Climate Change Vulnerability Assessments: The Road to Resilience and Adaptation

March 13th, 2015

Coordinator: Michael J. Furniss, MJ Furniss & Associates

33rd Annual Salmonid Restoration Conference

Climate Vulnerability Assessment

The Road to resilience and adaptation

SRF 2015

CLIMATE VULNERABILITY ASSESSMENT

SRF 2015

Michael J. Furniss

Thanks to: Connie Millar, Jason Pa ; o n , Tom Leroy, Aldaron Laird,
David Peterson, Virginia Burke; , Linda Joyce, Sarah Hines , Susan Schlosser, Stephanie Klein, Chris Swanston, Kristen Schmidt, Jeffrey Guntle, Ken Roby, Cynthia Mackie, and others

Outline

1. Terminology
2. Conceptual Model
3. Why assess vulnerability
4. How to conduct an assessment
5. Case Study
6. A few lessons

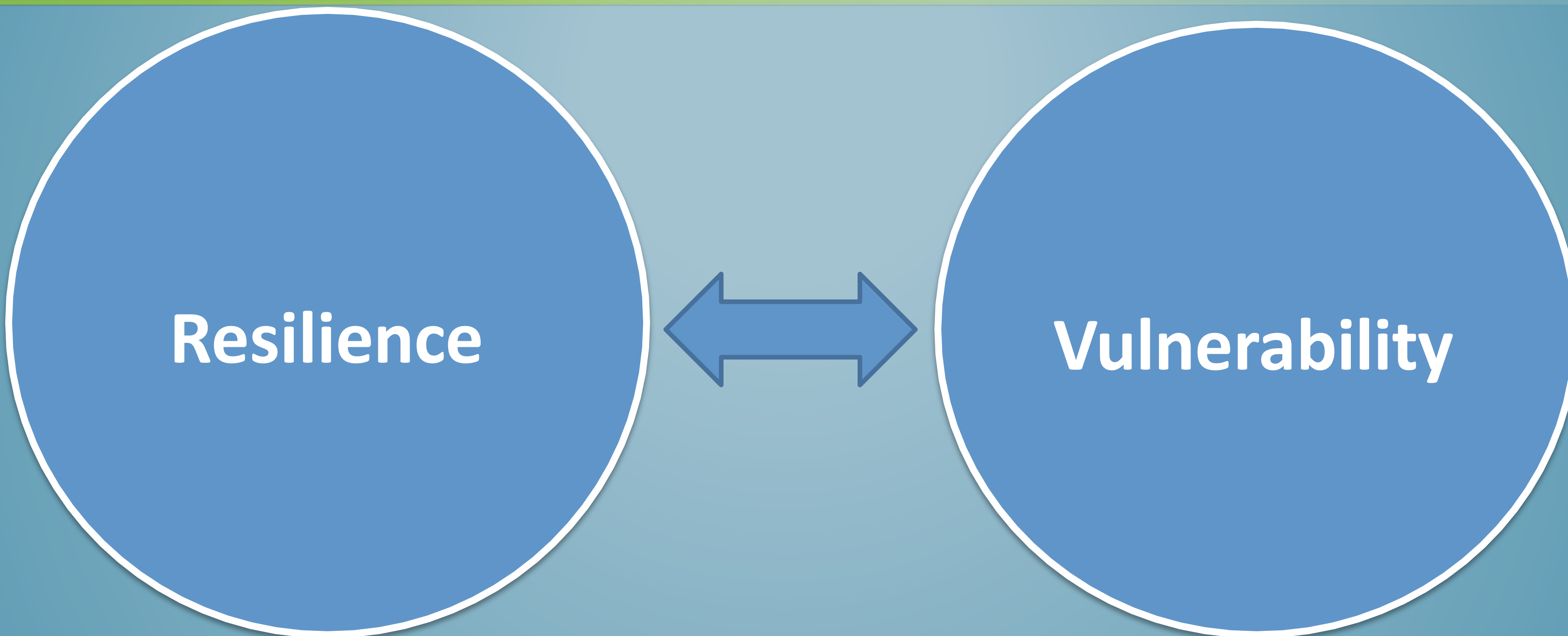
Climate Change Vulnerability

The degree to which geophysical, biological and socio-economic systems are suscepVble to, and unable to cope with, adverse impacts.

-IPCC

Resilience

Terminology



To promote resilience you need to know vulnerability

What is meant by "**Resilience**"

In ecology, resilience and resistance

Common climate adaptaVon usage:

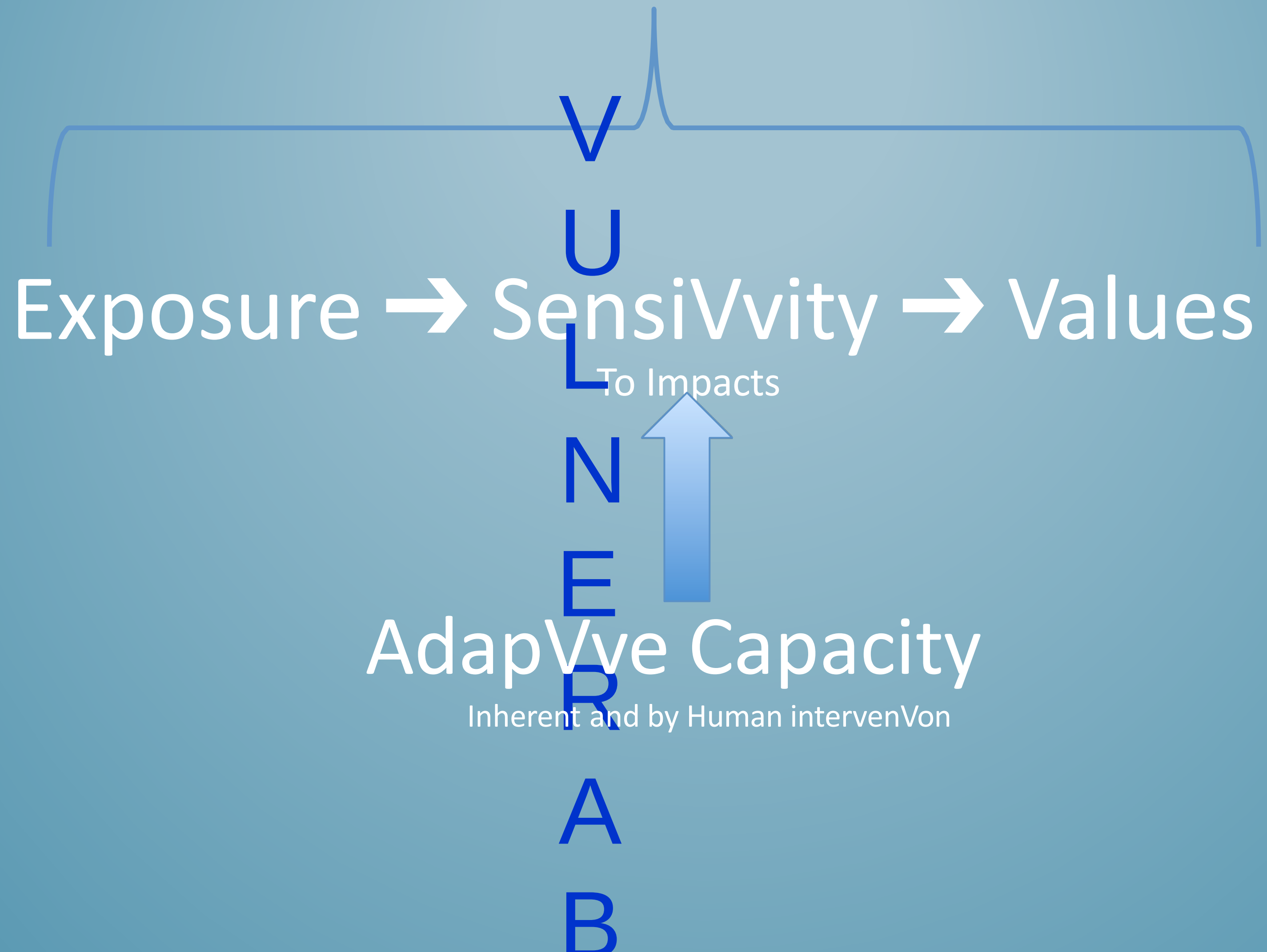
- Resilience = Resistance + Capacity to recover

- So *ability to resist impacts* is part of what is meant by most when using the term "resilience".

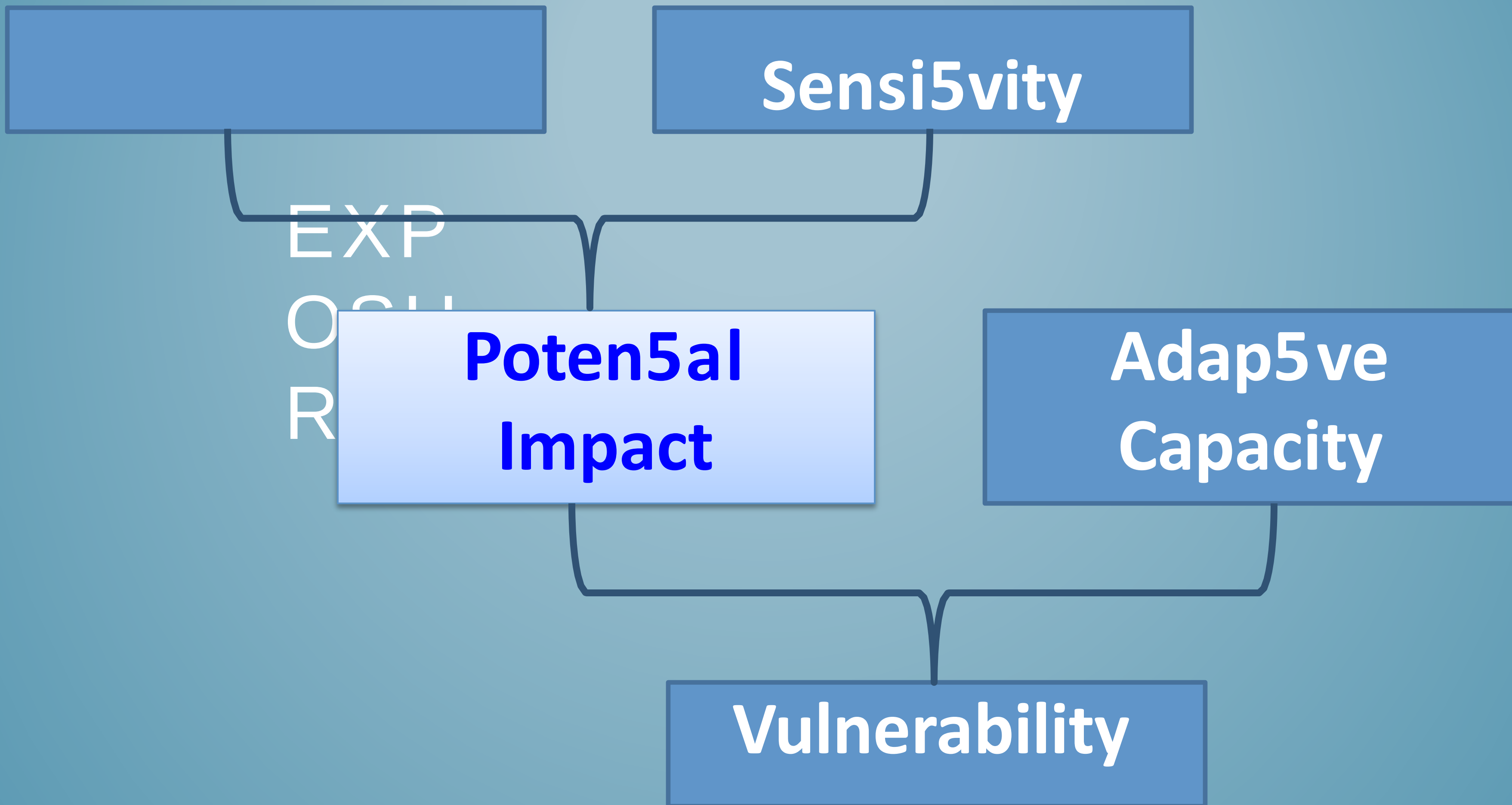
Exercise

Describe the characterisVcs of an ideal “resilient” watershed or landscape.

- Step 1: IdenVfy a list of watersheds.
- Step 2: Select one. (as a group or individuals)
- Step 3: IdenVfy its characterisVcs that create and maintain resilience.
- Step 4: Give a brief presentaVon with explainaVons

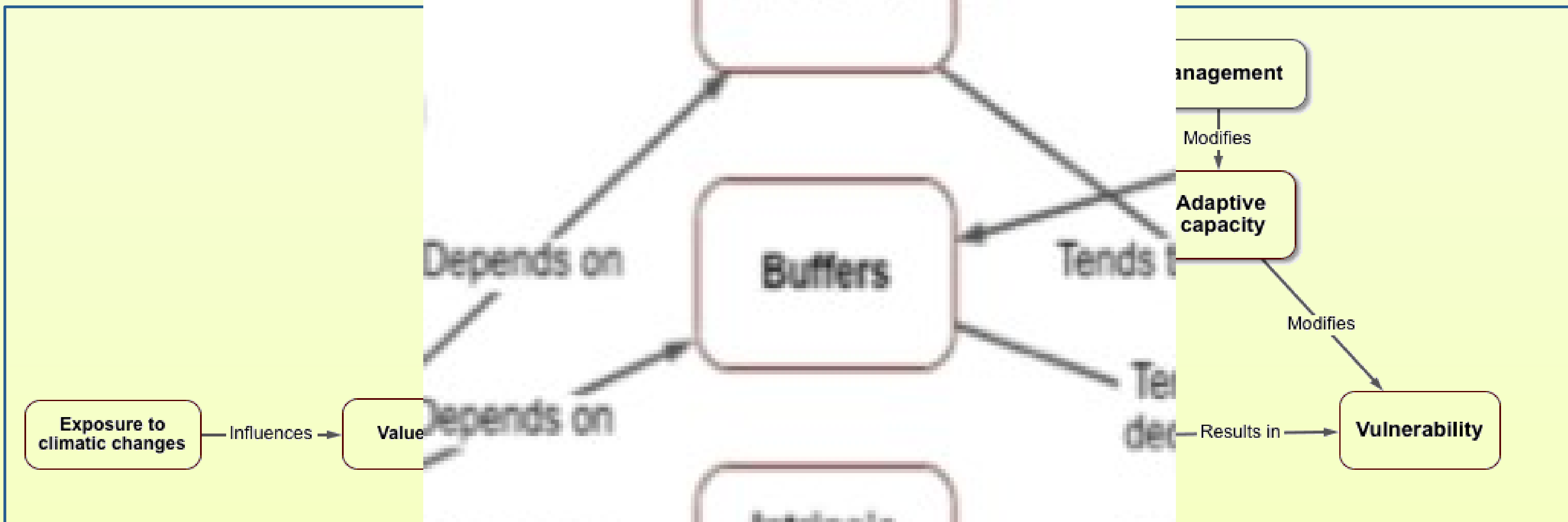

V U L N E R A B
Exposure → SensiVvity → Values
To Impacts
AdapVve Capacity
Inherent and by Human intervenVon

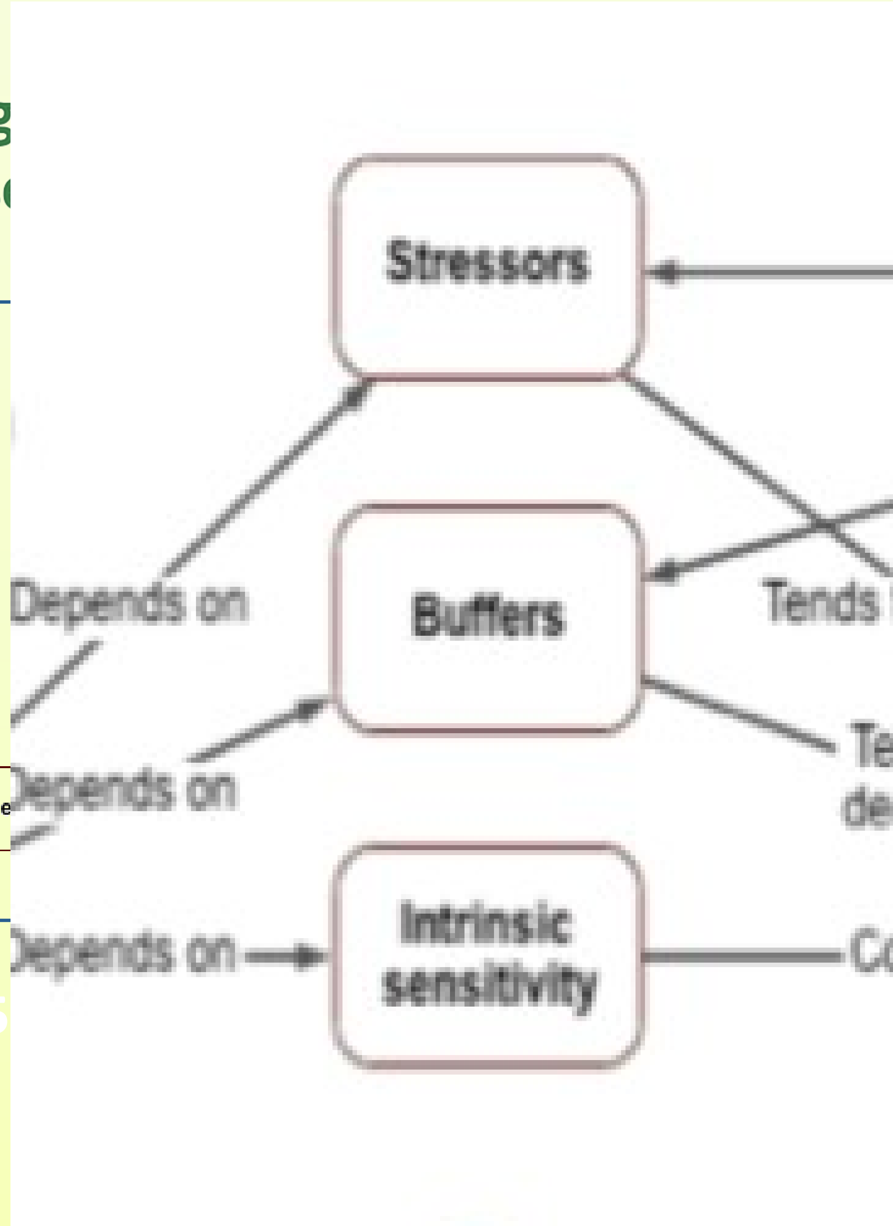
Components of Vulnerability



Exposure x Sensi5vity ÷ Adap5ve Capacity = Vulnerability

Detailed ontolog… …ability assessment, bas…





Exposure x Sensi5 … …rability

Two earthquakes

Loma Prieta (San Francisco USA) 1989

- Magnitude 6.9
- 62 dead
- 4,000 injured
- $6 billion in damages

Hai5 2010

- Magnitude 7
- 316,000 dead
- 300,000 injured
- $14 billion in damages

Fire risk signs. An indicator of vulnerability

Fire risk signs. An indicator of vulnerability

= Vulnerability to Wildfire

We can **adapt** with:

- Public Awareness
- Maintaining fire suppression and disaster response resources,
- Fuels treatments,
- Remote fire detecVon, and so on.

EXPOSURE

- Heat
- Wind
- Temperature
- Humidity

Sensi5vity

- Fuels
- Fuel moisture
- Topography
- Fire suppression resources
- Disaster response resources

Adaptive Capacity

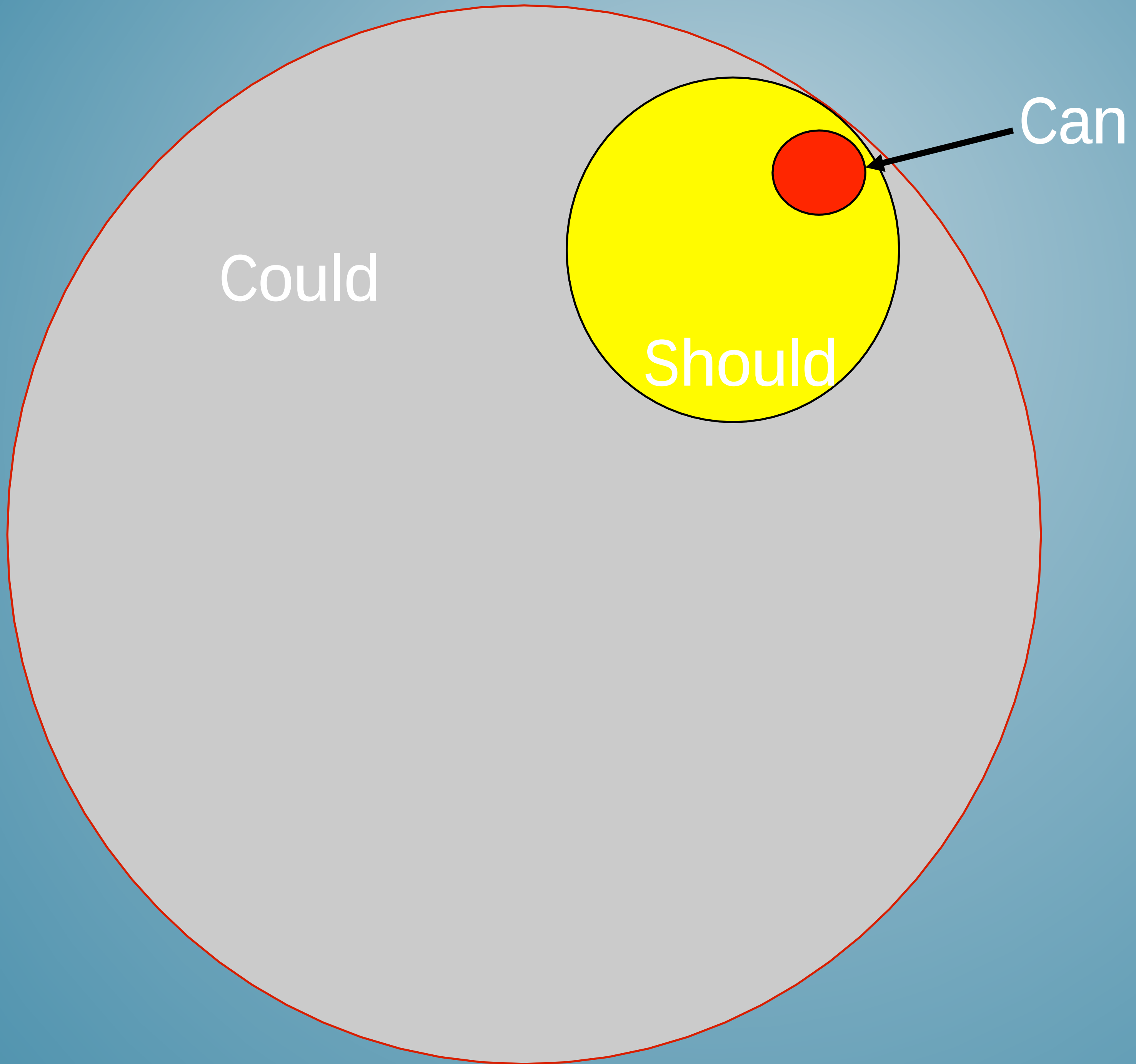
FuncVon of:

- Wealth
- Technology
- EducaVon & ExperVse
- InsVtuVons
- InformaVon
- Infrastructure
- “Social capital”

Having adapVve capacity does not mean it is *used* effecVvely

Why?

- Climate impacts?
- Which places are vulnerable?
- Which places are resilient?
    - What areas are the best candidates for refugia?
- Where will conflicts arise first, and worst?
- PrioriVes for adapVve efforts?
- Design context-sensiVve adaptaVons?
- Further assessment, tracking, and monitoring?

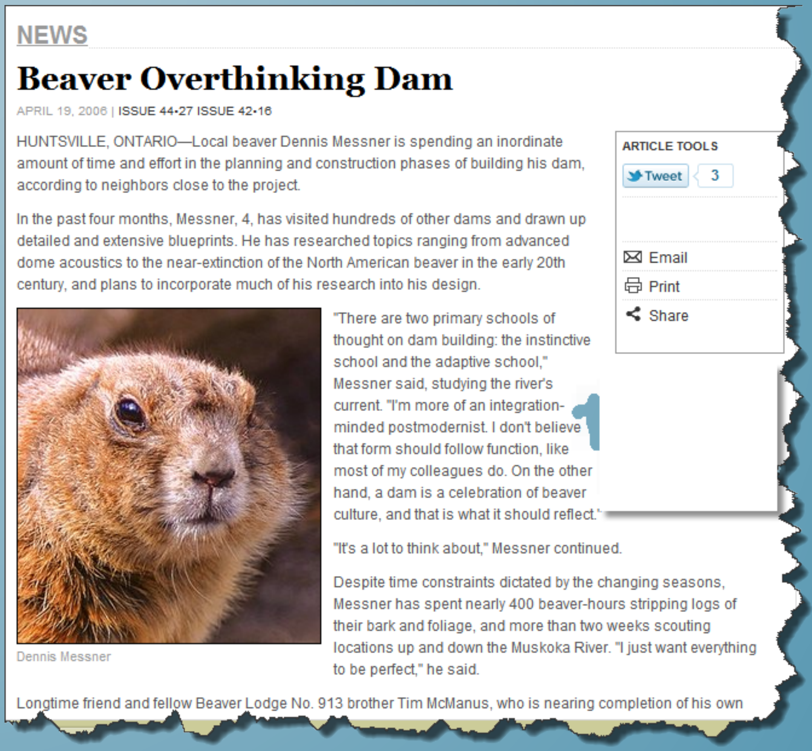

Can
Could
Should

Vulnerability ➔ Priority seh n g

	Low Vulnerability	High Vulnerability
Low Values	No Worries	Watch
High Values	Refugia	**Priority**

Focus vs. Comprehensivity

- Eco & Socio-economic is the ideal
- But do-able matters
- Start focused



NEWS

Beaver Overthinking Dam

APRIL 19, 2006 | ISSUE 44•27 ISSUE 42•16

HUNTSVILLE, ONTARIO—Local beaver Dennis Messner is spending an inordinate amount of time and effort in the planning and construction phases of building his dam, according to neighbors close to the project.

In the past four months, Messner, 4, has visited hundreds of other dams and drawn up detailed and extensive blueprints. He has researched topics ranging from advanced dome acoustics to the near-extinction of the North American beaver in the early 20th century, and plans to incorporate much of his research into his design.

"There are two primary schools of thought on dam building: the instinctive school and the adaptive school," Messner said, studying the river's current. "I'm more of an integration-minded postmodernist. I don't believe that form should follow function, like most of my colleagues do. On the other hand, a dam is a celebration of beaver culture, and that is what it should reflect."

"It's a lot to think about," Messner continued.

Despite time constraints dictated by the changing seasons, Messner has spent nearly 400 beaver-hours stripping logs of their bark and foliage, and more than two weeks scouting locations up and down the Muskoka River. "I just want everything to be perfect," he said.

Longtime friend and fellow Beaver Lodge No. 913 brother Tim McManus, who is nearing completion of his own

Dennis Messner

ARTICLE TOOLS

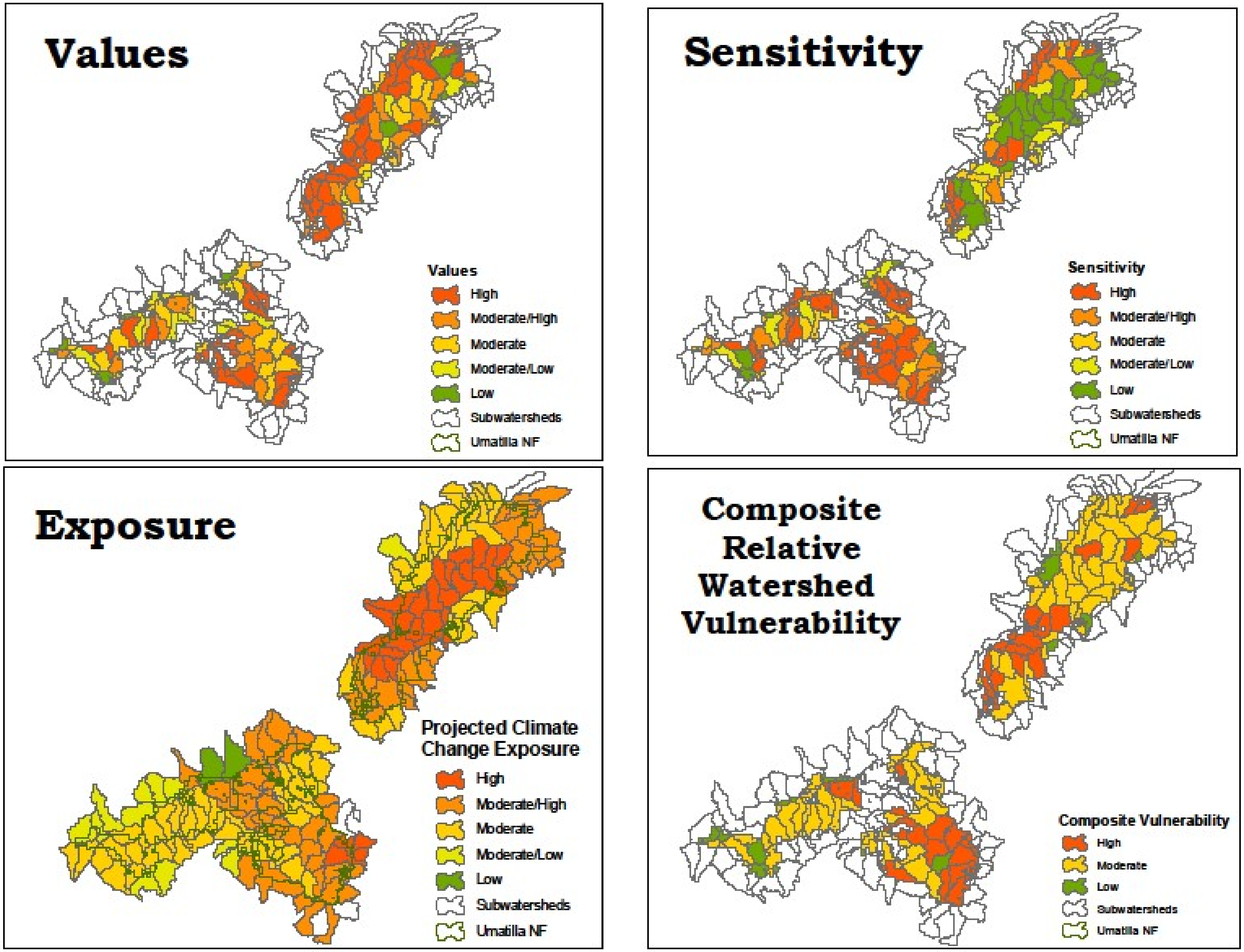
Tweet 3

Email

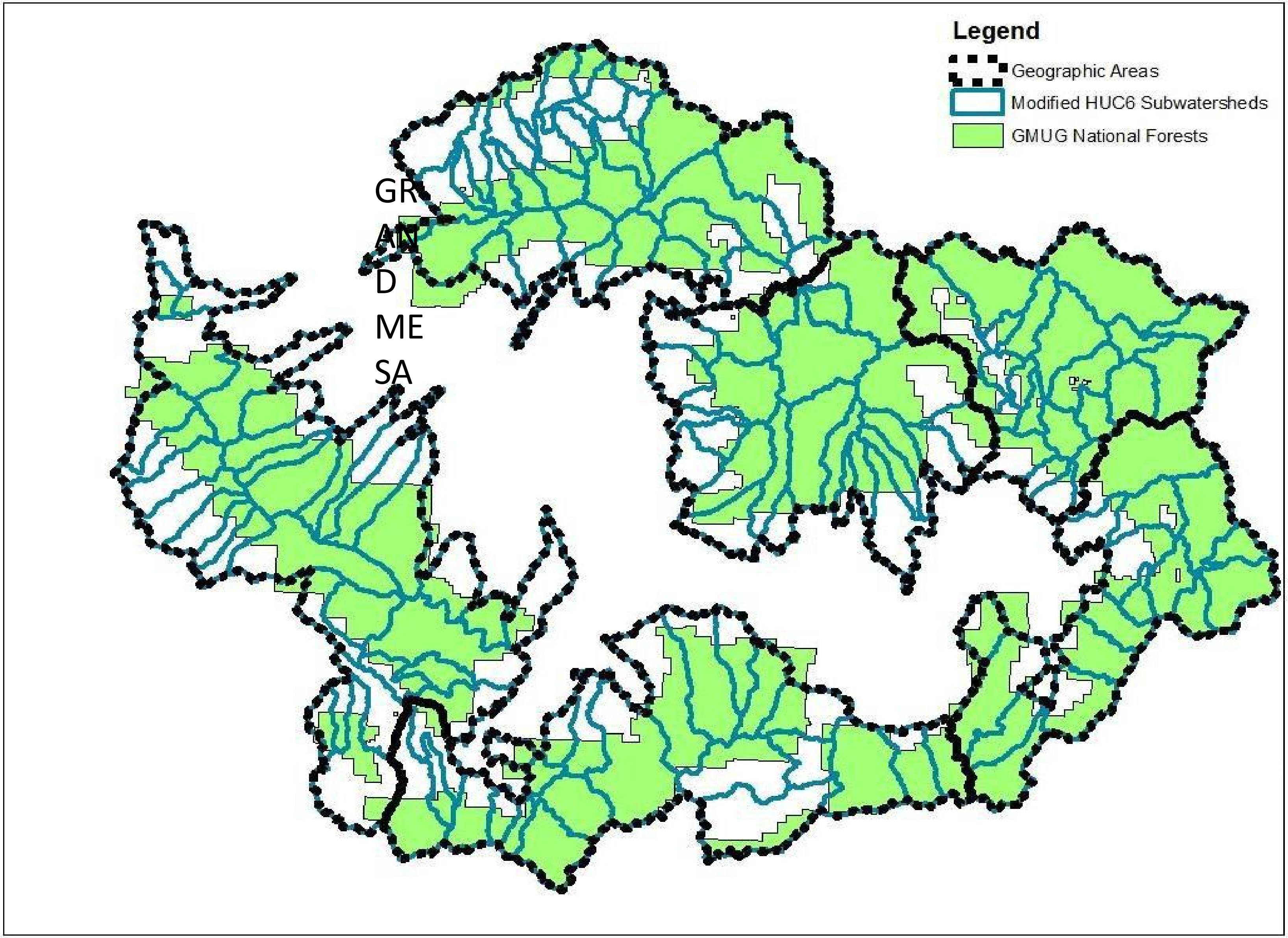
Print

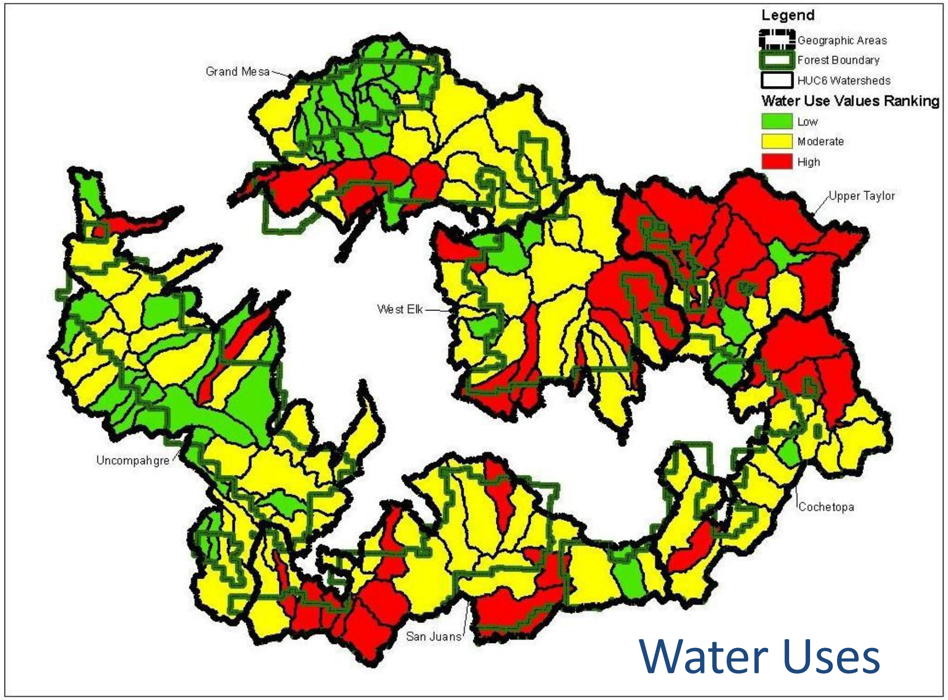
Share

Umatilla NF

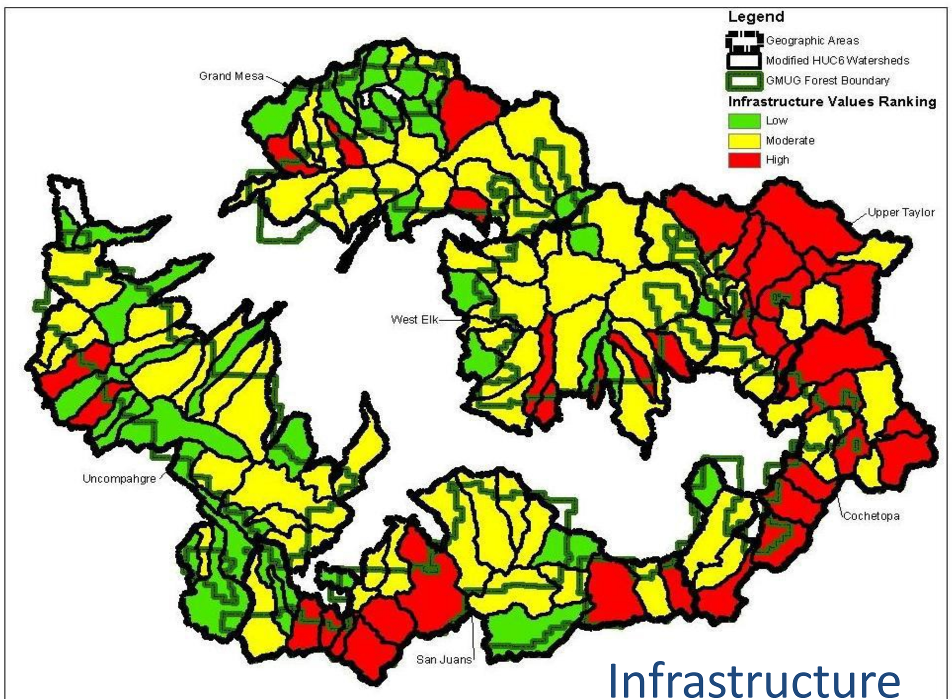

Values
Values
High
Moderate/High
Moderate
Moderate/Low
Low
Subwatersheds
Umatilla NF
Sensitivity
Sensitivity
High
Moderate/High
Moderate
Moderate/Low
Low
Subwatersheds
Umatilla NF
Exposure
Projected Climate Change Exposure
High
Moderate/High
Moderate
Moderate/Low
Low
Subwatersheds
Umatilla NF
Composite Relative Watershed Vulnerability
Composite Vulnerability
High
Moderate
Low
Subwatersheds
Umatilla NF

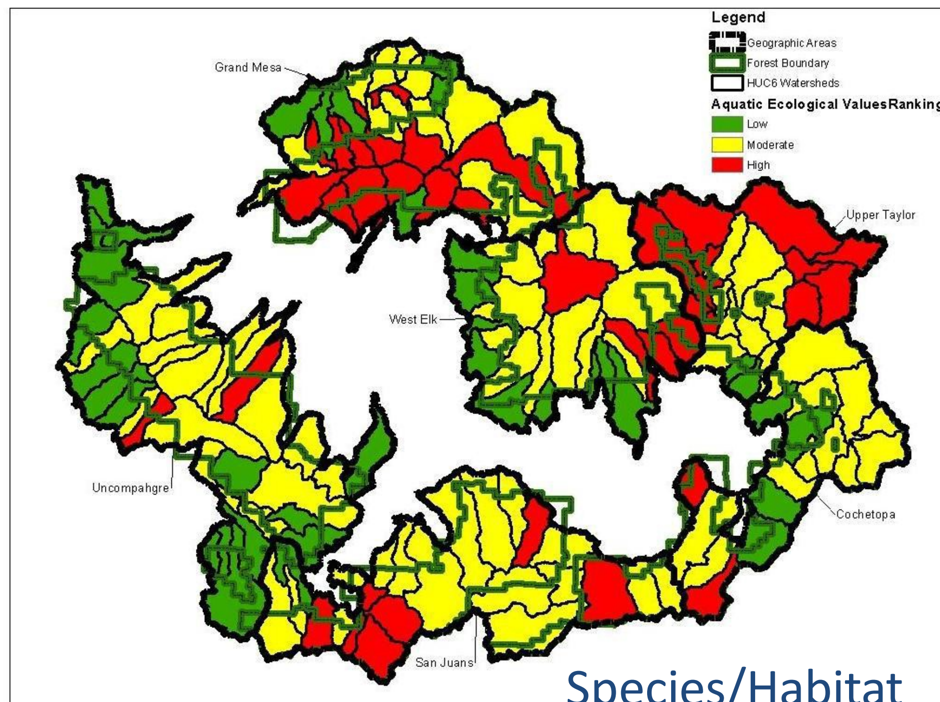
Scales of Assessment



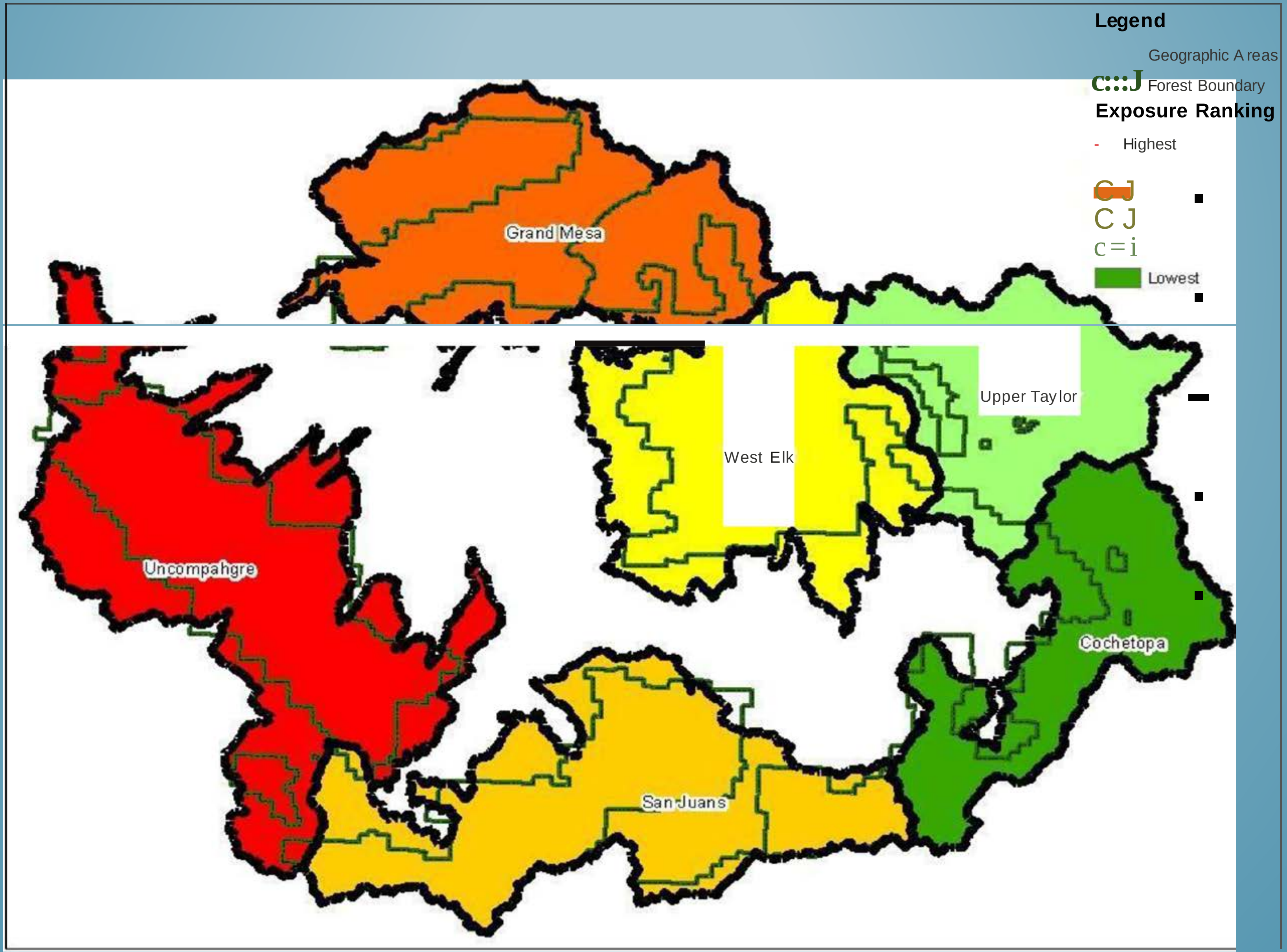


Water Uses
Infrastructure
Species & Habitats

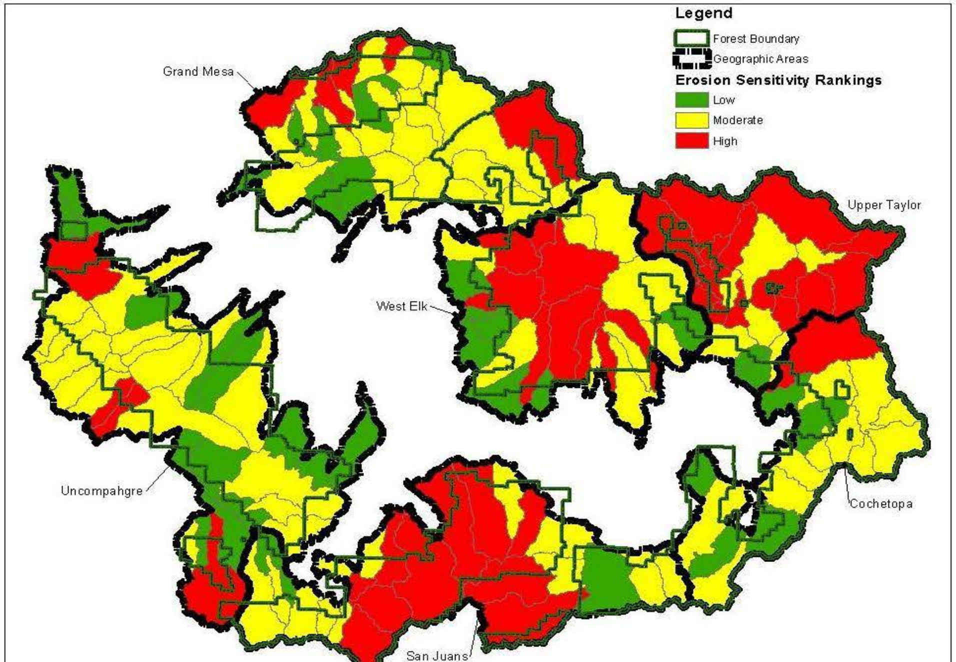




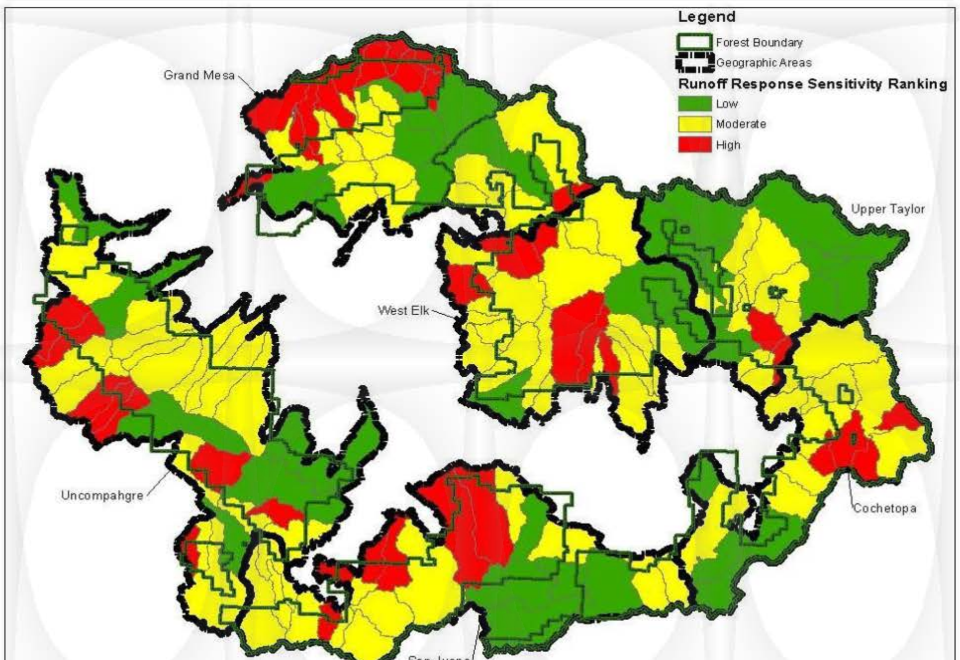
Exposure ranking



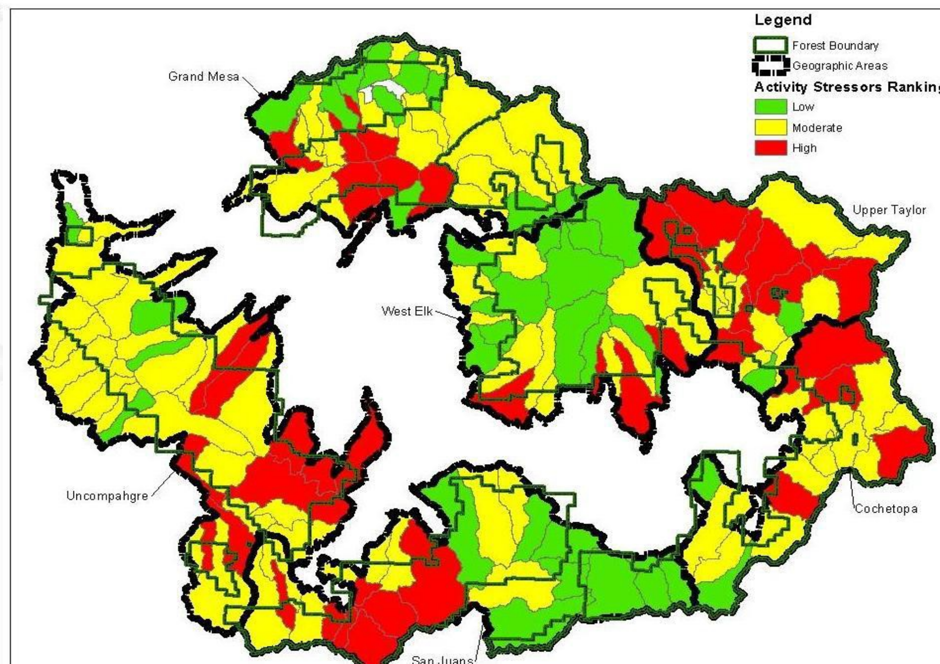
Watershed Hazards–SensiVvit & Stressors



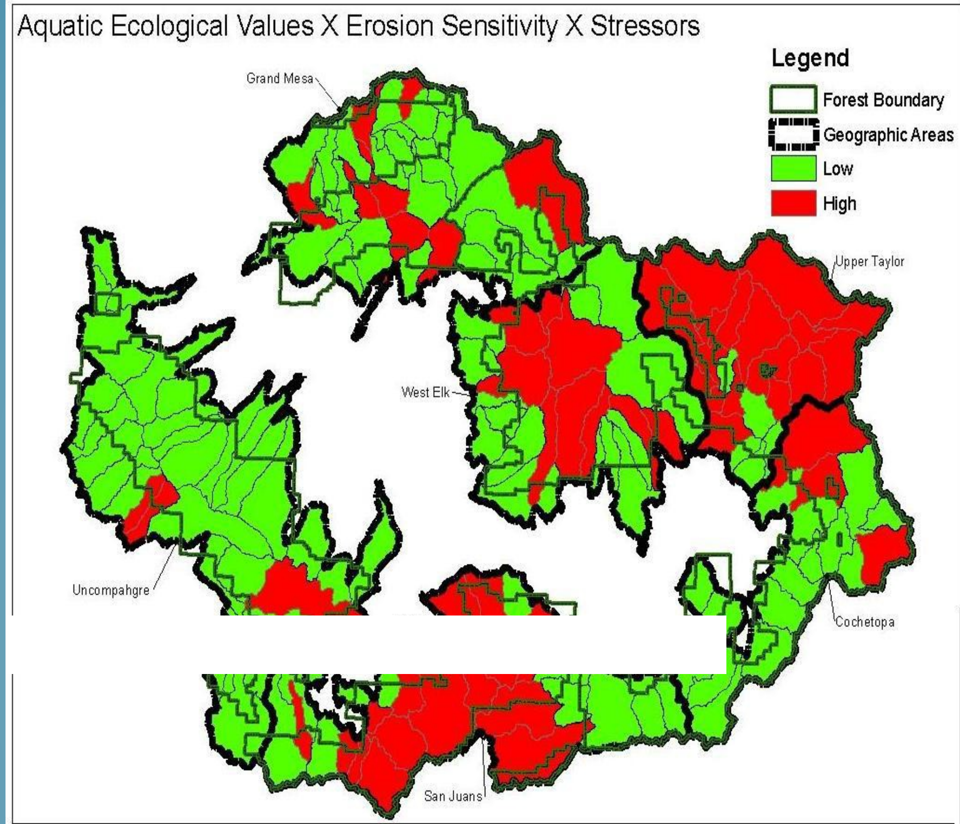
Erosion / Sediment ProducVon (SensiVvity)



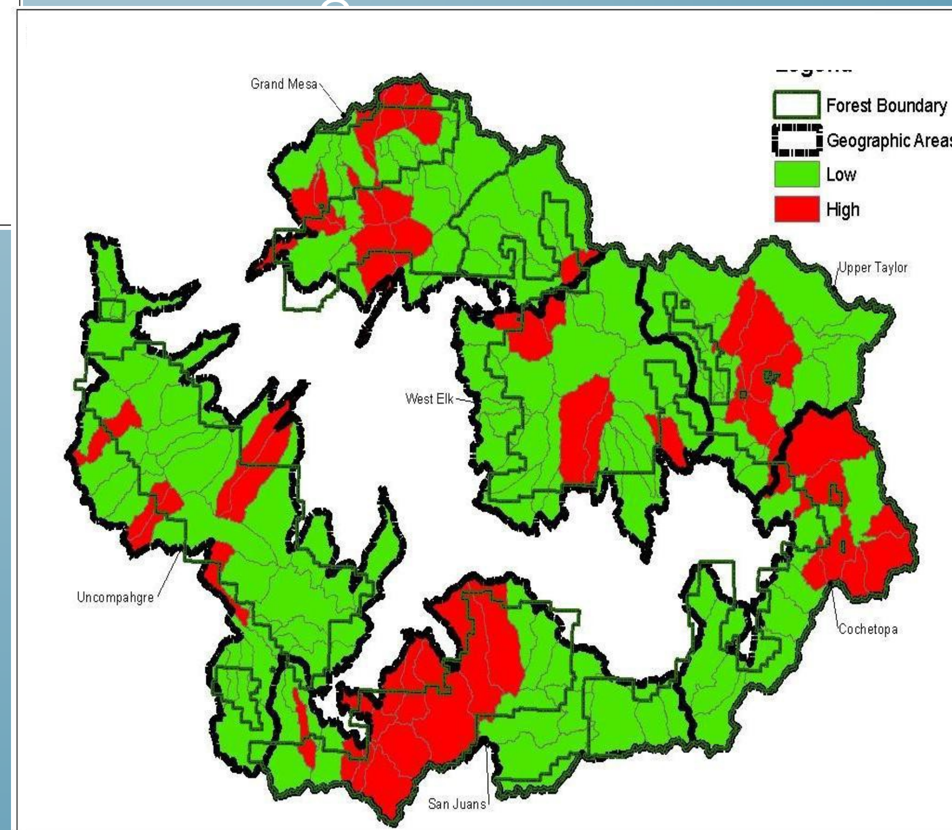
Runoff Response (SensiVvity)



AcVviVes (Stressors)

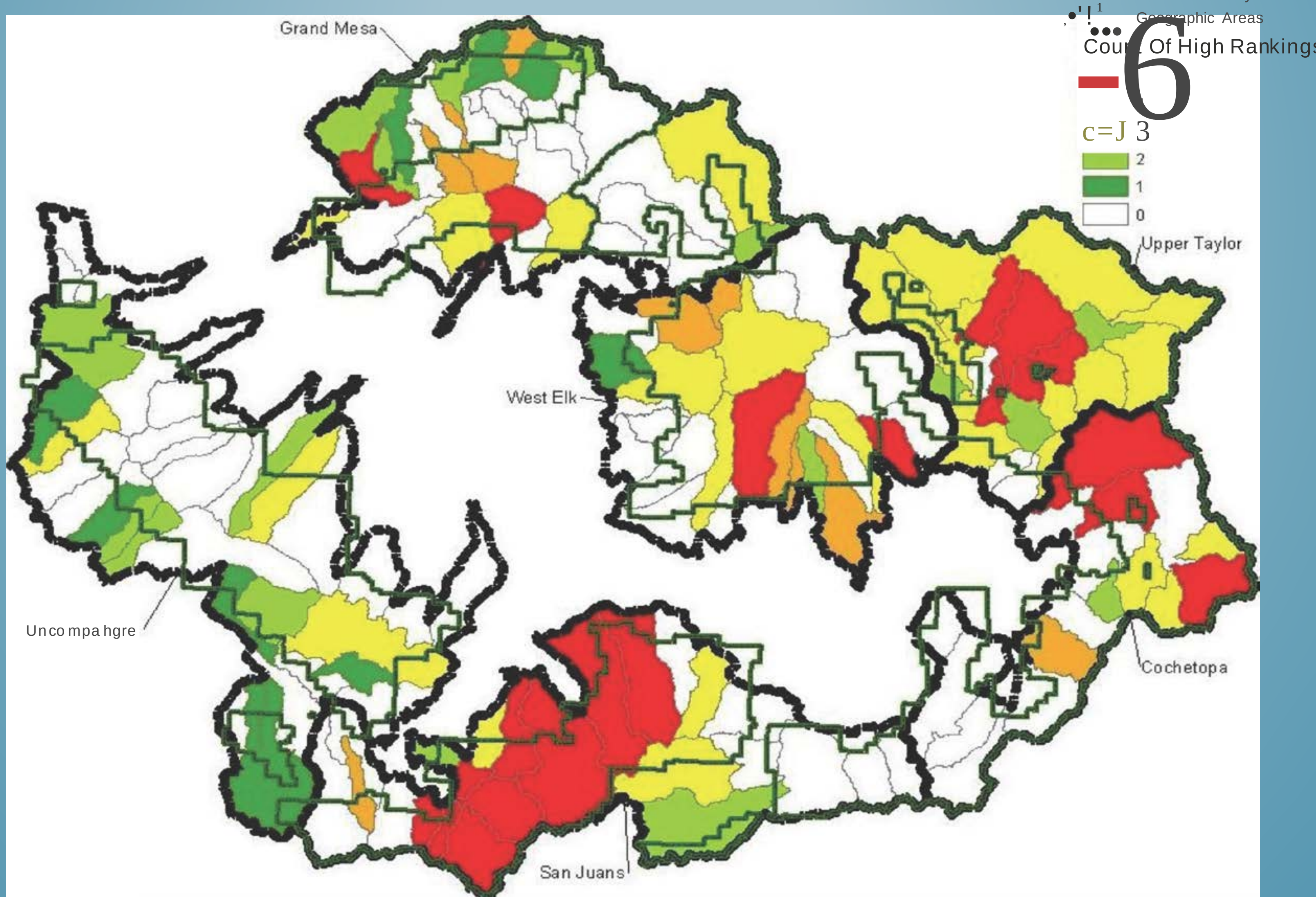

Aquatic Ecological Values X Erosion Sensitivity X Stressors
Legend
Forest Boundary
Geographic Areas
Low
High
Grand Mesa
Upper Taylor
West Elk
Uncompahgre
Cochetopa
San Juans

A
Q
U
A
5


Forest Boundary
Geographic Areas
Low
High
Grand Mesa
Upper Taylor
West Elk
Uncompahgre
Cochetopa
San Juans

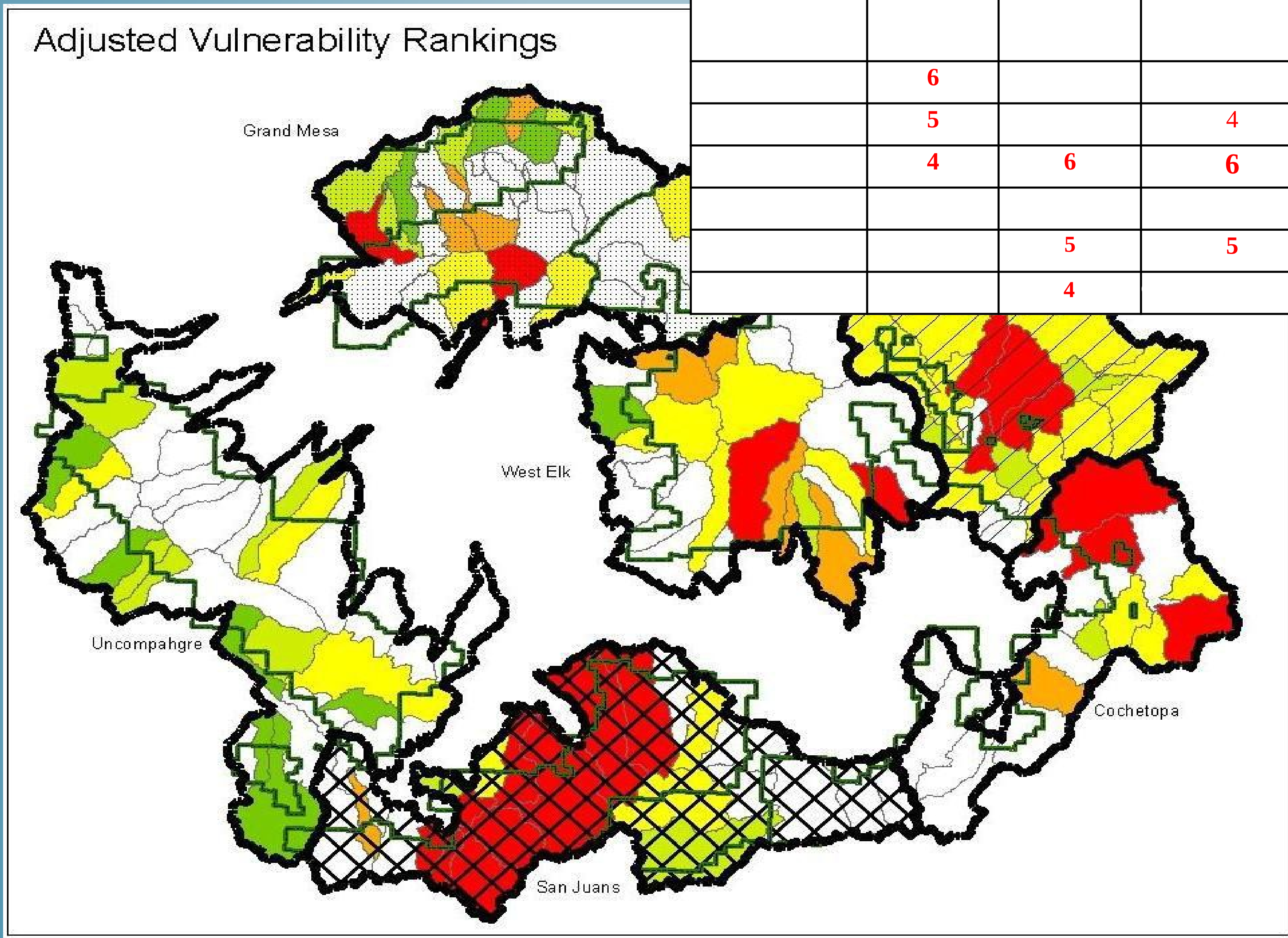
Overall sensitivity

Overlap of High Values X Sensitivity X Stressors Risk Rankings



Vulnerability

	6		
	5		4
	4	6	6
		5	5
		4	



Top level focus and reporting of vulnerability analyses. Which to choose?

- Species?
- Specific Habitats?
- By exposure mechanism?
- Sector?
- **Places** – Watersheds someVmes ideal

Reflects an ecosystems and ecosystems services approach

Recommended Steps

1. Set up the assessment. Iden5fy values.

    Define scenarios of change

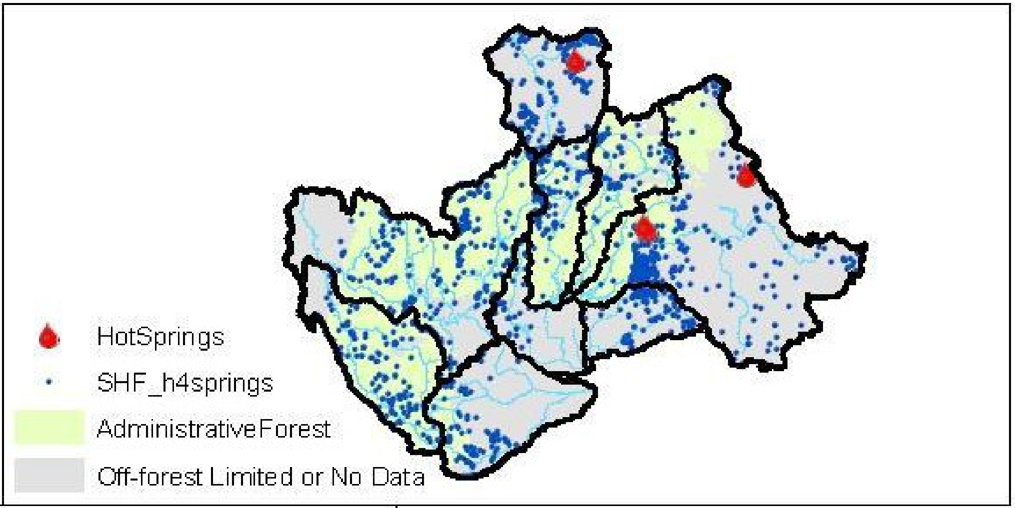
2. Assess Exposure
3. Evaluate the sensi5vity of iden5fied values
4. Evaluate and Categorize Vulnerability
5. Set Priori5es for Adap5ve Responses
6. Cri5que the Assessment

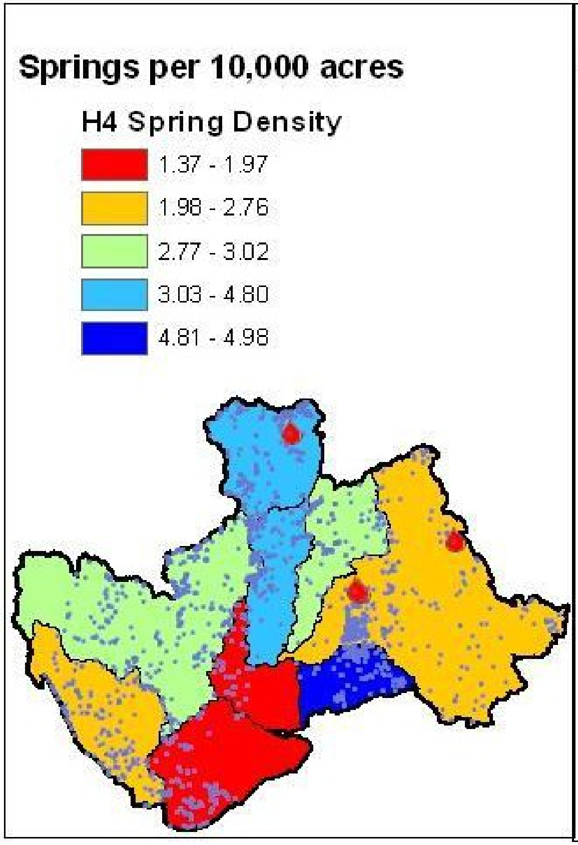
Vulnerability will be greater in

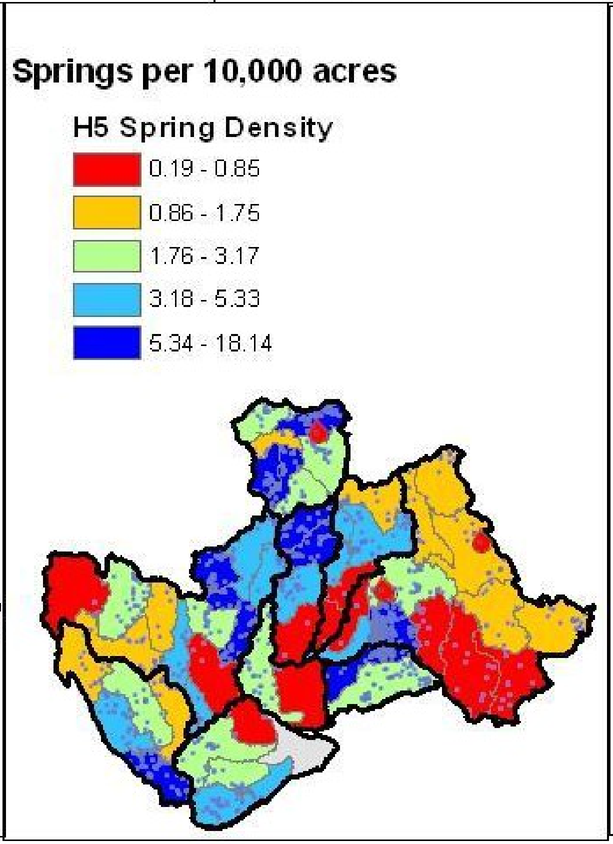
- Low diversity ecosystems
- High stressors, cumulaVve effects, and populaVon pressure
- Over-allocated and inadequate water supplies
- Shallow, fragile, and dry soils
- Species already in decline
- Fragmented ecosystems
- Threatened, endangered, and rare species

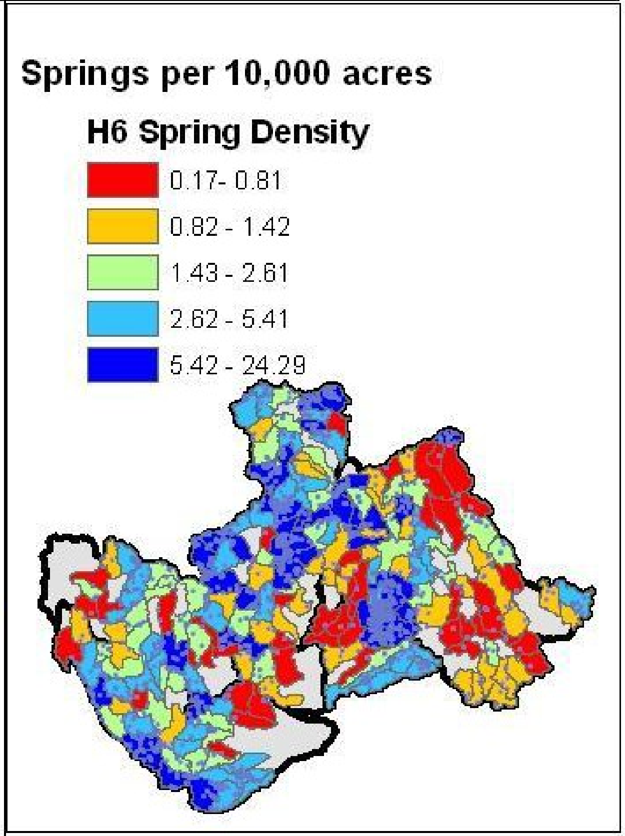
SCALE MATTERS!

Spring Density









Generalizations about climate change vulnerability of human populations

Vulnerability will be greater in

- Highly dense populaVons
- Low resources for health care
- Low resources for disaster and emergency response
- Over allocated, polluted, and inadequate water supplies
- Low diversity of agricultural cropping systems
- High proporVon of women and children in the populaVon
- Serious exisVng problems

A few lessons

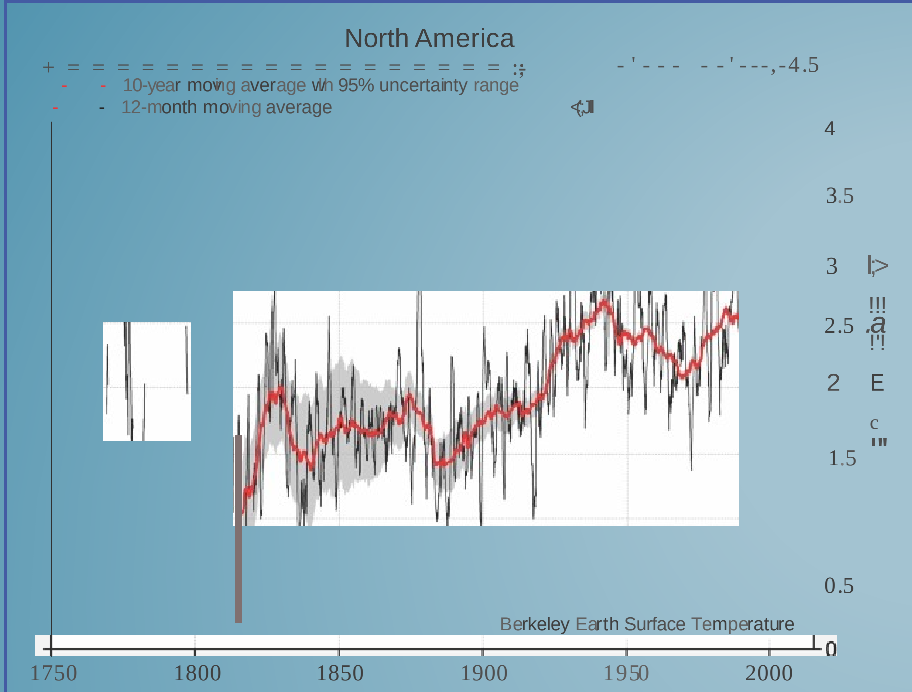
- Terminology – don’t bog down
- Don’t obsess about exposure
  - Review observaVons and projecVons
  - Agree on scenarios
- Focus on sensiVvity
  - How to reduce it
- Subwatershed (HUC-6) good for reporVng

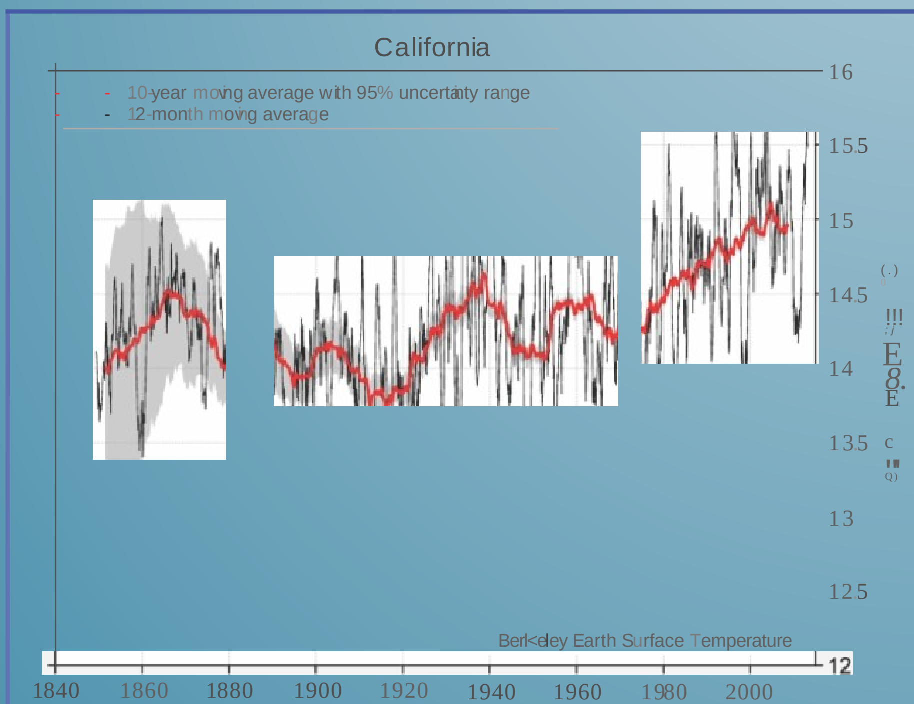
What’s new?

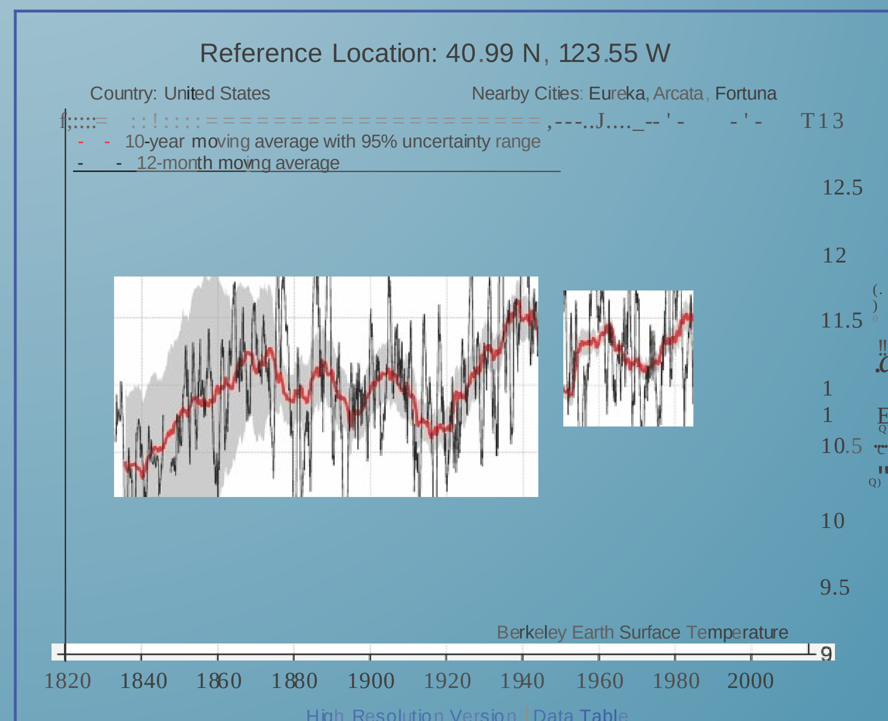
CC is a risk mul5plier

- WHAT we can do it the same
- WHERE and HOW MUCH we should do might change

North Coast Climate Refuge?


North America
10-year moving average with 95% uncertainty range
12-month moving average
4
3.5
3
2.5
2
1.5
0.5
0
Berkeley Earth Surface Temperature
1750
1800
1850
1900
1950
2000


California
10-year moving average with 95% uncertainty range
12-month moving average
16
15.5
15
14.5
14
13.5
13
12.5
12
Berkeley Earth Surface Temperature
1840
1860
1880
1900
1920
1940
1960
1980
2000

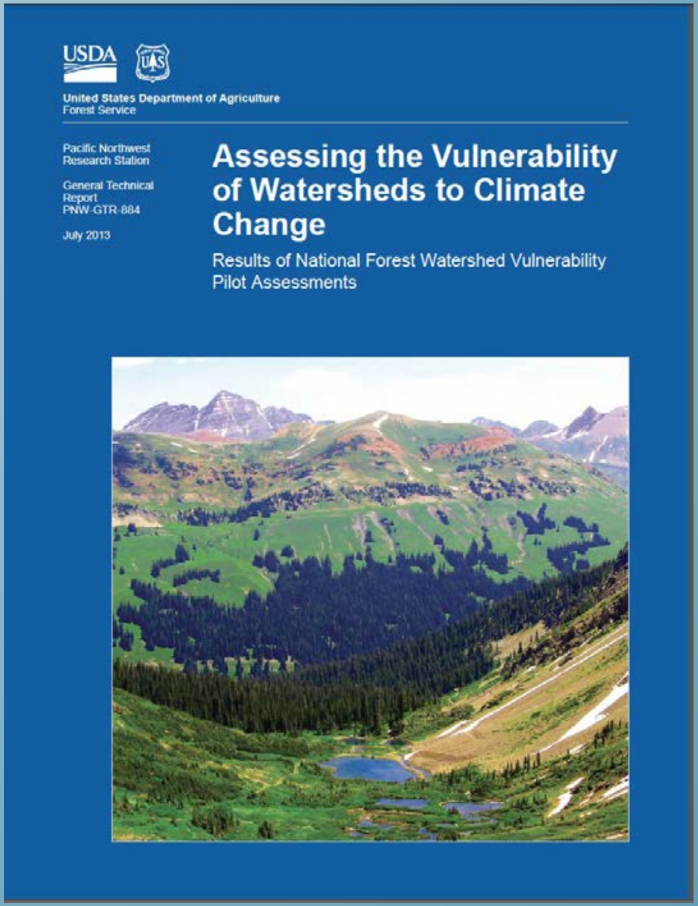

Reference Location: 40.99 N, 123.55 W
Country: United States
Nearby Cities: Eureka, Arcata, Fortuna
10-year moving average with 95% uncertainty range
12-month moving average
13
12.5
12
11.5
10.5
10
9.5
9
Berkeley Earth Surface Temperature
1820
1840
1860
1880
1900
1920
1940
1960
1980
2000
High Resolution Version | Data Table

Recommended Steps

1. **Set up the assessment. Iden5fy values.**
2. **Assess Exposure**
3. **Evaluate the sensi5vity of iden5fied values**
4. **Evaluate and Categorize Vulnerability**
5. **Set Priori5es for Adap5ve Responses**
6. **Cri5que the Assessment**

Assigned Reading

- Read this publicaVon (in References and Readings):
- BCC_GTR_884 Watershed Vulnerability Assessment



In-Class Questions
(after reading pub referenced in last slide)

- What is this report about?
- What is the challenge to the USFS? Climate change, how will it affect ecosystems values and services, parVcularly those related to water, how to prepare/manage/adapt? How to begin to develop insVtuVonal capacity to do this kind of work.
- What are typical water resource values for USFS lands? (infrastructure, species, habitats, water supply)
- How do they define watershed resilience? Ability to resist and recover from disturbance, impacts. What do you think "resilience" means?
- What is exposure?
- Where does exposure data come from? GCMs – downscaled to local predicVons for future climate, temp, rainfall typically.
- Could be linked with hydrologic models to give stream flow, groundwater recharge rates. Hard to do this accurately, peak flows, droughts.
- What is sensiVvity?
- How does management affect sensiVvity? (some factors of sensiVvity are intrinsic – geology, locaVons, some are management related, harvest, roads.

In-Class Questions
(after reading pub referenced in last slide)

- What is the discussion of HUC 4 5 6 about? (Hydrologic UnitCategory scale of watershed size – USGS delineaVon – enVre USA mapped. Scale or resoluVon. Larger scale may have more climate exposure data, but obscures finer trends.
- Management best done at HUC 6 scale. See figure 3.
- What is vulnerability (interacVon of climate exposure with values at risk and watershed sensiVvity)
- What is an adapVve management response? (road work, buy water rights, grazing allotments, fire regimes, meadow funcVoning)
- What if we find out a parVcular species is going to be extremely difficult to save? (Consider puh n g money somewhere else. Triage).
- What are the advantages of local historical data? (it happened -verified, management relevant, easy to Ve into local resource. Smaller scale data owen available, be; er than broad scale GCMs.
- Discuss Figure 2. Provide examples of each of the bubbles and arrows in the figure. What point is the figure trying to illustrate?

In-Class Questions
(after reading pub referenced in previous slide)

- Report menVoned NEPA requirements and watershed condiVon work – an area staff have experience with. How can we learn more about NEPA and watershed condiVon assessments?

correlaVon exists between condiVon and resilience of watersheds, and climate change is one of many factors natural and human, that affect watershed condiVon and hydrology. – are these assumpVons realisVc?

- *Dcuss Figure 2. Provide examples of each of the bubbles and arrows in the figure. What point is the figure trying to illustrate?*

Exercise

- Describe the characterisVcs of an “vulnerable” watershed or landscape.
- Which elements of vulnerability could be modified to make the place more resilient?

- Which places (watersheds) should be our focus for reducing environmental effects and risk? Which areas are most in need of restoraVon?
- Which places (watersheds) are good candidates for refugia, new protected areas? Which areas can anchor the conservaVon of species and ecosystem types?
- Which places (watersheds) should be reviewed and assessed for the applicaVon of land management best pracVces to reduce climate impacts?
- Which populaVons and communiVes are at greatest risk, so that they can receive priority for assistance in health delivery, disaster response readiness, migraVon, and educaVon and awareness?
- Which values may be irretrievably lost, and which can be sustained?
- Which areas will have the greatest conflicts, so that these can be pro-acVvely managed with land-use planning, water allocaVon, restoraVon, public awareness, and so on. Which areas are most at risk for water shortages?
- Which species are at greatest risk of loss, and for which we may collect seed, consider assisted migraVon, habitat restoraVon, and establishing refugia for conservaVon?
- What addiVonal informaVon, GIS layers, and analysis is most needed for the future?
- Where and how should monitoring and evaluaVon be conducted? For how long?
- What research is needed to resolve criVcal uncertainVes revealed by the VA?

IniVally can be the most difficult step:

- Cmate change projecVons are available globally. Downscaled projecVons available in only a few places
  - What emission scenarios to use?
  - What Vme period?
  - What a ; ributes?

Using globally available projecVons is sufficient for most VAs at this

Important Finding from USFS assessment pilots:

- Don't obsess about exposure projecVons & downscaled projecVon not necessary for most vulnerability assessments –focus on sens Uncertain about exposure, clear on values, sensiVvity to impacts, importantly, on adapVve capacity.

Exposures

- Drought
- Cold spell
- Hot spell
- Early onset of rain season
- Delayed onset of rain season
- Heavy rain
- Flooding (rain), landslide
- Heavy storm, whirlwind
- Cold humid wind
- Hot dry wind
- Saline water intrusion/ winds

Recommended Reading

- Furniss, Michael J.; Roby, Ken B.; Cenderelli, Dan; Chatel, John; Cliwon, Caty F.; Clingenpeel, Alan; Hays, Polly E.; Higgins, Dale; Hodges, Ken; Howe, Carol; Jungst, Laura; Louie, Joan; Mai, ChrisVne; MarVnez, Ralph; Overton, Kerry; Staab, Brian P.; Steinke, Rory; Weinhold, Mark. 2013. **Assessing the vulnerability of watersheds to climate change: results of na5onal forest watershed vulnerability pilot assessments.** Gen. Tech. Rep. PNW-GTR-884. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research StaVon. 32 p. plus appendix. h; p://bit.ly/watervulnerability

- Morgan, C. L. (2011). **Vulnerability Assessment: A Review of Approaches.** Building Resilience to climate change impacts-coastal southeast asia Gland, Switzerland: IUCN. h; p ://data.iucn.org/dbtw-wpd/edocs/2011-068.pdf

- Glick, Pa ; y; Stein, Bruce A.; Edelson, Naomi A. 2011. **Scanning the conserva5on horizon: A guide to climate change vulnerability assessment.** Washington, D.C.: NaVonal Wildlife FederaVon. 168 p. h; p://www.fs.fed.us/rm/pubs_other/rmrs_2011_glick_p001.pdf

References

- Scanning the ConservaVon Horizon: A Guide to Climate Change Vulnerability Assessment. 2011. NaVonal Wildlife FederaVon, Washington, D.C. Retrieved from h; p ://www.nwf.org/vulnerabilityguide
- Gardali, T., N. E. Seavy, R. T. DiGaudio, and L. A. Comrack. 2012. A climate change vulnerability assessment of California's at-risk birds. PLoS ONE 7:e29507. doi: 10.1371/ journal.pone.0029507
- Black, Bruce, & Egener (2009) AdapVng to Climate Change: A Risk-Based Guide for Alberta MunicipaliVes. Retrieved November 22, 2009 from: h; p ://adaptaVon.nrcan.gc.ca/projdb/pdf/176a_e.pdf
- Carter, Parry, Nishioka , & Harasawa (1994) Technical guidelines for assessing climate change impacts and adaptaVons. University College London, England and Centre for Global Environmental Research, Tsukuba, Japan, 59 pp
- Harford, D. (2008) Climate Change AdaptaVon: Planning for BC. Retrieved from Pacific InsVtute for Climate SoluVons website: www.pics.uvic.ca/research.php
- Hon, D (2002) Extending the risk process to manage opportuniVes. InternaVonal Journal of Project Management, 20, 235–240.

References

- Noble, Bruce, Egener, (2005) An Overview of the Risk Management Approach to Climate Change in Canada. Retrieved March 11, 2010 from: h; p://adaptaVon.nrcan.gc.ca/pdf/NobleBruceEgener2005_e.pdf
- USDA Forest Service, 2009. ImplementaVon Guide for Assessing and Tracking Changes to Watershed CondiVon. Watershed, Fish, Wildlife, Air, and Rare Plants Staff, Washington, DC., Draw Manuscript, Oct. 30, 2009, 82 p.
- K. Gallo et al. 2005. Northwest Forest Plan–the first 10 years (1994–2003): Prelimary assessment of the condiVon of watersheds. PNW-GTR-647
- Trush, W. J., S. M. McBain, and L. B. Leopold. 2000. A; ributes of an alluvial river and their relaVon to water policy and management. Proceedings of the NaVonal Academy of Sciences 97: 11858–11863.
- DEBANO, L.F., AND L.J. SCHMIDT. 1990. Healthy riparian areas as related to watershed stability. P. 55–56 in Proc. of conf. XXI erosion control: Technology in transiVon. Internat. Erosion Control Assoc., Steamboat Springs, CO. 324 p.

References

- NRCAN (Natural Resources Canada) (2007) From Impacts to AdaptaVon: Canada in a Changing Climate. Chapter 8 –BriVsh Columbia. Retrieved November 28, 2009 from h; p://adaptaVon.nrcan.gc.ca/assess/2007/index_e.php
- Parzen, J. (ed). (2008). Chicago Area Climate Change Quick Guide: AdapVng to the Physical Impacts of Climate Change. For MunicipaliVes and Other OrganizaVons. Retrieved March 9, 2010 from: h; p ://www.chicagoclimateacVon.org/filebin/pdf/ Chicago_Quick_Guide_to_Climate_Change_PreparaVon_June_2008.pdf
- Schneider, Semenov, & Patwardhan, (2007) Assessing key vulnerabiliVes and the risk from climate change. Chapter 19, ContribuVon of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, 976 pp
- Snover, Whitely Binder, Lopez, Willmo; , Kay, Howell, & Simmonds. (2007). Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments. In associaVon with and published by ICLEI – Local Governments for Sustainability, Oakland, CA.
- Halifax Regional Municipality (2007) Climate Change: Developer's Risk Management Guide.

References

Vulnerability Assessment Frameworks and Guidance

Intergovernmental Panel on Climate Change (IPCC). 2005. *Guidance Notes for Lead Authors of the IPCC Fourth Assessment Report on Addressing UncertainEes.* Intergovernmental Panel on Climate Change, Geneva. h; p ://www.ipcc.ch/pdf/supporVng-material/uncertainty-guidance-note.pdf.

NaVonal Research Council (NRC). 2009. *Informing Decisions in a Changing Climate.* Panel on Strategies and Methods for Climate-Related Decision Support, Commi; ee on the Human Dimensions of Global Change. Division of Behavioral and Social Sciences and EducaVon. NaVonal Academies Press, Washington, D.C. h; p://www.nap.edu/openbook.php?record_id=12626&page=R1.

Olmos, S. 2001. *Vulnerability and AdaptaEon to Climate Change: Concepts, Issues, Assessment Methods.* Climate Change Knowledge Network, InternaVonal InsVtute for Sustainable Development, Winnipeg h; p://www.cckn.net/pdf/va_foundaVon_final.pdf. United NaVons Framework ConvenVon on Climate Change (UNFCCC). 2008. *Compendium on Methods and Tools to Evaluate Impacts of, Vulnerability and AdaptaEon to, Climate Change.* UNFCC, Bonn, Germany. h; p ://unfccc.int/adaptaVon/nairobi_work_programme/knowledge_resources_and_publicaVons/items/2674.php.

References

U.S. Environmental ProtecVon Agency (EPA). 2009. *A Framework for Categorizing the RelaEve Vulnerability of Threatened and Endangered Species to Climate Change.* EPA/600/R-09/011. NaVonal Center for Environmental Assessment, Washington, D.C. h; p://www.epa.gov/ncea.

U.S. Global Change Research Program (USGCRP). 2009. *Global Climate Change Impacts in the United States.* A report of the USGCRP. USGCRP, Washington, D.C. h; p://www.globalchange.gov/usimpacts/.

Williams, S.E., L.P. Shoo, J.L. Isaac, A.A. Hoffmann, and G. Langham. 2008. Towards an integrated framework for assessing the vulnerability of species to climate change. *PloS Biology* 6: 2621–2626. h; p://www.plosbiology.org/arVcle/info:doi/10.1371/journal.pbio.0060325

References

General Climate Change Adapta5on Principles and Planning

AssociaVon of Fish and Wildlife Agencies (AFWA). 2009. *Voluntary Guidance for States to Incorporate Climate Change into State Wildlife AcEon Plans and Other Management Plans.* AFWA, Washington, D.C. h; p://www.fishwildlife.org/pdfs/ClimateChangeGuidance%20Document_Final_reduced%20size.pdf.

Glick, P., A. Staudt, and B. Stein. 2009. *A New Era for ConservaEon: Review of Climate Change AdaptaEon Literature.* NaVonal Wildlife FederaVon, Washington, D.C. h; p://www.nwf.org/News-and-Magazines/Media-Center/Reports/Archive/2009/~/media/PDFs/Global Warming/Reports/CimateChangeAdaptaVonLiterature

Review.ashx.

Groves, C., M. Anderson, C. Enquist, E. Girvetz, T. Sandwith, L. Schwarz, and R. Shaw. 2010. *Climate Change and ConservaEon: A Primer for Assessing Impacts and Advancing Ecosystem-based AdaptaEon in The Nature Conservancy.* The Nature Conservancy, Arlington, VA. h; p://conserveonline.org/workspaces/climateadaptaVon/documents/a-primer-for-assessing-impacts/view.html.

References

General Climate Change Adapta5on Principles and Planning

Heller, N.E., and E.S. Zavaleta. 2009. Biodiversity management in the face of climate change: A review of 22 years of recommendaVons. *Biological ConservaEon* 142: 14–32. h;p://www.lagunadesantarosa.org/knowledgebase/sites/default/files/Heller%20and%20Zavaleta%202009.pdf

Lawler, J.J. 2009. Climate change adaptaVon strategies for resource management and conservaVon planning. *Annals of the New York Academy of Sciences* 1162: 79–98. h;p://training.fws.gov/branchsites/lkm/climate_change/june_09/cc-adaptreview.pdf.

Mawdsley, J.R., R. O'Malley, and D.S. Ojima. 2009. A review of climate-change adaptaVon strategies for wildlife management and biodiversity conservaVon. *ConservaEon Biology* 23: 1080–1089. h;p://cses.washington.edu/cig/outreach/seminarfiles/2009seminars/Mawdsley-etal-2009.pdf

References

General Climate Change Adapta5on Principles and Planning

NaVonal Research Council (NRC). 2010. *AdapEng to the Impacts of Climate Change.* America's Climate Choices: Panel on AdapVng to the Impacts of Climate Change. NaVonal Academies Press, Washington, D.C. h; p ://americasclimatechoices.org/paneladaptaVon.shtml.

U.S. Climate Change Science Program (U.S. CCSP). 2008. *Preliminary Review of AdaptaEon OpEons for Climate-sensiEve Ecosystems and Resources.* A report by the U.S. Climate Change Science Program and the Subcommi; ee on Global Change Research. S.H. Julius and J.M. West (eds.); J.S. Baron et al. (authors). U.S. EPA, Washington, D.C. h; p://downloads.climatescience.gov/sap/sap4-4/sap4-4-final-report-all.pdf.

NOAA FISHERIES

SWFSC - FED

Choosing and Using Climate Change Scenarios for Vulnerability Assessments of California's Salmonids

Nate Mantua
Southwest Fisheries Science Center
Santa Cruz, CA

33rd Annual Salmonid Restoration Conference
Santa Rosa, CA March 13, 2015

Motivation

- California's climate is extreme, and California's salmonids are at the warm end of their range
  - California's climate has always been important for its salmon, and has likely become more important with lost and degraded habitats, and smaller and simplified fish populations (diminished portfolio effects)

- Climate is changing – need to develop an understanding for the space-time evolution of climate risks for California's salmon to inform conservation and restoration planning

Klamath River fish kill 2002 – a case where a short-term heat and drought amplified existing stresses on cold water

- **Disease, high fish densities, low flows and a very warm river combined to result in a massive kill of adult chinook salmon in the lower Klamath River**

Conservation concerns over the offspring from the 2002 returns led to a curtailed CA/OR chinook season in 2005, and sharp restrictions in 2006

Pacific Fishery Management Council *NEWS RELEASE*

FOR IMMEDIATE RELEASE : Thursday, April 10, 2008

Contact: Ms. Jennifer Gilden, Communications Officer, 503-820-2280
Dr. Donald McIsaac, Executive Director, 503-820-2280

RECORD LOW SALMON FISHERIES ADOPTED

SEATTLE, Wash – The Pacific Fishery Management Council today adopted the most restrictive salmon fisheries in the history for the West Coast, in response to the unprecedented collapse of Sacramento River fall Chinook and the exceptionally poor status of coho salmon from Oregon and Washington. The recommendation will be forwarded to the National Marine Fisheries Service for approval by May 1, 2008.

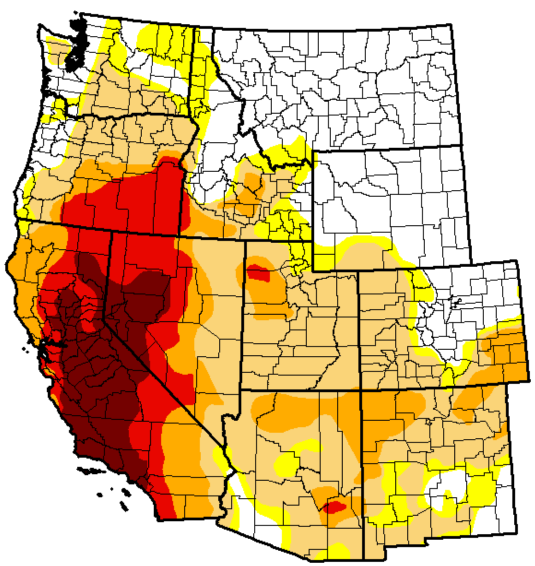
"This is a disaster for West Coast salmon fisheries, under any standard," said Council chairman Don Hansen. "There will be a huge impact on the people who fish for a living, those who eat wild-caught king salmon, those who enjoy recreational fishing, and the businesses and coastal communities dependent on these fisheries."

- Climate variability had a hand in this disaster too … this time it was terrible ocean conditions due to delayed upwelling

2015: extended drought + a very warm ocean, a bad combination for California's salmon

U.S. Drought Monitor

West



March 10, 2015

(Released Thursday, Mar. 12, 2015)

Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	29.72	70.28	59.80	29.93	16.62	7.04
Last Week 3/3/2015	29.95	70.05	59.79	29.48	16.62	7.04
3 Months Ago 12/9/2014	34.32	65.68	55.16	34.01	18.98	8.45
Start of Calendar Year 12/30/2014	34.76	65.24	54.48	33.50	18.68	5.40
Start of Water Year 9/30/2014	31.48	68.52	55.57	35.65	19.95	8.90
One Year Ago 3/11/2014	27.09	72.91	58.65	40.20	15.27	3.61

Intensity:

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

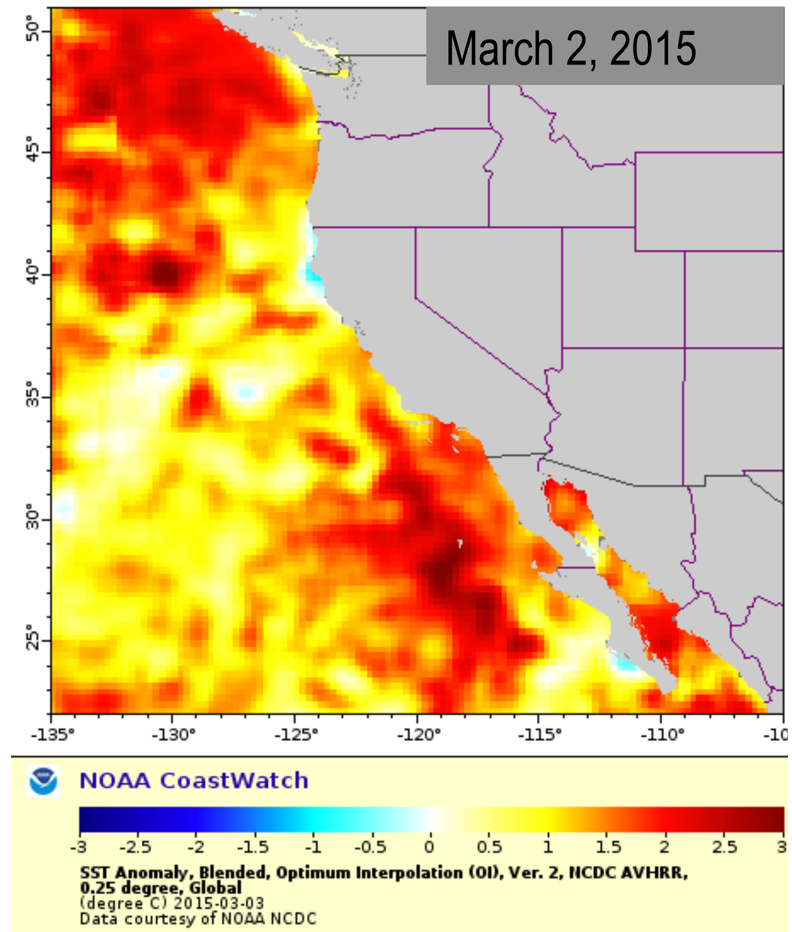
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:

Matthew Rosencrans

CPC/NCEP/NWS/NOAA

http://droughtmonitor.unl.edu/



Conservation Biology

Special Section

Choosing and Using Climate-Change Scenarios for Ecological-Impact Assessments and Conservation Decisions

AMY K. SNOVER,* ‡‡ NATHAN J. MANTUA,*† JEREMY S. LITTELL,*‡ MICHAEL A. ALEXANDER,§ MICHELLE M. MCCLURE,** AND JANET NYE††

*Climate Impacts Group, University of Washington, Box 355674, Seattle, WA 98195, U.S.A.
†National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center, 110 Shaffer Road, Santa Cruz, CA 95060, U.S.A.
‡Department of Interior Alaska Climate Science Center, U.S. Geological Survey, 4210 University Drive, Anchorage, AK 99508, U.S.A.
§NOAA, Earth System Research Laboratory, R/PSD1, 325 Broadway, Boulder, CO 80305-3328, U.S.A.
**National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Fisheries Science Center, 2725 Montlake Boulevard East, Seattle, WA 98112, U.S.A.
††School of Marine and Atmospheric Sciences, Stony Brook University, Stony Brook, NY 11794-5000, U.S.A.

Snover et al. (2013): *Conservation Biology,* **27**: 1147–1157. doi: 10.1111/cobi.12163

- Material in this presentation is based on this article, which was part of a special issue of Conservation Biology focused on *Climate Change and the Endangered Species Act*
- My goal today is to apply Snover's general guidelines to the specific case of California's salmonids

Snover et al. 2013

- Literature synthesis to support objective approaches to choosing and using future climate scenarios
- Addresses common misconceptions about the accuracy and utility of climate change projections
- Provides structured approach & general guidelines for C&U scenarios
- Examples from marine science, ESA-relevant assessments and others

The challenge

- Effective use of climate change information is limited by misperceptions about the strengths and weaknesses of available information, the large and growing number of future climate scenarios, and best practices for coping with <u>uncertainty</u> in future projections
  - 3 key streams of uncertainty in future climate scenarios are (1) future greenhouse gas and aerosol concentrations, (2) climate model errors, and (3) natural variability in the Earth system (long-lived climate oscillations, El Niño, random climate wandering from “the butterflies”, volcanic activity, etc.)

Coping with uncertainty:
Addressing misperceptions about climate scenarios

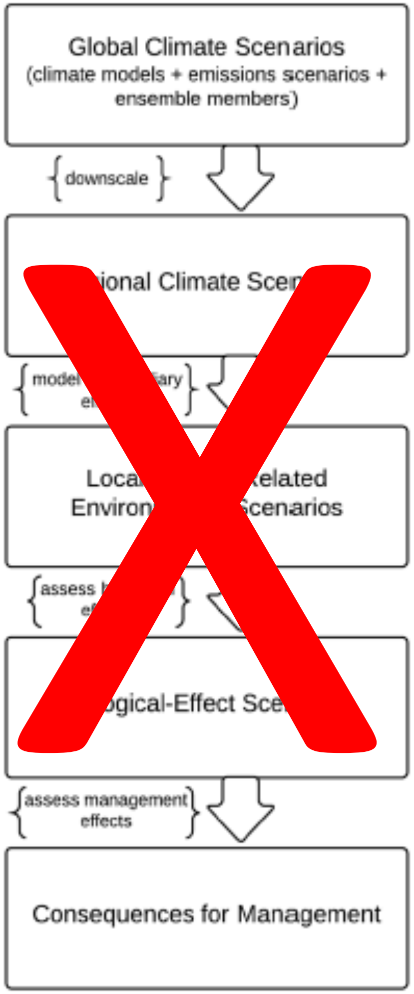
Myth	**Climate scientists can identify the "best" or most likely scenarios.**
Reality	It is impossible to determine the "best" climate-change scenario due to uncertainty in future greenhouse gas emissions, climate model deficiencies, and natural climate variability
Take home	Choosing the "best" scenario for a particular analysis depends on characteristics of the biological system of interest and the associated decision context.

Myth	**Because global climate models don't always agree on the projected direction of change in important variables, their output is not useful.**
Reality	Even in such cases, robust scenarios of future conditions can be developed when biological effects are dominated by changes in other, better-understood variables.
Take home	An essential first step for choosing relevant scenarios for analysis is understanding the primary local climate-related drivers of the biological system of interest.

From Snover et al. 2013, Table 3

Selecting climate scenarios for ecological-impact assessments.

Step 1: Begin with the end in mind

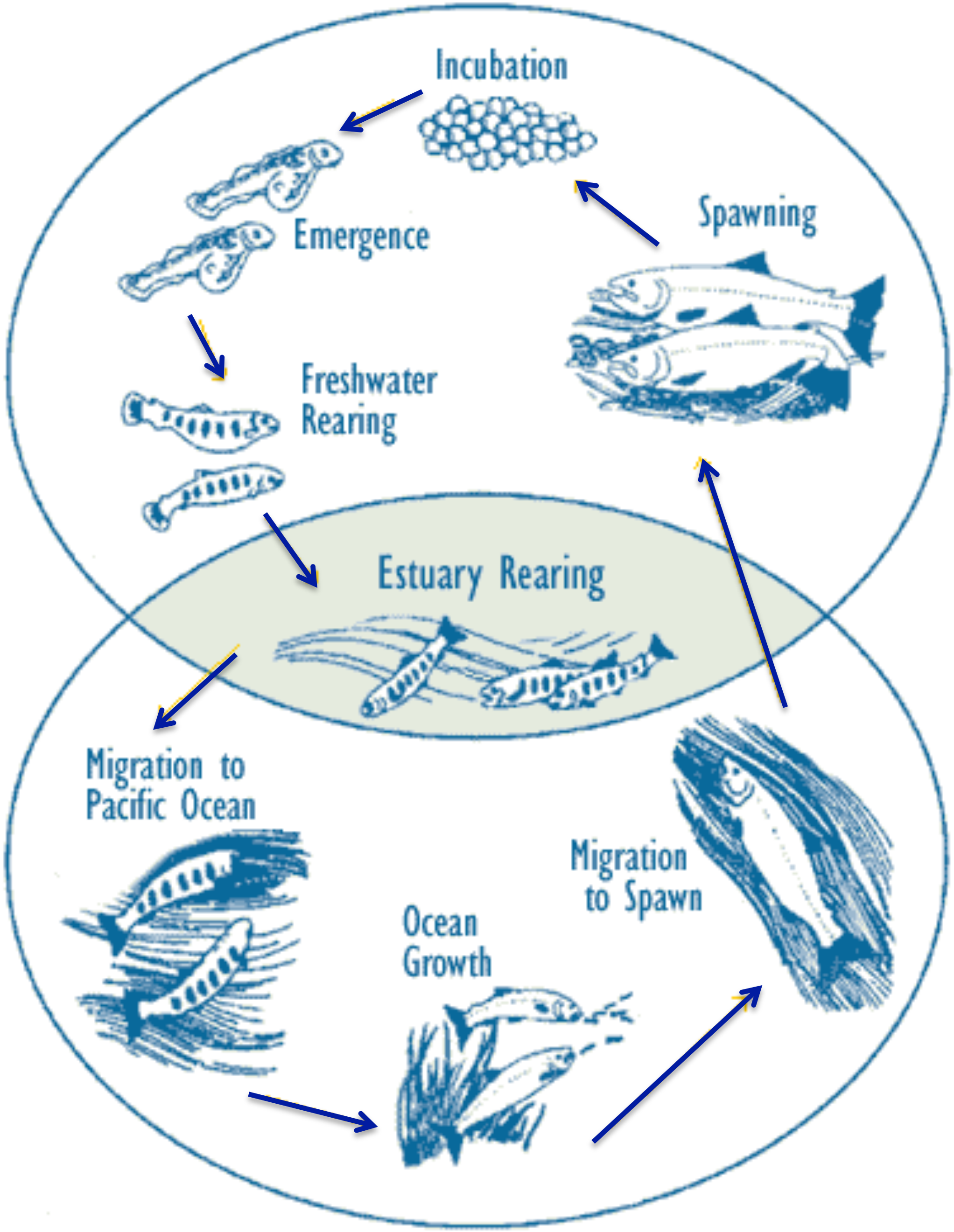


Step #1: Identify primary local climate drivers of the biological system of interest

1a: develop a conceptual model to identify climate effect pathways for the target species or ecosystem

1b: identify the local climate drivers

The top-down impact assessment: a common method of assessing climate impacts



The salmon lifecycle, a terrific conceptual model for identifying climate effects

Their complex lifecycle that includes freshwater spawning and rearing, (sometimes) estuary rearing, and an extended ocean life for growth and maturation puts them in highly dynamic climate-driven habitats.

Climate effects …

- freshwater habitats: flow and temperature
- estuaries: temperature, FW inflows, sea level rise
- ocean: upwelling, currents and related ocean conditions

Selecting climate scenarios for ecological-impact assessments.
Step 2: Determine appropriate sources of information

Climate drivers of key habitat pathways:

Freshwater Flow and T: air temperature and precipitation drive hydrologic responses

Estuaries: again, air temperature and precipitation drive hydrologic inputs from upstream; sea level rise is key driver on the ocean side

Ocean: surface winds, both local and basin scale, key for coastal upwelling and currents

Can I use GCM output directly?

Do I need to use downscaled data?

Where do I find information about my local climate driver?

- Decision-tree and guiding questions for selecting among GCM output, downscaled data, output from intermediary impacts models
- Choice depends on how well processes controlling local climate are spatially resolved

Benefits from expertise in climate/ climate impacts modeling

Selecting climate scenarios for ecological-impact assessments.

Step 2: Determine appropriate sources of information

Freshwater: typically use hydrologic models to translate downscaled air temperature and precipitation into hydrologic responses

Estuaries: inflows from output of a hydrologic model; sea level rise scenarios from climate models may be adequate; a variety of estuary habitat models have been used in different studies

Ocean: key for coastal upwelling is high-resolution surface winds; may need to use regional, high-resolution ocean-atmosphere models to account for feedbacks between surface winds and surface temperatures (these models are just now being developed and operated in climate studies)

Selecting climate scenarios for ecological-impact assessments.

Step 3: Select (a subset of) scenarios for analysis

Objectively select (a subset of) scenarios for use in impact assessment based on:

- whether climate-model errors significantly affect model sensitivity to global warming
- effect of natural climate variability
- time horizon of associated decisions
- observed emission trends
- decision context and risk tolerance

Guidance & examples provided for each case

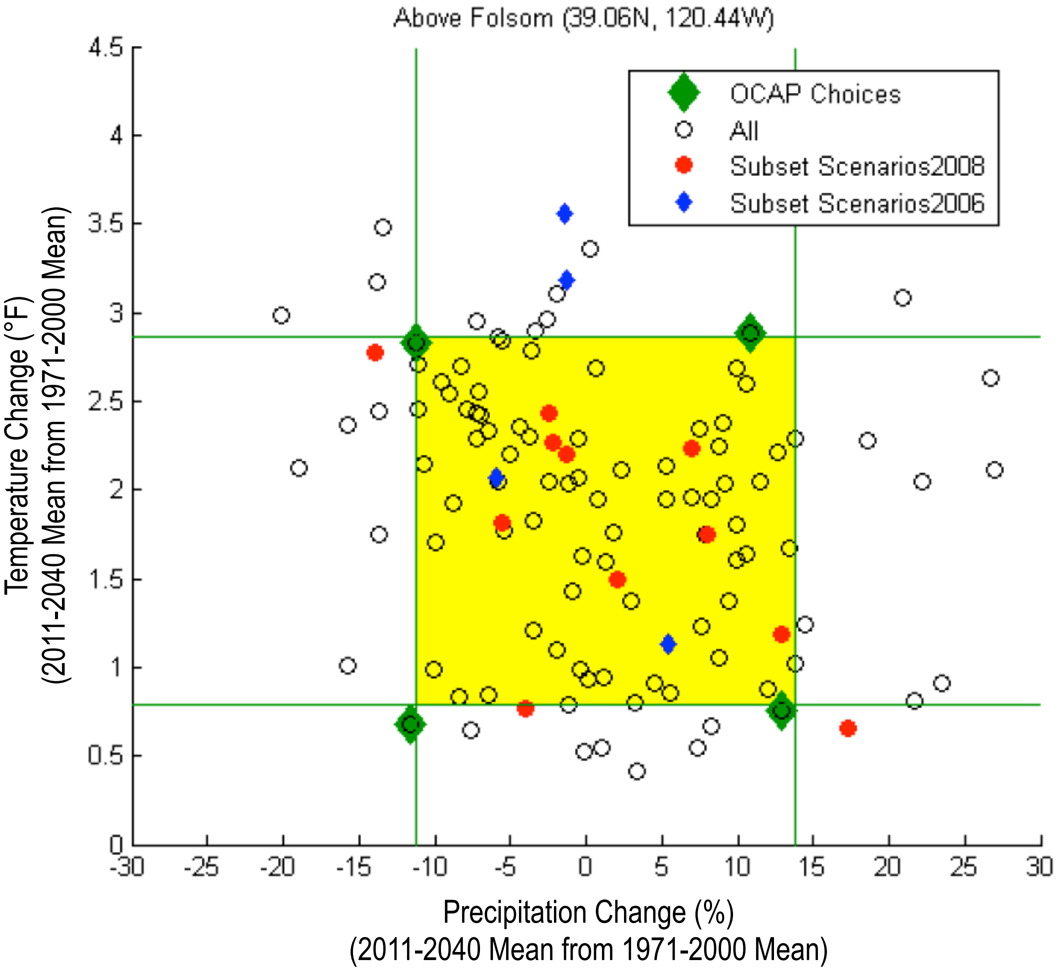
Requires knowledge of decision context – time frame, risk tolerance, reversibility, etc., as well as expertise in climate science & system of interest

A bracketing approach

20+ different climate models, multiple future emissions scenarios, and each model is run multiple times == literally hundreds of future climate scenarios to choose from!

- At right, 4 future climate scenarios were selected from a much larger collection to represent warmest/ driest, warmest/wettest, least warm/ driest, least warm/wettest …

The focus here was an impacts assessment for Central Valley hydrology and water resources

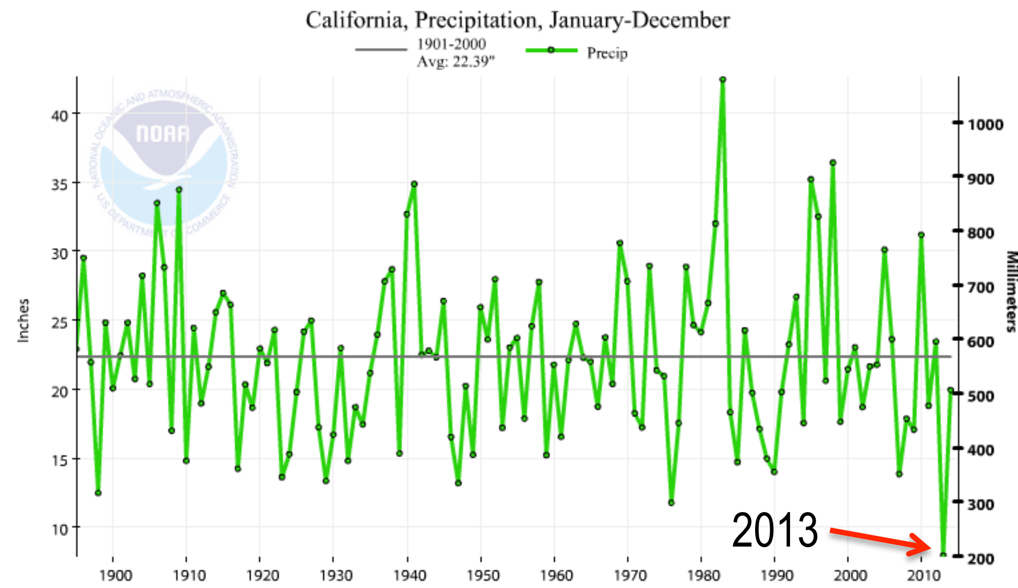


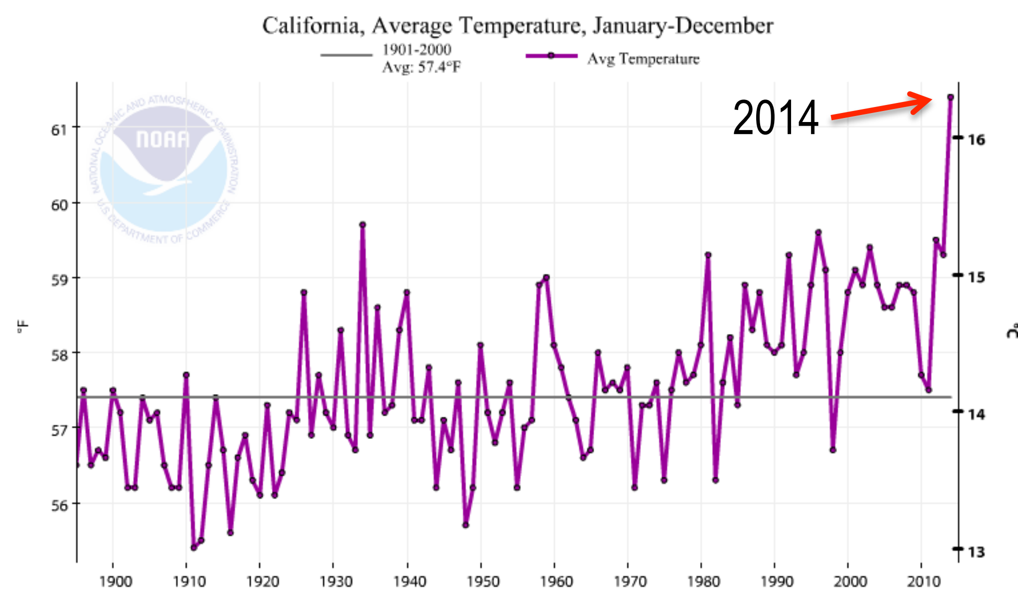
From the Bay Delta Conservation Plan Climate Change Strategy Whitepaper (2009)

Future Scenarios continued

You don't need climate models to generate future scenarios for evaluating climate vulnerability

- The historical climate record has lots of informative variability, including extremes (see 2013 and 2014!)
- Paleoclimate records provide deeper insights into future climate possibilities
- You can generate synthetic climate futures (just make them up!) to evaluate climate sensitivity
    - This is especially valuable when you have an easy to run quantitative model that uses climate inputs
    - an option for the challenging problem of future ocean conditions





Take Home

- For future climate scenarios relevant to California's salmon
  - Key climate-driven pressure points include stream flow and temperature, sea level rise and hydrologic impacts on estuaries, and ocean conditions
  - Many future scenarios are available for California's air temperature, precipitation, hydrology, and sea level rise
  - Some are available for stream flow and coastal upwelling winds
  - very few available for comprehensive ocean conditions
- We recommend interaction among climate scientists, natural and physical scientists, and decision makers throughout the process of choosing and using climate-change scenarios for ecological impact assessment

California golden trout: can their warming streams handle cattle grazing and climate change?

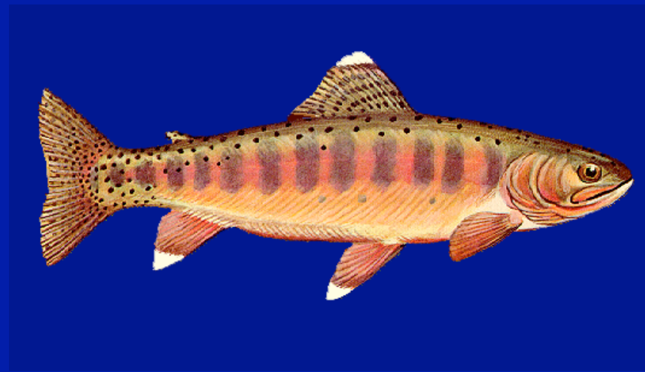
Kathleen R. Matthews

USDA PSW Forest Service Research

Sebastien Nussle & Stephanie Carlson

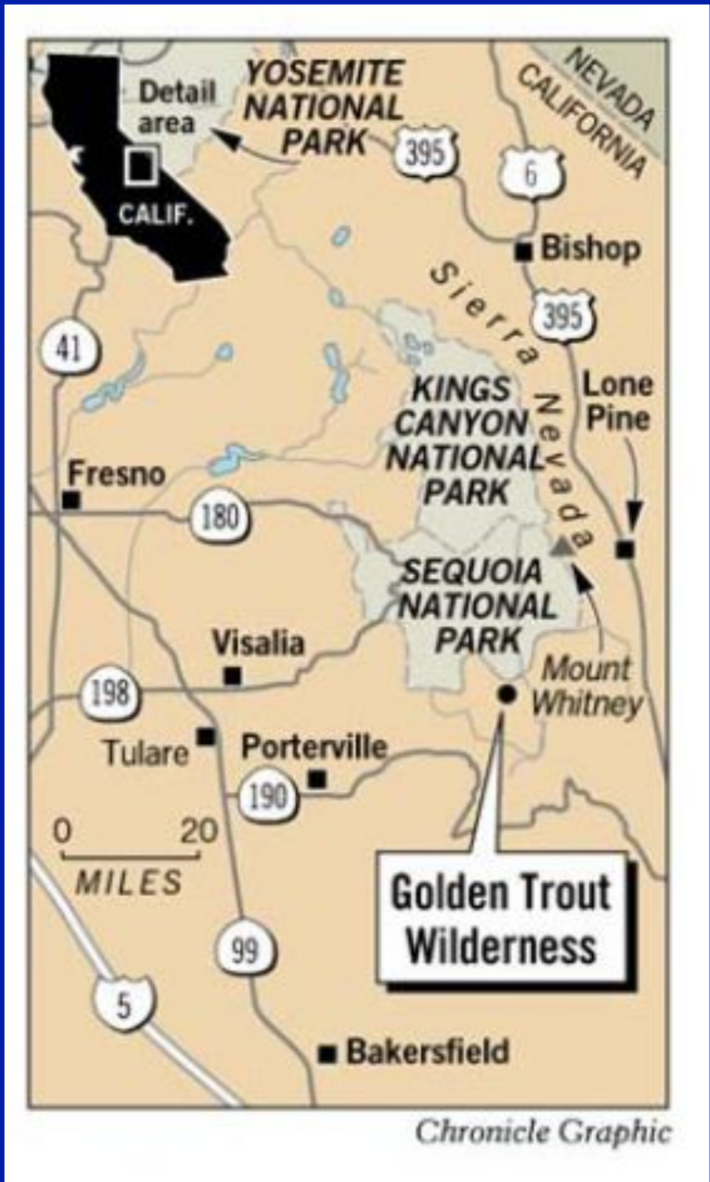
UC Berkeley ESPM

Pacific Southwest Research Station

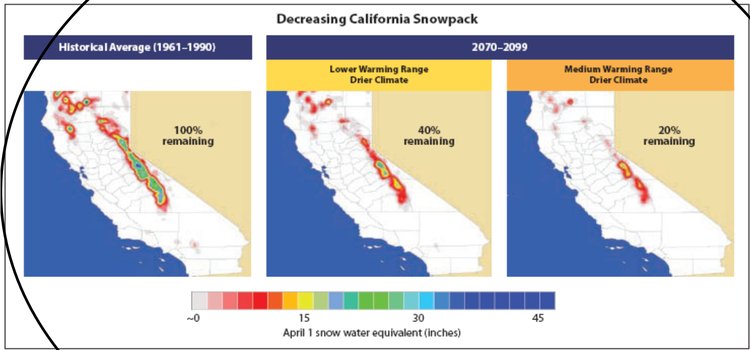


California Golden Trout

- California's state fish; one of few native fish >8000 ft; inhabits high elevation meadow streams in the southern Sierra
- Native to South Fork Kern River and Golden Trout Creek; not native to lakes
- Most of its native range now within Golden Trout Wilderness



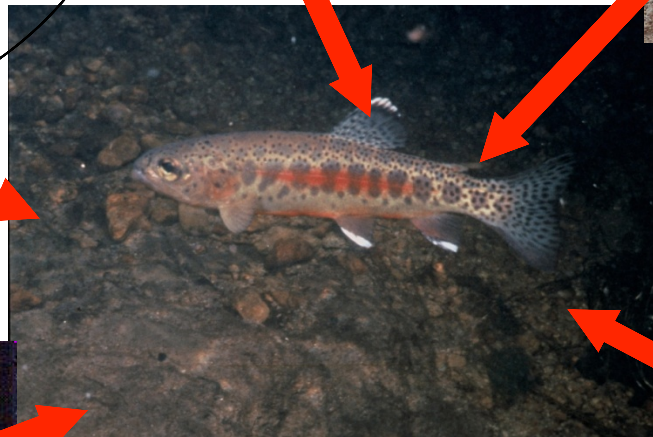
Golden Trout Wilderness encompasses most of the subalpine meadows of the Kern Plateau—all meadows grazed since the 1800s

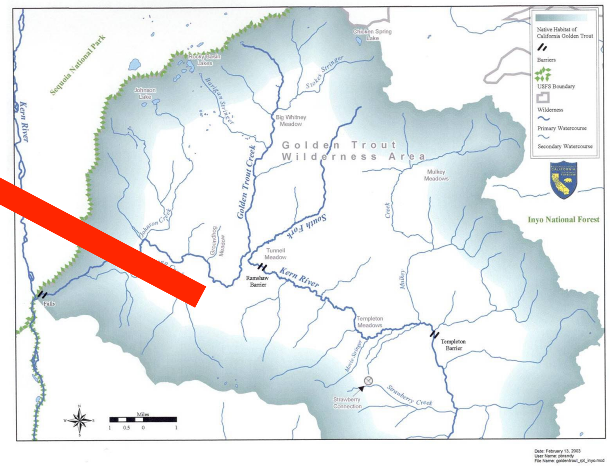


Climate warming

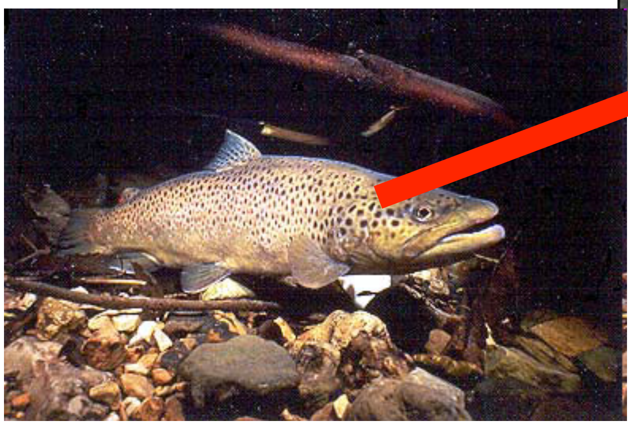
Loss of genetic diversity

Degraded habitat from cattle grazing





Limited distribution and in headwaters



Can Golden Trout handle another stressor?

Non-native trout

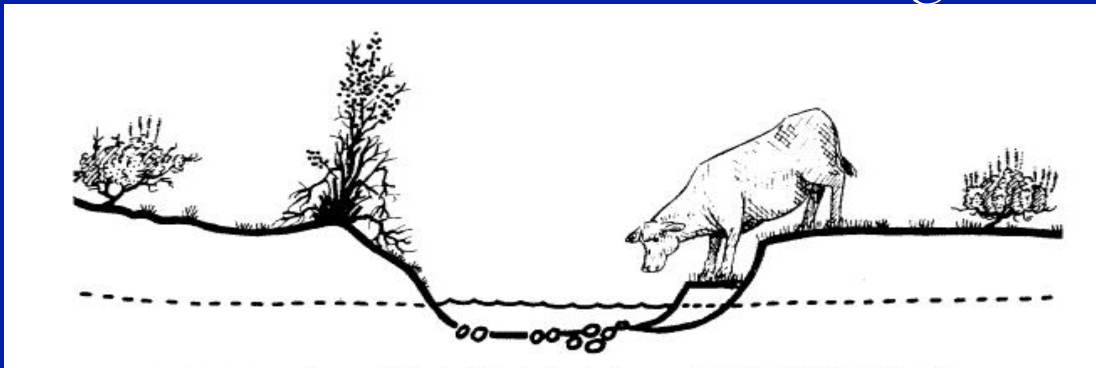
Climate change: some factors that may influence golden trout and their habitat

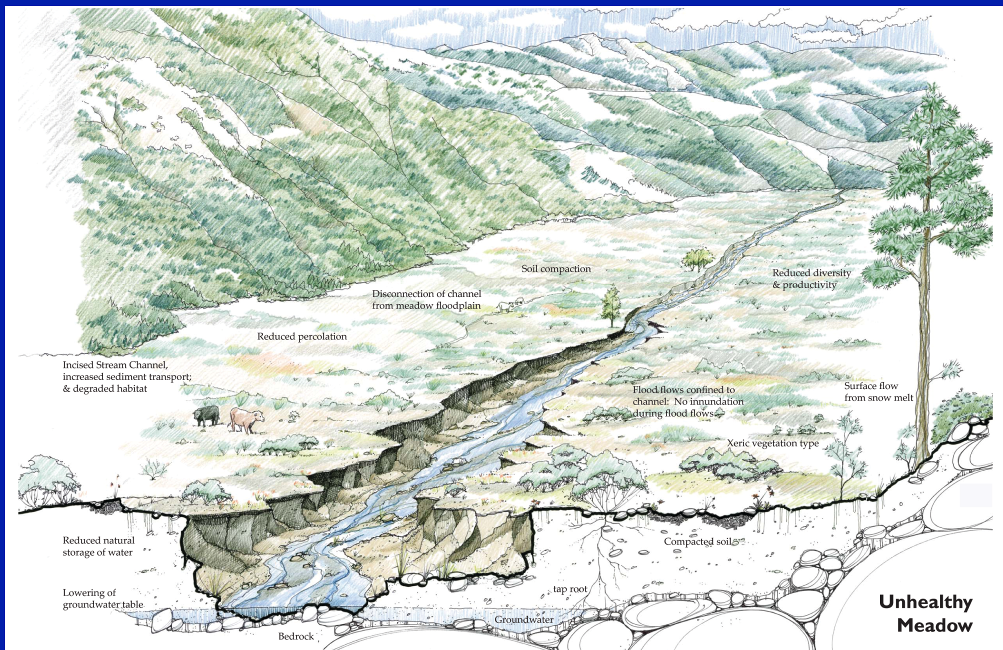
- Decreased snowpack—may be more dramatic at lower elevation (<9000 ft)
- Earlier snowmelt some year-round mountain streams going dry by summer
- More sediment scouring from increased precipitation
- Increasing water and air temperatures- 2-5°C over next 100 years

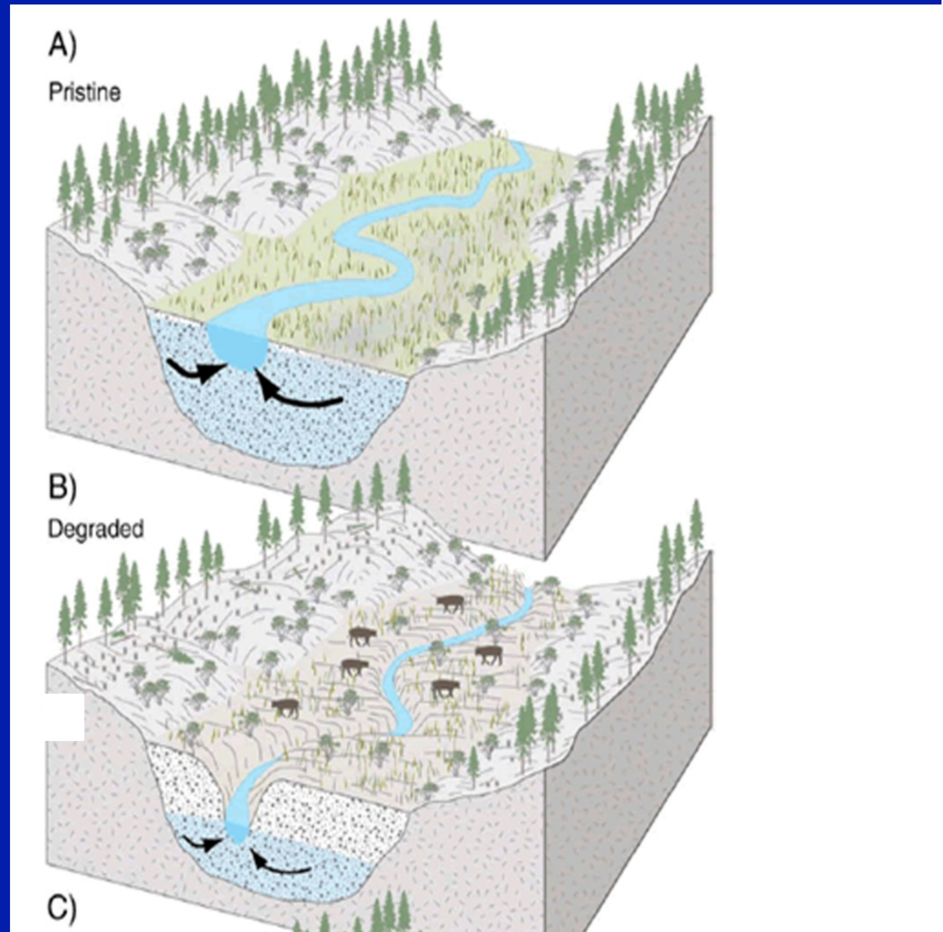
How are they doing??

- Were threatened by exotic trout
- Genetic integrity imperiled
- Very dense, stunted populations
- Stream habitat degraded
- Water temperatures are high
- Limited distribution & at the headwaters

Cows and Meadow streams- all of the GTW streams have been grazed

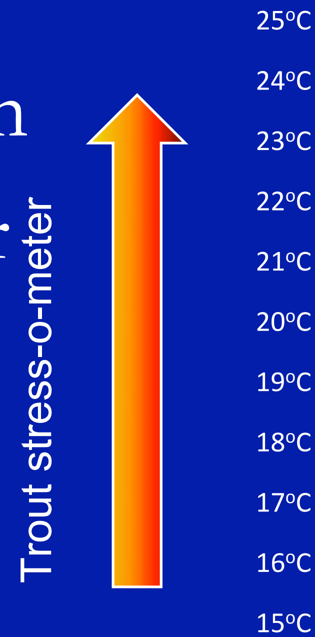






What happens to trout with warmer (>21°C) water temperature?

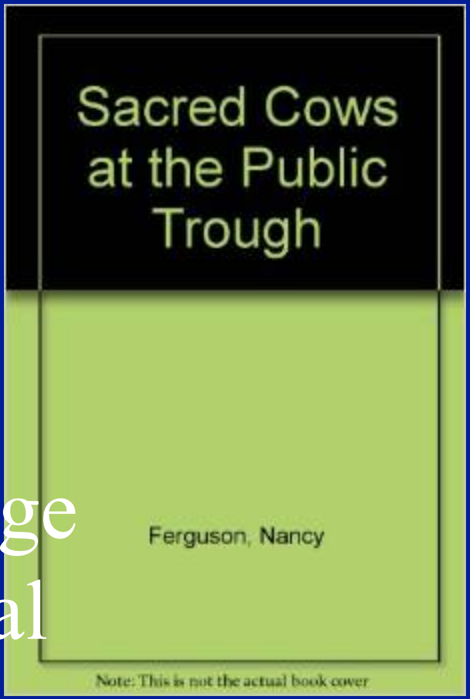
- Increased metabolism/decreased growth
- Increased susceptibility to disease/fungal infections
- Decreased survival/low condition
- Dissolved oxygen becomes lower



Climate change and cattle grazing—similar stressors to aquatic systems

Predicted climate change effects	Known effects of cattle grazing	Combined—double whammy??
Increasing water and air temperatures- 2-7^{o}C	Reduced streamside vegetation and widened/ shallow streams lead to higher water temperatures	Lethal water temperatures for salmonids
Reduced snowpack, less water availability, reduced vegetation growth	Reduced streamside vegetation from grazing and subsequent bank instability	Inability to keep to stream cool--lethal water temperature and reduced dissolved oxygen
What can we do? Climate adaptation	**Current condition**	**Action**
Need resilient stream ecosystems to adapt to future warming	Low resiliency to future warming and little opportunity for recovery	Beschta et al. (2013) recommend eliminating grazing (especially in wilderness) to ensure stream habitats can tolerate future warming

Livestock grazing in the West: Sacred cows at the public trough revisited—AFS Fisheries (8/14) President's Commentary



"Livestock grazing exacerbates climate change effects on stream, riparian, and upland natural resources."

"Greatly reducing public land livestock grazing… would reduce the susceptibility of.. resources to climate change."

Golden Trout Wilderness temperature vulnerability assessment

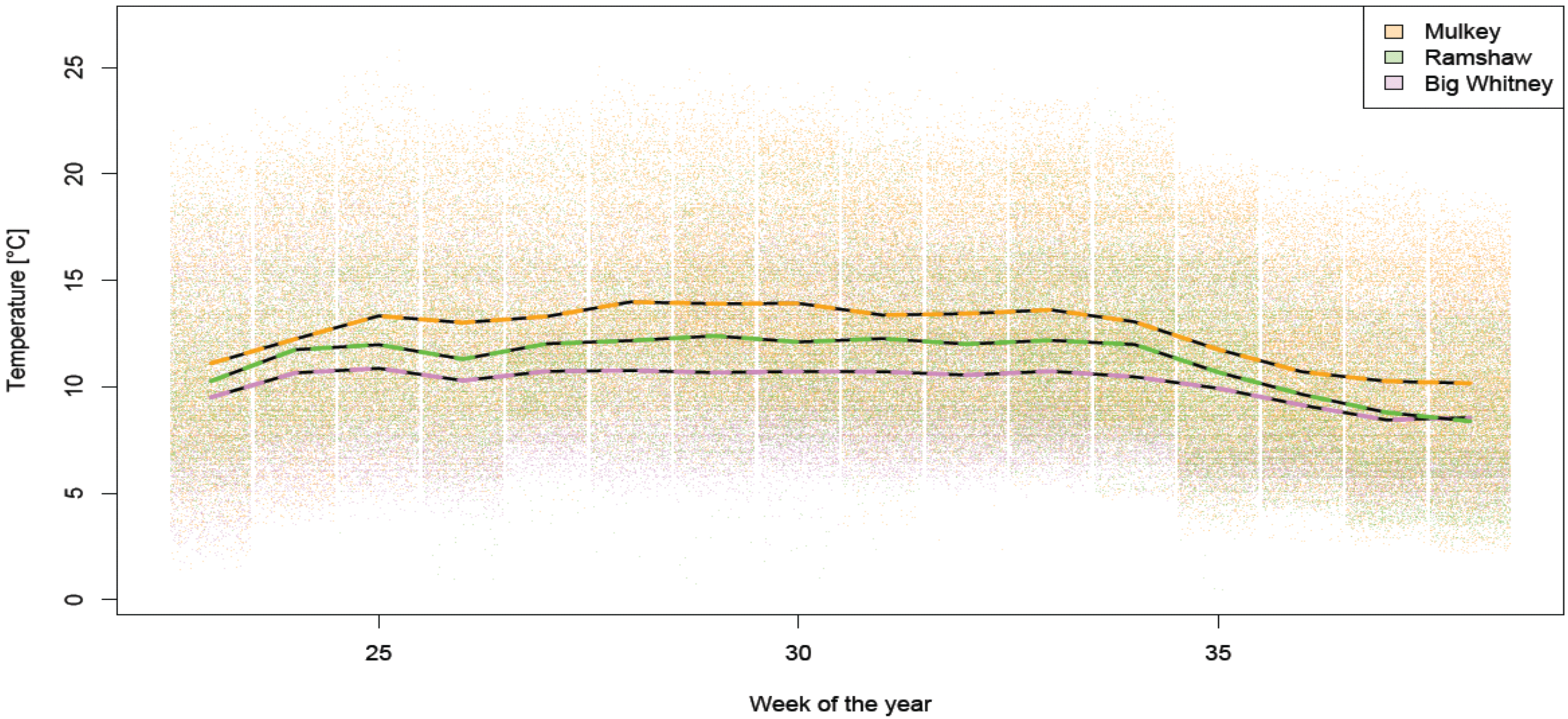
90 temperature probes record data every 20 minutes

Quantified stream water temperatures, shading & dissolved oxygen (DO) in three meadows: Mulkey, Ramshaw, and Big Whitney

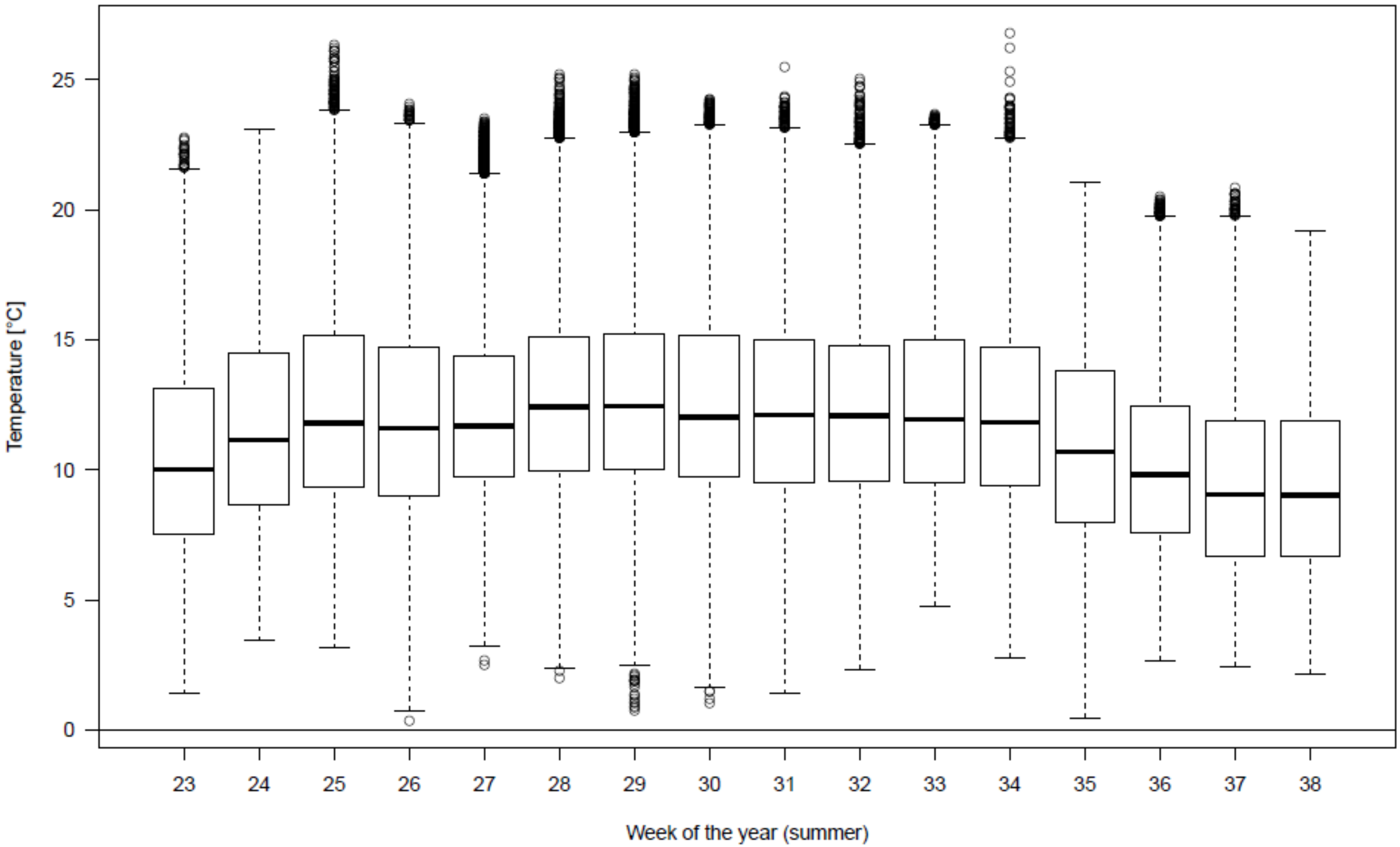
Preliminary findings/concerns from 2008-2013

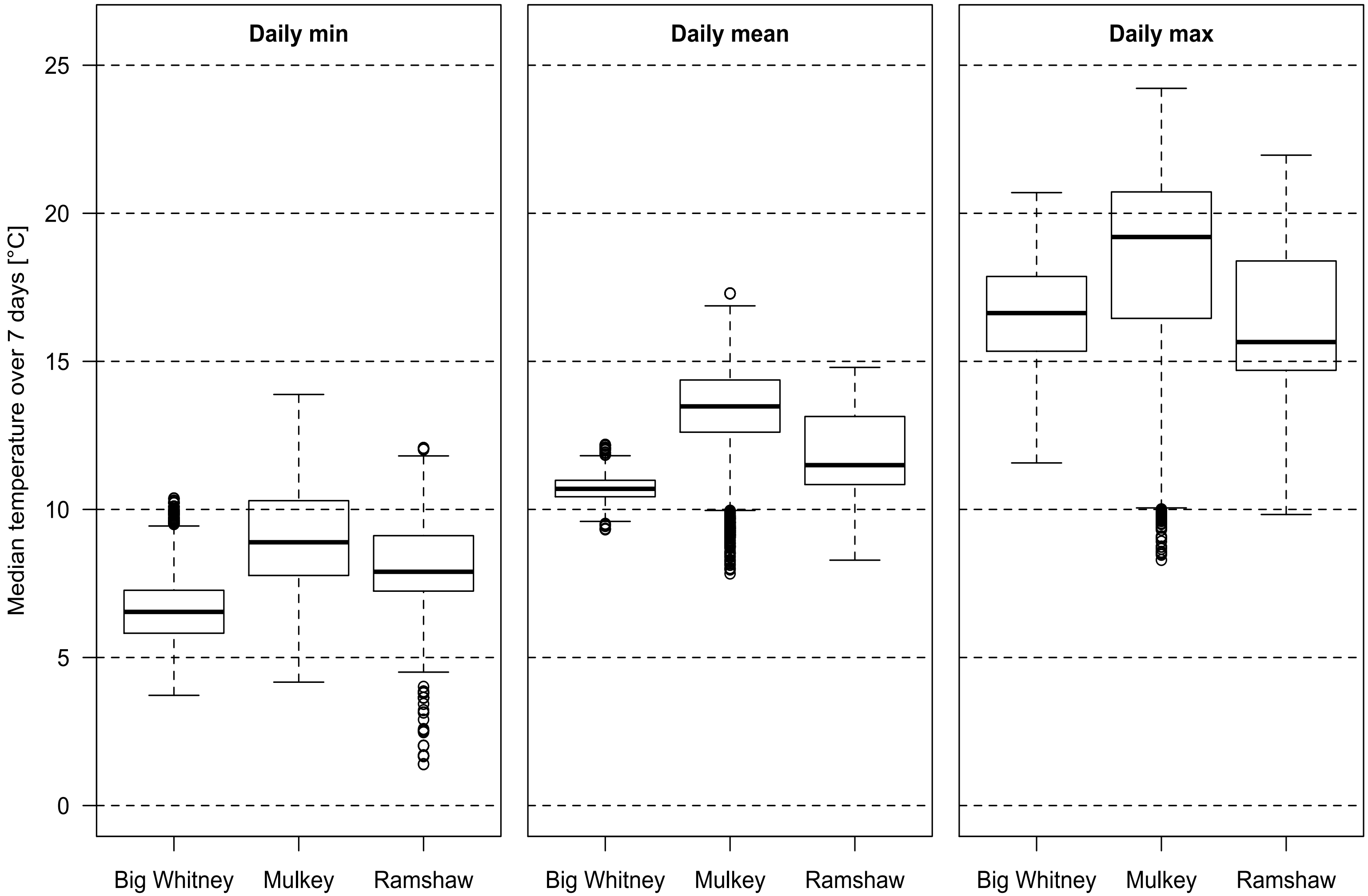
- Maximum temperatures in summer reach 26°C, up to 55 days w/water temperature exceeding 20°C
- Diel (24 hr) fluctations range up to 15°C
- Stressful combination of high temperature and low shading
- Streams don't have resilience to future warming
- CGT are in the headwaters, no place to go

Summer mean water temperatures-Mulkey, Ramshaw & Big Whitney



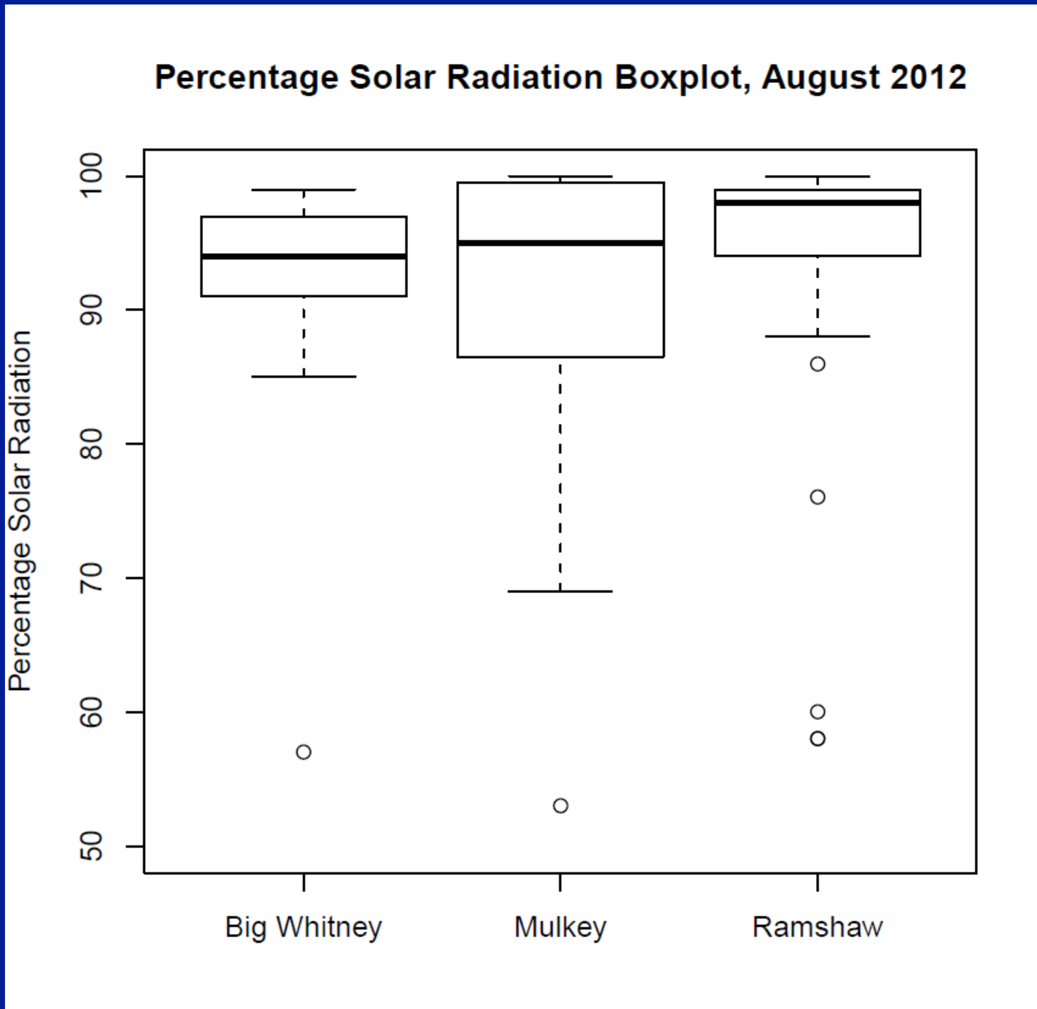
Summer range of water temperatures—all 3 meadows

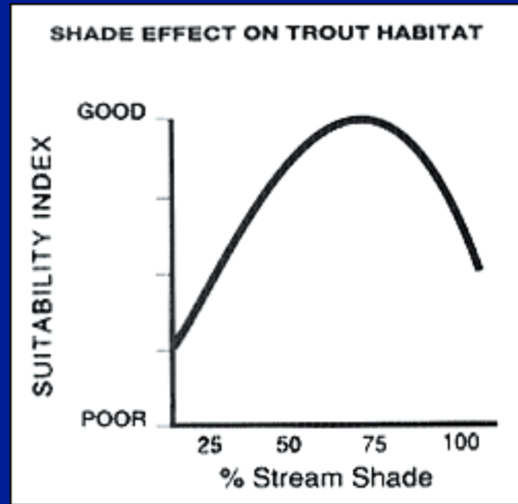




Daily min
Daily mean
Daily max
Median temperature over 7 days [°C]
0
5
10
15
20
25
Big Whitney
Mulkey
Ramshaw
Big Whitney
Mulkey
Ramshaw
Big Whitney
Mulkey
Ramshaw

Solar input high (>90%) & shading low (<10%)

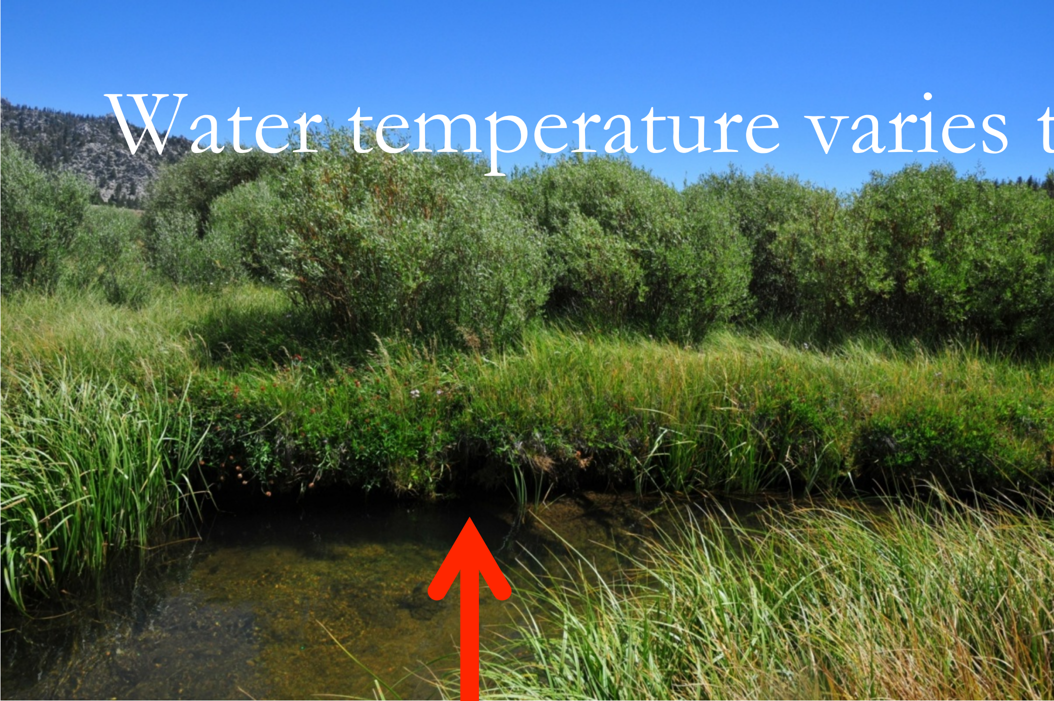




Reference: Raleigh, R.F.; Hickman, T.J.; Nelson, K.L; Maughan, O.E. 1980. Riverine habitat evaluation procedures for rainbow trout.

50-80% shading considered good

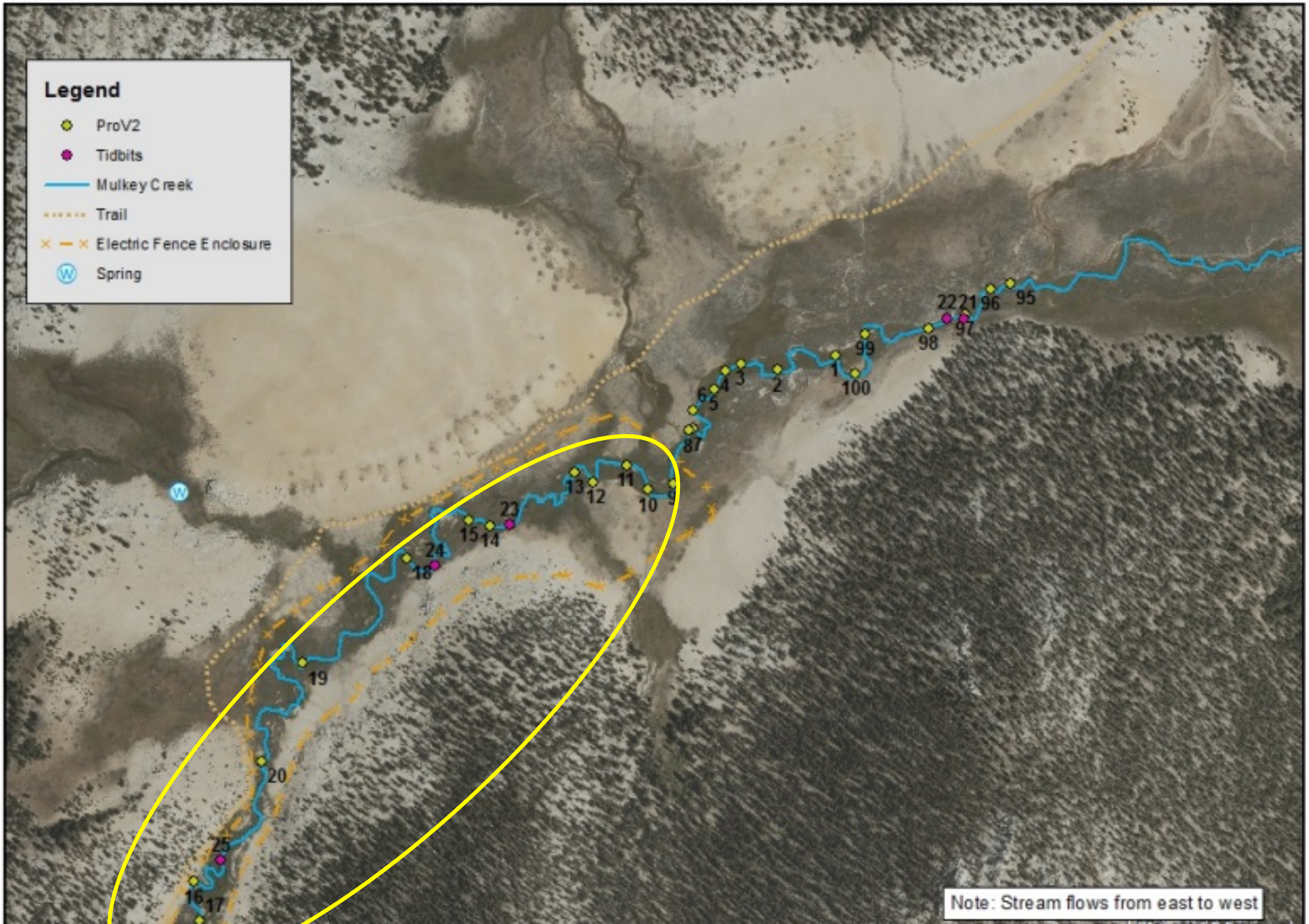
Water temperature varies throughout stream



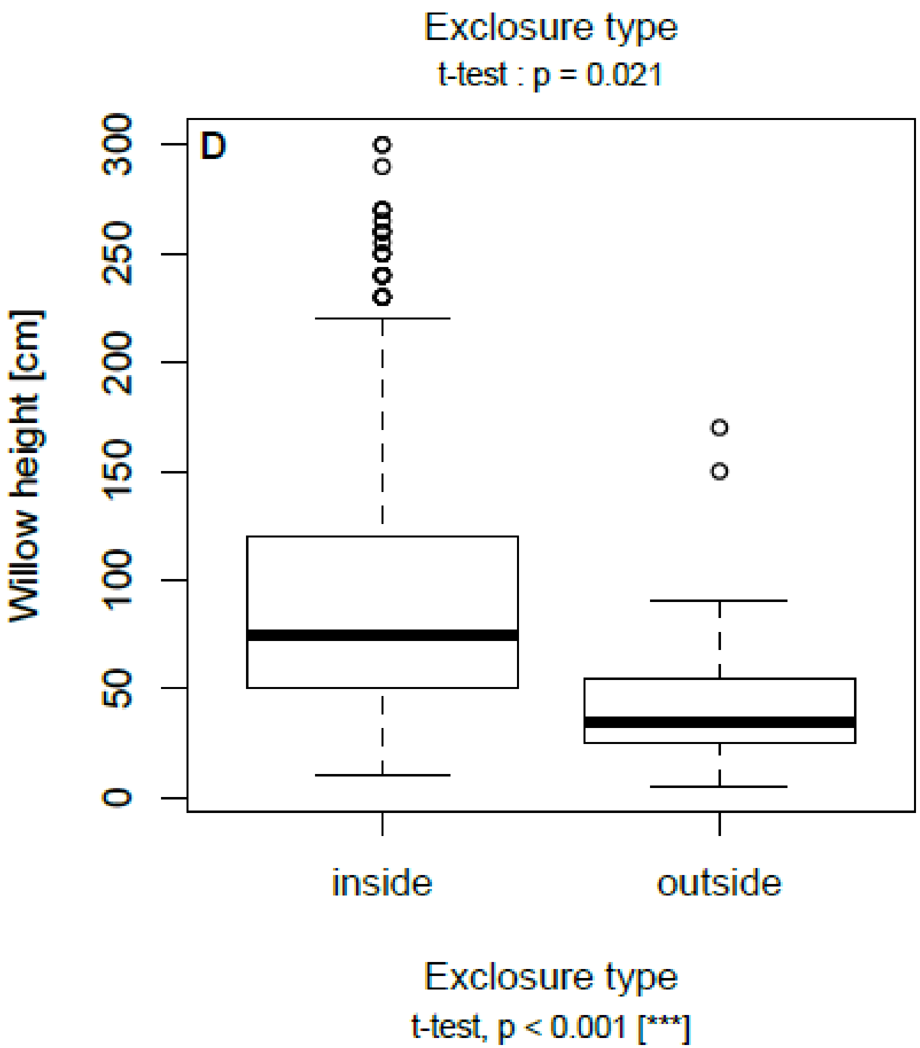
- Shaded undercut bank, 1 m deep
- Coolest temperatures found here

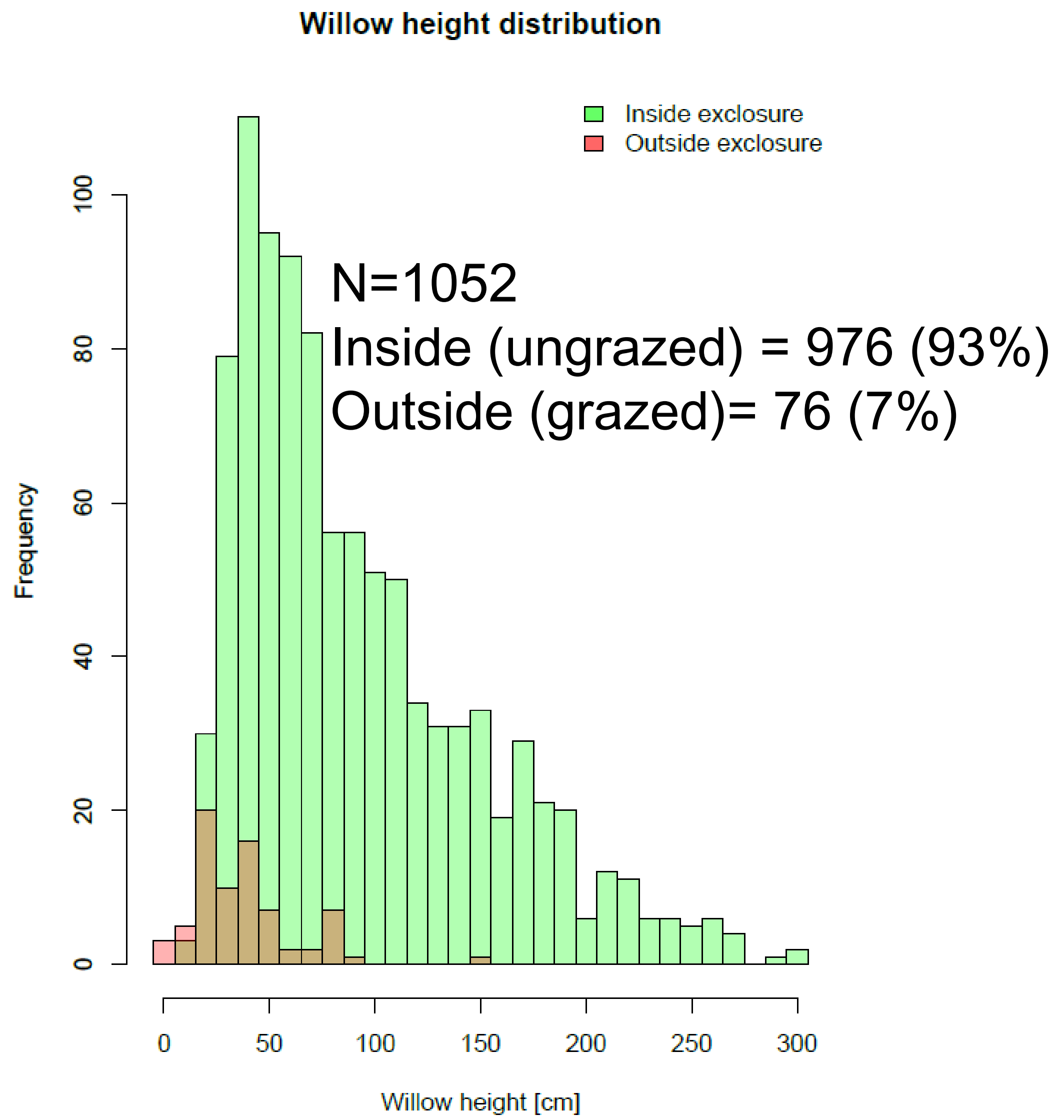
- Open to solar radiation, .2 m deep
- Highest temperatures found here

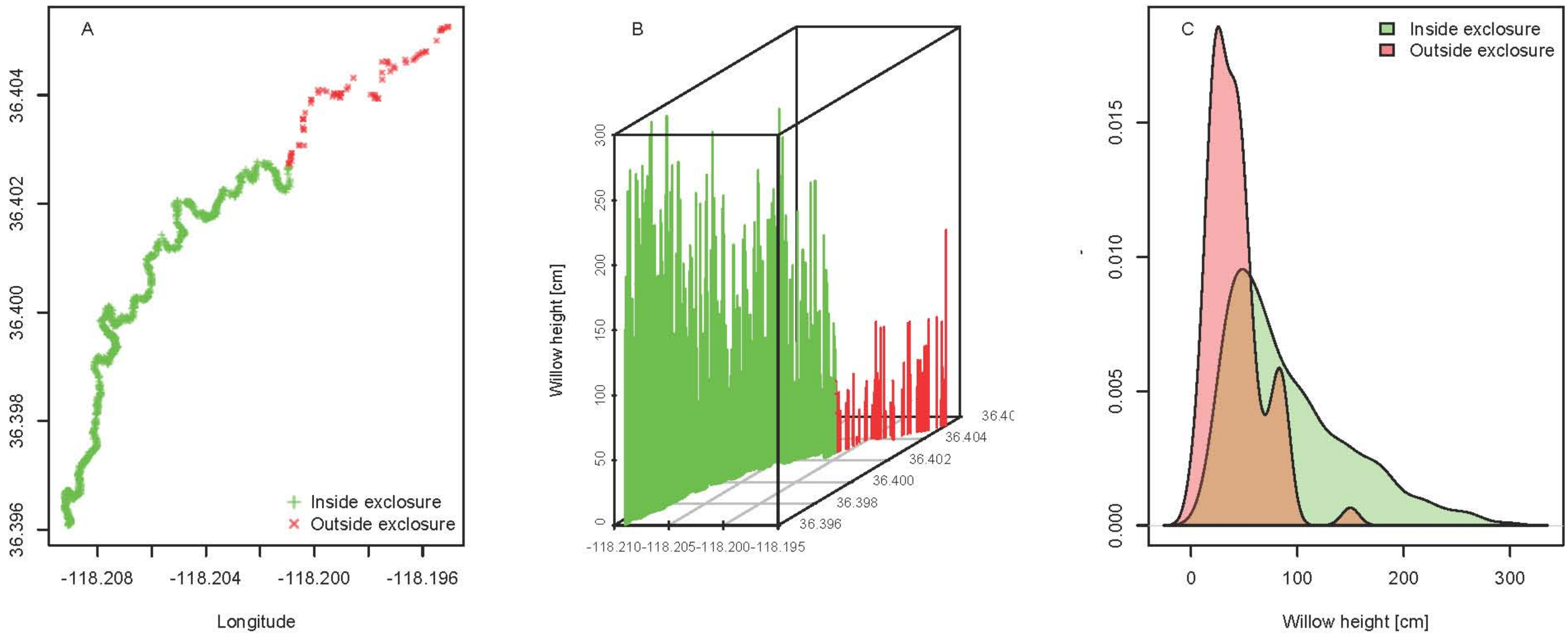
Mulkey Meadow Probe Locations

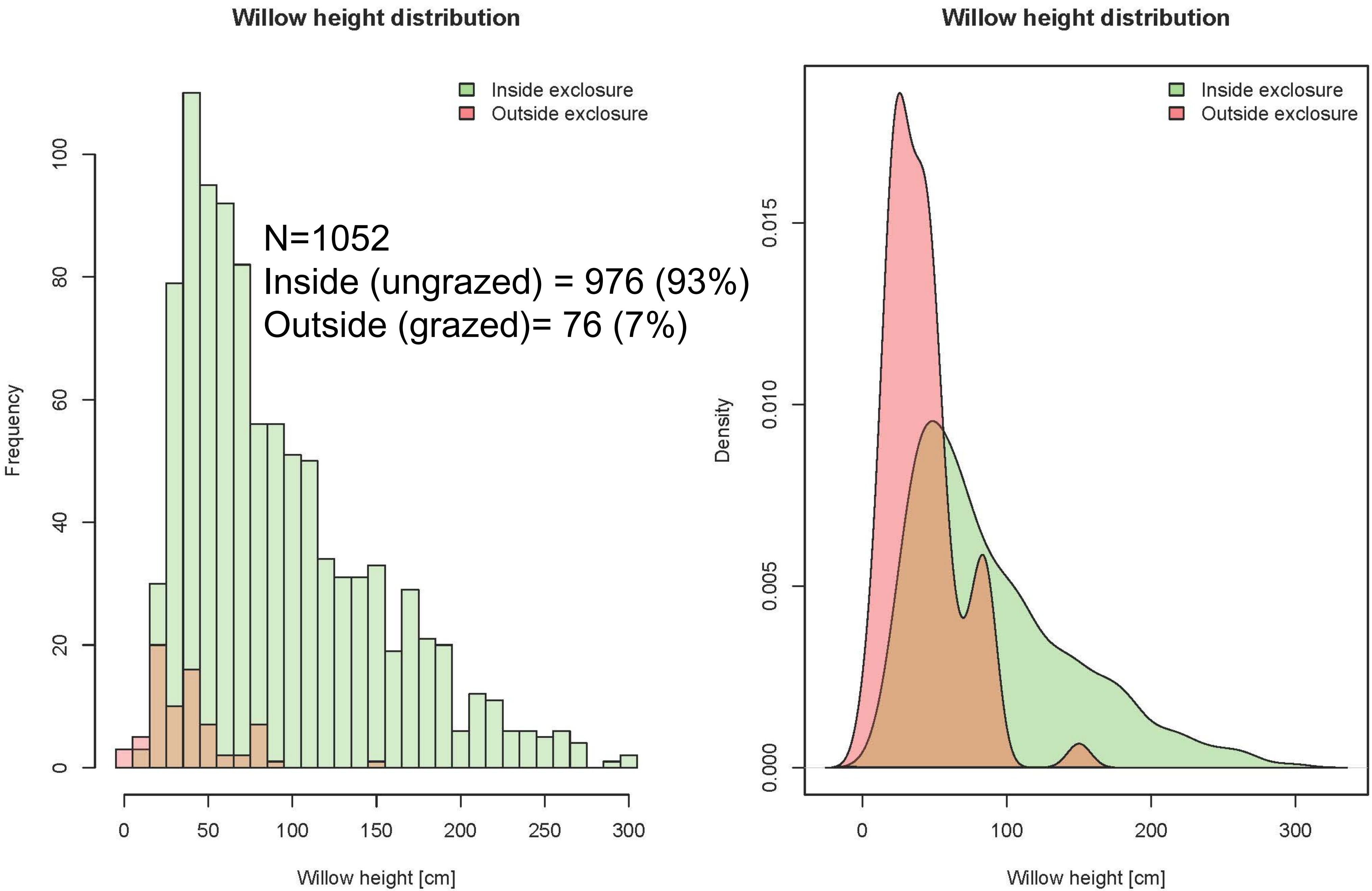


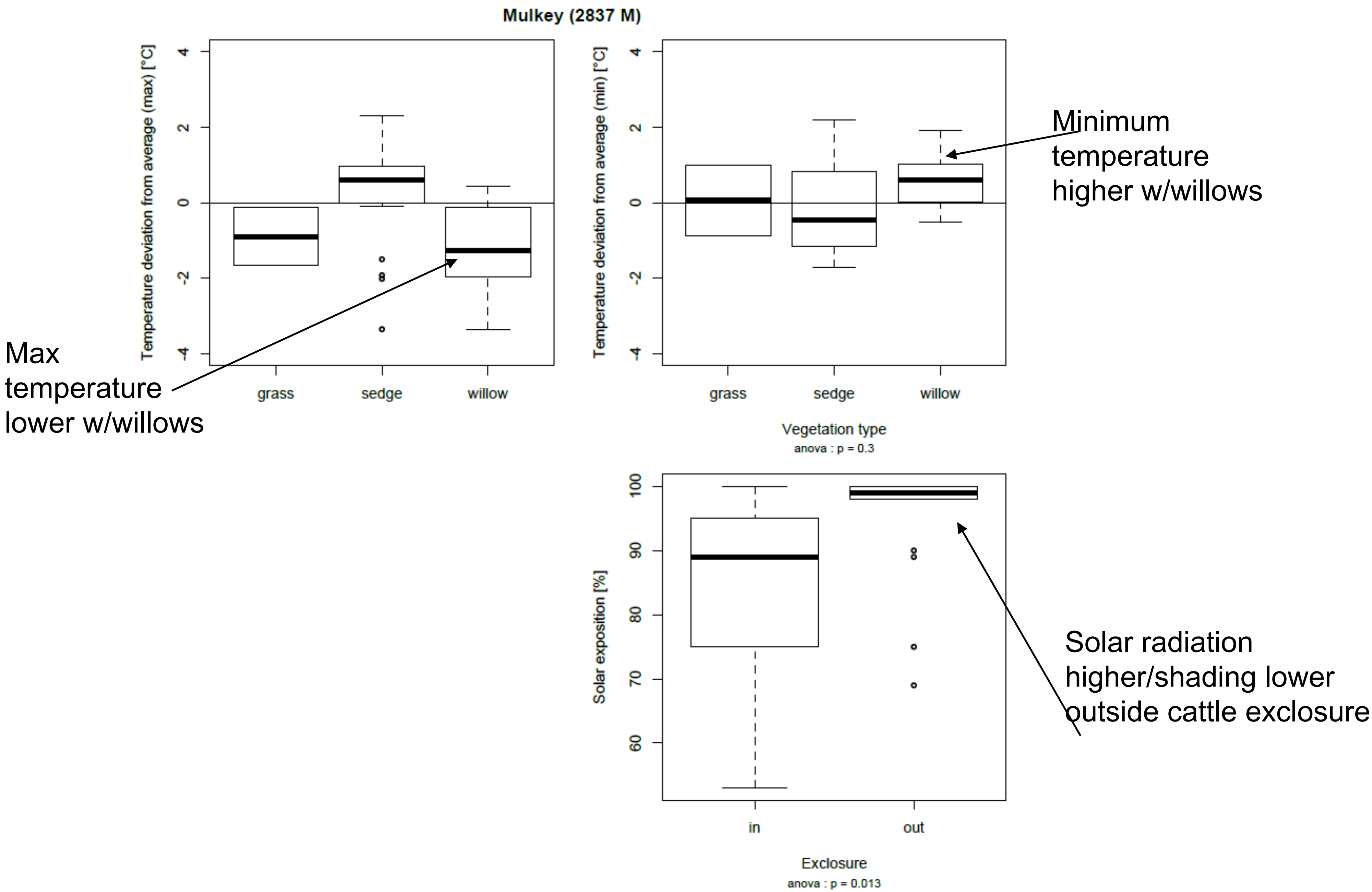
Willow numbers and heights inside and outside Mulkey cattle exclosures

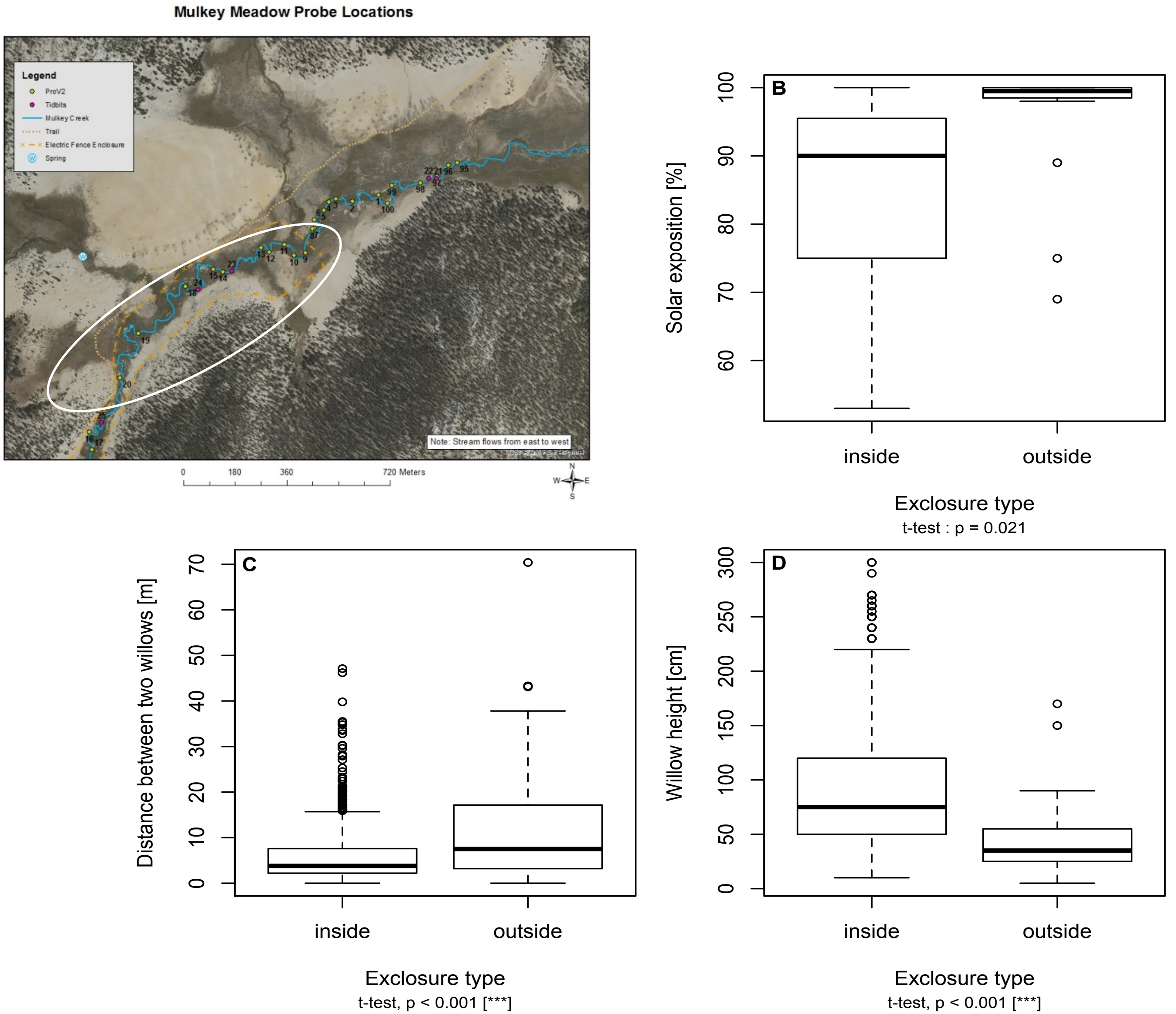


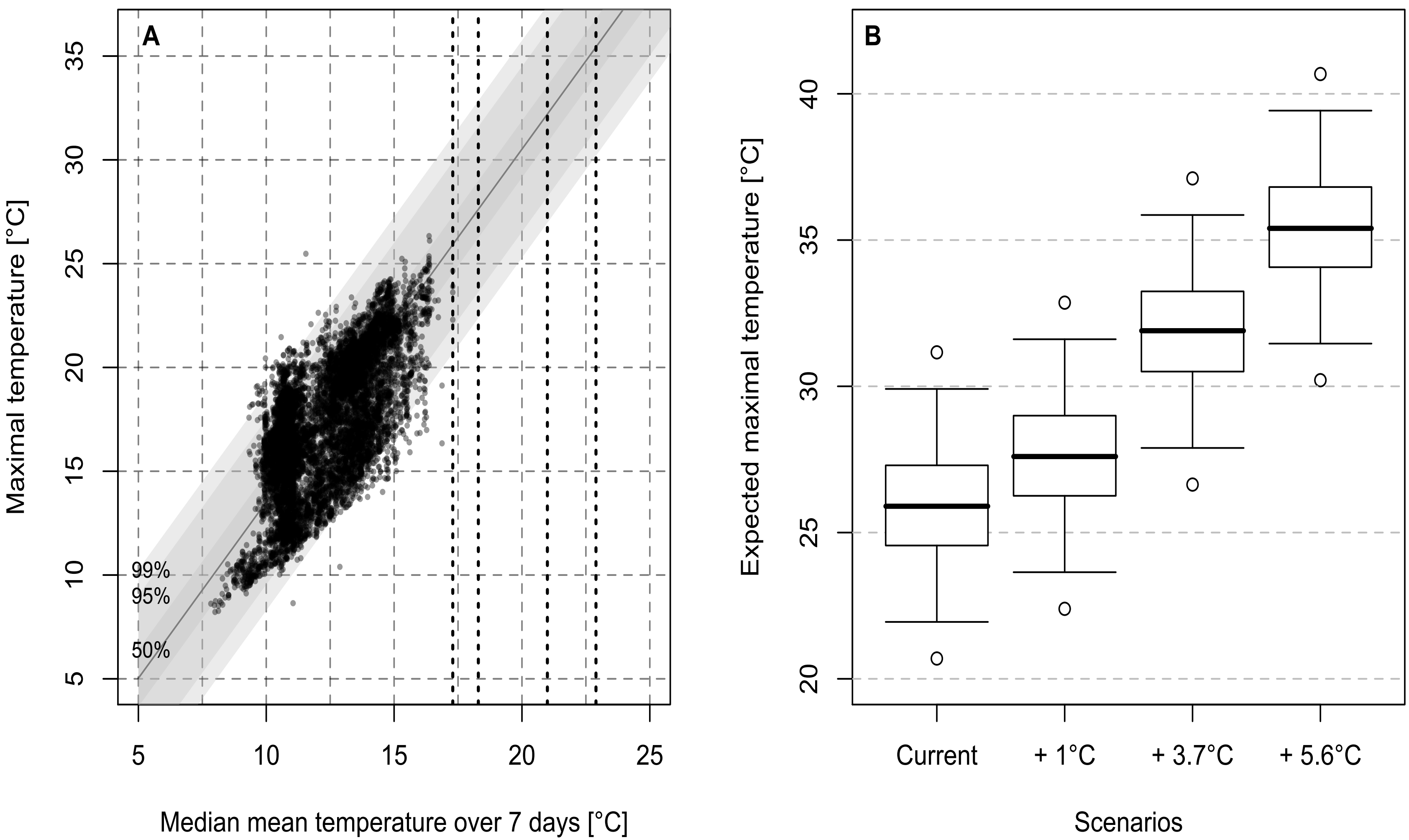



A
36.396
36.398
36.400
36.402
36.404
-118.208
-118.204
-118.200
-118.196
Longitude
Inside exclosure
Outside exclosure
B
Willow height [cm]
0
50
100
150
200
250
300
-118.210-118.205-118.200-118.195
36.396
36.398
36.400
36.402
36.404
C
Inside exclosure
Outside exclosure
0.000
0.005
0.010
0.015
0
100
200
300
Willow height [cm]

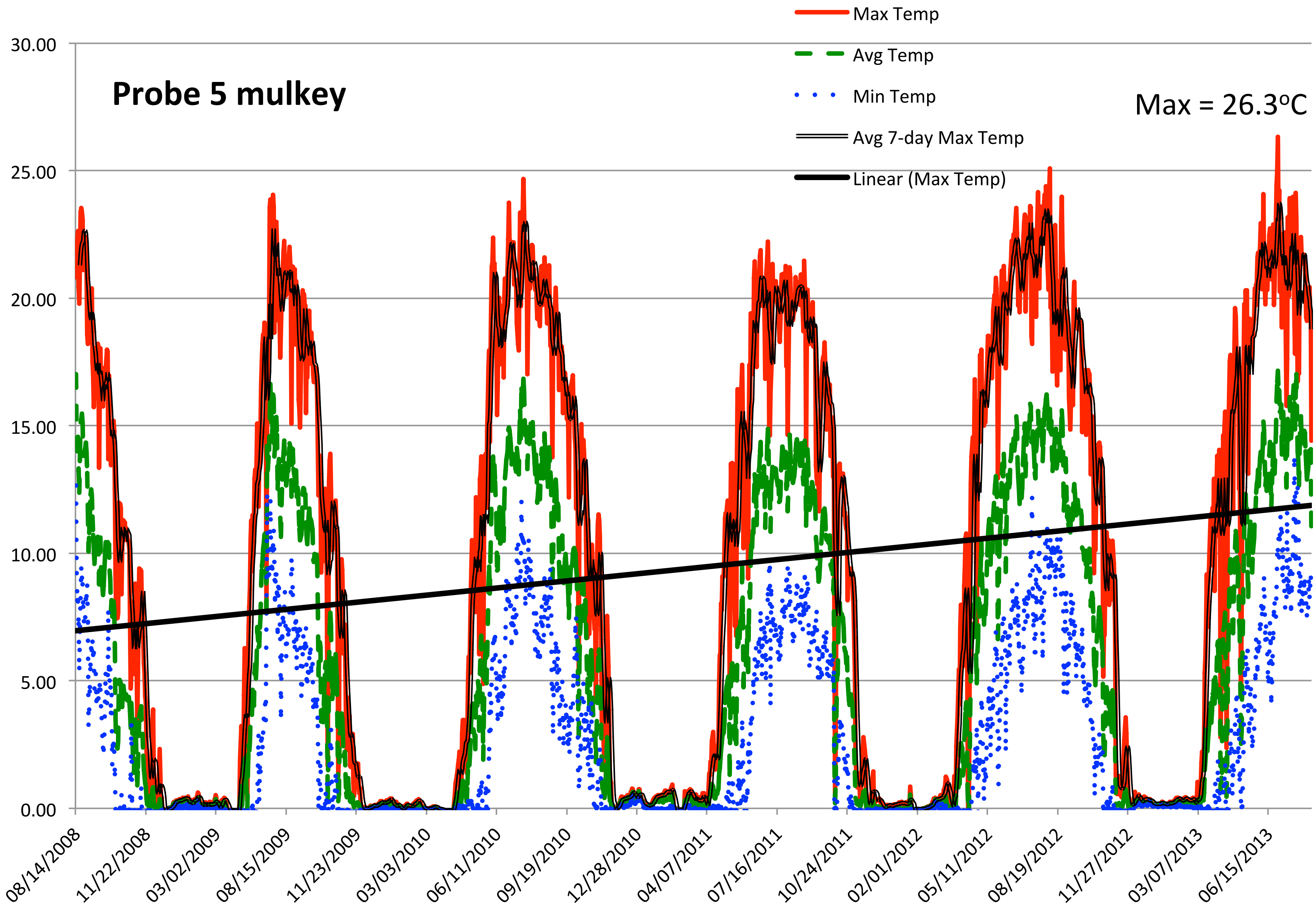

Willow height distribution
Inside exclosure
Outside exclosure
N=1052
Inside (ungrazed) = 976 (93%)
Outside (grazed)= 76 (7%)
Frequency
0
20
40
60
80
100
0
50
100
150
200
250
300
Willow height [cm]
Willow height distribution
Inside exclosure
Outside exclosure
Density
0.000
0.005
0.010
0.015
0
100
200
300
Willow height [cm]

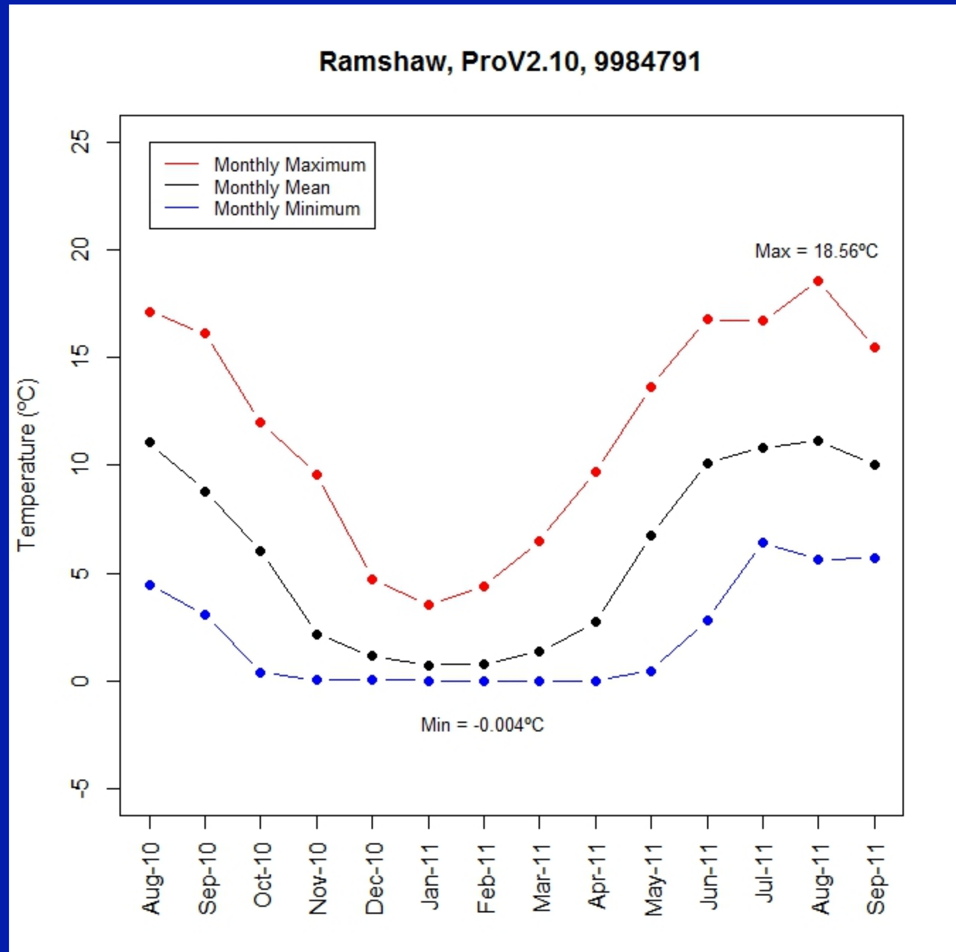

Mulkey (2837 M)
Temperature deviation from average (max) [°C]
4
2
0
-2
-4
grass
sedge
willow
Max temperature lower w/willows
Temperature deviation from average (min) [°C]
Minimum temperature higher w/willows
Vegetation type
anova : p = 0.3
Solar exposition [%]
100
90
80
70
60
in
out
Exclosure
anova : p = 0.013
Solar radiation higher/shading lower outside cattle exclosure


Mulkey Meadow Probe Locations
Legend
ProV2
Tidbits
Mulkey Creek
Trail
Electric Fence Enclosure
Spring
Note: Stream flows from east to west
0
180
360
720 Meters
N
W
E
S
B
Solar exposition [%]
inside
outside
Exclosure type
t-test : p = 0.021
C
Distance between two willows [m]
inside
outside
Exclosure type
t-test, p < 0.001 [***]
D
Willow height [cm]
inside
outside
Exclosure type
t-test, p < 0.001 [***]


A
Maximal temperature [°C]
35
30
25
20
15
10
5
99%
95%
50%
5
10
15
20
25
Median mean temperature over 7 days [°C]
B
Expected maximal temperature [°C]
40
35
30
25
20
Current
+ 1°C
+ 3.7°C
+ 5.6°C
Scenarios

Some stream sections exceed 20°C >55 days

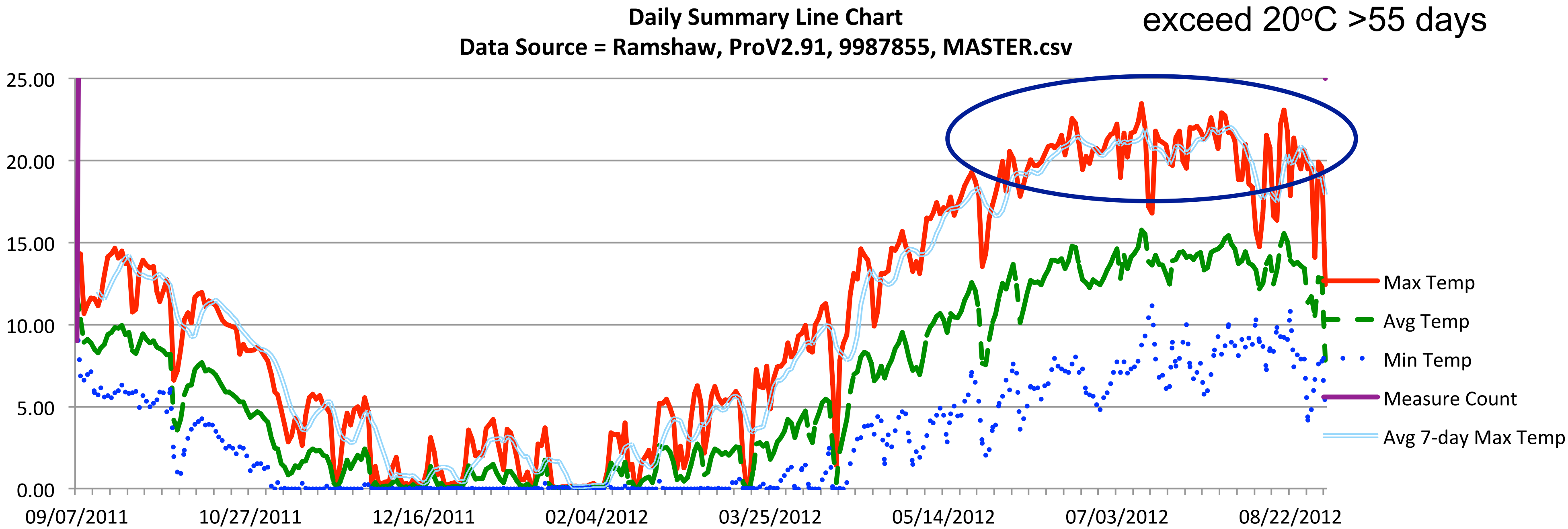




Ramshaw meadow recovering stream areas, water temperatures did not exceed 19°C

Average 7 Day Max Temperature

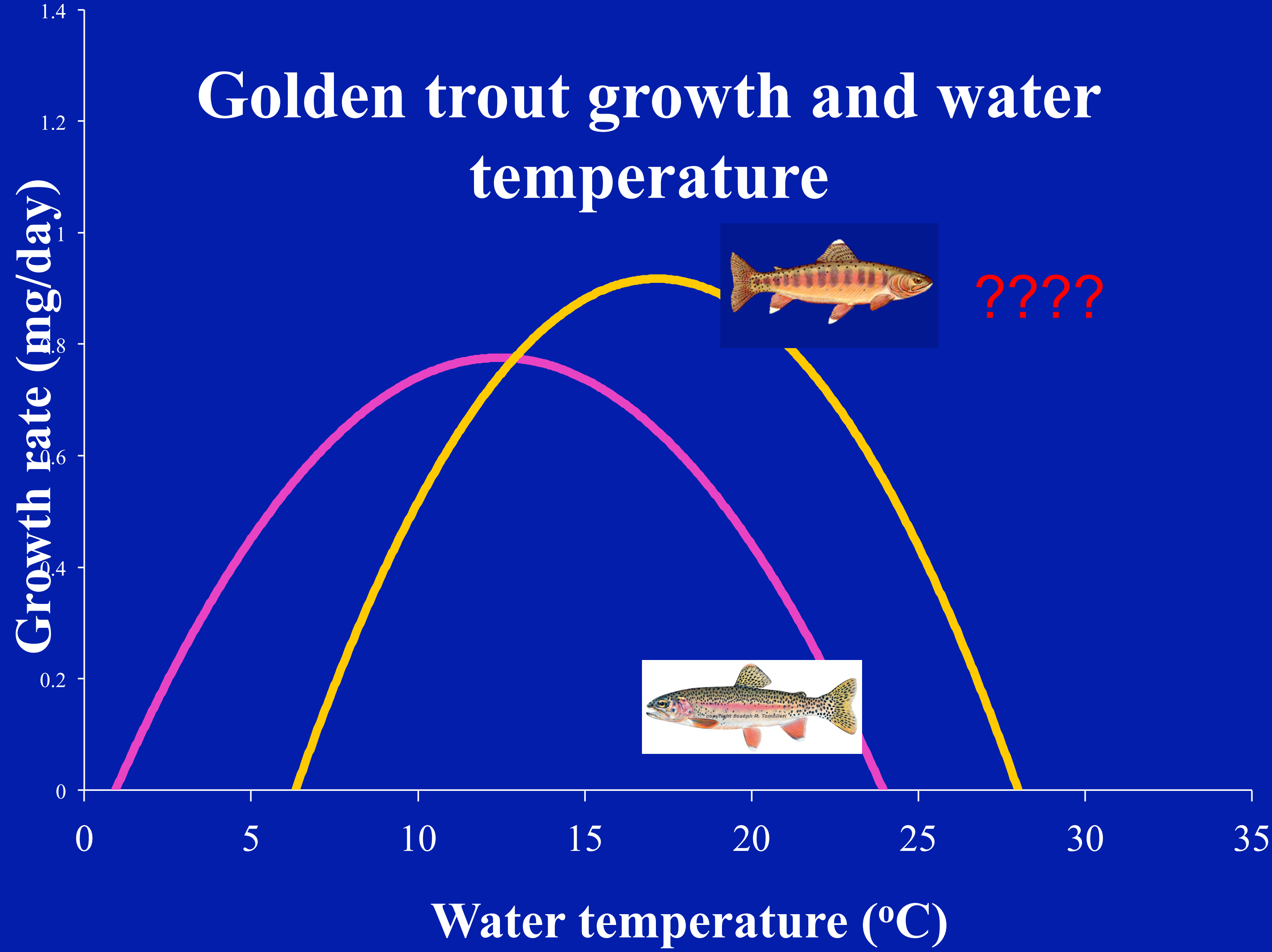
Some stream sections exceed 20°C >55 days



What is thermally "suitable habitat" for golden trout?

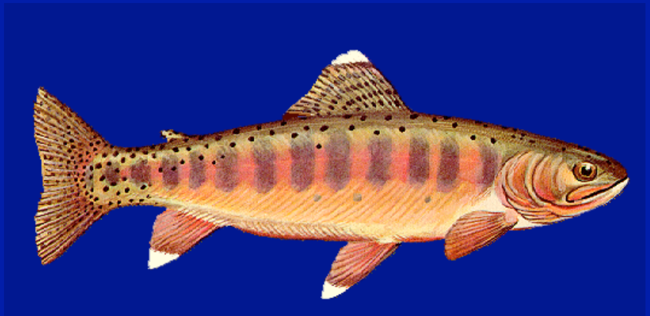
- For most trout, upper tolerance is 20-24^{o}C
- Nothing is known regarding temperature tolerances for golden trout

Golden trout growth and water temperature



Is CGT stream habitat resilient to climate warming?

- No! None of the streams withstand increased warming
- Interim thresholds for conservation??
- Restoration should prioritize keeping streams cool



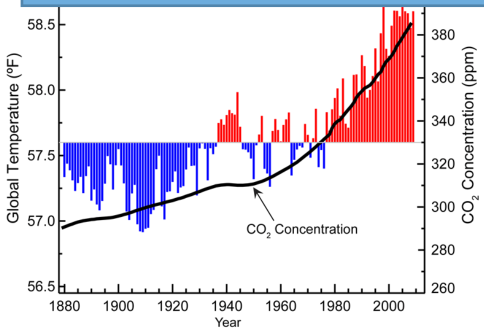
Can Golden Trout handle both stressors??

Climate change

Warmer temperature & reduced snowpack predicted to increase water temperatures

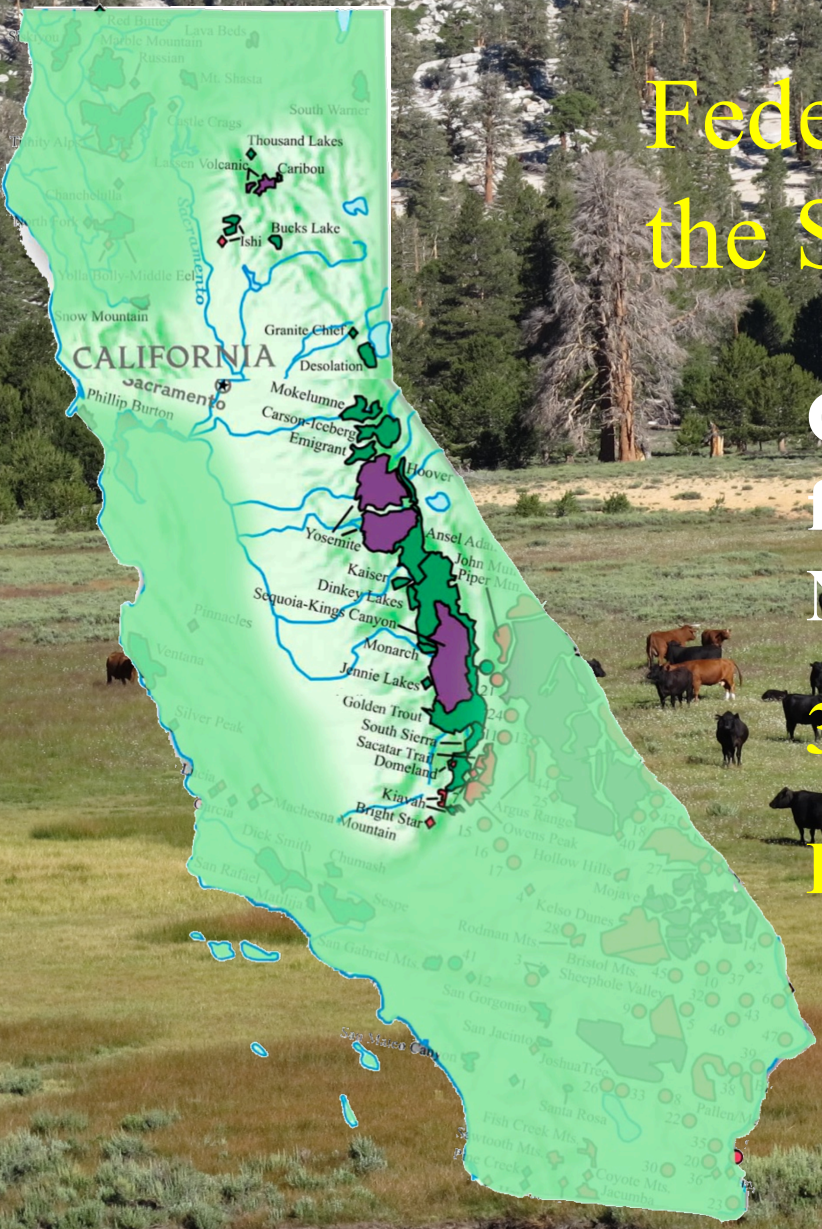
Cattle grazing

Reduced streamside vegetation and widened streams have led to increased water temperatures



???

Federal Wilderness in the Sierra Nevada



Of the 12 million acres of federal land in the Sierra Nevada

3.7 million acres (30 %) are

Designated Wilderness

Wilderness Act of 1964

"An area of wilderness is further defined…to mean an area of Federal land retaining its primeval character and influence…which is generally protected and managed to preserve its natural conditions and which generally appears to have been affected primarily by forces of nature, with the imprints of man's work substantially unnoticeable"

WILDERNESS 50 years 1964–2014 YOURS: TO ENJOY TO PROTECT

The American Legacy of Wilderness

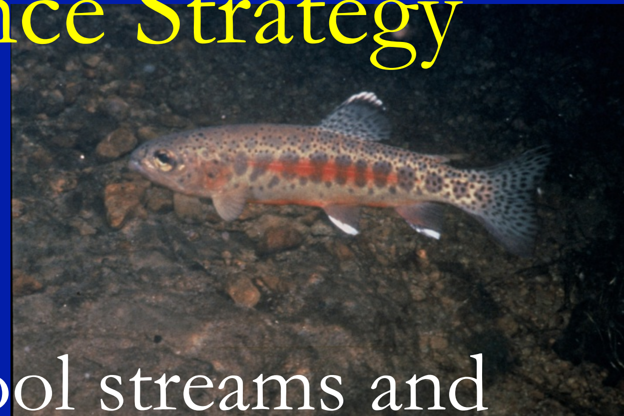
Honoring 50 Years of Preservation, Use, and Enjoyment

Beschta et al. 2013 Environmental Management article on Grazing and Climate Change

"Removing or reducing livestock across large areas of public land would alleviate a widely recognized and long-term stressor and make these lands less susceptible to the effects of climate change."

"we recommend removing livestock …from national parks, monuments, wilderness areas, and wildlife refuges wherever possible…"

California Golden Trout Resilience Strategy



- Focus on management actions that cool streams and increase resiliency—restoration
- Set aside refuges or reference sites in Wilderness– areas that minimize or eliminate activities such as grazing that render stream habitats less resilient to increased warming
- Open question—Can we have resilient salmonid streams and cattle grazing??

Funded by: USDA Forest Service Pacific Southwest Research Station, National Fish & Wildlife and the Sierra Pacific Flyfishers