How Climate Extremes Affect Salmonid Recovery

Gordon Reeves, Emeritus Scientist
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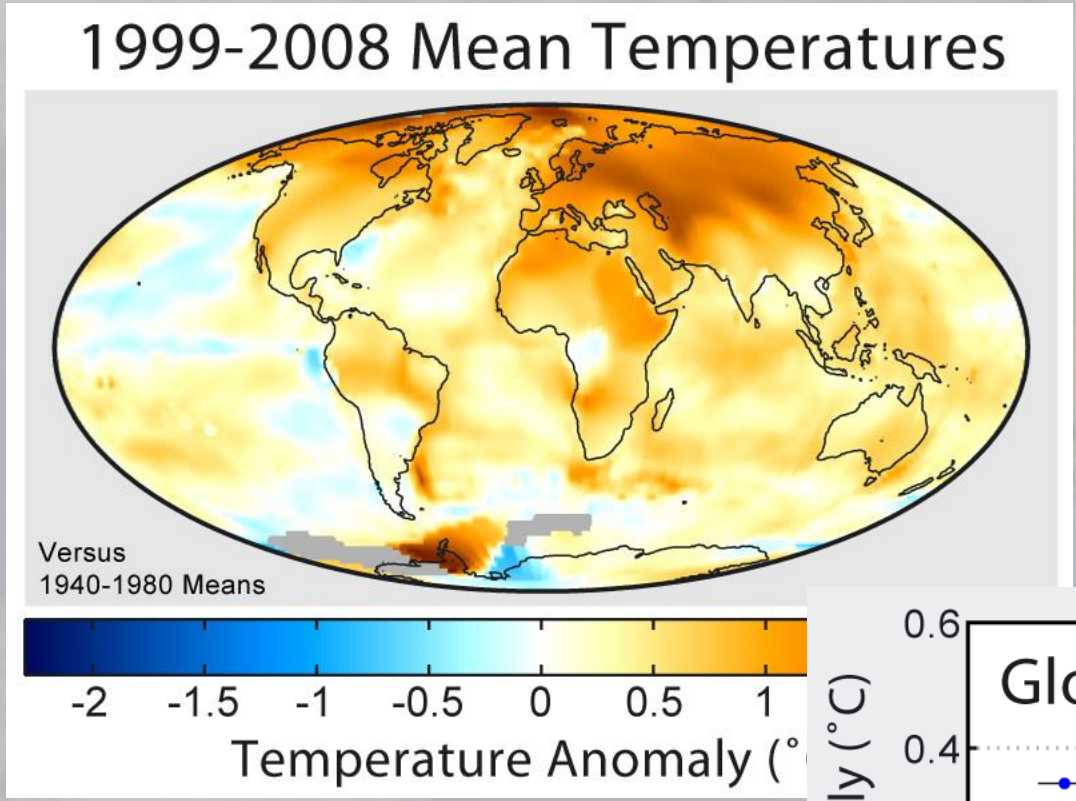
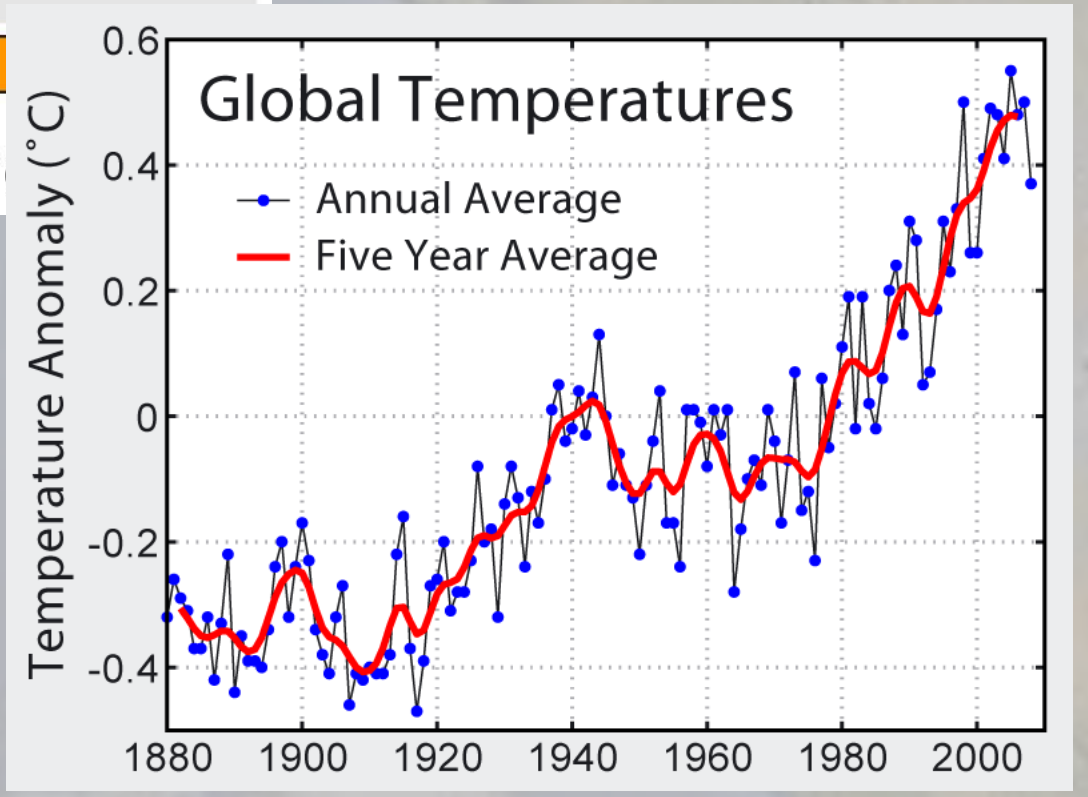
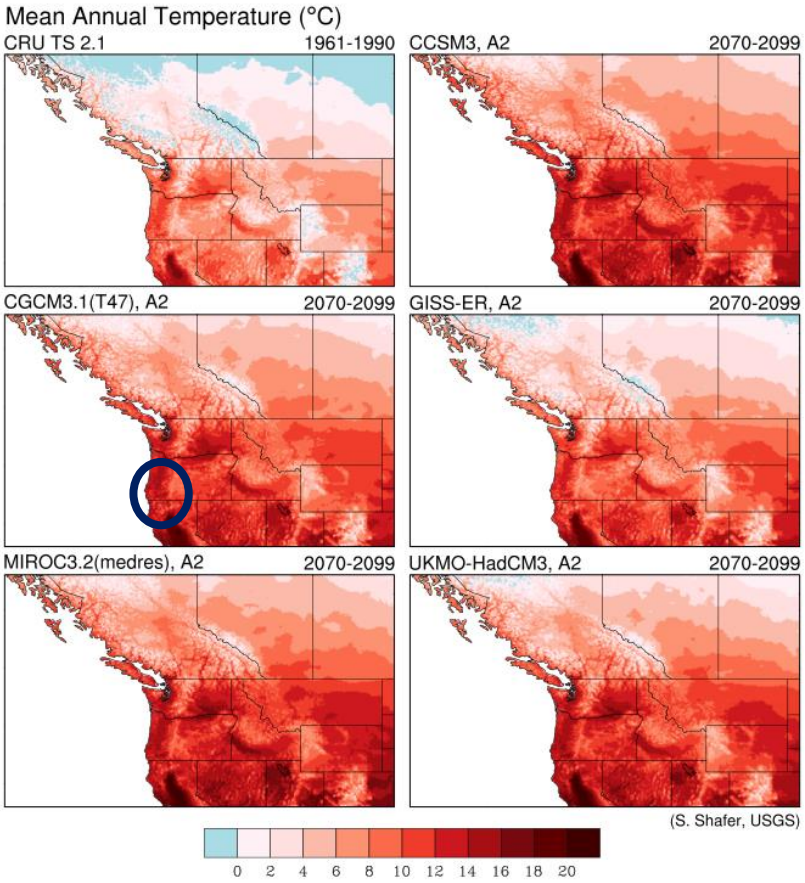

1999-2008 Mean Temperatures
Versus
1940-1980 Means
-2
-1.5
-1
-0.5
0
0.5
1
Temperature Anomaly (°

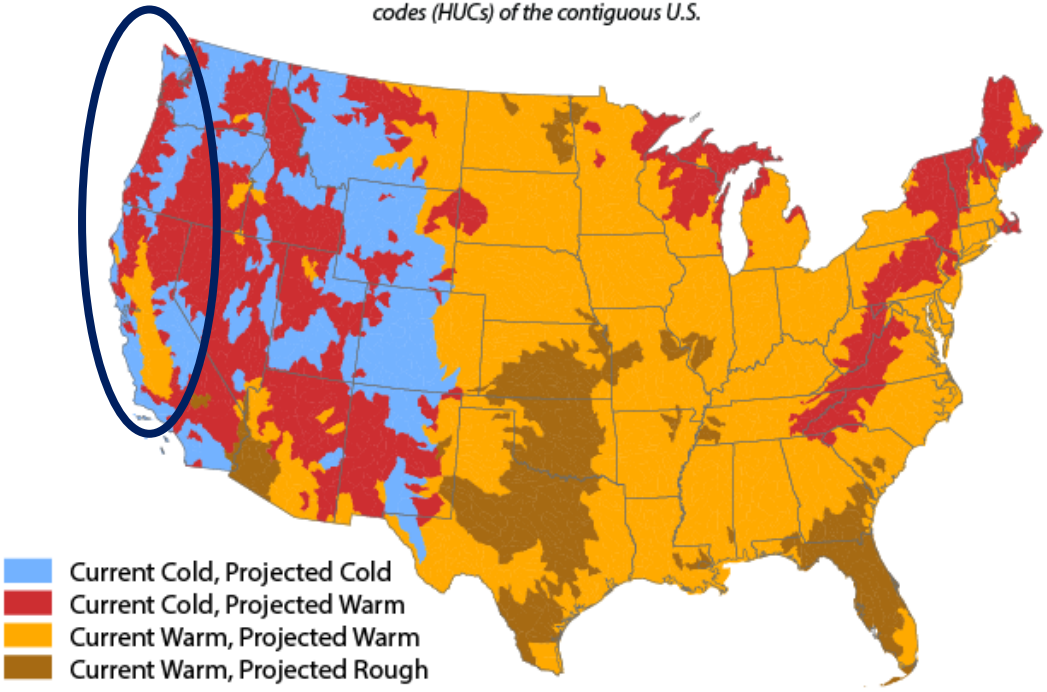

Global Temperatures
Annual Average
Five Year Average
Temperature Anomaly (°C)
0.6
0.4
0.2
0
-0.2
-0.4
1880
1900
1920
1940
1960
1980
2000



CRU TS 2.1 (Mitchell and Jones 2005), CCSM3 (Collins et al. 2006), CGCM3.1(T47) (Scinocca et al. 2008), GISS-ER (Schmidt et al. 2006), MIROC3.2(medres) (K-1 Developers 2004), UKMO-HadCM3 (Gordon et al. 2000)

Figure 1. Projected Impact of Unmitigated Climate Change on Potential Freshwater Fish Habitat in 2100

Change in distribution of areas where stream temperature supports different fisheries under the Reference scenario using the IGSM-CAM climate model. Results are presented for the 8-digit hydrologic unit codes (HUCs) of the contiguous U.S.

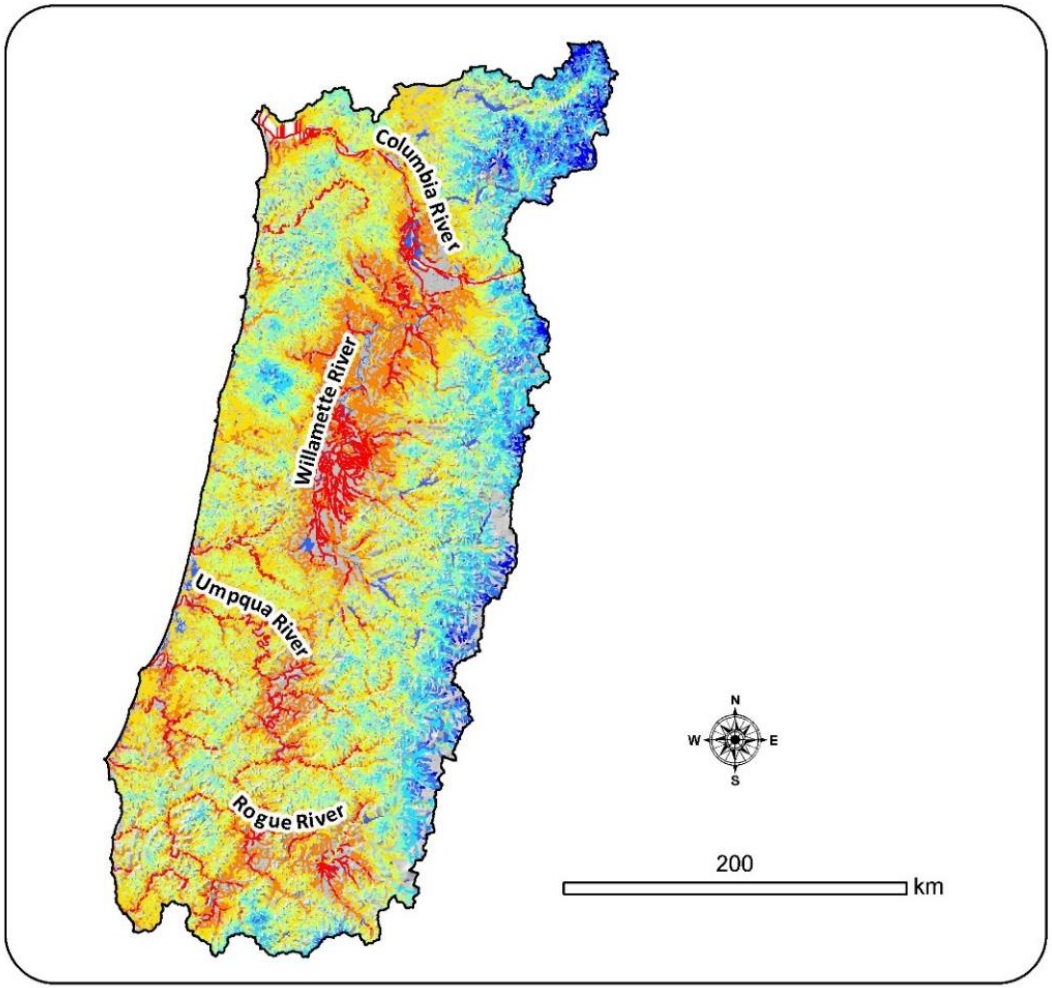


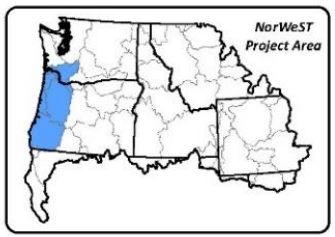
For more information, visit EPA's "Climate Change in the United States: Benefits of Global Action" at www.epa.gov/cira.

NorWeST Stream Temperature

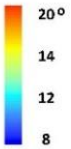
Modeled Mean August Stream Temperature
2040s A1B Prediction

Lower Columbia, Willamette,
N. OR Coastal, and S. OR Coastal
Hydrologic Unit Codes
170800, 170900, 171002, 171003





Scenario 30:
Mean August
Stream Temperatuture
2040s A1B Prediction



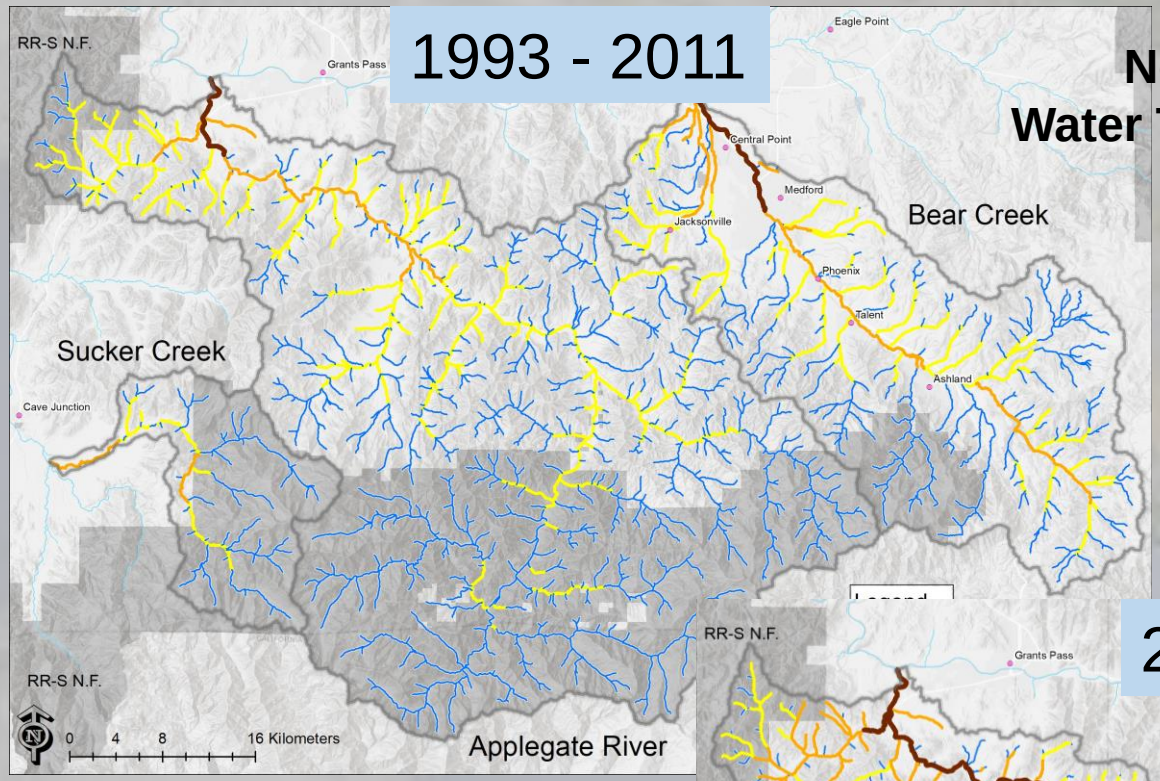
NorWeST
Stream Temp

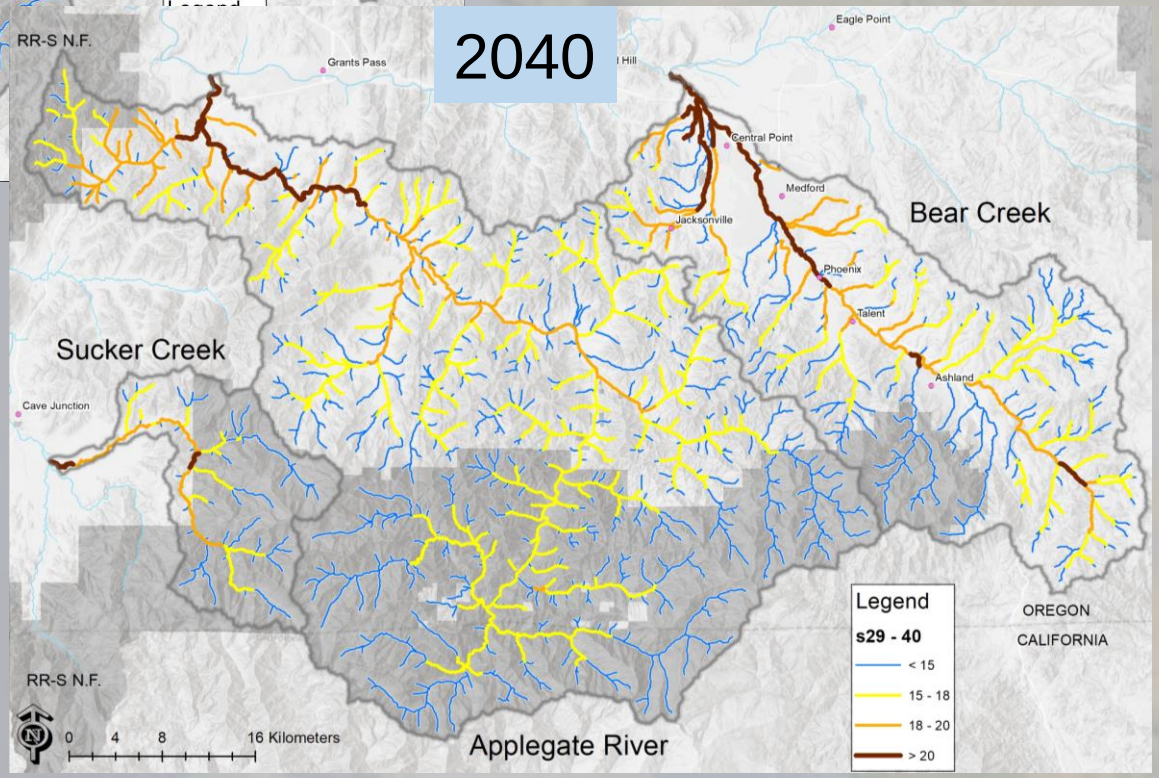
Boise Spatial Streams Group

http://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST.html

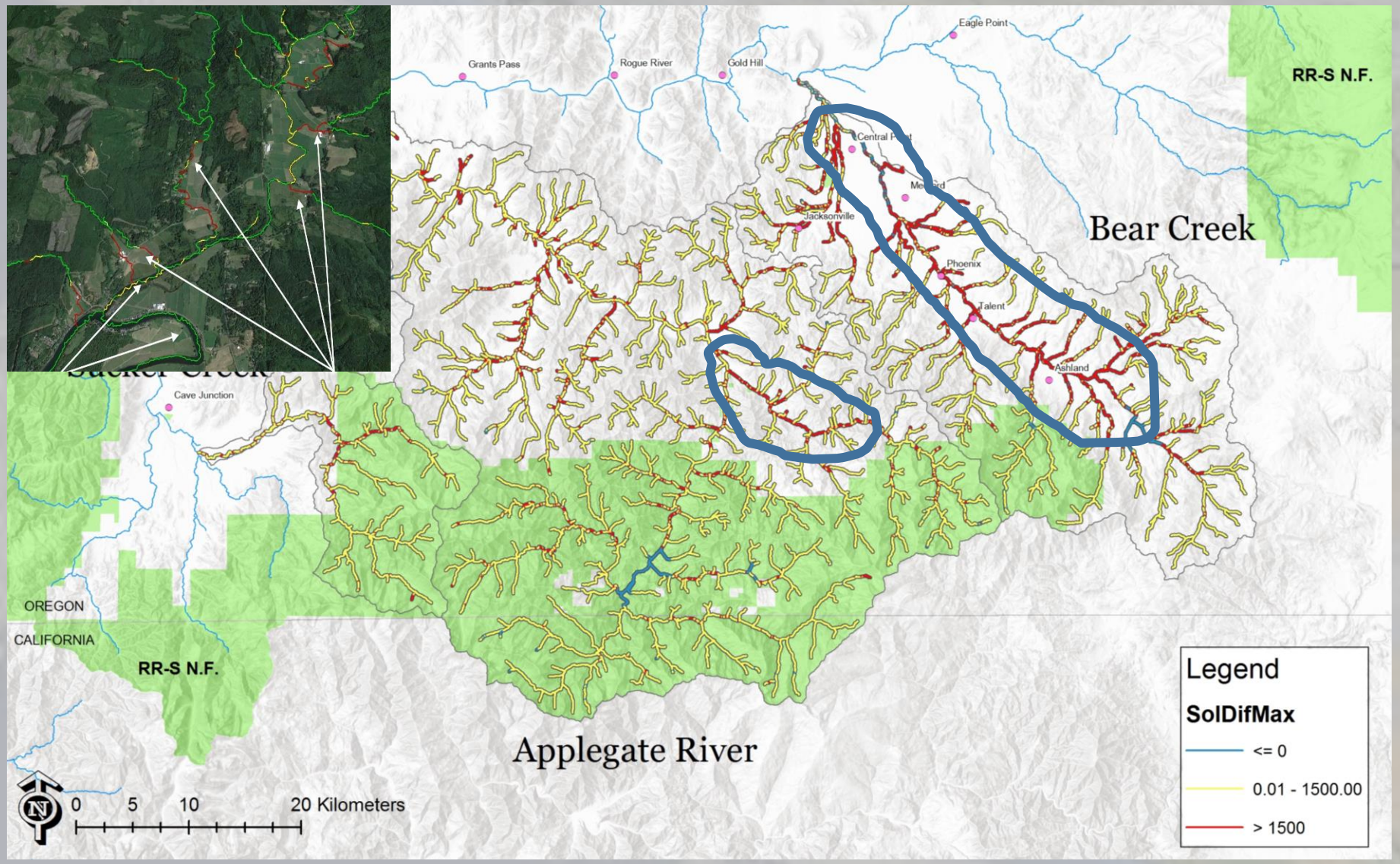

TUNIS 1500 MI.
TUNIS 1500 MI.
TUNIS 1500 MI.

NorWeST Modeled August Water Temperatures (°C) 1993 - 2011





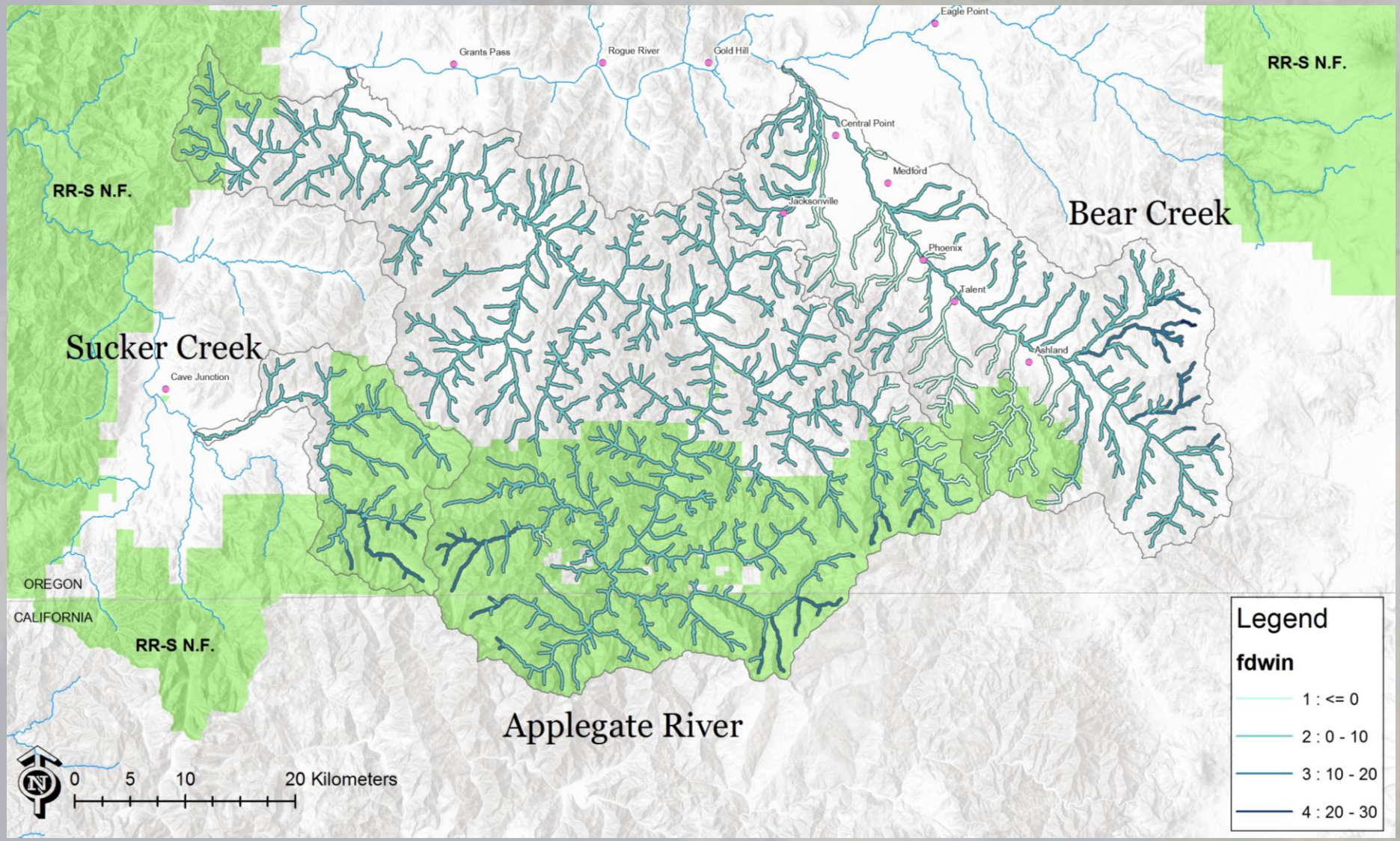
Influence of Riparian Vegetation on Water Temperature



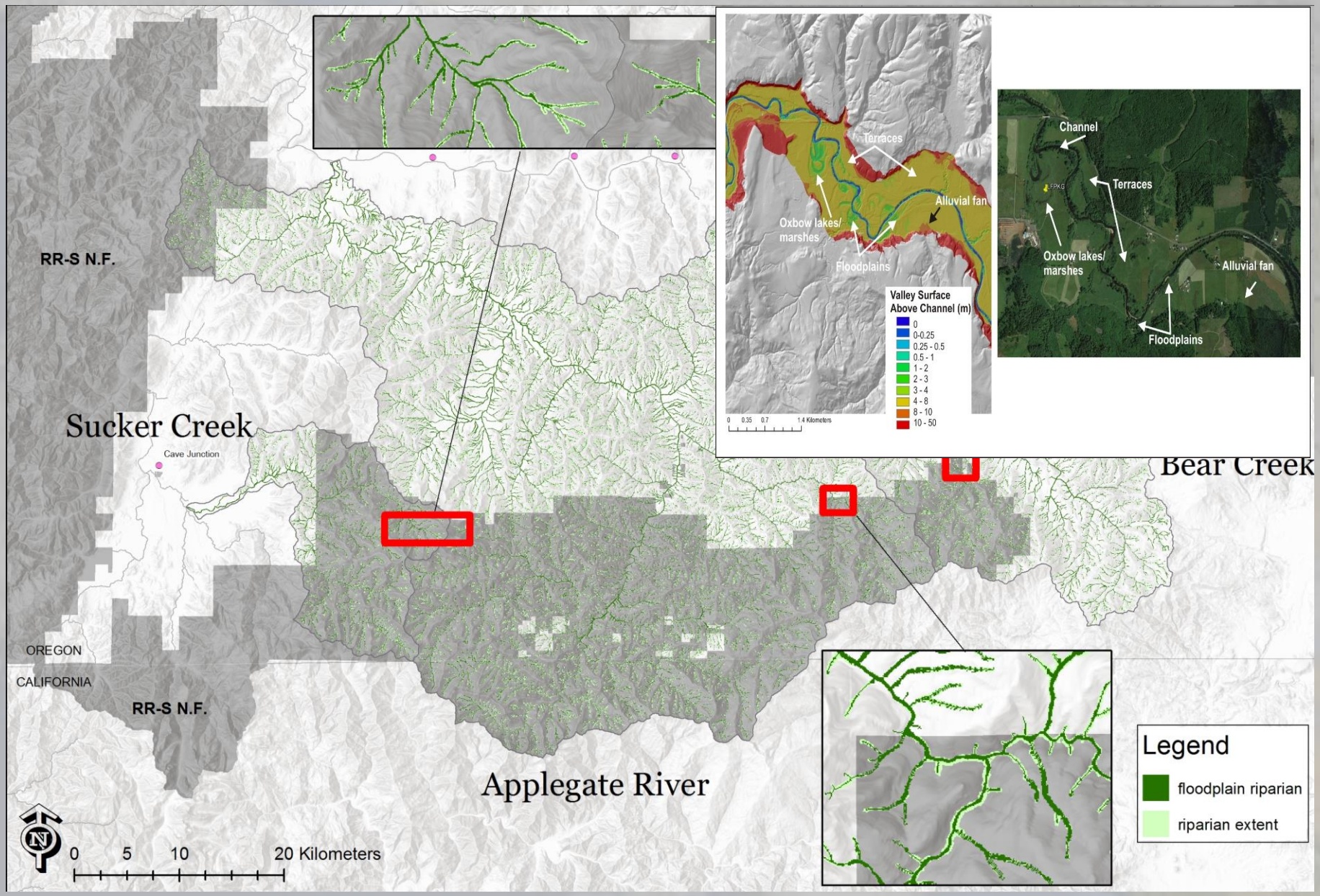
2040 August Water Temperature

Riparian Influence

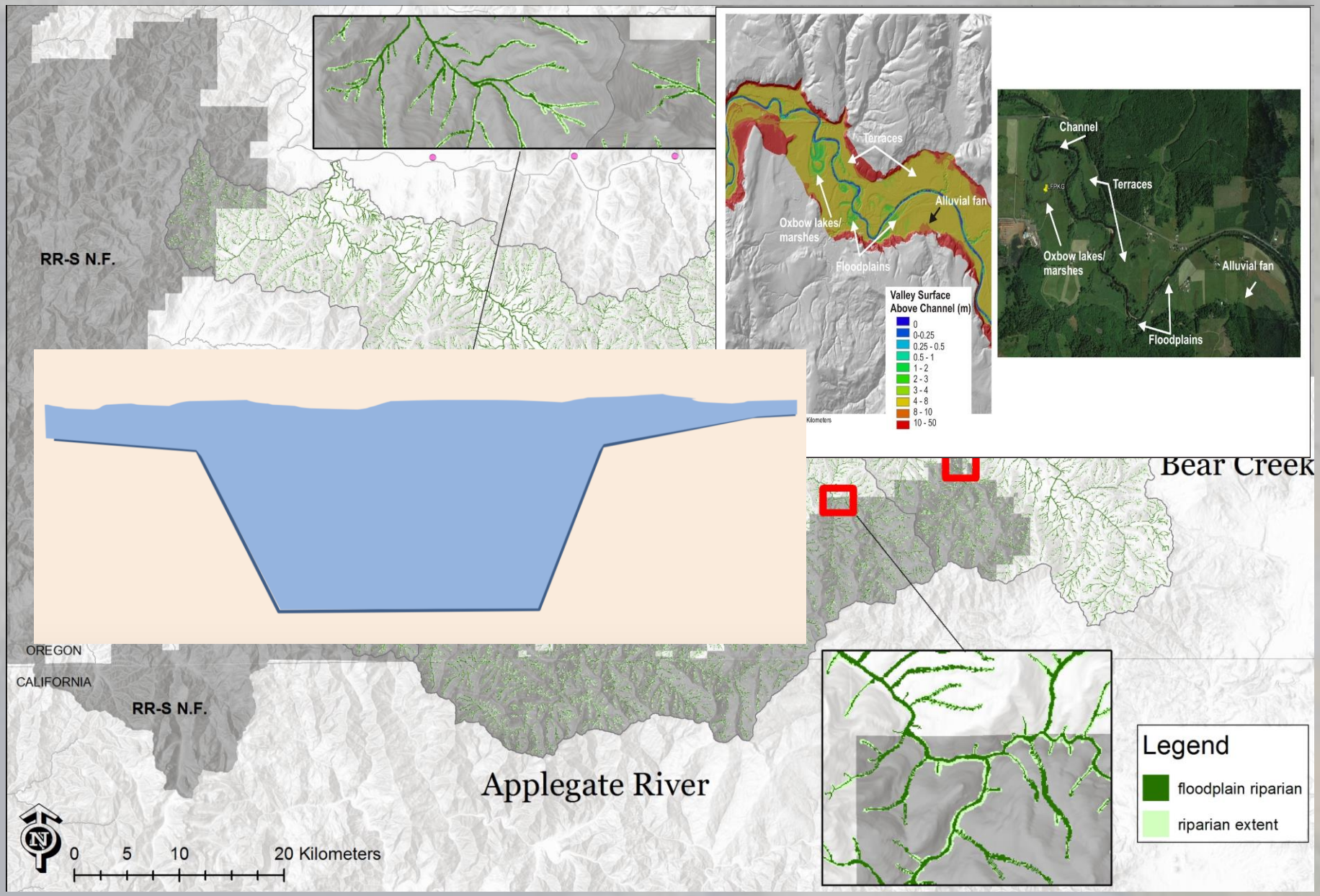
Projected Increases In Winter Stream Flows 2040



Location of Floodplains

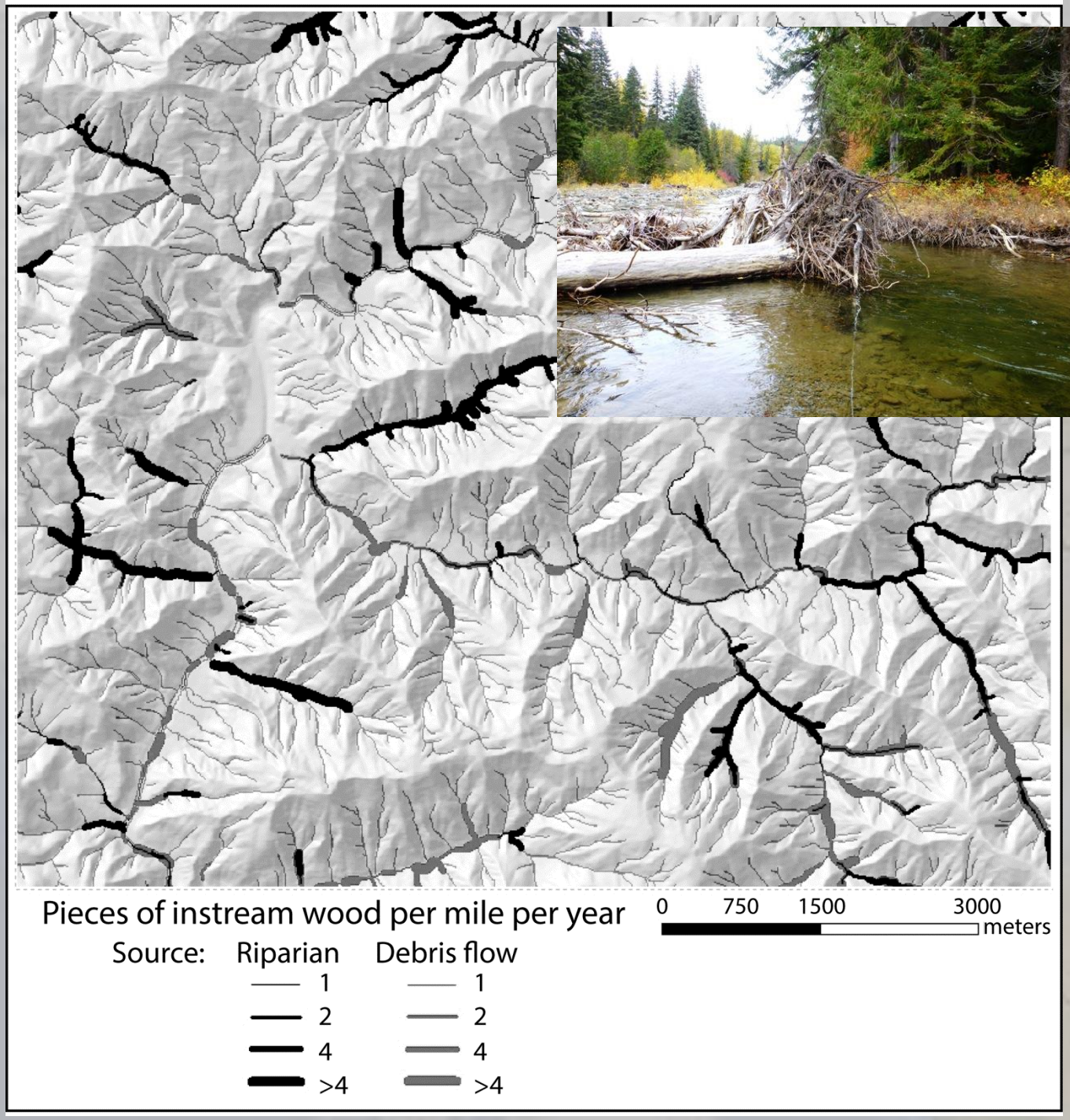


Location of Floodplains

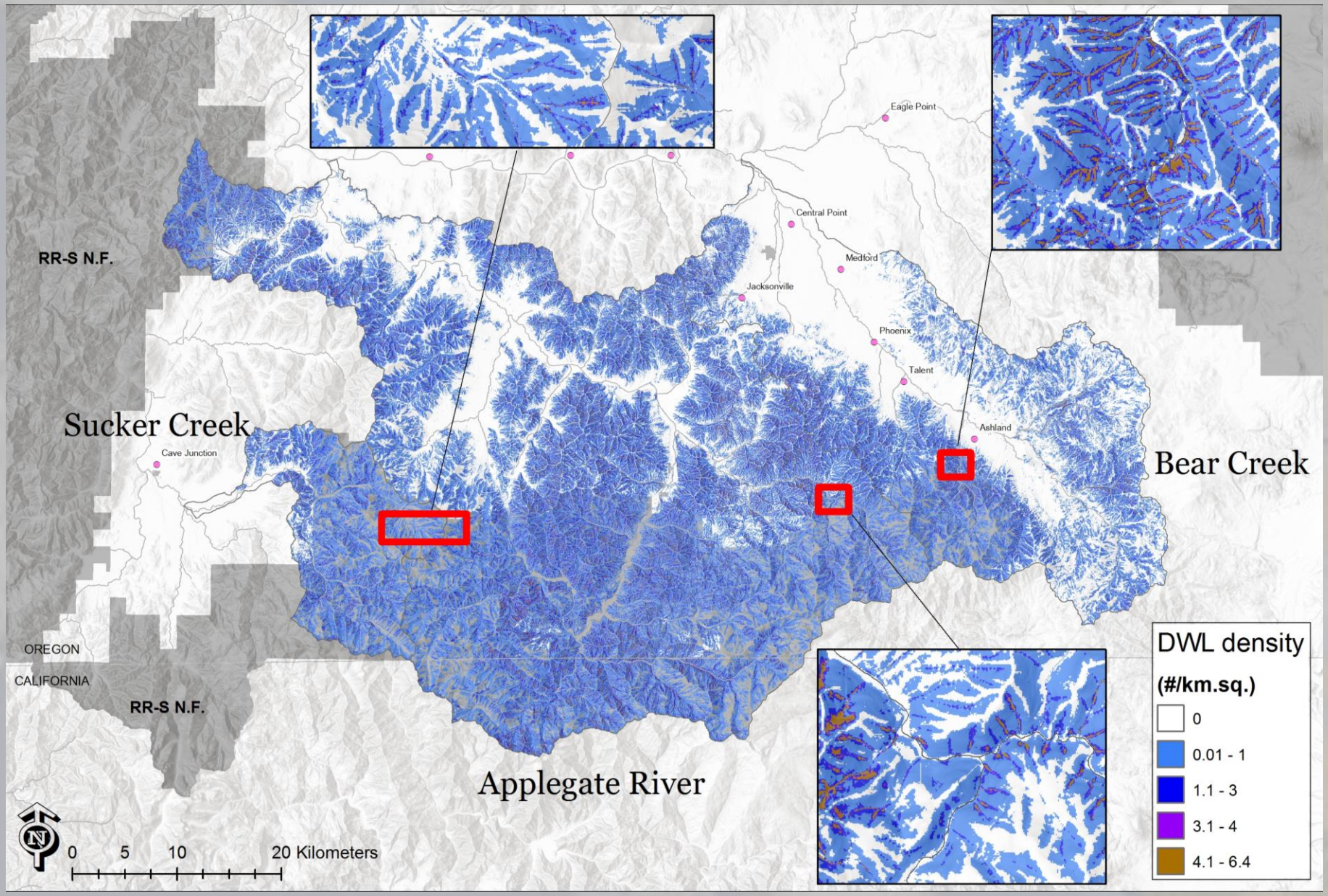


Large Wood Input

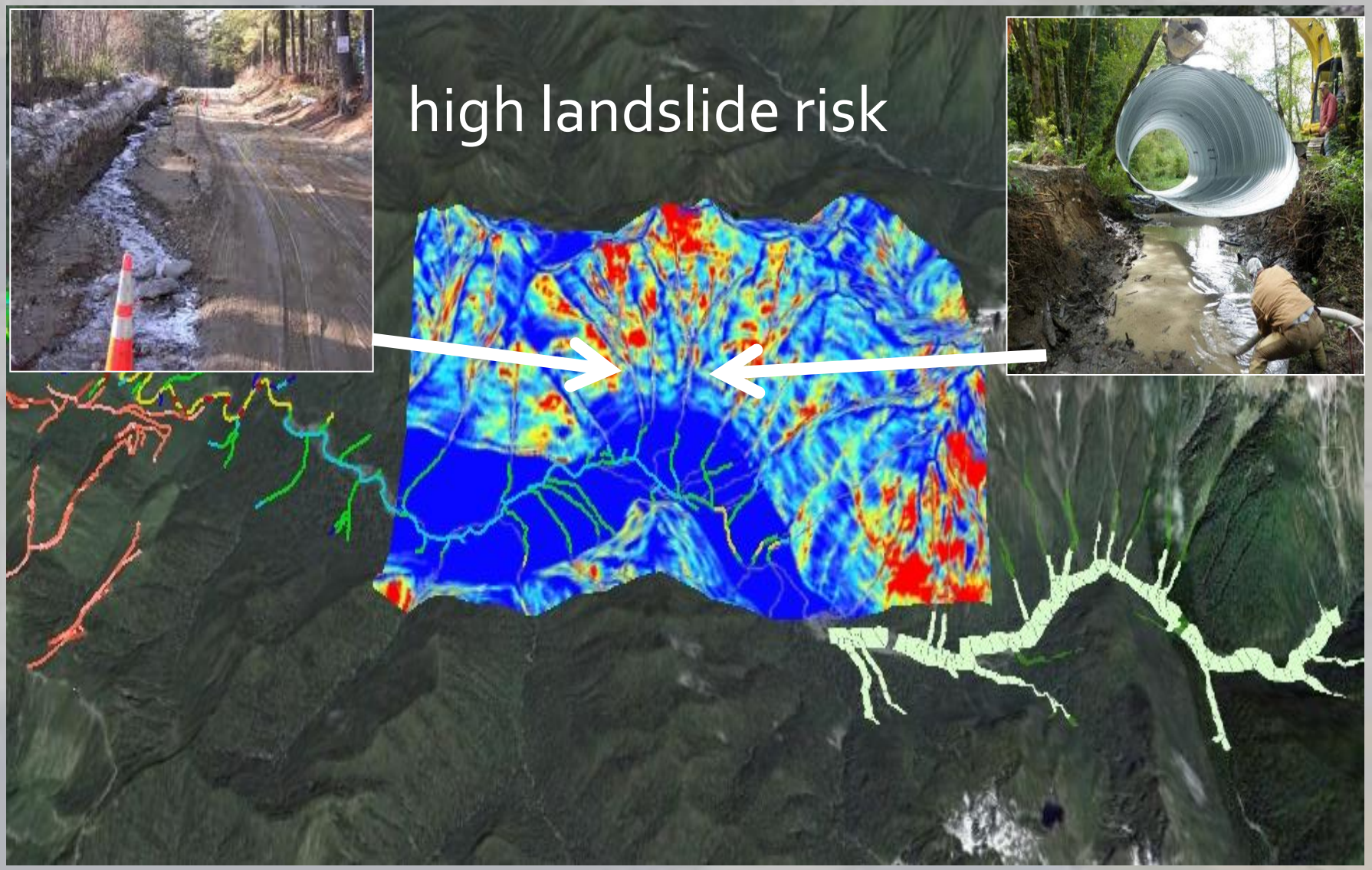
0.2-0.5 m diameter



Density of Landslides

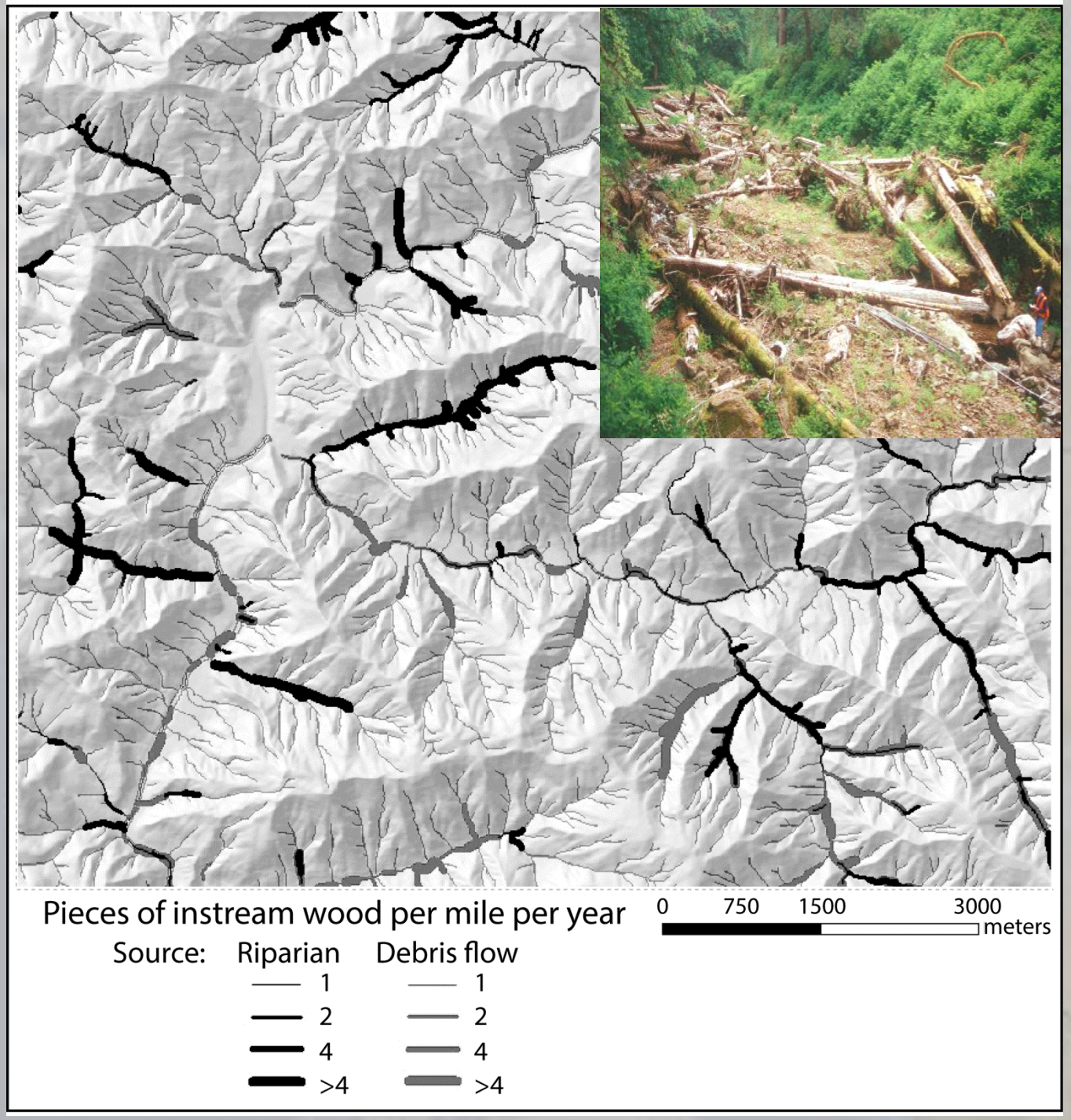


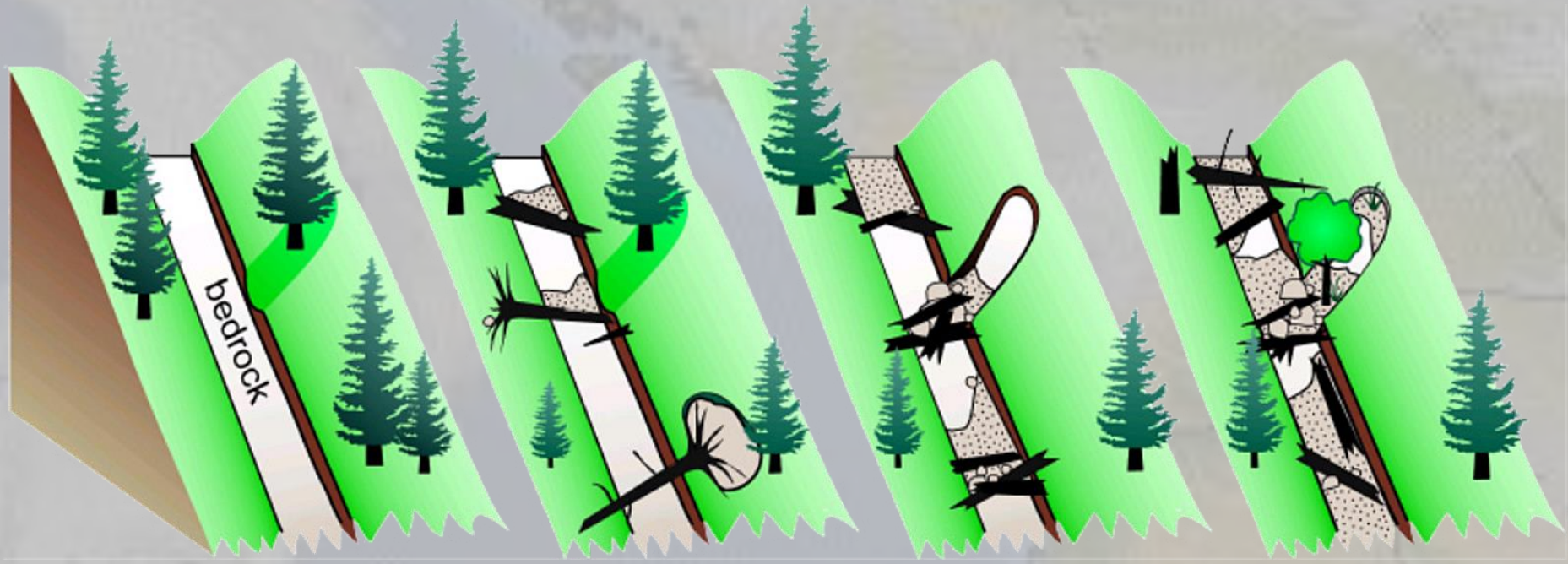
Priority Areas for Restoration



From: TerrainWorks (www.terrainworks.com)

Large Wood Input





0 to 30 yrs

30 to 60 yrs

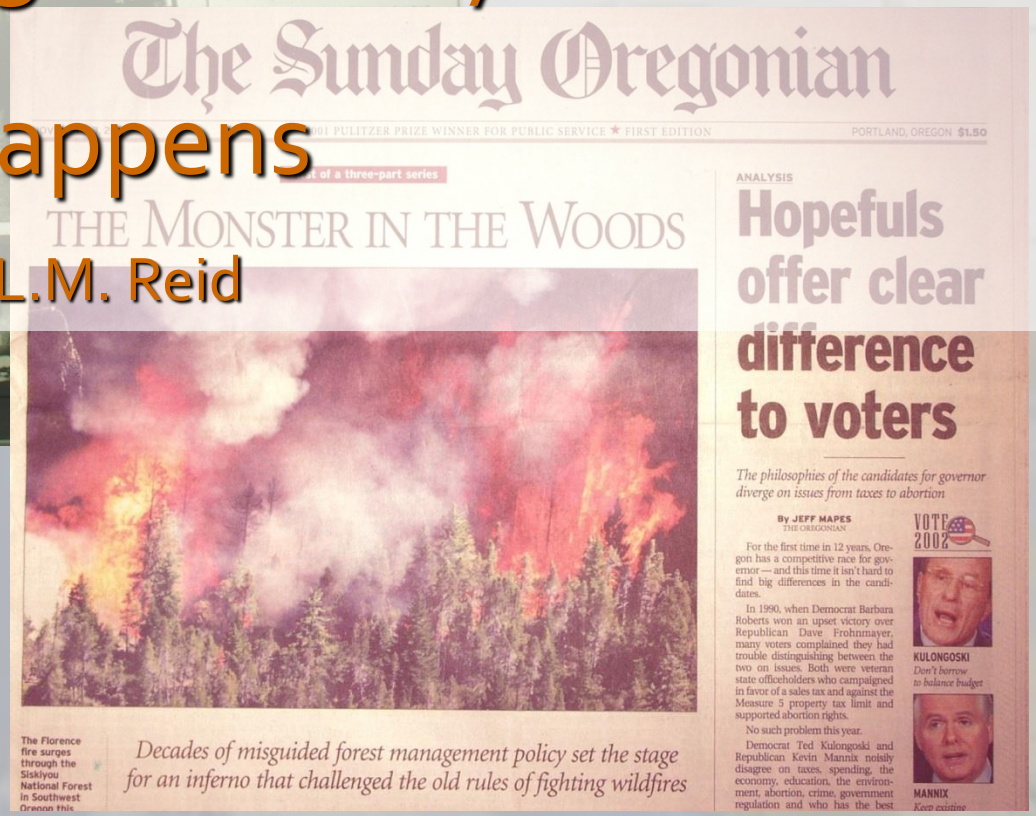
60 to 90 yrs

> 90 yrs

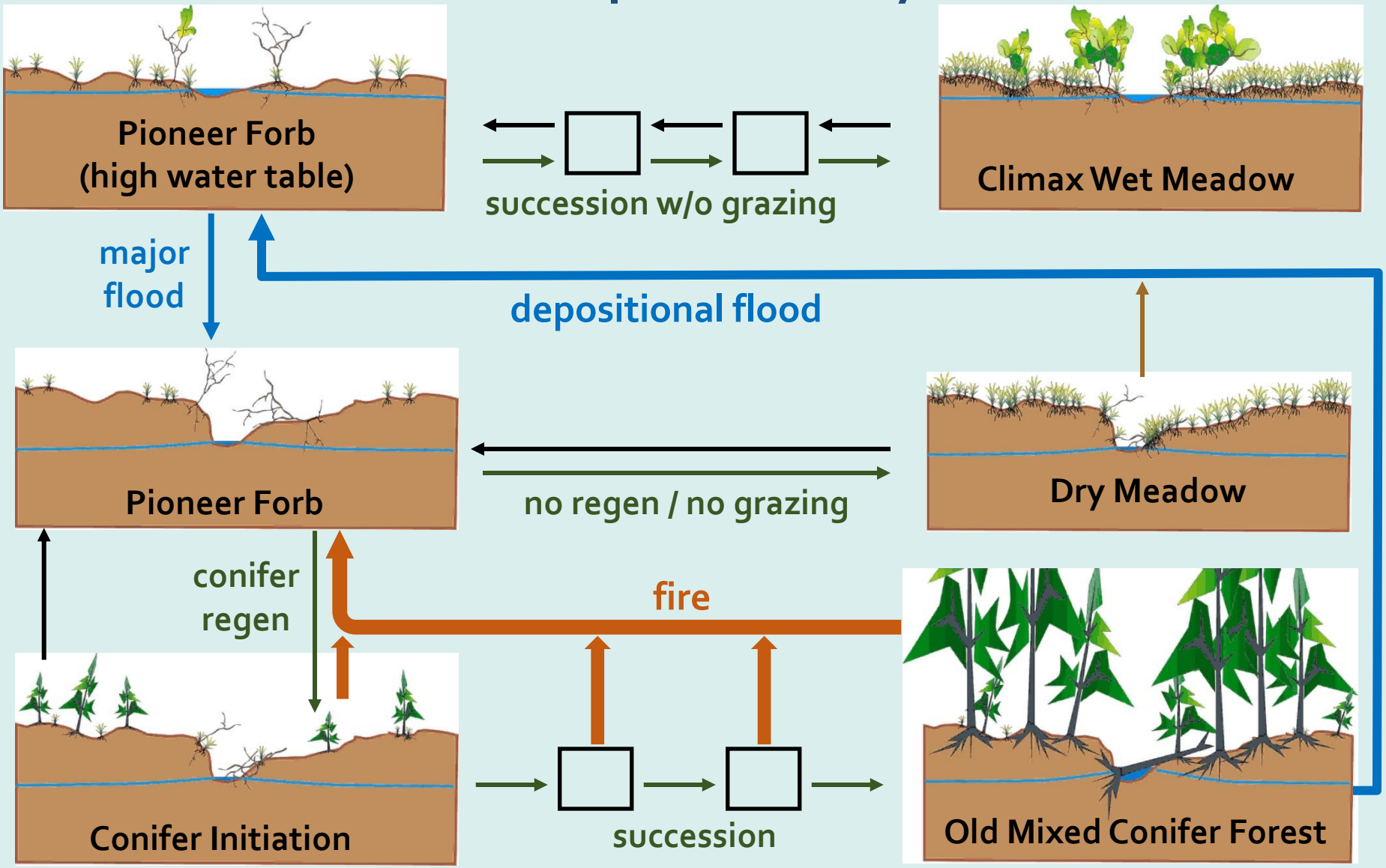
Time Since the Previous Debris Flow

Sometimes High Intensity Trauma Happens

L.M. Reid

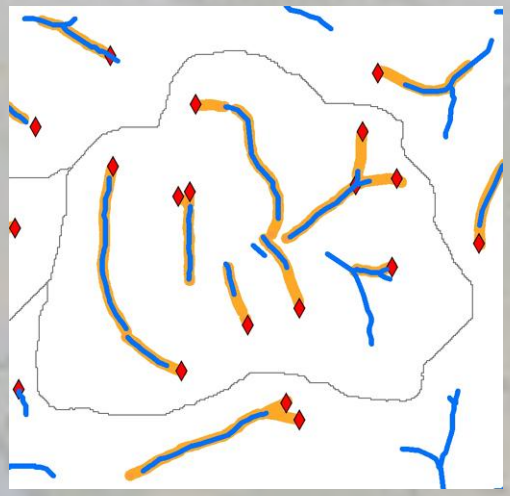


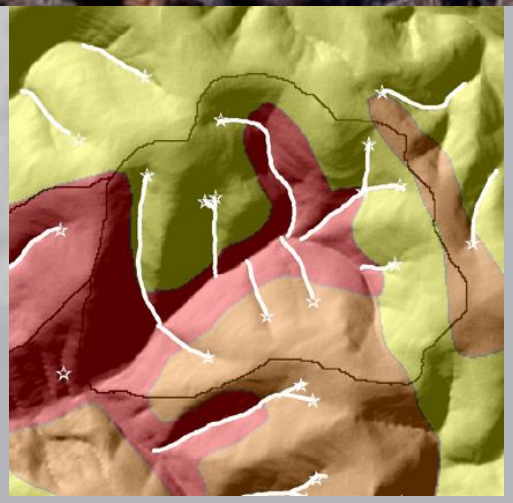
Hypothetical Effect of Fire on Meadow Riparian Ecosystems



Wondzell et al. 2007

East Fork Cable Creek





"Winners" & "Losers"

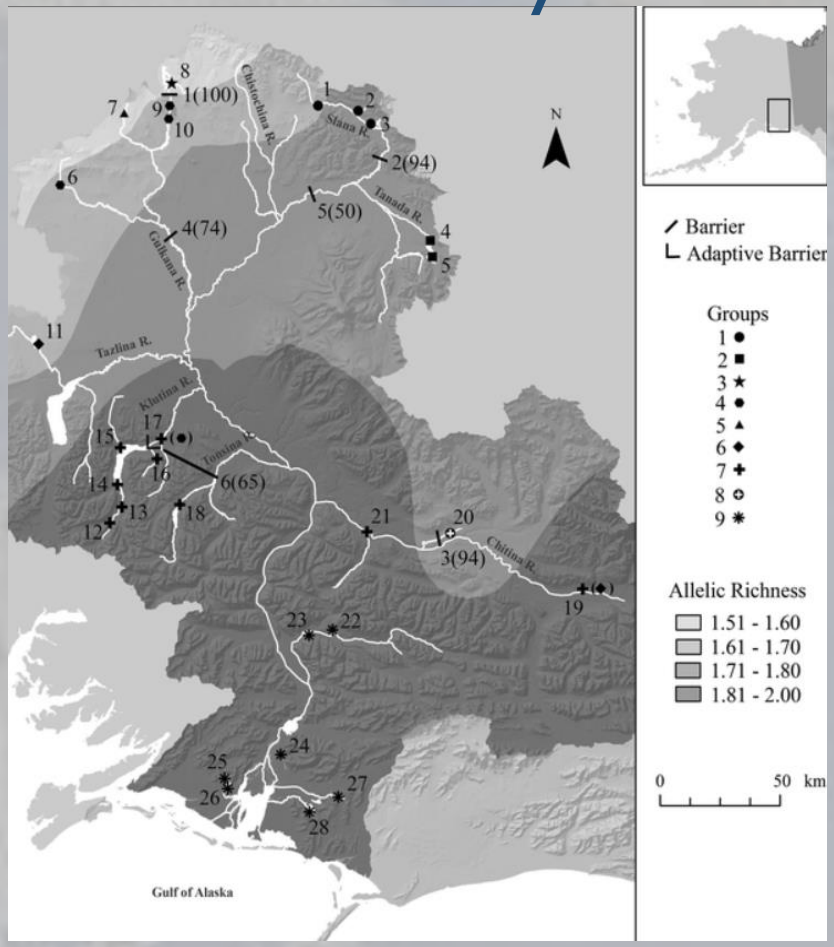
Winning Strategies	Losing Strategies
Habitat generalist	Habitat specialist
Shorter time in fresh water	Long freshwater rearing
High stray rate	Low stray rate
Spring spawning	Fall spawning
Brief exposure OR high tolerance to high temperatures	Extended exposure to high temperatures

	Chum Salmon	Sockeye Salmon
	Pink Salmon	Coho Salmon
	fall Chinook Salmon	spring Chinook Salmon
native minnows	winter steelhead	summer steelhead
native suckers	Westslope Cutthroat Trout	Bull Trout
many non-natives	Coastal Cutthroat Trout	Mountain Whitefish

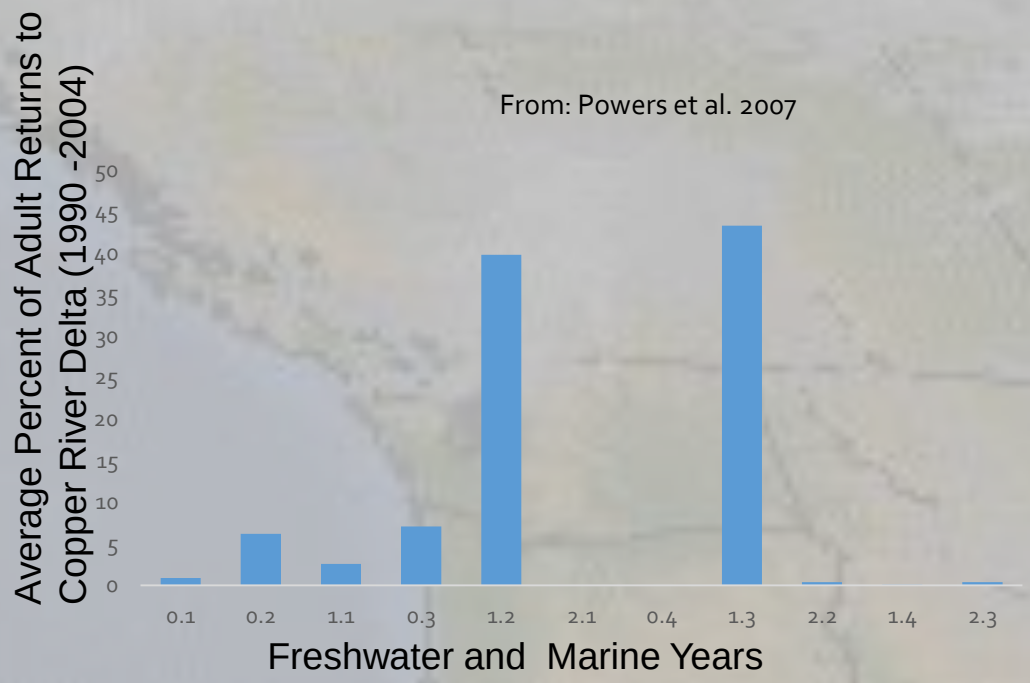
Lower risk ⟷ **Higher risk**

From: Reeves et al. 2018

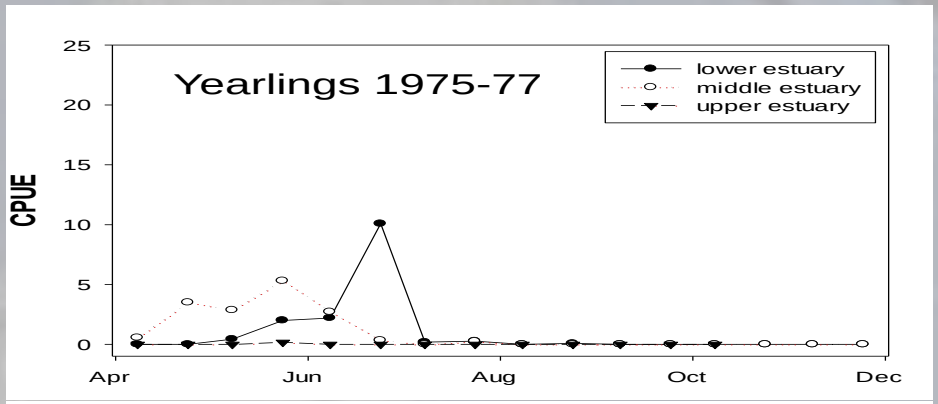
Genetic and Life-history Diversity of Sockeye Salmon in the Copper River, AK

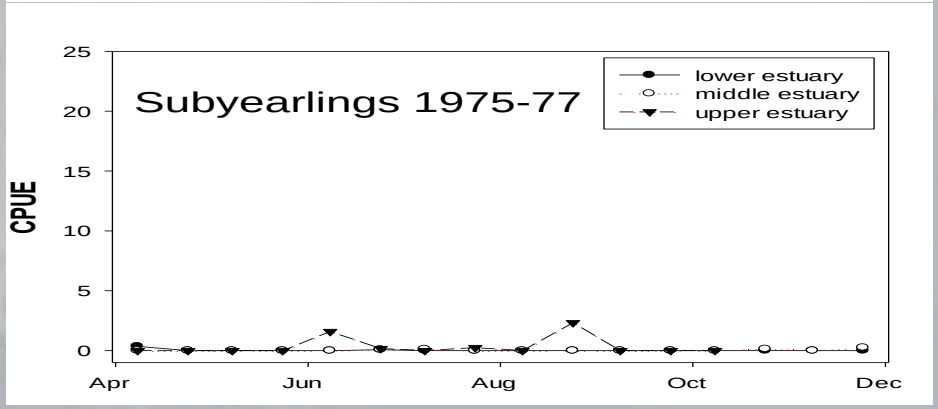


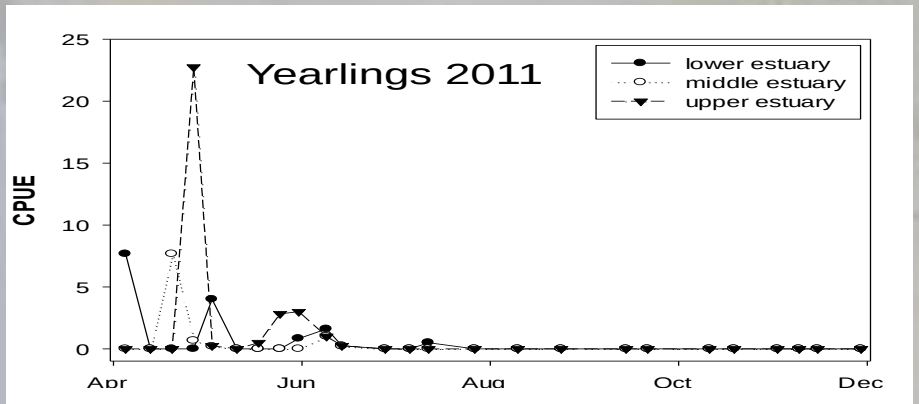
From: Ackerman et al. 2013

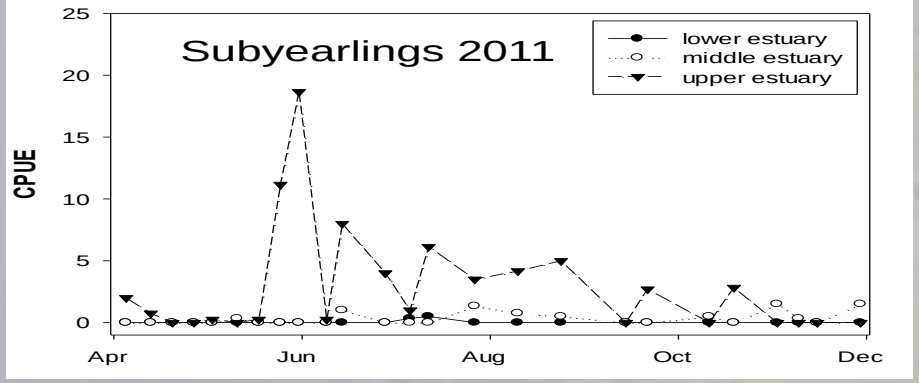


Life-history response of Coho Salmon to changes in estuarine habitat





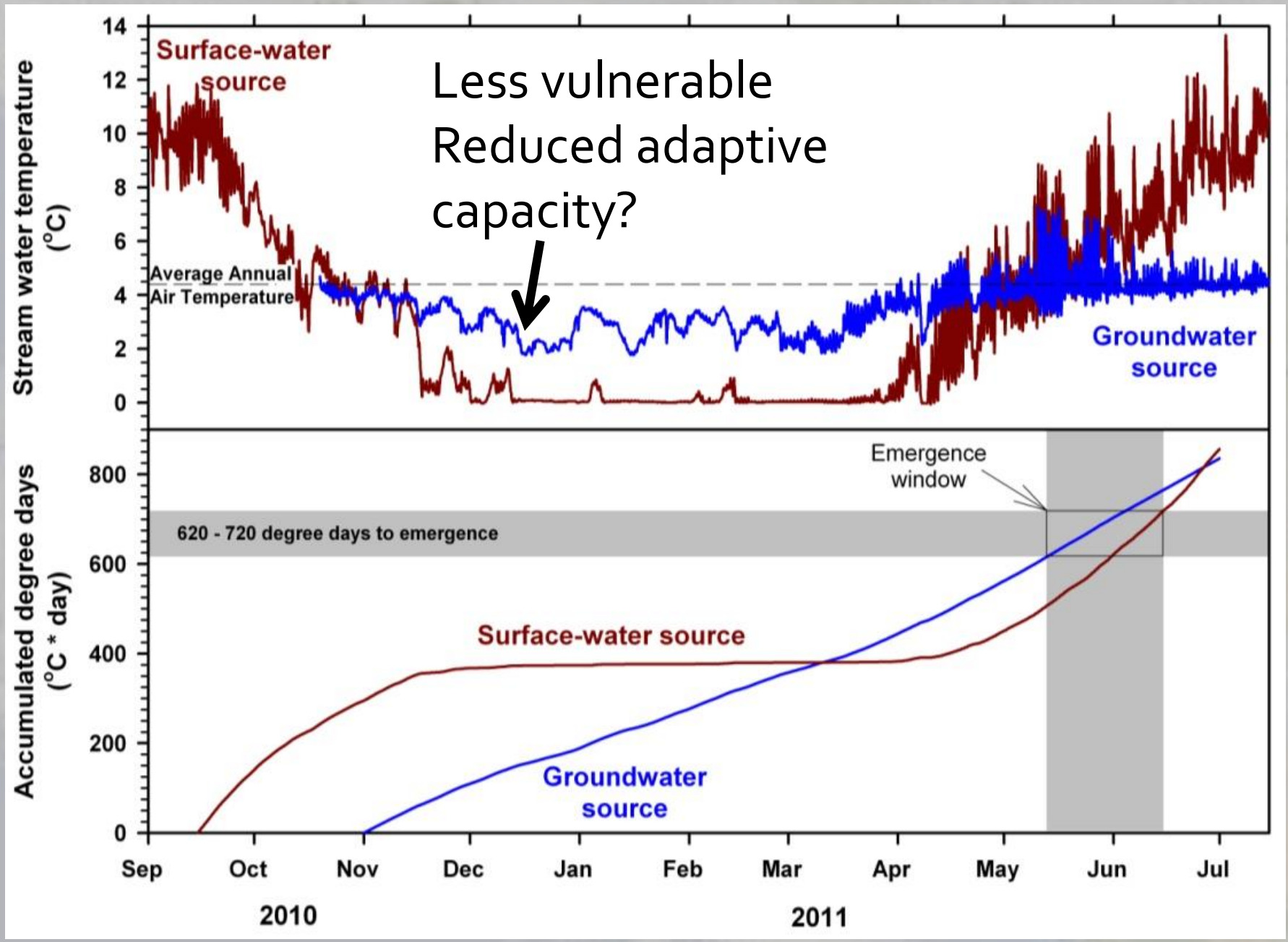


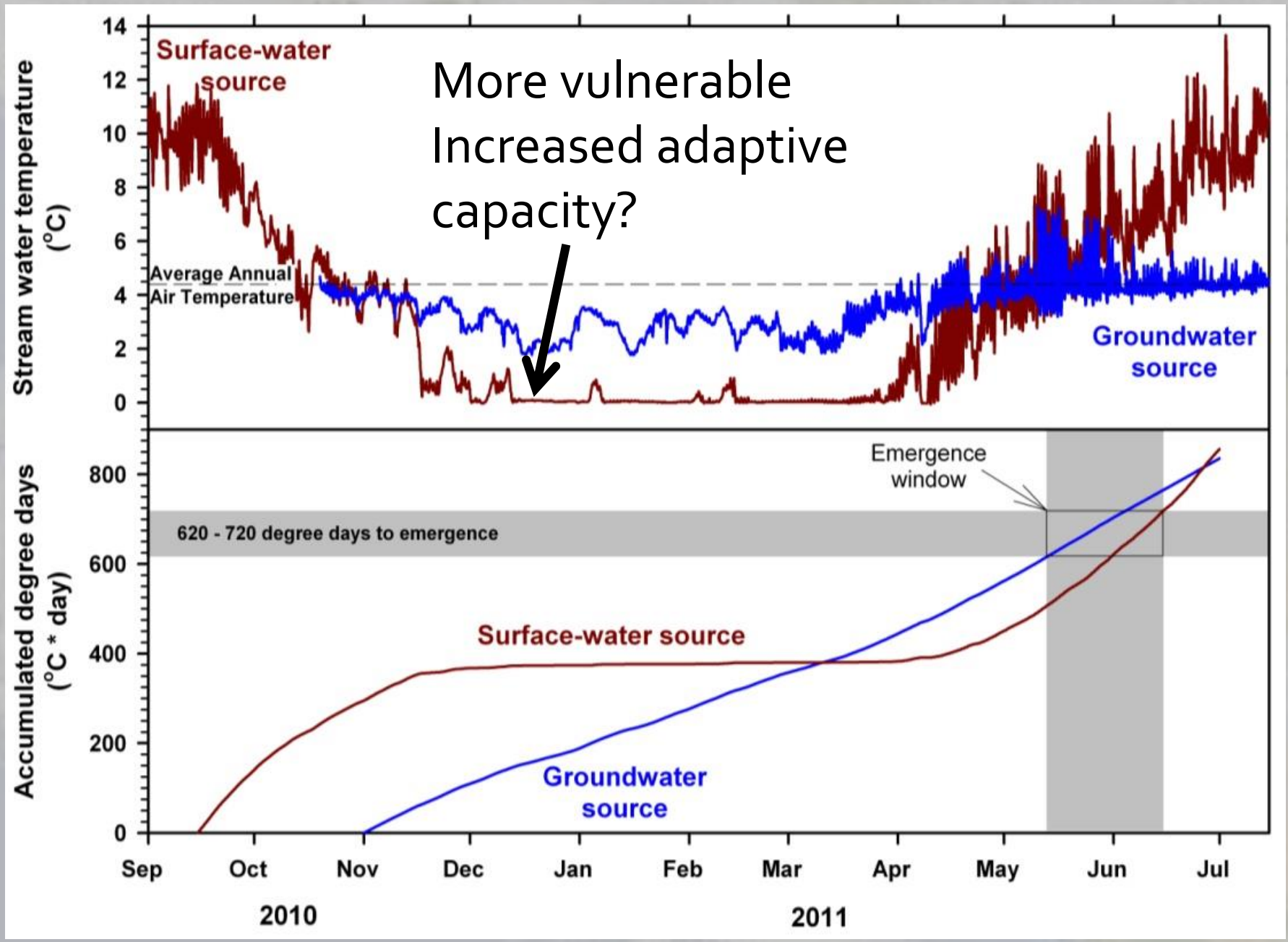


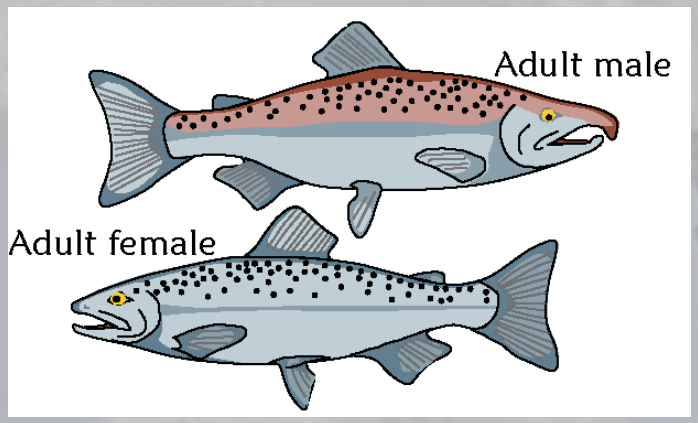
Full diking

Post-diking

Jones et al. 2014


Stream water temperature (°C)
Surface-water source
Less vulnerable
Reduced adaptive capacity?
Average Annual Air Temperature
Groundwater source
Accumulated degree days (°C * day)
Emergence window
620 - 720 degree days to emergence
Surface-water source
Groundwater source
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
2010
2011


Surface-water source
More vulnerable
Increased adaptive capacity?
Average Annual Air Temperature
Groundwater source
Stream water temperature (°C)
14
12
10
8
6
4
2
0
Emergence window
620 - 720 degree days to emergence
Surface-water source
Groundwater source
Accumulated degree days (°C * day)
800
600
400
200
0
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
2010
2011



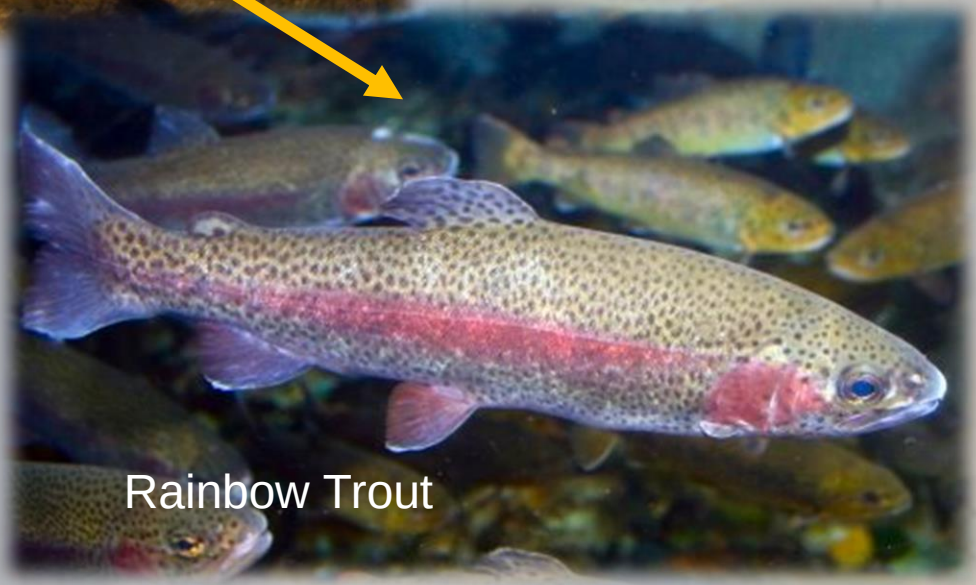
Adults: Ocean

- Water temp ↑
- Upwelling timing △
- pH △

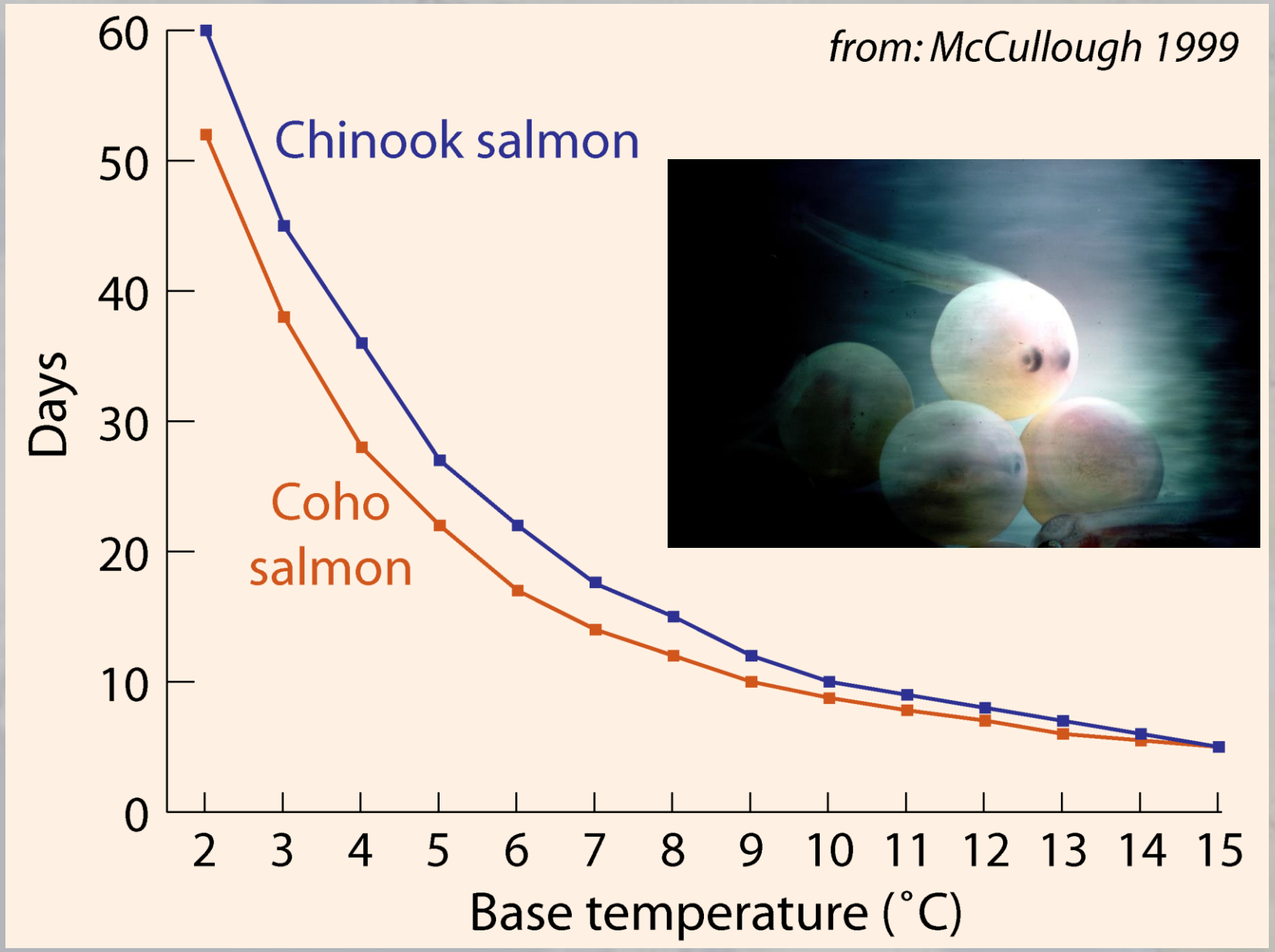
- decreased growth and survival in marine environment
  - smolts
  - adults
- decreased food supplies


Steelhead
© Morgan Bond

?


Rainbow Trout

Reduced Number of Days to Emergence from Each 1°C Increase in Water Temperature from Base



Meeting the Challenges of Climate Changes

- Need to understand the expression of climate change at the local scale
  - Need to be strategic
  - Focus on restoring ecological processes
  - In-channel restoration is the first step, not the last

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Meeting the Challenges of Climate Changes

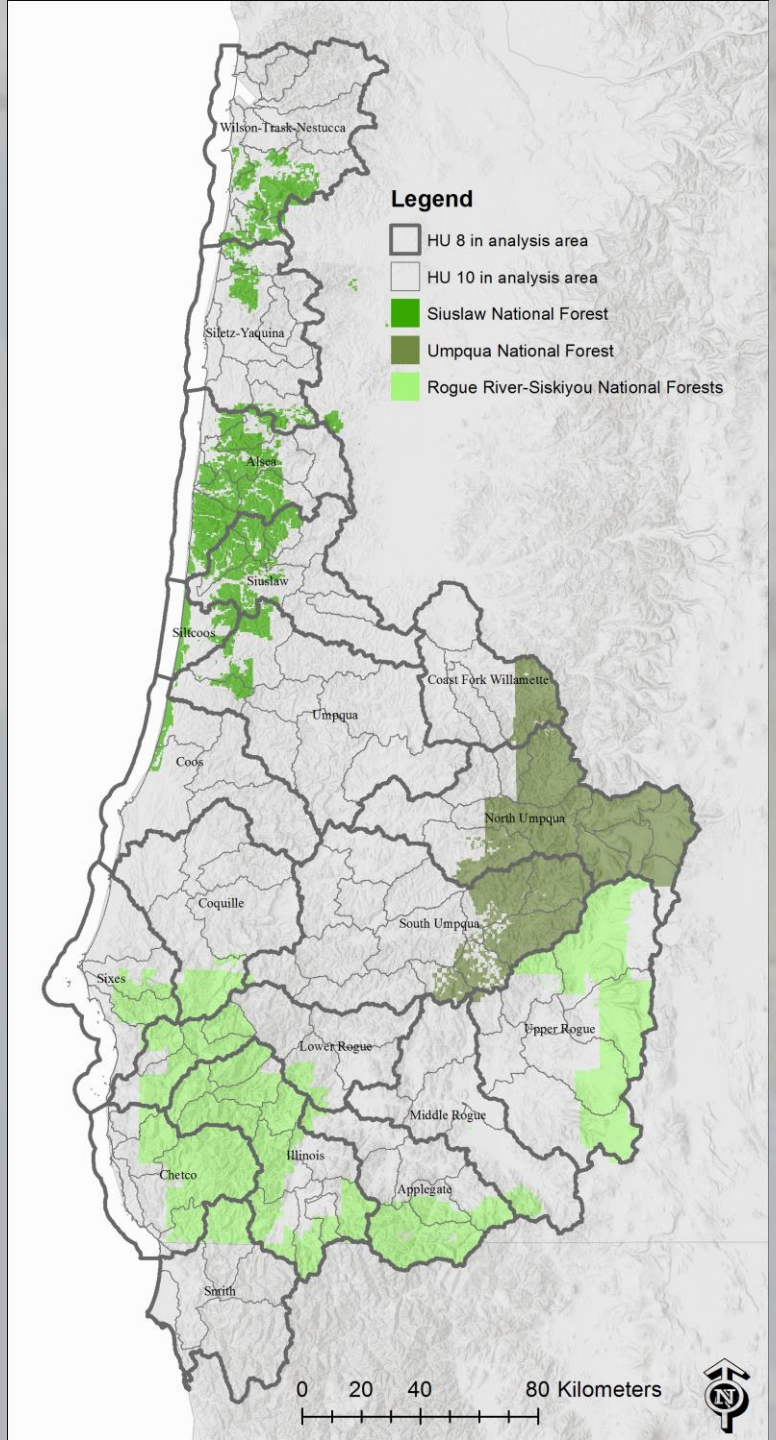
- Need to understand the expression of climate change at the local scale
  - Need to be strategic
  - Focus on restoring ecological processes
  - In-channel restoration is the first step, not the last
- Will be "Winners & Losers"
- Focus on restoring biological diversity

From: J. Asel

Go Big or Go Home!

"The significant problems we face today cannot be solved with the same level of thinking that were at when we created them."

Albert Einstein

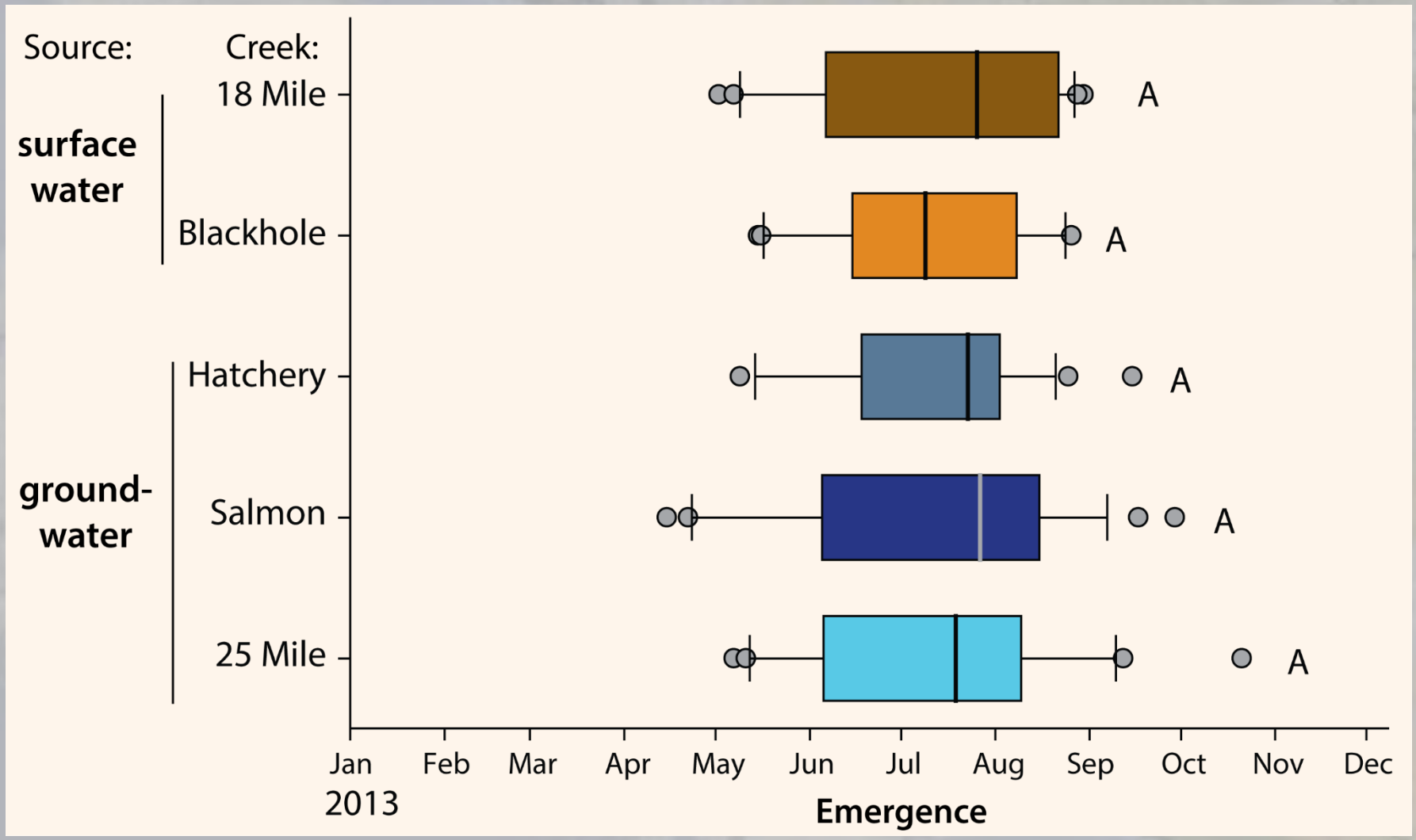

Legend
HU 8 in analysis area
HU 10 in analysis area
Siuslaw National Forest
Umpqua National Forest
Rogue River-Siskiyou National Forests
Wilson-Trask-Nestucca
Siletz-Yaquina
Alsea
Siuslaw
Siltcoos
Coast Fork Willamette
Umpqua
Coos
North Umpqua
Coquille
South Umpqua
Sixes
Upper Rogue
Lower Rogue
Middle Rogue
Illinois
Chetco
Applegate
Smith
0 20 40 80 Kilometers
N

Uses

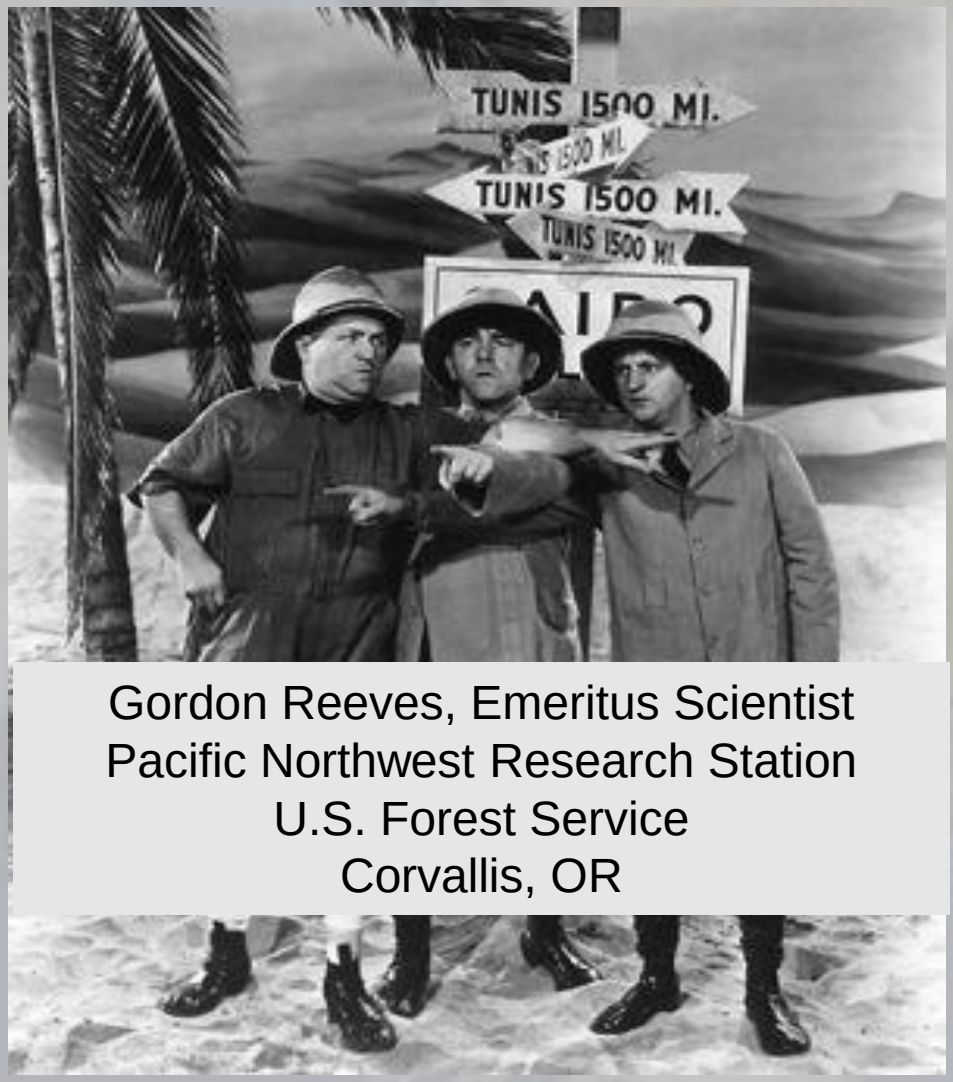
- Climate change vulnerability assessments
- Modeling
- Monitoring
- Restoration prioritization
- Collaborations

Estimated Times of Spawning of Coho Salmon on the Copper River Delta, AK

Estimated Time of Emergence of Coho Salmon on the Copper River Delta, AK



How Climate Extremes Affect Salmonid Recovery



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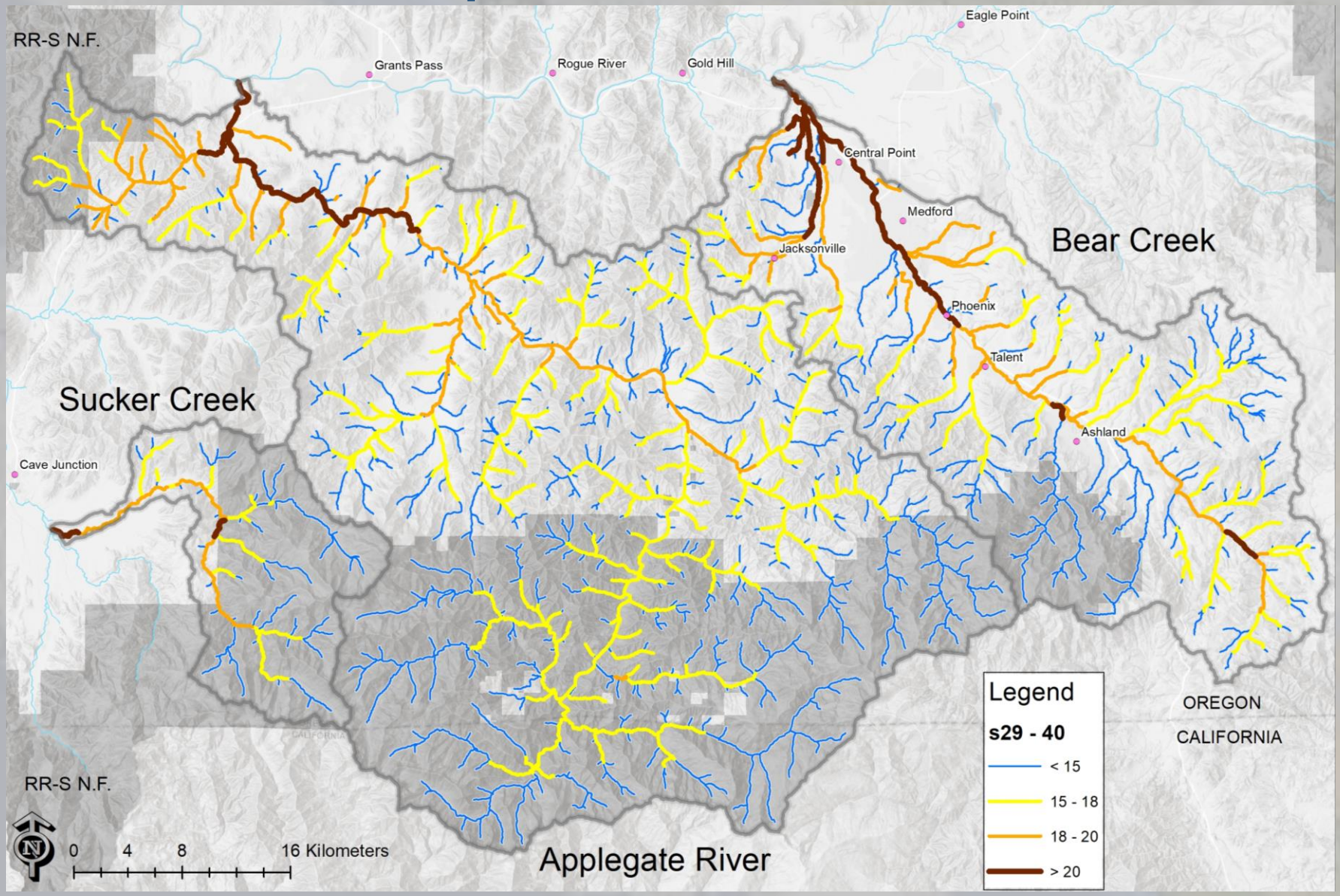
NorWeST Modeled August Water Temperatures (°C) 1993 - 2011



NorWeST Modeled August Water Temperatures (°C) 2040