Plenary Session

34th Annual Salmonid Restoration Conference
held in Fortuna, CA from April 6-9, 2016.

Session Overview

- Master of Ceremonies:
  - Thomas Williams, NOAA Fisheries, Southwest Fisheries Science Center

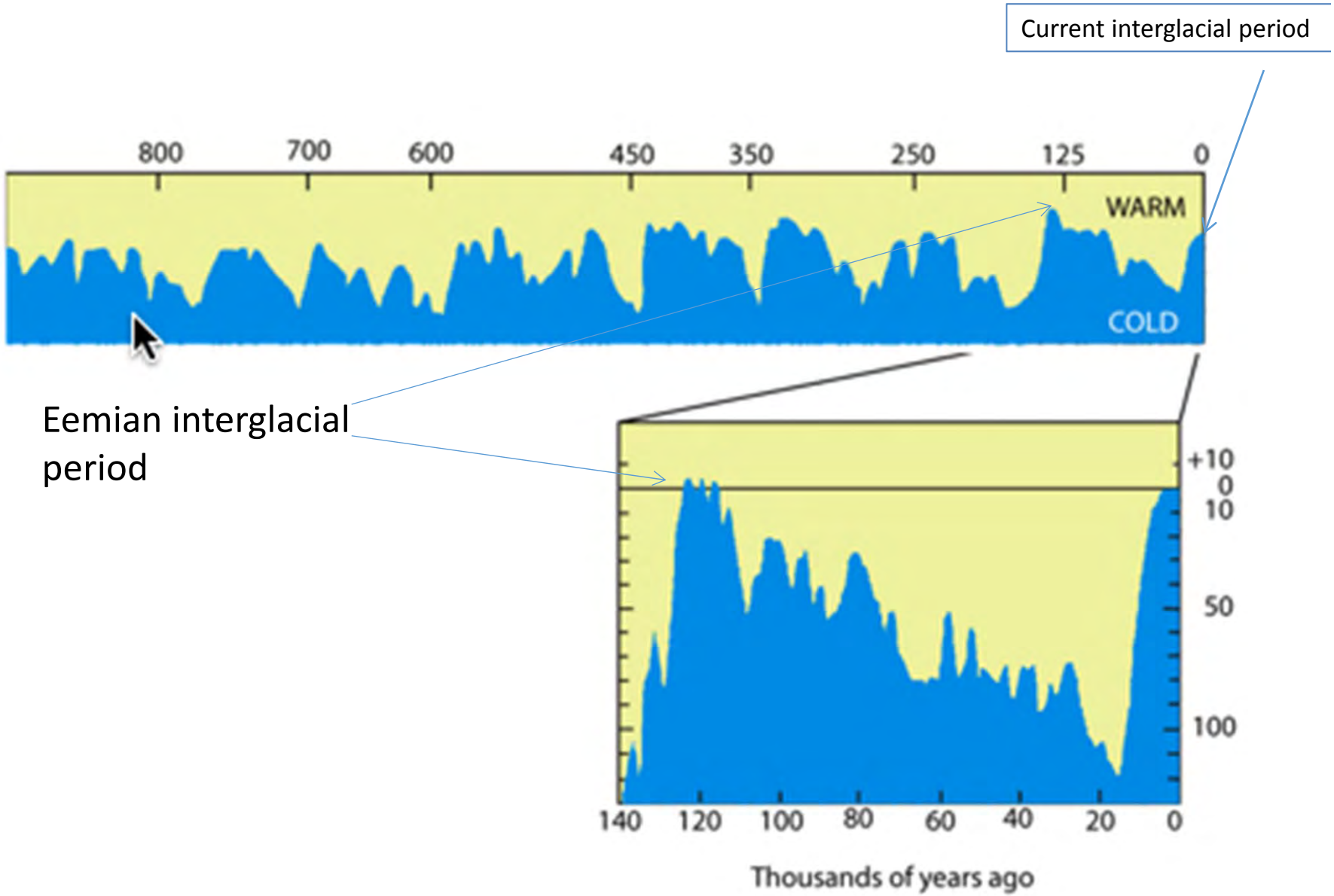
Presentations

(Slide 4) Homage to the Interface: Coastal Deltas, Estuaries, & Floodplains
Michael Furniss, MJ Furniss & Associates

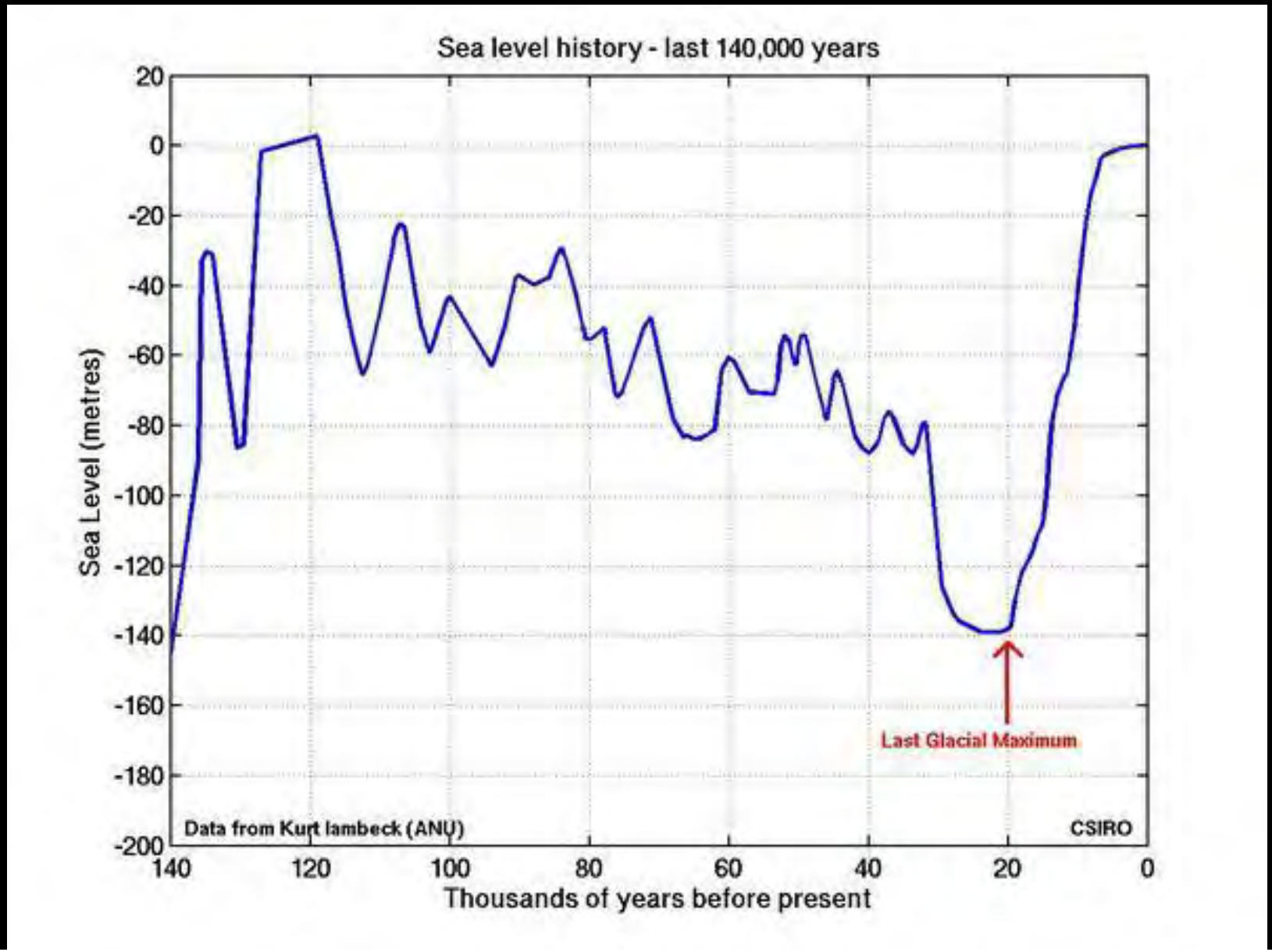
(Slide 17) Drought, Floods, and Alternate States of Algal-Based Food Webs in the Thirsty Eel
Mary Power, UC Berkeley

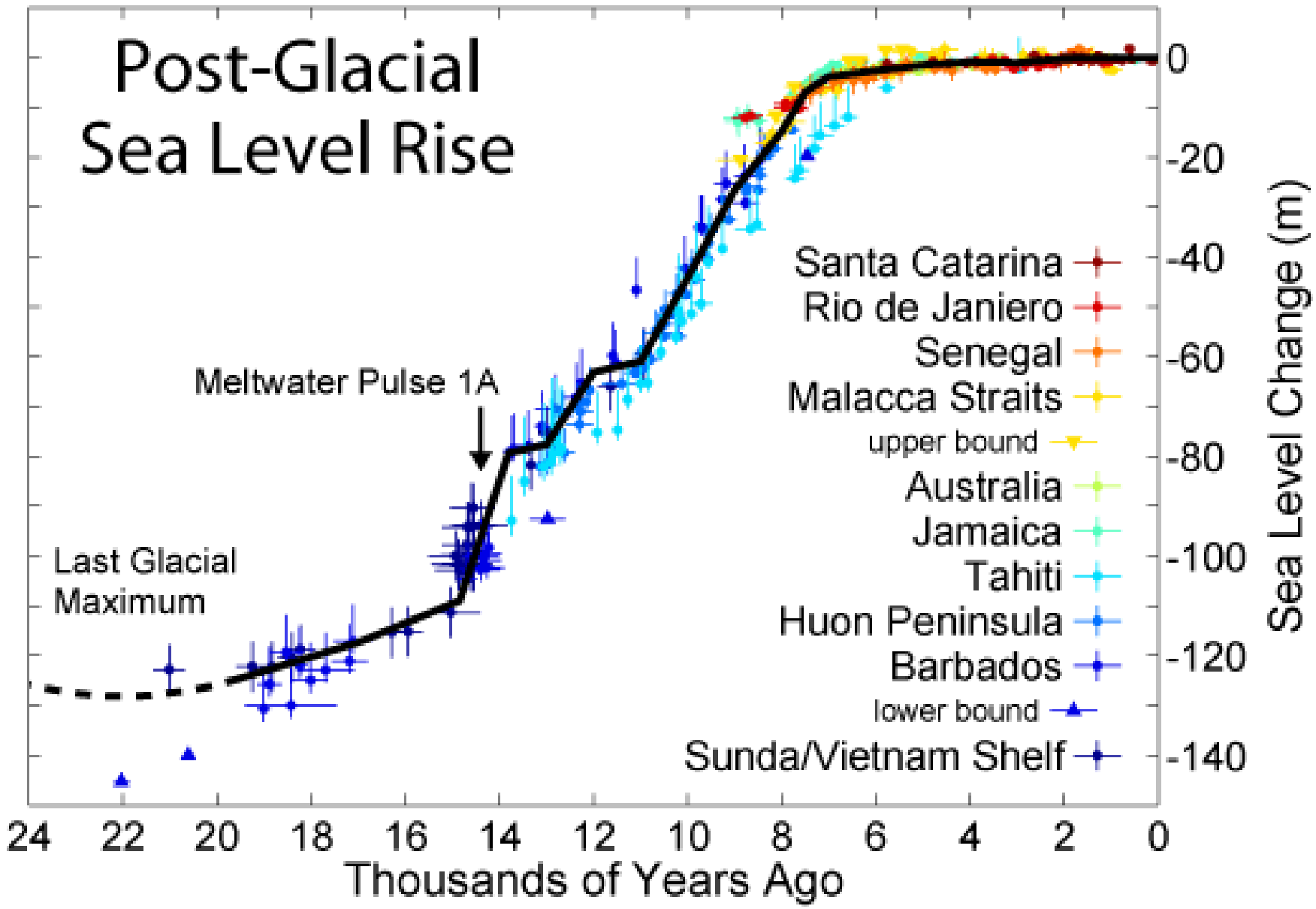
(Slide 4) Ridges to River—Ecological Restoration
Merv George, Jr., Six Rivers National Forest, U.S. Forest Service
*presentation not included

(Slide 79) Climate Change, Drought, and the Future of California Salmonids
Peter B. Moyle, Center for Watershed Sciences and Department of Wildlife, Fish and Conservation Biology, UC Davis

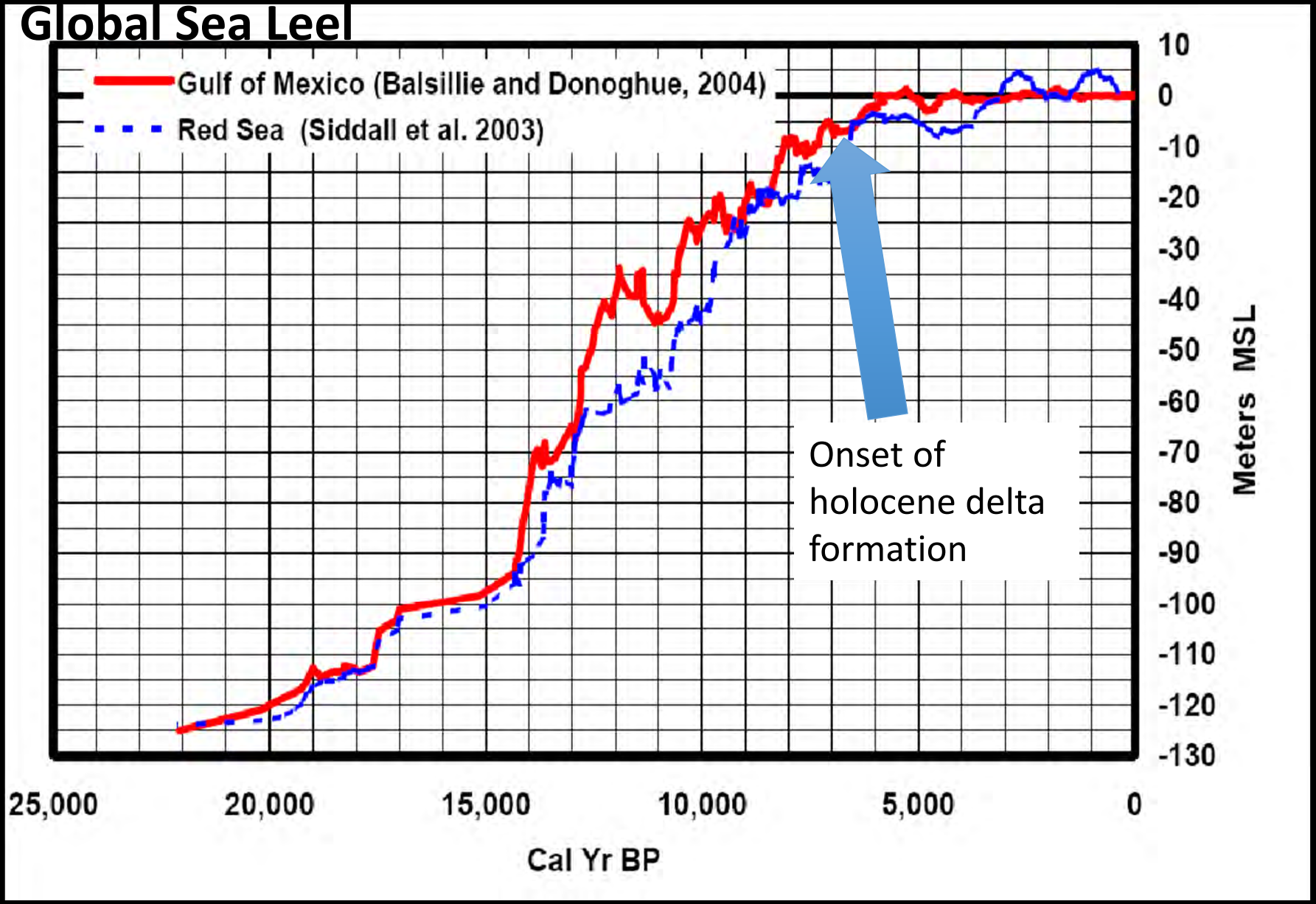

Current interglacial period
800
700
600
450
350
250
125
0
WARM
COLD
Eemian interglacial period
+10
0
10
50
100
140
120
100
80
60
40
20
0
Thousands of years ago

Sea Level History in the Last 140,000 years



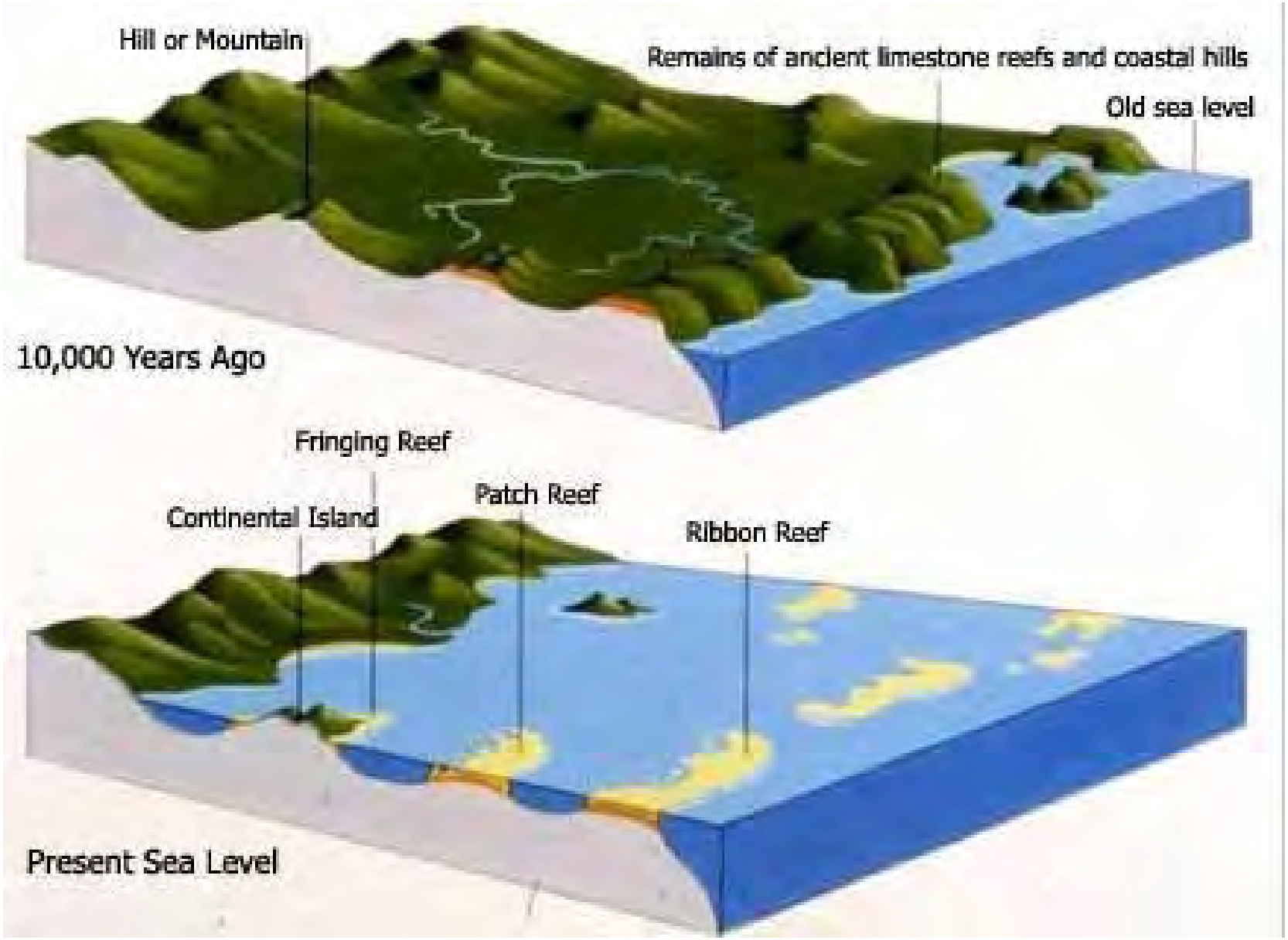

Post-Glacial
Sea Level Rise
Meltwater Pulse 1A
Last Glacial
Maximum
Santa Catarina
Rio de Janiero
Senegal
Malacca Straits
upper bound
Australia
Jamaica
Tahiti
Huon Peninsula
Barbados
lower bound
Sunda/Vietnam Shelf
0
-20
-40
-60
-80
-100
-120
-140
Sea Level Change (m)
24
22
20
18
16
14
12
10
8
6
4
2
0
Thousands of Years Ago

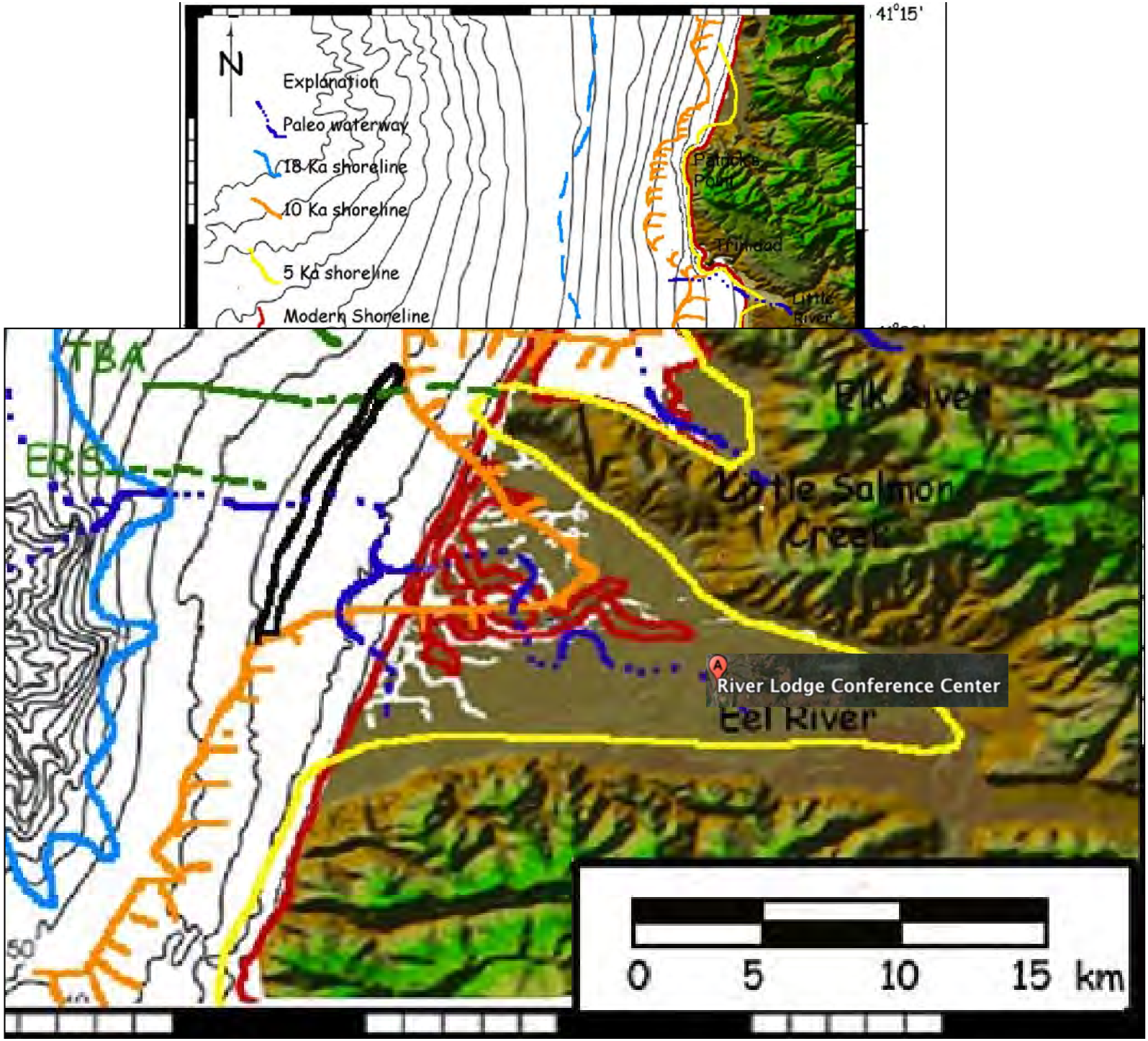
Global Sea Leel



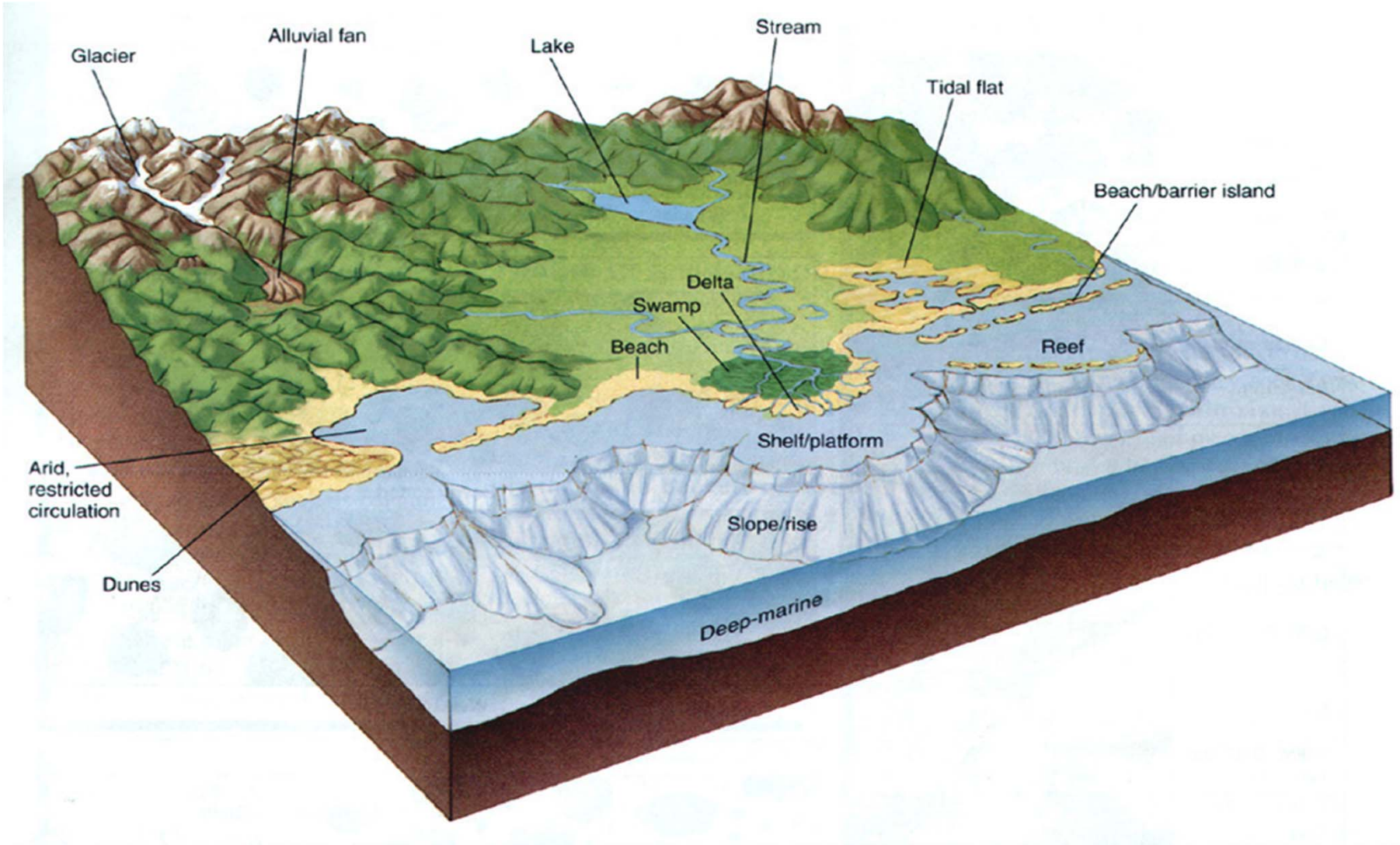
V. Burkett - MJFurniss

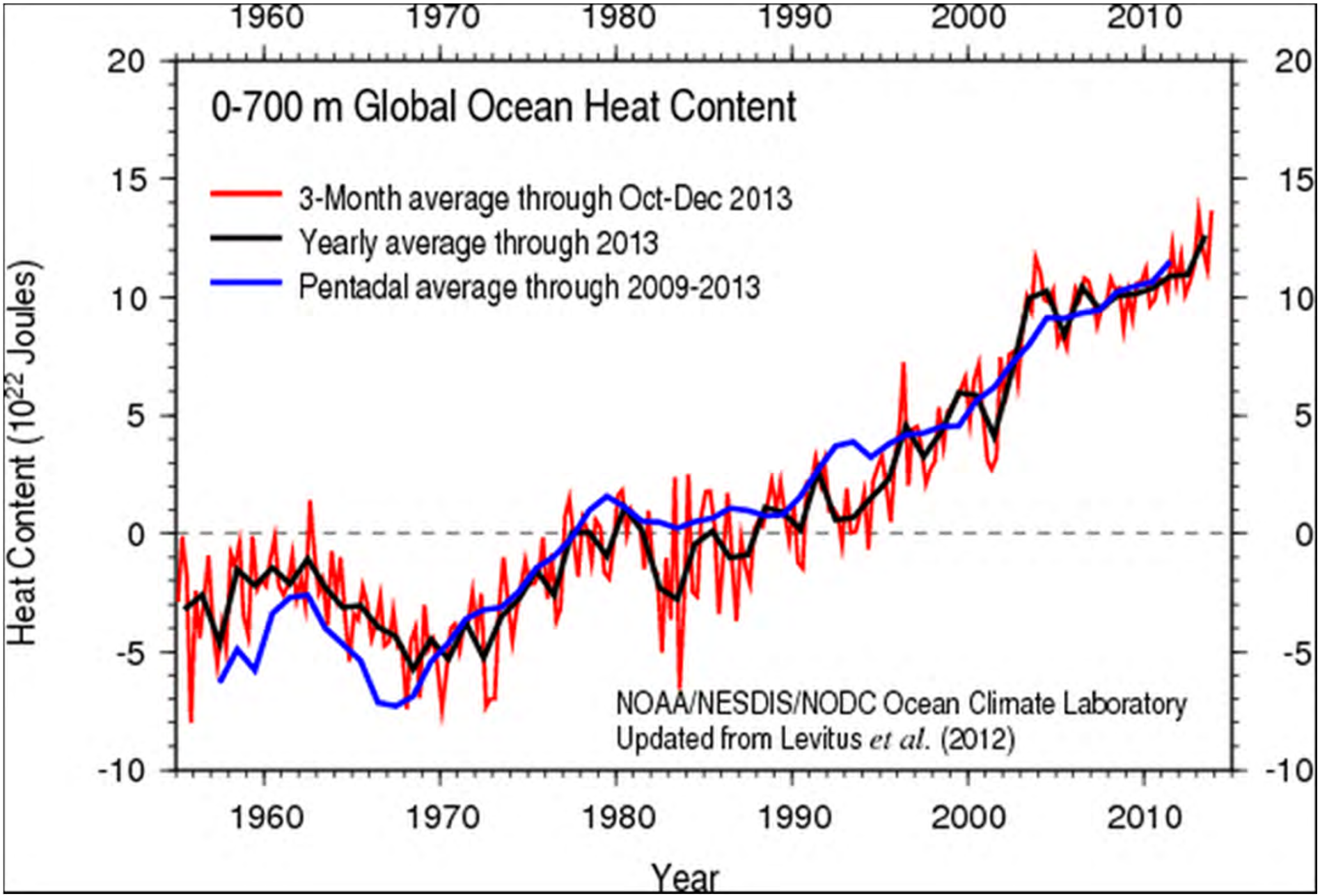
High and Low Sea Level "stands"

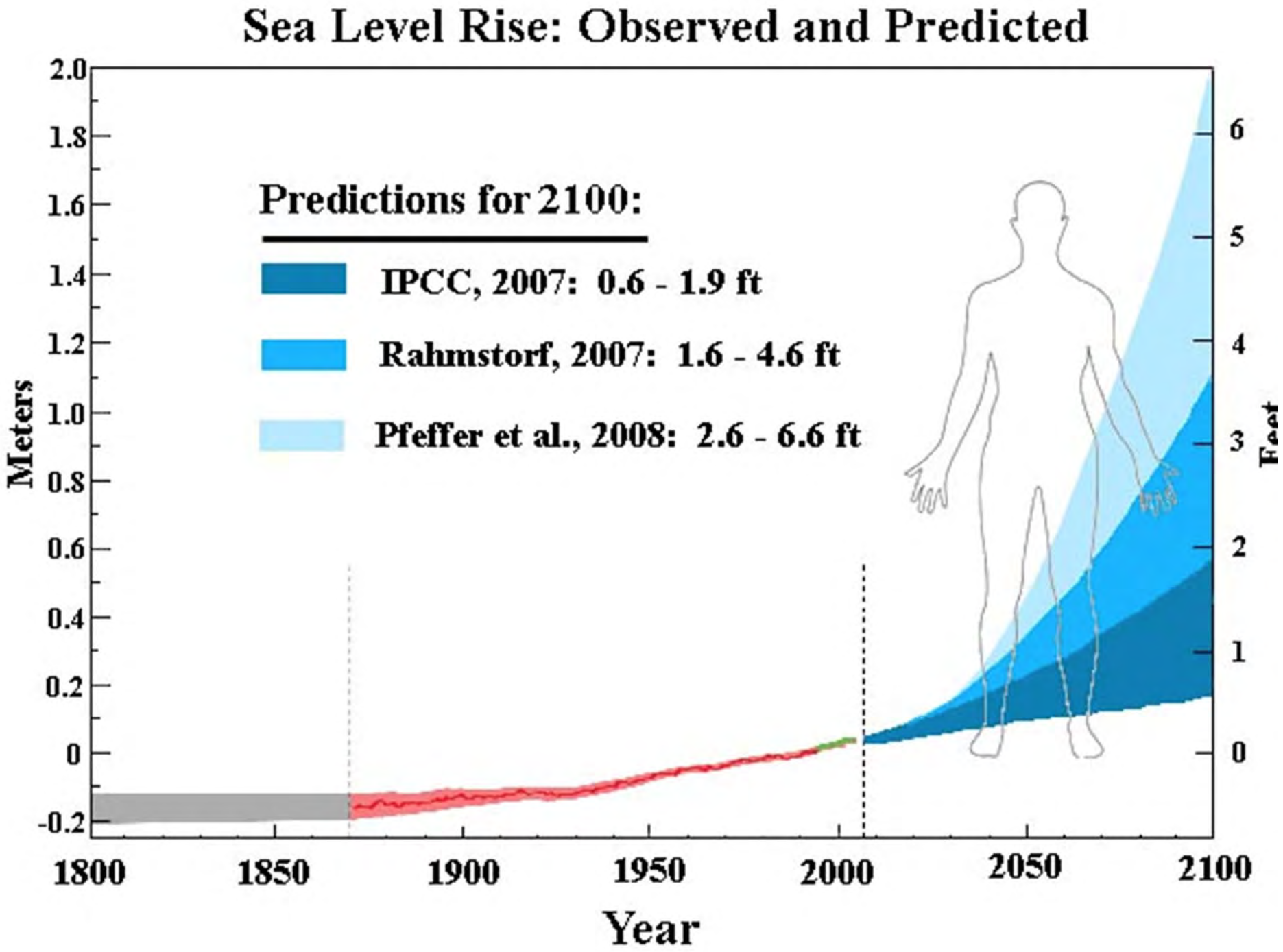


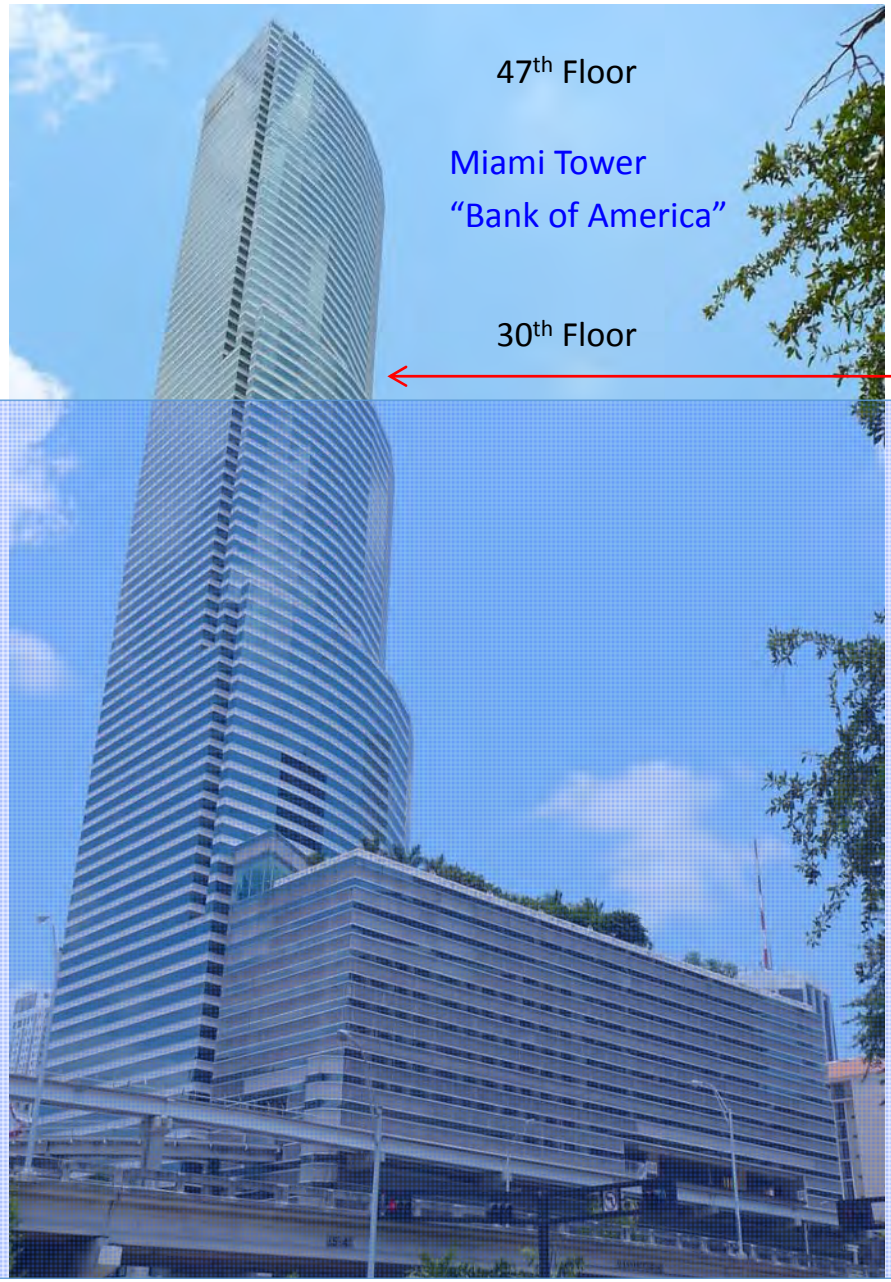

41°15'
N
Explanation
Paleo waterway
18 Ka shoreline
10 Ka shoreline
5 Ka shoreline
Modern Shoreline
Patricks Point
Trinidad
Little River
TBA
ERS
Elk River
Little Salmon Creek
River Lodge Conference Center
Eel River
0
5
10
15 km

Coastal depositional features form best during a stable sea level

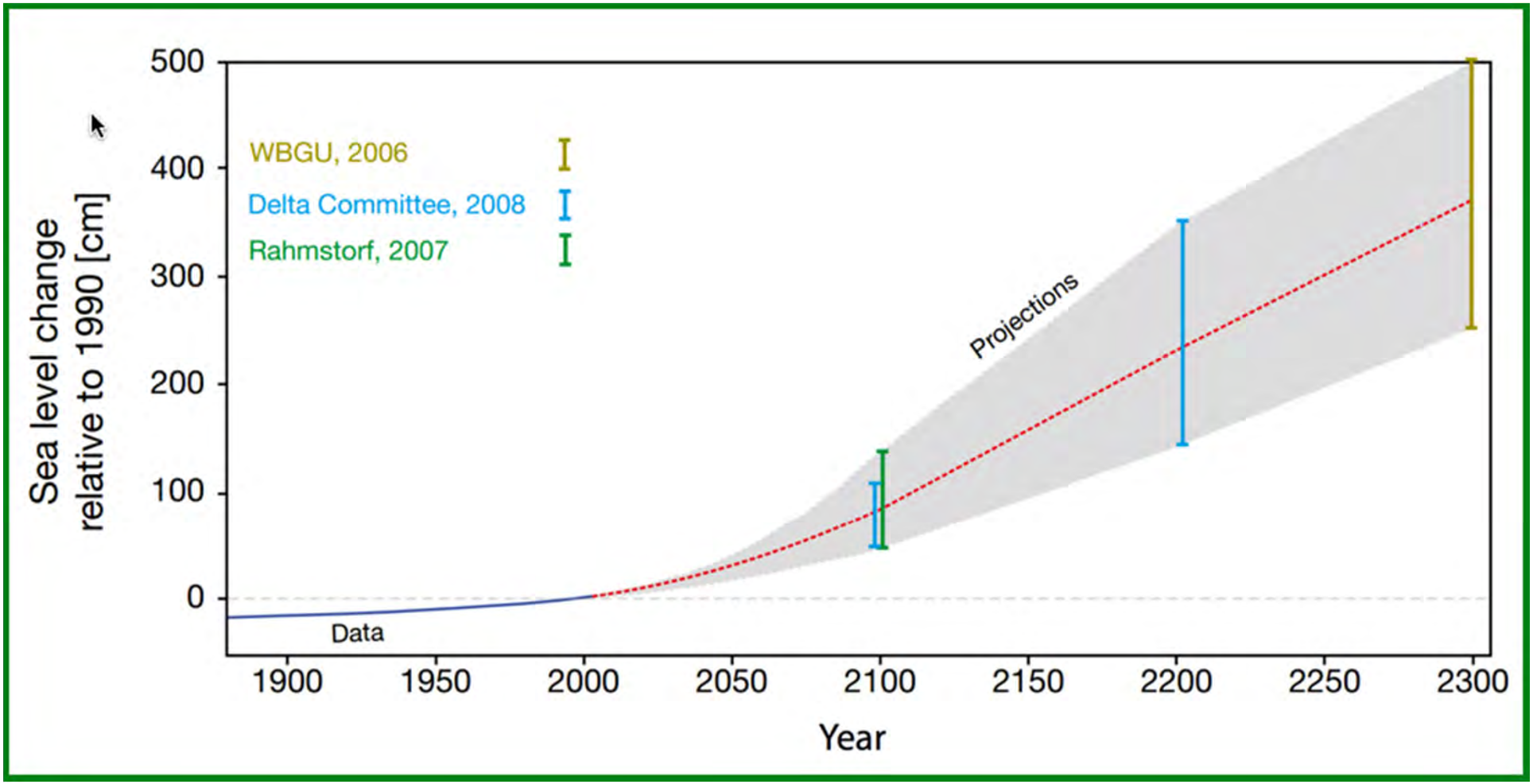



0-700 m Global Ocean Heat Content
3-Month average through Oct-Dec 2013
Yearly average through 2013
Pentadal average through 2009-2013
NOAA/NESDIS/NODC Ocean Climate Laboratory
Updated from Levitus et al. (2012)
Heat Content (10^{22} Joules)
Year
1960
1970
1980
1990
2000
2010
20
15
10
5
0
-5
-10


Sea Level Rise: Observed and Predicted
Predictions for 2100:
IPCC, 2007: 0.6 - 1.9 ft
Rahmstorf, 2007: 1.6 - 4.6 ft
Pfeffer et al., 2008: 2.6 - 6.6 ft
Meters
Feet
Year
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
-0.2
6
5
4
3
2
1
0
1800
1850
1900
1950
2000
2050
2100

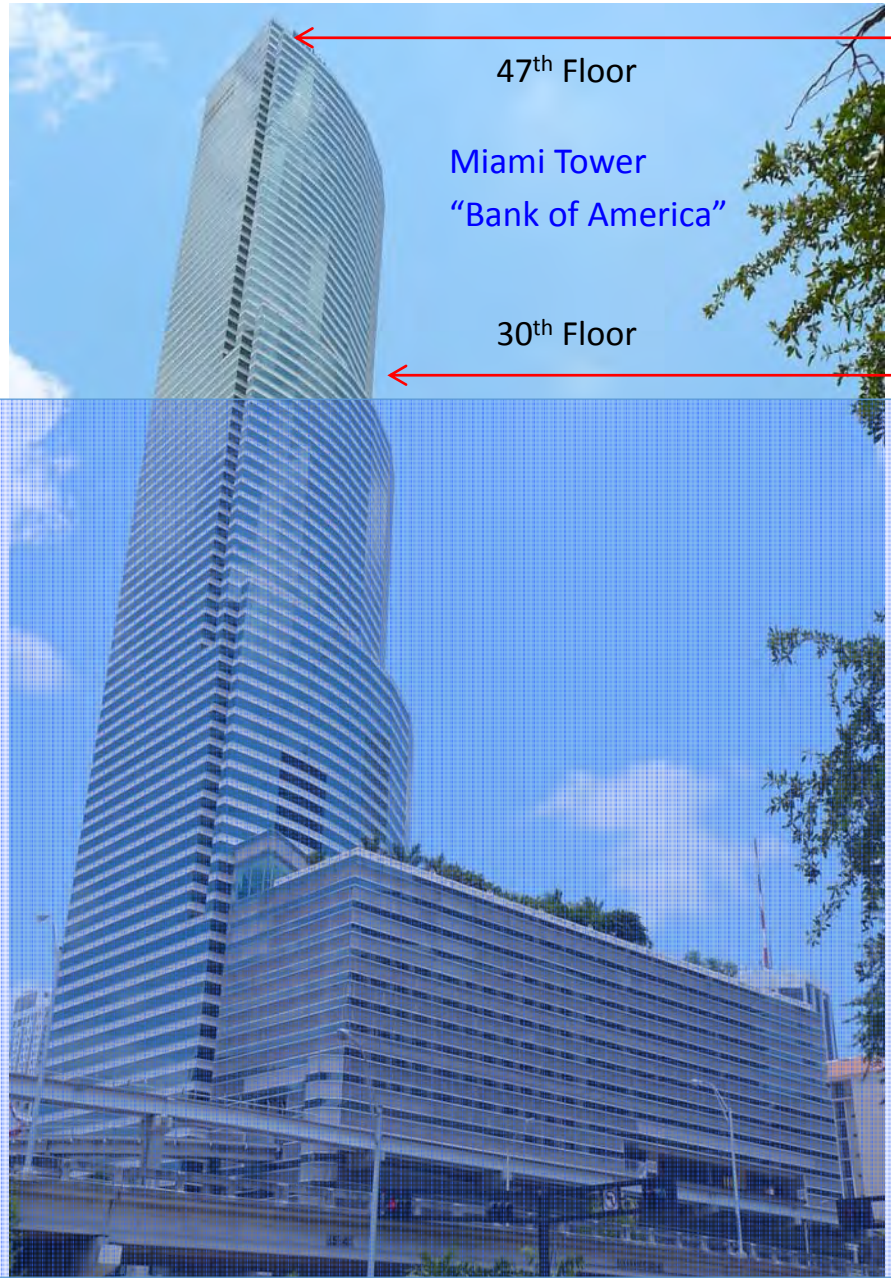

47th Floor
Miami Tower
"Bank of America"
30th Floor
Present Sea Level
390 ft (120 m)
20,000 years ago
Last Ice Age

Sea Level Rise beyond 2100



Greenland 7m SLE

Antarctica 57m SLE



When all ice melts

212 ft (65 m)

Present Sea Level

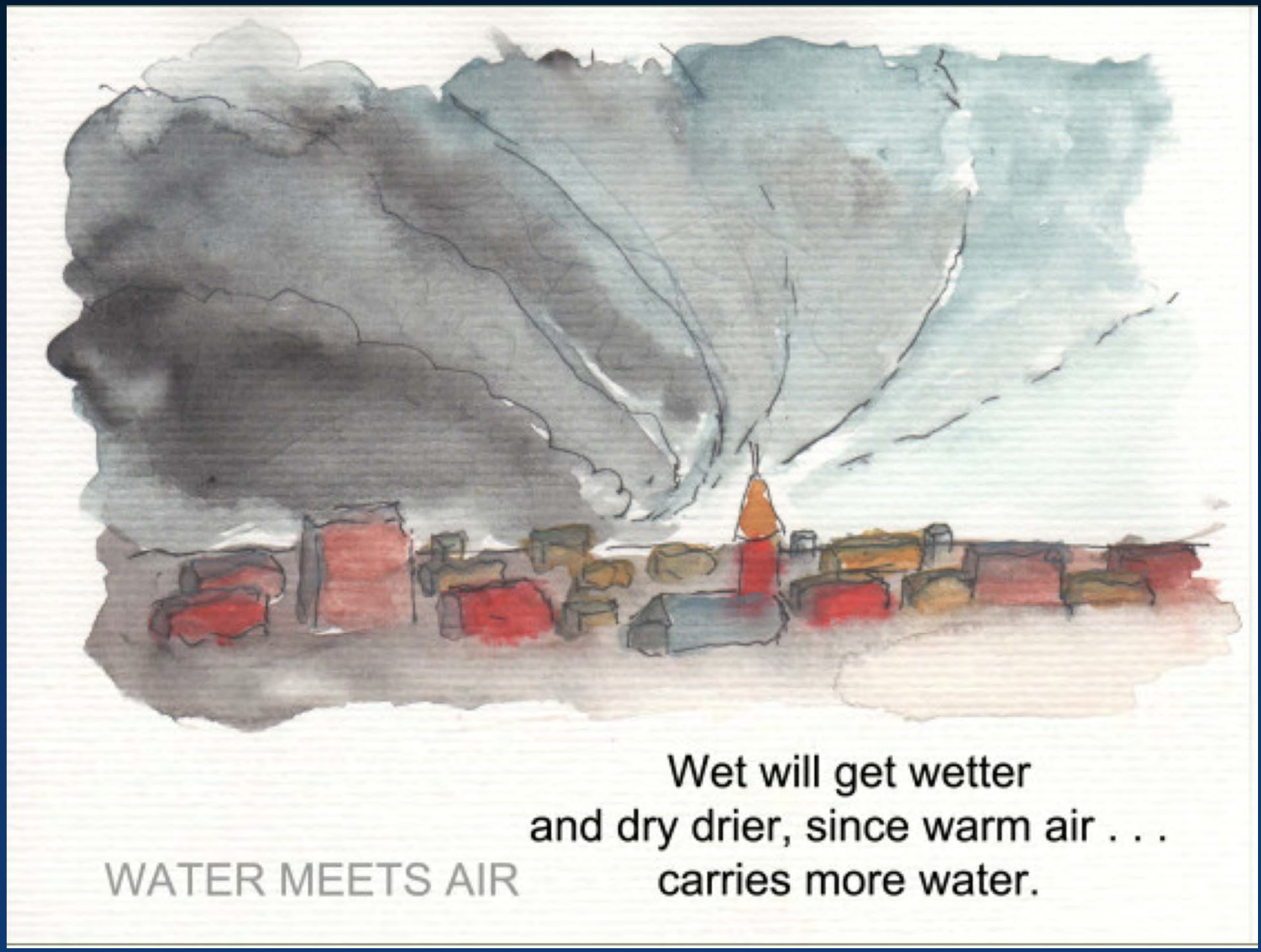
390 ft (120 m)

20,000 years ago

Last Ice Age

DROUGHT, FLOODS AND ALTERNATE STATES IN ALGAL-BASED RIVER FOOD WEBS: THE THIRSTY EEL

Salmon Restoration Federation Conference
Fortuna CA, April 8 2016
mepower@berkeley.edu
Angelo.berkeley.edu



http://daily.sightline.org/2013/12/16/the-entire-ipcc-report-in-19-illustrated-haiku/

Gregory C Johnson

California North Coast, considered a relatively water-rich region in California


Photo-Bill Trush

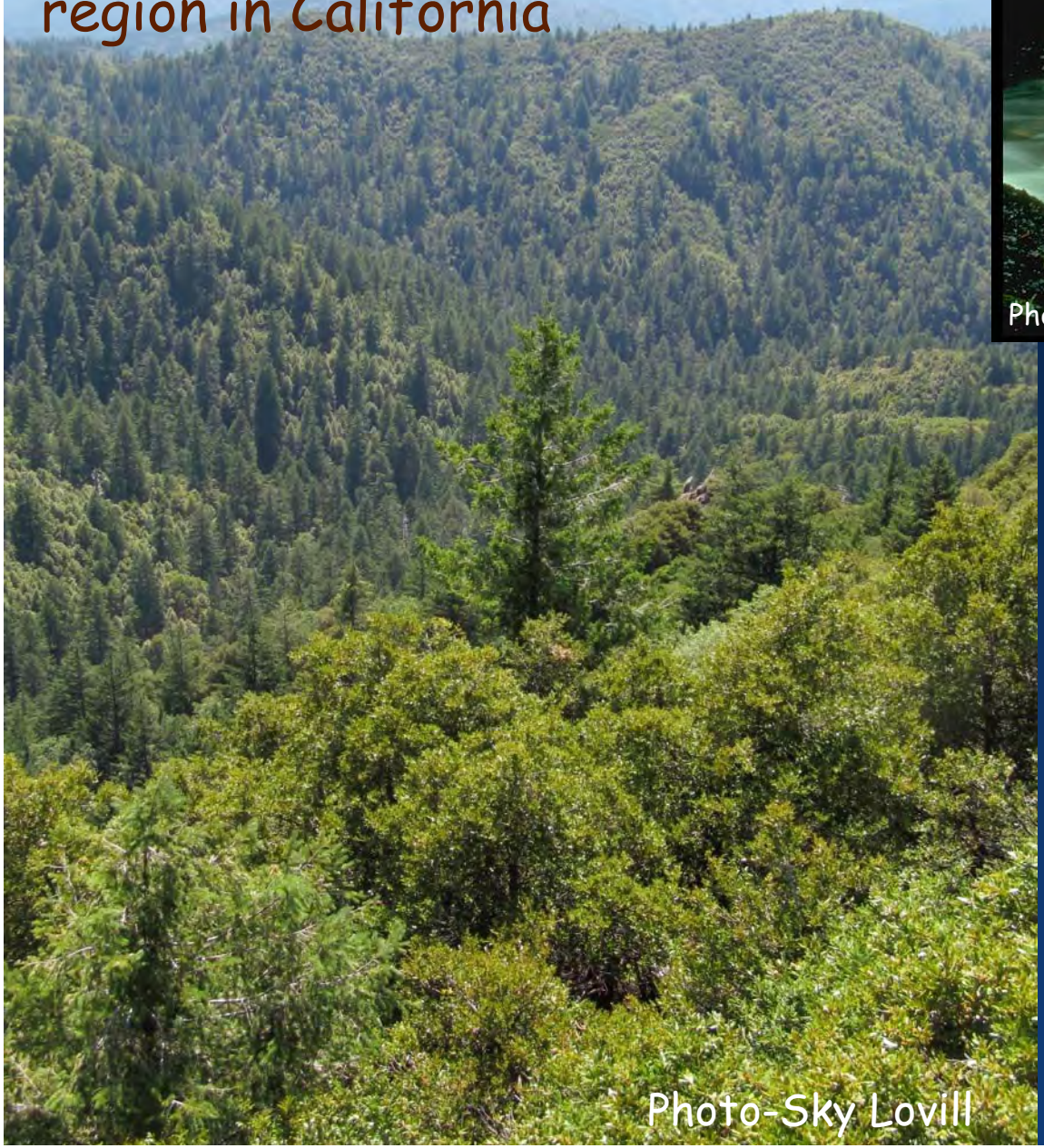
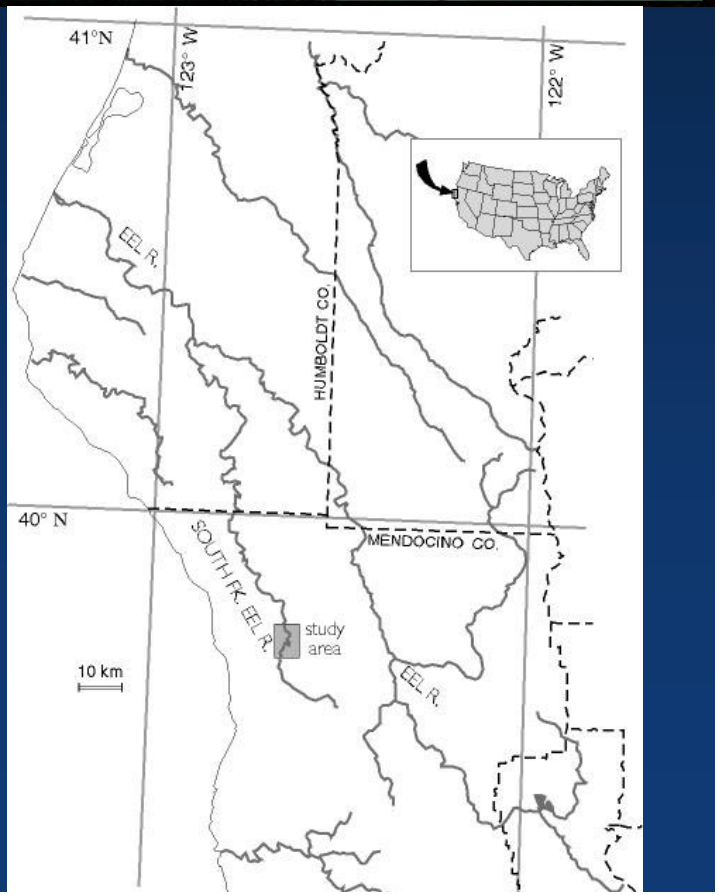
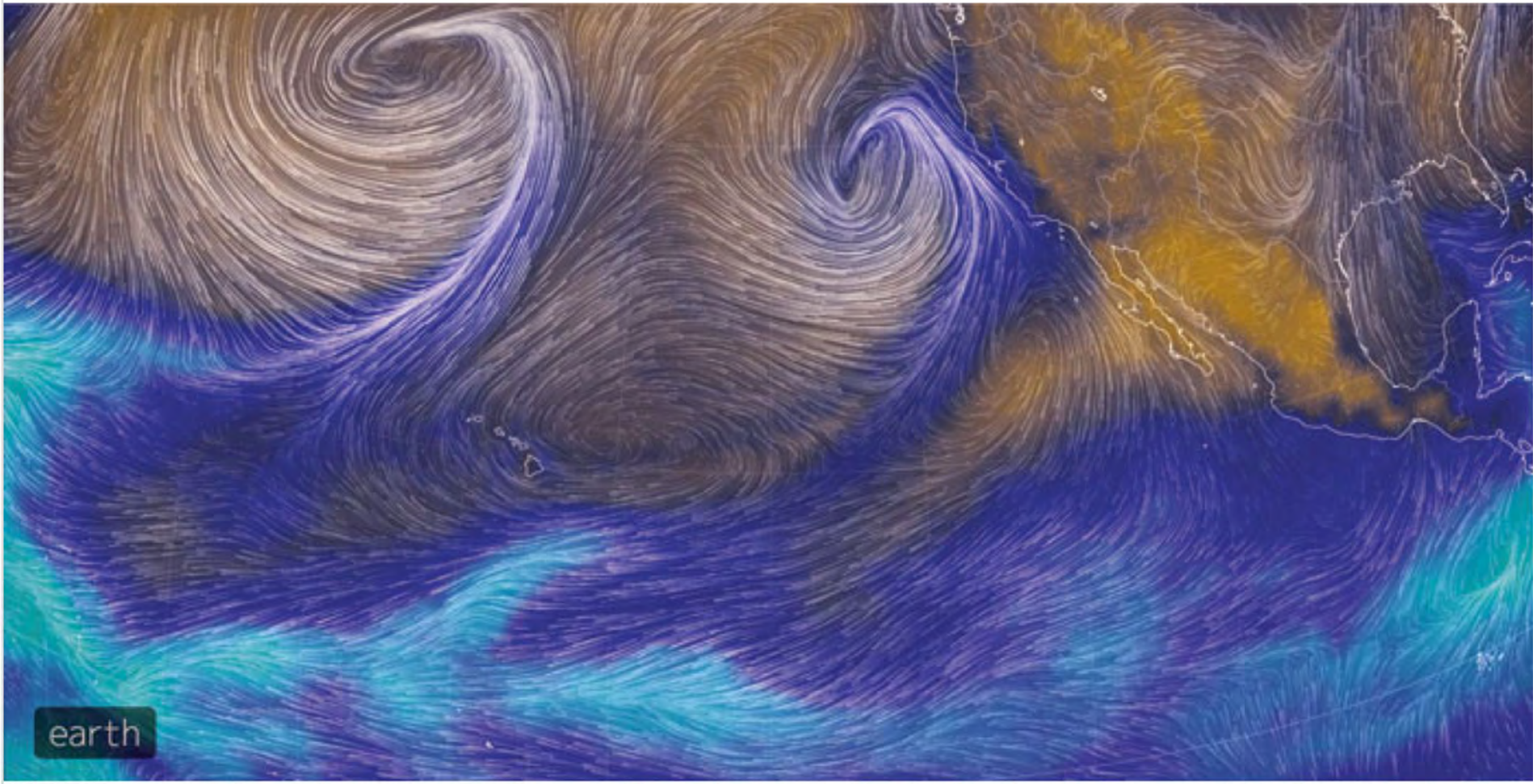


Photo-Sky Lovill



1964 Christmas Flood
Rio Dell Times archive

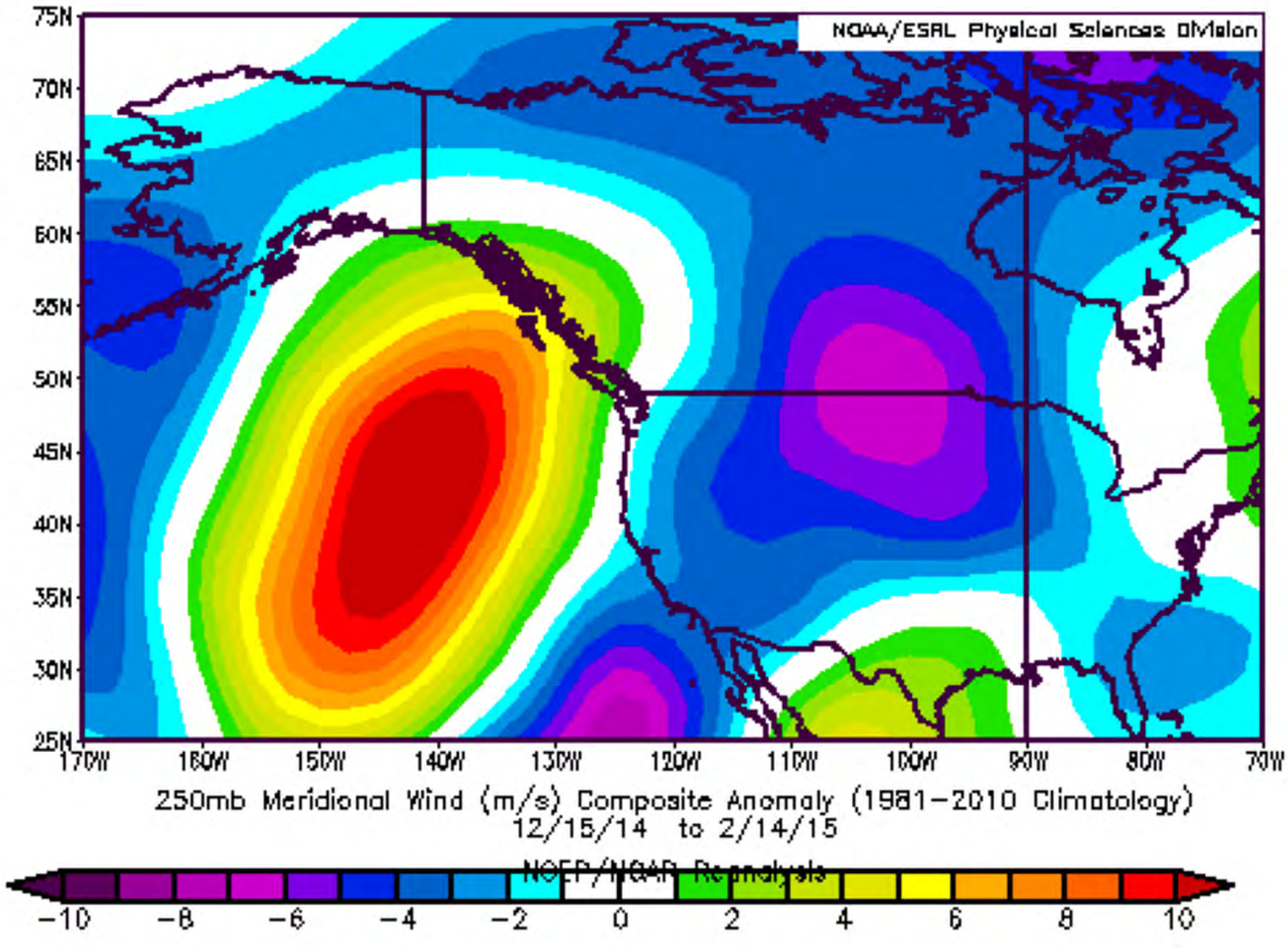
Atmospheric Rivers, aka "Pineapple Express"



An intense plume of atmospheric water vapor (blue-purple) stretches from the Hawaiian Islands northeast across the Pacific and splashes into the California coast on the morning of February 8, 2015, in this image from a visualization created with earth.nullschool.net

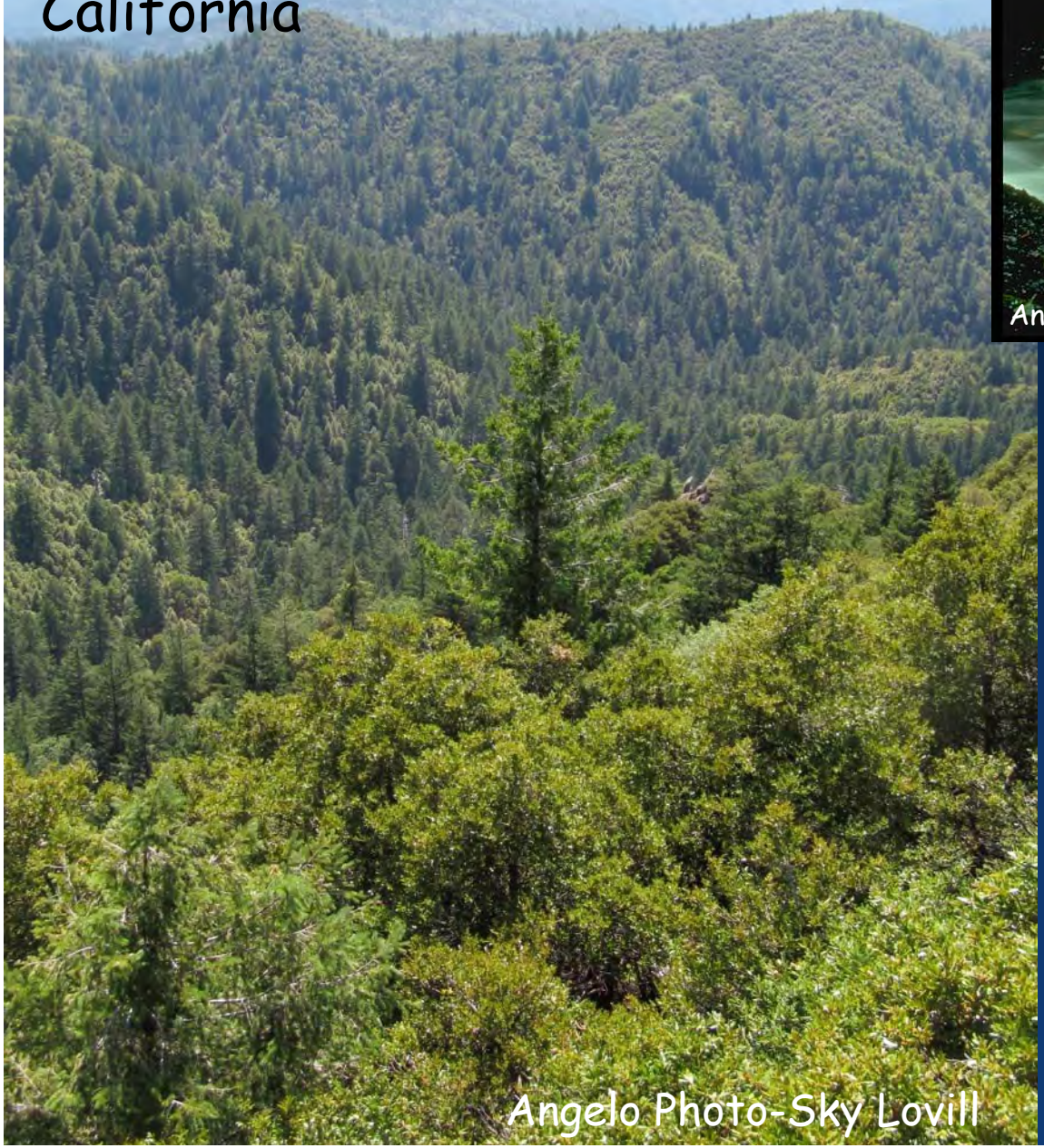
Rowntree, Les. 2015. *Bay Nature* magazine
https://baynature.org/wp-content/uploads/2015/06/Sky-River_final_ES.jpg

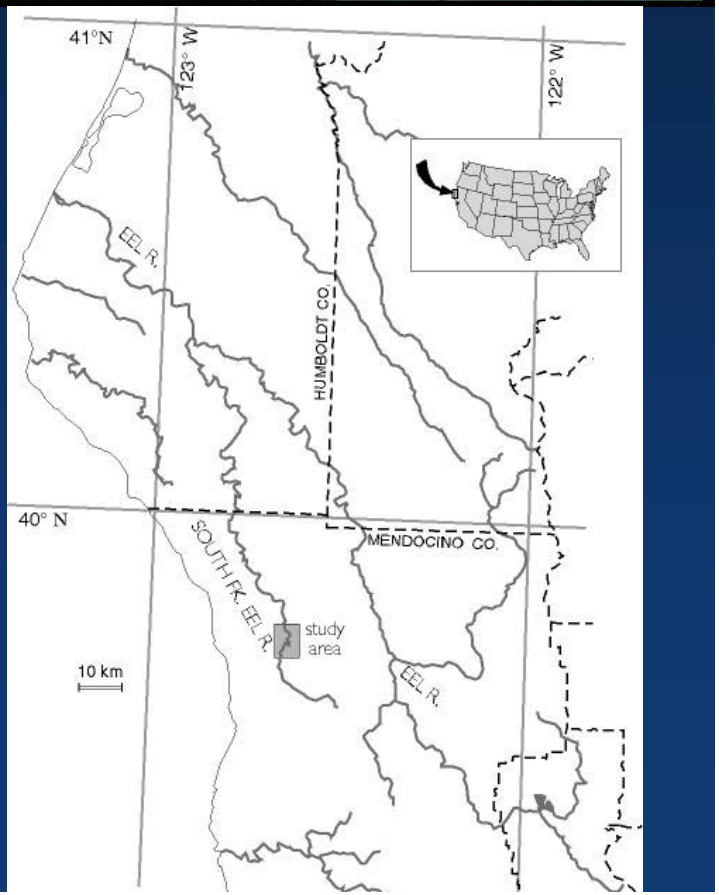
"Ridiculously Resistant Ridge"
http://www.weatherwest.com



California North Coast, considered a water-rich region in California


Angelo Photo-Bill Trush

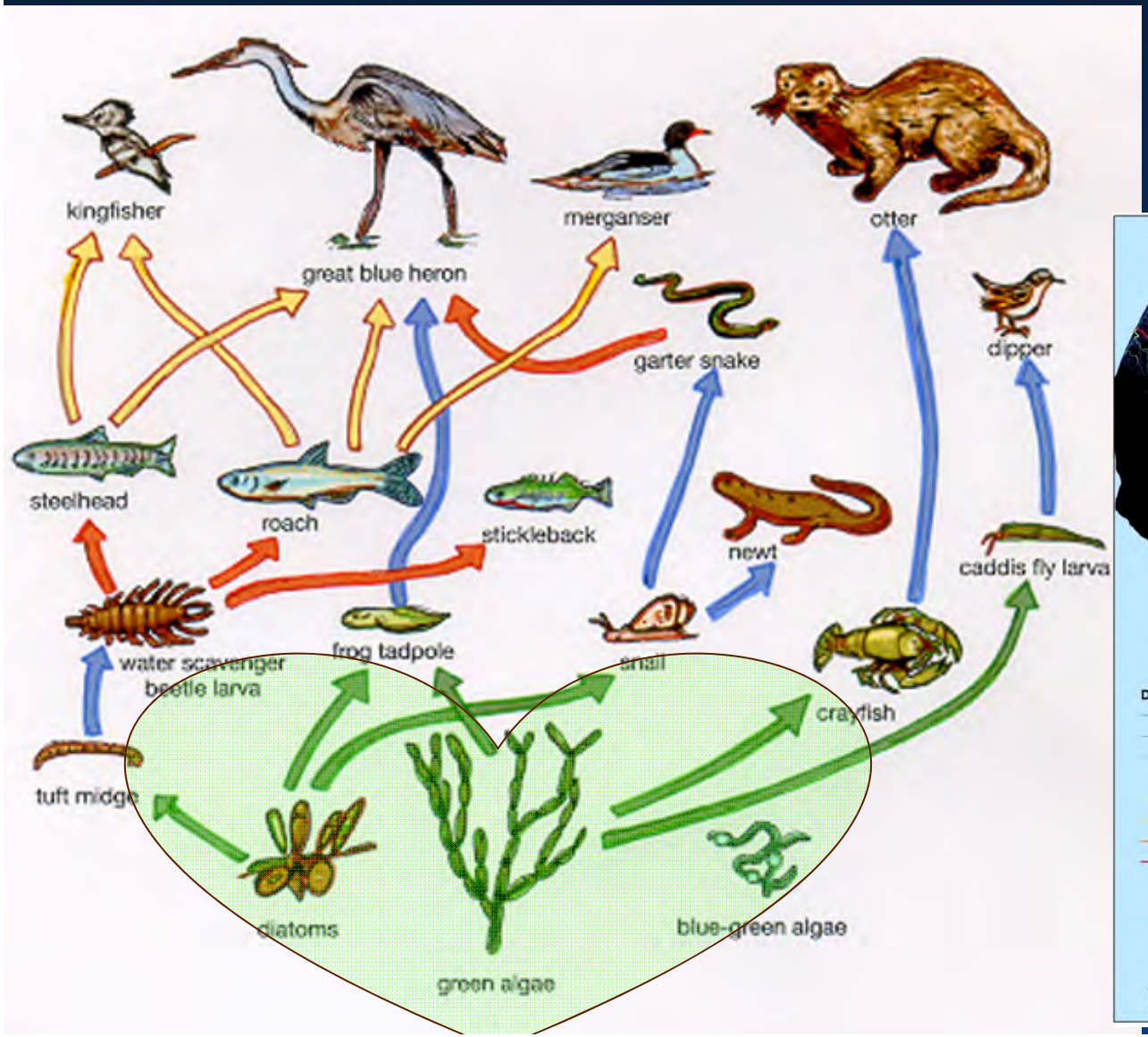

Angelo Photo-Sky Lovill

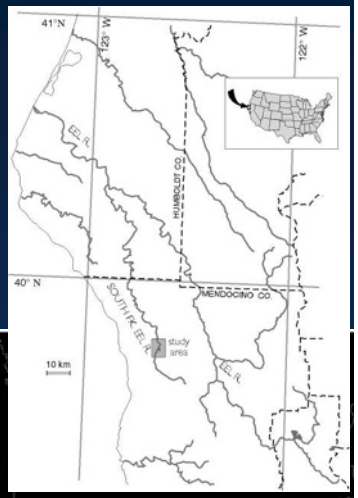


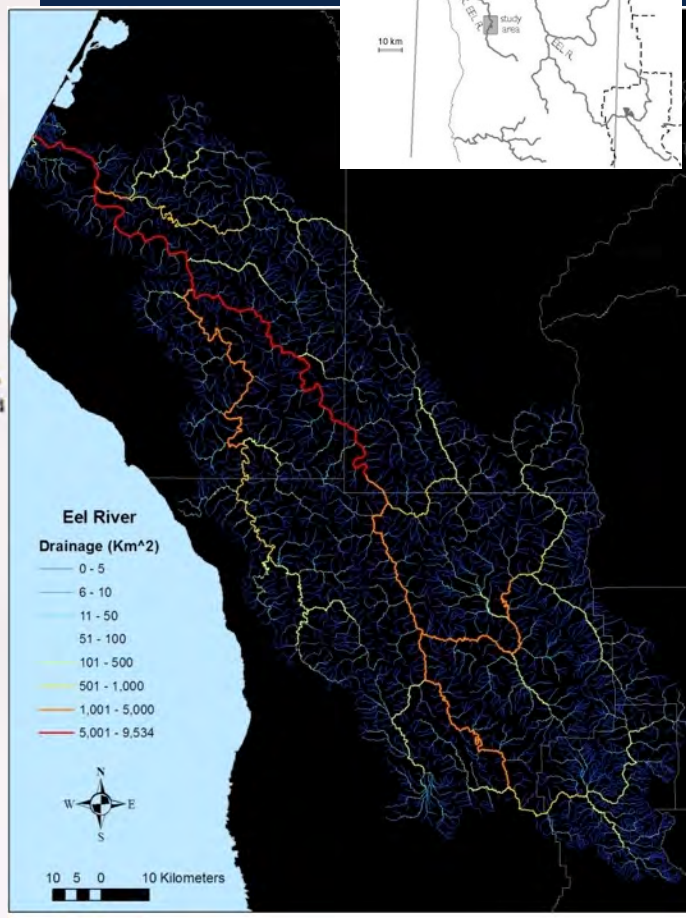
Water-starved Eel River goes to ground near Fortuna (Sept. 14, 2014 Press Democrat)

A pool of water between dry sections of the main stem of the Eel River at Fortuna. (KENT PORTER/ PD)

Consequences of drought or floods for river (and coastal) food webs?

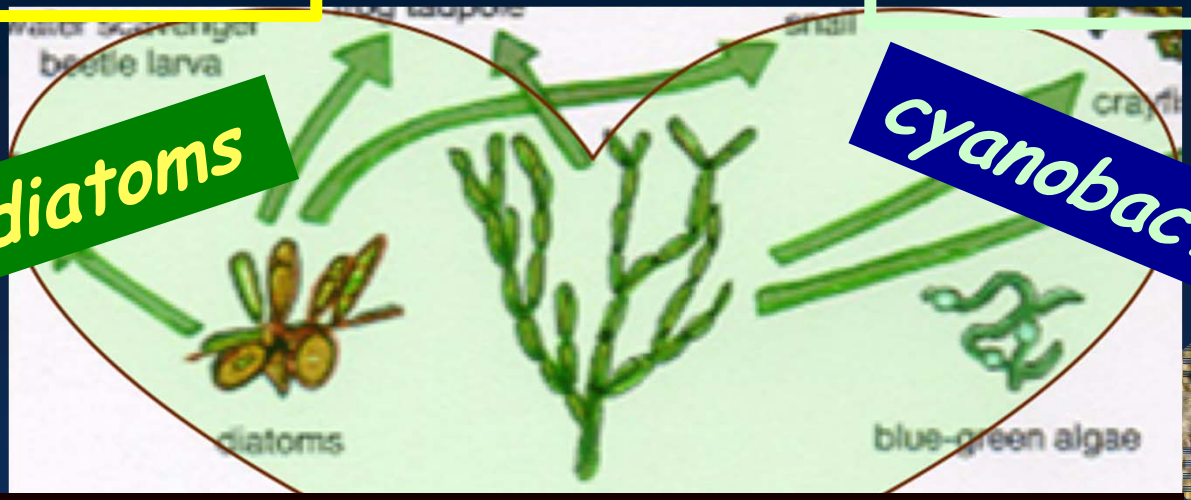






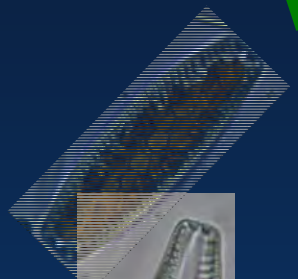
The Good

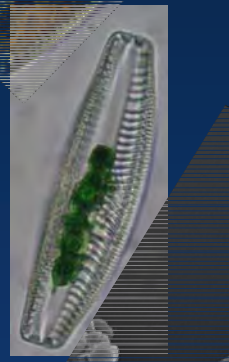
The Bad



diatoms

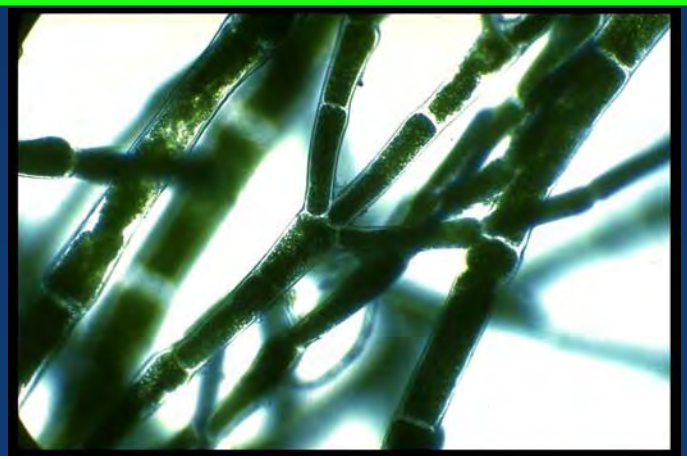
cyanobacteria

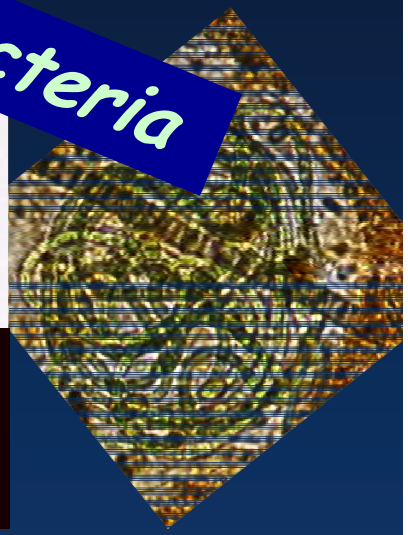




Filamentous green macroalgae: Cladophora

The Structural

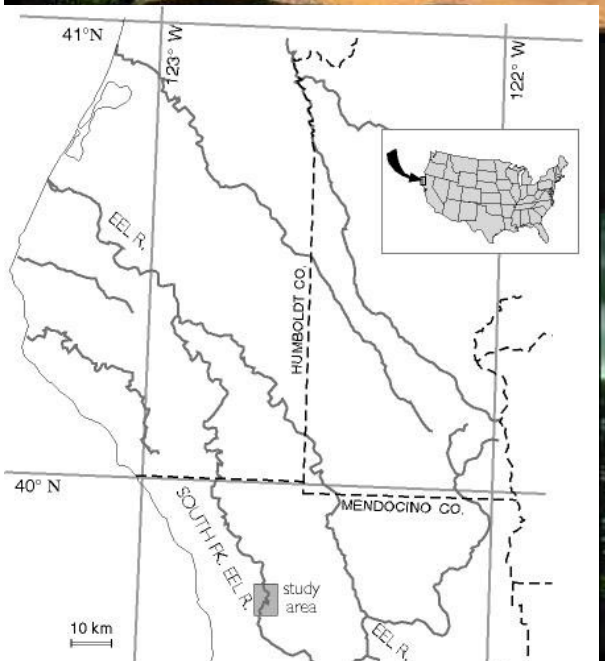


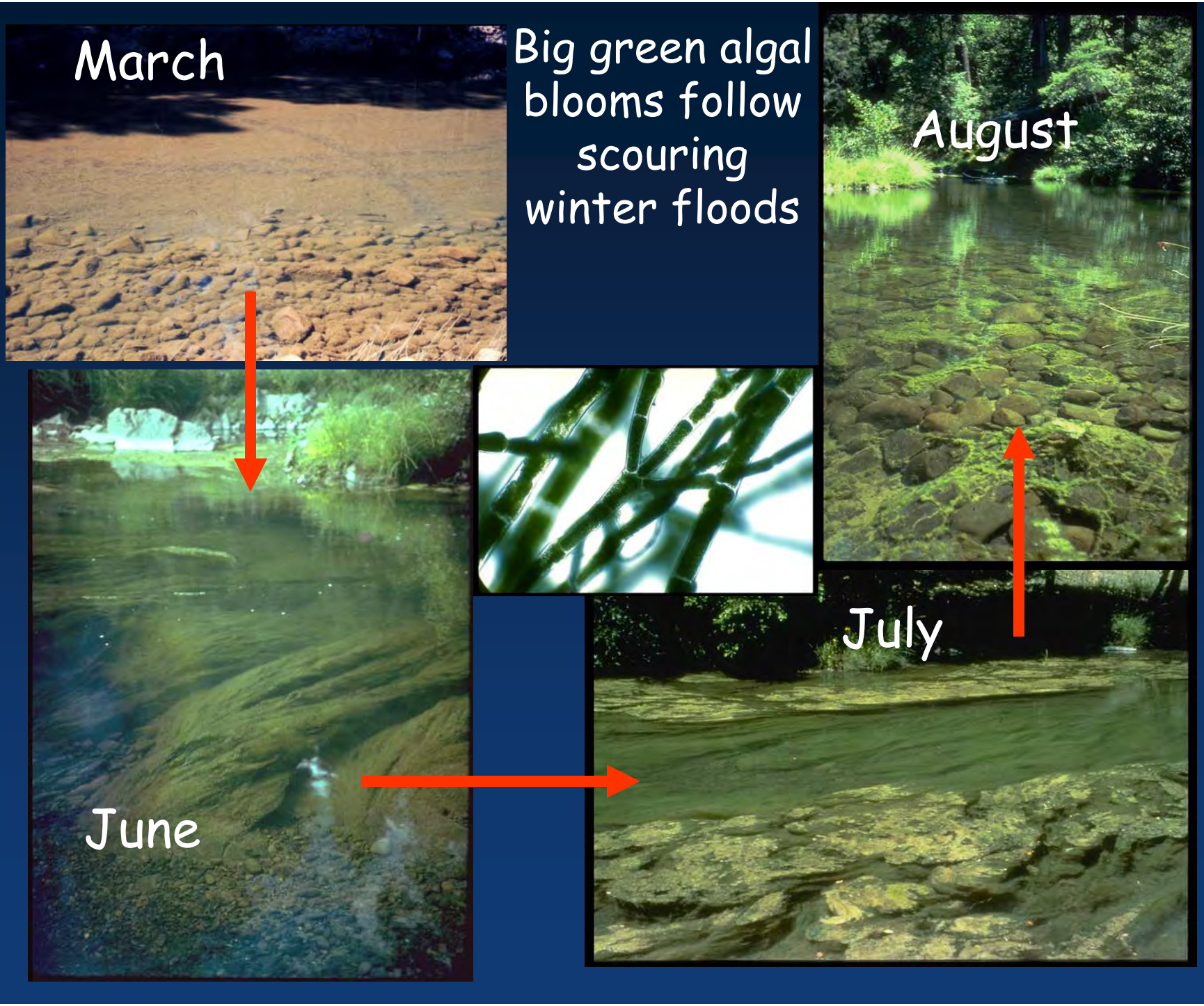


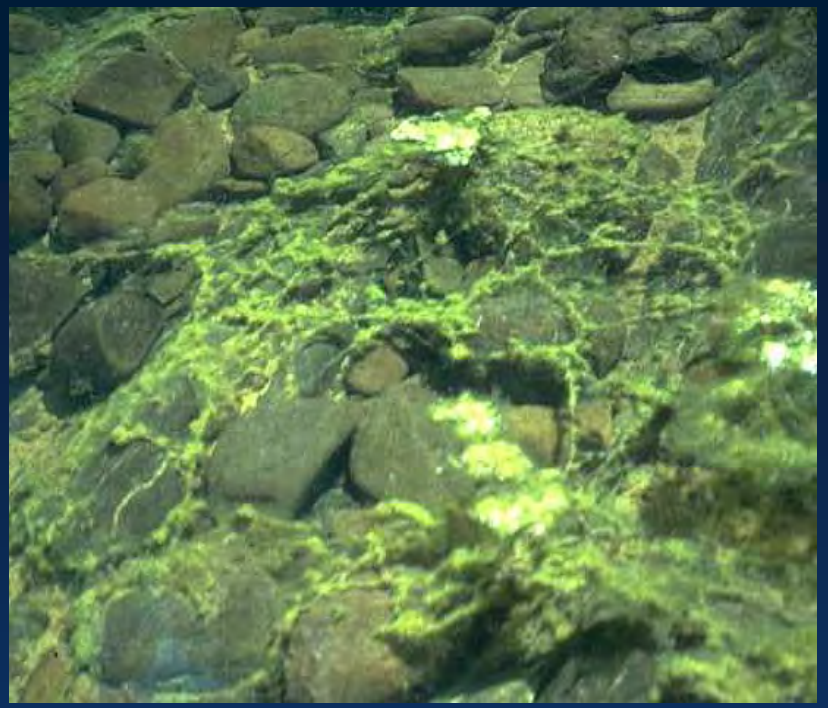
Epiphytic

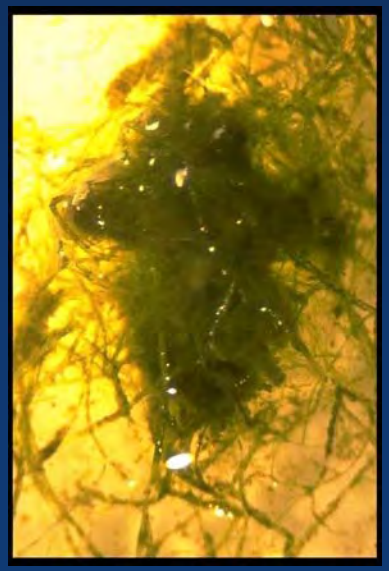
Epilithic

Eel River, Northwestern CA Mediterranean seasonality




March
Big green algal blooms follow scouring winter floods
August
June
July

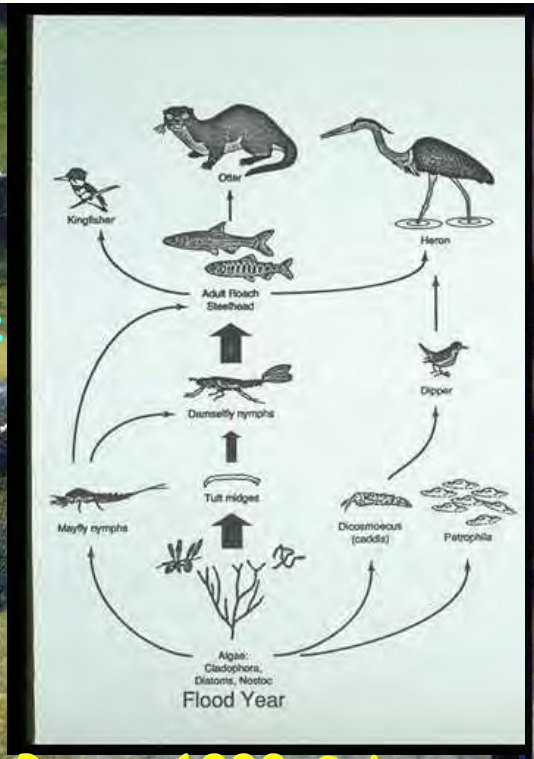




Fish ⟷ algae?

Thanks, Jennifer Nielsen

1989-flood (4 levels)
1990-drought (2 levels)
1991-drought (2 levels)
1993-flood, spring spate (3 levels)
1997-flood (4 levels)



Power 1990 Science

Wootton et al. 1996 Science

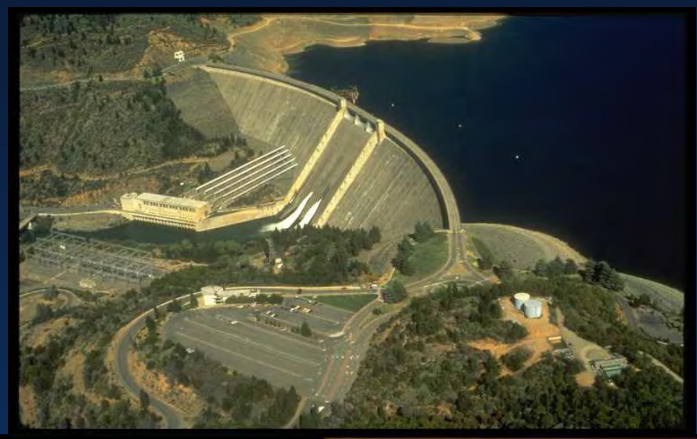
Power et al. 2008 Ecol. Monogr

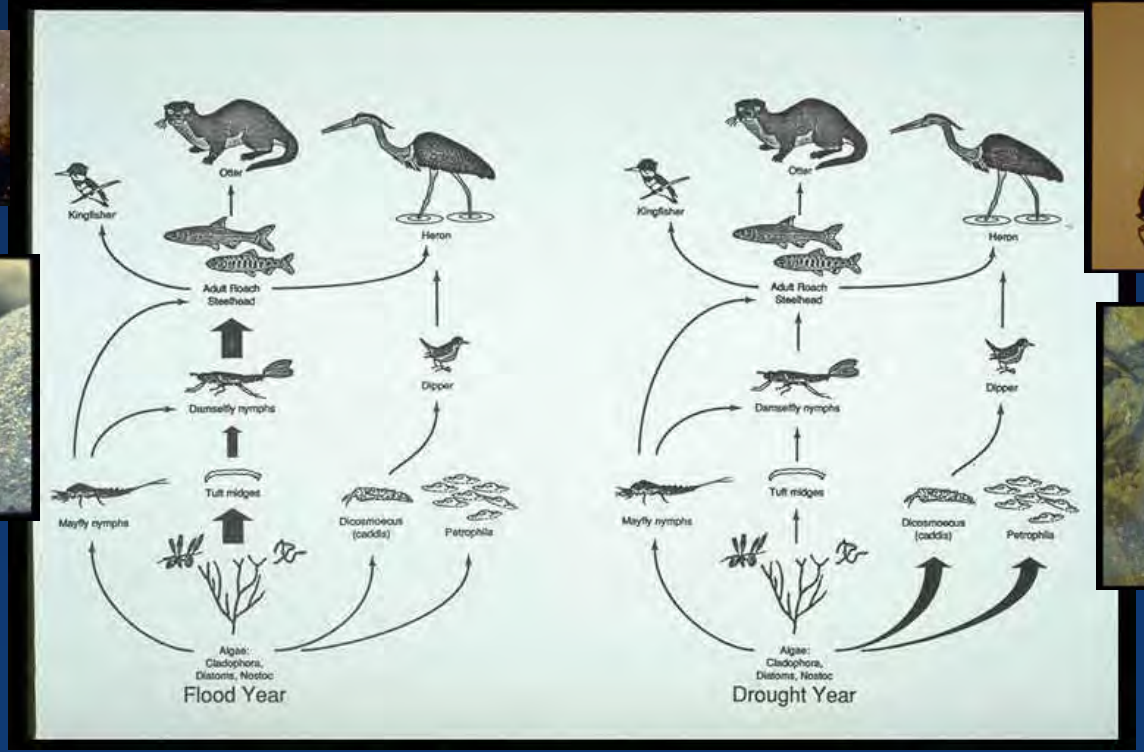
Enclosures, fish

Exclosures, no fish

Scour—longer food chains with vulnerable grazers link fish to algae

No scour—predator resistant grazers sequester and wipe out algae

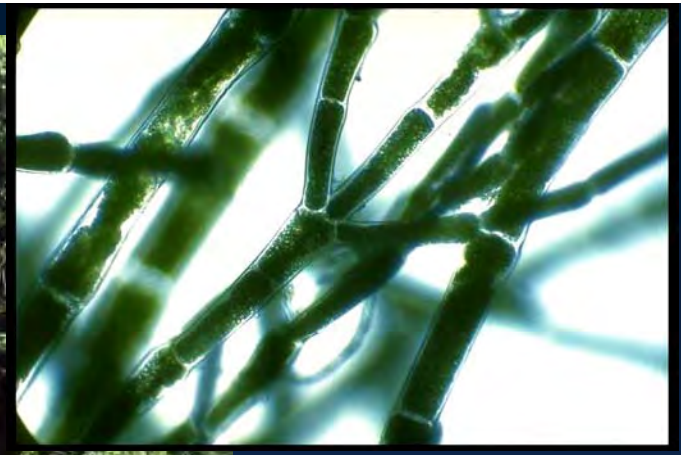




Flood:
Edible grazers

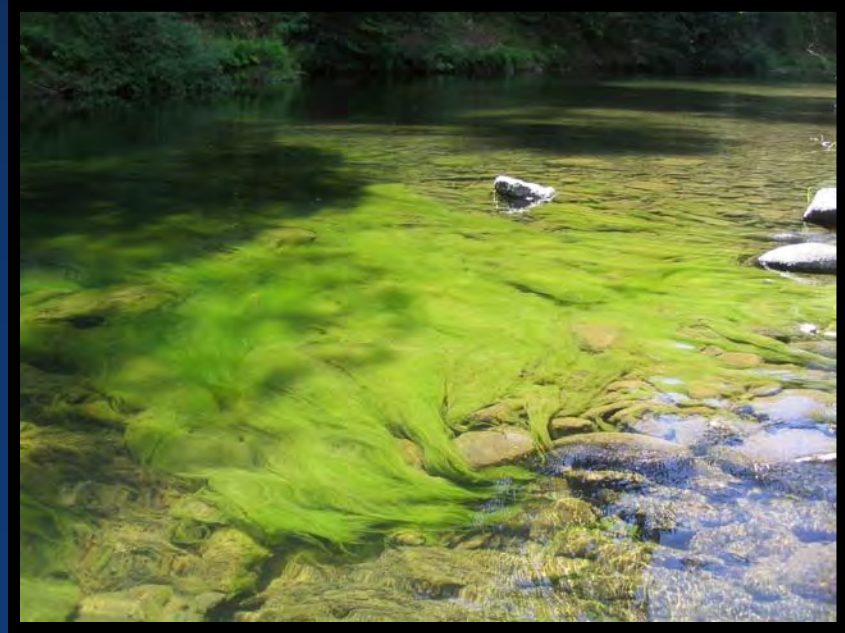
Drought:
Inedible grazers

Rex Lowe

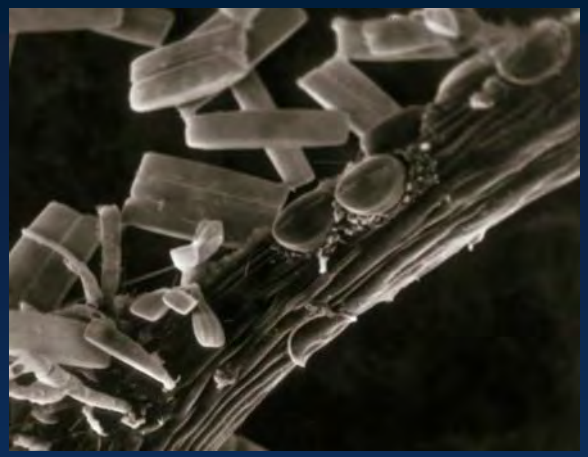


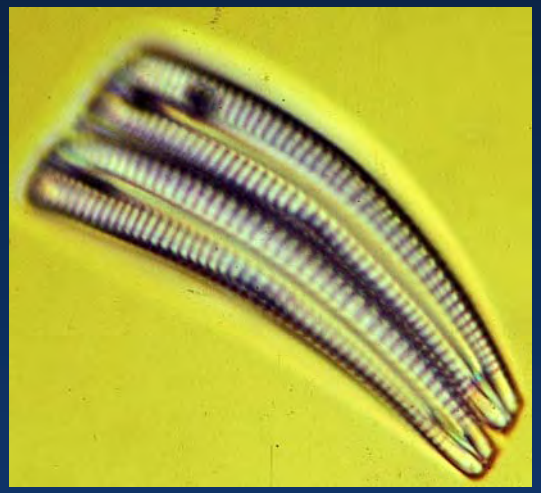
Cladophora: branched filamentous green macroalga

Bed scour, drainage areas > 100 km^2: *Cladophora* proliferations, increasing ecological surface area 2000 to 200,000 x

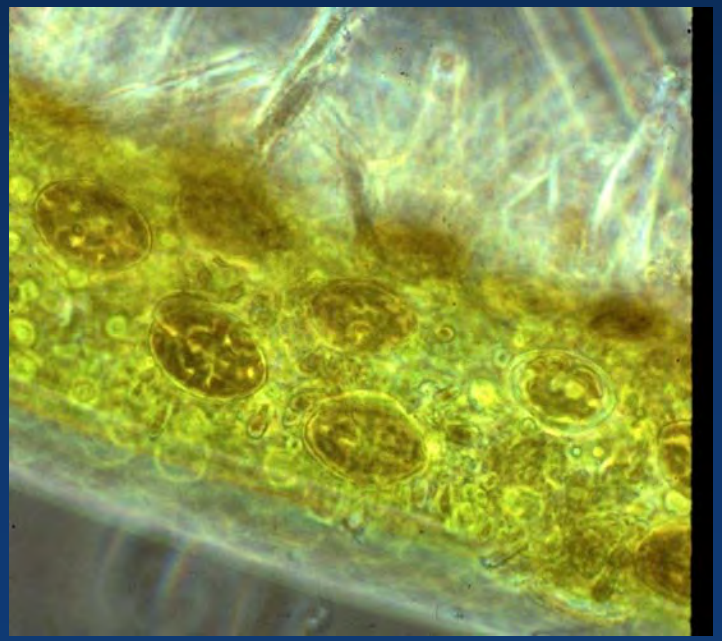


Epiphytes on yellow Cladophora



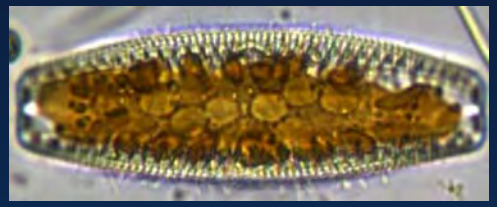


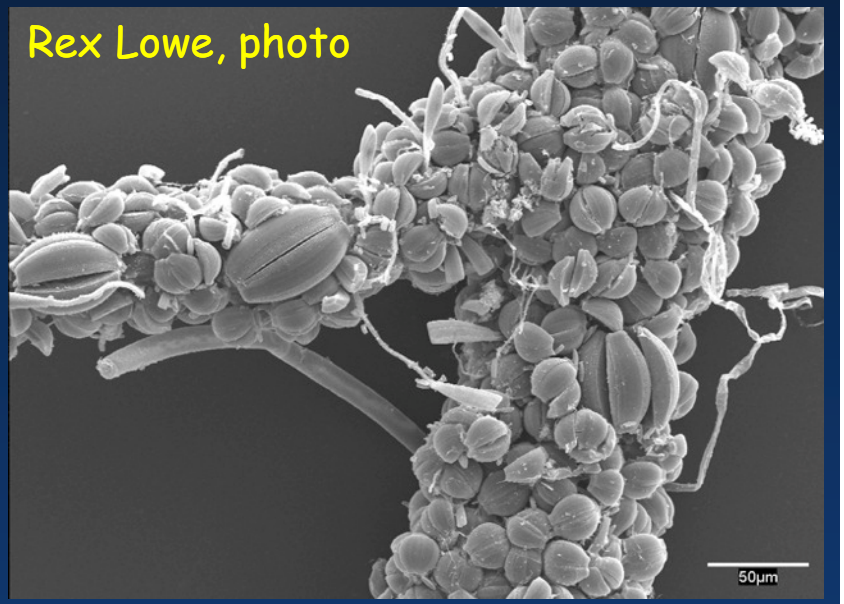
Rhoiciosphenia



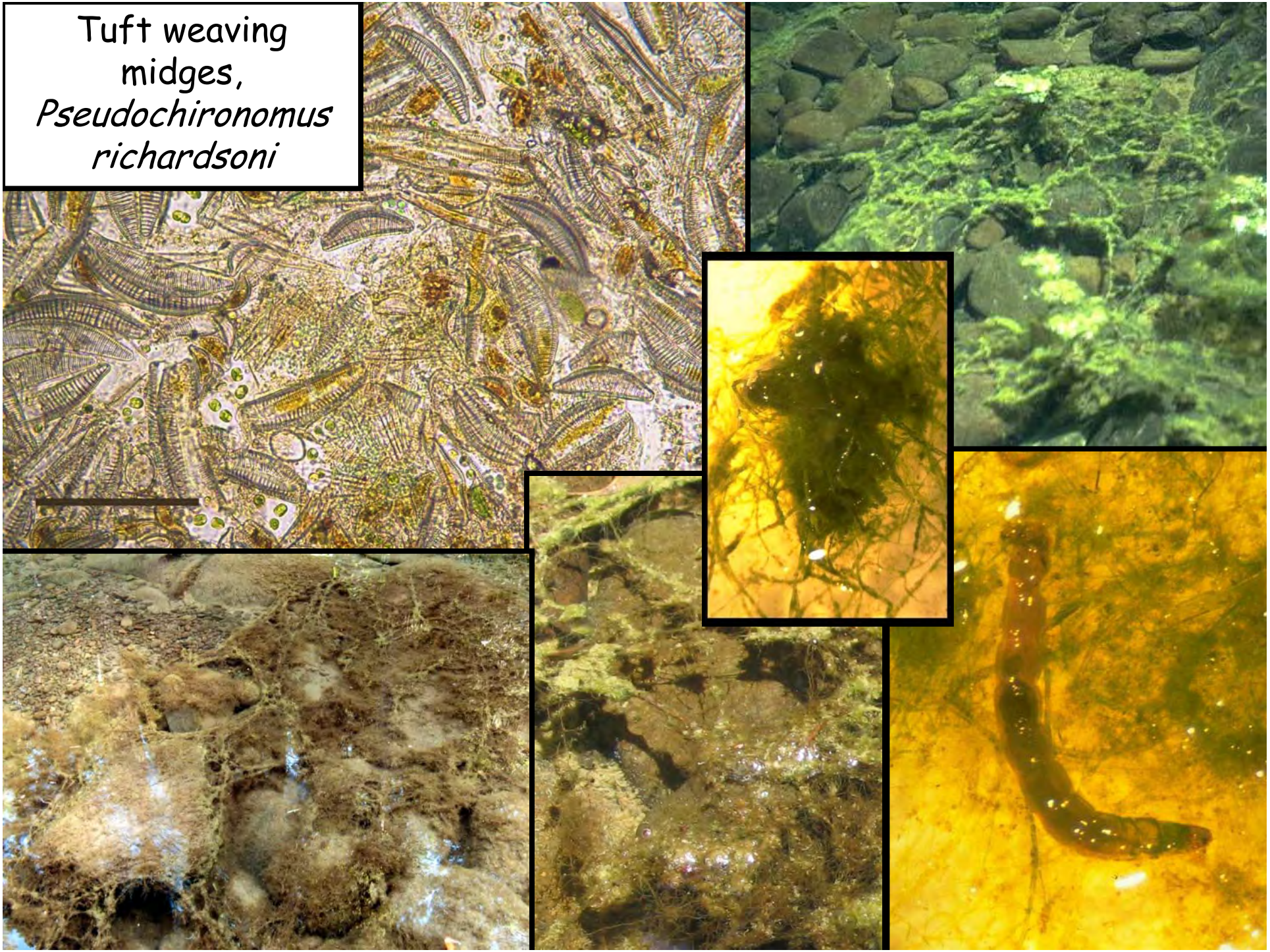
Gomphonema

Rusty Cladophora: *Epithemia turgida, E. sorex*

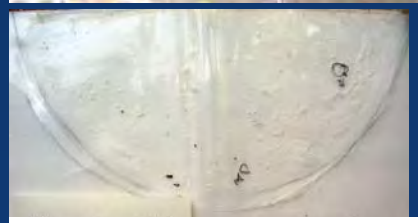




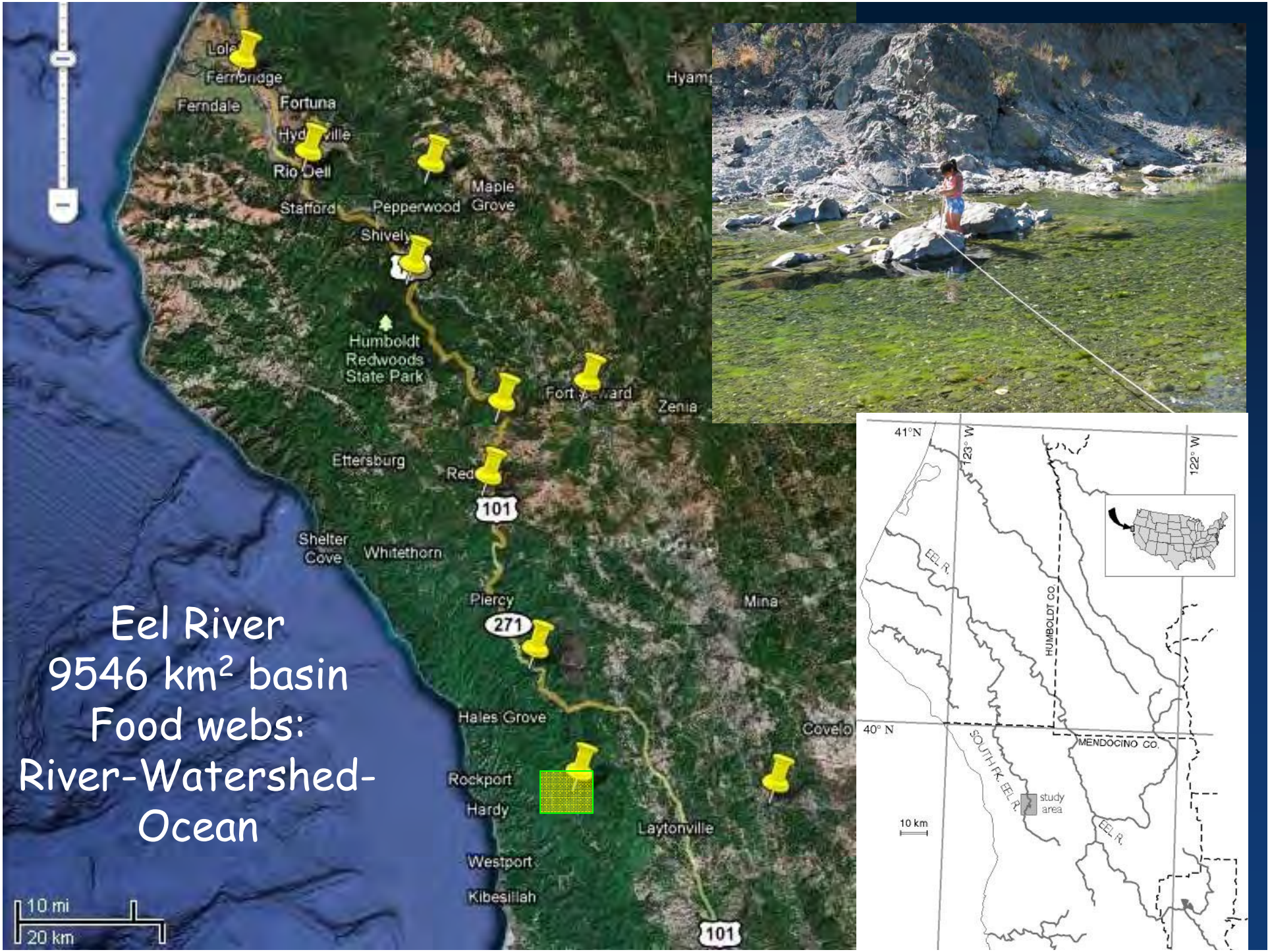
Tuft weaving midges, *Pseudochironomus richardsoni*

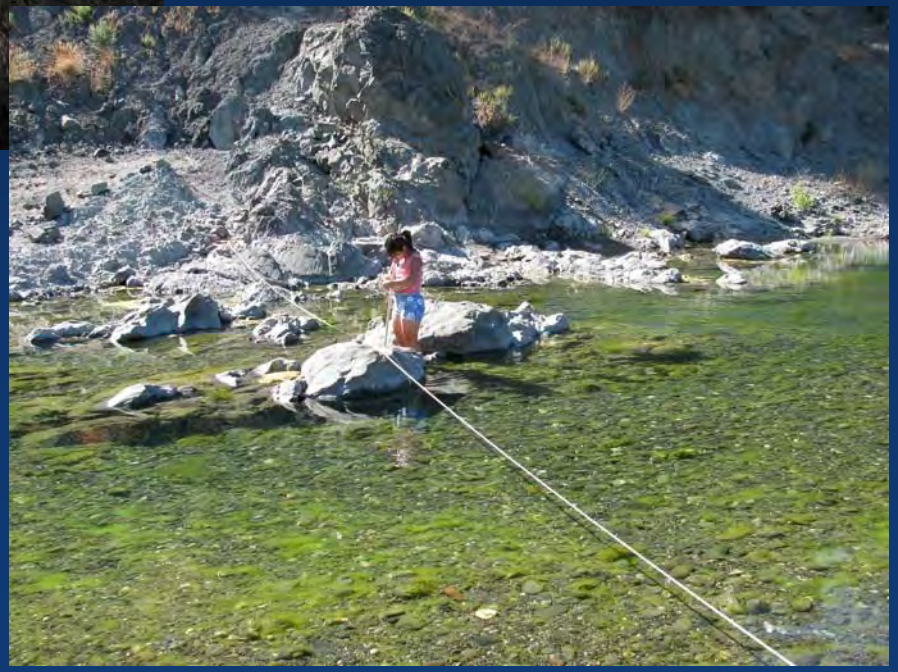


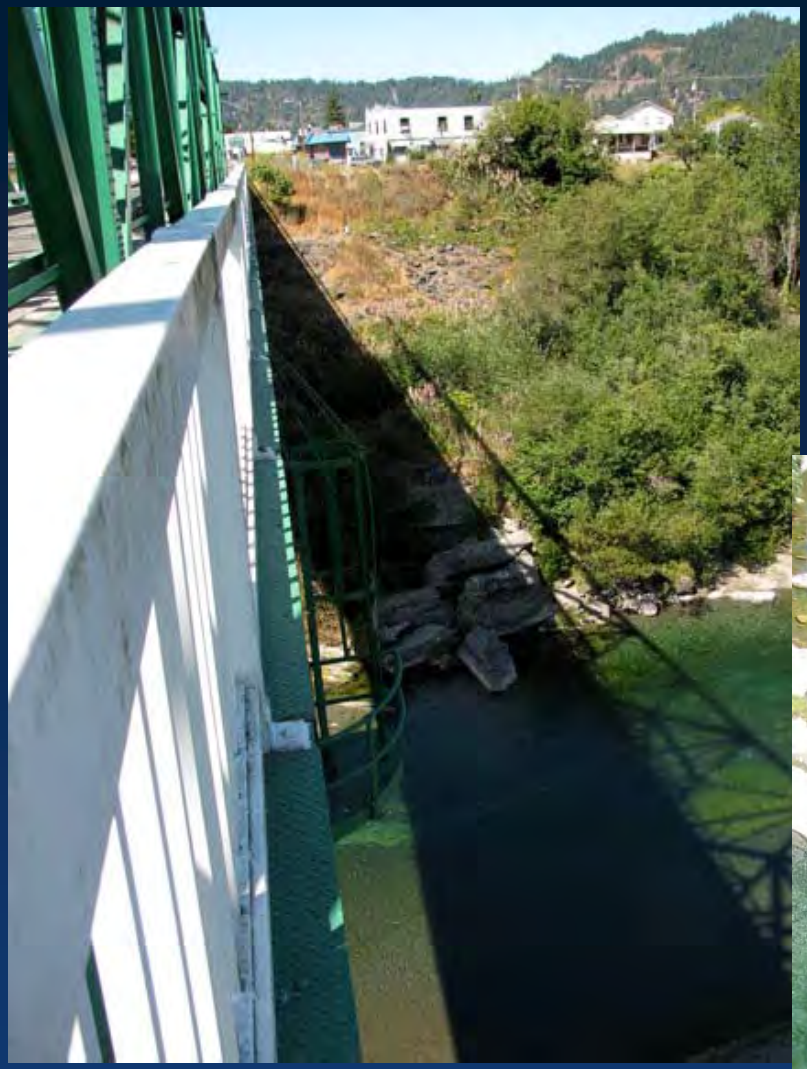
25x increase in aerial rates of insect emergence



Oedogonium Green Clad. Yellow Clad. Rusty Clad.


Ferndale
Fortuna
Rio Dell
Stafford
Pepperwood
Maple Grove
Shively
Humboldt Redwoods State Park
Zenia
Ettersburg
101
Shelter Cove
Whitethorn
Piercy
271
Mina
Hales Grove
Covelo
Rockport
Hardy
Laytonville
Westport
Kibesillah
10 mi
20 km
Eel River
9546 km² basin
Food webs:
River-Watershed-
Ocean
41°N
123° W
122° W
EEL R.
HUMBOLDT CO.
MENDOCINO CO.
40° N
SOUTH FK. EEL R.
study area
10 km





Fate of the Algae?

Rotting

Stranding

Terrestrial food web

Insect emergence

Algae (C, N)

River food web: long or short food chains?

Deep ocean burial

Near shore marine food web

Intertidal food web


Charlene Ng

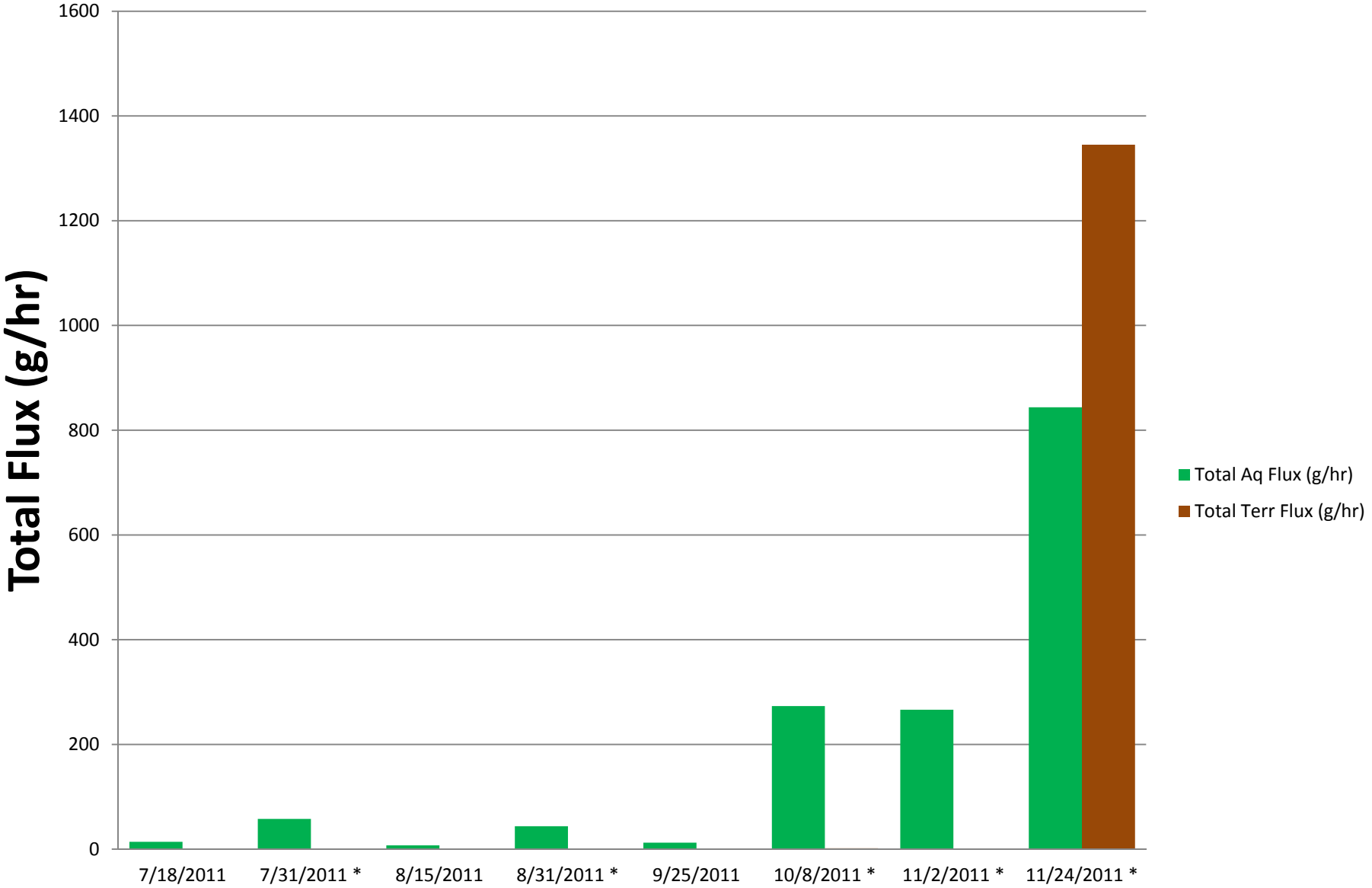

Parasite Ladies



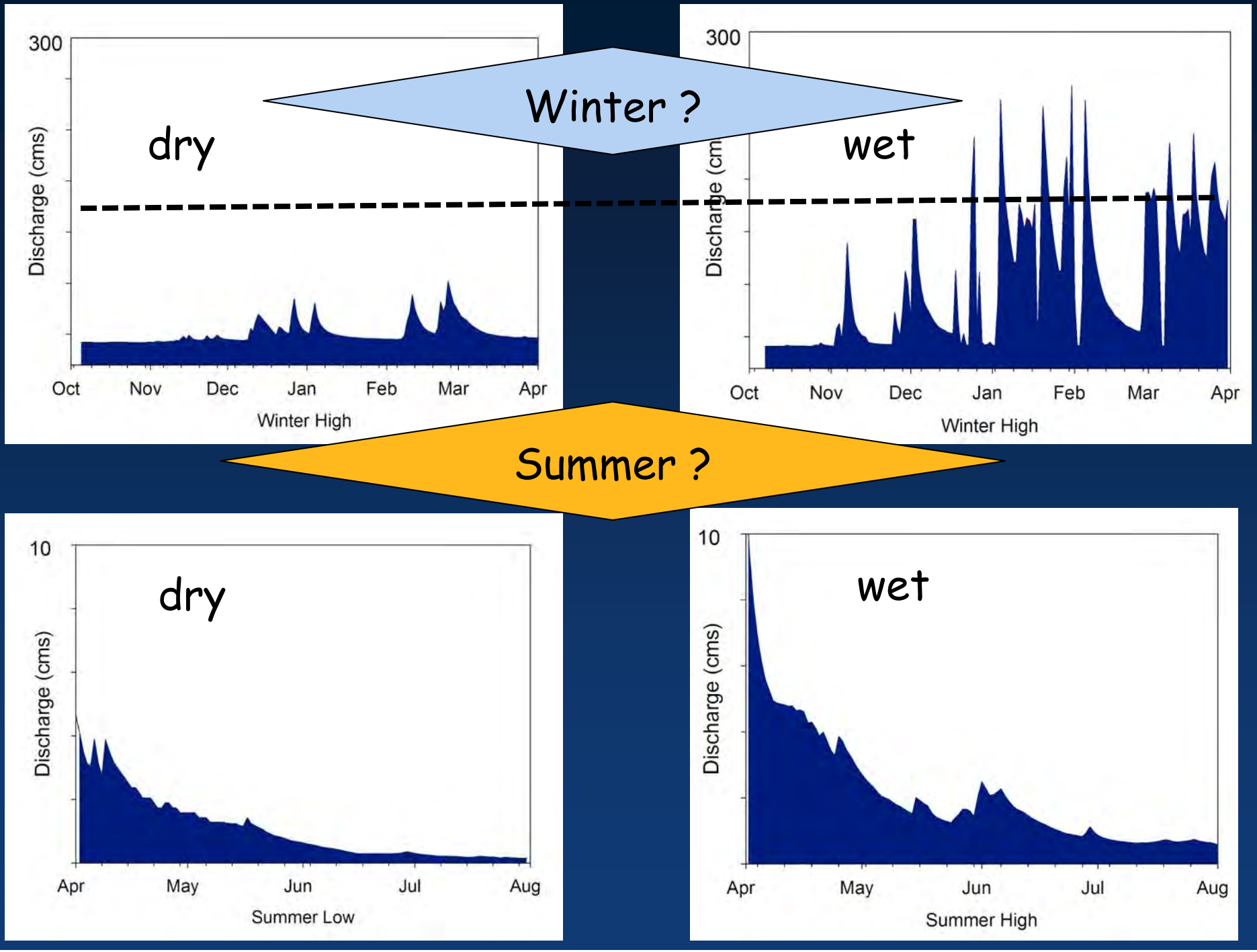

Intertidal Cafeteria trials

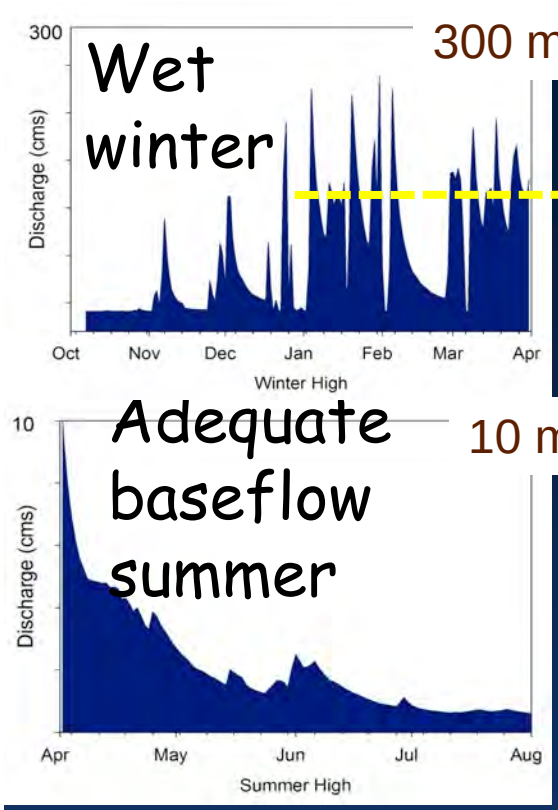


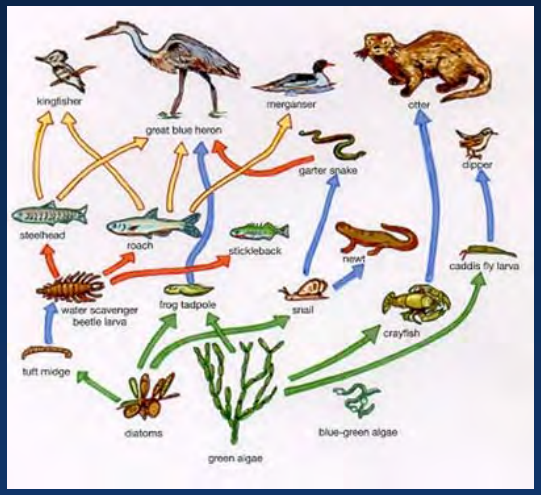
Organic Matter Flux at Fernbridge

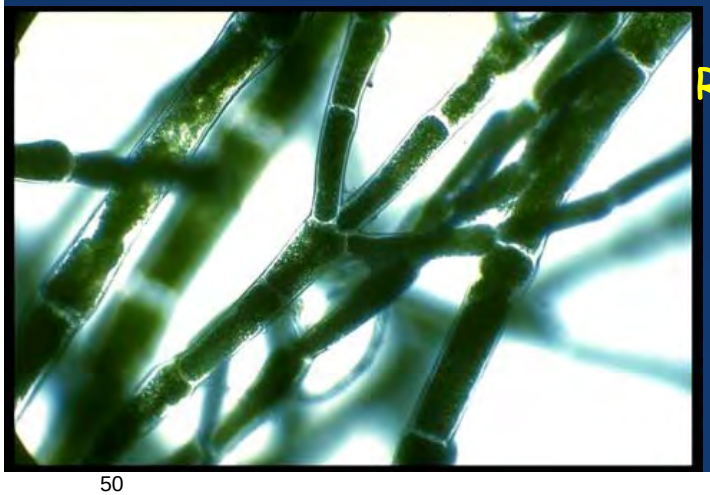


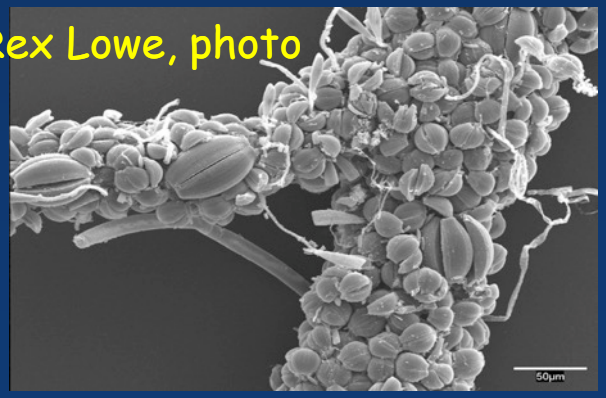
* Flux on these dates was subsampled, and total flux was estimated as the drift collected divided by by the ratio of the discharged sampled to the total discharge

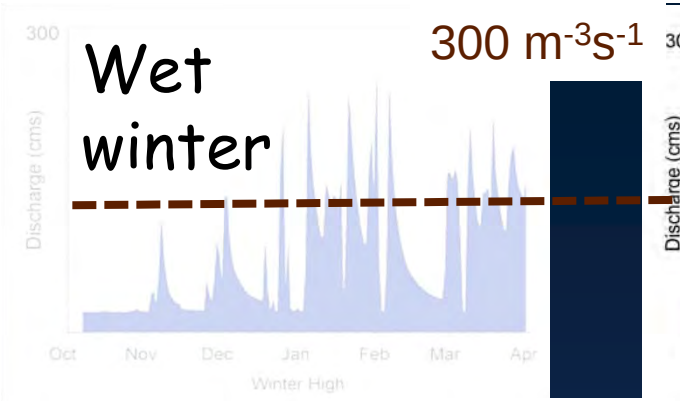

Winter ?
dry
wet
300
Discharge (cms)
Oct
Nov
Dec
Jan
Feb
Mar
Apr
Winter High
Summer ?
10
Apr
May
Jun
Jul
Aug
Summer Low
Summer High

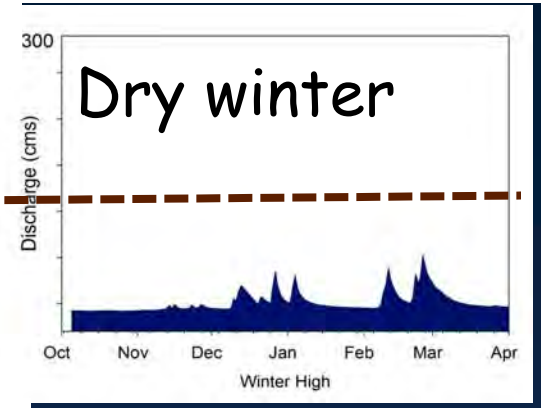

Wet winter
300 m-3s-1
Bed Scour
Discharge (cms)
300
Oct
Nov
Dec
Jan
Feb
Mar
Apr
Winter High
Adequate baseflow summer
10 m-3s-1
10
Discharge (cms)
Apr
May
Jun
Jul
Aug
Summer High

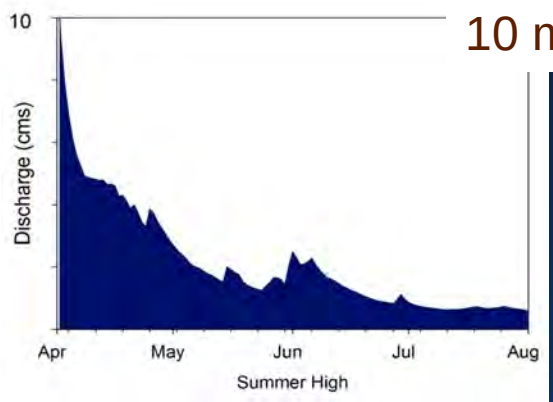

kingfisher
great blue heron
merganser
otter
garter snake
dipper
steelhead
roach
stickleback
newt
caddis fly larva
water scavenger beetle larva
frog tadpole
snail
crayfish
tuft midge
diatoms
blue-green algae
green algae




Rex Lowe, photo
50µm





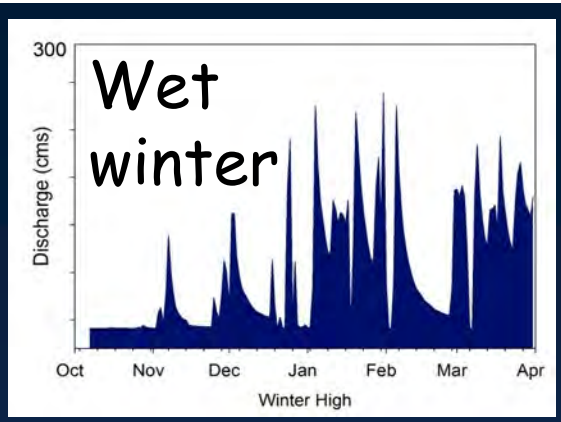


Armored grazers suppress algal accrual and fish production

Wet winter

300 $m^{-3}s^{-1}$

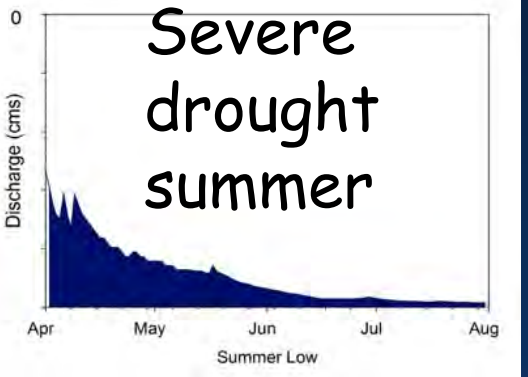
Dry winter



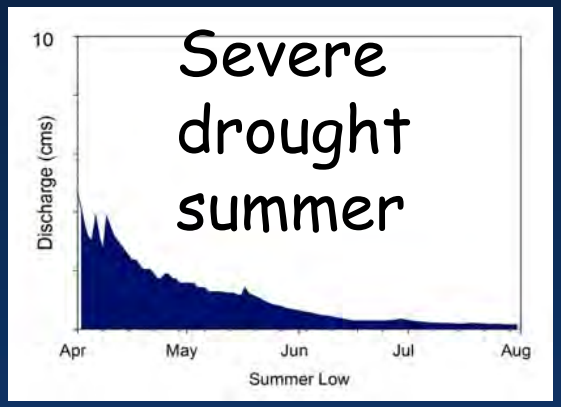
Wet winter

Adequate baseflow summer

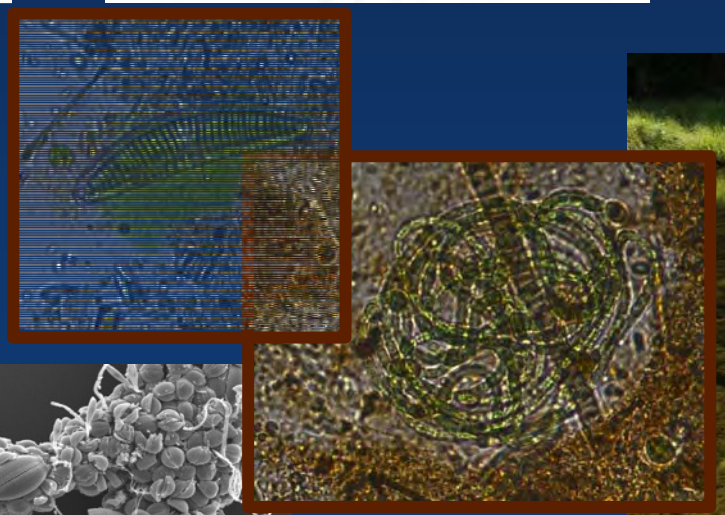
10 $m^{-3}s^{-1}$

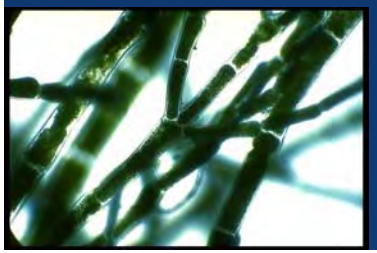


Severe drought summer



Severe drought summer





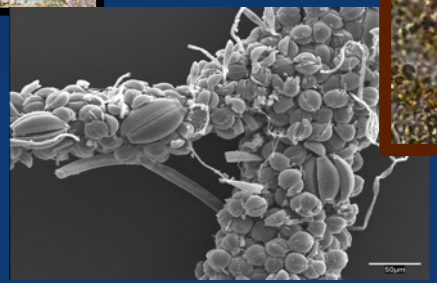
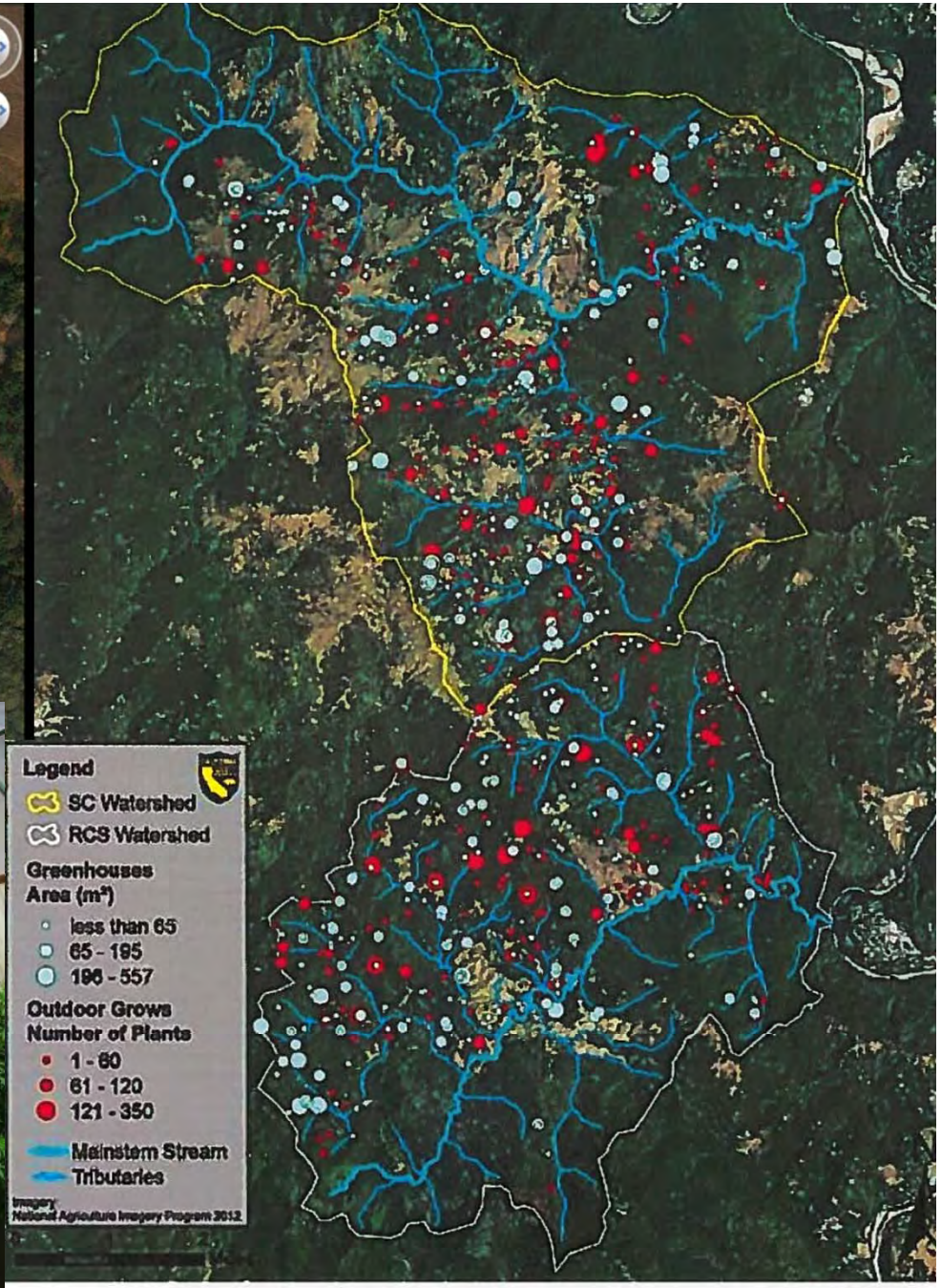


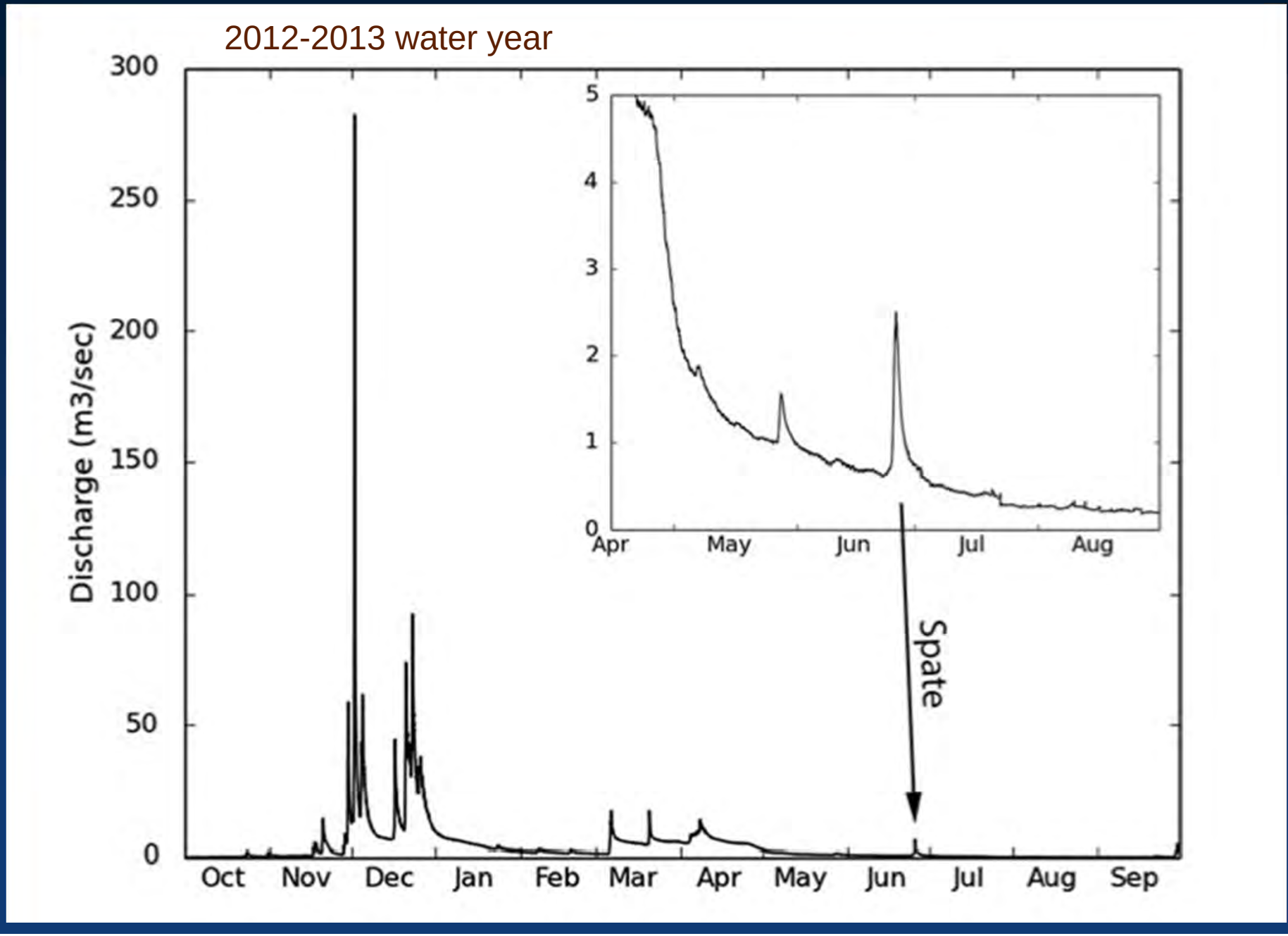

Photo by Scott Bauer, Ca DFW
Bauer et al., 2015,. PLOS One
Carah et al. 2015, BioScience

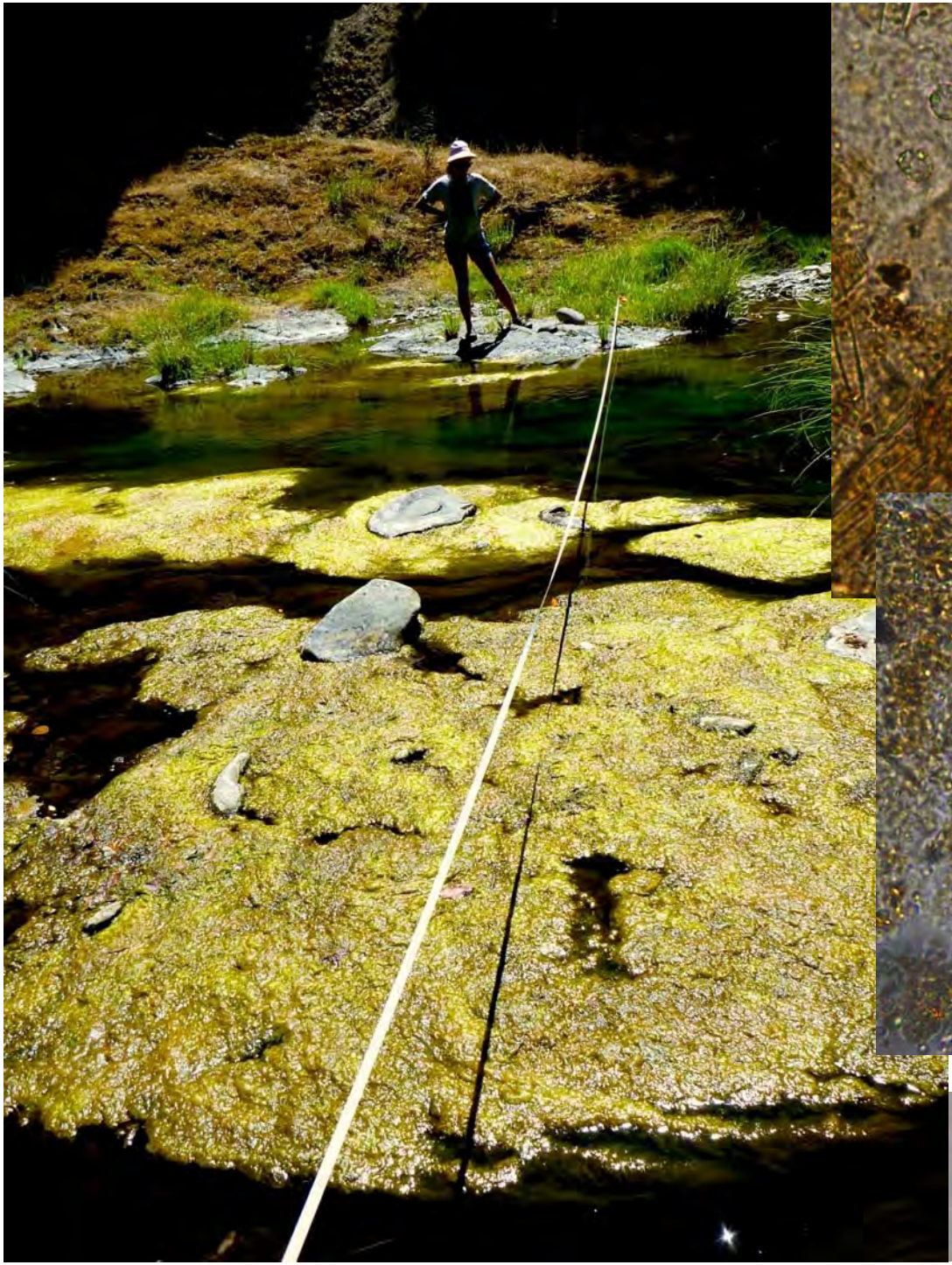
Bauer et al., 2015, PLOS One

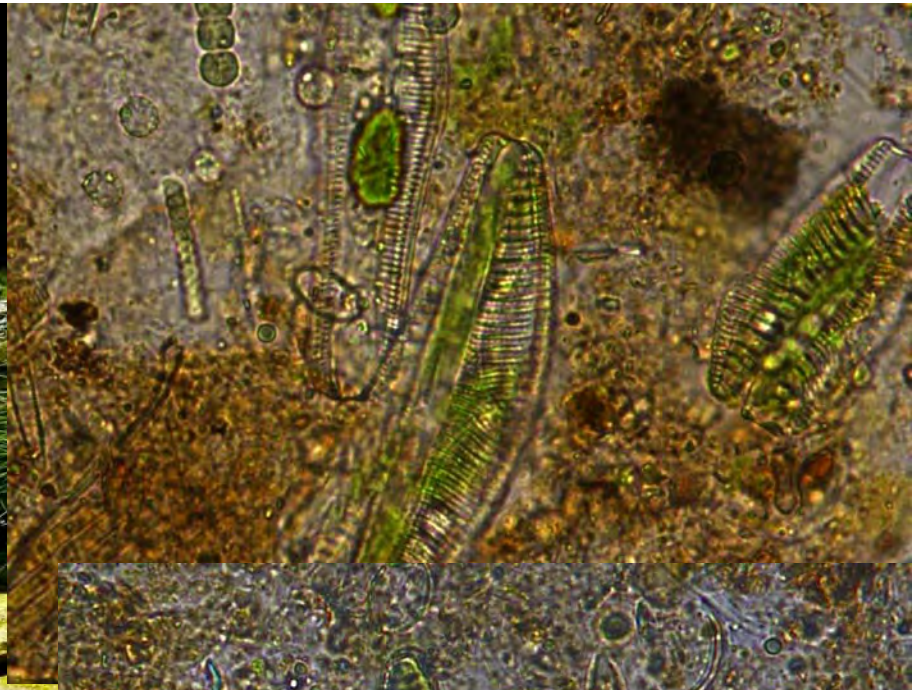


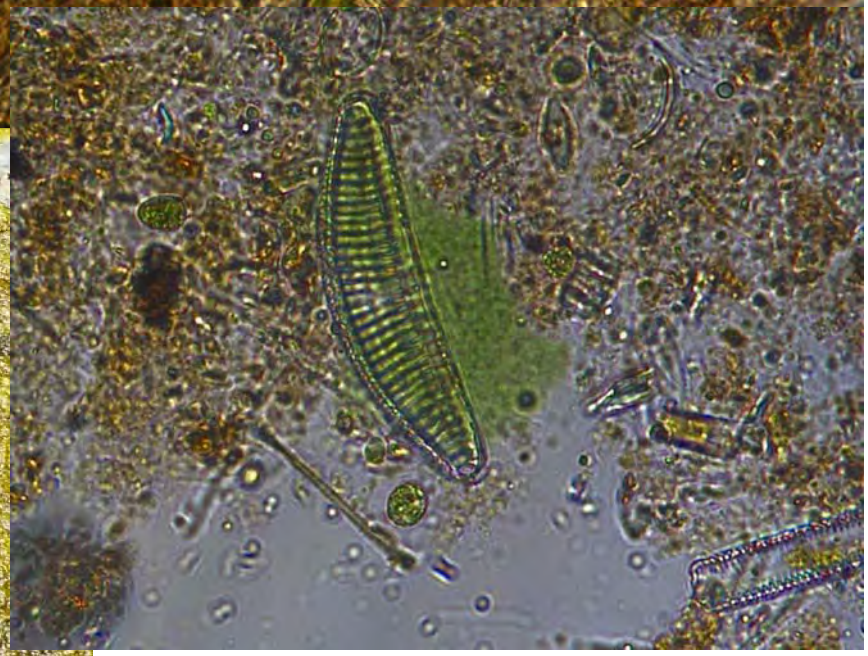
re 4. Salmon Creek and Redwood Creek South watersheds, with outdoor MCSs and
nhouses marked.

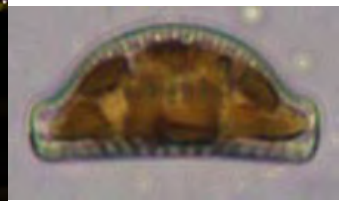
Power, Bouma-Gregson, Carlson and Higgins 2016 (Copeia): The Thirsty Eel

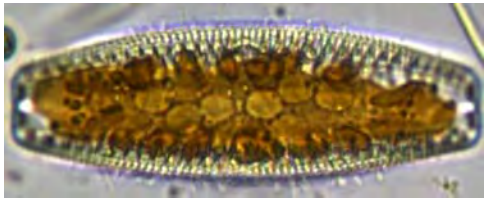


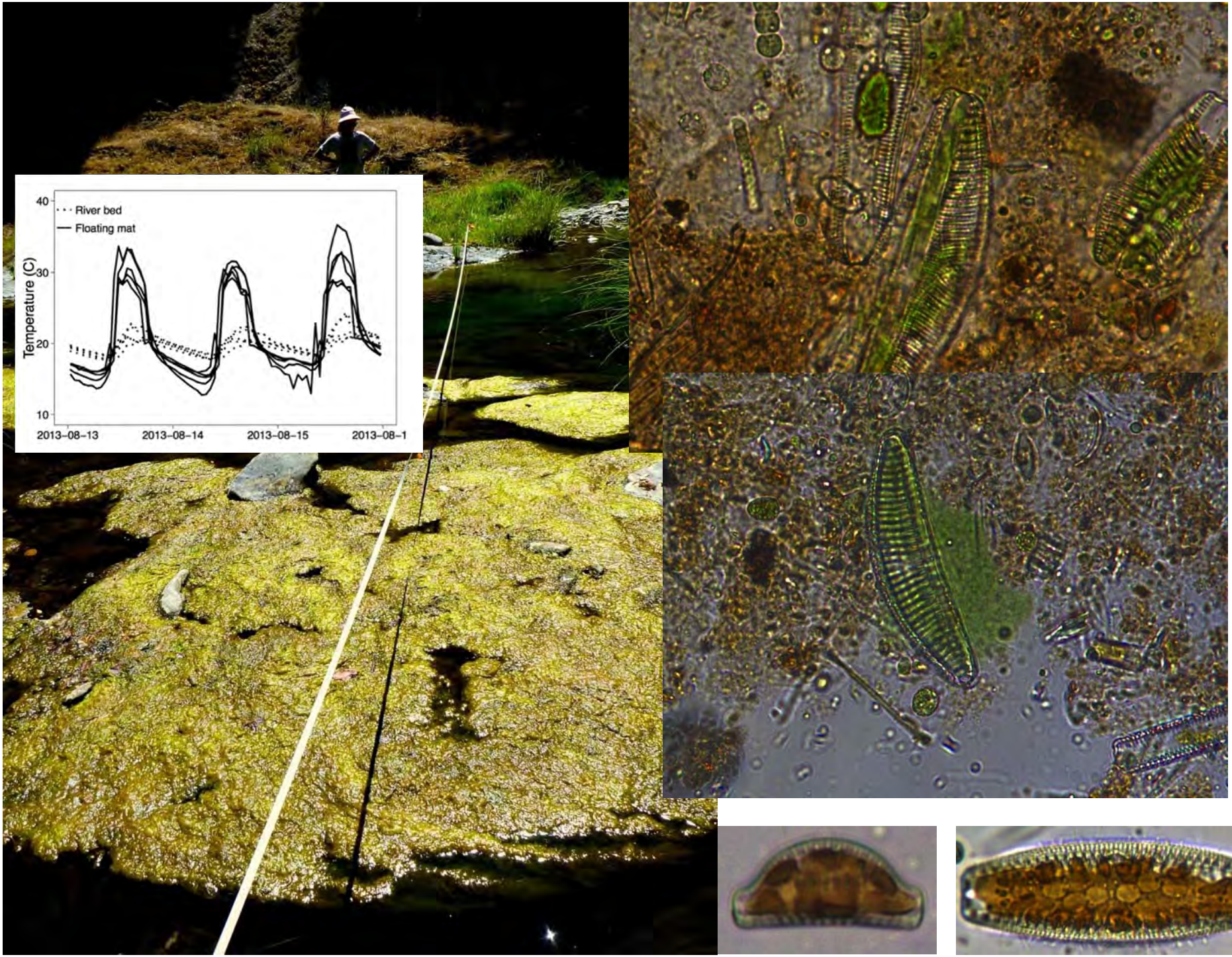


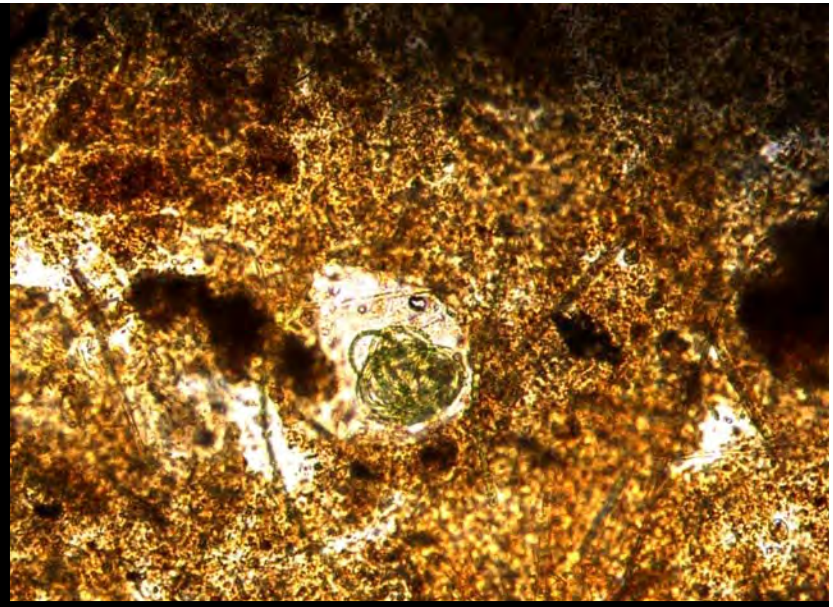


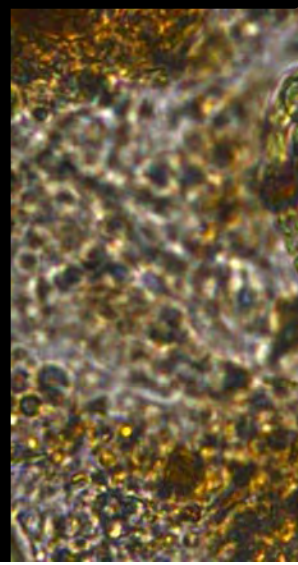







River bed
Floating mat
Temperature (C)
40
30
20
10
2013–08–13
2013–08–14
2013–08–15
2013–08–1





Cyanotoxins in the Eel
Keith Bouma-Gregson, Ph.D. candidate

Dog Deaths

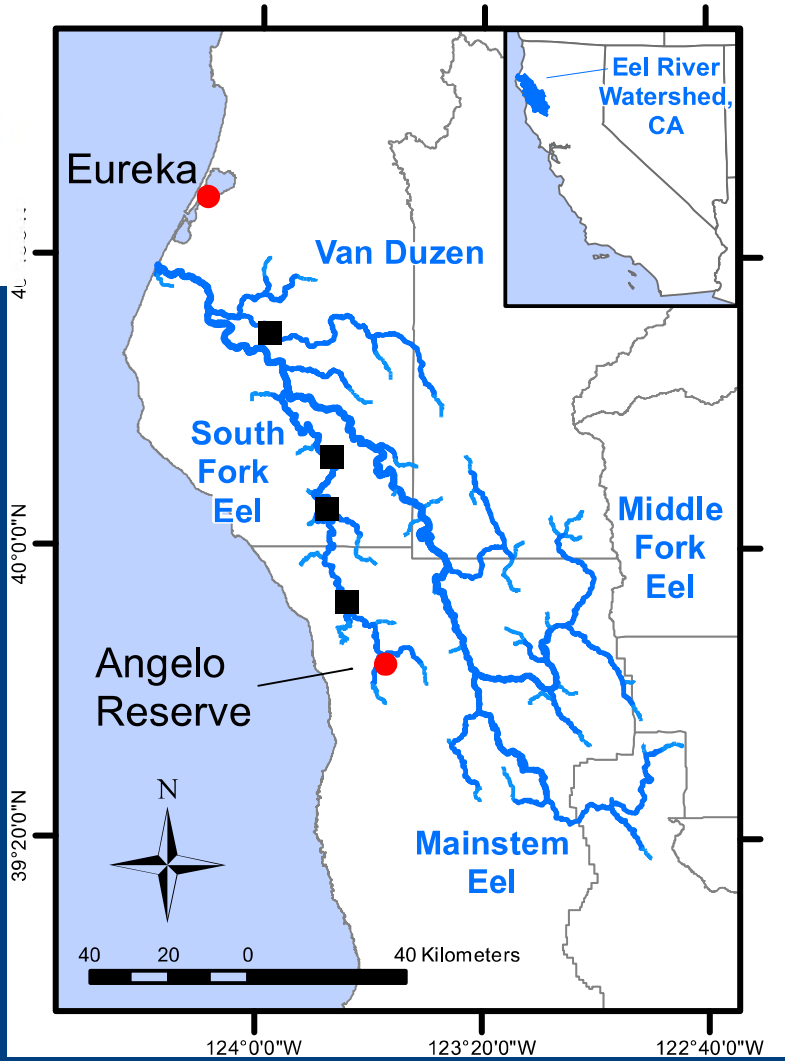
Humboldt County Department of Health and Human Services
Division of Environmental Health
100 H Street - Suite 100 - Eureka, CA 95501
Voice:707-445-6215 - Fax: 707-441-5699 - Toll Free: 800-963-9241
envhealth@co.humboldt.ca.us

Blue Green Algae (BGA) - Detailed Fact Sheet
For Distribution to Animal Health Workers
Prepared by: Harriet Hill, Division of Environmental Health, revised July 2010

Journal of Veterinary Diagnostic Investigation
http://vdi.sagepub.com/

Diagnosis of Anatoxin-a Poisoning in Dogs from North America
Birgit Puschner, Brent Hoff and Elizabeth R. Tor
J VET Diagn Invest 2008 20: 89
DOI: 10.1177/104063870802000119

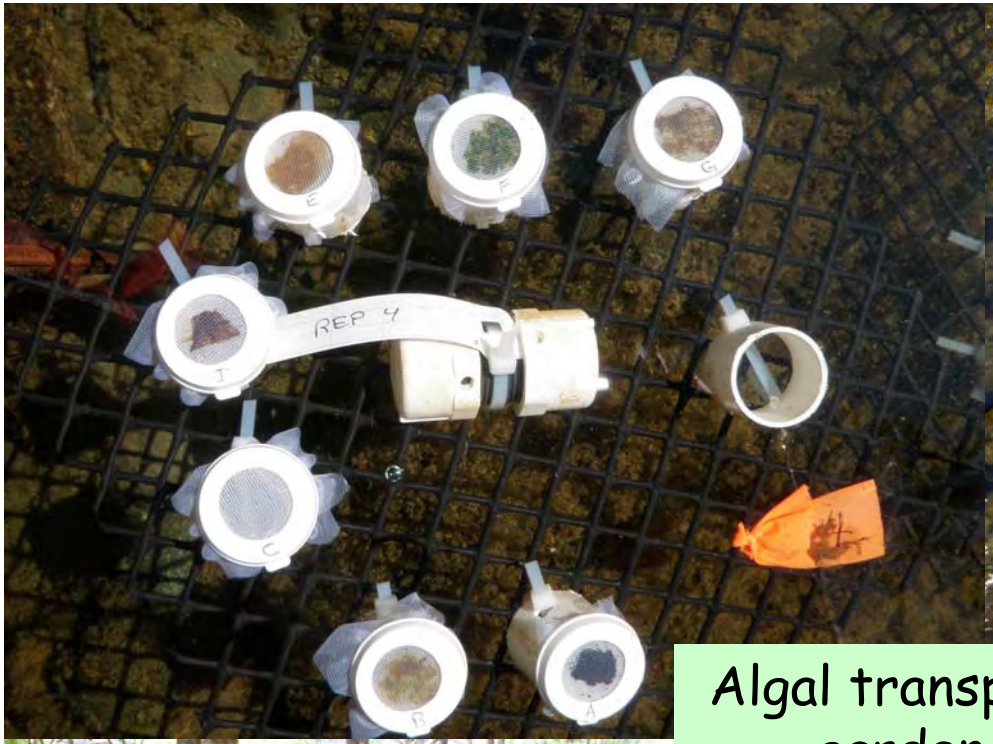
Backer et al. 2013.
Toxins 5:1597-1628



Keith Bouma-Gregson, UCB

Raphael Kudela, UCSC SPATT samplers
Characterization and deployment of Solid Phase Adsorption Toxin Tracking (SPATT) resin for monitoring of microcystins in fresh and saltwater

Harmful Algae 11 (2011) 117–125

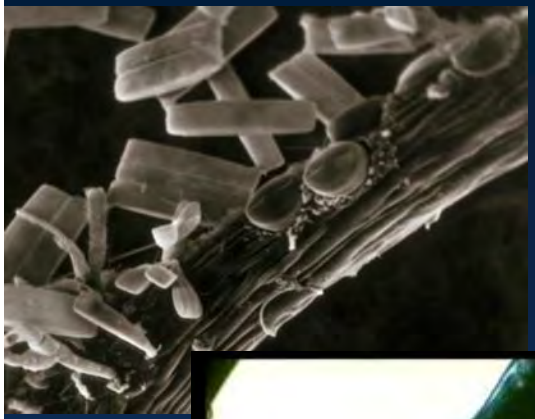


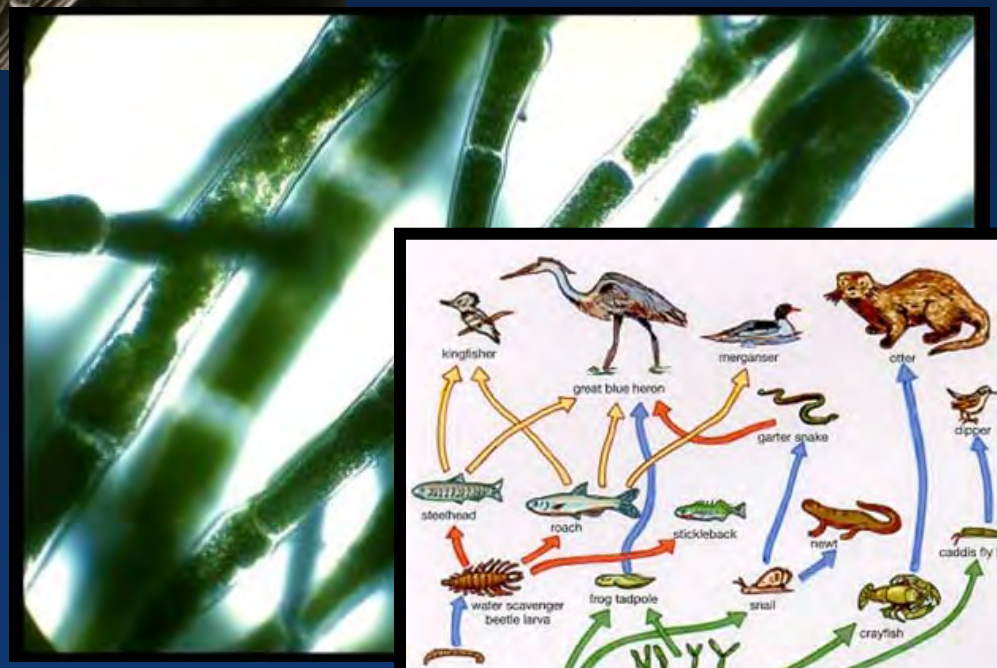
Algal transplant and common garden experiments

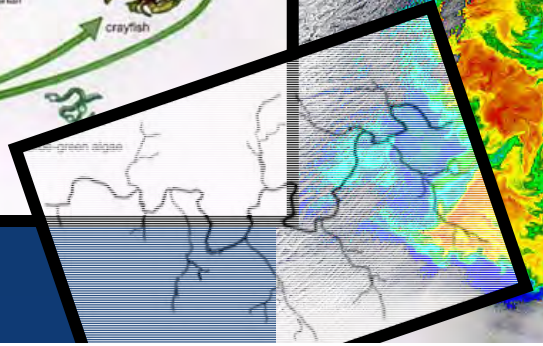
Thanks Rex Lowe, Paula Furey, and Keith Bouma-Gregson

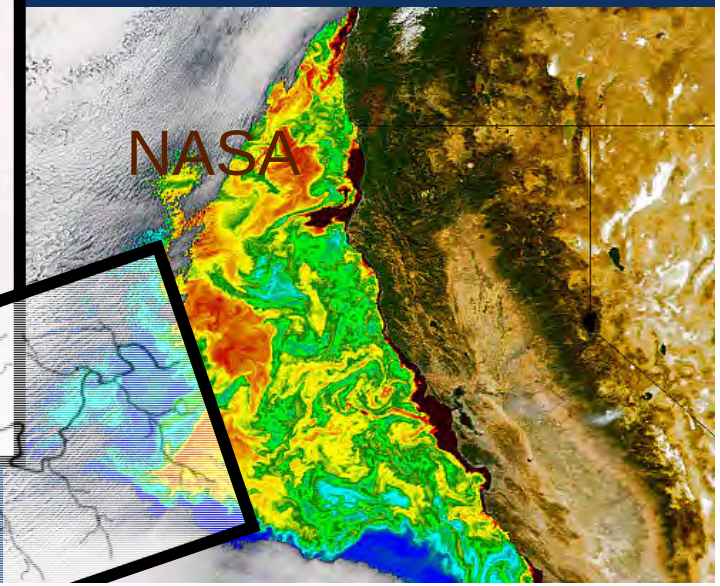
How does hydrology control the type and fate of algae in river (and coastal) food webs?

And what can we do about it?



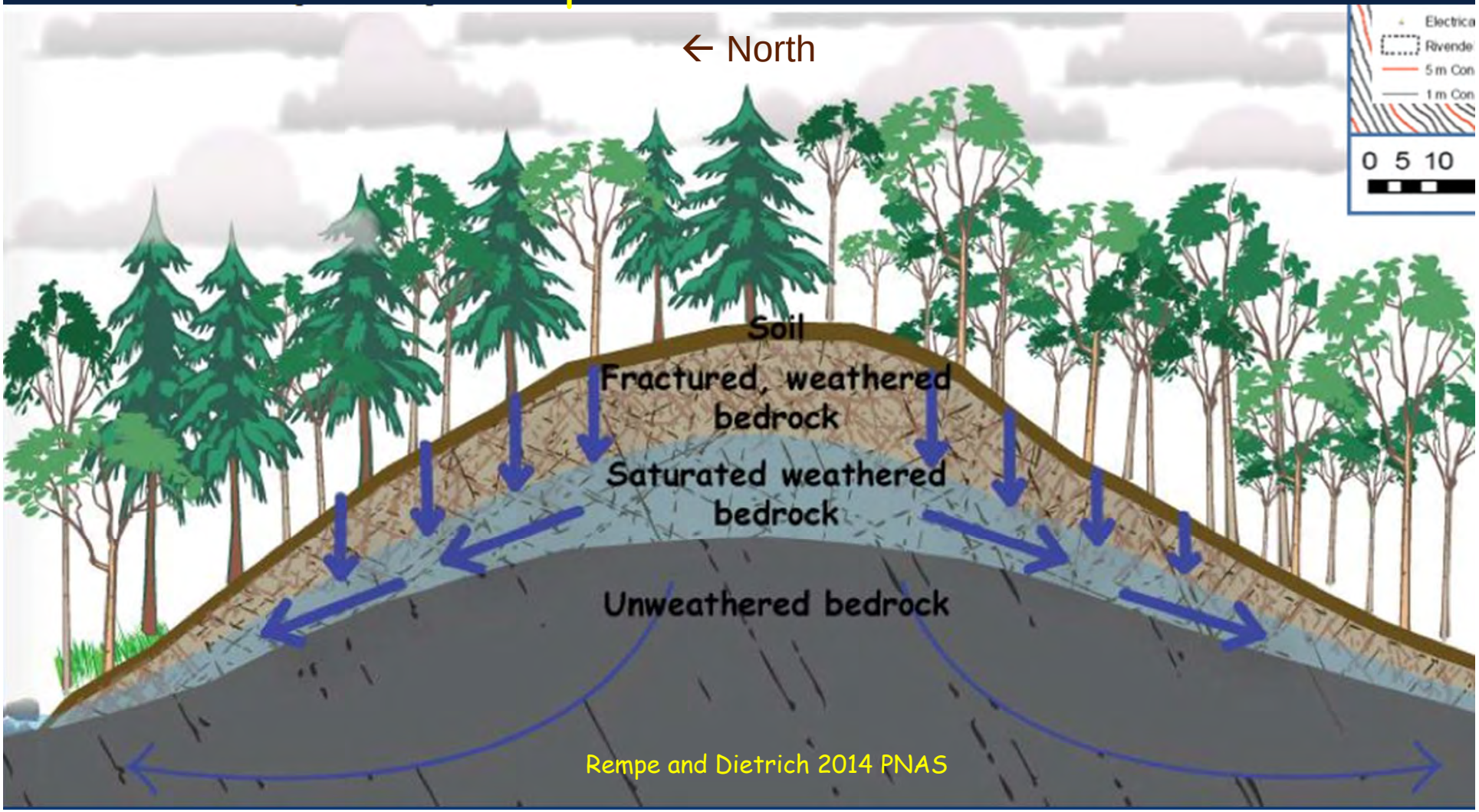




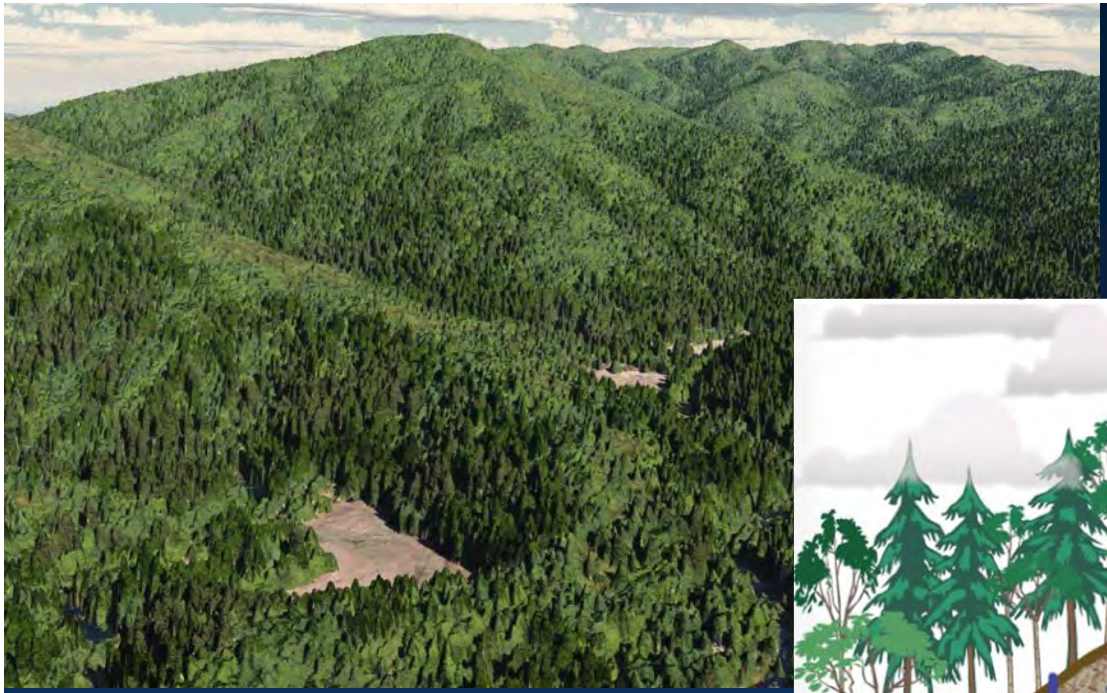


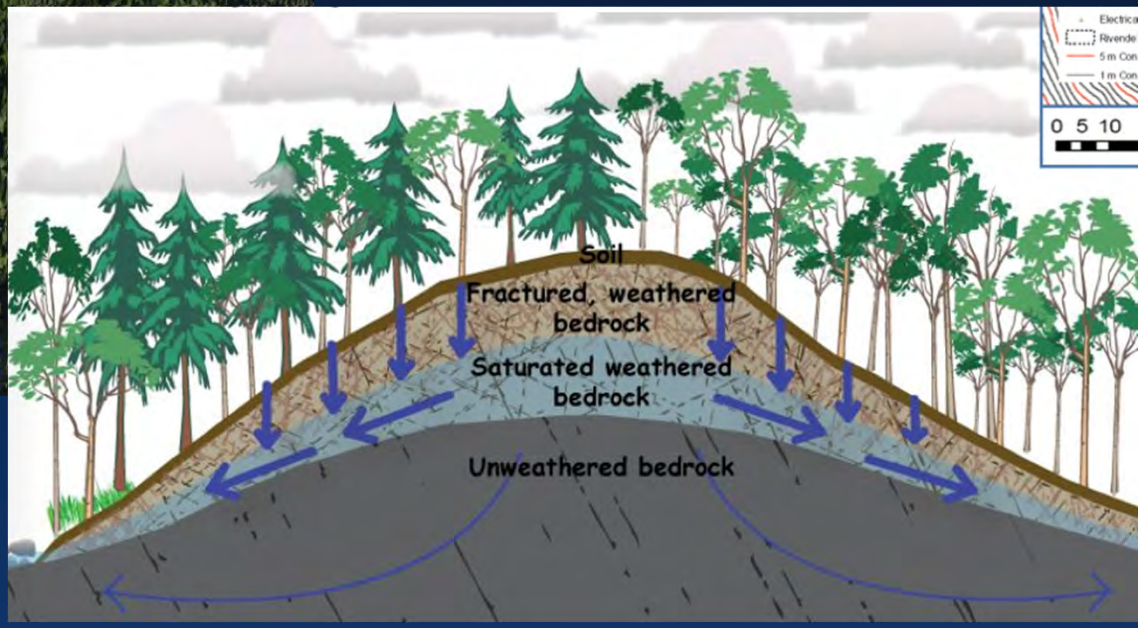
Critical Zone: from the top of the vegetation canopy to the "bottom of the water table"

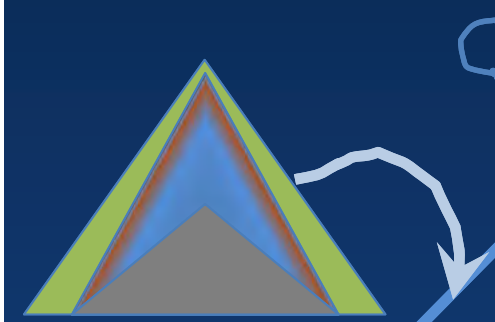
= unweathered bedrock where water is no longer mobile enough to sustain plants or surface waters.

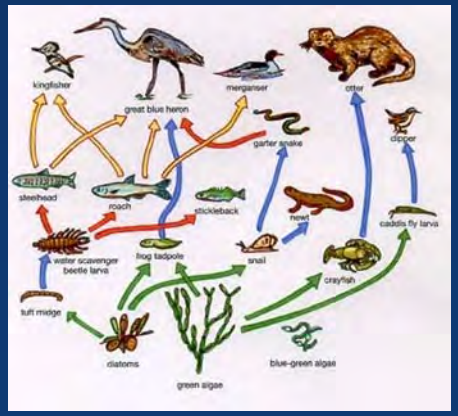


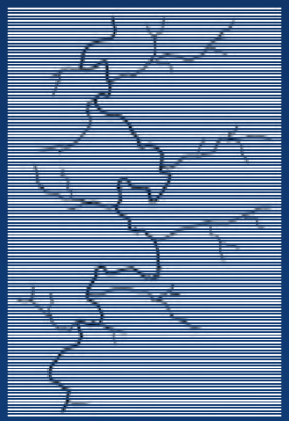
What lies beneath → what lies beyond

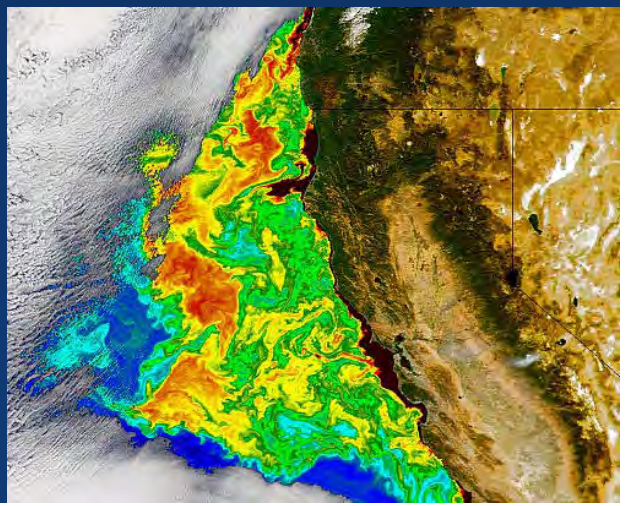




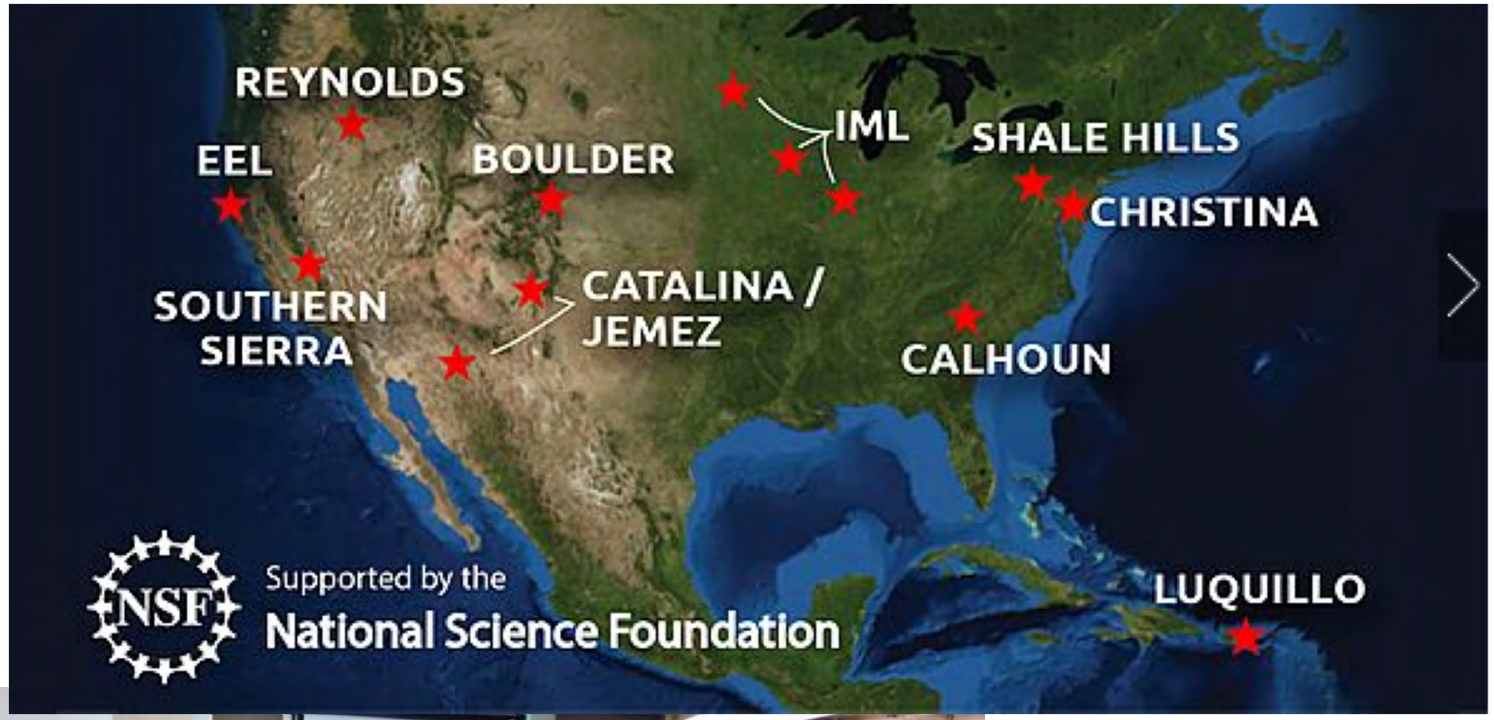








Eel River Critical Zone Observatory

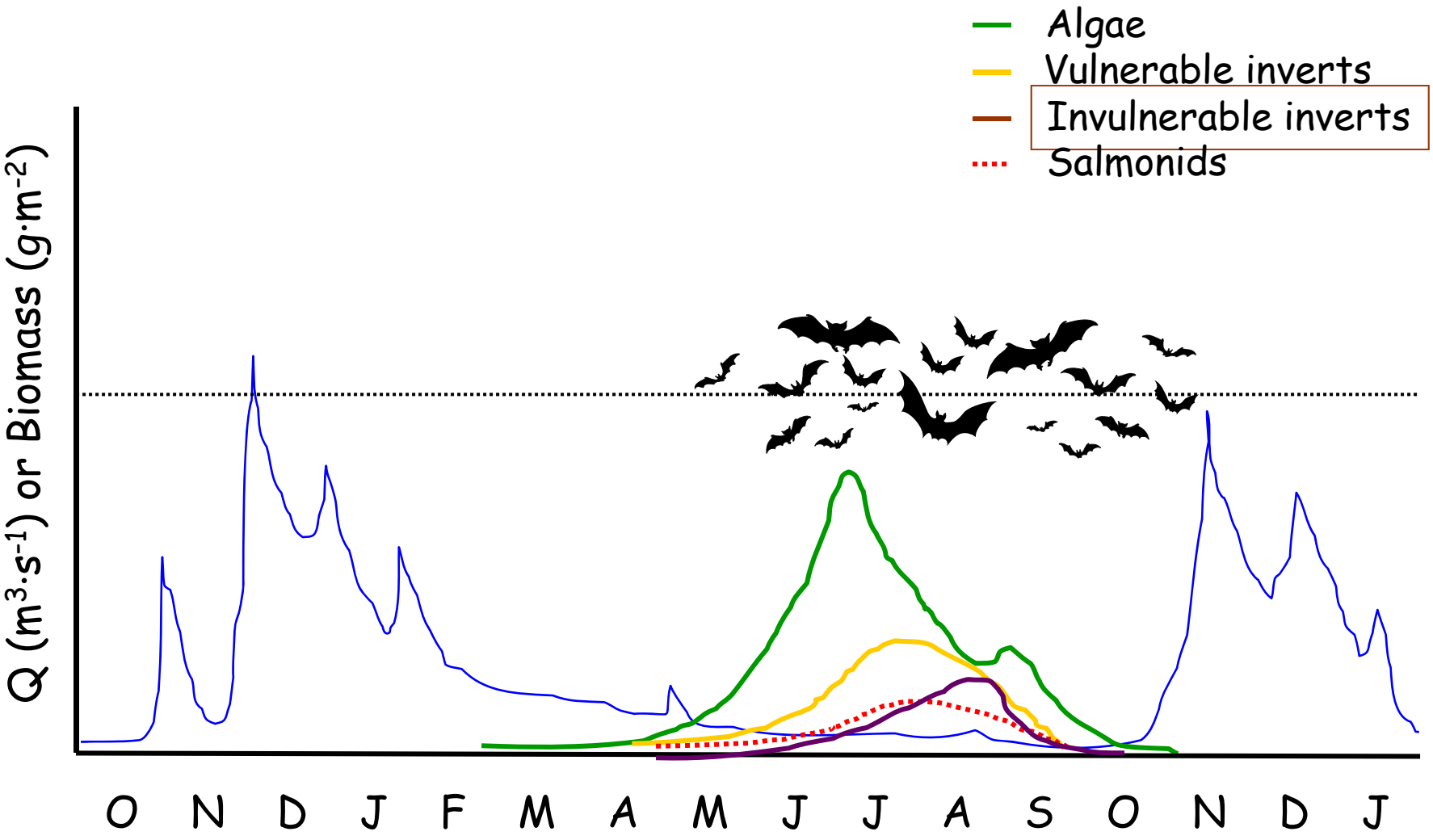


Jim Bishop- geochemist
Jill Banfield- geobiologist
Mary Firestone – soil microbiologist
Stephanie Carlson- river ecologist
Todd Dawson- tree physiologist
Sally Thompson- ecohydrologist
Inez Fung- atmospheric scientist
Mary Power- food web ecologist
Bill Dietrich- geomorphologist
Collin Bode data manager

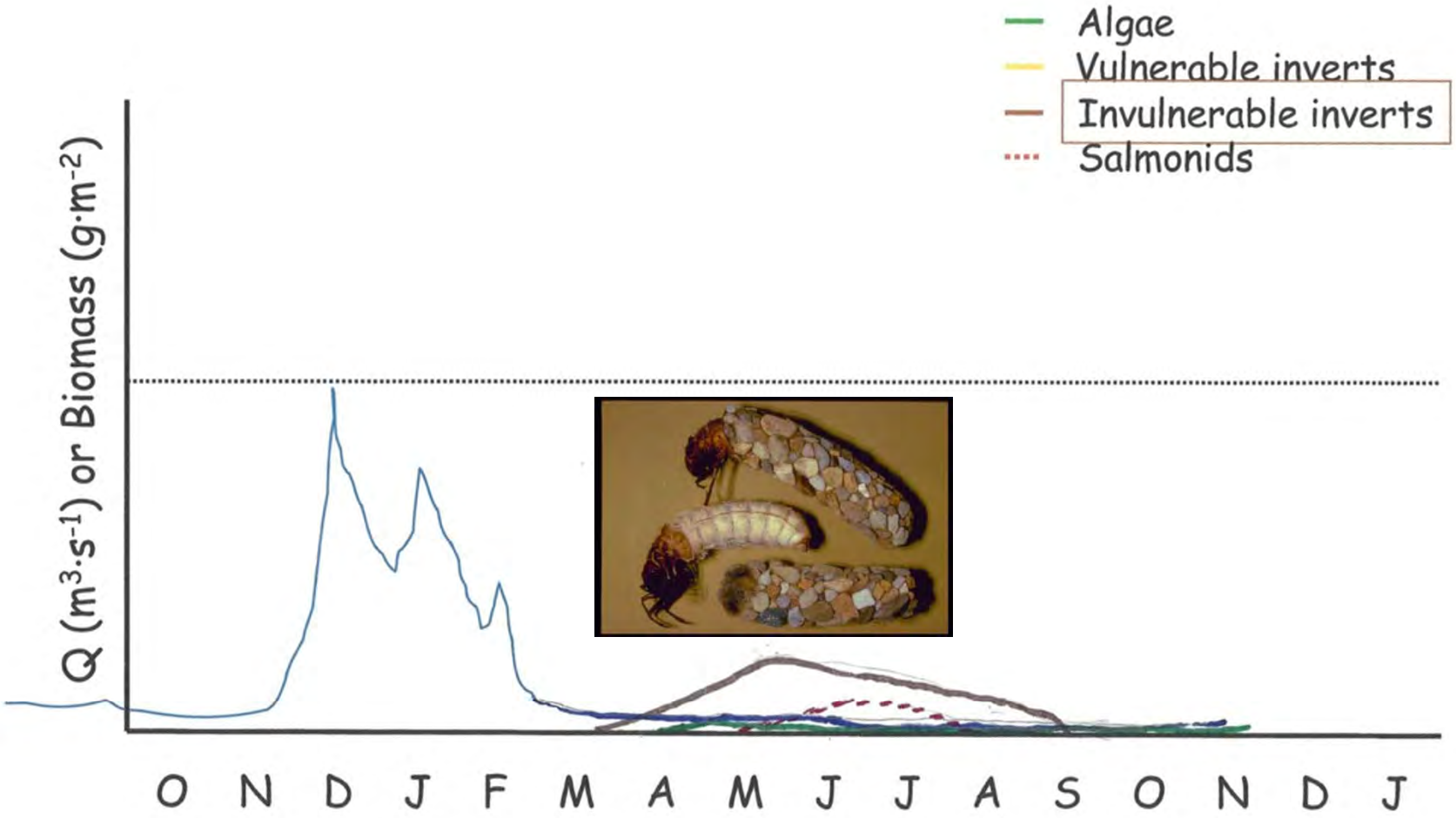
Making a killing or a living? Forest tending and sustaining cool flowing water in rivers during drought?

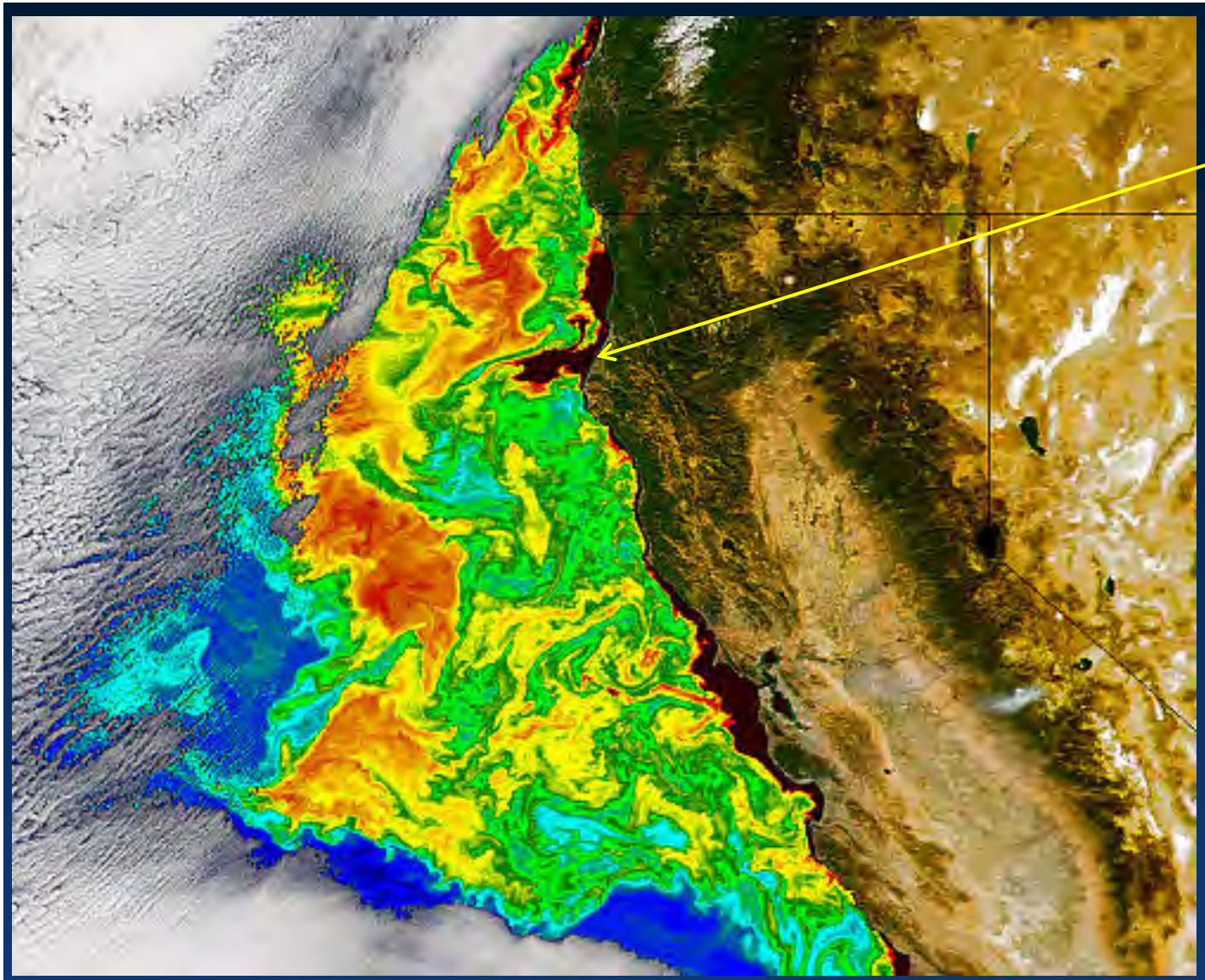
Karuk-Berkeley Consortium
Round Valley Tribes

'Typical' Mediterranean Seasonality



Drought (sub-bankfull scour) winter





Chlorophyll blooms off mouth of Eel River

Some out of synch with ocean upwellings

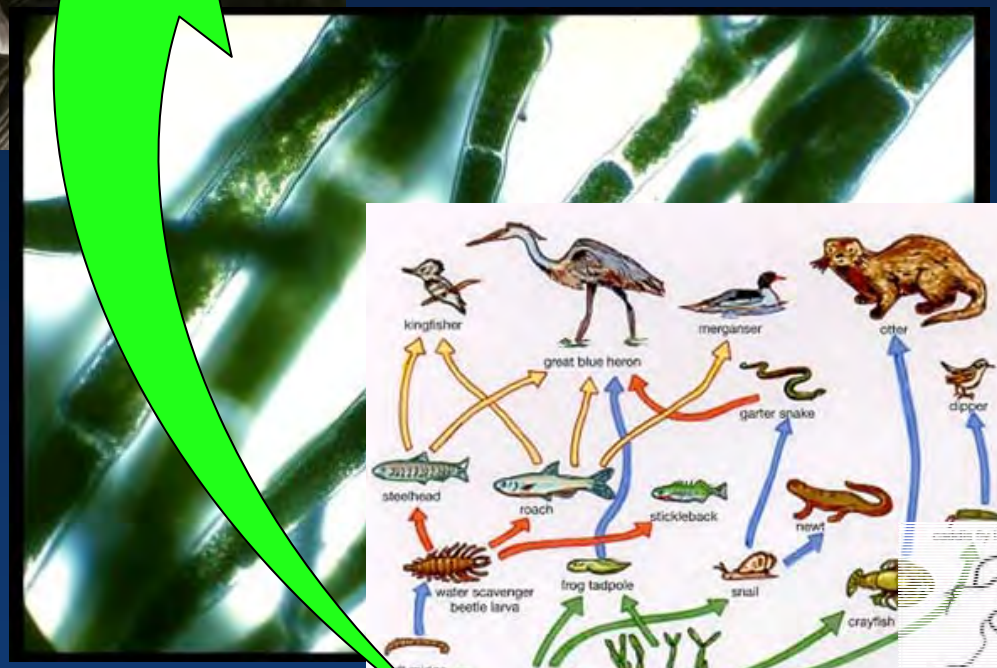
What do riverine algae deliver to coastal ocean?

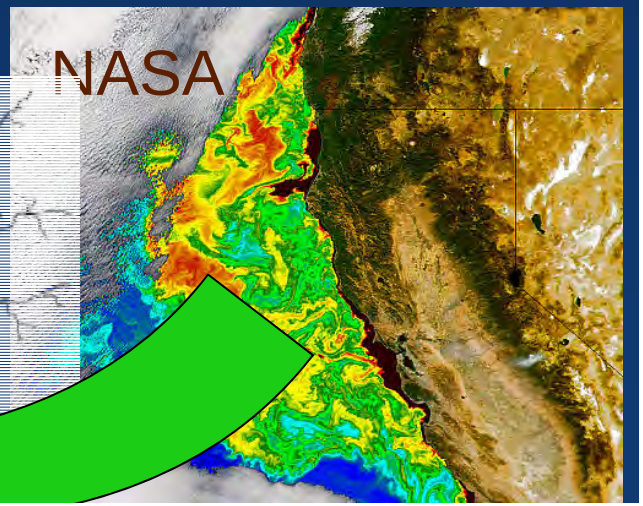
Will the amount and seasonality of affect algal-mediated river-to-ocean and river-to upland fluxes?

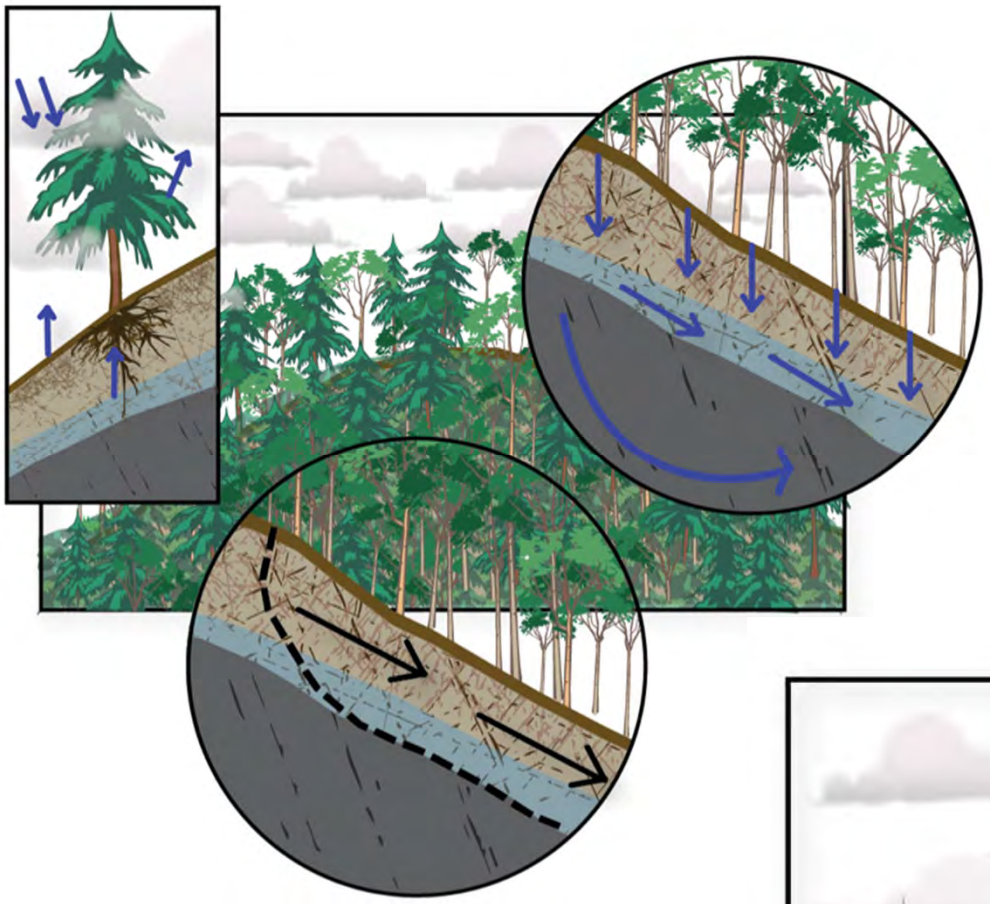
What does the Eel deliver to the ocean besides distilled water?

http://disc.sci.gsfc.nasa.gov/oceancolor

How much and what type of algae? Linked scales of controls and consequences...





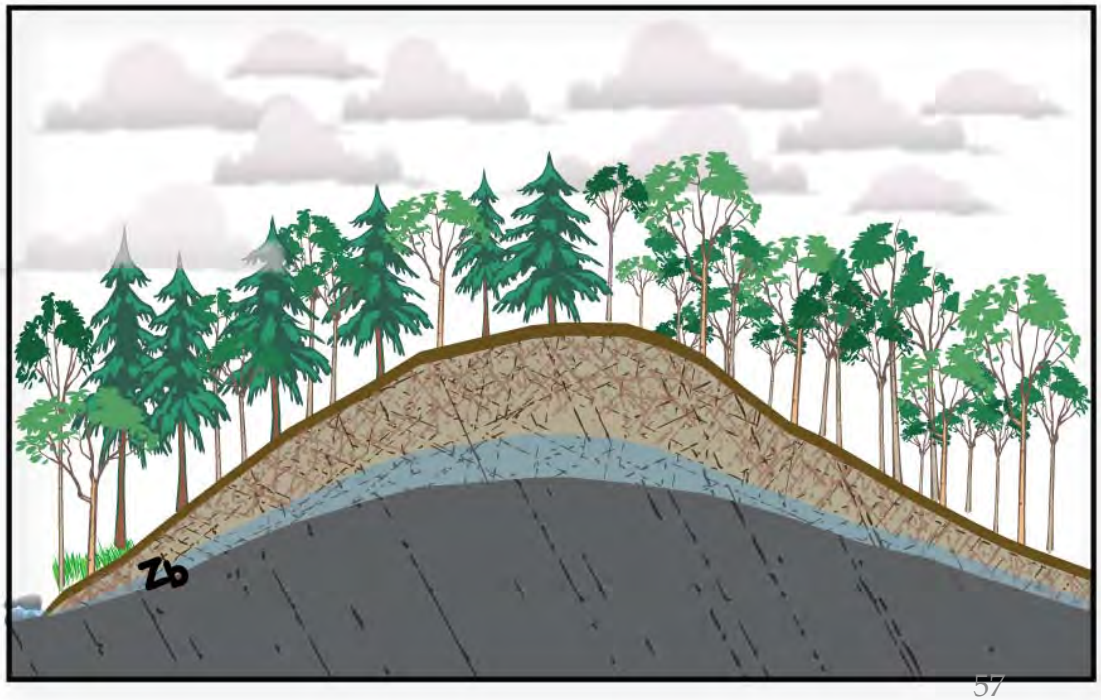


The hydrologic dynamics of hillslope interiors

Daniella Rempe
University of California, Berkeley

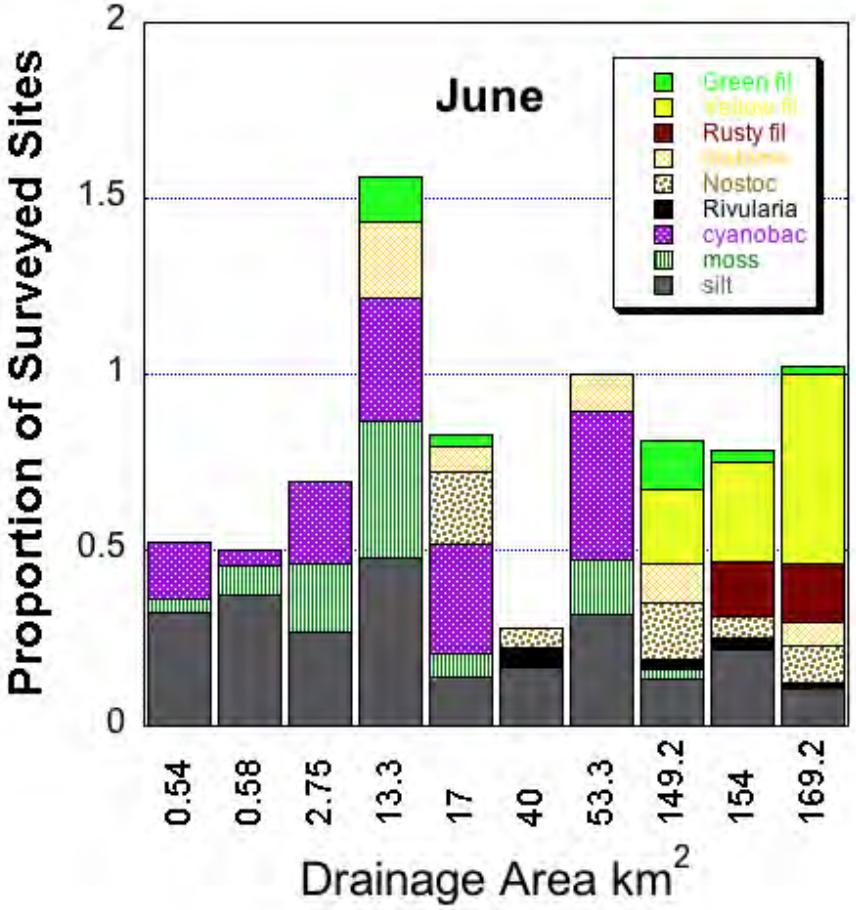
daniella.rempe@berkeley.edu

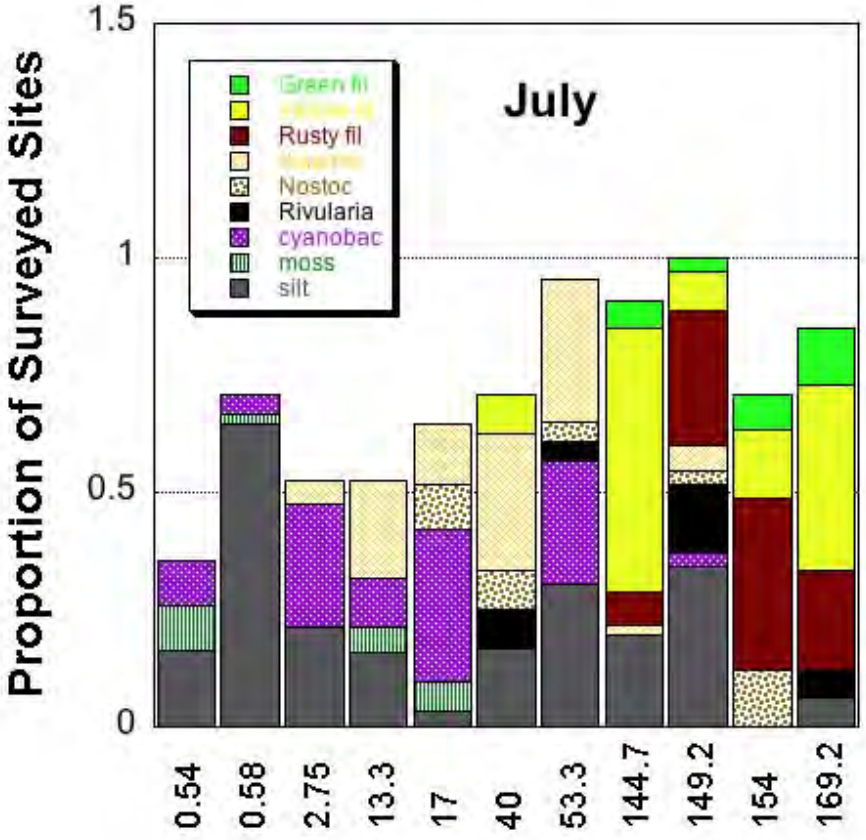
University of Texas, Austin
March 2015

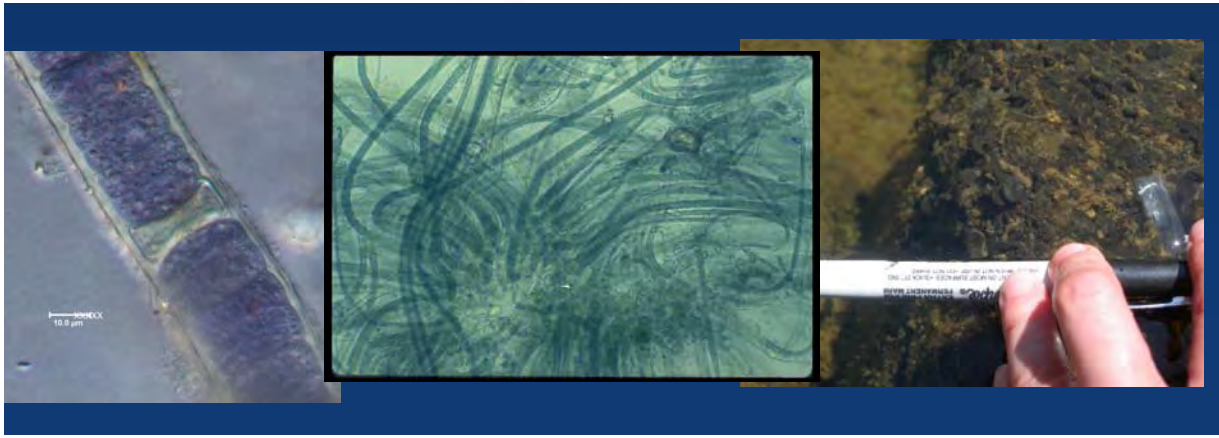



←Thanks Paula!!
←Thanks, Rex!!!


Sasquatch stole
my underpants
←Thanks, Rex!!!


June
Proportion of Surveyed Sites
Drainage Area km2
Green fil
Rusty fil
Nostoc
Rivularia
cyanobac
moss
silt
0
0.5
1
1.5
2
0.54
0.58
2.75
13.3
17
40
53.3
149.2
154
169.2


July
Proportion of Surveyed Sites
Green fil
Rusty fil
Nostoc
Rivularia
cyanobac
moss
silt
0
0.5
1
1.5
0.54
0.58
2.75
13.3
17
40
53.3
144.7
149.2
154
169.2



1st basinwide estimate: 24,000 kg y^{-1} N fixed by Eel River cyanobacteria.

****How much makes it to the sea?

Eel River

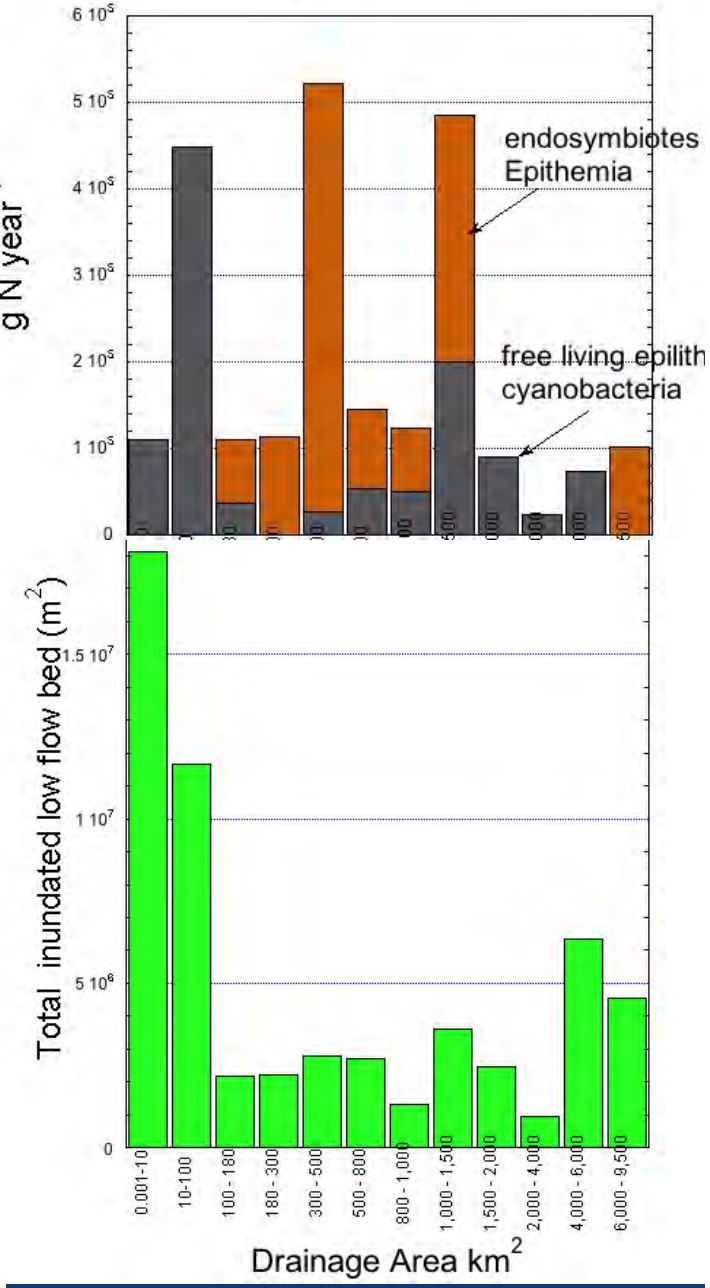
Drainage (Km^2)

- 100 - 180
- 180 - 300
- 300 - 500
- 500 - 800
- 800 - 1,000
- 1,000 - 1,500
- 1,500 - 2,000
- 2,000 - 4,000
- 4,000 - 6,000
- 6,000 - 9,534

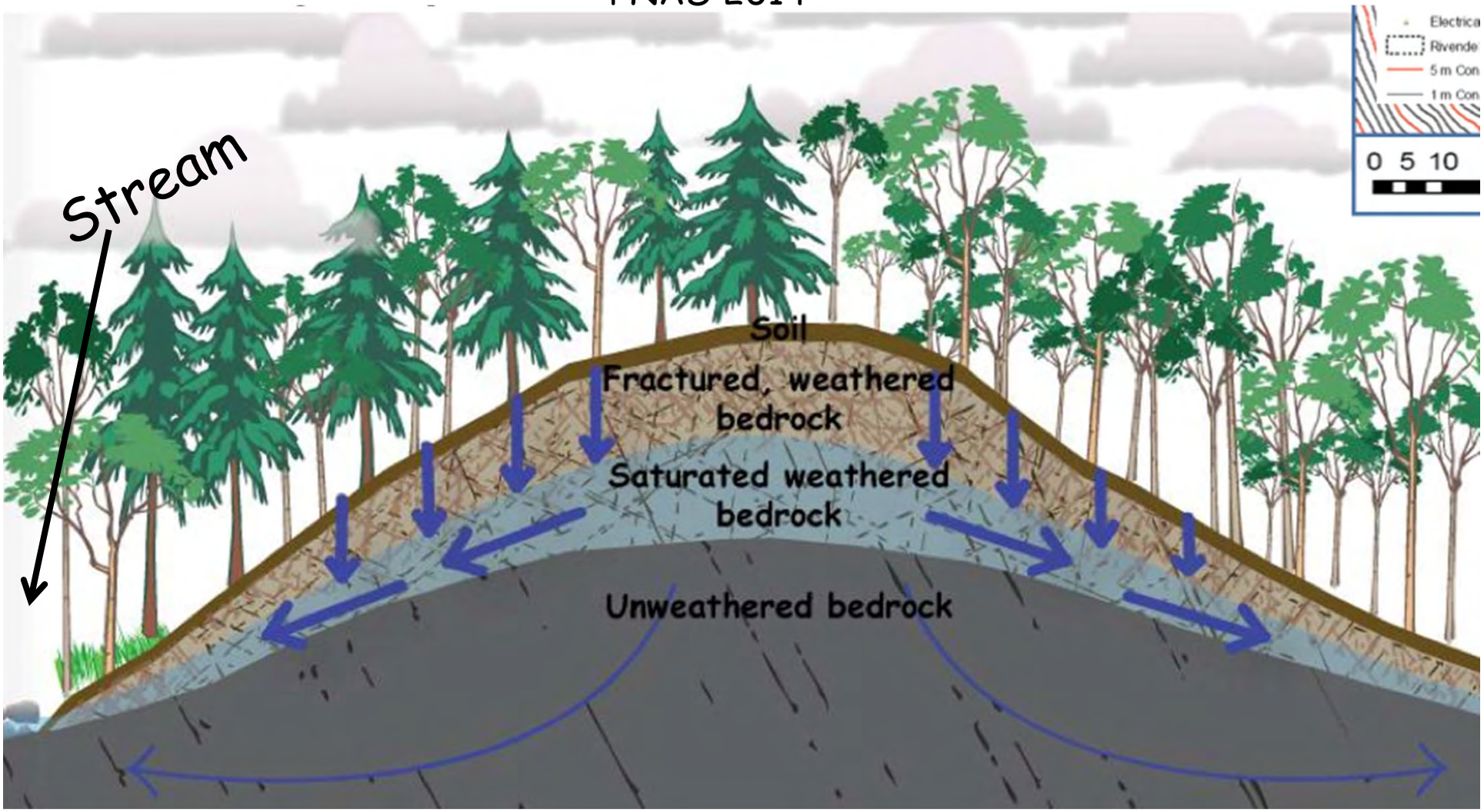
N W E S

20 10 0 20 Kilometers

Basinwide nitrogen loaded by cyanobacteria



Daniela Rempe, Bill Dietrich PNAS: a bottom up view of Critical Zone evolution and dynamics
PNAS 2014



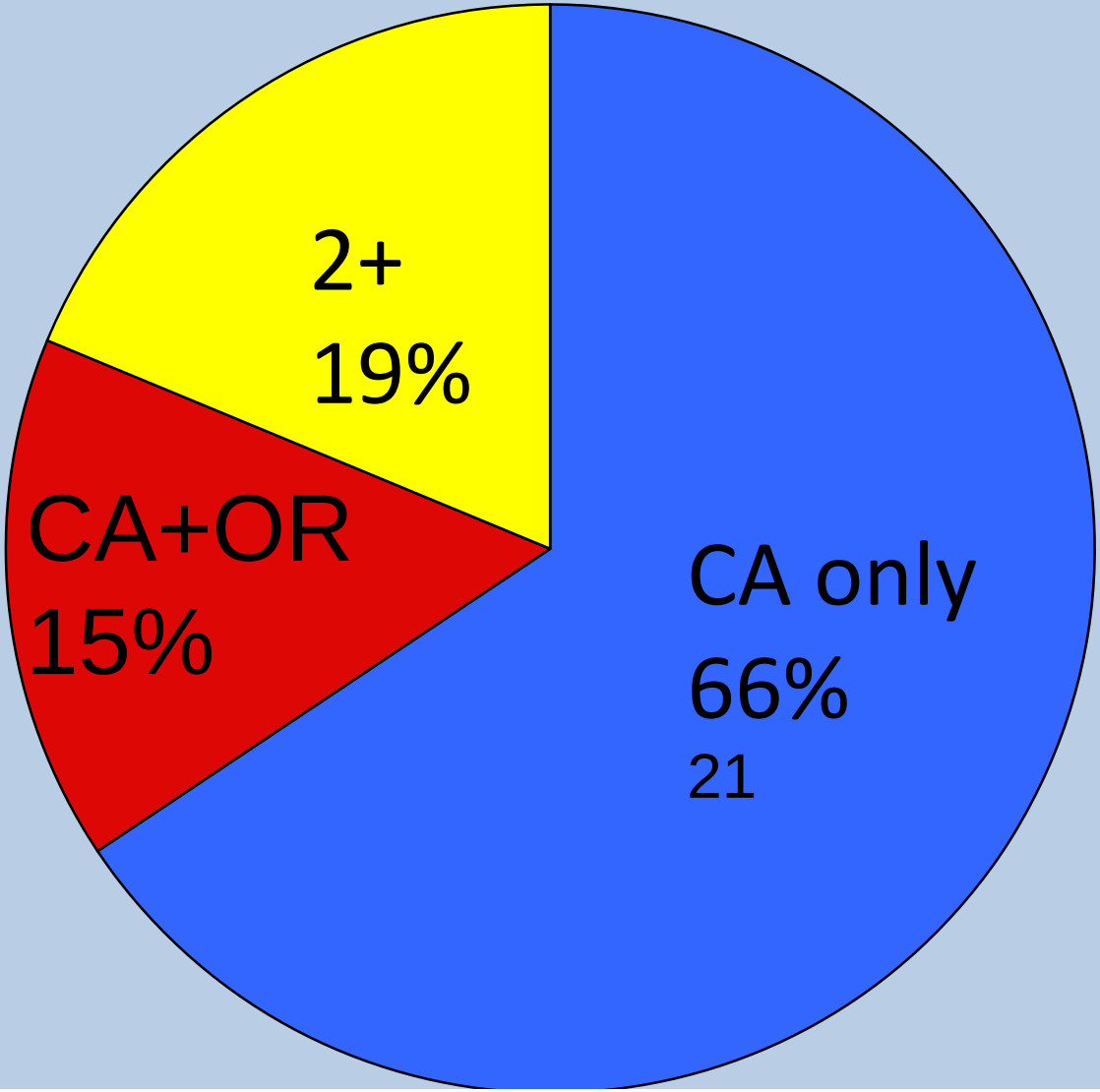
Extinction or Reconciliation: Alternative Futures for California salmonids

Peter B Moyle
Center for Watershed Sciences, UC Davis
SRF, April 8, 2016

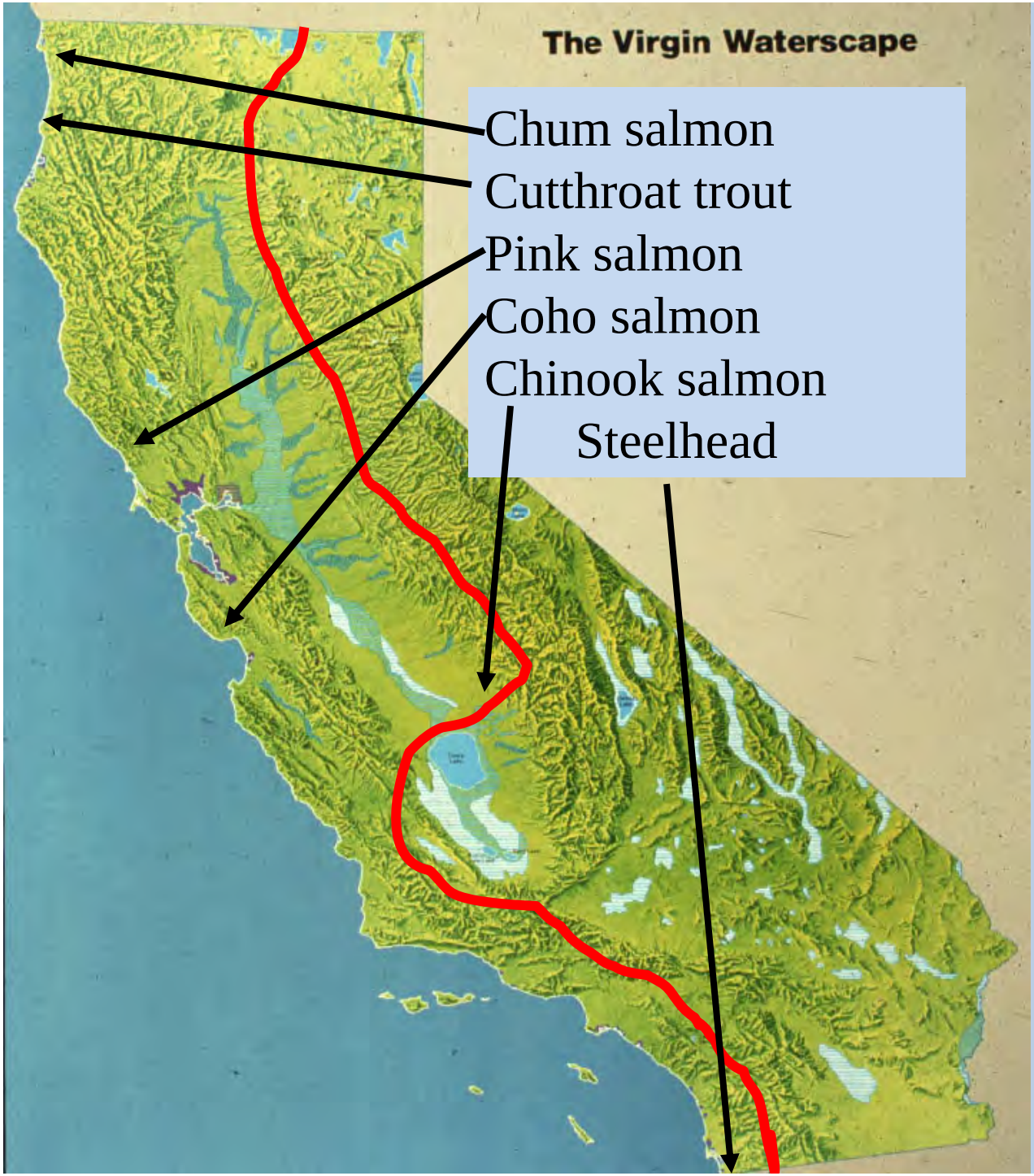
32 kinds of salmon and trout in California!

3 golden trout
3 rainbow/redband trout
3 cutthroat trout
12 salmon
8 steelhead
bull trout
mountain whitefish

Most of California's 32 salmonids are found ONLY in California

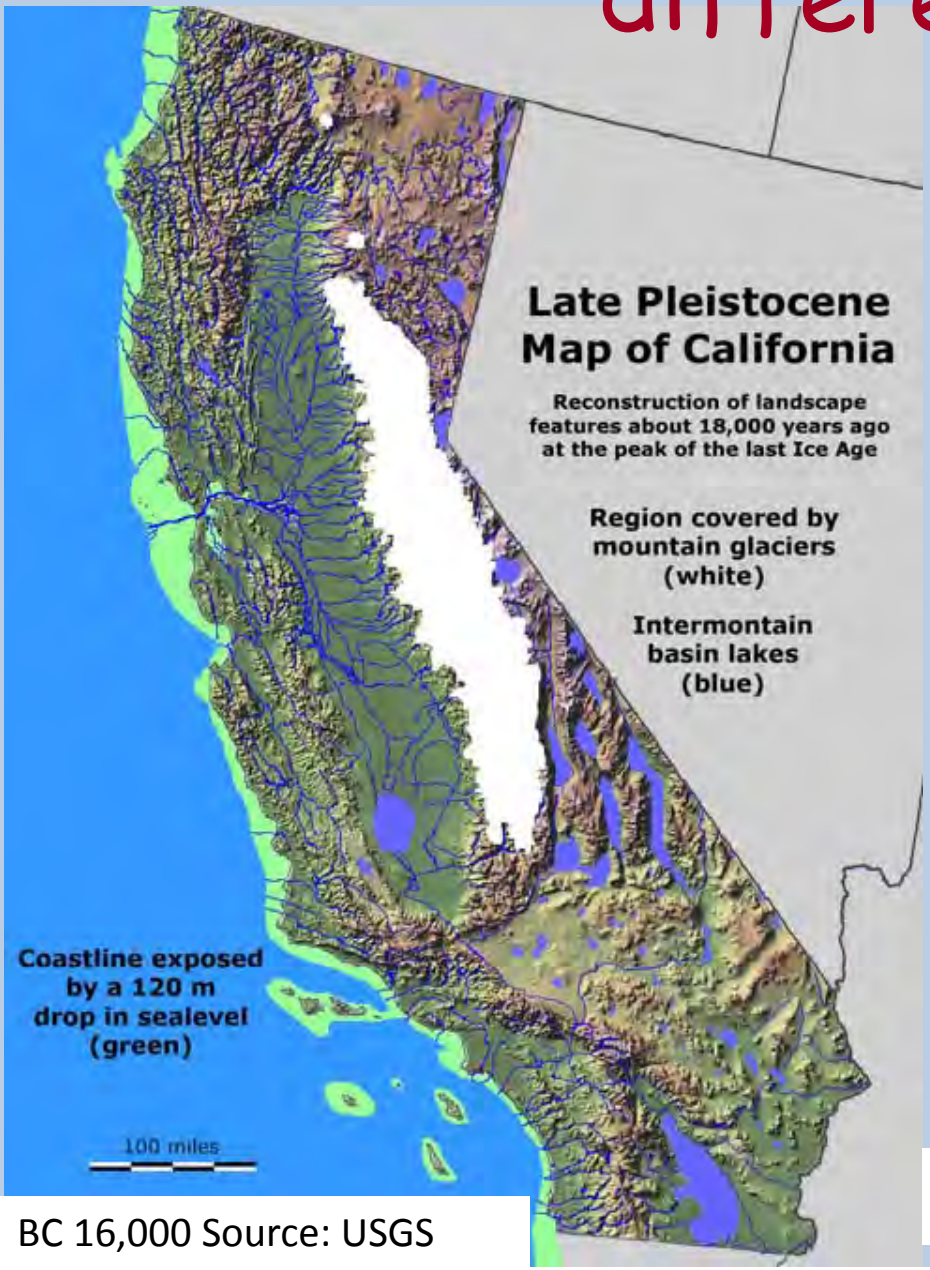


81%
endemic



California has southernmost populations of many species

CV Salmonids adapted to a different CA



BC 16,000 Source: USGS

Satellite photo 1851, Mark Snyder

Salmon, Steelhead, and Trout in California

Status of an Emblematic Fauna

A report commissioned by California Trout, 2008

November 2008

PETER B. MOYLE, JOSHUA A. ISRAEL, AND SABRA E. PURDY

CENTER FOR WATERSHED SCIENCES,

UNIVERSITY OF CALIFORNIA, DAVIS

DAVIS, CA 95616

UCDAVIS

Center for Watershed Sciences

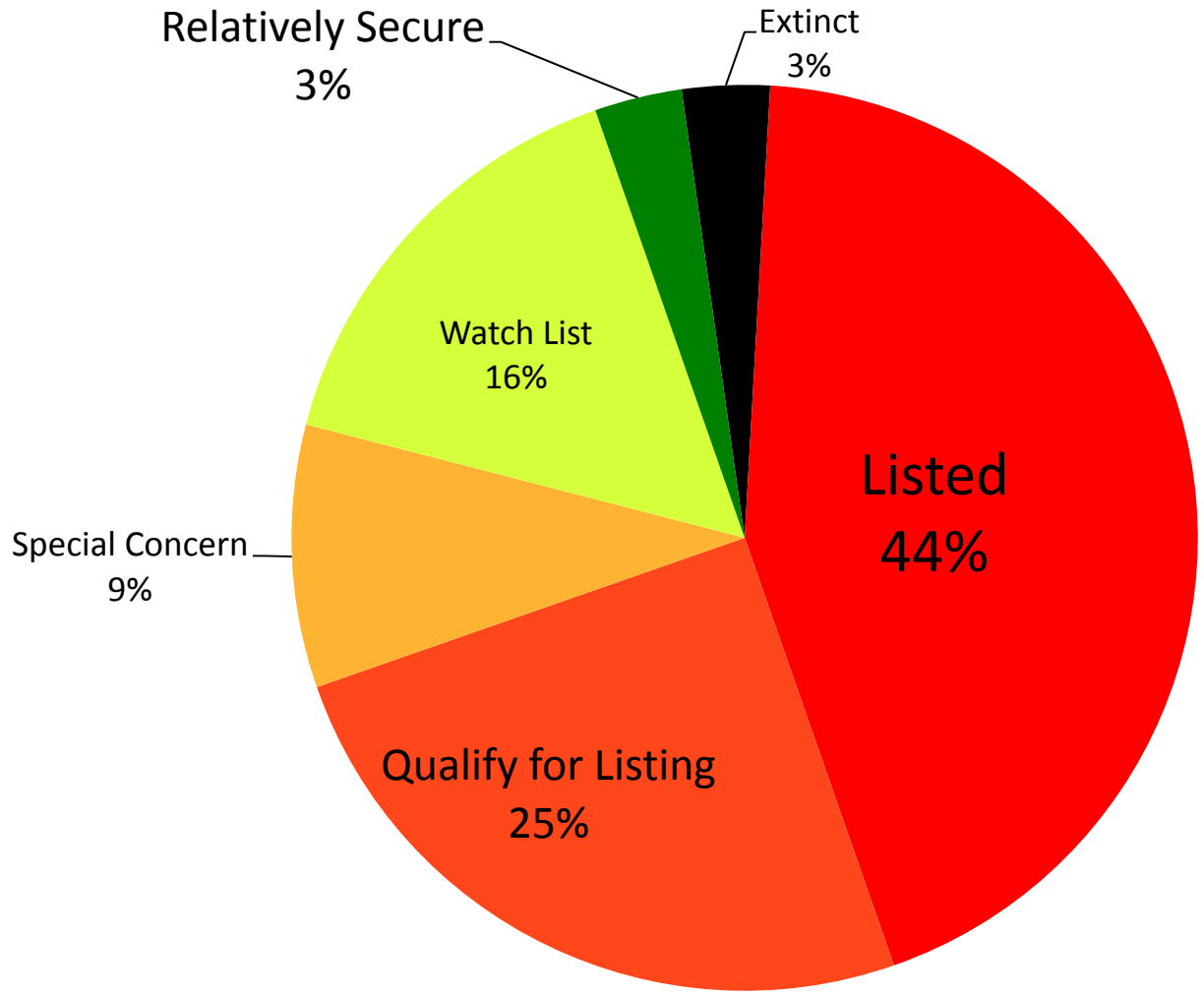
Beyond Conservation: New knowledge for a new era of river restoration and management.

CALIFORNIA TROUT

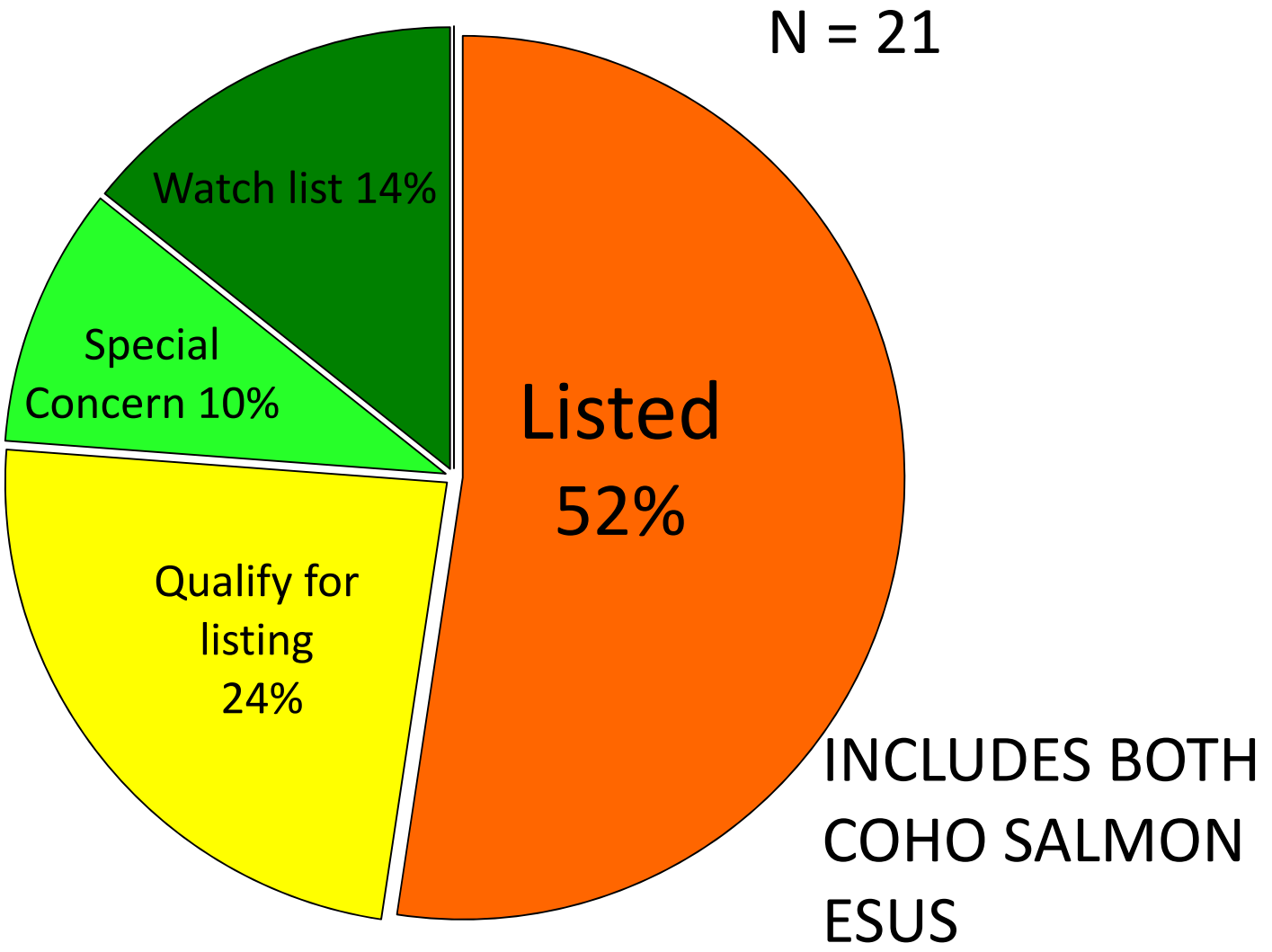
FISH · WATER · PEOPLE

STATUS OF CALIFORNIA SALMONIDS, N = 32

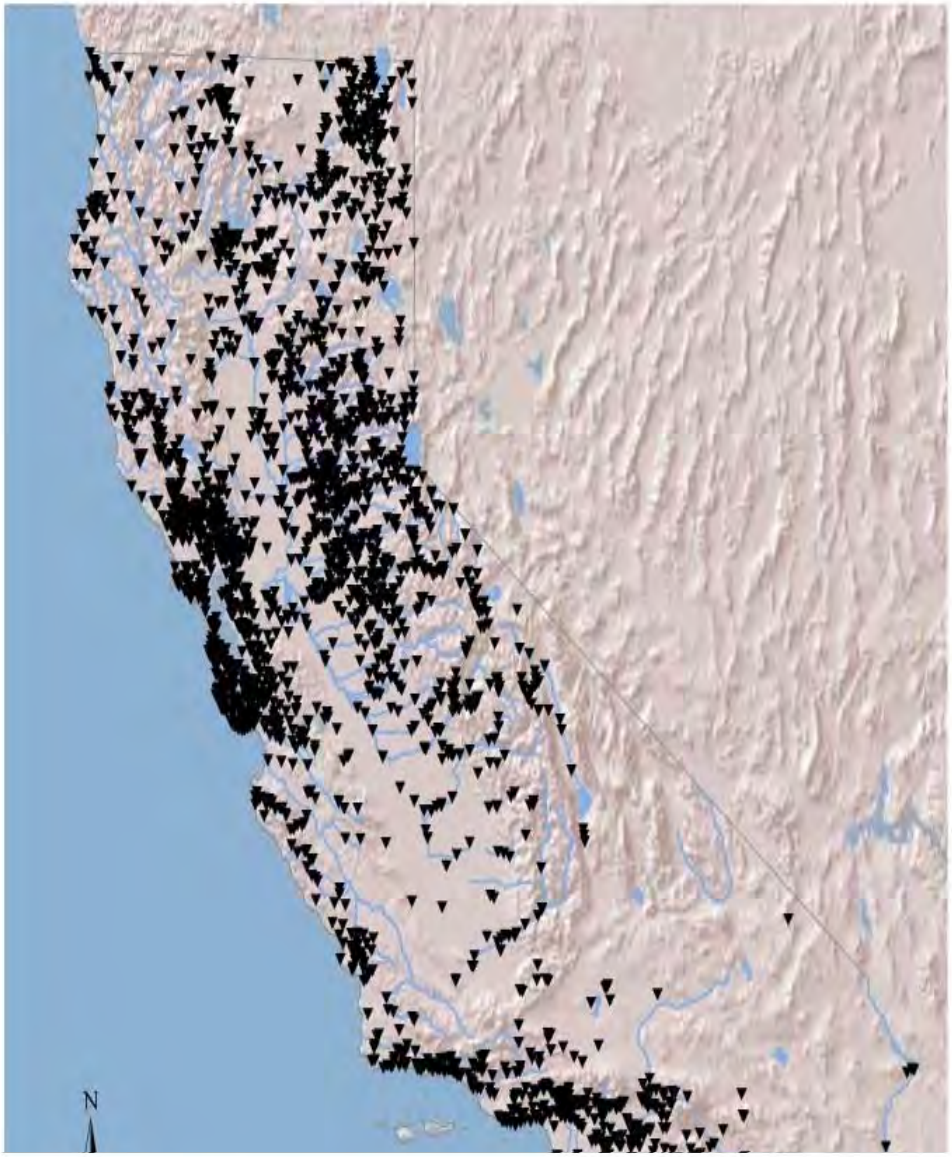
Anadromous 21, Non-anadromous 11



ANADROMOUS CA SALMONIDS



Change in salmonid status 2007-2016



Competition for water

1440

‘large’ dams (1.8+ m)

753 potentially harming fish

250 more than 20 m high

Grantham et al. 2014

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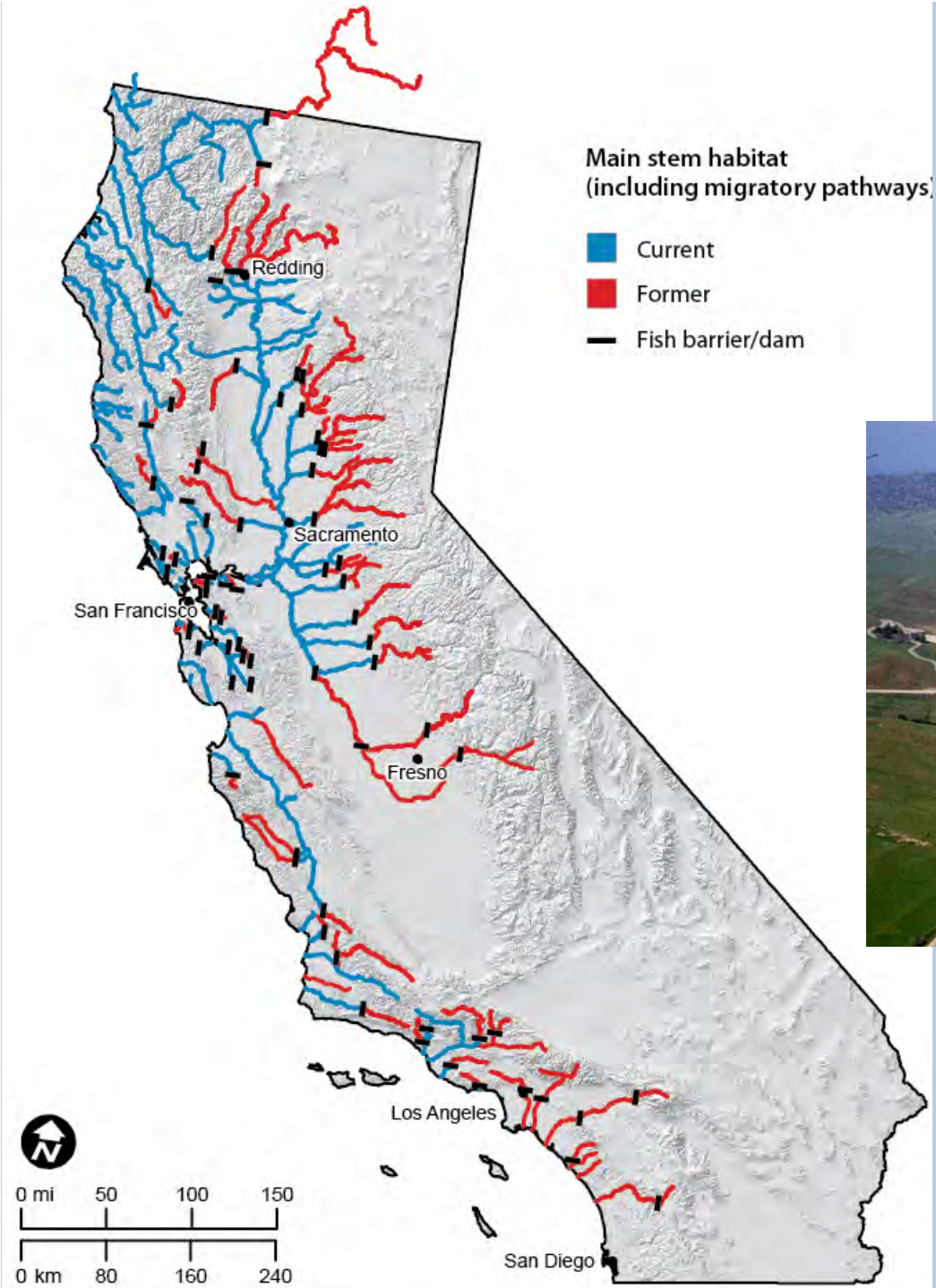
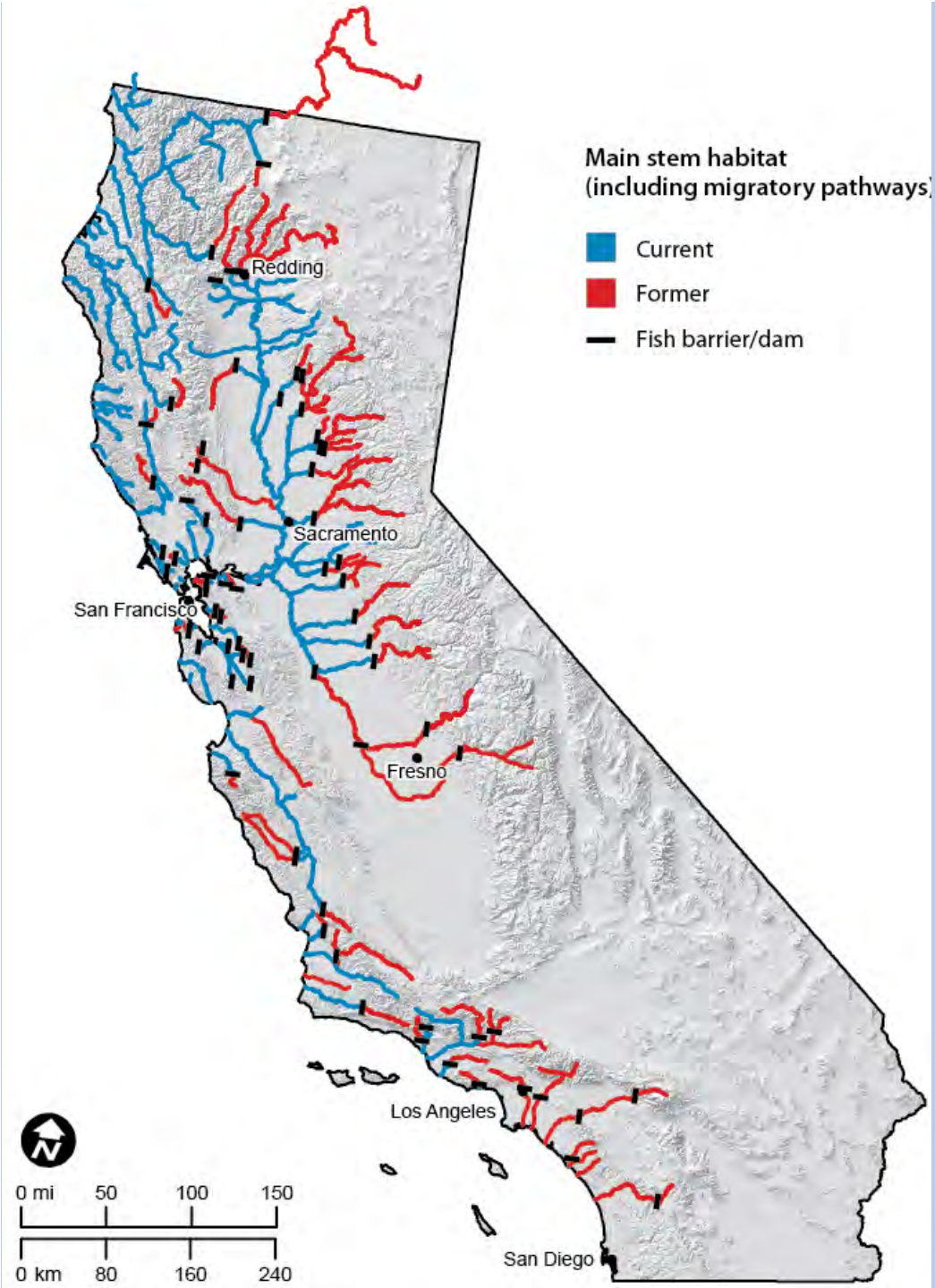


SALMON & STEELHEAD:

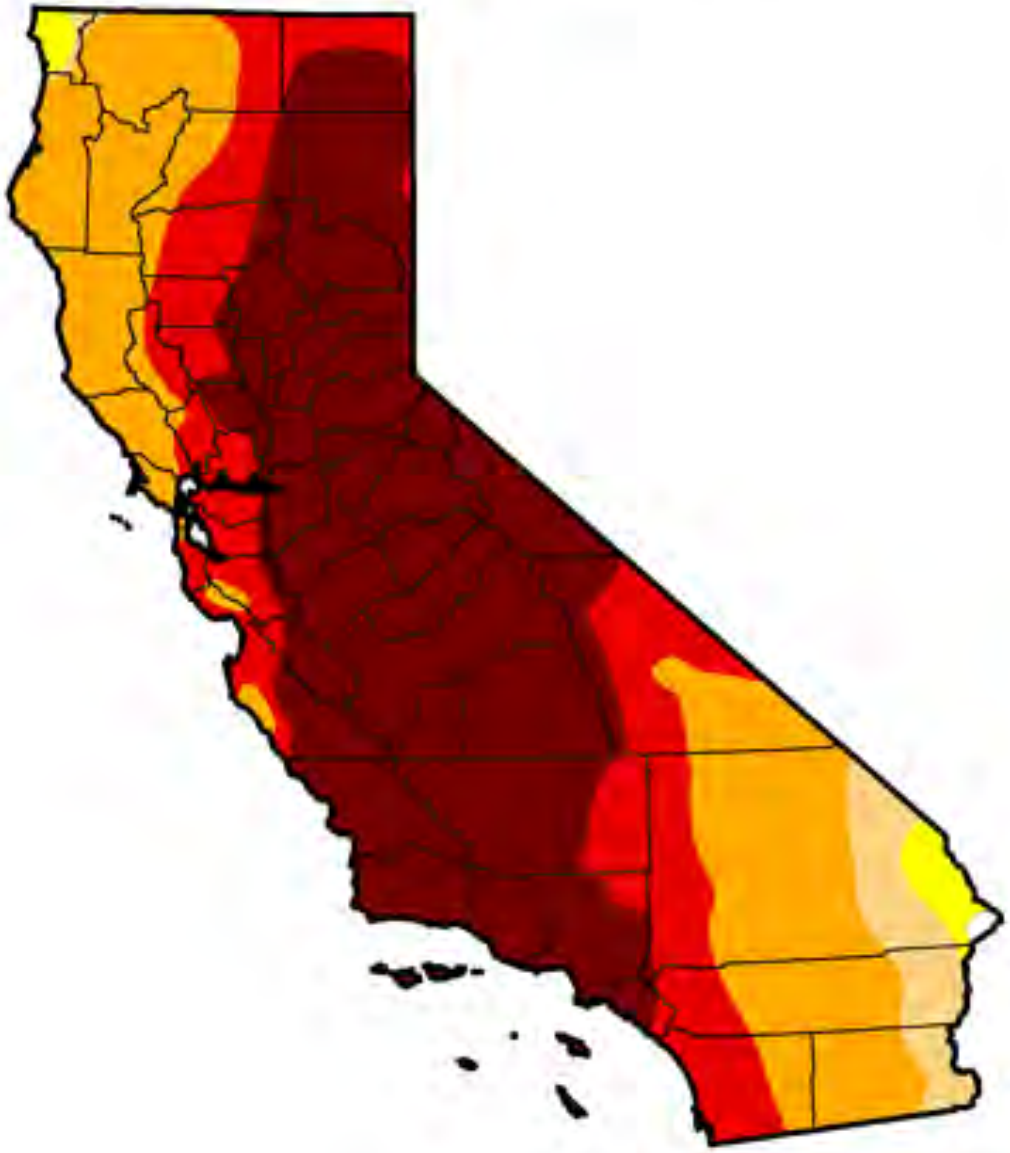
70% of habitat lost



Other factors

Climate change
Land use
Diversions
Hatchery practices
Contaminants
Alien species
Disease
Etc...

U.S. Drought Monitor
California



May 5, 2015
(Released Thursday, May. 7, 2015)
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.14	99.86	98.28	93.91	66.60	46.77
Last Week 4/28/2015	0.14	99.86	98.11	93.44	66.60	46.77
3 Months Ago 2/3/2015	0.16	99.84	98.13	93.57	77.46	39.99
Start of Calendar Year 12/30/2014	0.00	100.00	98.12	94.34	77.94	32.21
Start of Water Year 9/30/2014	0.00	100.00	100.00	95.04	81.92	58.41
One Year Ago 5/6/2014	0.00	100.00	100.00	95.93	76.68	24.77

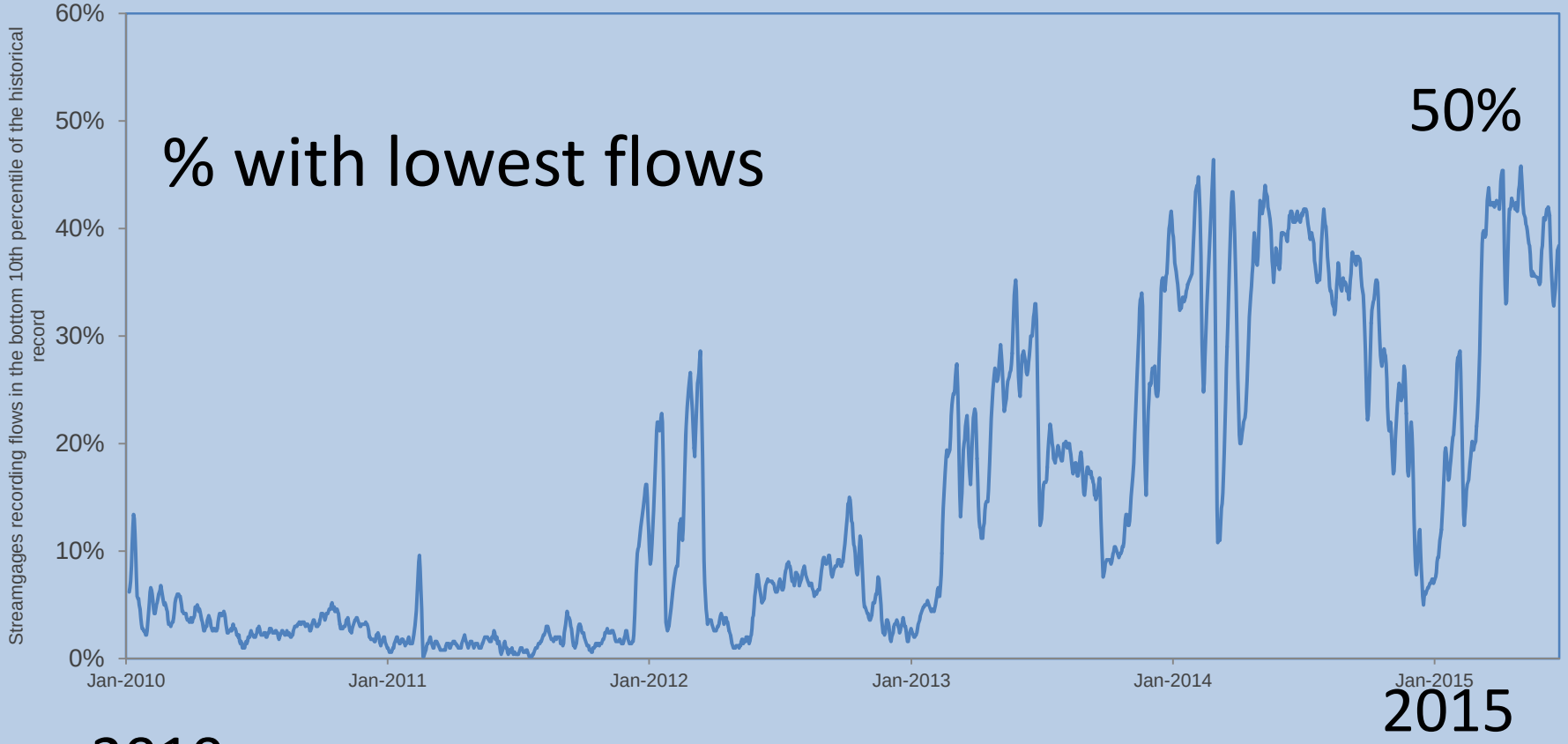
Intensity:

- 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.

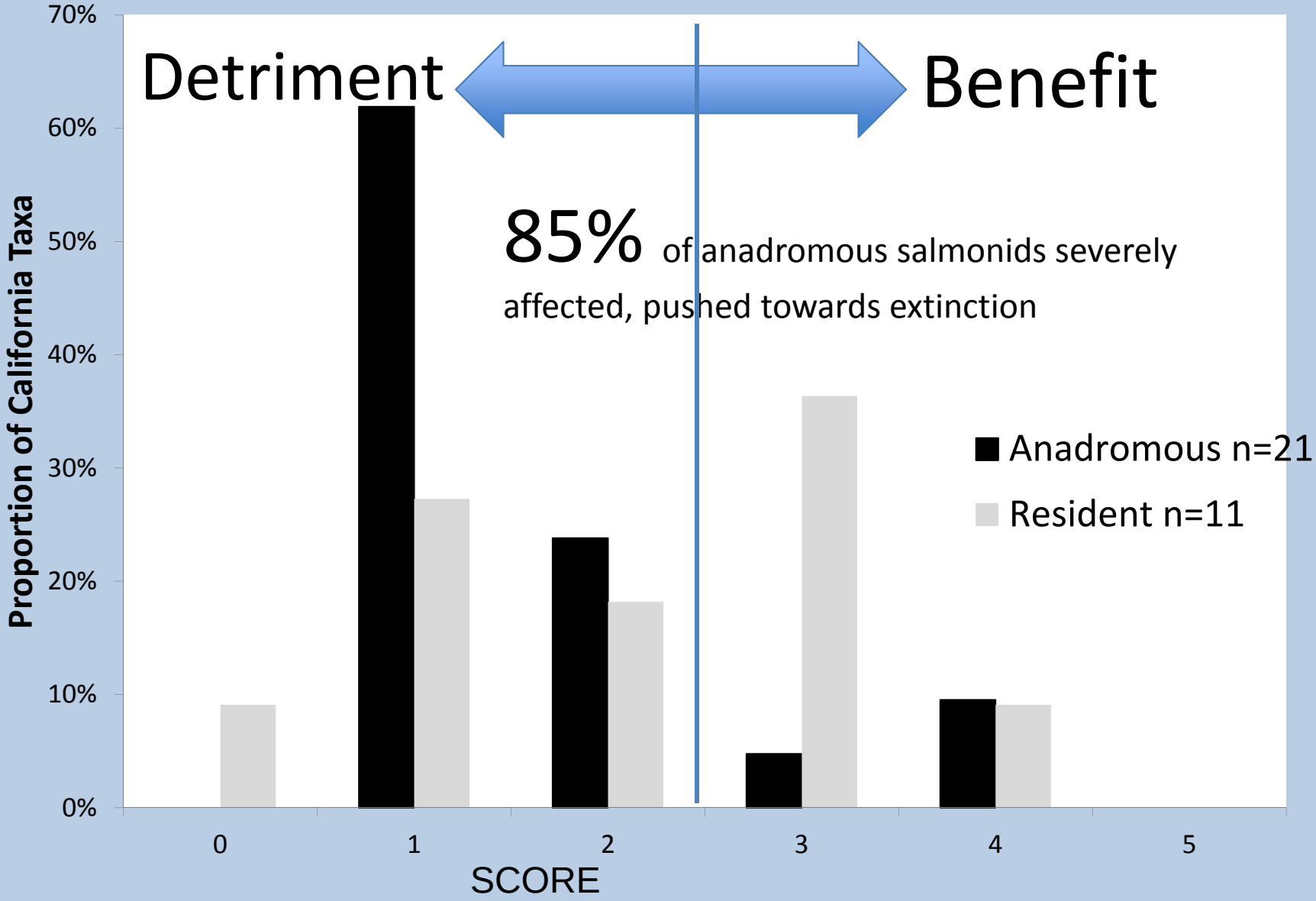
Author:
Mark Svoboda
National Drought Mitigation Center

http://droughtmonitor.unl.edu/



40+% CA stream gages recording flows in lowest 10% of historic flows (PPIC 2015)

Climate change effects: salmonids



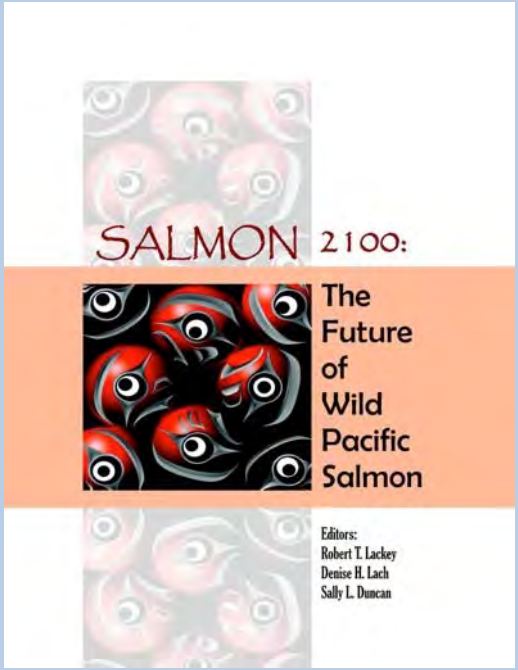
EXTINCTION HAPPENS !

Bull trout, *Salvelinus confluentus*

2ND TO LAST BULL TROUT CAUGHT, 1975

What should we do?

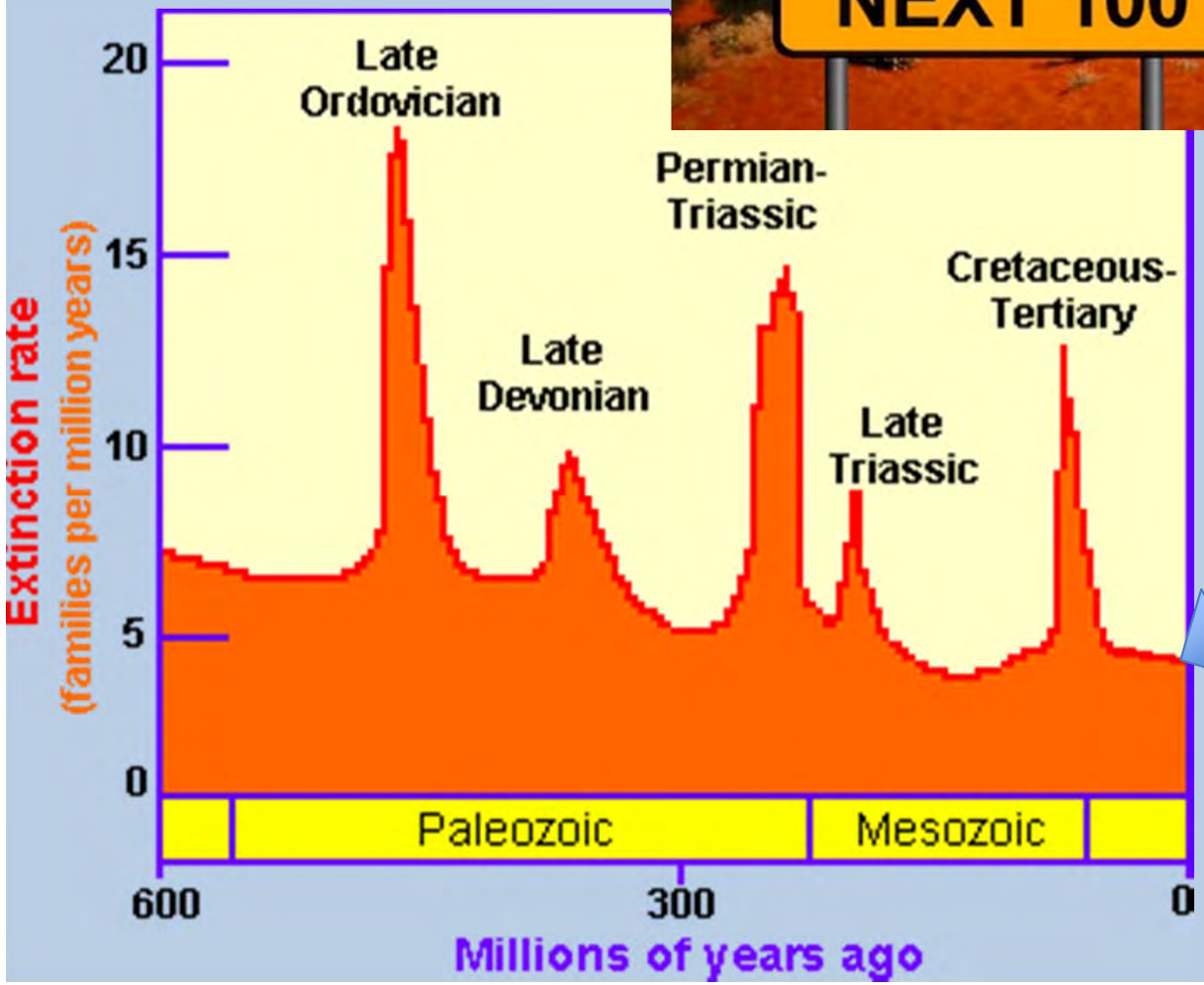
"Most experts concluded that by 2100 wild salmon in the Central Valley will be extirpated or minimally abundant if current trends continue."
Franks and Lackey 2015, OSU



Forecasting the Most Likely Status of Wild Salmon in the California Central Valley in 2100

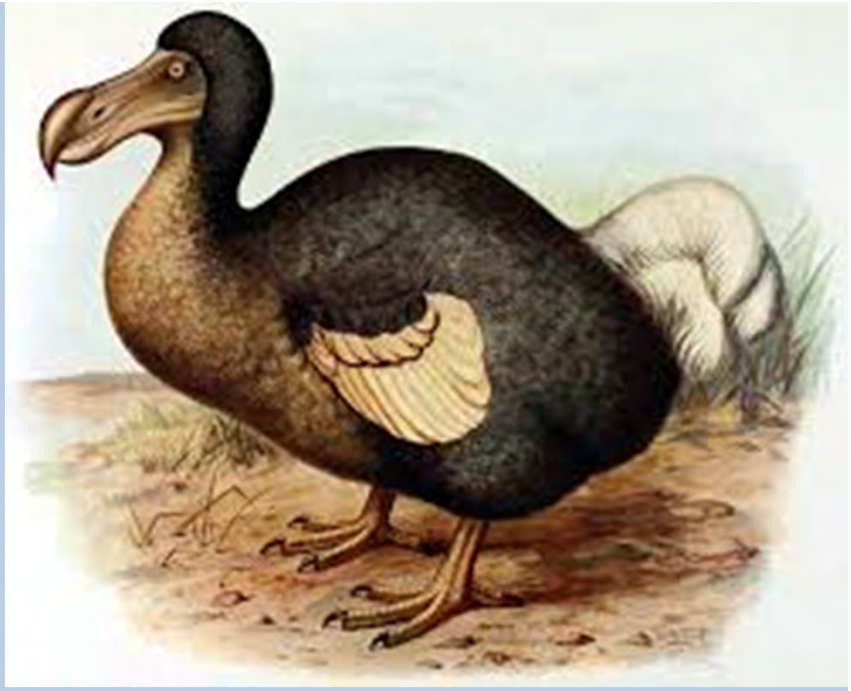
Extinction vs. Reconciliation

Alan Harthorne Friends of Butte Creek



Sixth Mass Extinction Starting

Extinction



- What is it?
- How is it declared?
- How should it be determined?
  - A proposal.

What is extinction?

1. Conservation reliance
2. Regional extinction
3. Extinct in native range
4. Extinct in th wild
5. Visual extinction
6. Complete (global) extinction

Regional Extinction

- Species that are still extant, but extinct (extirpated) from a geographically defined part of range.

BULL TROUT

Conservation reliant species

- Species that depend on continuous human intervention to sustain populations.
- Extinct without human help.

Winter run Chinook salmon

Extinct in Wild

- A species that is entirely maintained by captive populations with no self-sustaining presence in natural environment. Extreme conservation reliance.

Eagle Lake rainbow trout (more later)

Extinct in native range

- Still extant as wild populations but absent from native range; all populations the result of introductions outside native range.

Sacramento perch

Visually extinct species

- Species so rare no one sees them any more; unverified extinction.

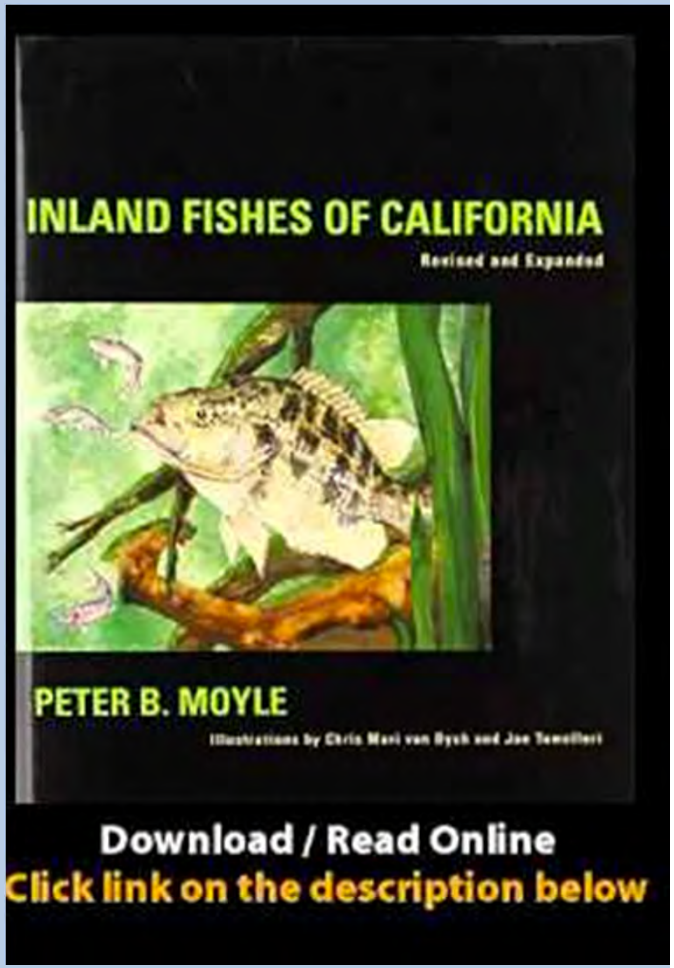
IUCN (1994): a species is extinct “when there is no reasonable doubt the last individual has died.”

Global (absolute) extinction

- A species which is no longer present in wild or in captive populations on planet Earth.

How is extinction be determined?

- No widely accepted criteria
- Consensus of experts
- Reported in literature
  - Inland Fishes of California

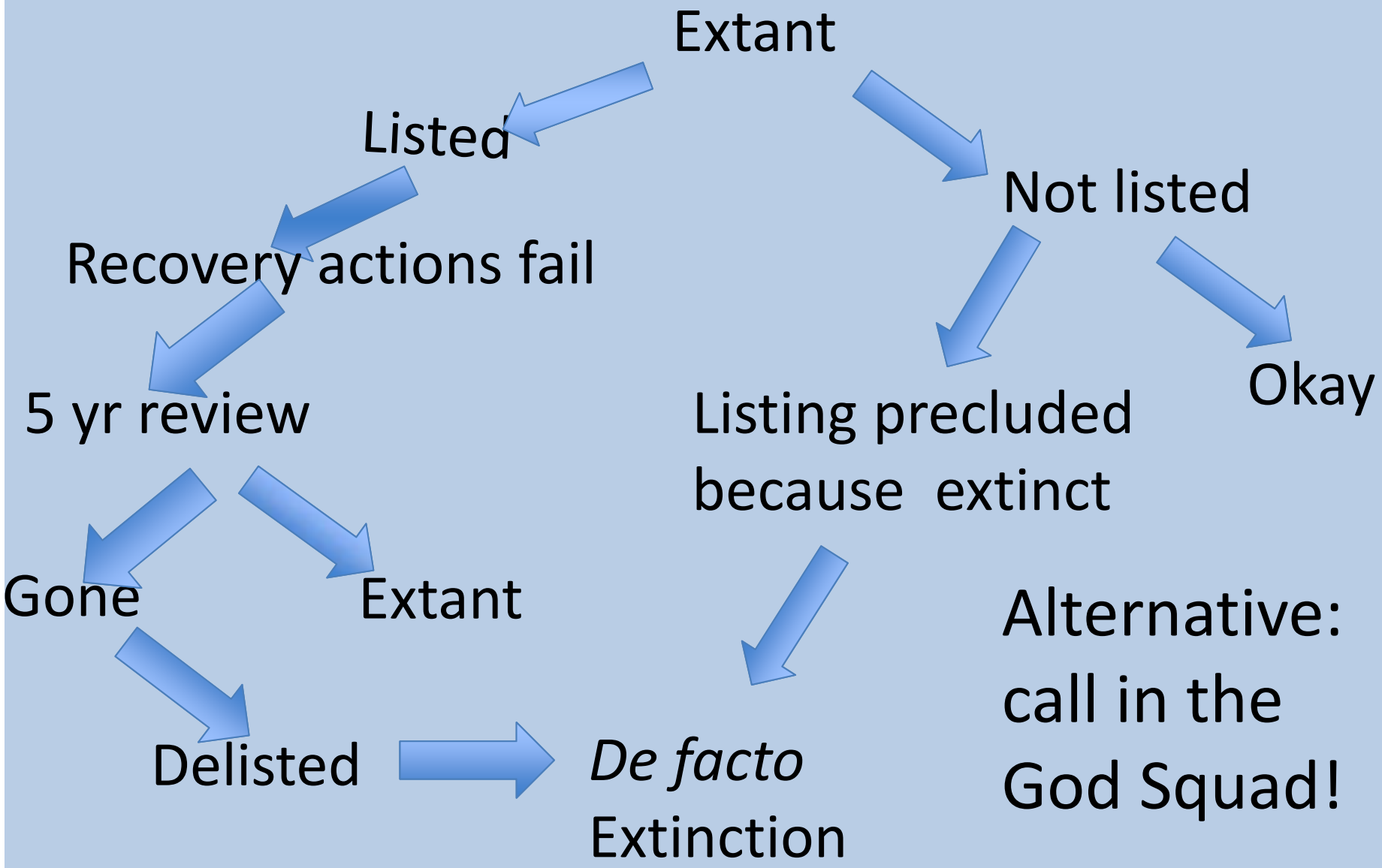


- IUCN: 50 years of no detection
- USFWS (informal): 20 years

How is global extinction deterimined officially?

1. Species listed under state and federal ESAs
2. Recovery actions fail
3. 5 year review: determined not to be extant
4. Delisted (de facto extinction)
5. Feds: Director of USFWS approves decision
6. State: CDFW petitions Fish and Game Commission

How extinction is declared



How should extinction be determined? A **proposal** for fish in CA

1. Take all recovery actions
    1. Including extreme measures
    2. Until they fail
2. Determine absence from routine surveys
3. Do intensive surveys in likely & unlikely places
4. Go back to routine surveys for x generations
5. Determine likelihood it is still extant
6. Present findings to Multiagency Committee
7. Committee makes recommendation to director of CDFG or Fish and Game Commission
8. Governor declares extinction

1. Take all recovery actions
ordinary and extraordinary

Sacramento winter run Chinook salmon

2. Absence from routine surveys

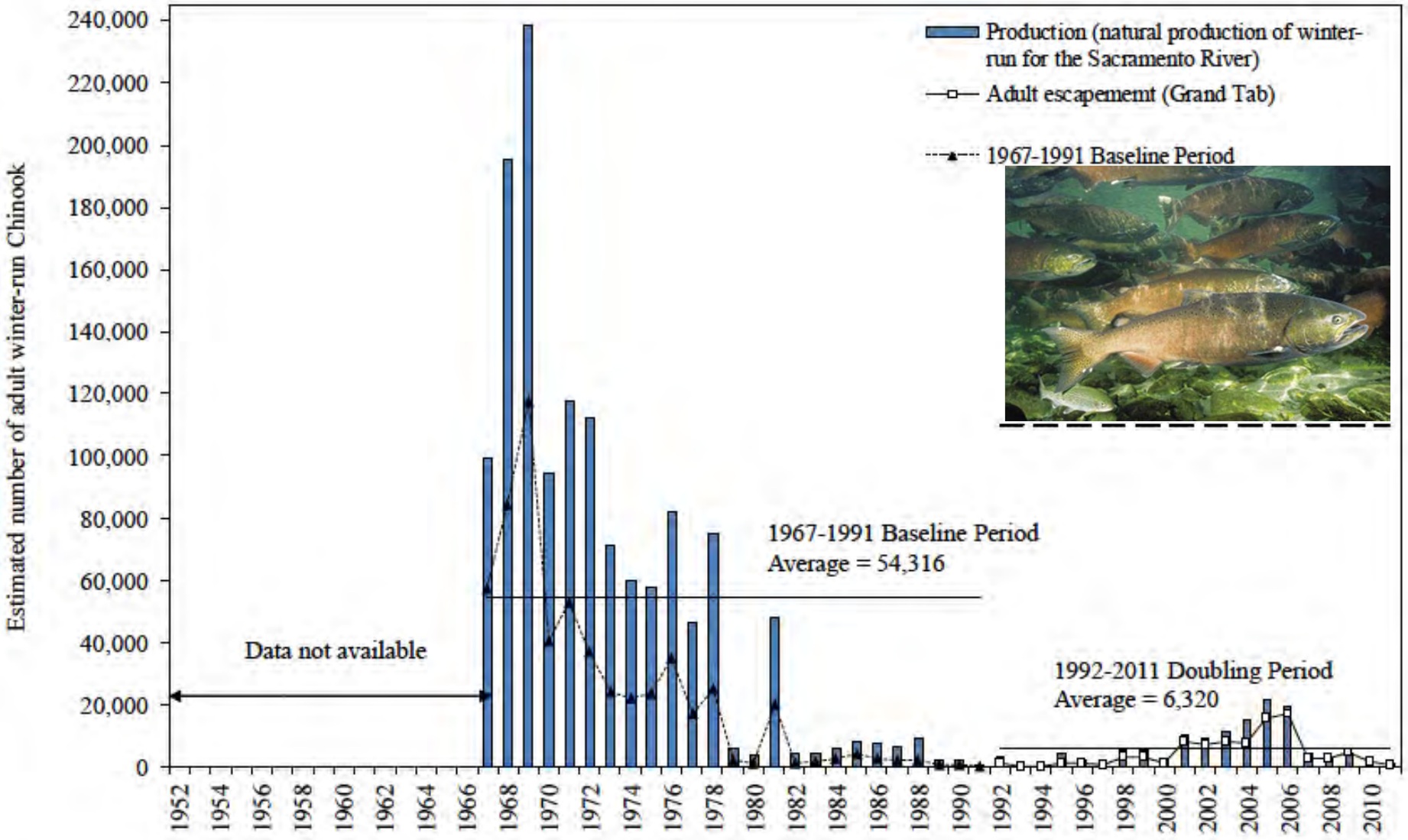
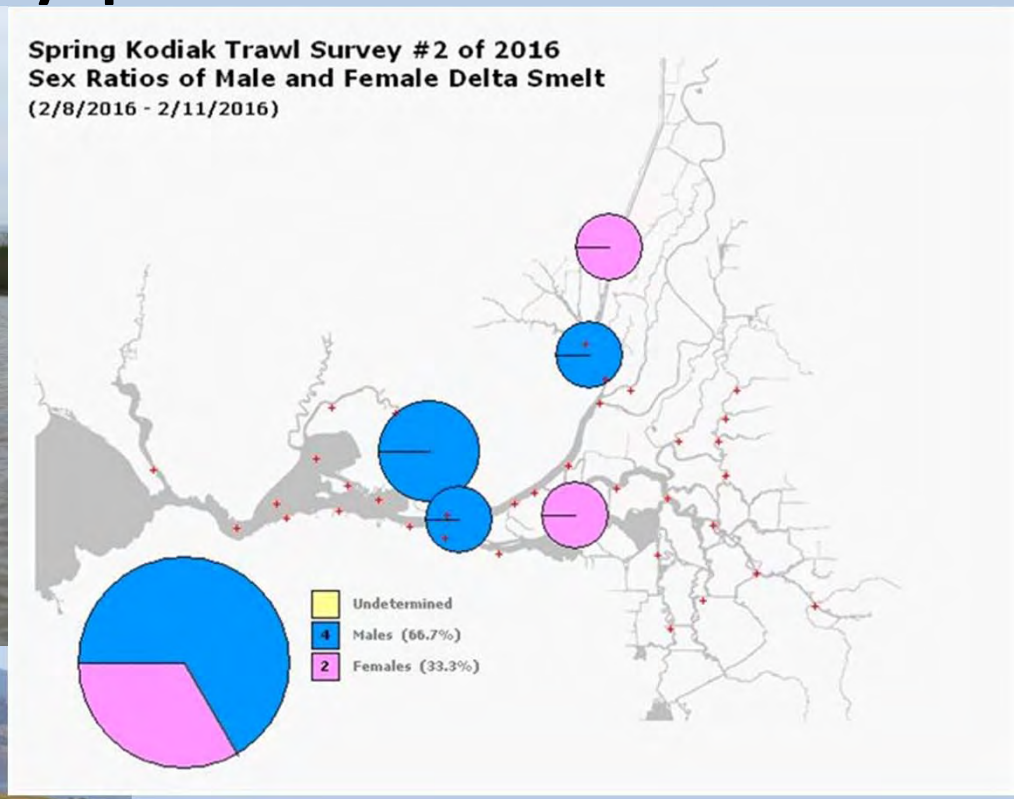


Figure 8. Estimated yearly adult natural production, and in river adult escapements for above RBDD mainstem Sacramento River winter-run Chinook salmon. 1992 - 2011 numbers are from CDFG Grand Tab (Apr 24, 2012). 1967-1991 Baseline Period numbers are from Mills and Fisher (CDFG, 1994).

3. Intensive surveys in likely and unlikely places



Make a determined effort to find extant population

4. Go back to routine surveys for x generations

- Generation time 1-5 years = 10 generations
- Generation time 5+ years = 5 generations
- Isolated or small habitats = 1 generation/year

Coho salmon = 30 years

Declare Extinction

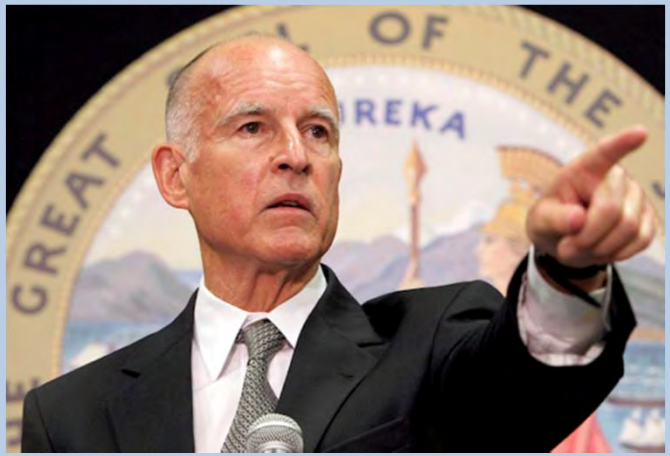
5. Determine species is extinct

   experts, modeling etc.

6. Present findings to Multiagency Committee

7. Committee makes recommendation to director of CDFW or Fish and Game Commission

8. Governor declares extinction



Reconciliation Ecology

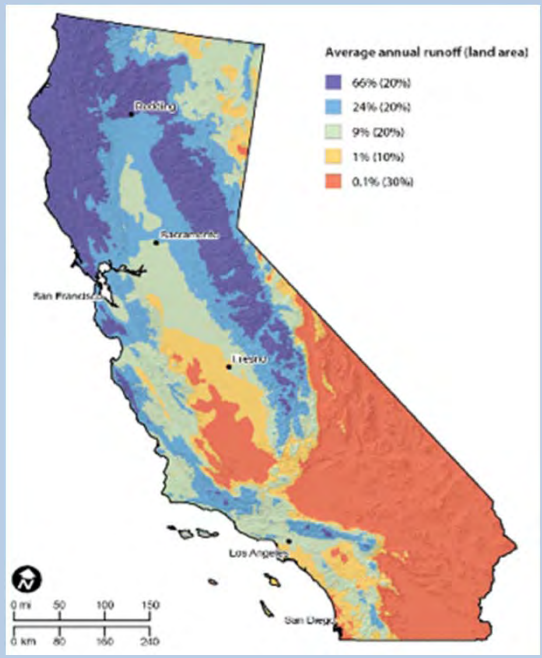
An alternative to extinction

- Most ecosystems are *novel ecosystems*
  - Alien species & altered habitats
  - Human dominated

- R.E. = Incorporate conservation into human dominated ecosystems

Reconciliation: Statewide strategy

- GOALS:
- A home for every species
  - –All life history stages
- Best examples of all major habitats
- All streams =living streams
  - –Natural hydrographs
- Drought preparedness
  - –Plans for every species
- Drought protection



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Eagle Lake, Lassen County

PINE CREEK

Egg Collection Facility

EAGLE LAKE

BLY TUNNEL

WILLOW CREEK

BOGARD SPRING CREEK

44

44

10 km

Historic spawning & rearing grounds
of Eagle Lake Rainbow Trout

BEST EXAMPLES of major habitats

Blue Creek

Yurok Tribal Salmon Sanctuary

THE YUROK TRIBE

WESTERN RIVERS CONSERVANCY

Shasta River : Spring-fed Streams

All streams = living streams

Environmental Flows Below Dams

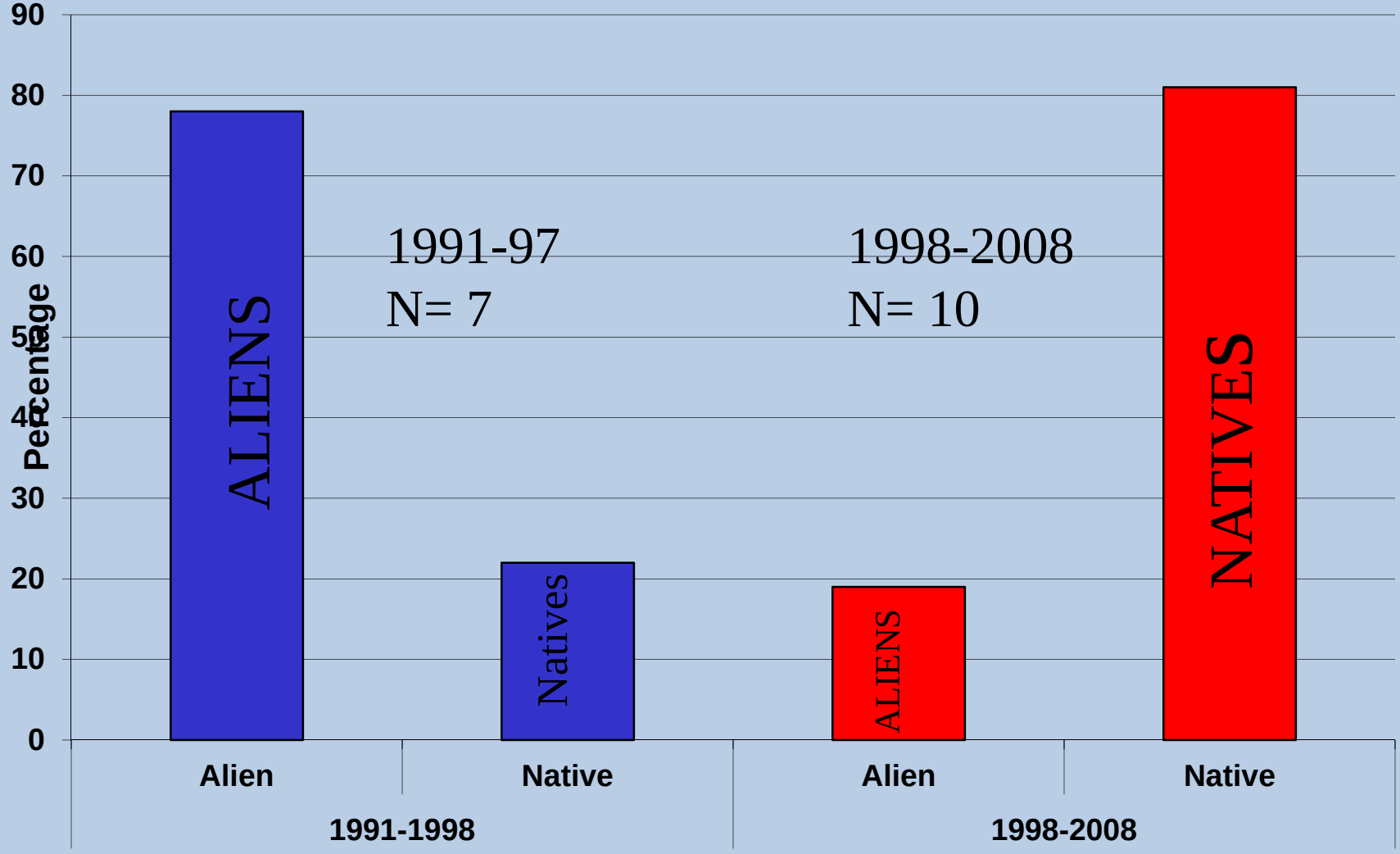
FOLSOM RESERVOIR, AMERICAN RIVER

Environmental flows first, then flows for direct human use

LOWER PUTAH CREEK

- Regulated by dams
- 30km Riparian “shred”
- Novel Ecosystem
- Model for reconciled aquatic/riparian ecosystems

MANAGING THE FLOW REGIME FOR NATIVE FISHES

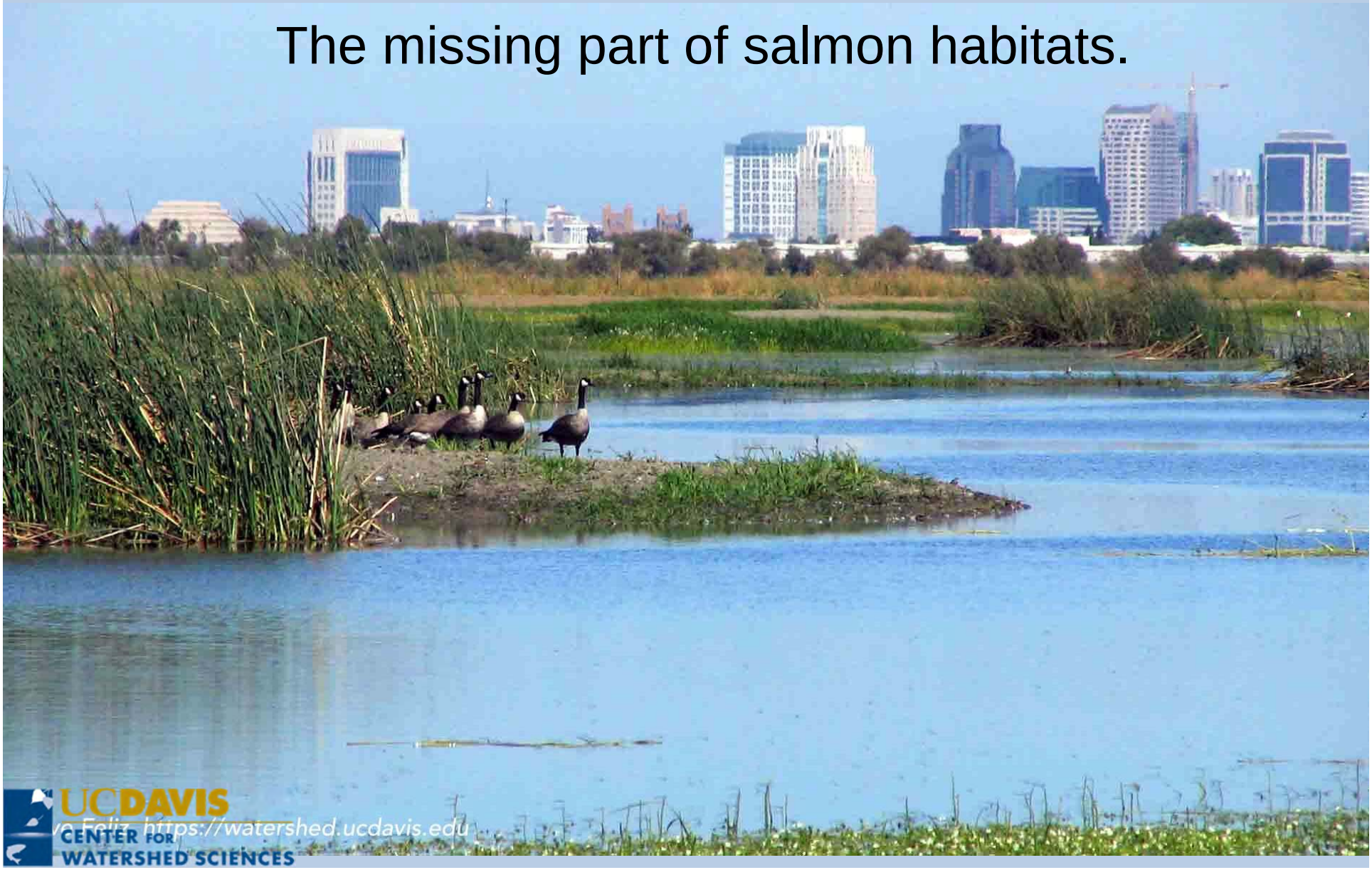


BEFORE AFTER

Chinook salmon spawning, December 2013
Photo by Ken Davis

Re-connect Floodplains

The missing part of salmon habitats.



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https://watershed.ucdavis.edu

Salmon can thrive in rice fields in winter

Jacob Katz 9 AM Saturday

Native Fish Rescue Facilities

- "Emergency rooms" for fish
  - Drought
- Proposed Rio Vista facility for Delta fishes
- "Re-purposing" trout hatcheries
  - e.g., Mt Shasta Hatchery
- Ponds and other facilities statewide

REMEMBER: ONLY *YOU* CAN PREVENT FISH EXTINCTIONS!

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WFCB

CALIFORNIA TROUT
FISH · WATER · PEOPLE