# Effects of drought on inland fishes of California

**California Aquatic Bioassessment Workgroup**

**Oct 21, 2015**

Peter B. Moyle

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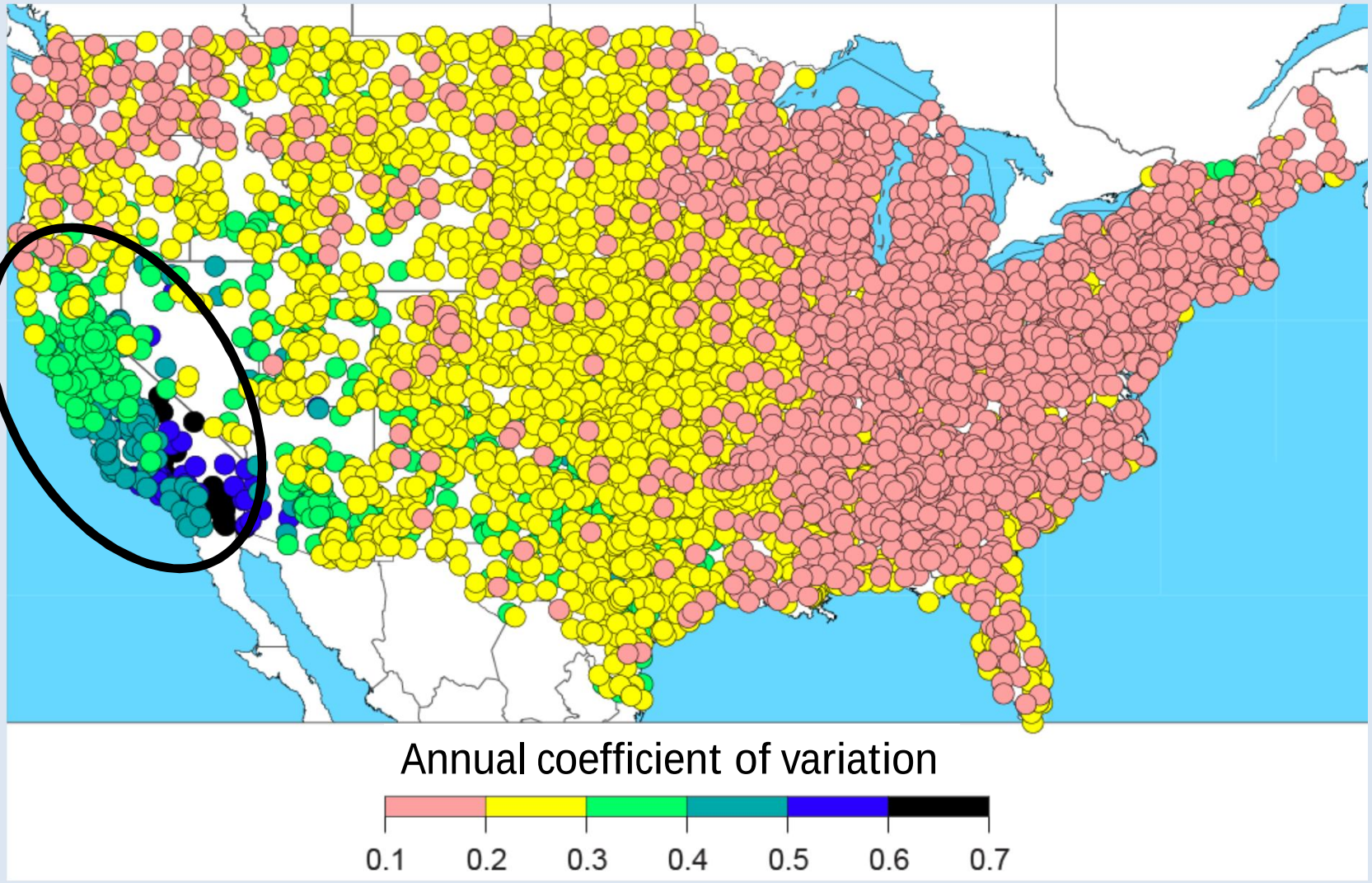
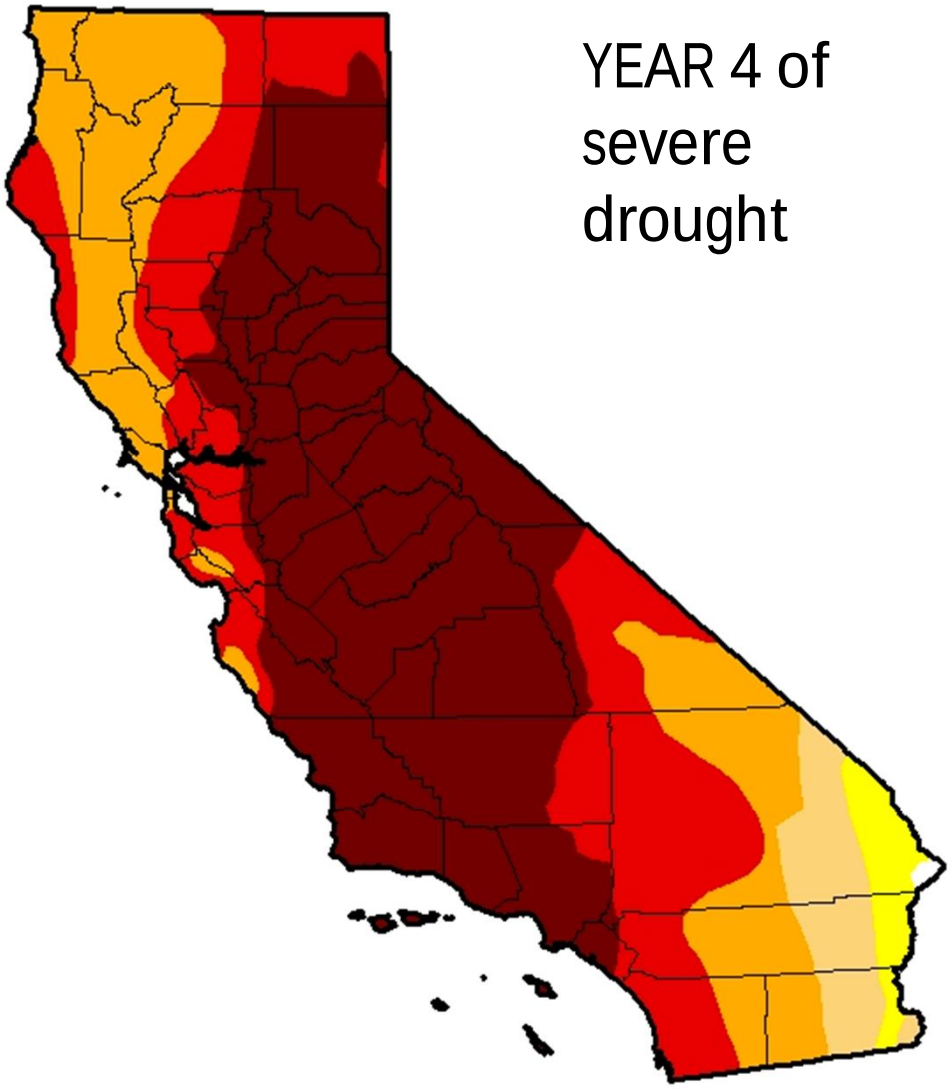
# Most annual rainfall variability in US




NOTES: Dots represent the coefficient of variation of total annual precipitation at weather stations for 1951-2008, Larger values have more year-to-year variability.

SOURCE: Dettinger, M., F. Ralph, T. Das, P. Neiman, and D. Cayan (2011), "Atmospheric Rivers, Floods and the Water Resources of California," *Water*, 3(2), 445-478.

# U.S. Drought Monitor
# California



YEAR 4 of severe drought

## August 25, 2015

*(Released Thursday, Aug. 27, 2015)*

Valid 8 a.m. EDT

*Drought Conditions (Percent Area)*

| | None | D0-D4 | D1-D4 | D2-D4 | D3-D4 | D4 |
|---|---|---|---|---|---|---|
| **Current** | 0.14 | 99.86 | 97.35 | 92.36 | 71.08 | 46.00 |
| **Last Week** 8/18/2015 | 0.14 | 99.86 | 97.35 | 92.36 | 71.08 | 46.00 |
| **3 Months Ago** 5/26/2015 | 0.14 | 99.86 | 98.71 | 93.91 | 66.60 | 46.73 |
| **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** 8/26/2014 | 0.00 | 100.00 | 100.00 | 95.42 | 81.92 | 58.41 |

*Intensity:*

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

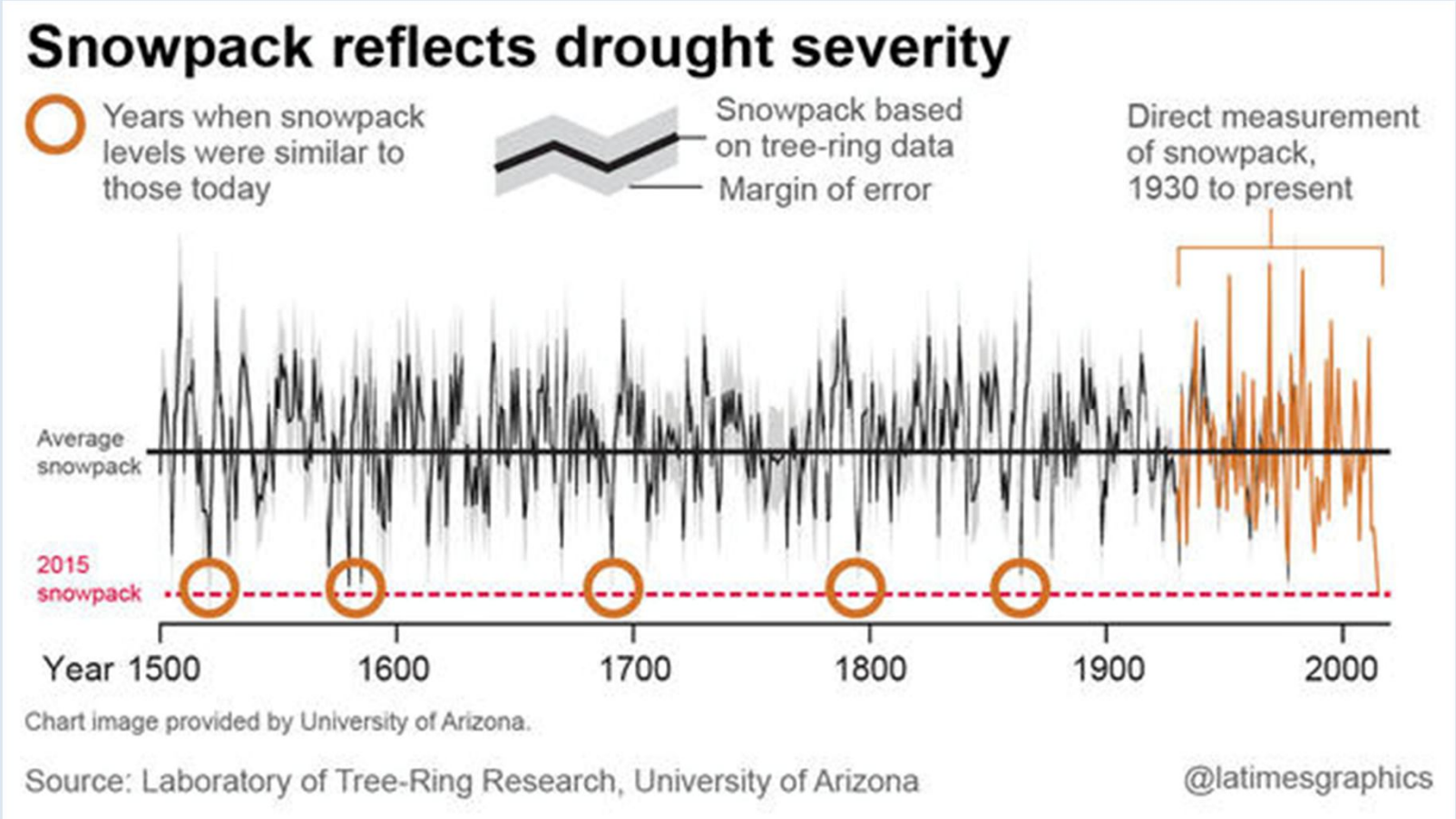
*The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.*

**Author:**
*Anthony Artusa*
*NOAA/NWS/NCEP/CPC*

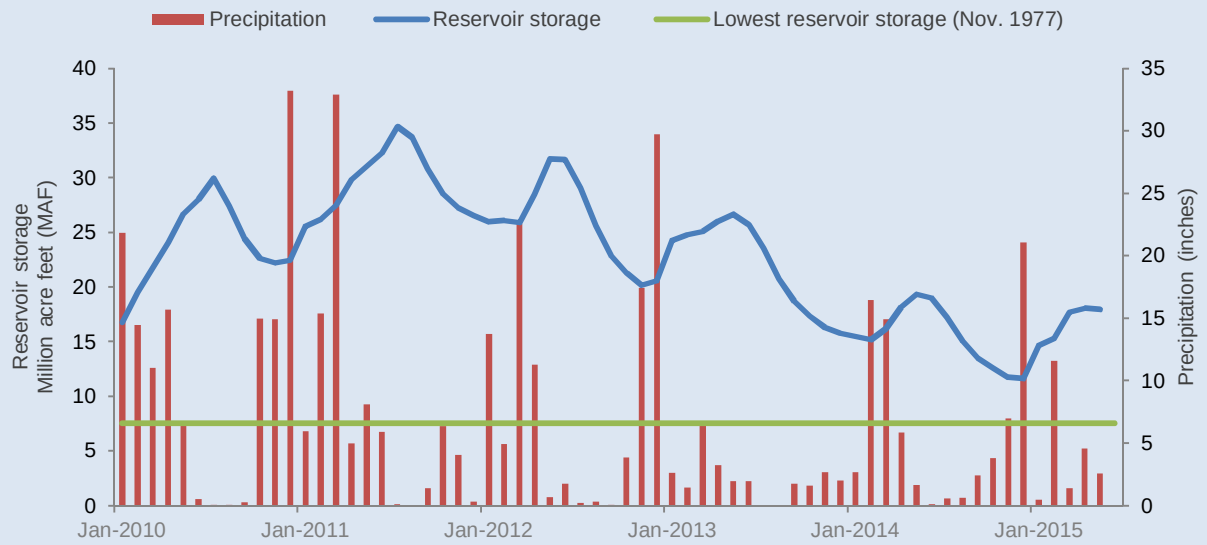
**http://droughtmonitor.unl.edu/**

# Sierra Nevada snowpack is much worse than thought: a 500-year low

LA Times Sept 14, 2015

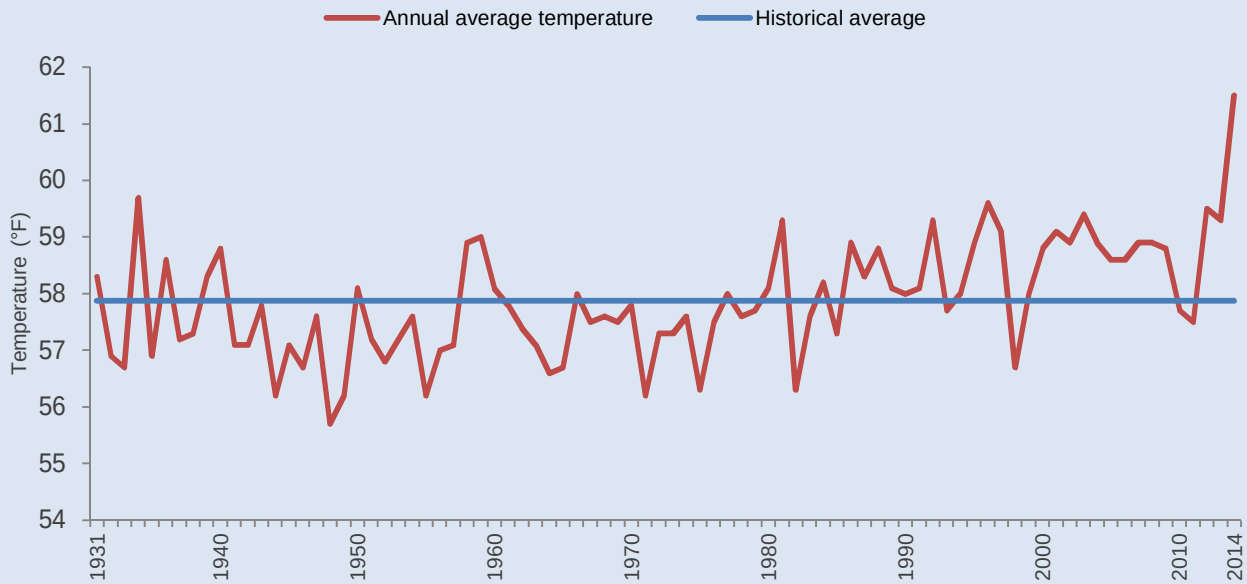


# Water Stored in Reservoirs has Fallen




PPIC 2015

# CA is experiencing record heat



# Drought effects:

Three sectors

## Cities
## Farms
## Environment

# Cities

So far…

- Investments paid off
- Regional cooperation
- Conservation working


"California urban water use drops 27.3 percent, exceeds 25% mandate…"

Press release SWRCB July 30, 2015

Economic impacts likely to remain small

Thanks to Jay Lund

# Agriculture

# 2015 Estimated Agricultural Drought Impacts

| Description | Impact | Base year levels | Percent change |
|---|---|---|---|
| Surface water shortage (million acre-ft) | 8.7 | 18.0 | -48% |
| Groundwater replacement (million acre-ft) | 6.0 | 8.4 | 72% |
| Net water shortage (million acre-ft) | 2.7 | 26.4 | -10% |
| Drought-related idle land (acres) | 540,000 | 1.2 million* | 45% |
| Crop revenue losses ($) | $900 million | $35 billion | 2.6% |
| Dairy and livestock revenue losses ($) | $350 million | $12.4 billion | 2.8% |
| Costs of additional pumping ($) | $590 million | $780 million | 75.5% |
| Net revenue loss ($) | $1.8 billion | $48 billion | 3.7% |
| **Total economic impact ($)** | **$2.7 billion** | NA | NA |
| Direct job losses (farm seasonal) | 10,100 | 200,000# | 5.1% |
| **Total job losses** | **21,000** | NA | NA |

* NASA-ARC estimate of normal Central Valley idle land.

# Total agriculture employment is about 412,000, of which 200,000 is farm production.

# Drought & Agriculture 2015: UCD Study

"The agricultural economy continues to grow in this fourth year of drought thanks to the state's vast but declining stores of groundwater..."

"We are getting by well this year –much better than many had predicted- but there is no free lunch" Richard Howitt

# Drought effects:

# Environment


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

# Environmental water has low priority:

## Temporary Urgency Change Petitions

- State Water Resources Control Board
- Relax environmental flow and WQ requirements
- 2014 400,000 acre feet "water savings"
- 2015 683,000 acre feet "water savings"
- Mostly reduced Delta outflow

***1+ million af of environmental water appropriated for other purposes***

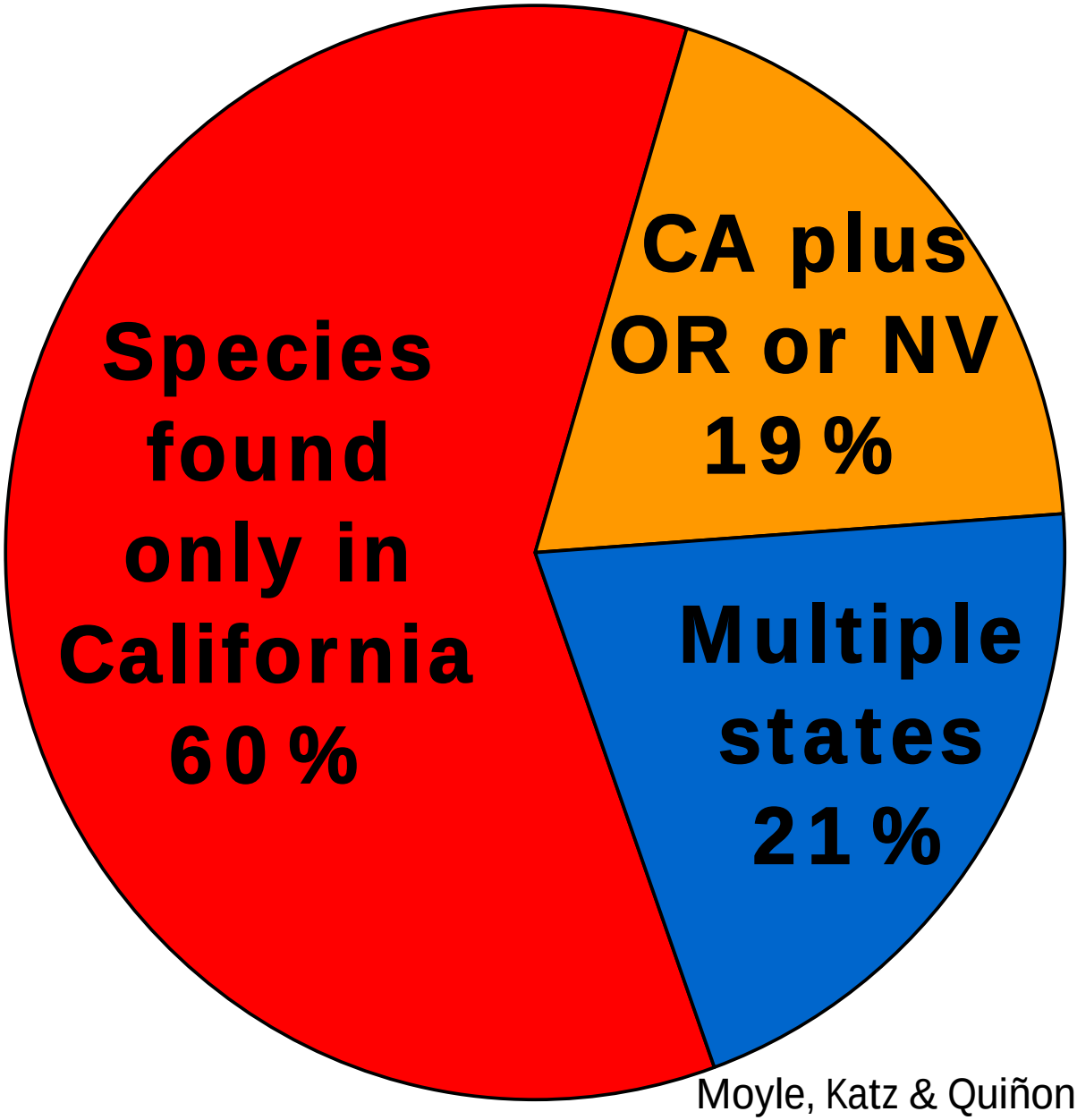
# Lund's Drought Test Grades

| Group | Tentative grade? | Comments to parents |
|---|---|---|
| Urban | A- | Excellent preparation; sometimes shows lack of regard for others in class; learned much from last test. |
| Agriculture | B+ | Good preparation, mostly. Quick learners. |
| Environment | D | Unprepared for test, or studied for a different test. |
| Government agencies | B | Test largely unexpected, but adapted with only some delay. Need to continue working together in future. |

# Drought effects on native fishes:

# 131 species


79%
endemic

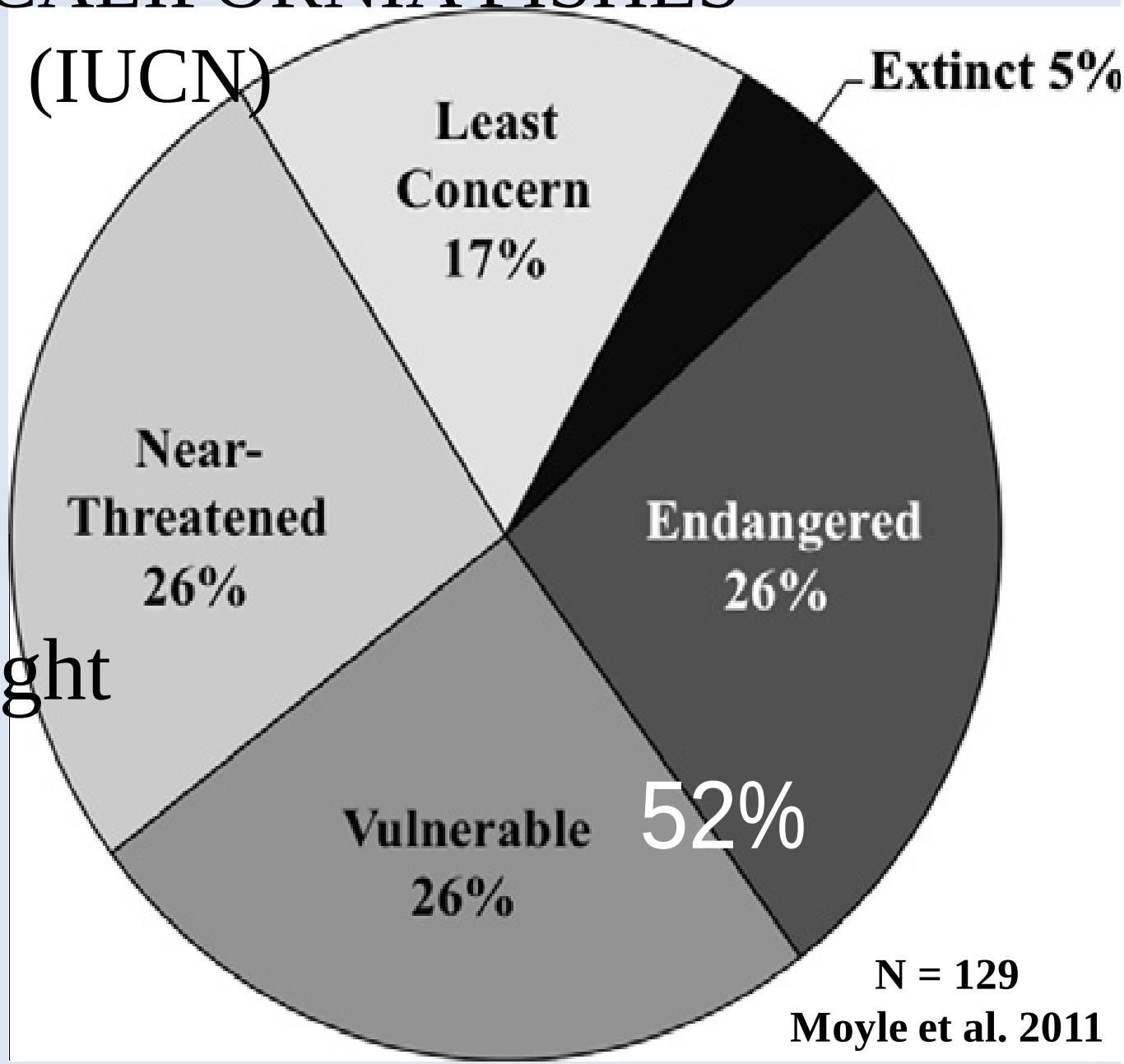



Moyle, Katz & Quiñones
Biological Conservation,
Vol 144, issue 10, Oct. 2011

# STATUS OF CALIFORNIA FISHES (IUCN)

83%

extinct or declining before drought



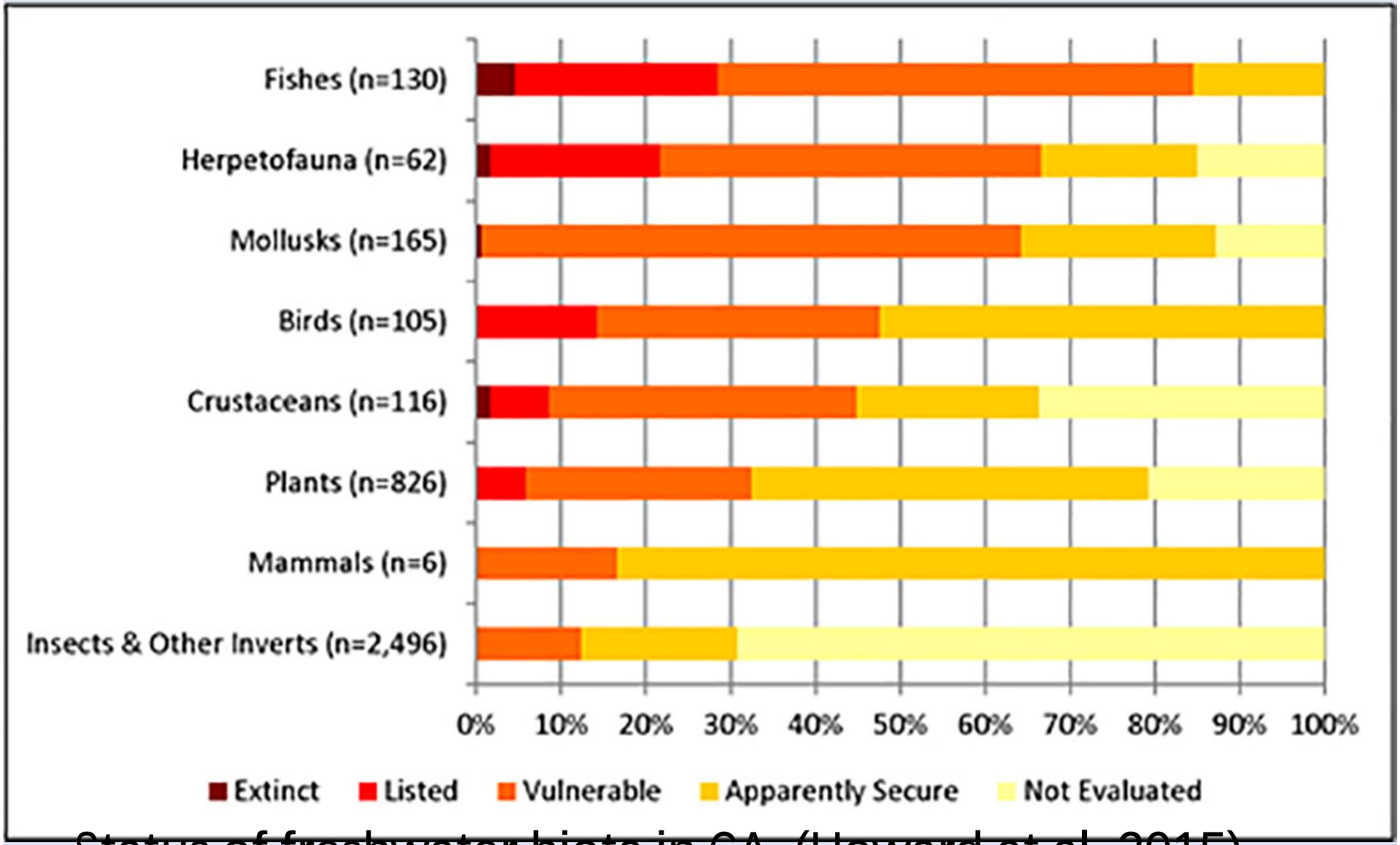
# 63 species

"Fish Species of Special Concern in California." 2015 CDFW

# 30 species

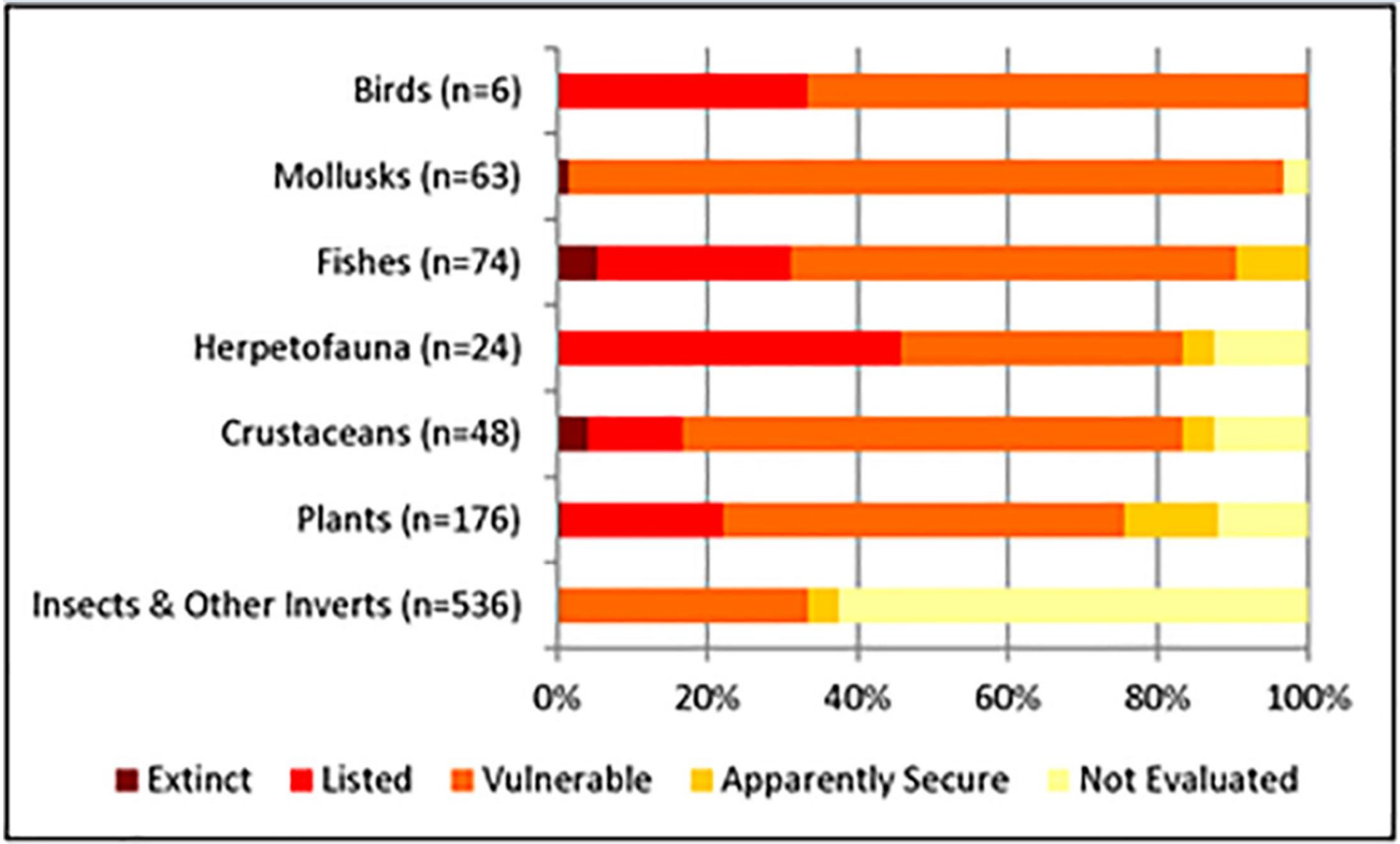
listed under state and federal ESAs

# More than fishes are in trouble!




Status of freshwater biota in CA (Howard et al. 2015)

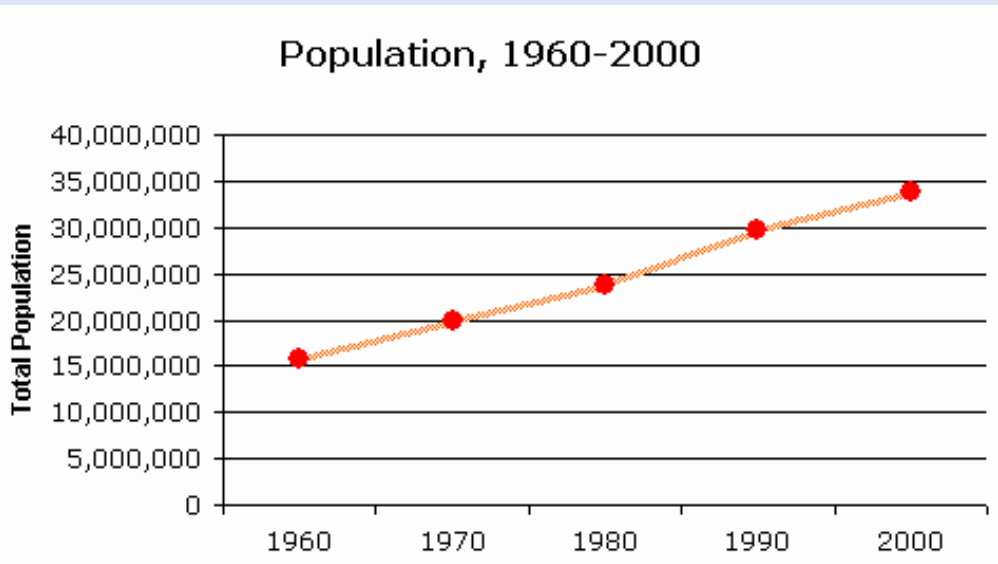
# Status of Endemic Aquatic Species

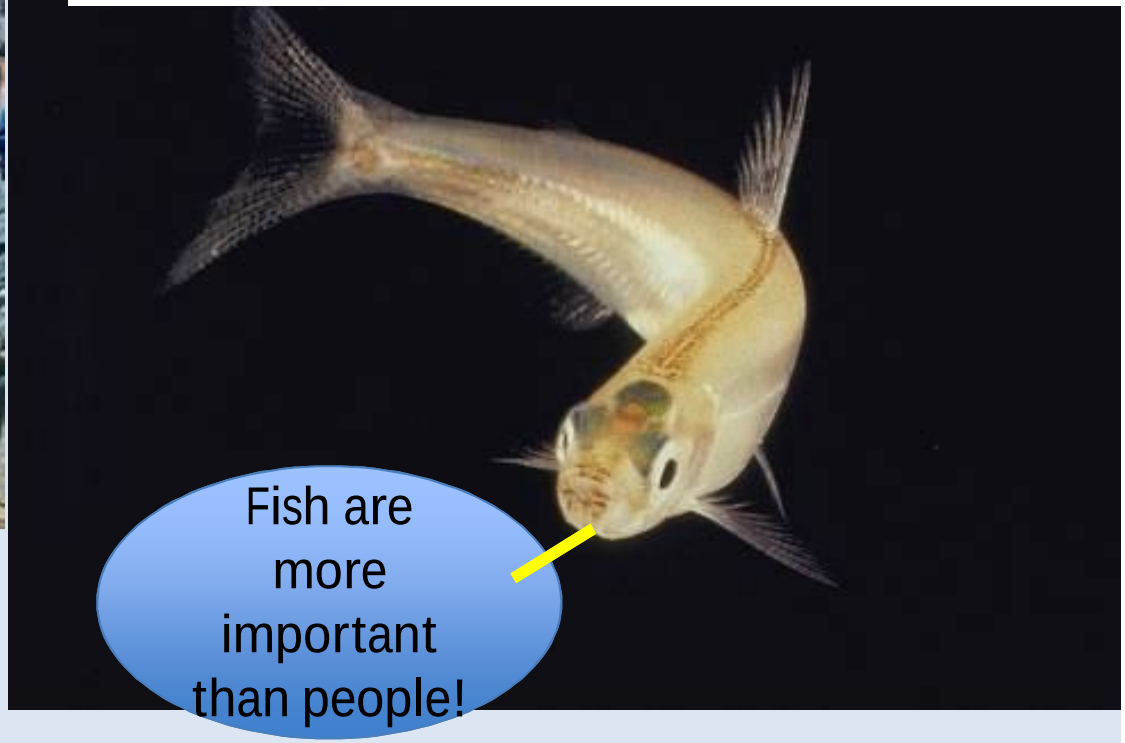


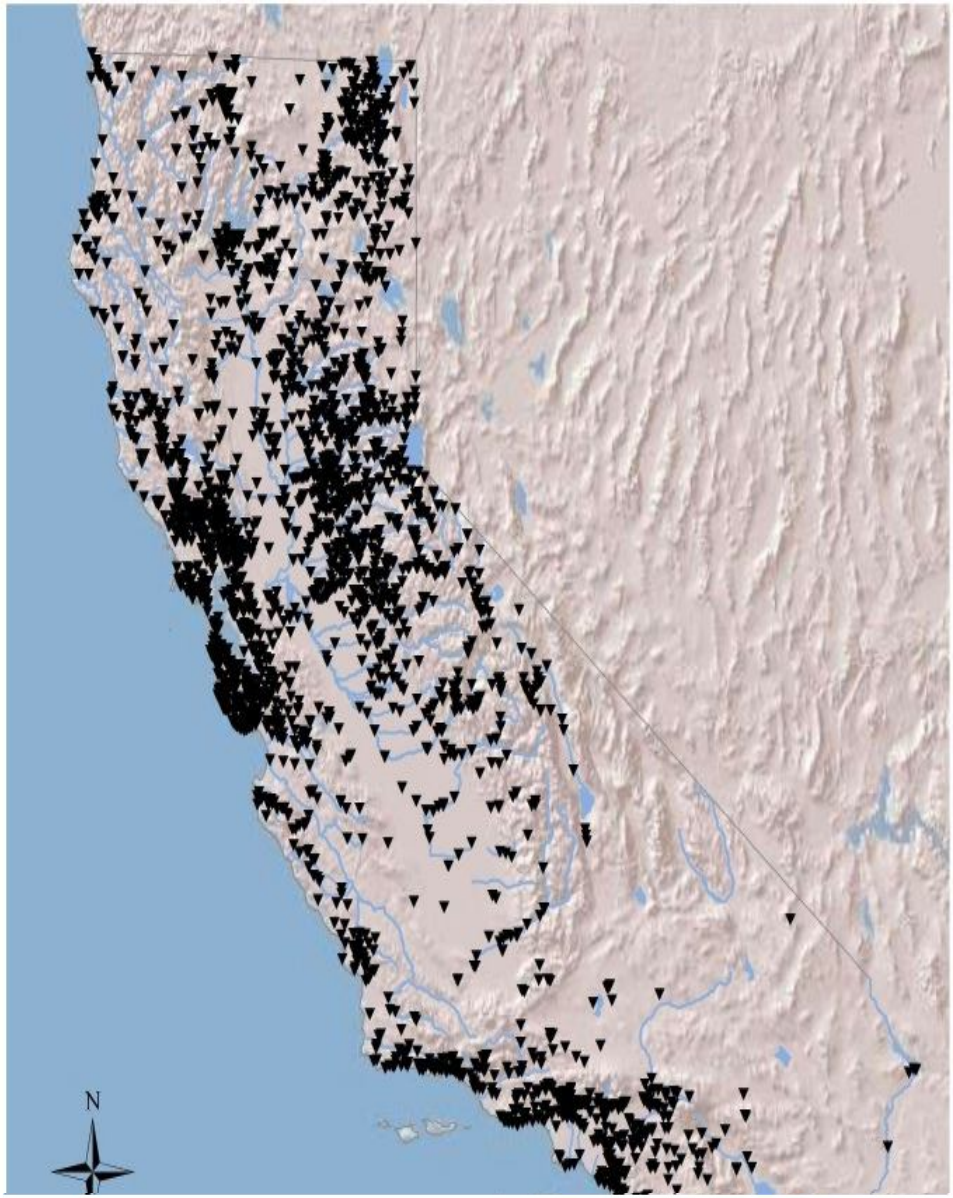
# Why are CA fishes in trouble?

1. Competition for water
2. Habitat change
3. Alien invasions
4. Drought


PEOPLE
ARE MORE
IMPORTANT
THAN FISH!


Population, 1960-2000
Total Population
40,000,000
35,000,000
30,000,000
25,000,000
20,000,000
15,000,000
10,000,000
5,000,000
0
1960
1970
1980
1990
2000


Fish are more important than people!




Competition for water

# 1440

‘large’ dams (1.8+ m)

1000s of small dams

450 more than 30 m high

Grantham et al. 2014

**Figure 1.1** Dams in the state of California.

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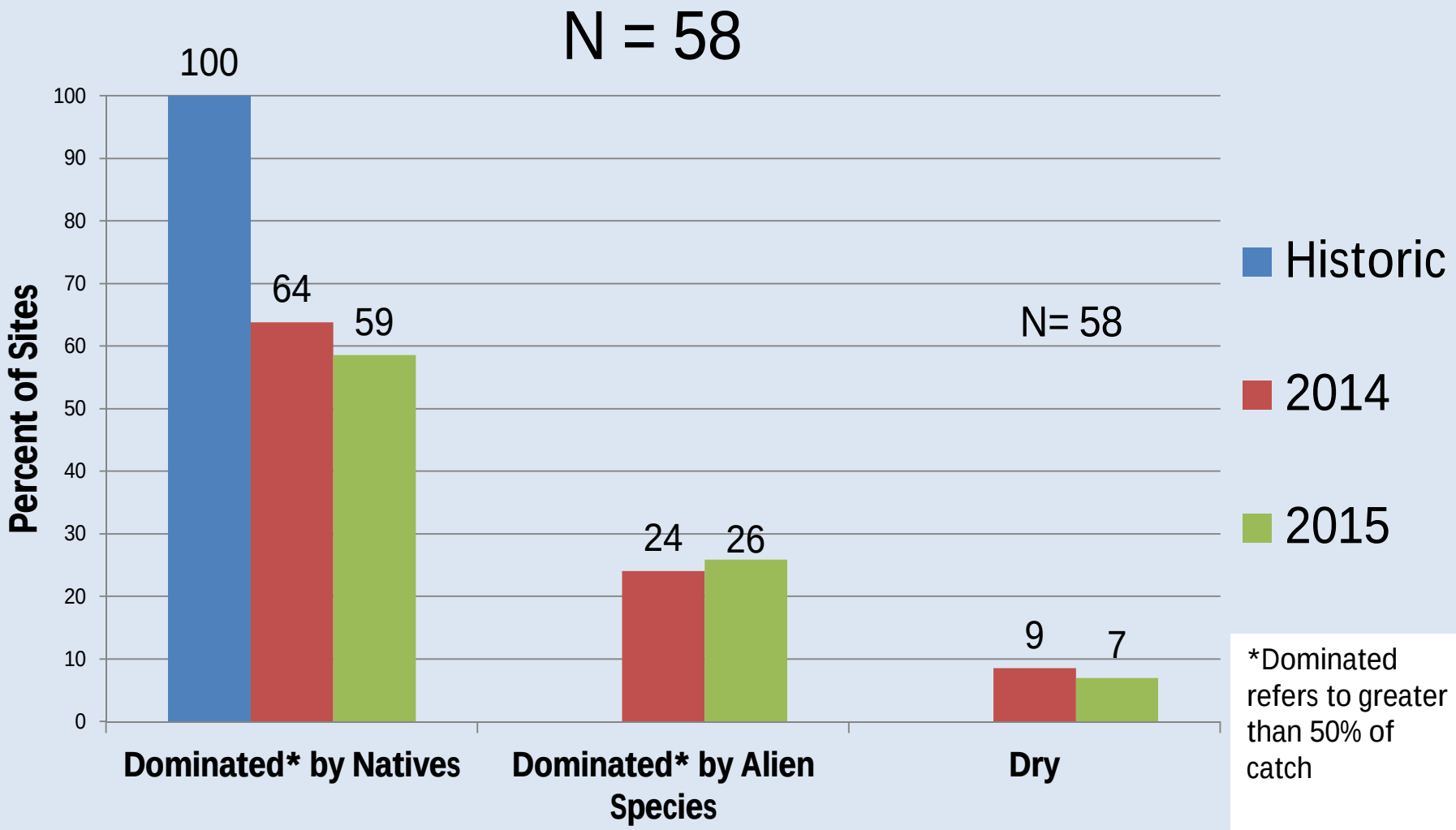
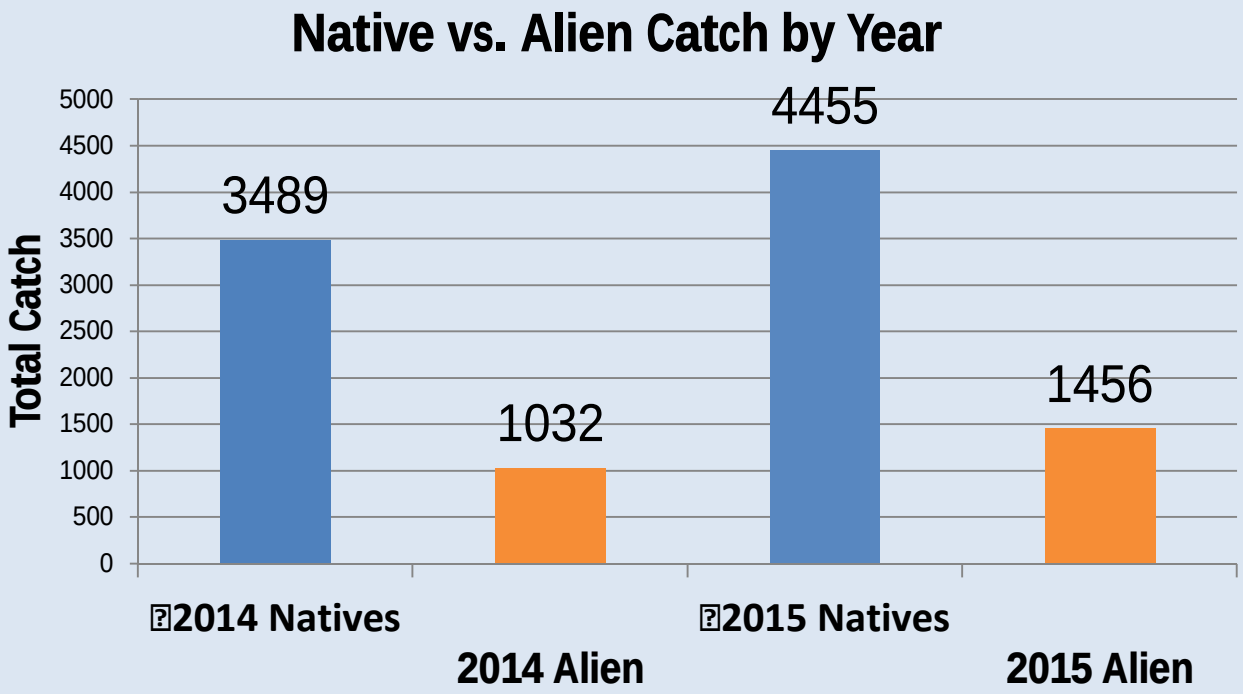
# ALIEN INVASIONS!

## 50 Alien fishes

## In all major watersheds

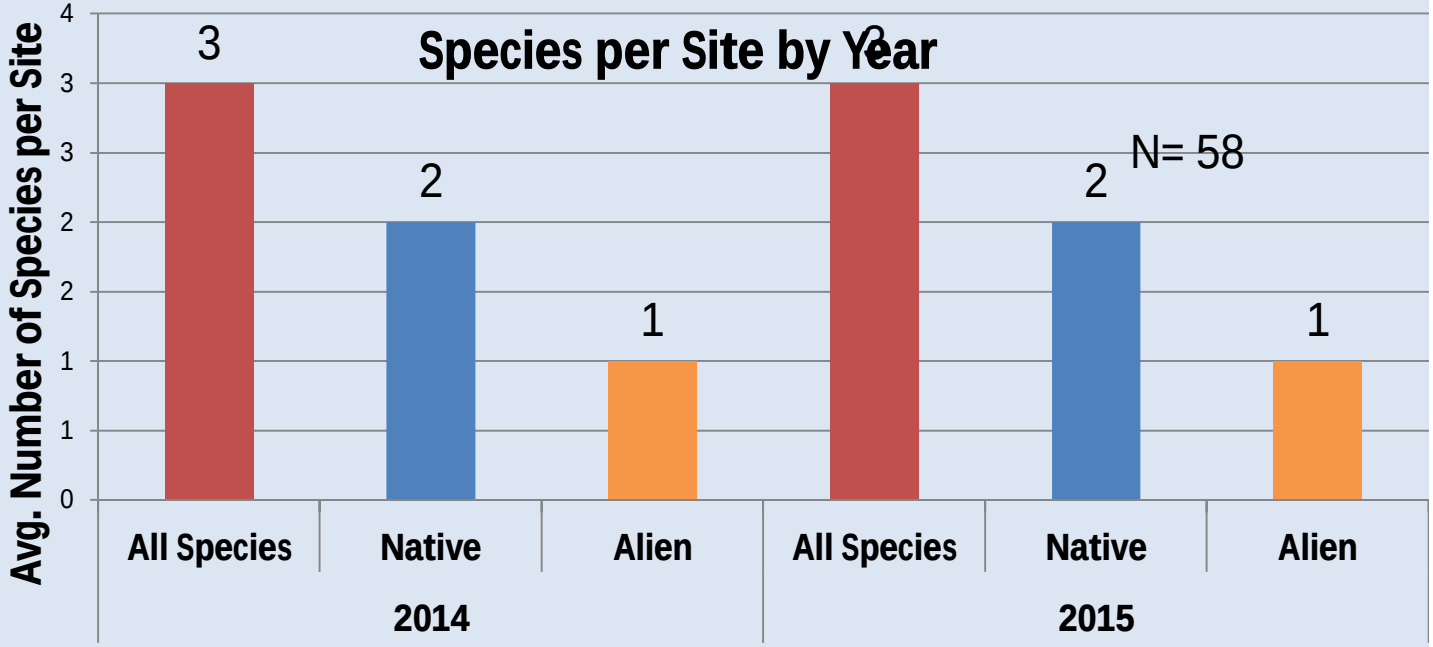
# Native foothill fishes sites 1980s vs 2014, 2105



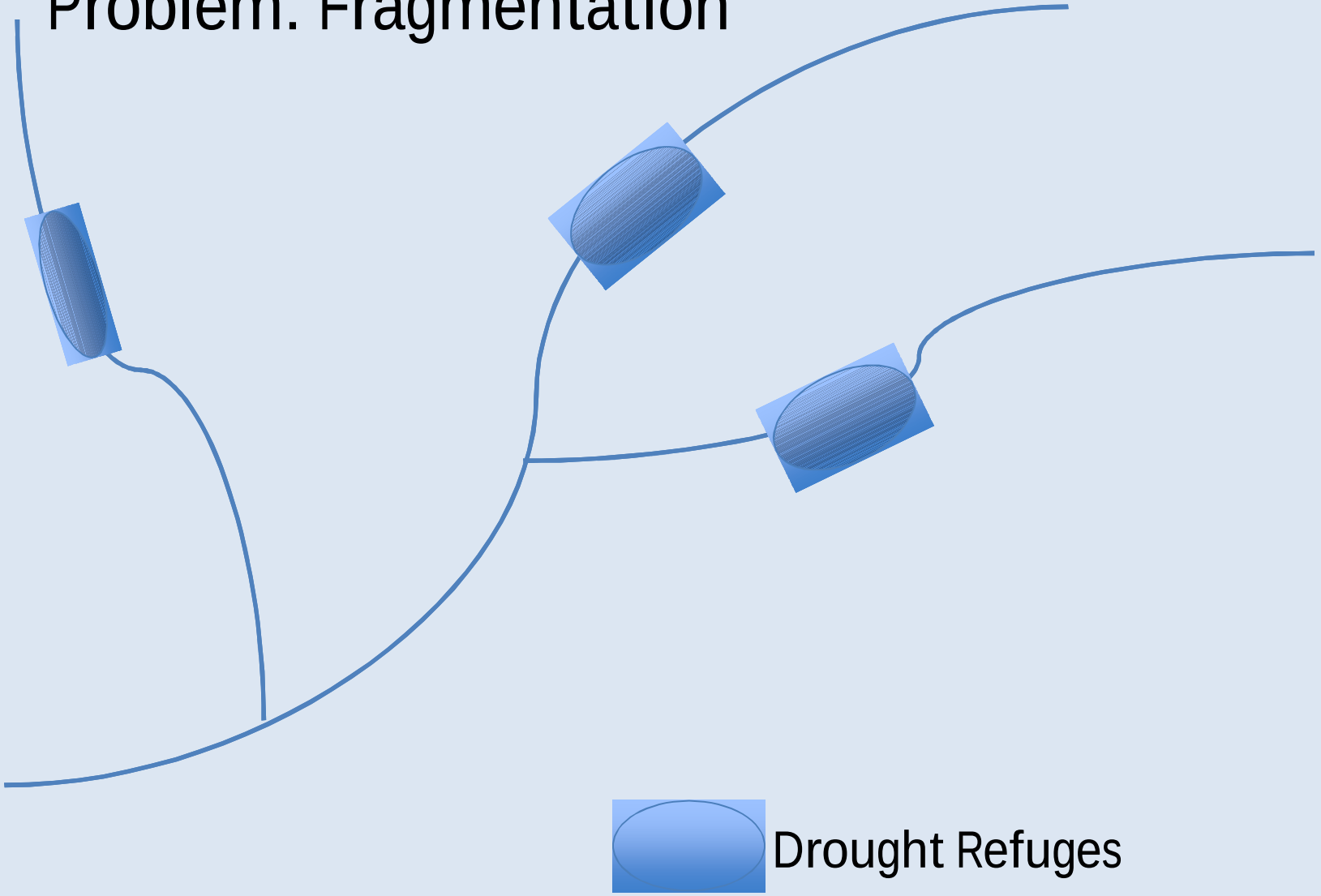



# NUMBERS CAUGHT

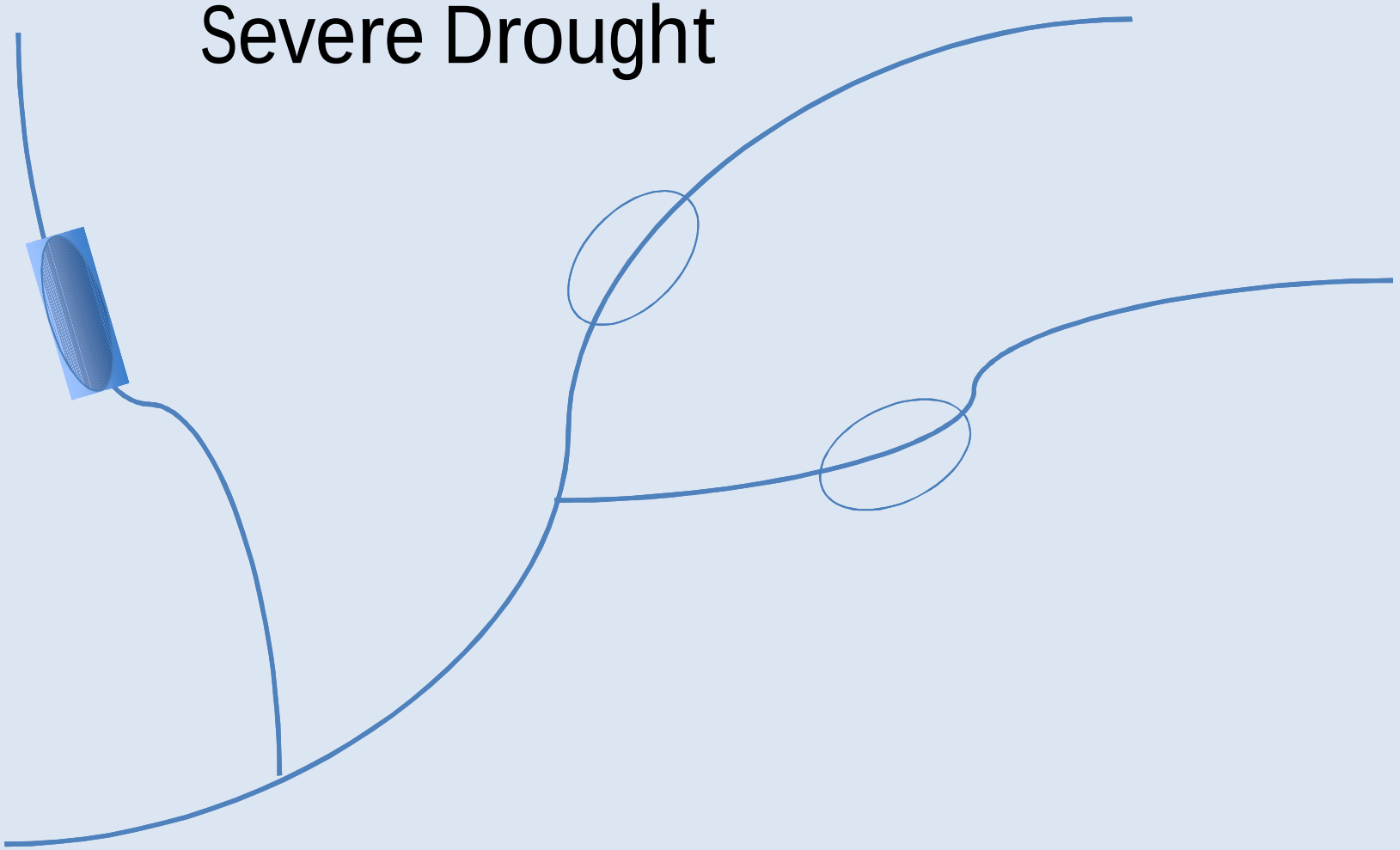
# SPECIES CAUGHT



# Problem: Fragmentation

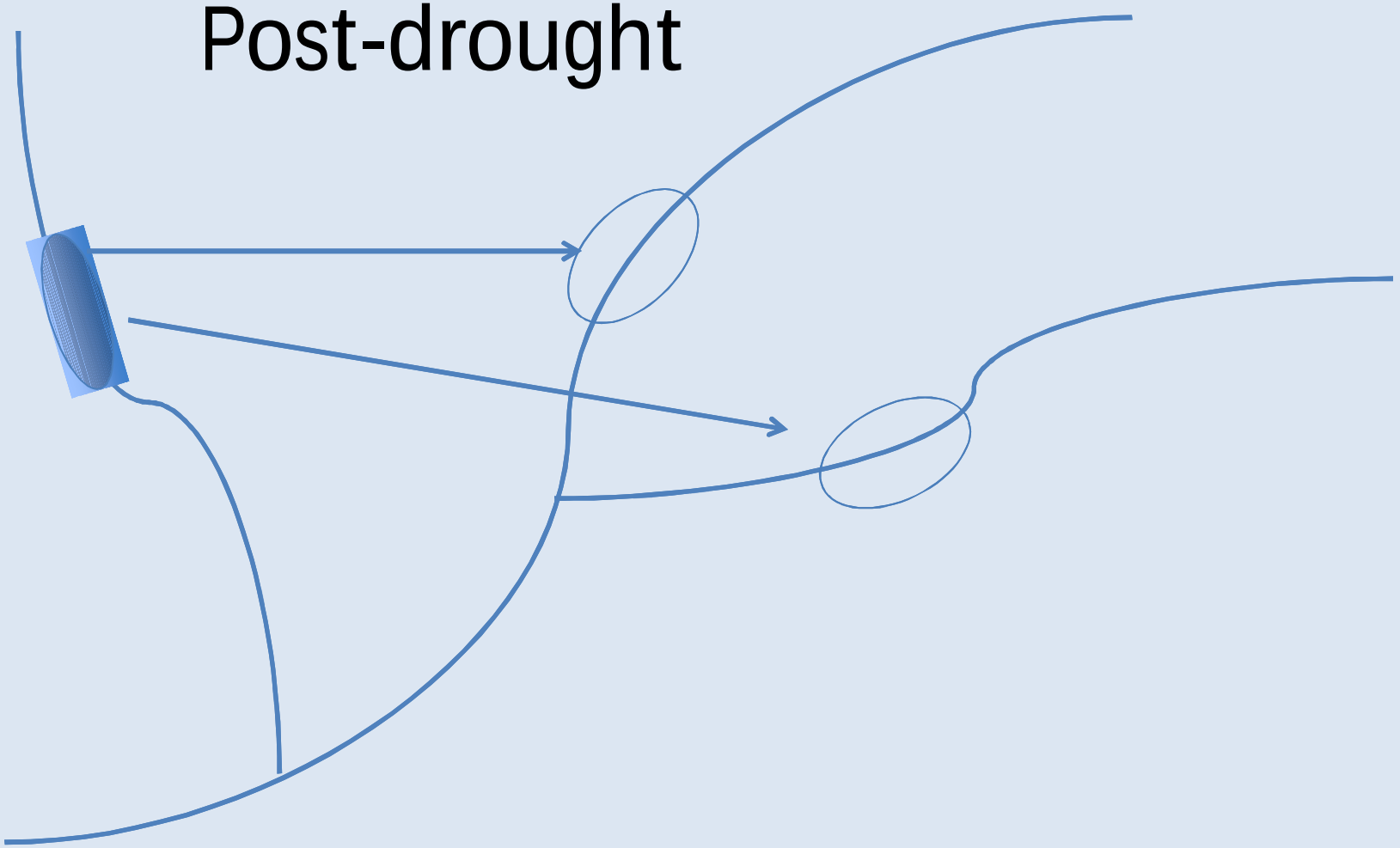


# Severe Drought

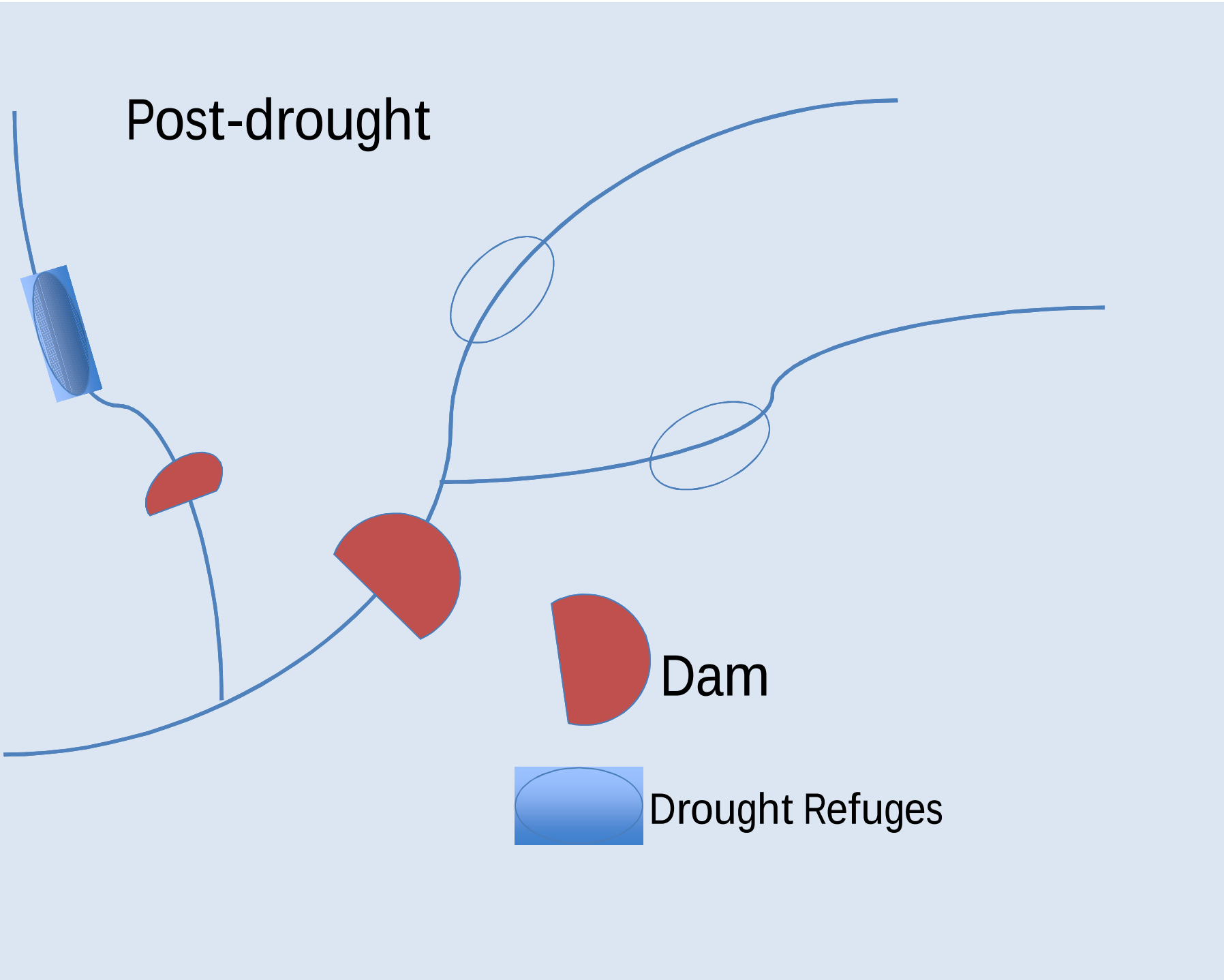


Drought Refuges

# Post-drought



Drought Refuges


Post-drought
Dam
Drought Refuges

# California is in perpetual severe drought from a native fish perspective

- Streams dewatered, warmer
- Access to upstream refuges denied (dams)
- Competition, predation, disease from alien species in refuges

# Drought: making bad conditions for native fish worse

- Warmer temperatures
- Reduced flow
- Less dilution of contaminants
  - Longer residence times?
- Increase in alien species abundance
- New invasions?
- Local extinctions

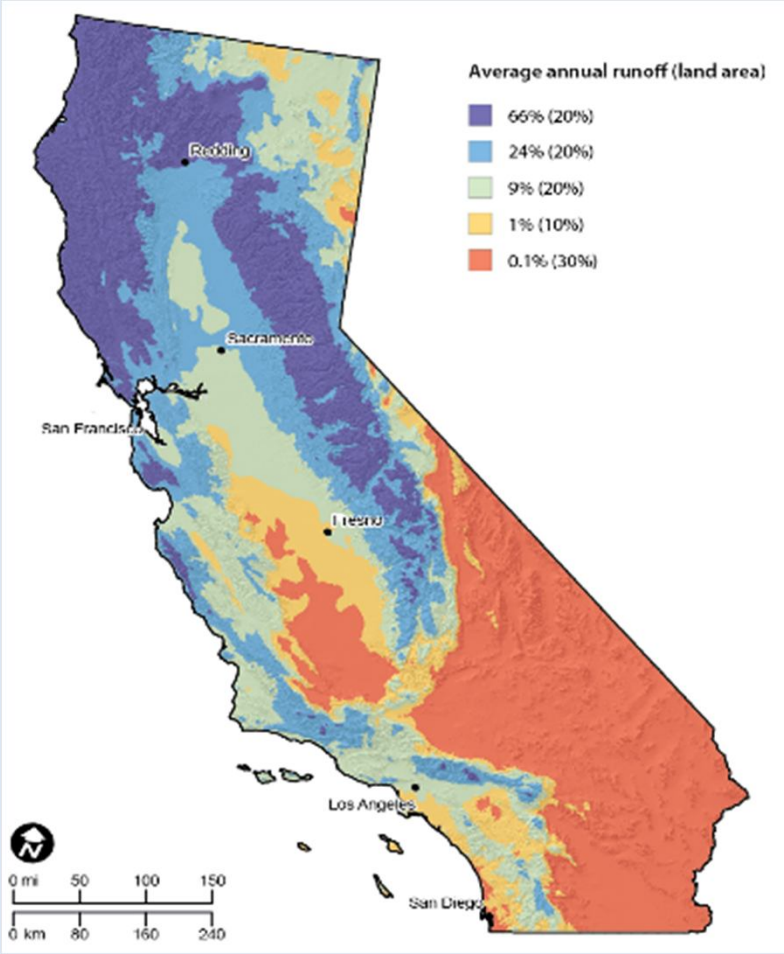
# Drought: the warm-up act for climate change

# SO, what can we do?



# Statewide strategy for aquatic conservation

- GOALS:
- Protect examples of all major habitats
- Self-sustaining populations of all native species
- Drought protection

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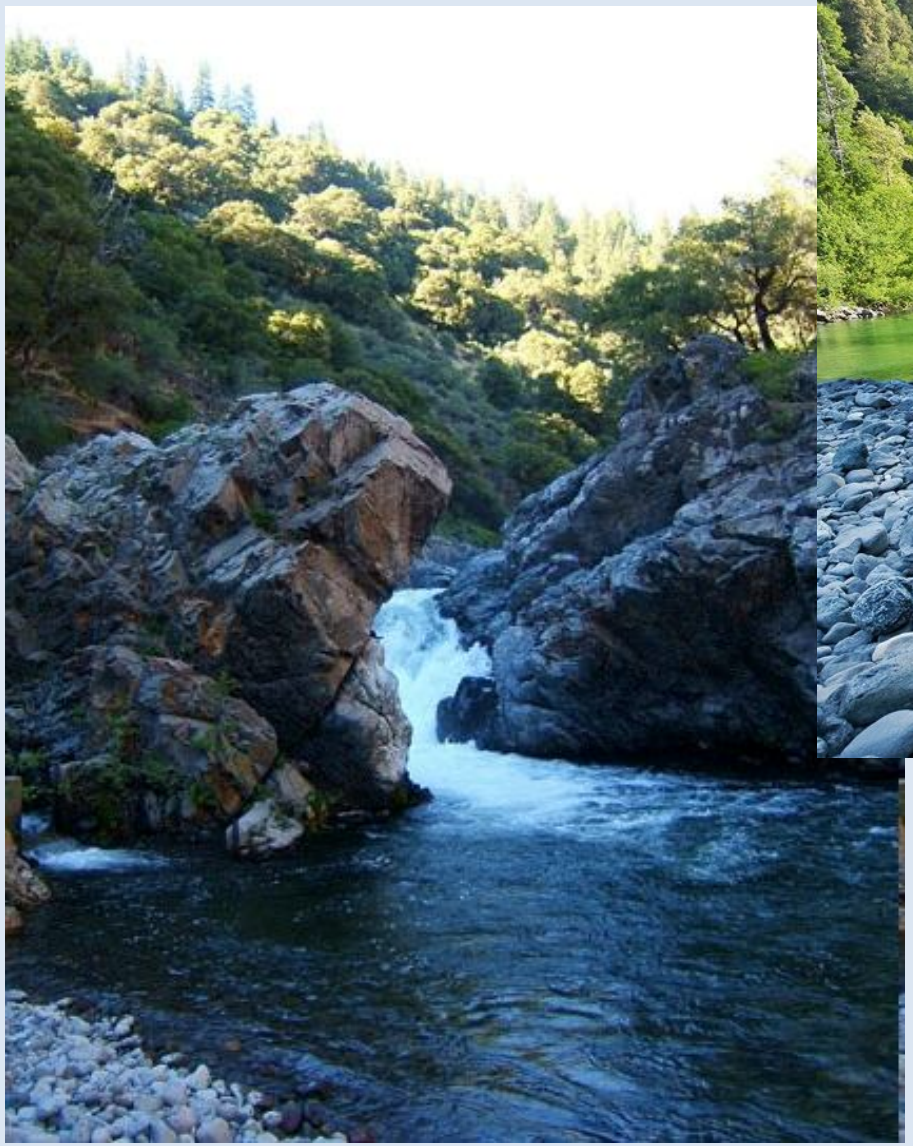
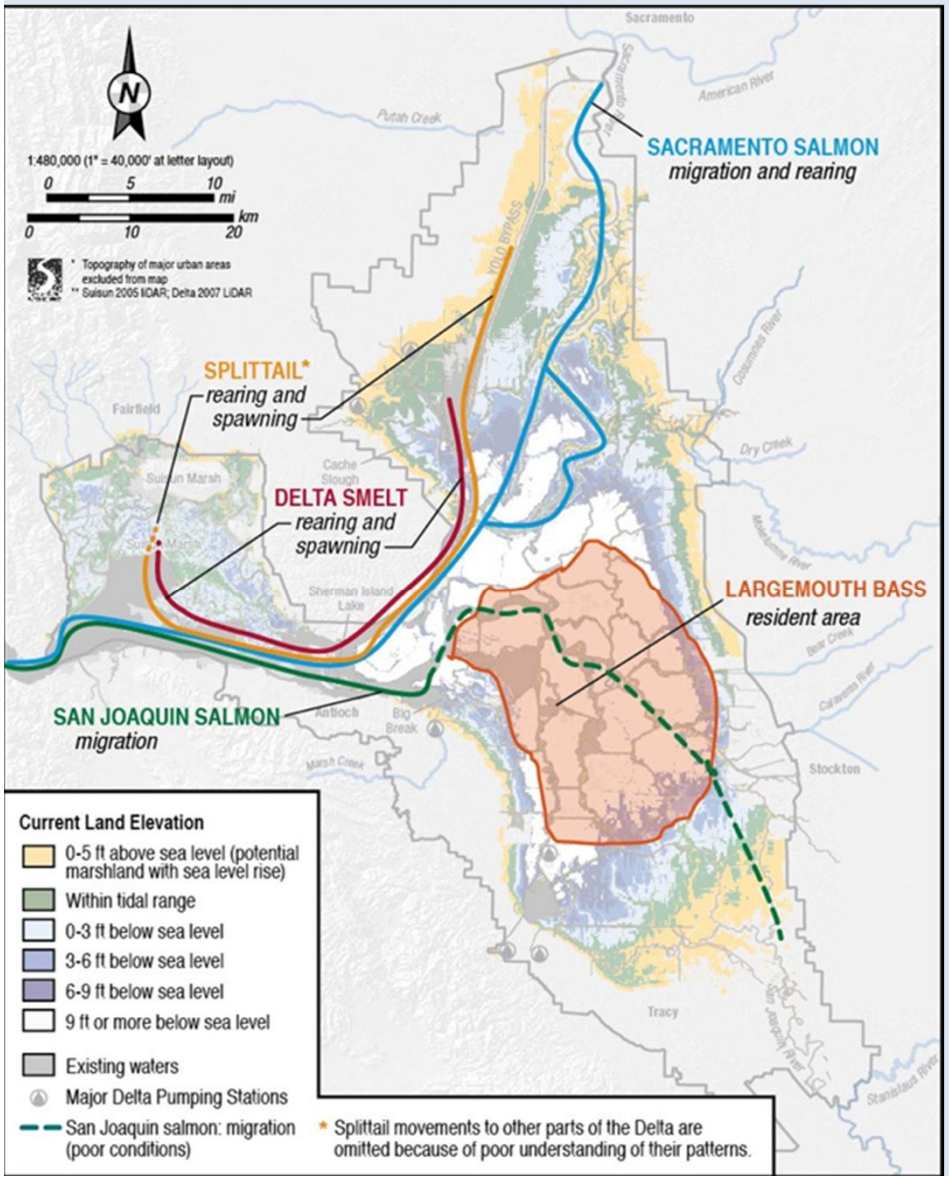
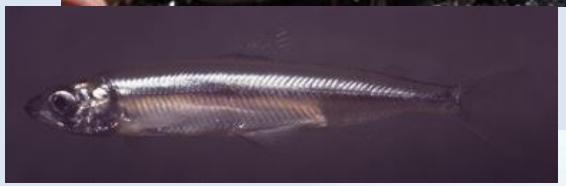
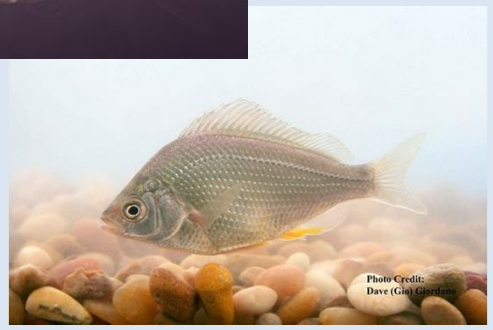
# Protect best of what is left



# Maintain a home for every native species



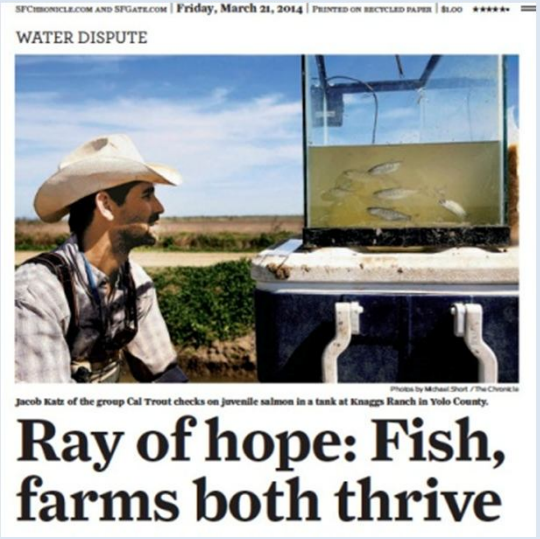





# Environmental Flows Below Dams


Grantham et al. 2014

# Reconcile Floodplains



SFCHRONICLE.COM AND SFGATE.COM | Friday, March 21, 2014 | PRINTED ON RECYCLED PAPER | $1.00

WATER DISPUTE

Photos by Michael Short / The Chronicle

Jacob Katz of the group Cal Trout checks on juvenile salmon in a tank at Knaggs Ranch in Yolo County.

**Ray of hope: Fish, farms both thrive**

Opperman, Moyle et al.
2016 UC Press

# Put a price on environmental water

**Why give away fish flows for free during a drought?**

Posted on February 11, 2014

By Jay Lund, Ellen Hanak, Barton “Buzz” Thompson, Brian Gray, Jeffrey Mount and Katrina Jessoe

California Water Blog

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# Establish “emergency rooms” for fishes on verge of extinction


UC Davis Fish Conservation and Culture Lab, Byron

# Conclusions

- Aquatic habitats and species deteriorating without drought
- Environment suffers the most from drought.
- CA native fishes are in severe decline.
- Drought accelerates decline.
  - warm-up for Climate Change
- Statewide strategy for aquatic conservation needed for ALL species
- There are solutions
- More extinctions will happen if we don’t act now.

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Thanks!