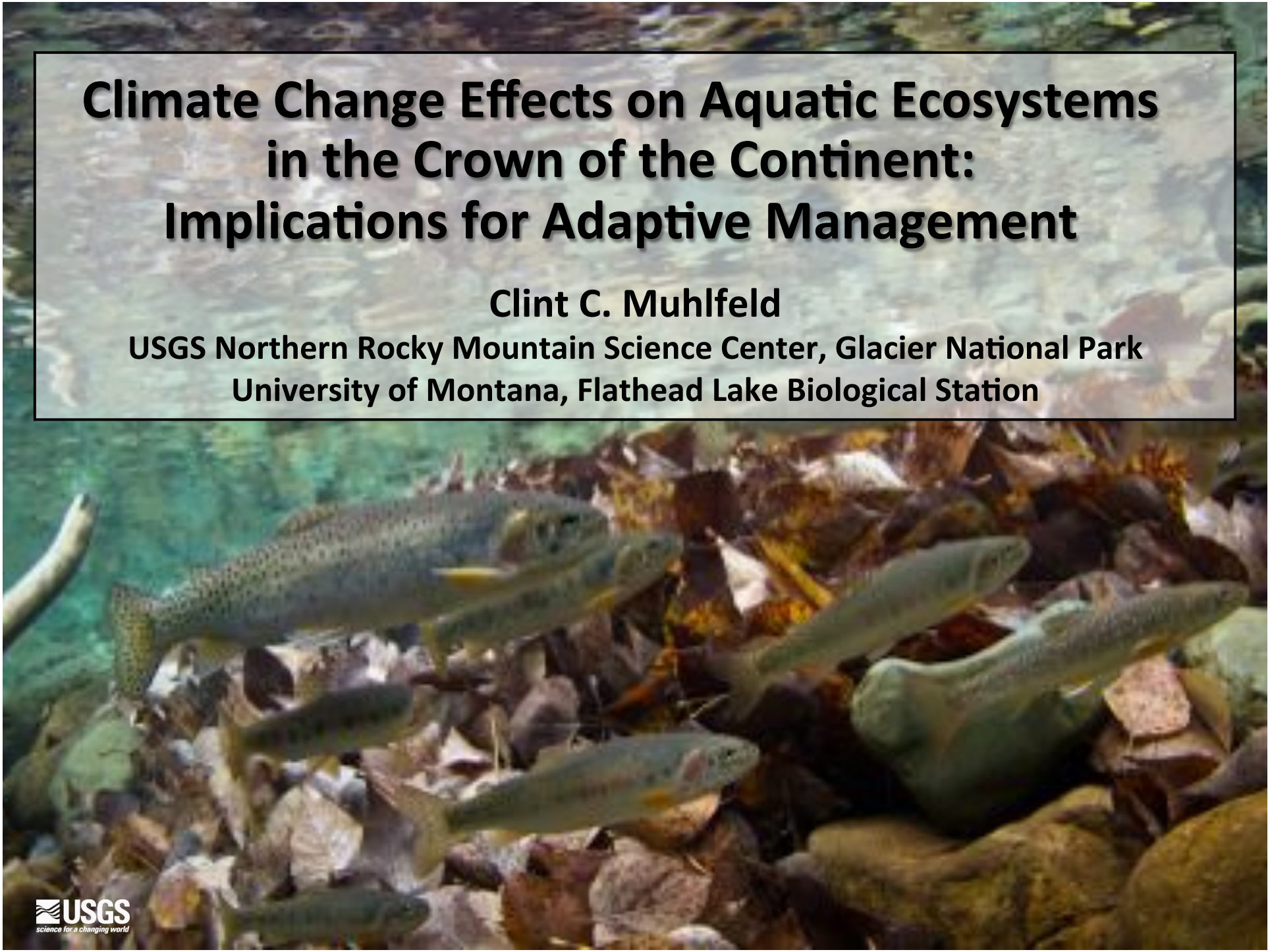
University of Montana, Flathead Lake Biological Station



A landscape undergoing change

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The Crown of the Continent Ecosystem

CCE Boundary

BC

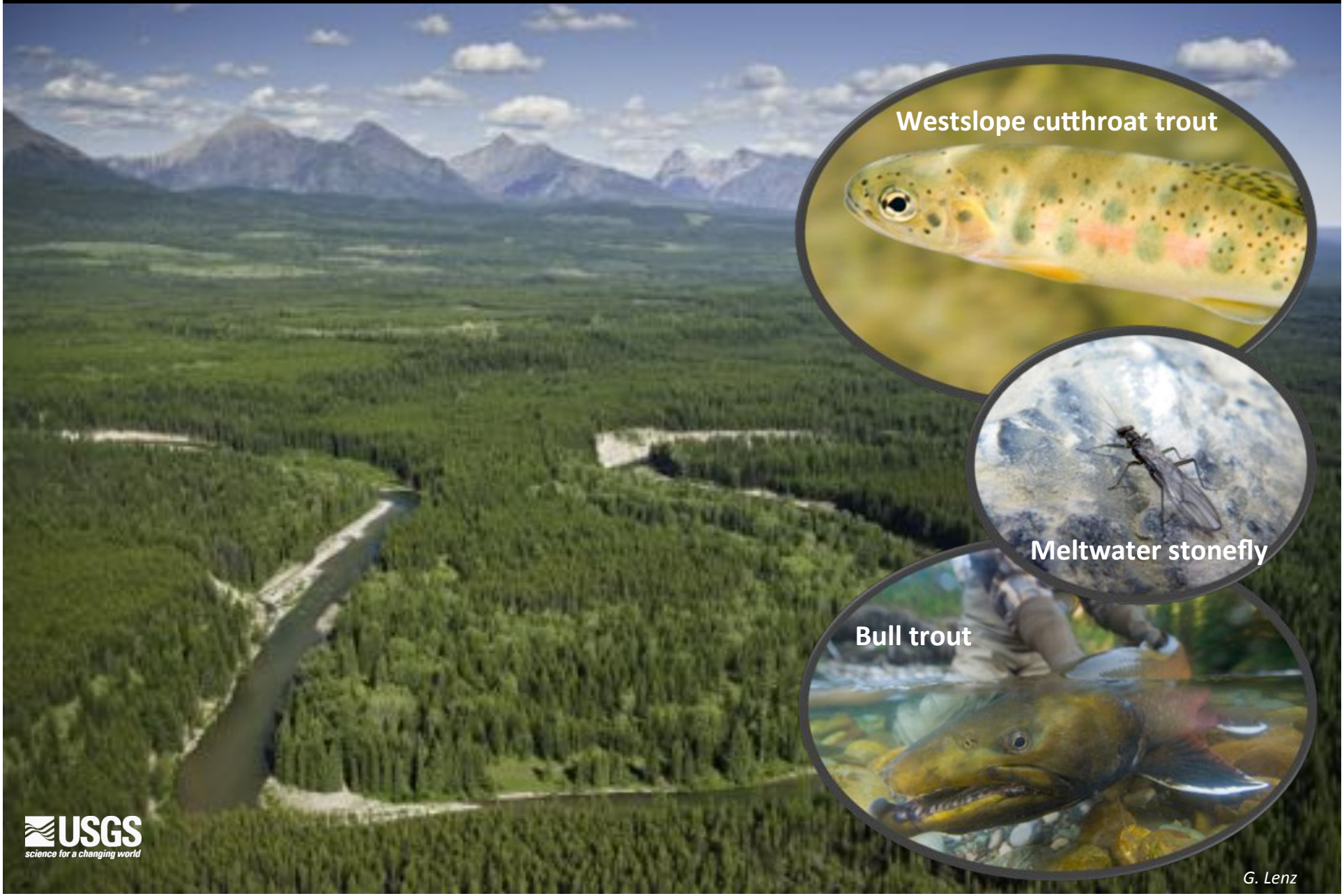
ALBERTA

GNP Boundary

MT

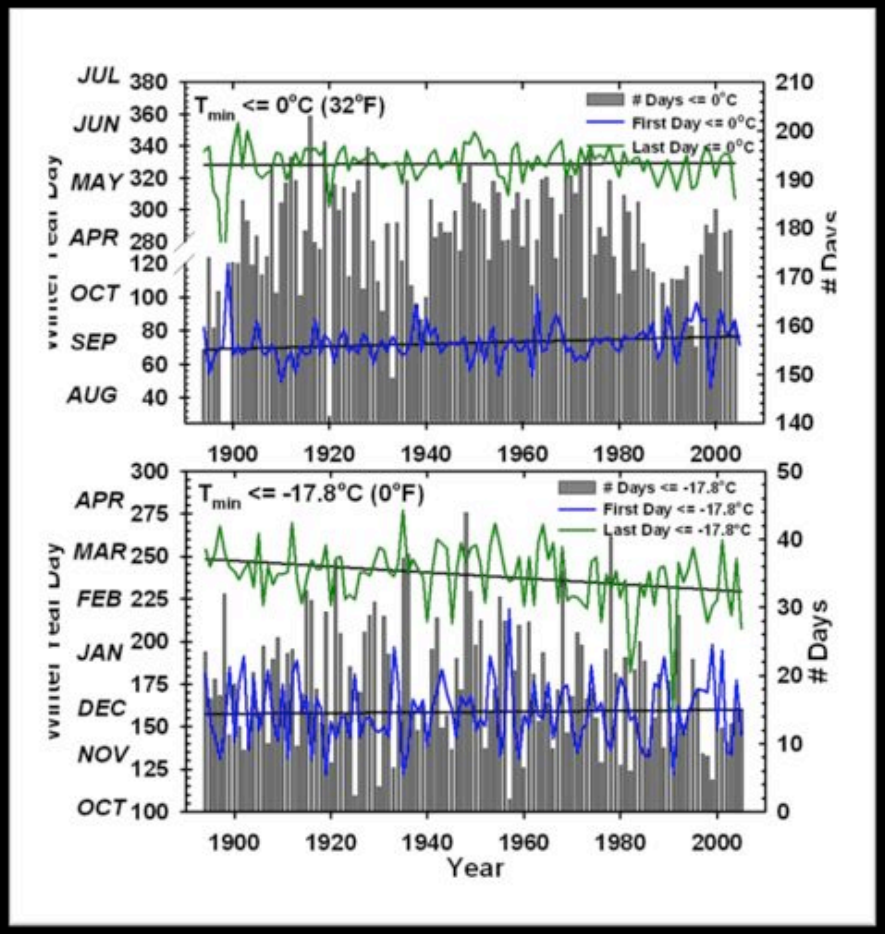
Flathead Watershed Boundary

The CCE – *A Native Species Stronghold*

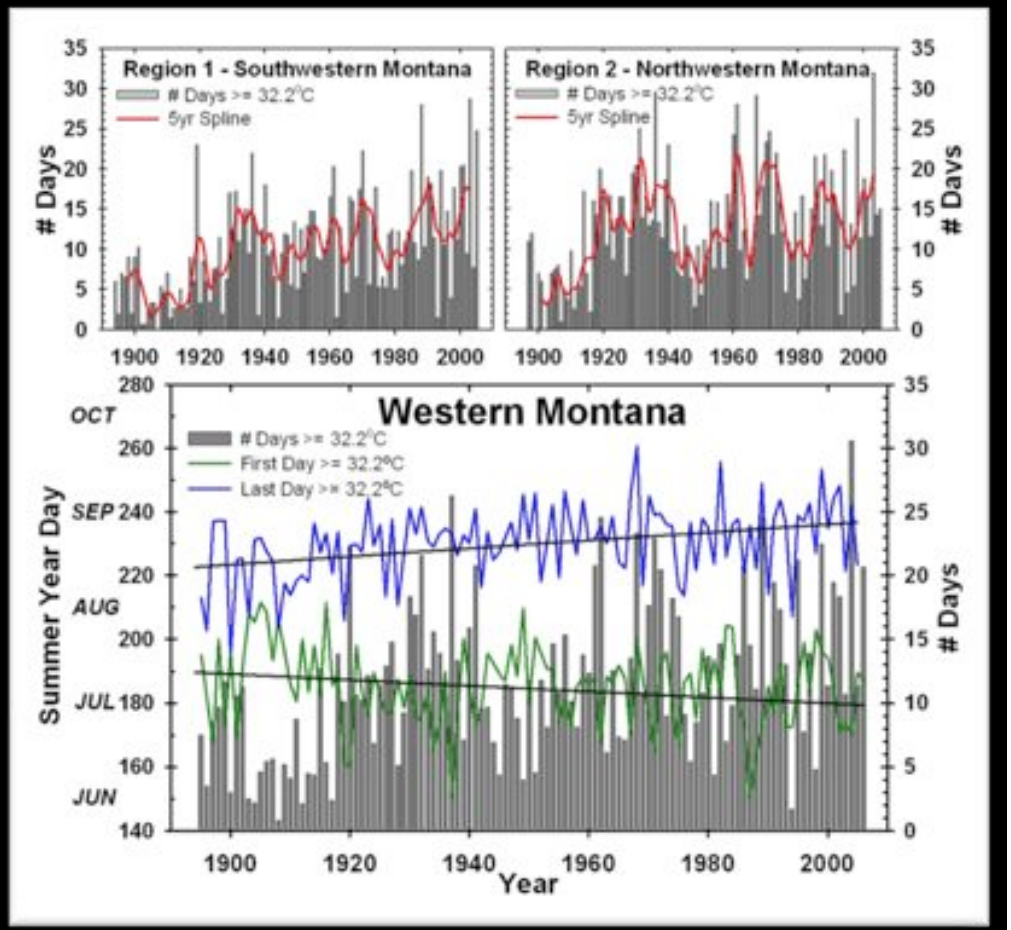


Temperatures are Rising

Loss of ~month of cold days (32°F)



3-fold increase in hot days (90°F)



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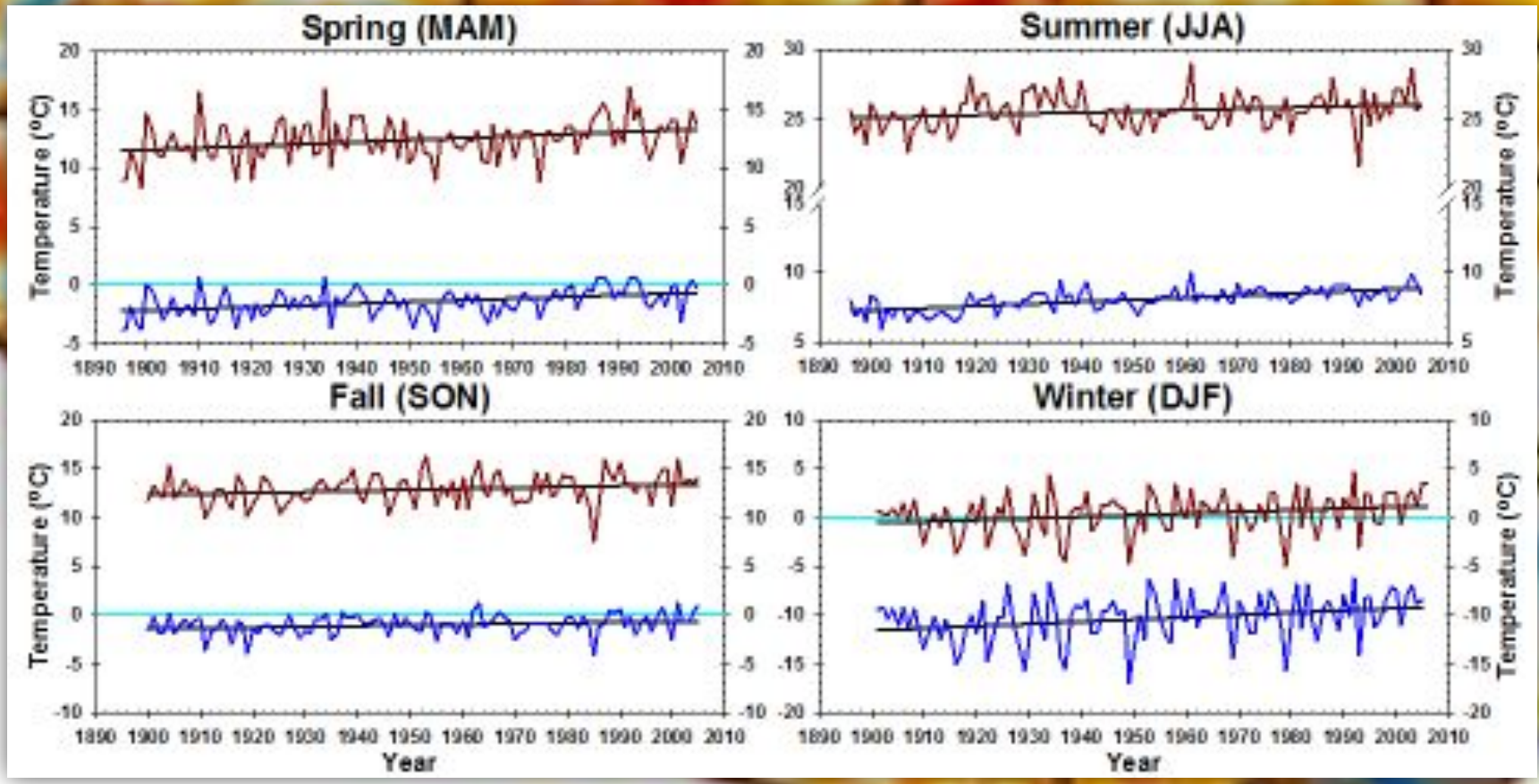
Pederson et al. (2010) *Climatic Change*

The Northern Rockies are Warming



~2 times the Global rise in air temperatures

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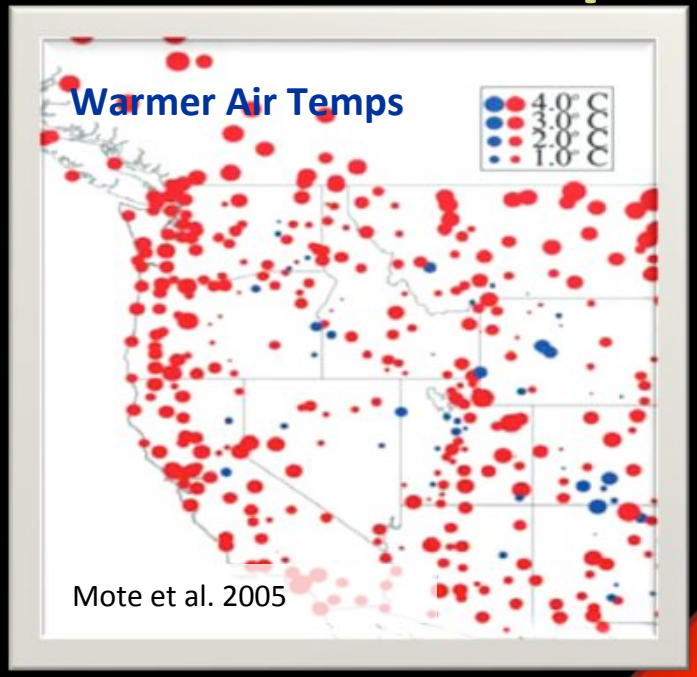
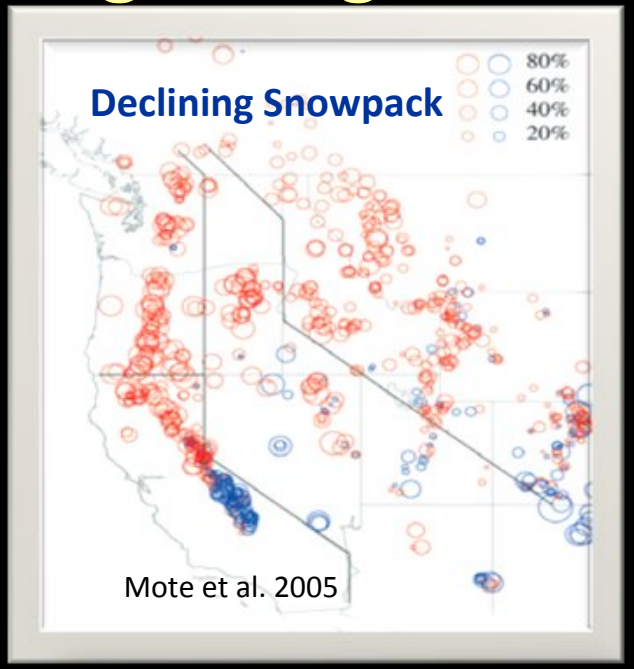
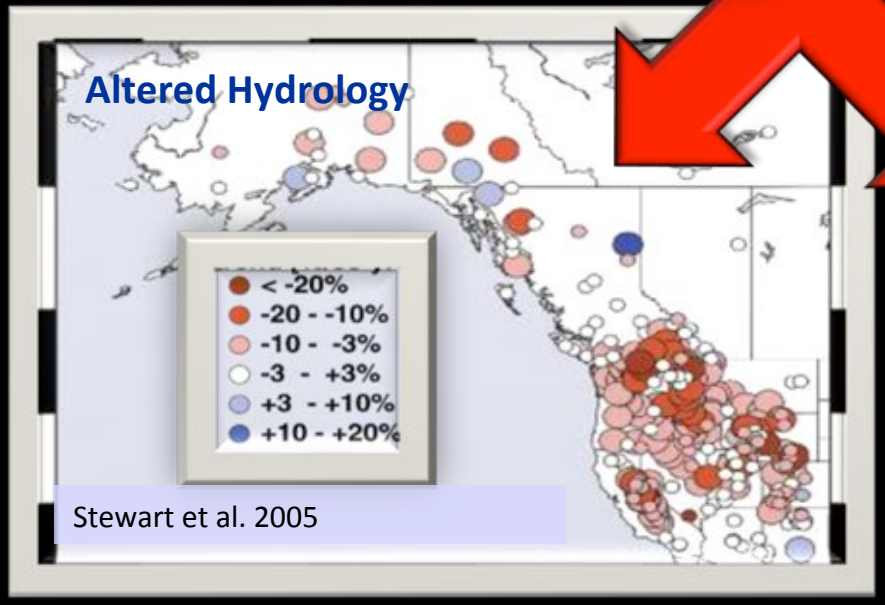
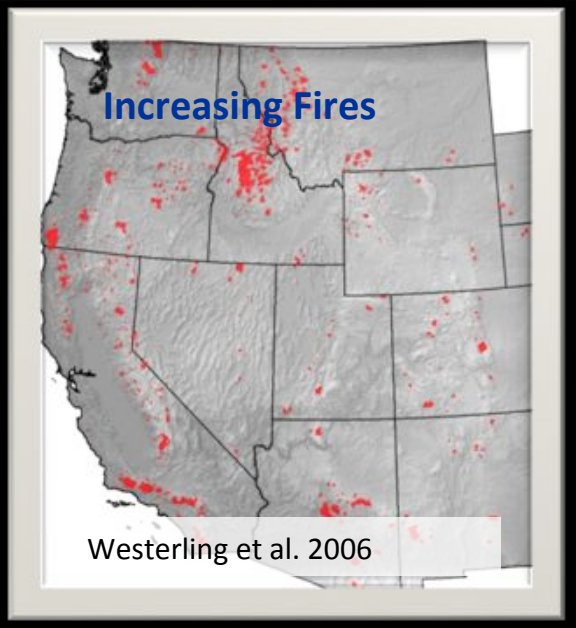
Pederson et al. (2010) *Climatic Change*

A Landscape Undergoing Change









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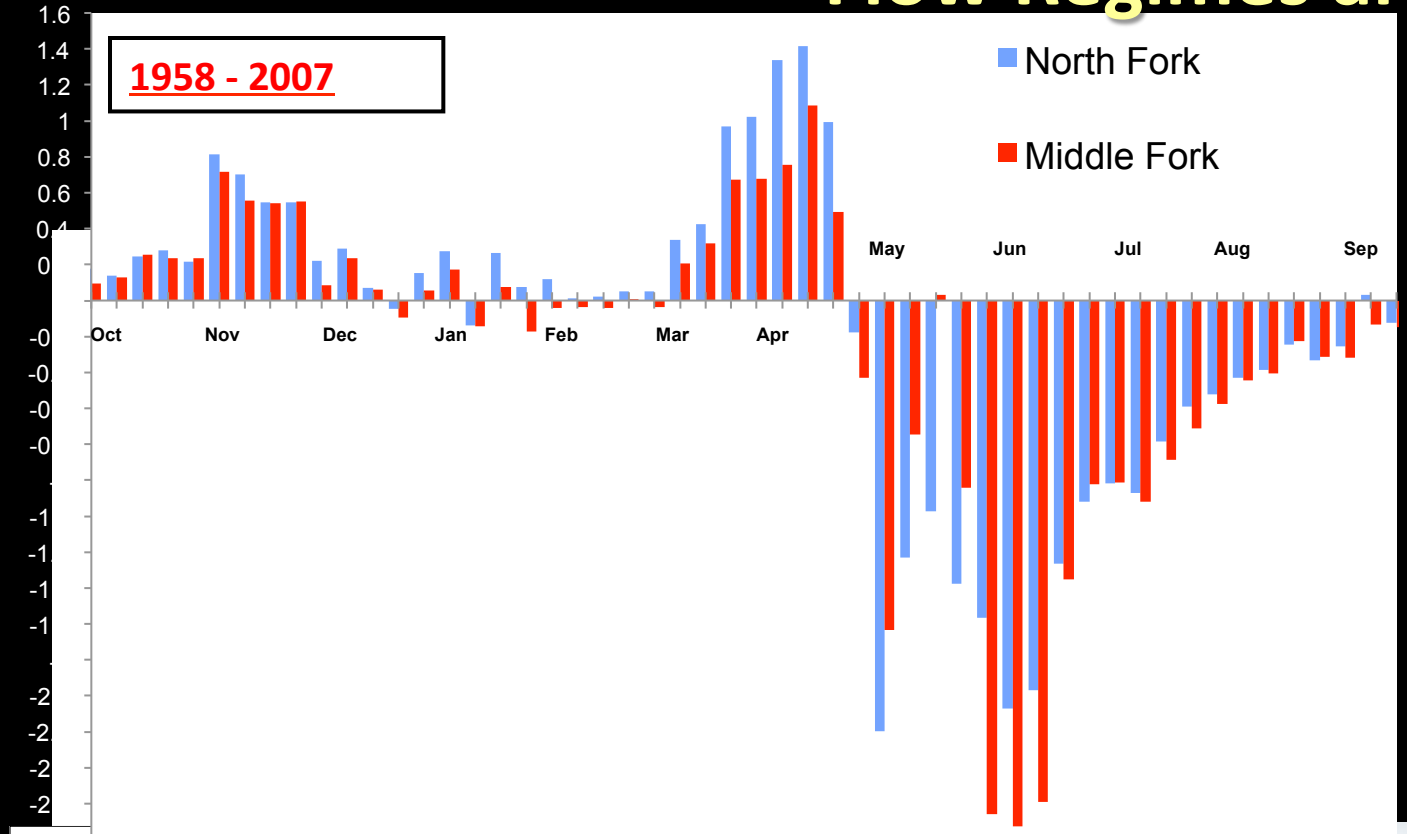
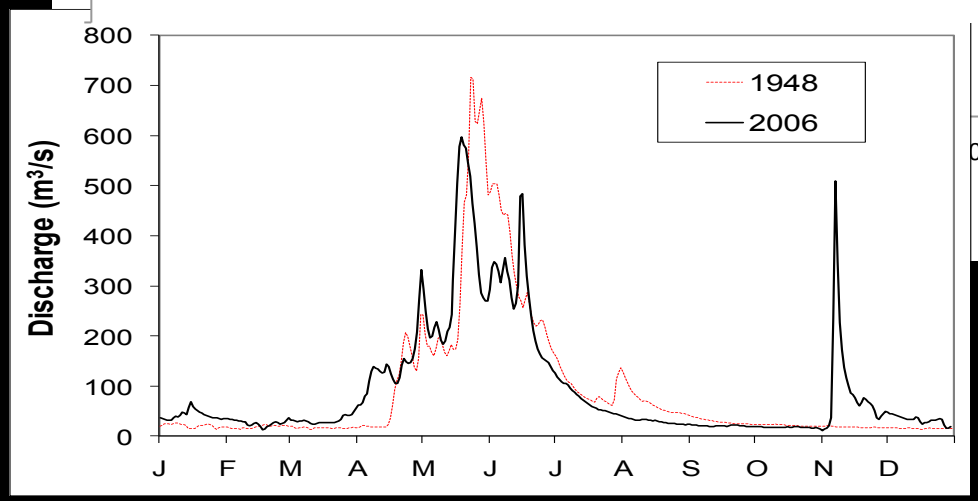
Flathead River Discharge

Flow Regimes are Changing





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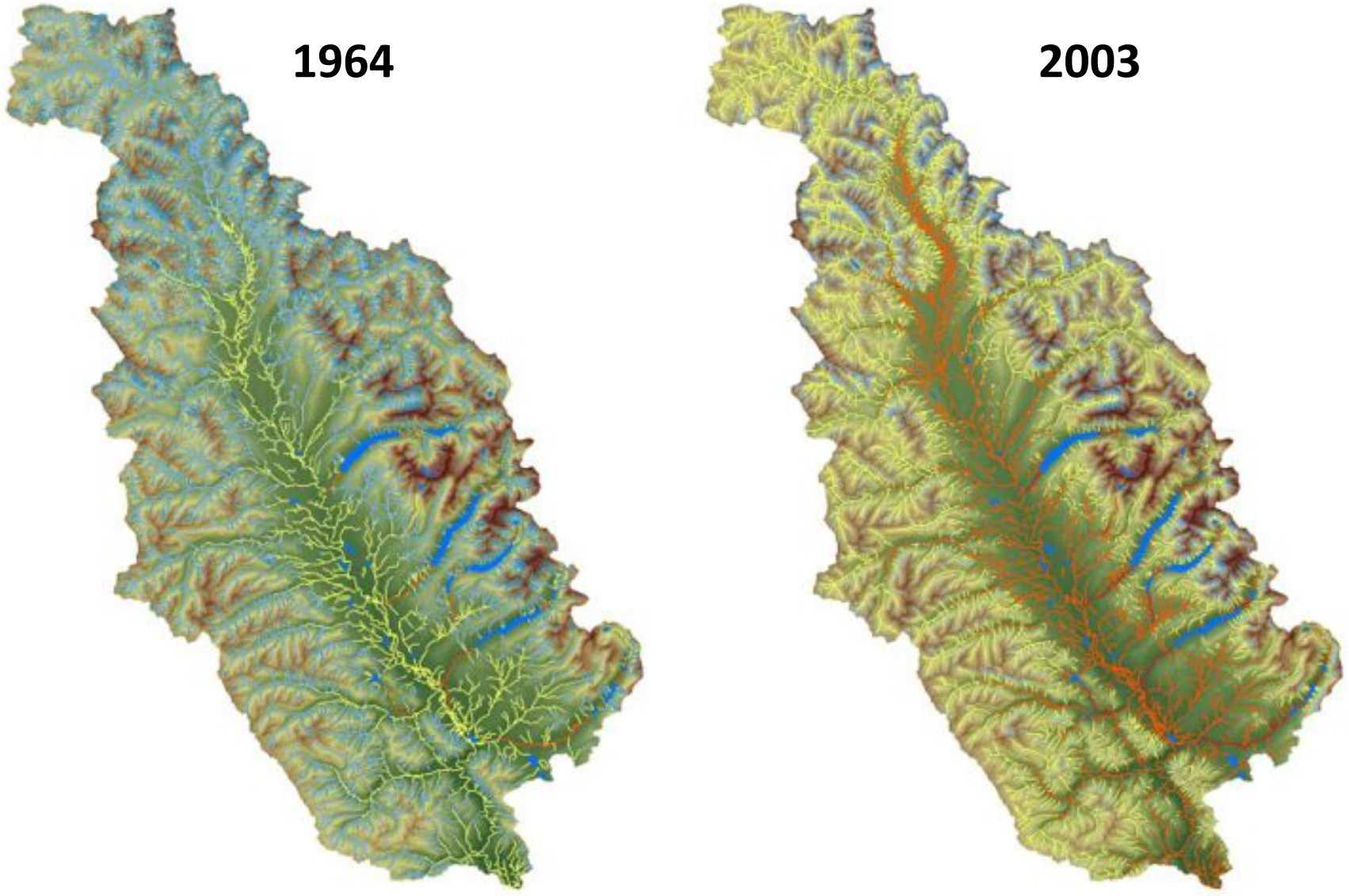
Stream temperatures are increasing



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USGS Repeat Photography Points in Glacier National Park

Sperry Glacier
Glacier National Park

Morton Elrod photo ***1907***
Courtesy Glacier NP Archives

Lisa McKeon photo, USGS ***2001***

Grinnell Glacier 1910 - 1998

1910 Photo by Kiser, GNP Archives

1998 Photo by McKeon, USGS

W. C. All
Courtesy of

L. McKeo
Courtesy of

D. Fagre, L. McKeon

Aquatic Stressors

Habitat alteration

Invasive species

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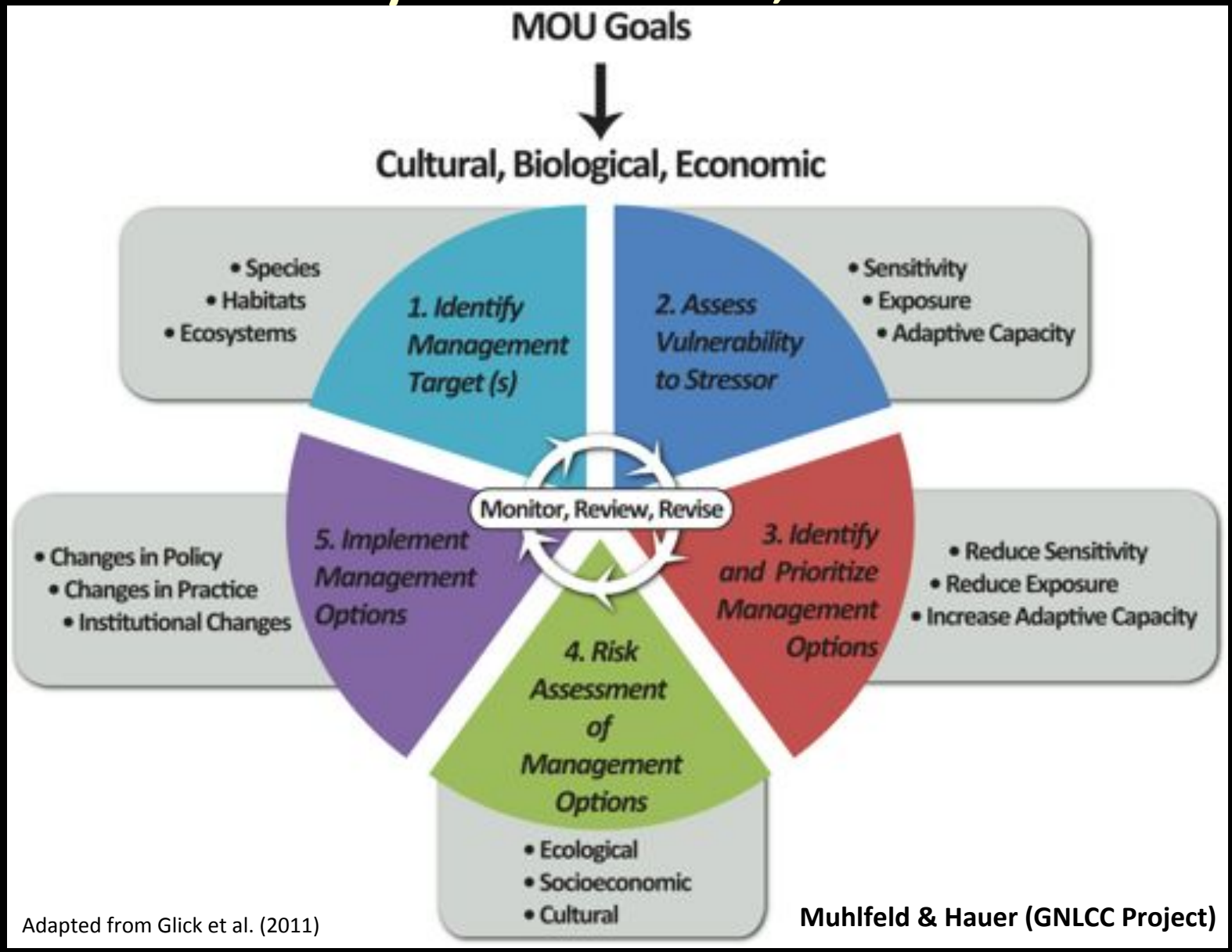
Aquatic Adaptation Strategy

Transboundary Flathead River, USA & Canada

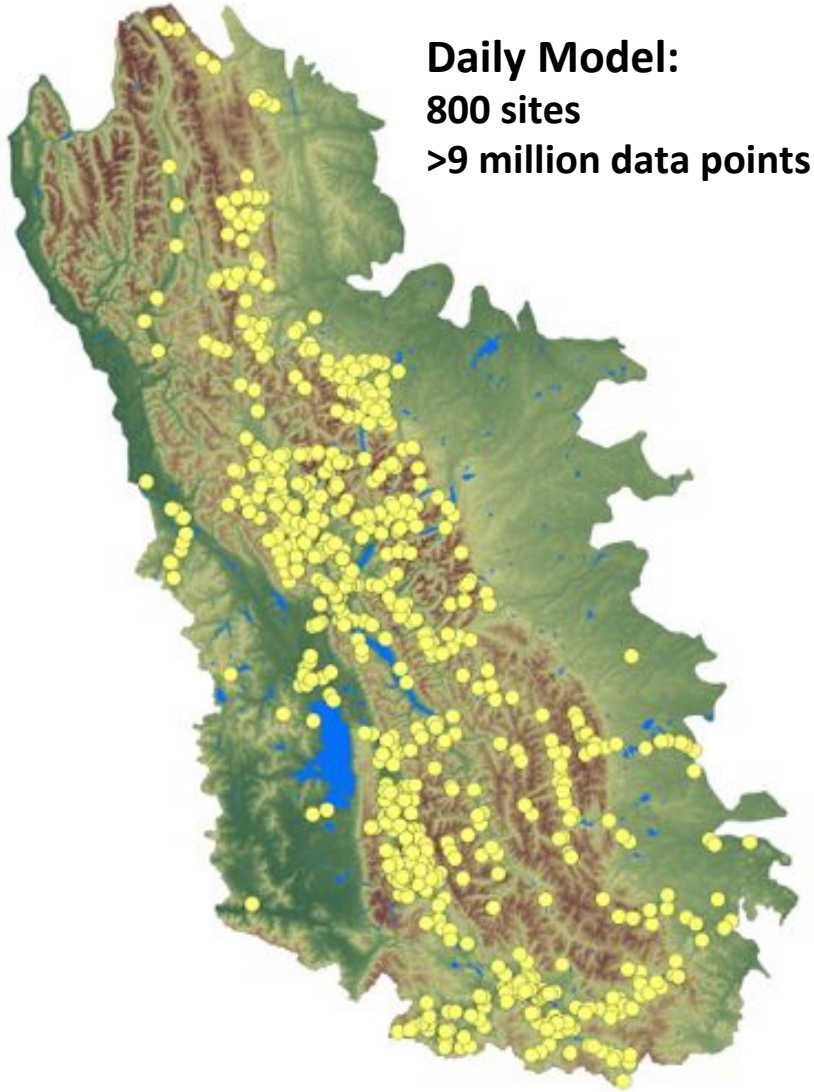


Adapted from Glick et al. (2011)

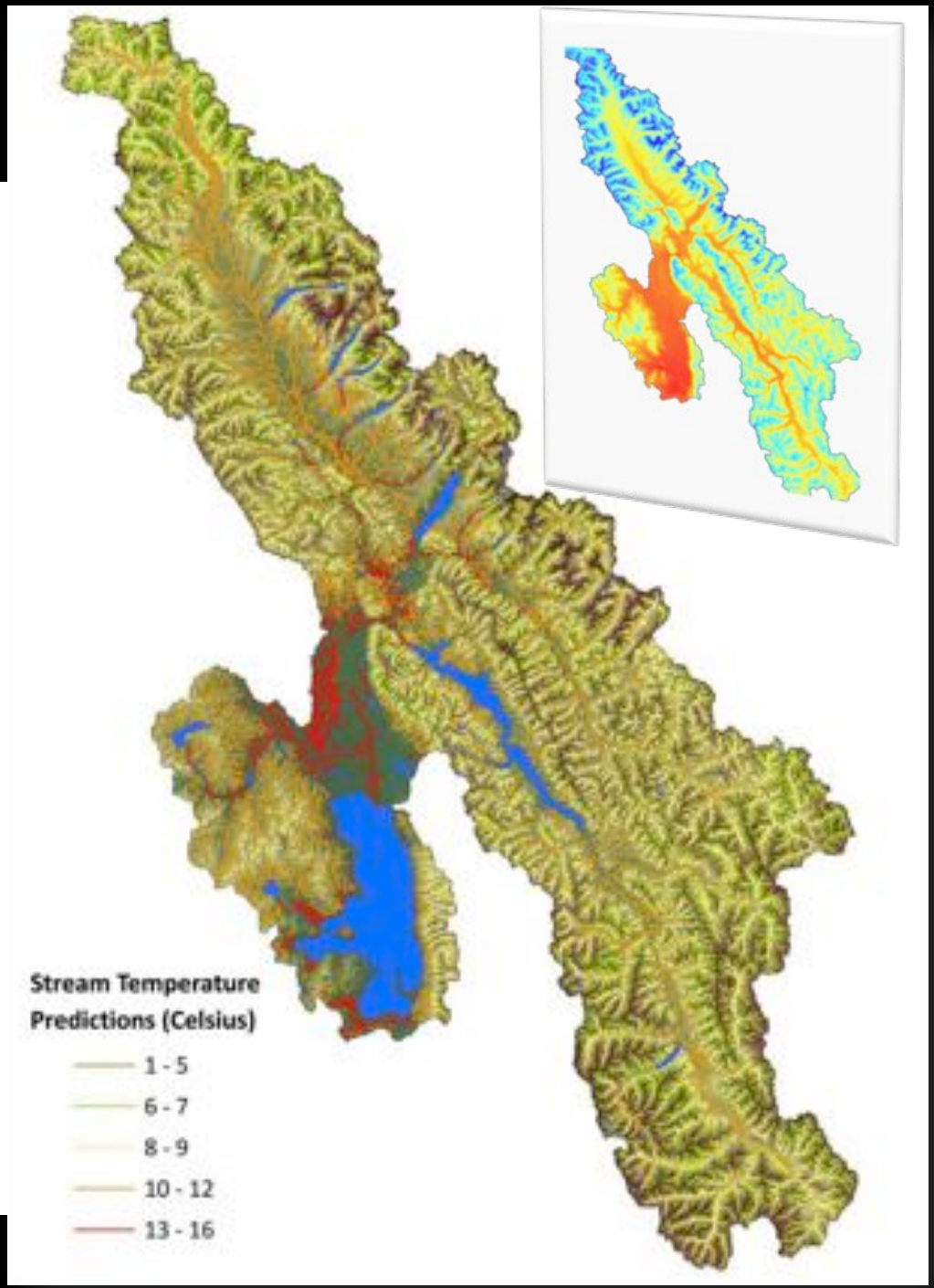
Muhlfeld & Hauer (GNLCC Project)

Bull Trout – *A Threatened Species*

CCE Stream Temperature Monitoring & Modeling

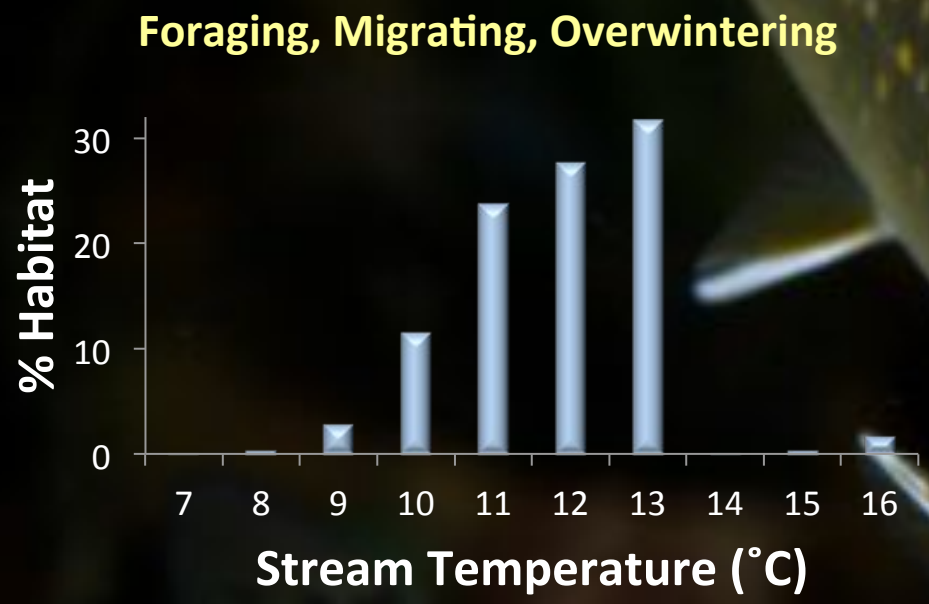


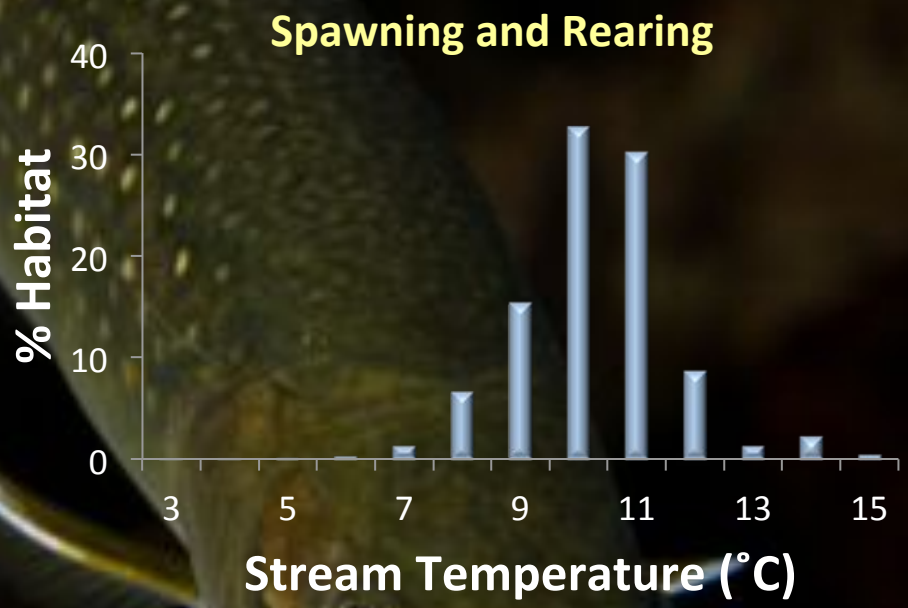
Daily Model:
800 sites
>9 million data points



Jones & Muhlfeld (*In-prep*)

Bull Trout Occupy Cold Waters





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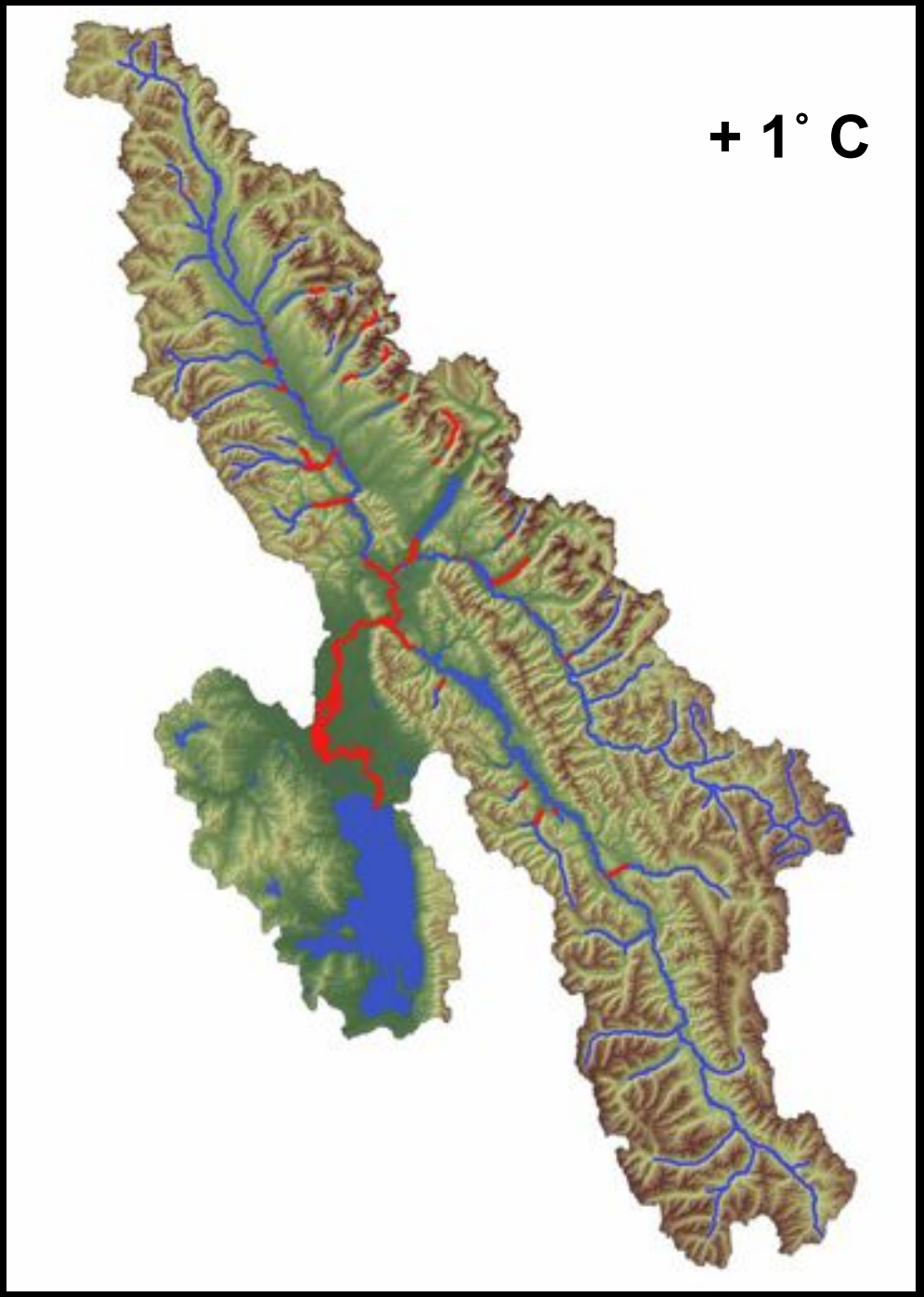
Jones et. al. (2013)

J. Sartore

- **20% Loss of FMO Habitat**
- **2% Loss of SR Habitat**

Exceedence of Thermal Thresholds



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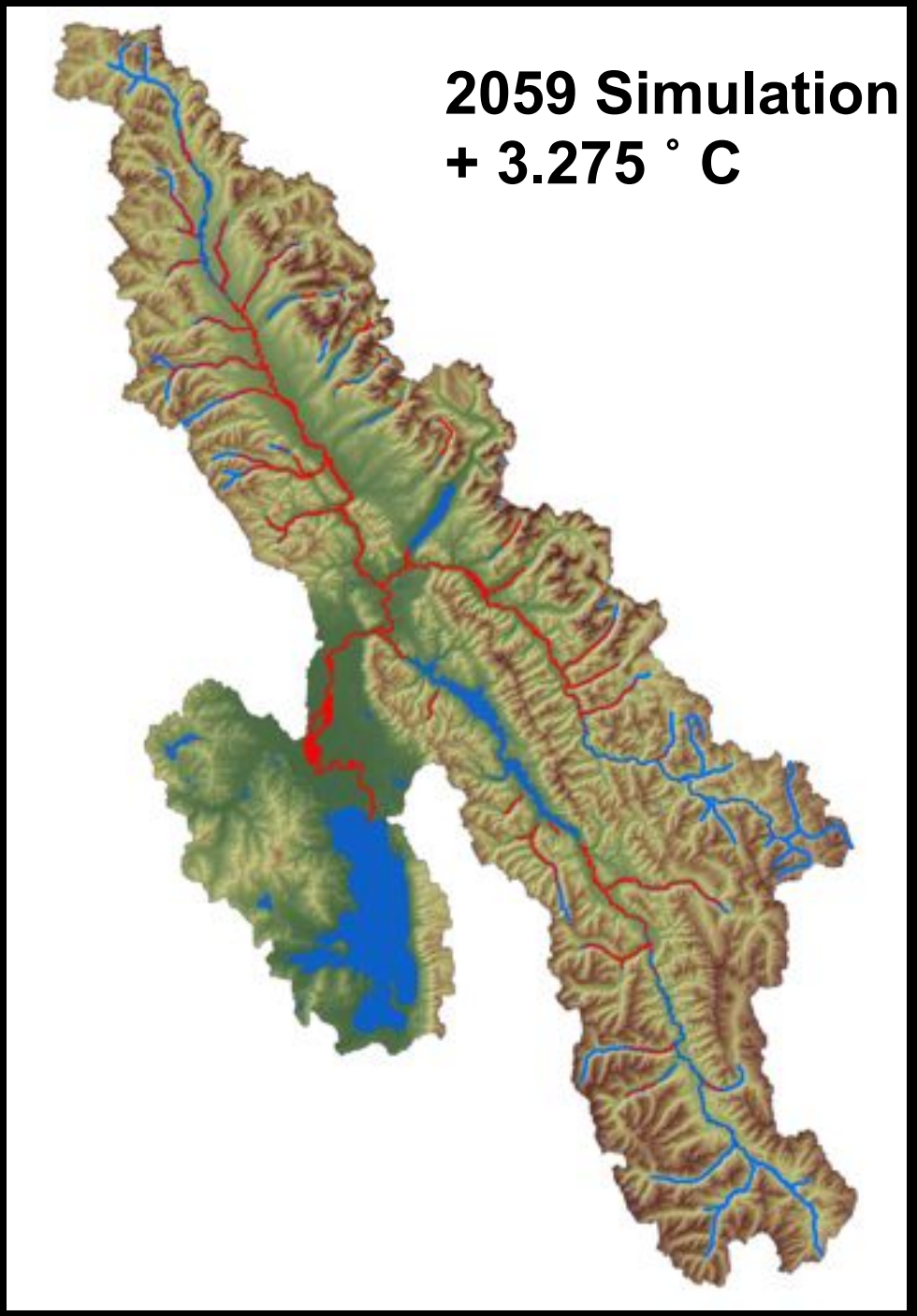
Jones et. al. (2013)

J. Sartore

- **58% Loss of FMO**
- **36% Loss of SR**

Exceedence of Thermal Thresholds



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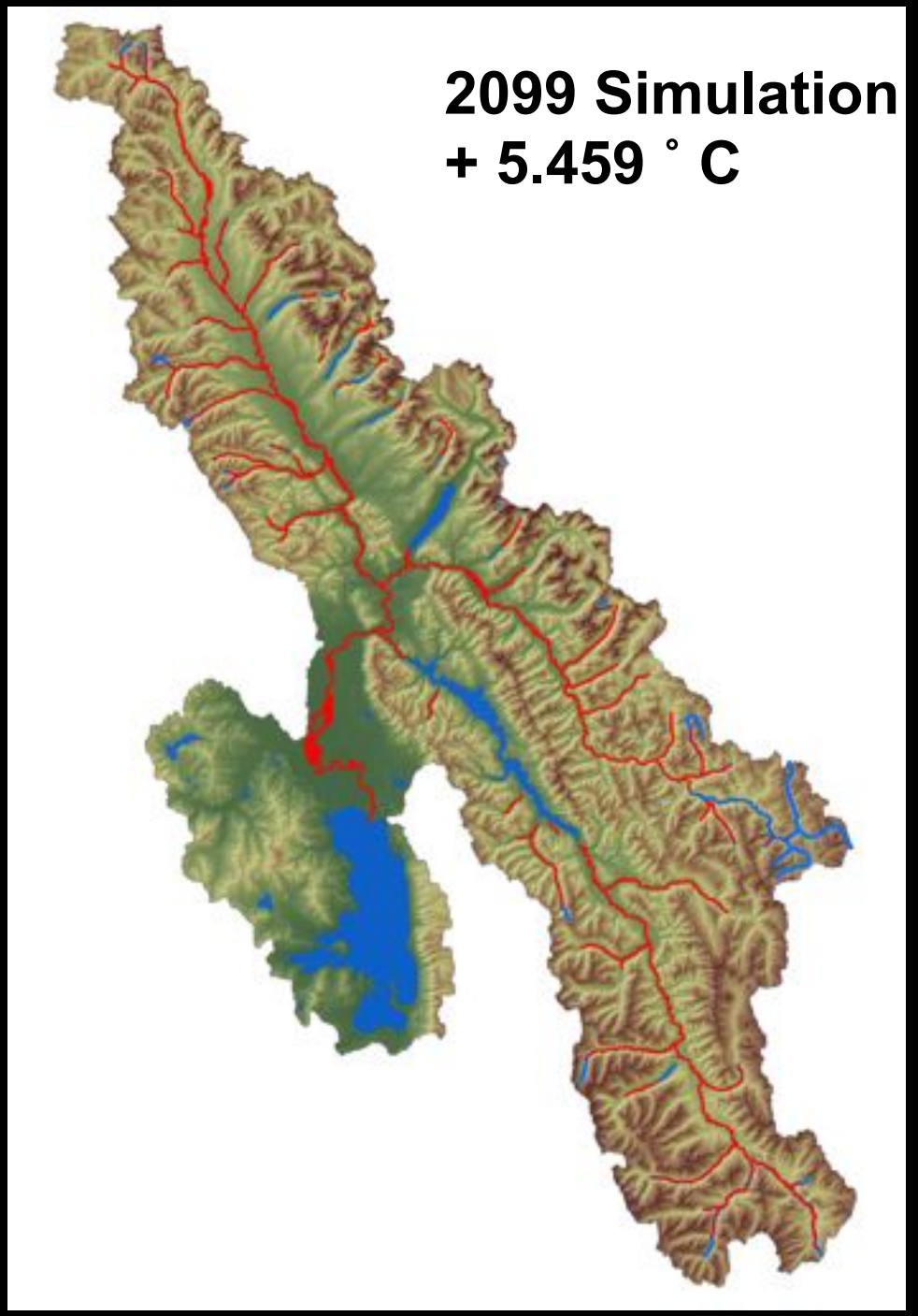
Jones et. al. (2013)

J. Sartore

- **86% Loss of FMO**
- **76% Loss of SR**

Exceedence of Thermal Thresholds



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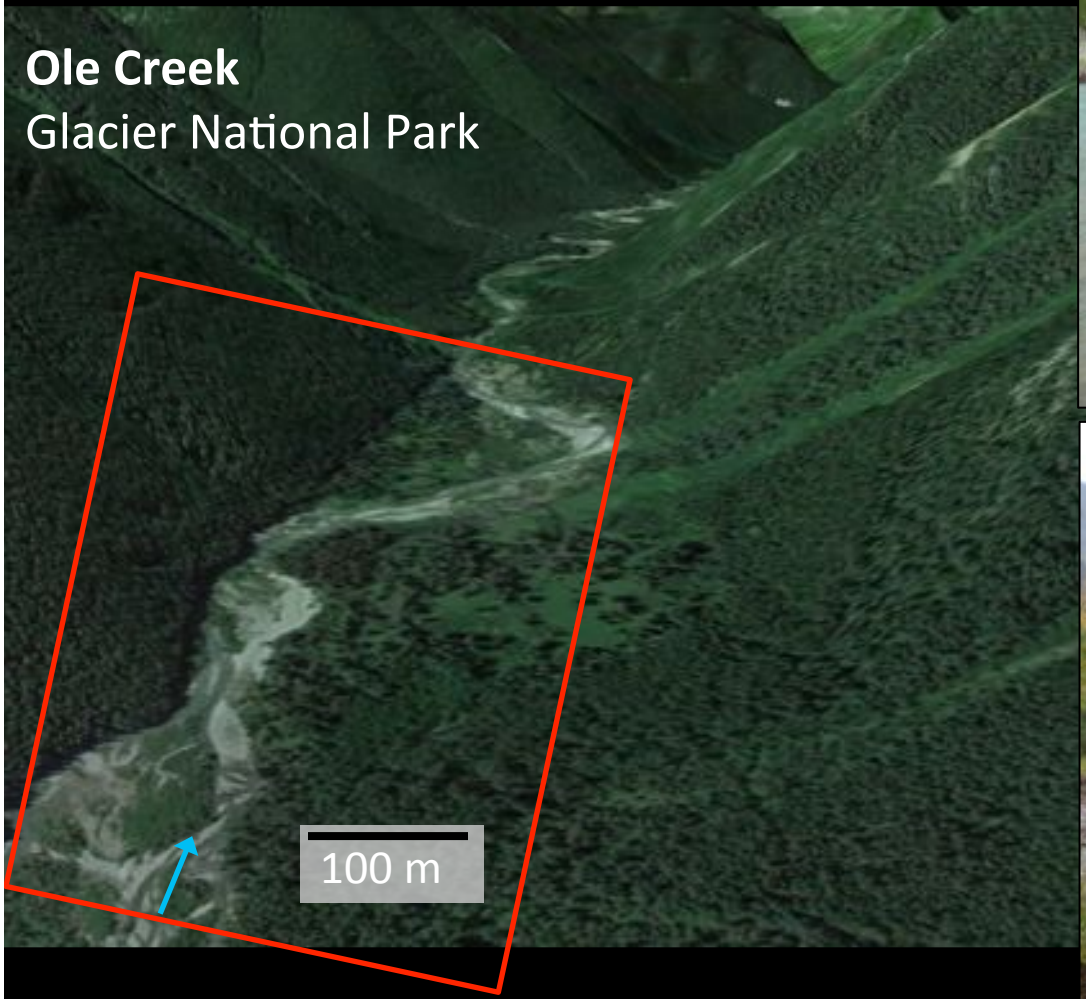
Jones et. al. (2013)

Groundwater upwelling zones are important bull trout spawning and rearing habitats

Ole Creek
Glacier National Park



Spawning habitat

Bean et al. (In-press)


Lake trout invasion in western Glacier National Park
Kintla
Upper Kintla
Akokala
Bowman
Cerulean
Quartz
Middle Quartz
Lower Quartz
Logging
Arrow
Trout
Rogers
McDonald
Lincoln
Harrison
Isabel
Upper Isabel
Continental Divide
North Fork Flathead River
Middle Fork Flathead River
NFMF Confluence
N
0 5 10
Bull Trout Lakes:
• 9 of 12 invaded
• 5 secure

Westslope Cutthroat Trout

M. Ready

M. Ready

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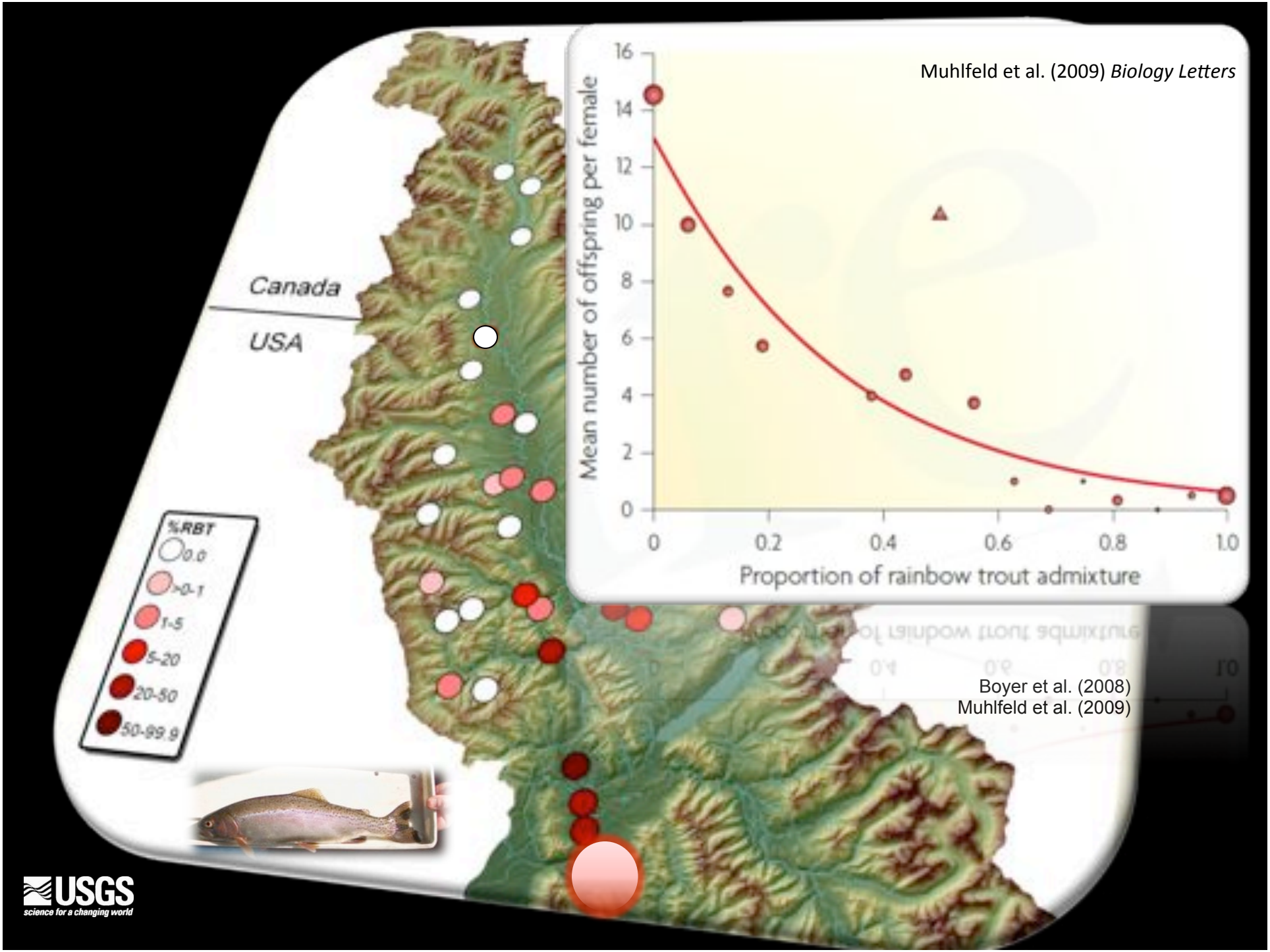
Canada
USA
%RBT
0.0
>0-1
1-5
5-20
20-50
50-99.9
Mean number of offspring per female
0
2
4
6
8
10
12
14
16
0
0.2
0.4
0.6
0.8
1.0
Proportion of rainbow trout admixture
Muhlfeld et al. (2009) *Biology Letters*
Boyer et al. (2008)
Muhlfeld et al. (2009)
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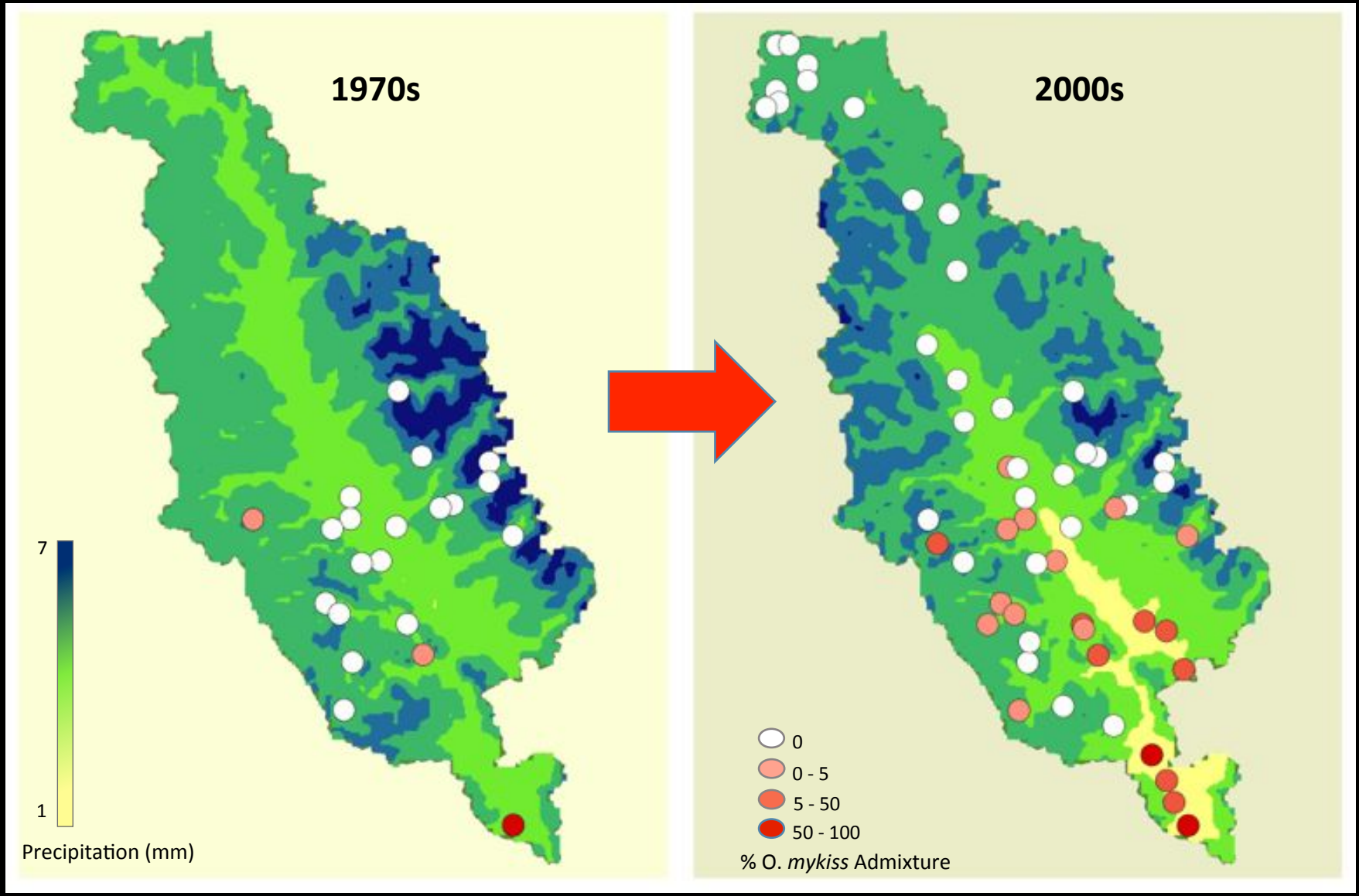
Hybridization Spreads with Decreasing Spring Precipitation



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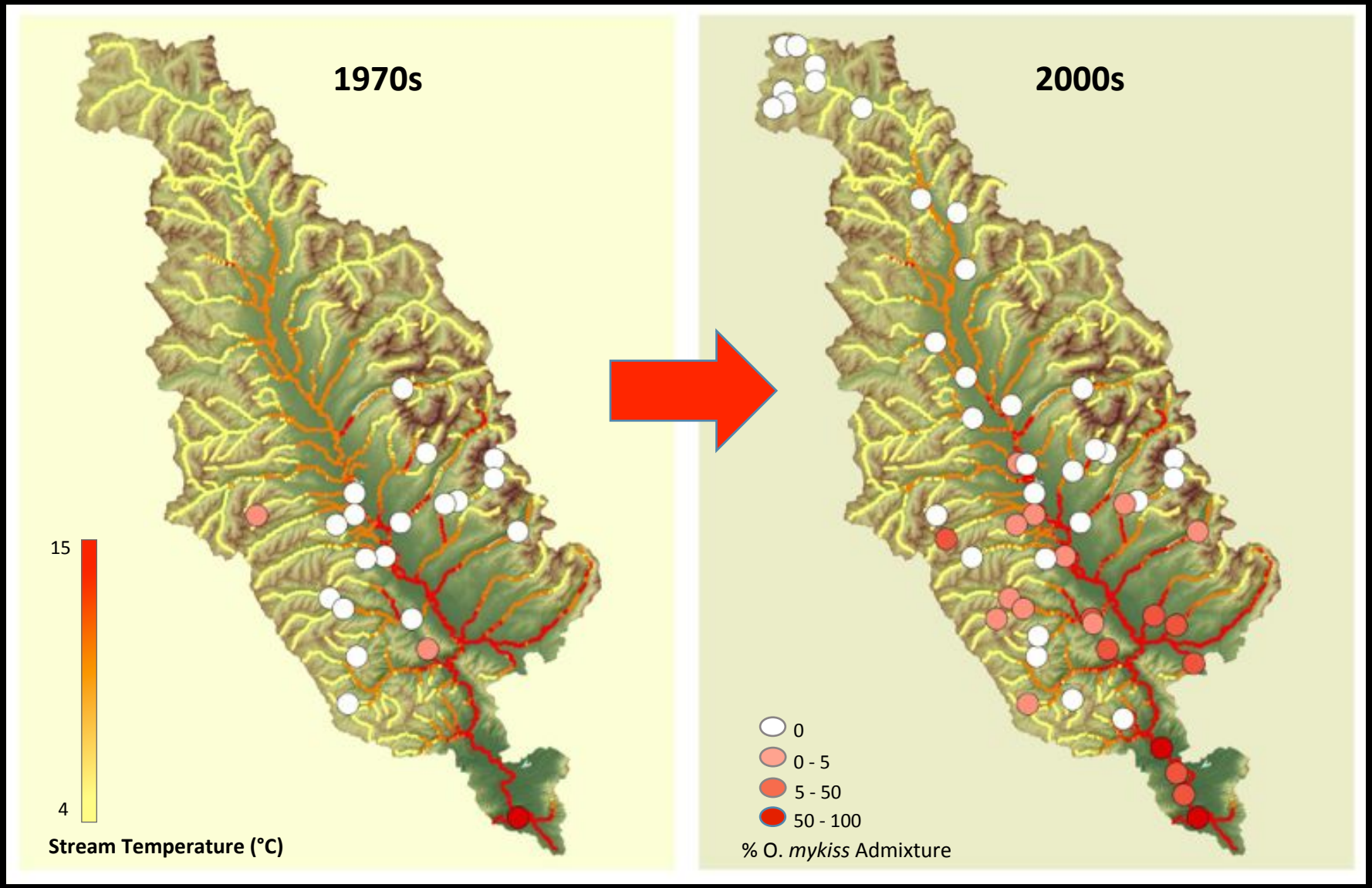
Muhlfeld et al. (In-revision) *Nature Climate Change*

Hybridization Spreads with Warming Stream Temperatures



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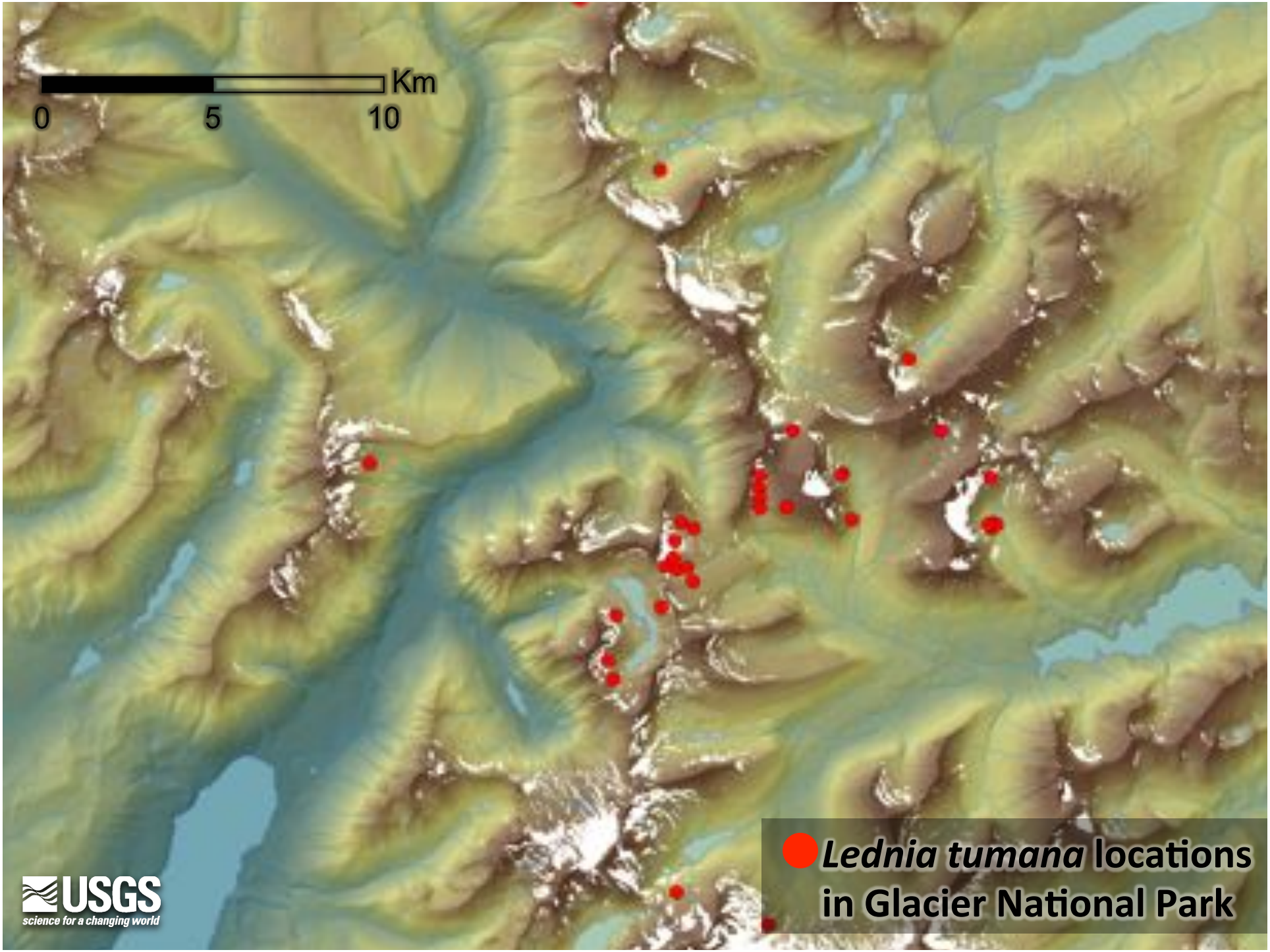
Muhlfeld et al. (In-revision) *Nature Climate Change*

The Meltwater Stonefly – *An ESA Candidate Species*

USGS


0
5
10
Km
USGS
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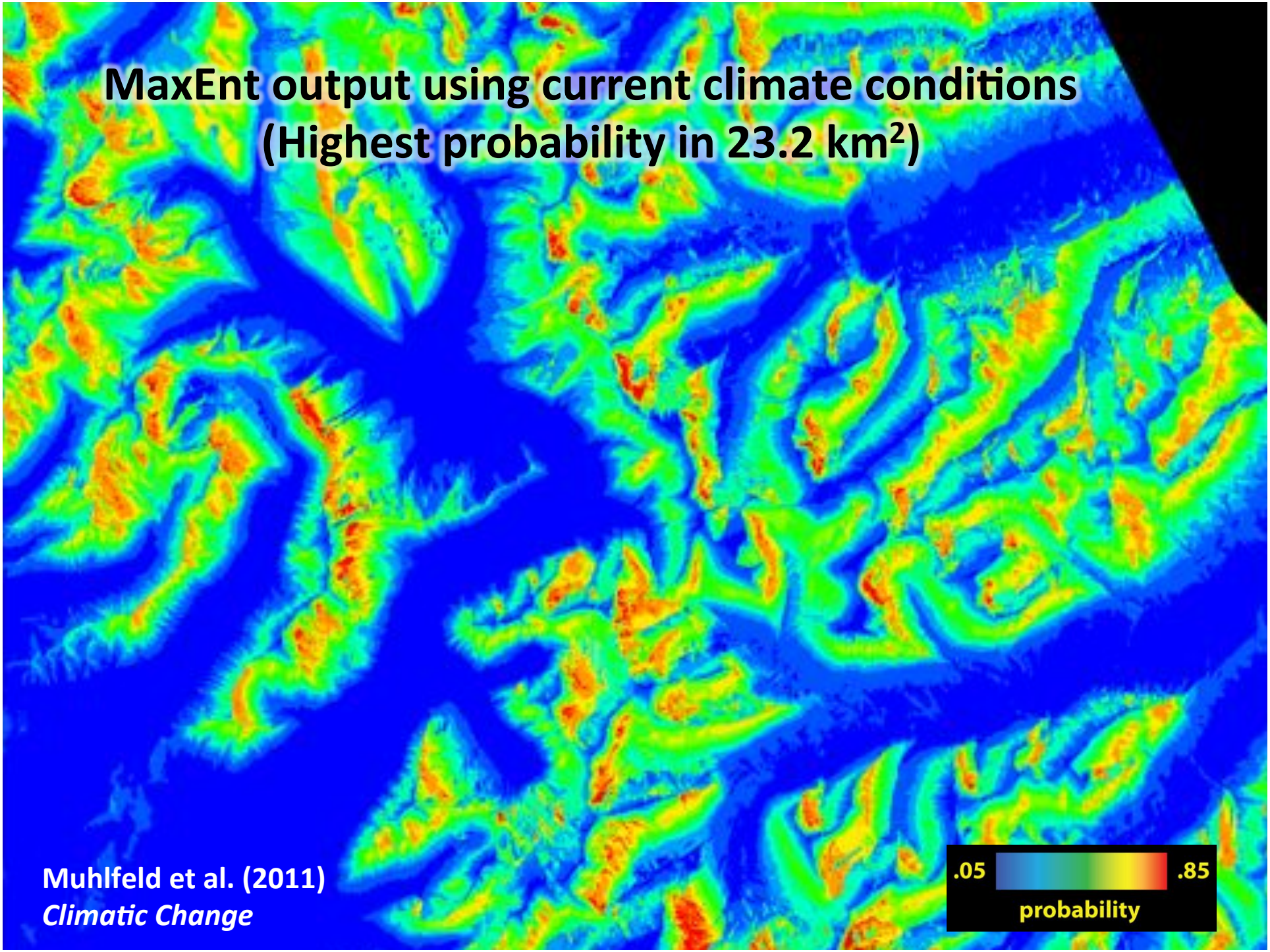
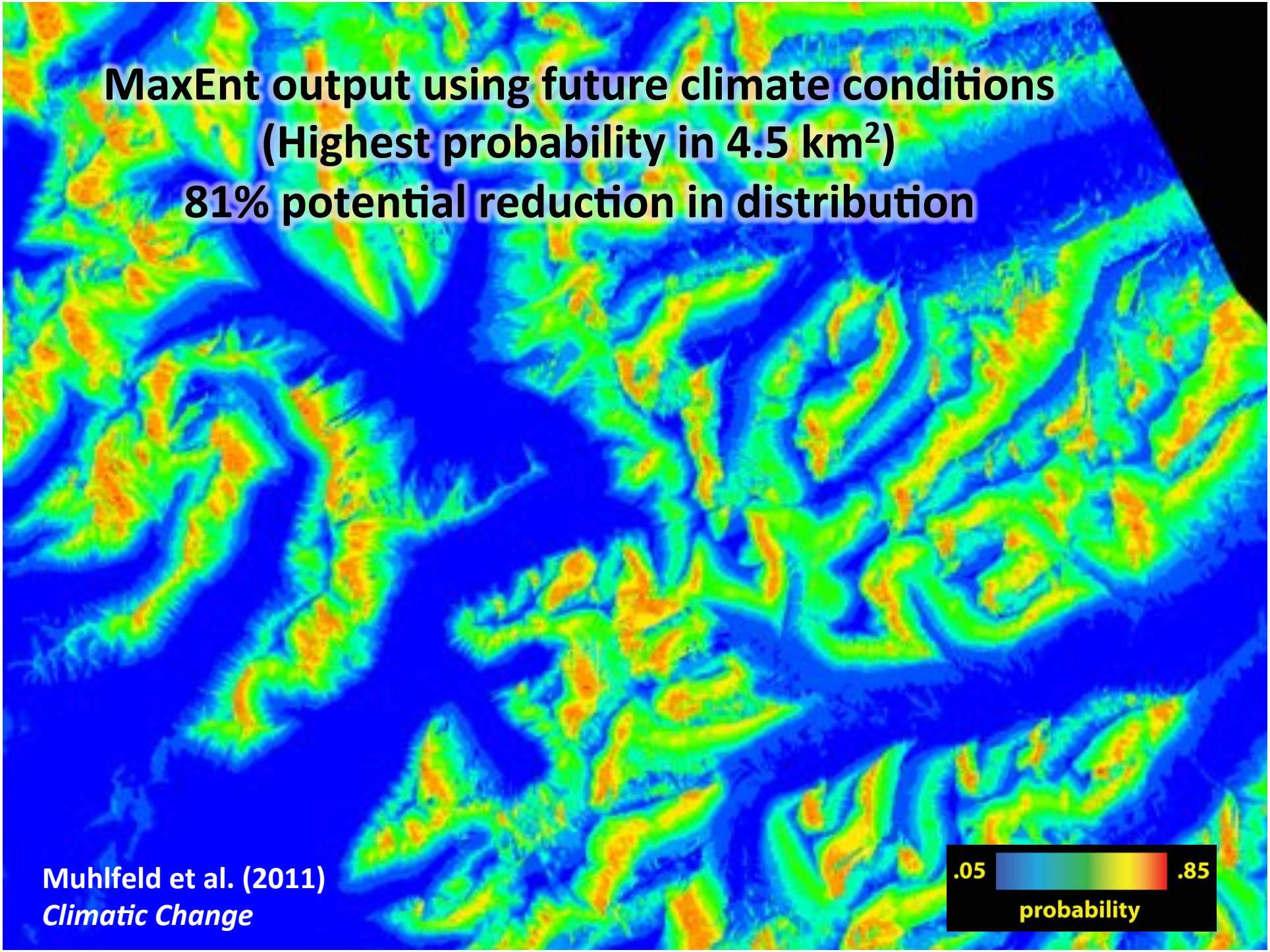
Lednia tumana locations
in Glacier National Park


MaxEnt output using current climate conditions
(Highest probability in 23.2 km²)
Muhlfeld et al. (2011)
Climatic Change
.05
.85
probability


MaxEnt output using future climate conditions
(Highest probability in 4.5 km²)
81% potential reduction in distribution
Muhlfeld et al. (2011)
Climatic Change
.05
.85
probability

“Skate to where the puck is going to be, not where it has been”

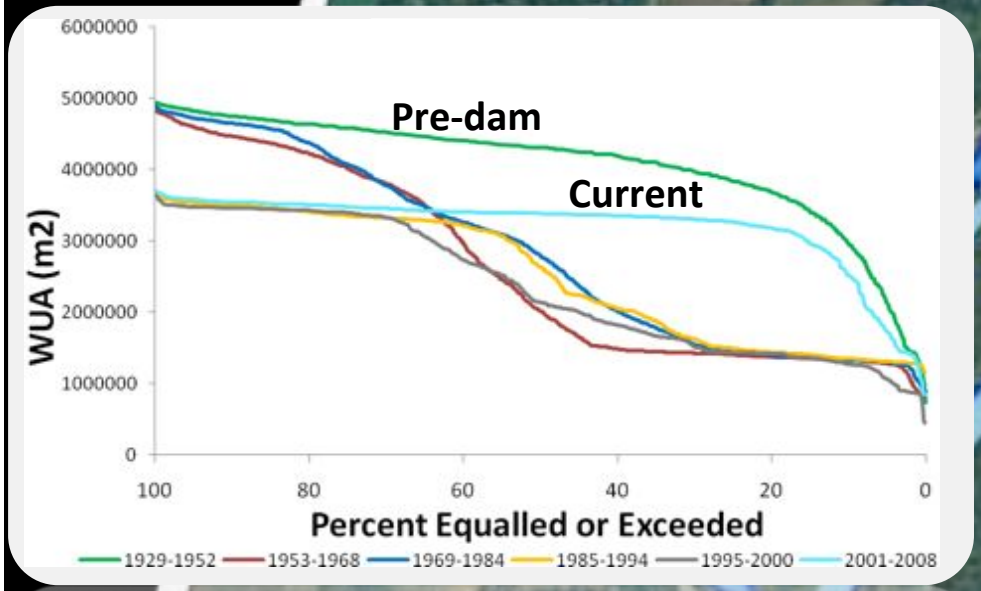
“You miss 100% of the shots you don’t take”

Protecting and Restoring Critical Habitats

Hauer & Muhlfeld (2010) ***Science***

G. Lenz

Fish Friendly Flows & Temperatures



Muhlfeld et al. (2012) *Riv. Res. App.*

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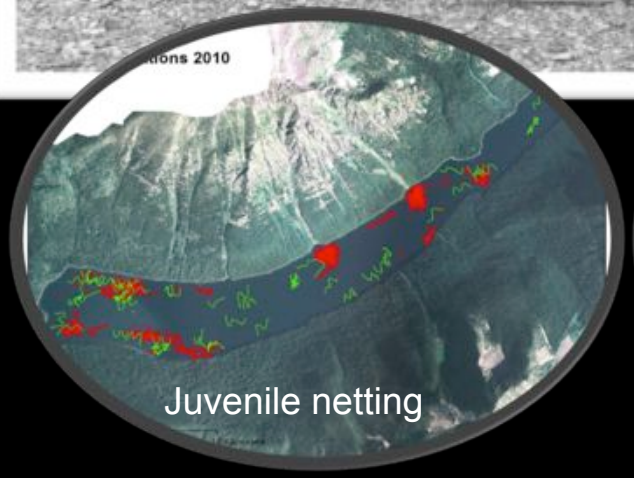
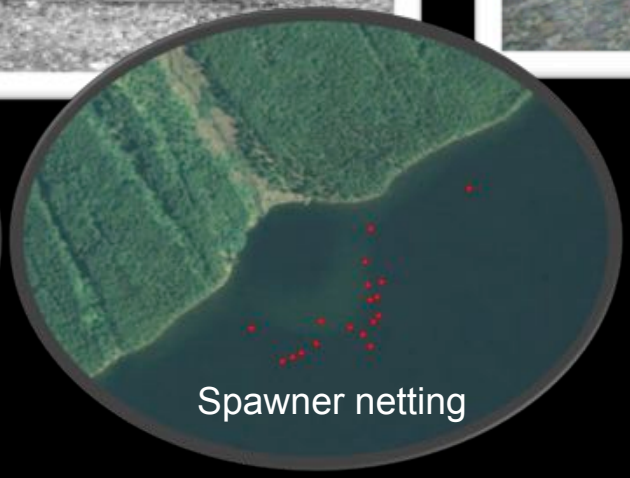
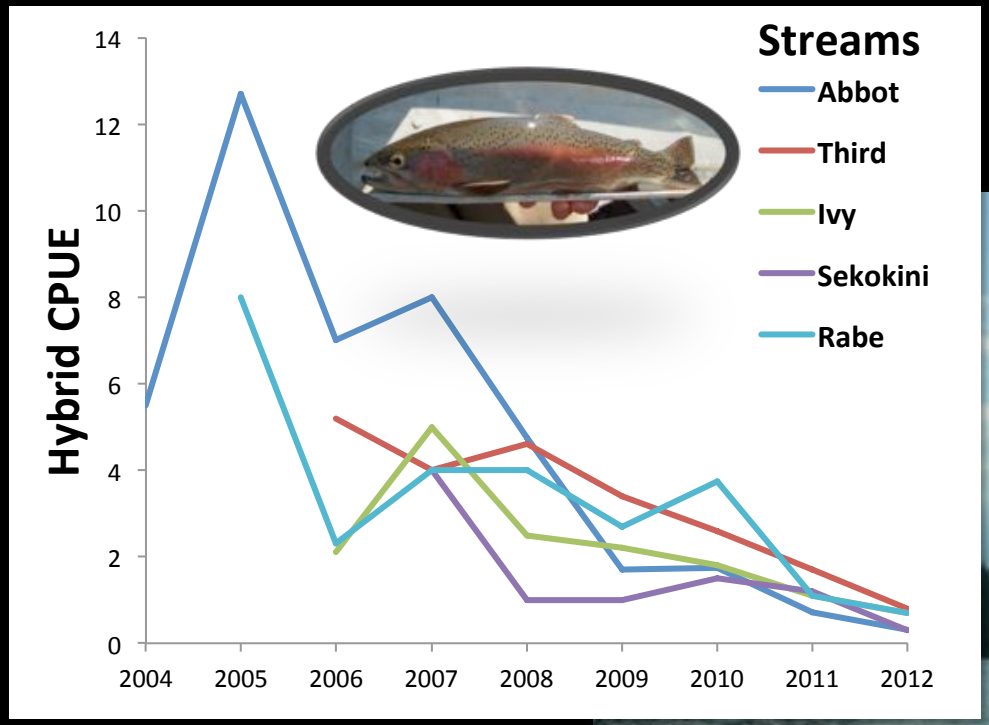
Suppression of Invasive Lake Trout

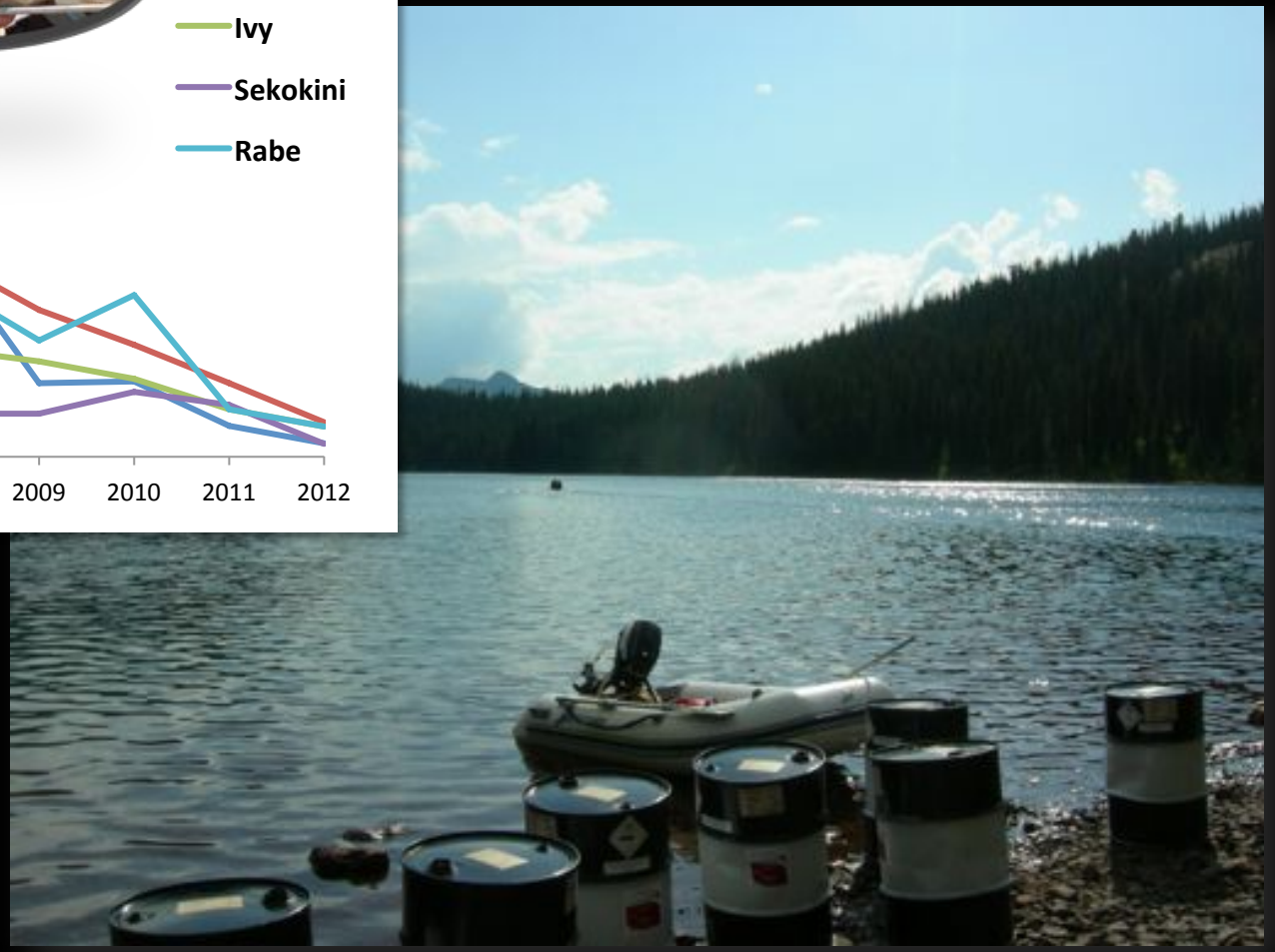

Juvenile netting


Spawner netting

Suppression & Eradication of Hybrid Sources



Management Strategy: Eliminate sources



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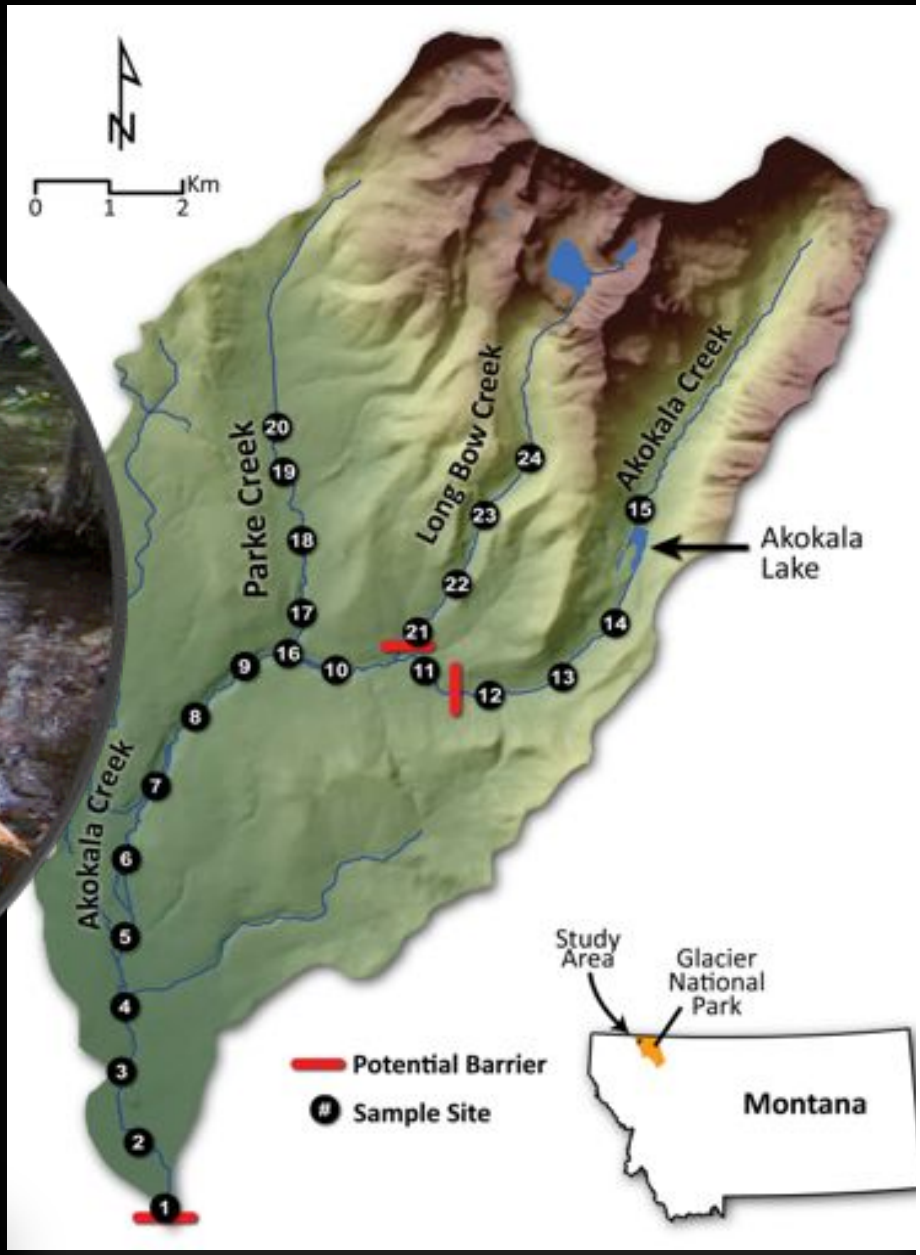
Using barriers to conserve native fish at risk from nonnative fish invasions

Quartz Creek, GNP



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Muhlfeld et al. (2012) *Open Fish Sci.*

Translocation of Imperiled Populations

Grace Lake, GNP

Galloway et al. (In-prep)