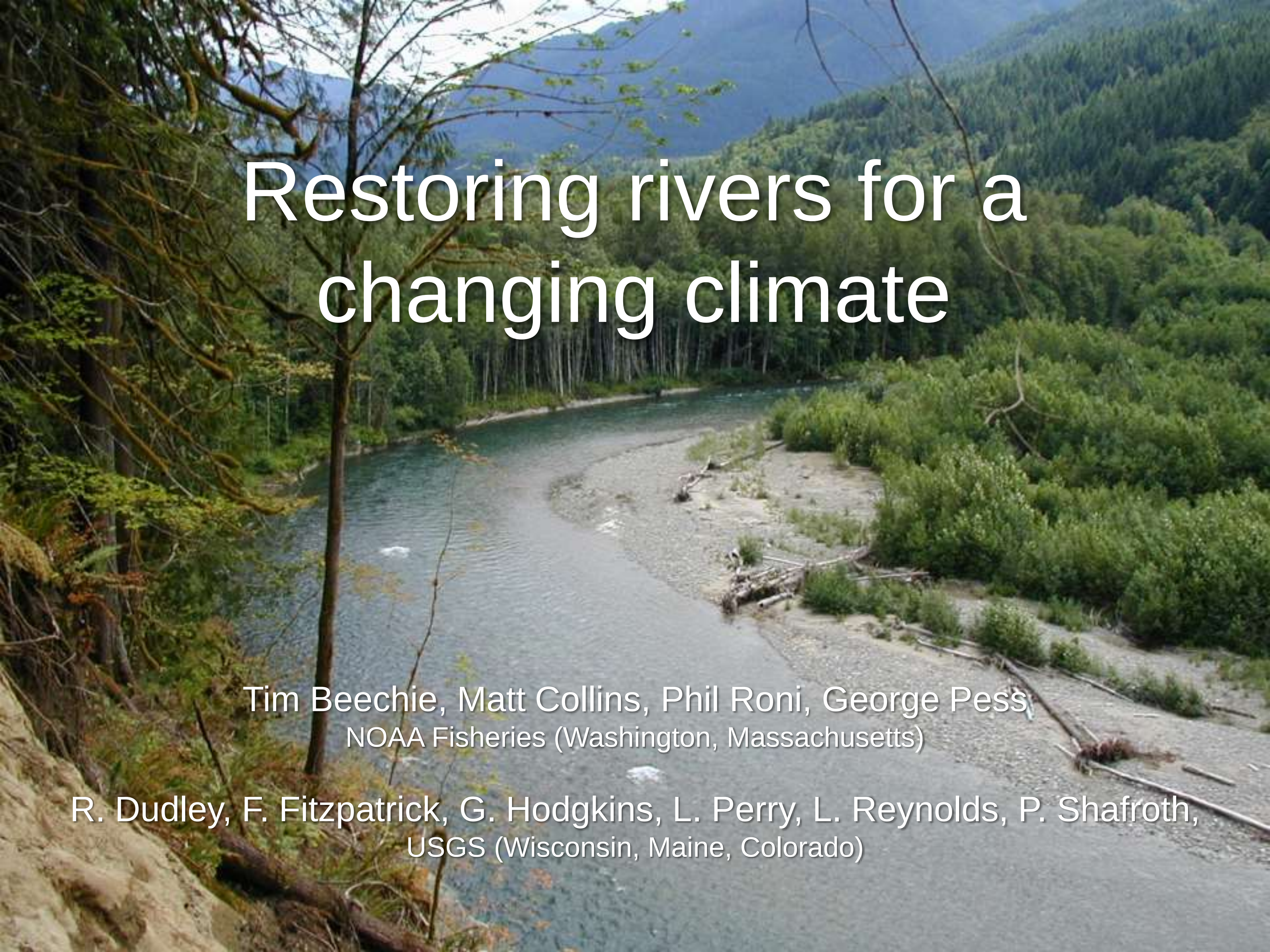


Restoring rivers for a changing climate

Tim Beechie, Matt Collins, Phil Roni, George Pess
NOAA Fisheries (Washington, Massachusetts)

R. Dudley, F. Fitzpatrick, G. Hodgkins, L. Perry, L. Reynolds, P. Shafroth,
USGS (Wisconsin, Maine, Colorado)

Key questions

- Question 1: Should we alter restoration plans to accommodate climate change?
- Question 2: How do we incorporate projected climate effects into river restoration design?

Do climate change projections alter restoration plans?

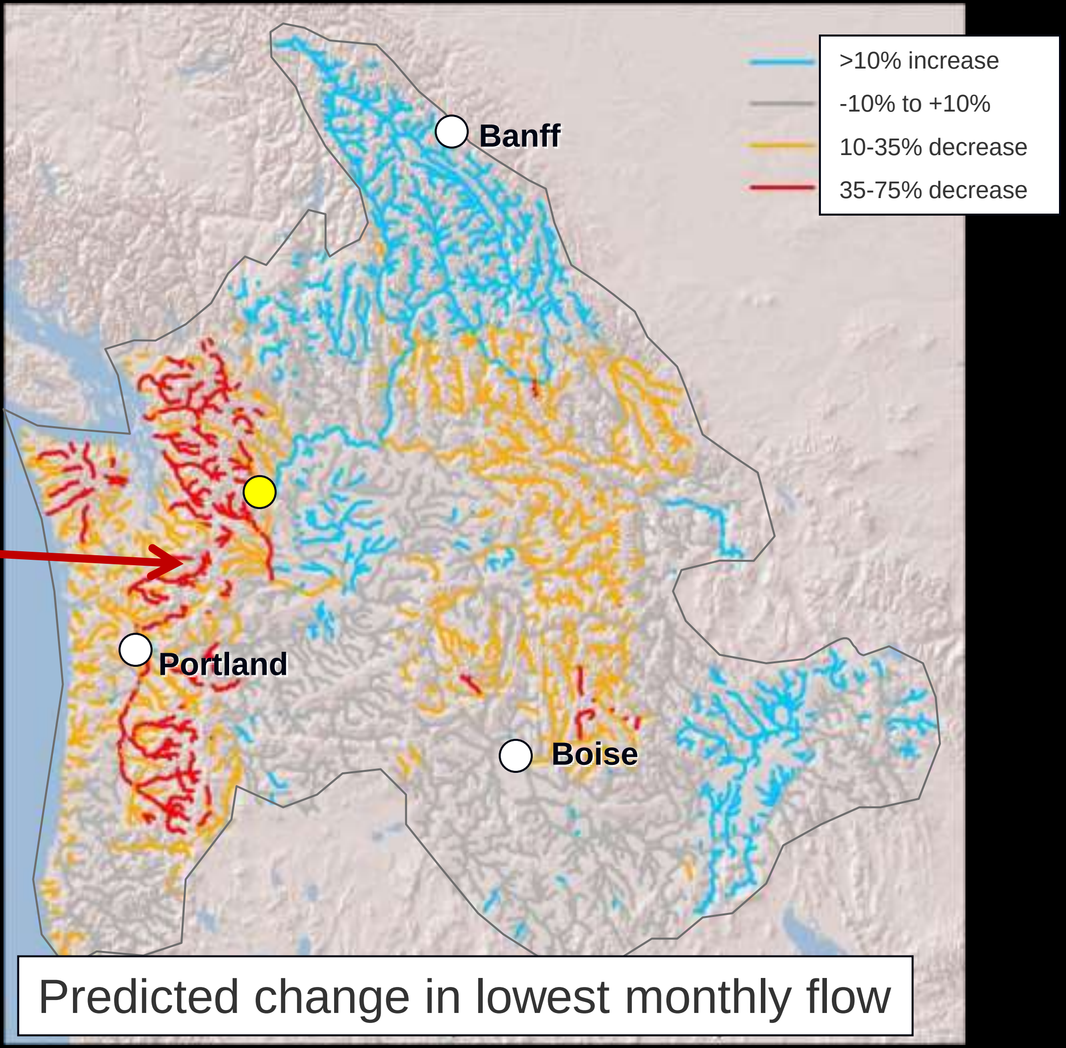
- What habitat factors limit salmon recovery?
- What are local predicted climate change effects?
- Do proposed restoration actions reduce climate change effects?
- Do proposed restoration actions increase habitat diversity or ecosystem resilience?

Beechie et al. 2013

Projected change in low flow

- Change in lowest monthly flow between 1980s and 2080s

35-75% Decrease

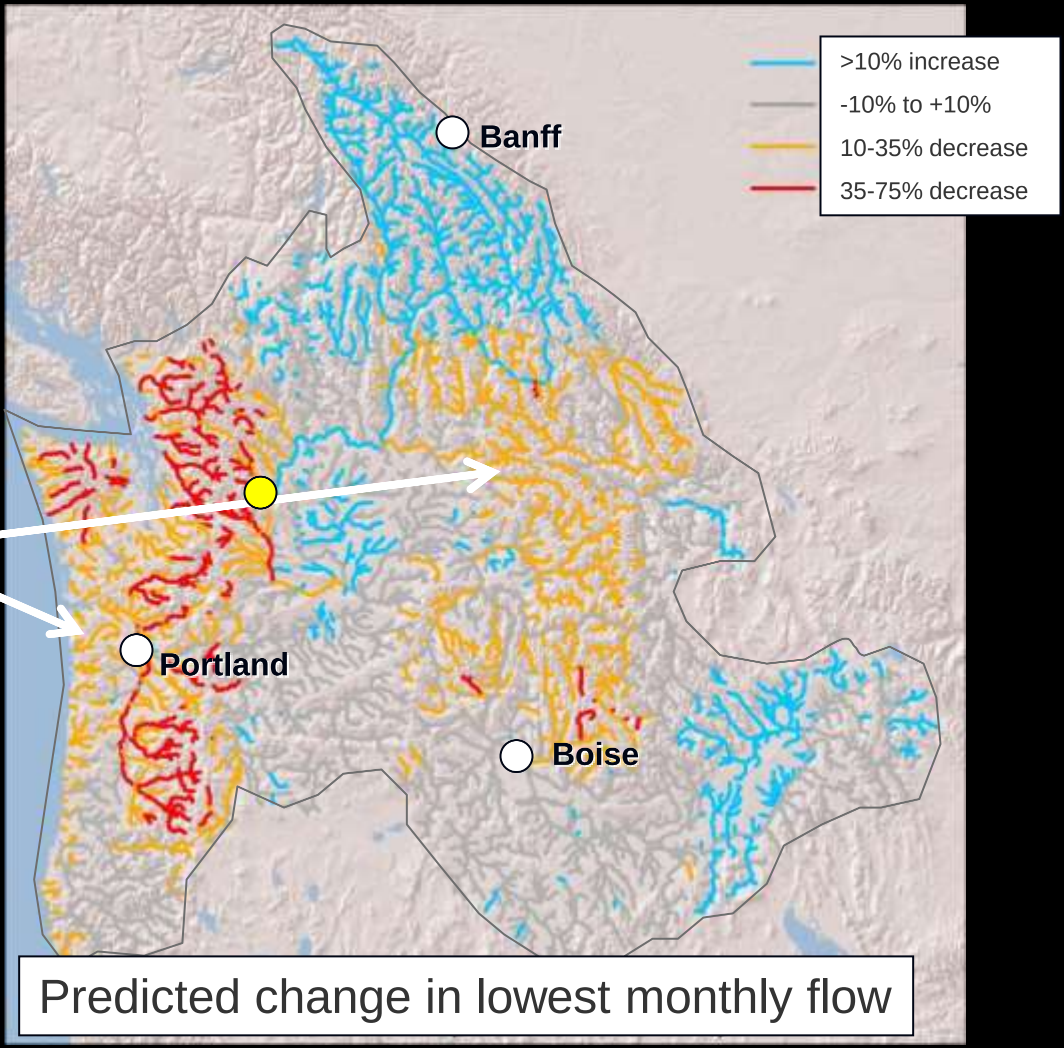


Beechie et al. 2013

Projected change in low flow

- Change in lowest monthly flow between 1980s and 2080s

10-35% Decrease

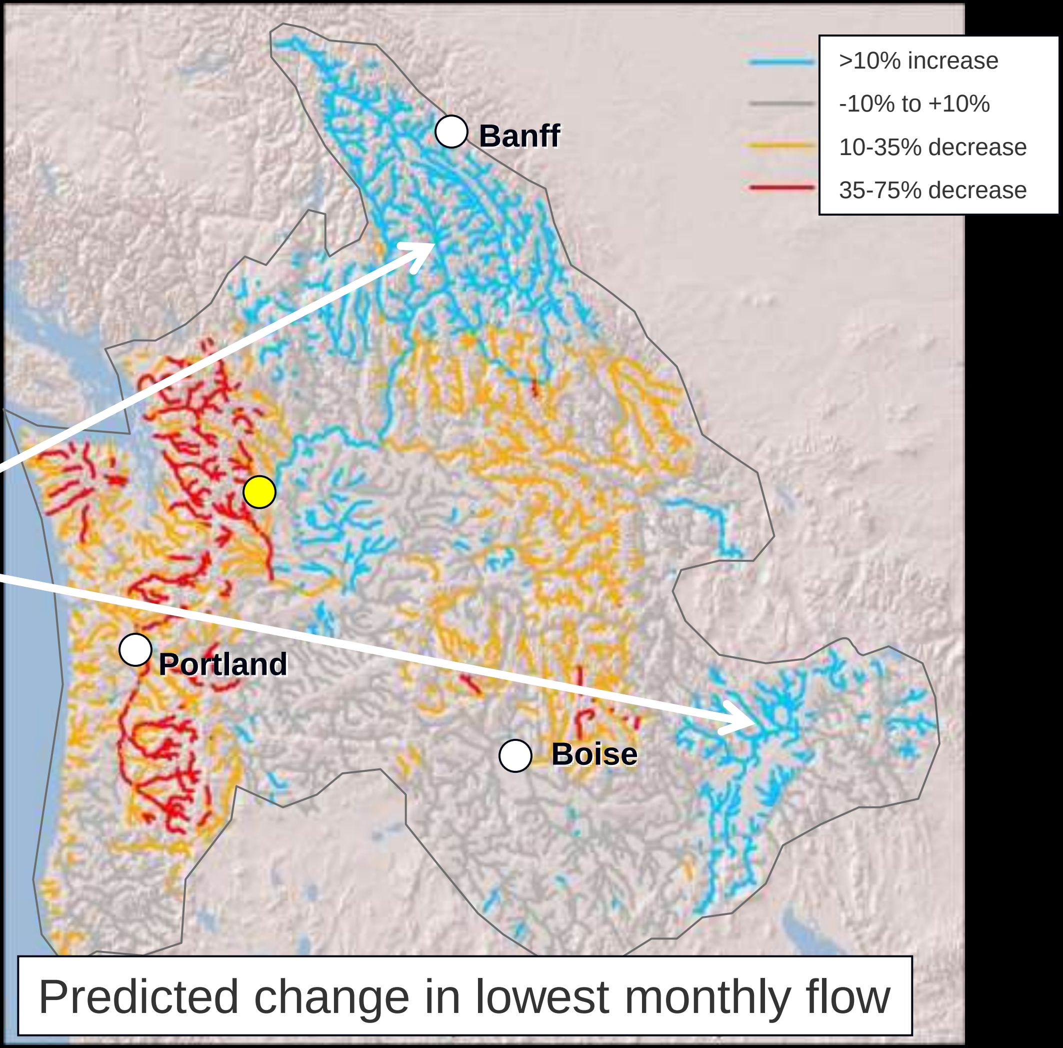


Beechie et al. 2013

Projected change in low flow

- Change in lowest monthly flow between 1980s and 2080s

>10% Increase

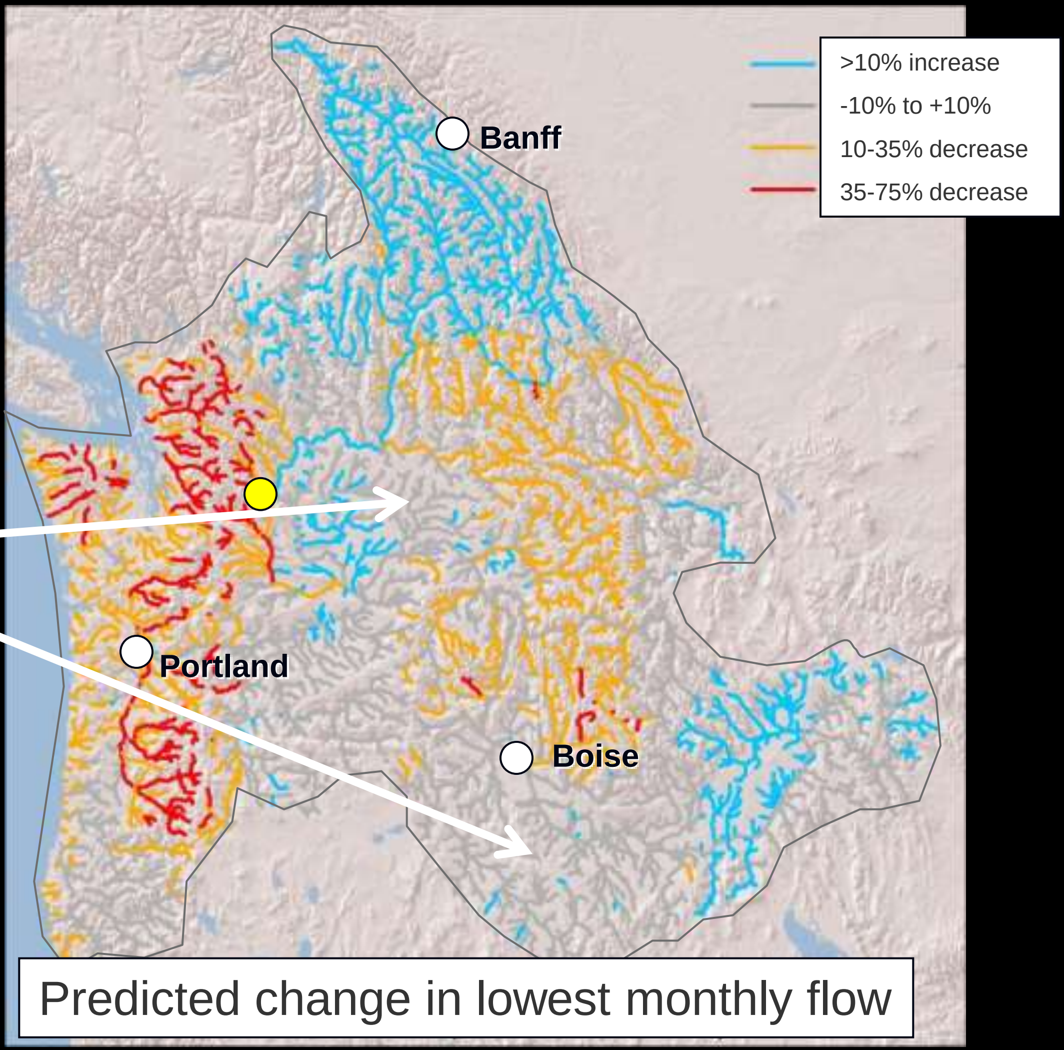


Beechie et al. 2013

Projected change in low flow

- Change in lowest monthly flow between 1980s and 2080s

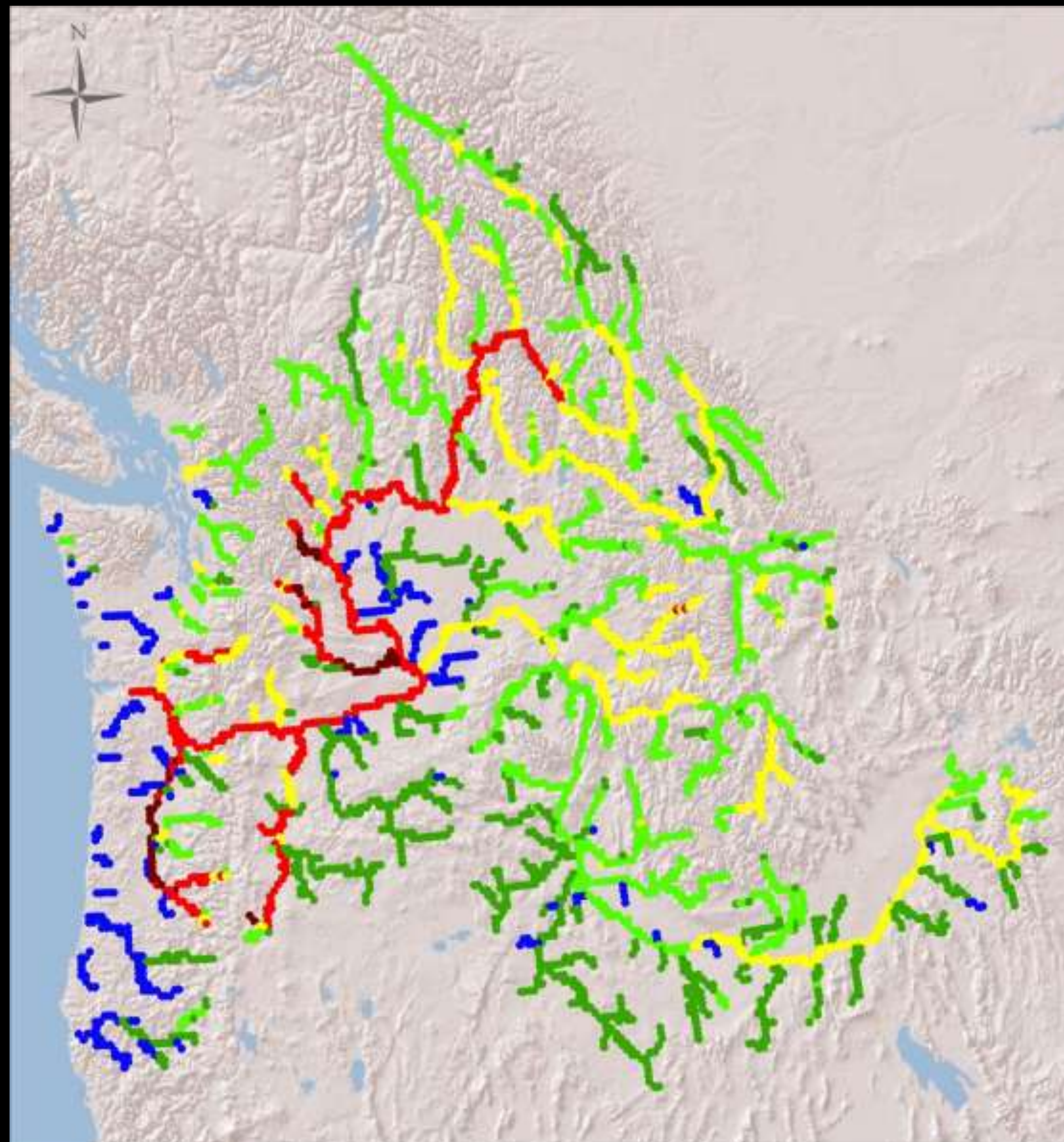
No change



Beechie et al. 2013

Modeled change in stream temperature

- <1°C
- 1-2°C
- 2-3°C
- 3-4°C
- 4-5°C
- 5-6°C
- >6°C



Wu et al. 2012

Ameliorating climate change effects

- Literature review to see if restoration actions can:
  - Reduce a peak flow effect?
  - Reduce a low flow effect?
  - Reduce a stream temperature effect?

Ameliorating climate change effects

- Eight categories of actions
  - Longitudinal connectivity
  - Lateral connectivity (floodplains)
  - Vertical connectivity (hyporheic zone)
  - Restore in-stream flow
  - Restore riparian vegetation
  - Reduce sediment supply
  - In-stream habitat enhancement
  - Nutrient enrichment

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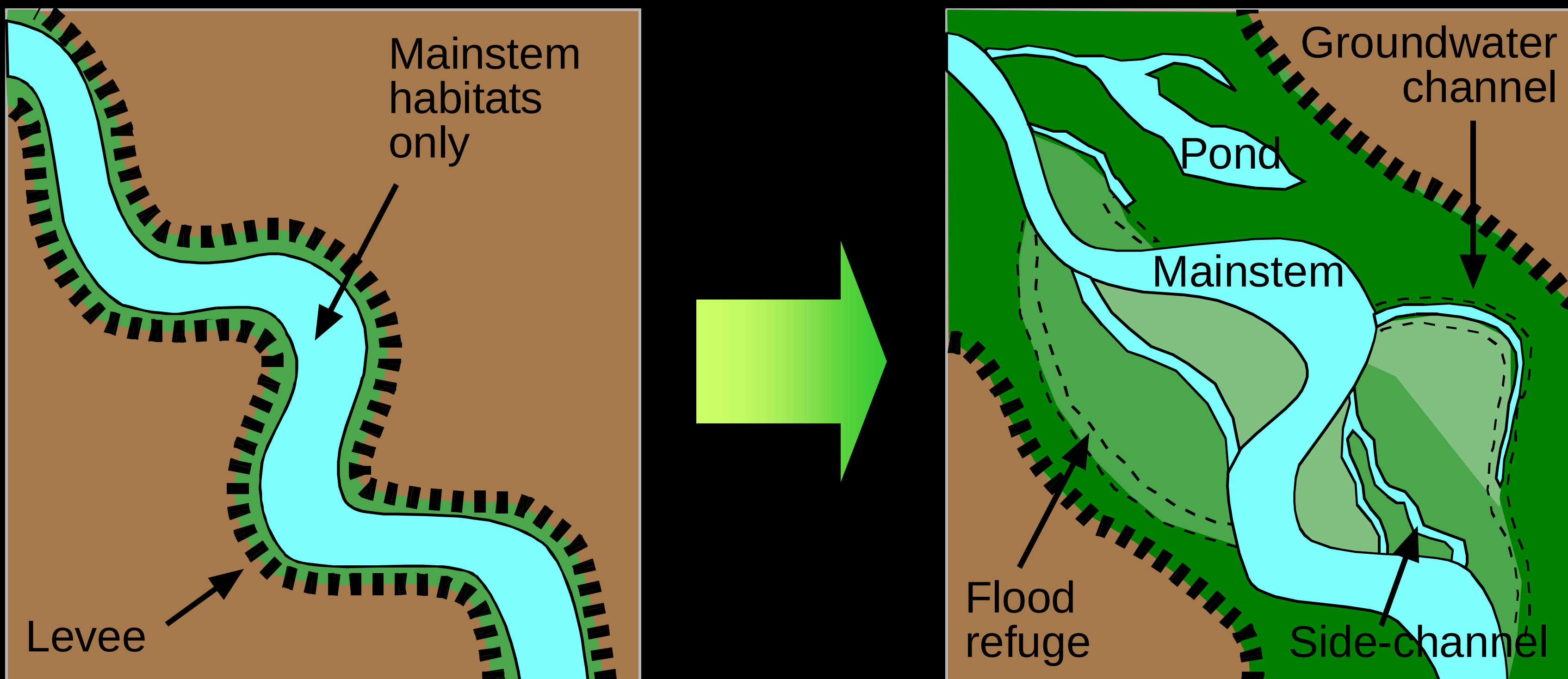
Increasing resilience to climate change



Waples et al. 2008

Reduce temperature

Decrease peak flow (or its effect)

Reducing climate change effects through restoration

Restoration action	Temperature increase	Low flow decrease	Peak flow increase	Increase resilience
Longitudinal connectivity	Y	Y	N	Y
Floodplain connectivity	Y	N	Y	Y
Restore incised channel	Y	Y	Y	Y
Restore in-stream flow	Y	Y	N	N/Y
Riparian rehabilitation	Y	N/Y	N	N
Sediment reduction	N	N	N	N
In-stream habitat	N	N	N	N
Nutrient enrichment	N	N	N	N

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Sediment reduction	N	N	N	N
In-stream habitat	N	N	N	N
Nutrient enrichment	N	N	N	N

Reducing climate change effects through restoration

Restoration action	Temperature increase	Low flow decrease	Peak flow increase	Increase resilience
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In-stream habitat	N	N	N	N
Nutrient enrichment	N	N	N	N

Reducing climate change effects through restoration

Restoration action	Temperature increase	Low flow decrease	Peak flow increase	Increase resilience
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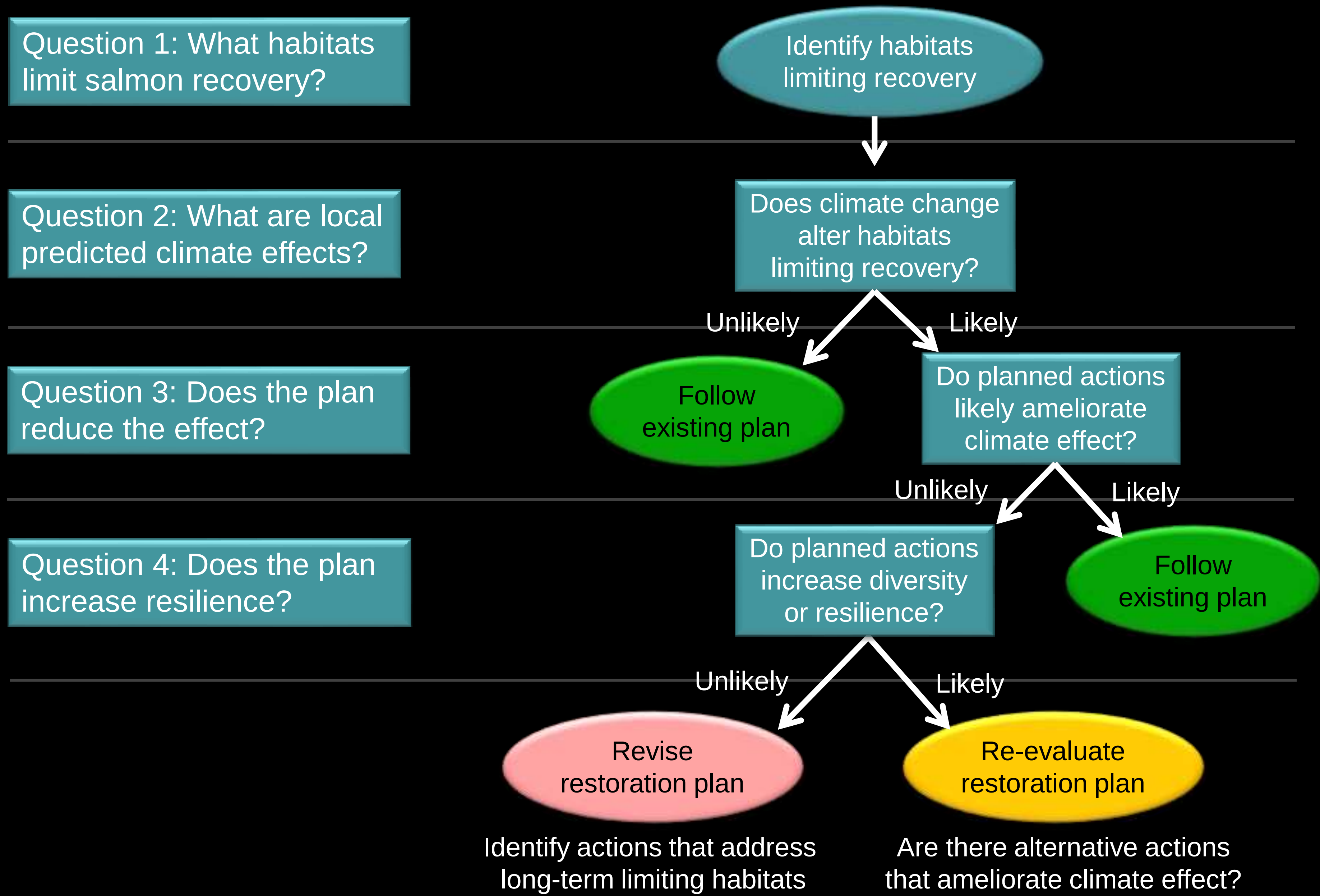
Restore incised channel	Y	Y	Y	Y
Restore in-stream flow	Y	Y	N	N/Y
Riparian rehabilitation	Y	N/Y	N	N
Sediment reduction	N	N	N	N
In-stream habitat	N	N	N	N
Nutrient enrichment	N	N	N	N

Evaluating a restoration plan



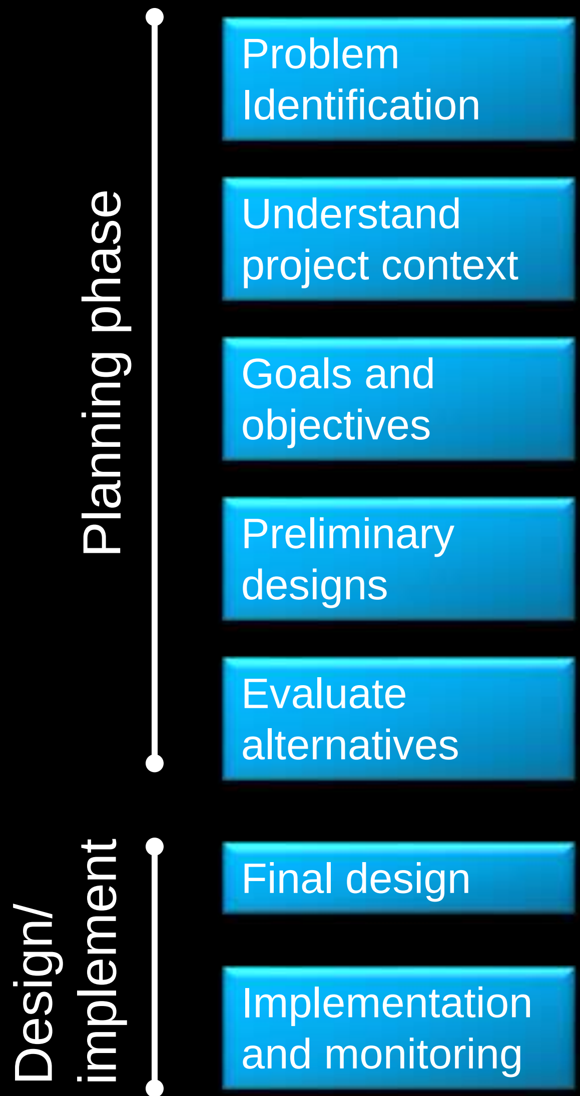
Nooksack River beta test

- Knowledge is there to answer the questions
- No new actions in 2 of 4 restoration zones
- Restore floodplain connectivity in zone 2 to increase peak flow resilience
- Increase emphasis on floodplain connectivity in zone 4 to restore thermal and flood refugia

Incorporating climate change into restoration design

Climate adaptation in project design

- Anticipated effects
  - Increased peak flows
  - Decreased low flows
  - Increased stream temperature



Climate adaptation in project design

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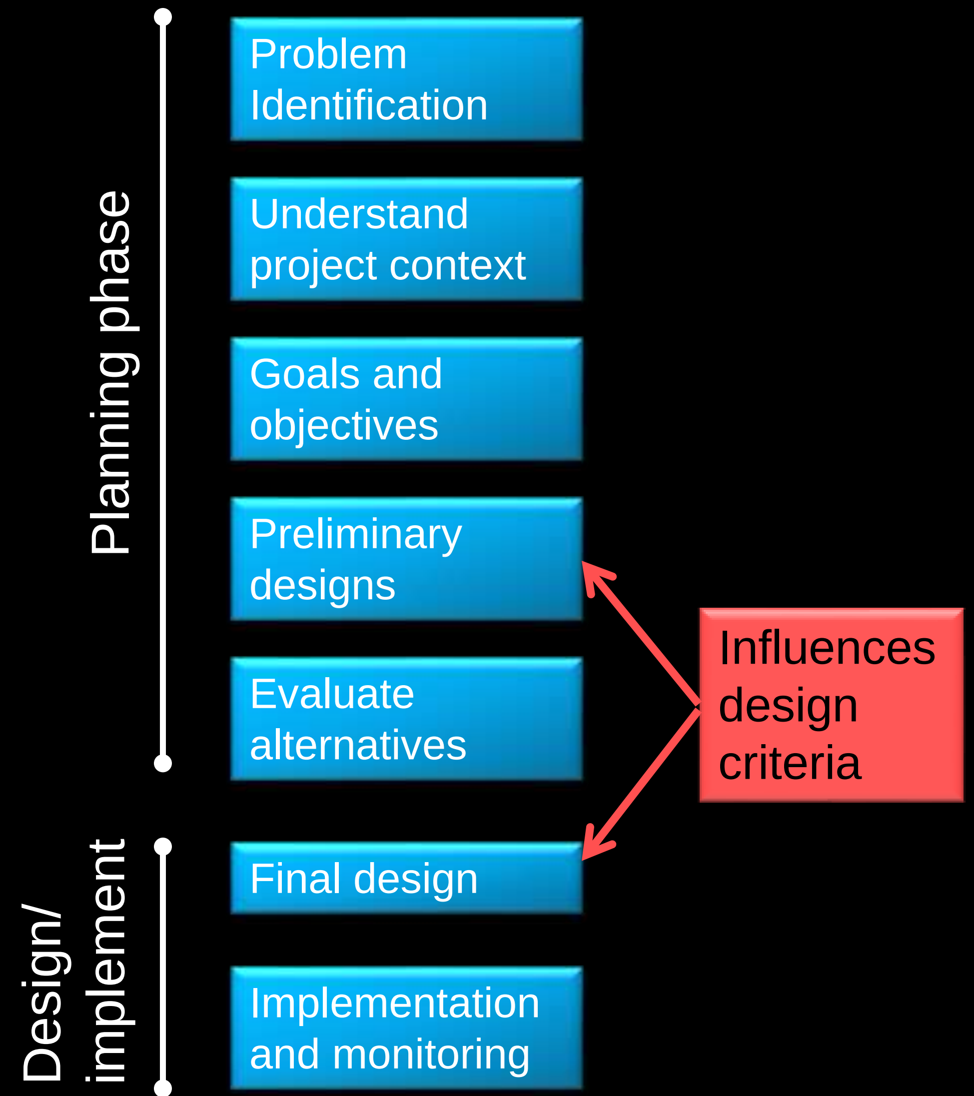
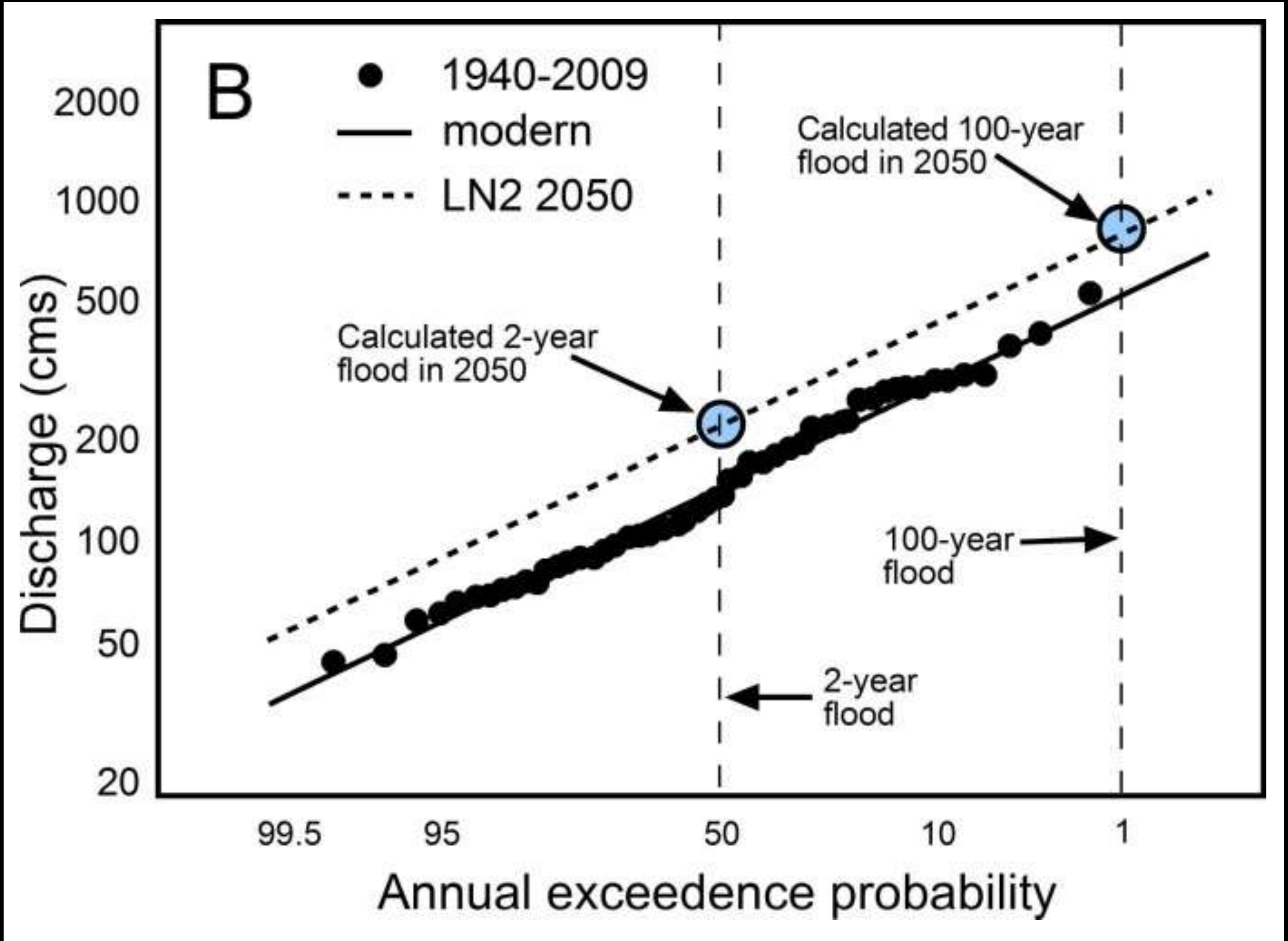


Example: peak flow



Example design guidelines (EU)

Country	Variable	Guideline
Belgium	Design floods	30% increase
United Kingdom	Design floods	20% increase for 2085
Germany/Bavaria	100-yr design flood	15% increase
Germany/Baden-Wurrtemberg	Design floods	Between 0% and 75% increase depending on location and RI
Norway	Design floods	0%, 20%, 40% increase depending on region and flood season
Sweden	Design floods	Between 5% and 30% increase depending on location

Conclusions

- Reduce effects of flow and temperature changes where possible
- Identify and advocate resilient restoration actions
- Develop simple tools to help Incorporate expected flow changes into restoration design

References

Beechie, T.J., M. Ruckelshaus, E. Buhle, A. Fullerton, L. Holsinger. 2006. Hydrologic regime and the conservation of salmon life history diversity. Biological Conservation 130(4):560-572

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