Flood Potential in the Southern Rocky Mountains Region

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Big Thompson River & US-34

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Collaborators:

Drake, Colorado
(Image source: NRCS exigent EWP)

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Overview of Problem

- Common flood analysis procedures do not facilitate a number of needs, such as:
  - Verification of at-a-station flood-frequency and regional regression analyses results
  - Quantifiable procedure for identifying and ranking extreme floods
  - Clear comparisons of how flood magnitudes and hazards vary across regions
  - Simple language for communicating expected flood hazards with the public and land managers

Estes Park, Colorado

Potential Solution

- A space-for-time substitution can be utilized to address these needs. Procedure:
  - Regressions of record peak discharges at long-term streamgages used to predict the *expected flood potential* (across zones of similar flood response)
  - Upper 90% prediction limit provides the *maximum likely flood potential* (floods greater than this limit defined as extreme)
  - Paleoflood data and shorter streamgage records can be utilized
  - Flood hazards can easily be compared between zones (using developed indices)
  - Seasonality and trend analyses can be performed (currently using the largest 5% floods)

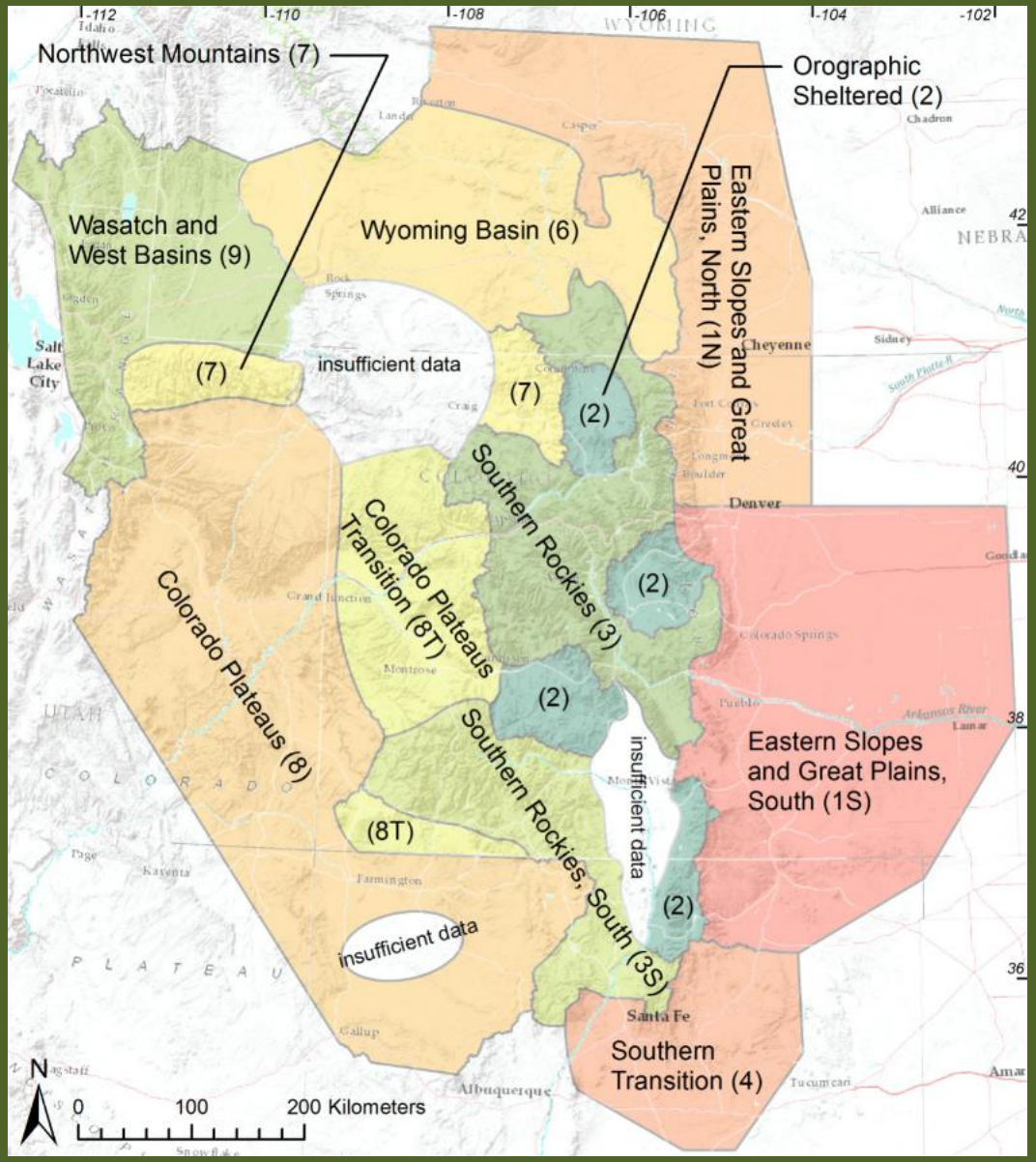
Potential Solution

- Such a procedure avoids communication pitfalls with terms such as “100-year flood” and “0.010 annual exceedance probability flood”
  - Reliance solely upon flood frequency is considered problematic by some specialists (Klemes, 1986; Klemes, 1989; Baker, 1994; Baker, 1998; Serinaldi, 2015)
  - The term “100-year flood” has been argued as “erroneous as science and misleading/destructive as public policy/communication” (Baker, 2008)

Estes Park, Colorado

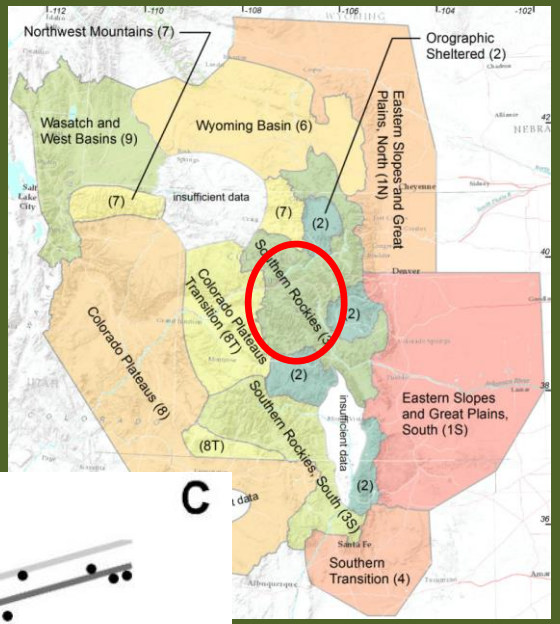
Flood Potential Zones

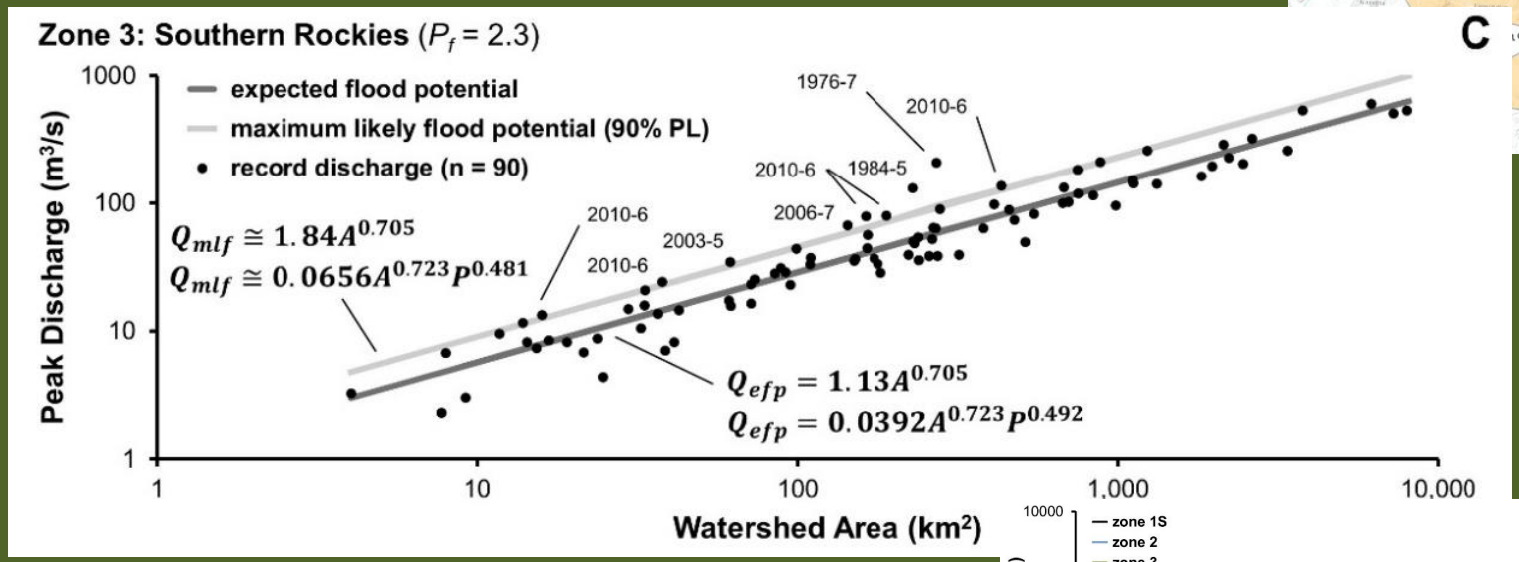
- Zones primarily based on physiographic provinces and sections, and experienced floods
- Relatively consistent flood hazards experienced across zones
- Substantially different flood hazards occur between zones

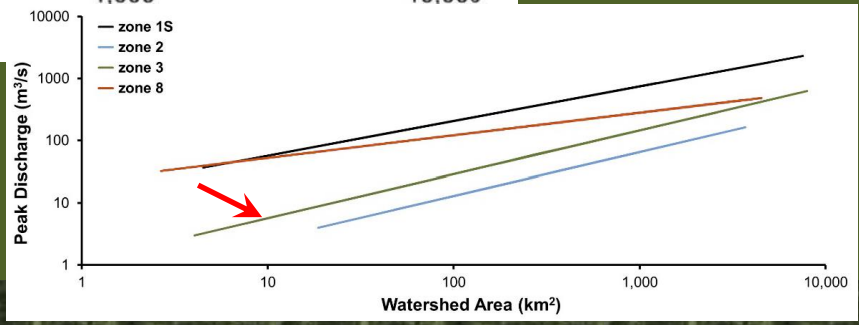


Flood Potential Zones

- **Zone 3: Southern Rockies**
  - Predictor – Area: $R^2 = 0.92$
  - Predictors – Area + Ave. Precip. : $R^2 = 0.93$







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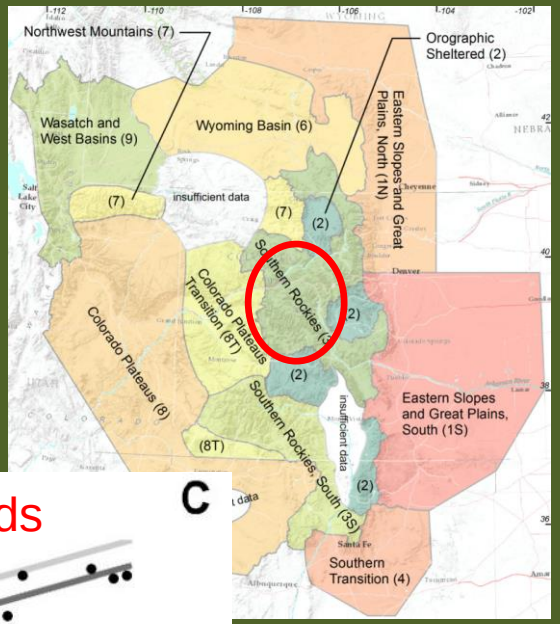
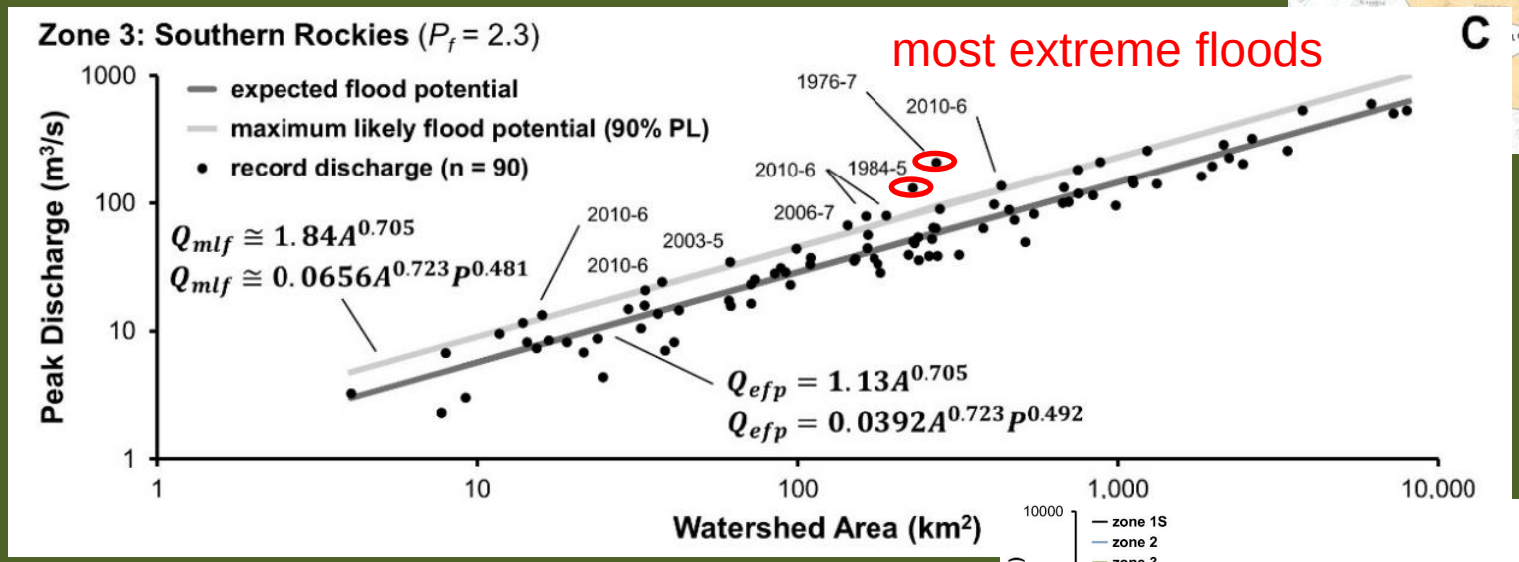
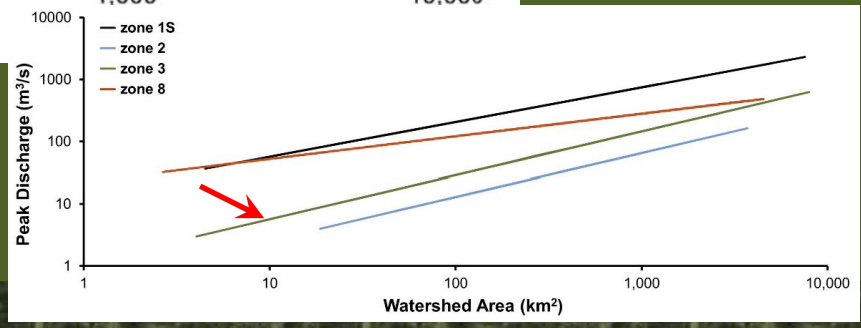
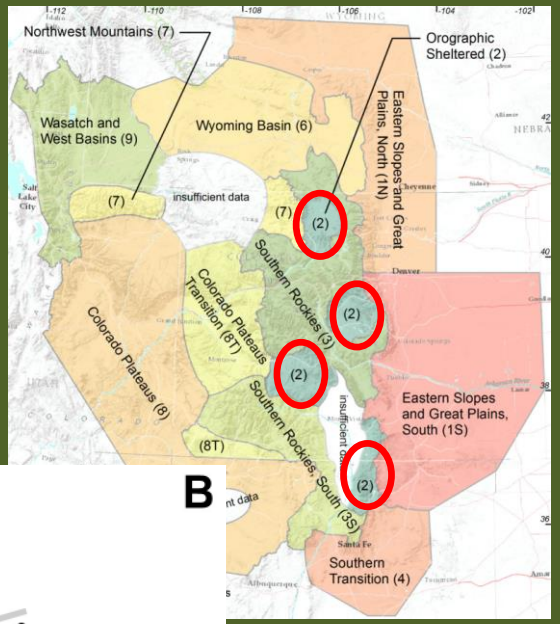


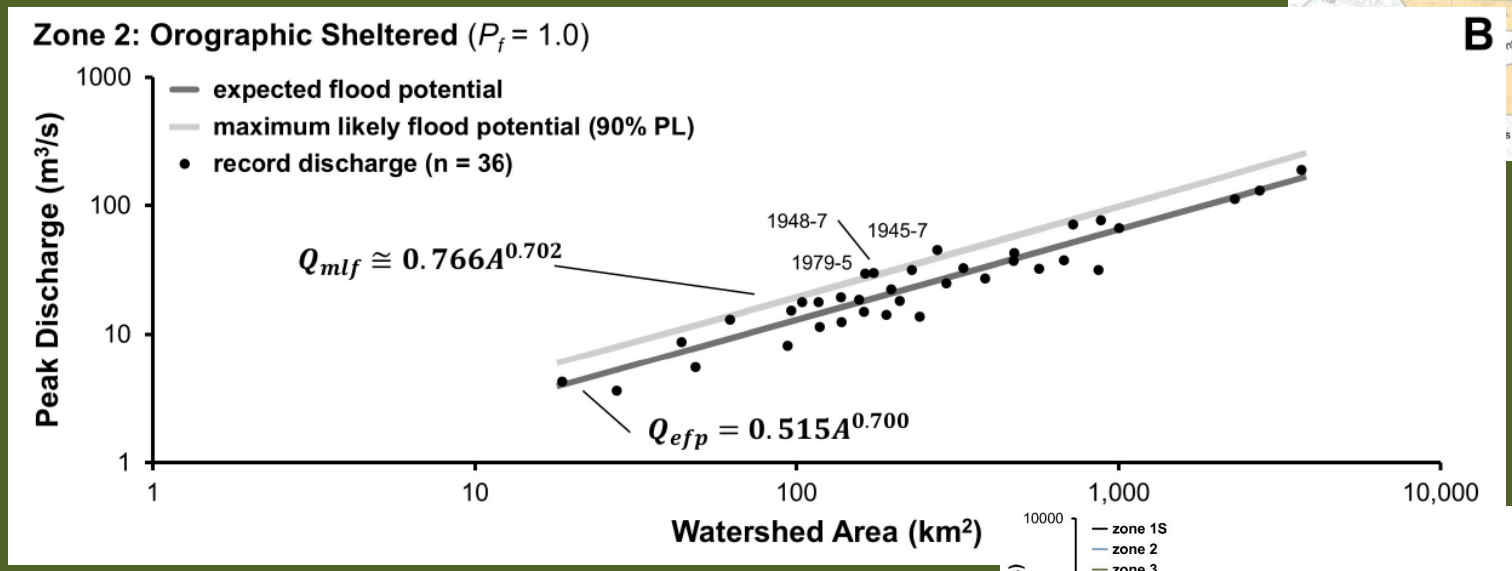


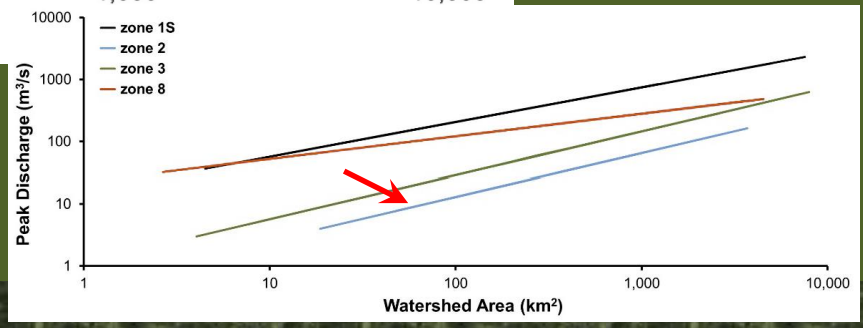


Flood Potential Zones

- **Zone 2: Orographic Sheltered (large mountain valleys of central CO and NM)**
  - Predictor – Area: $R^2 = 0.89$







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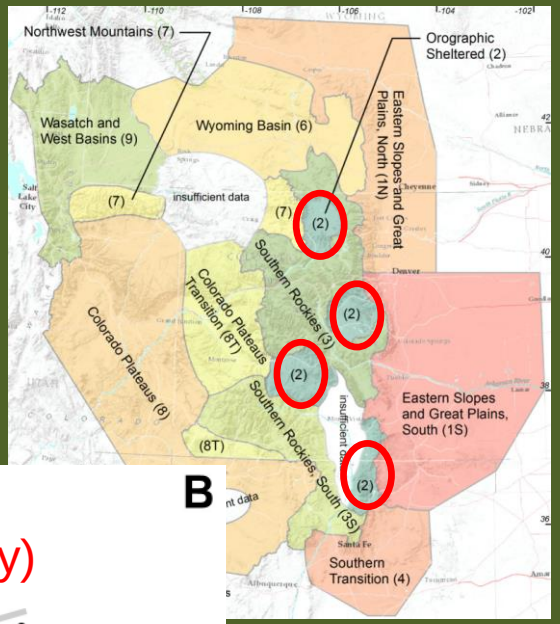
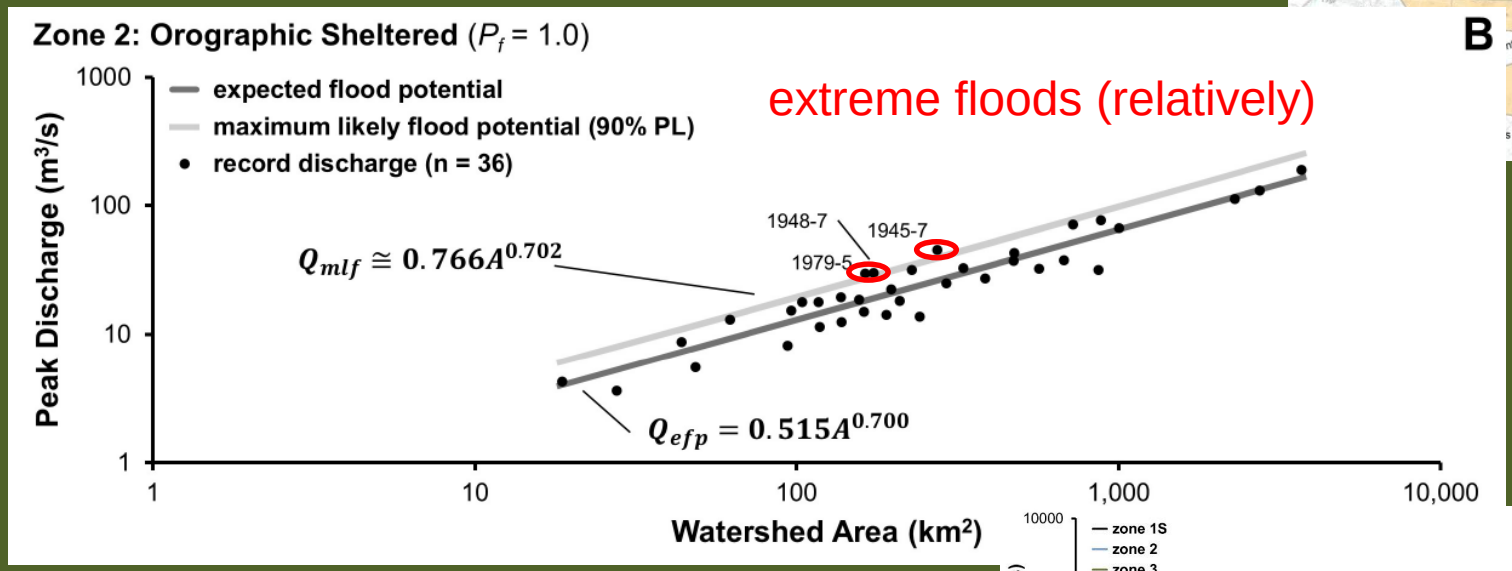
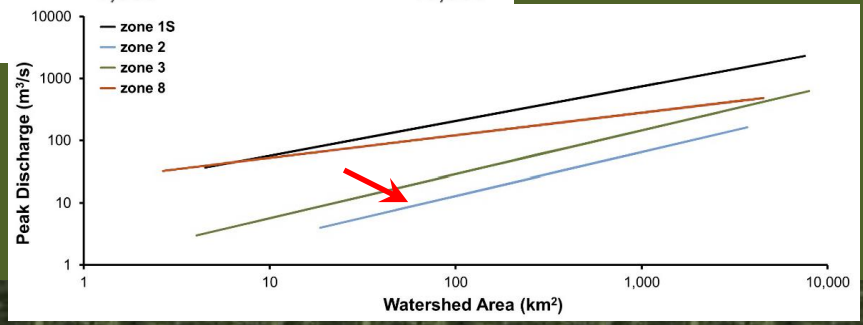






Indices

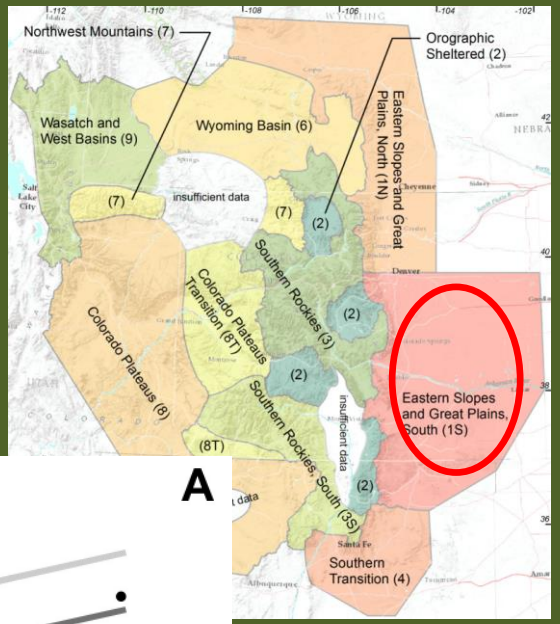
- To compare flood hazards between zones, indices are valuable
  - Flood Potential Index (P_f): comparison with flood potential in a standard zone (2)

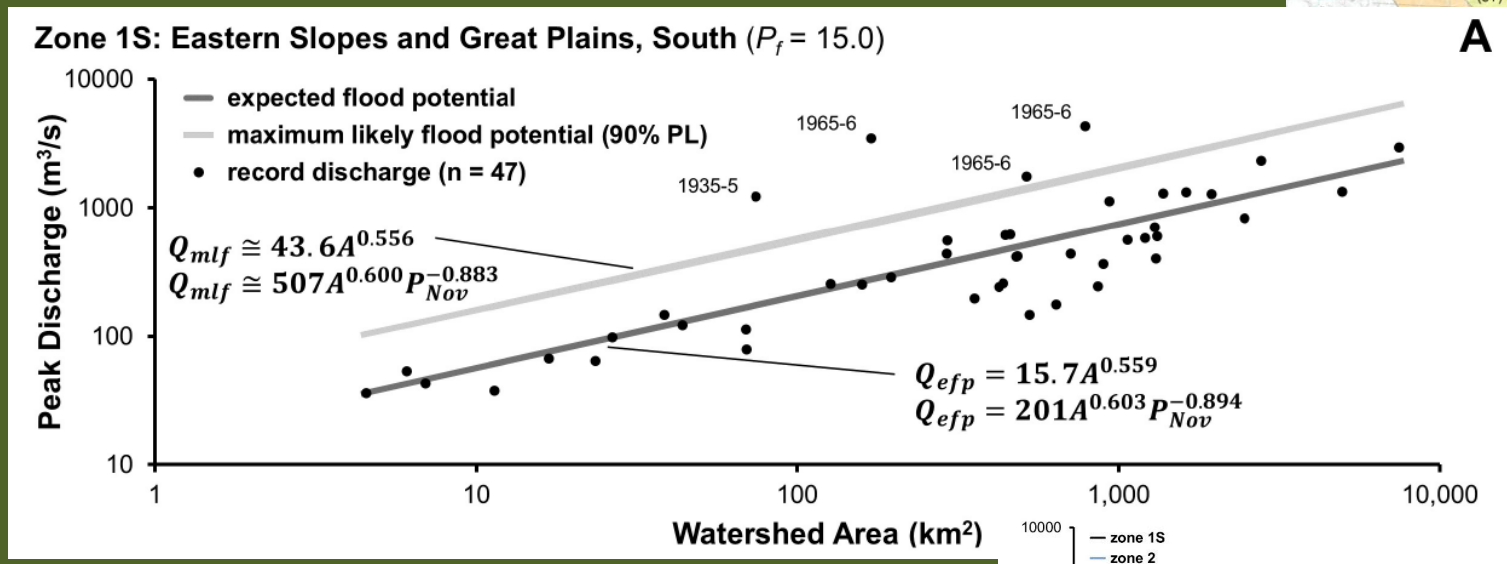
$$P_f = average\left({Q_{20}}/{4.15} + {Q_{200}}/{21.0} + {Q_{2000}}/{106}\right)$$

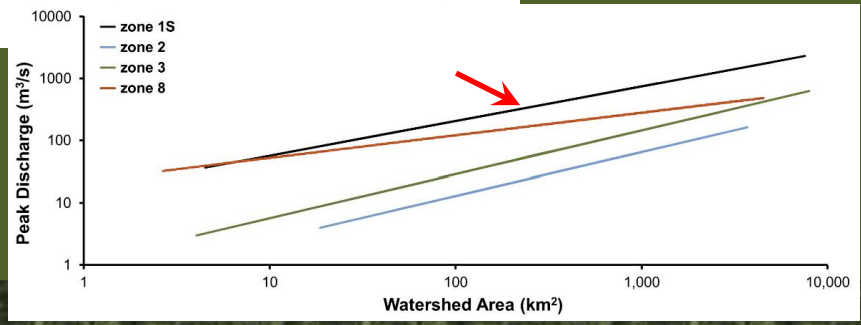
  - Variability Index (V_f): $V_f = {a_{mlf}}/{a_{efp}}$
  - Flashiness (Beard *F*): standard deviation of ln(Annual Peak Q)
  - Flood Hazard Index (H_f): $H_f = P_f * F$
  - Flood Extreme Index (E_f): $E_f = {Q}/{Q_{efp}}$

Flood Potential Zones

- **Zone 1S: Eastern Slopes and Great Plains, South**
  - Predictor – Area: $R^2 = 0.65$
  - Predictors – Area + Nov. Precip. : $R^2 = 0.70$







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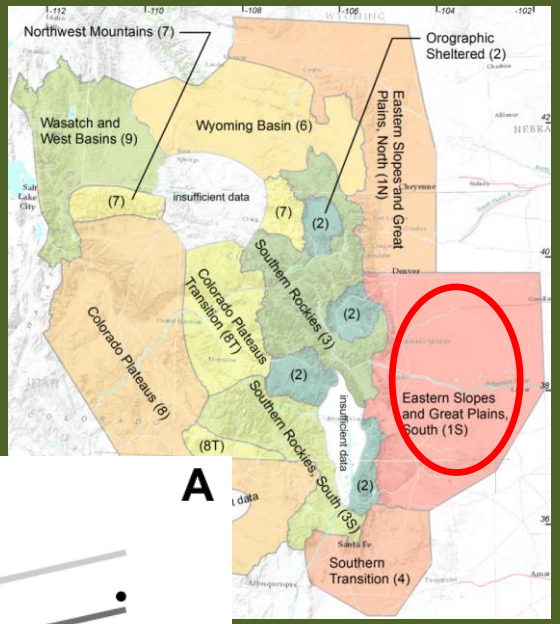

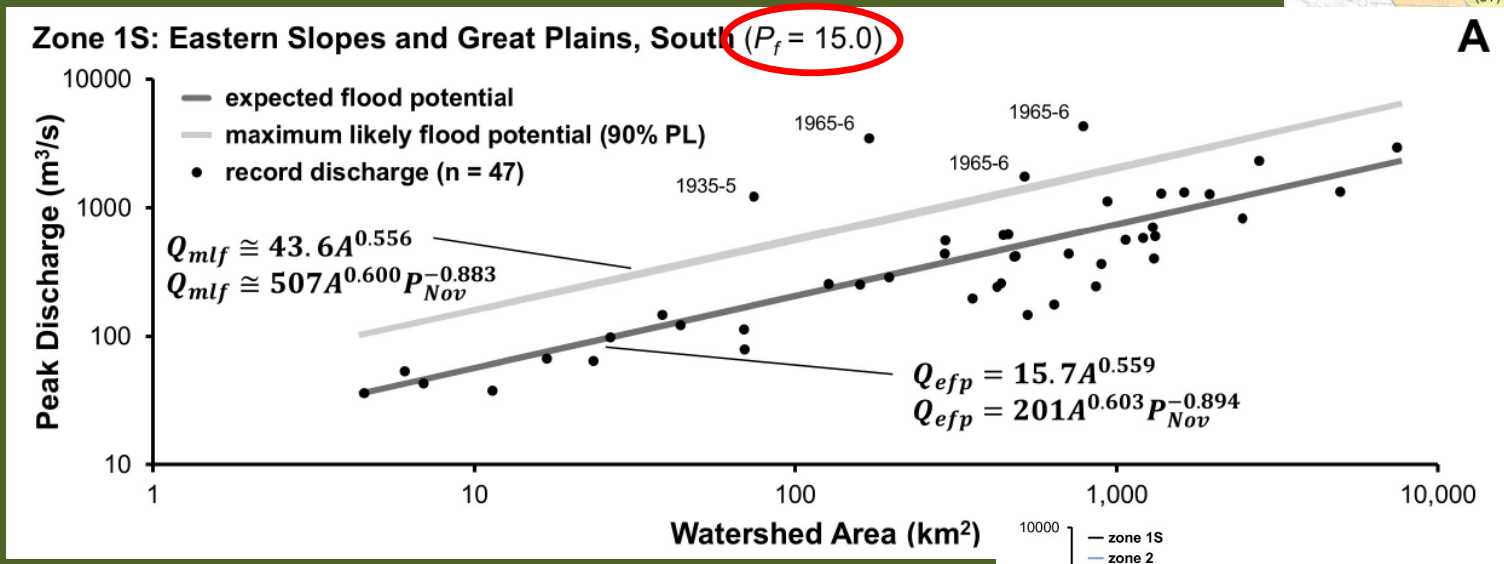

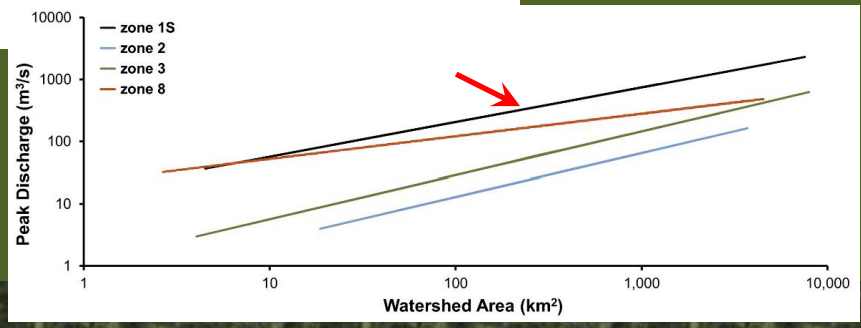

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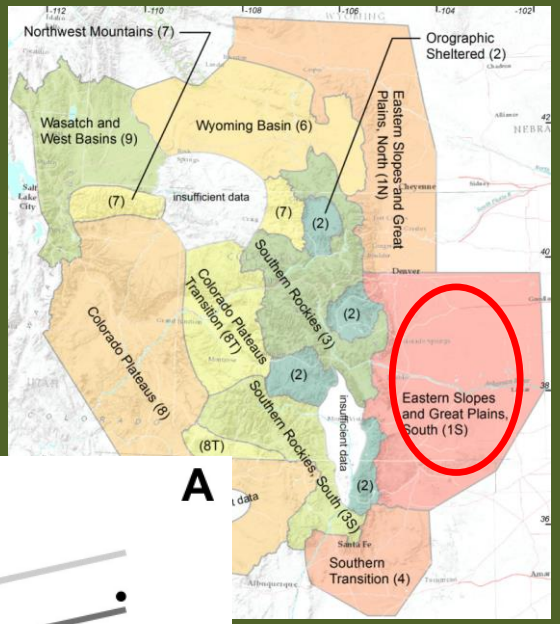
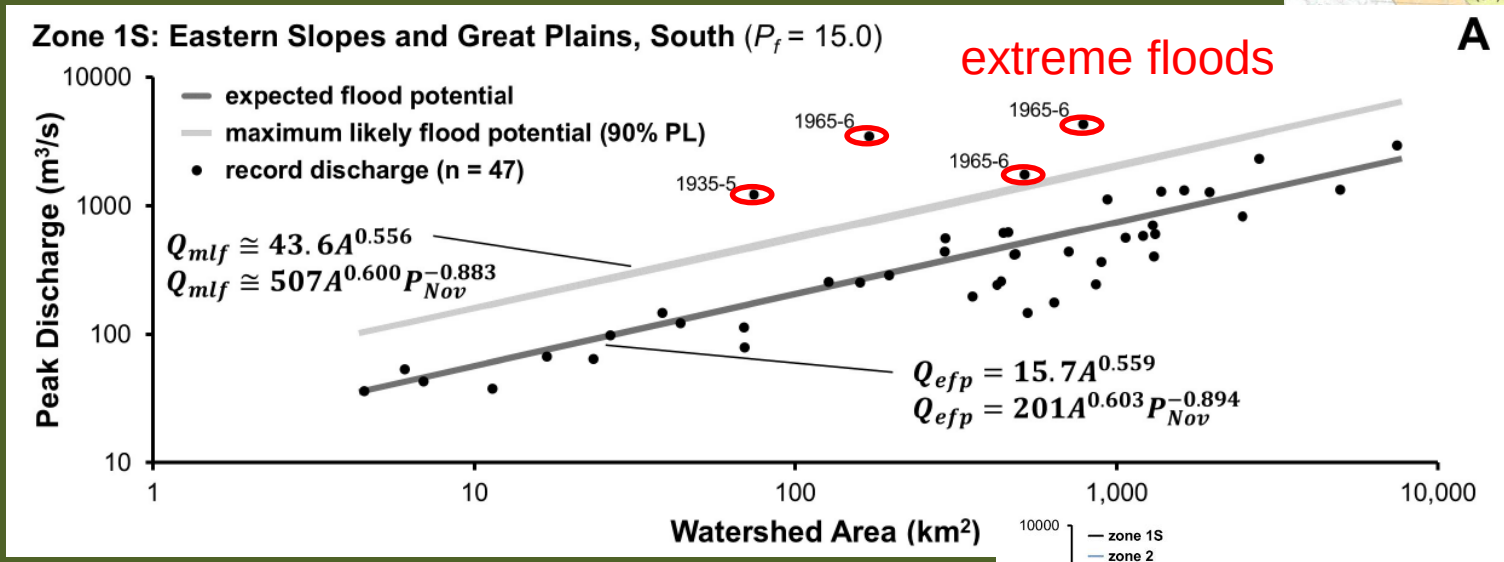
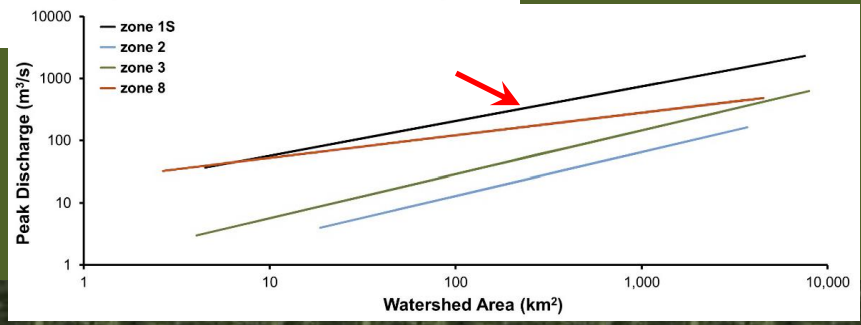
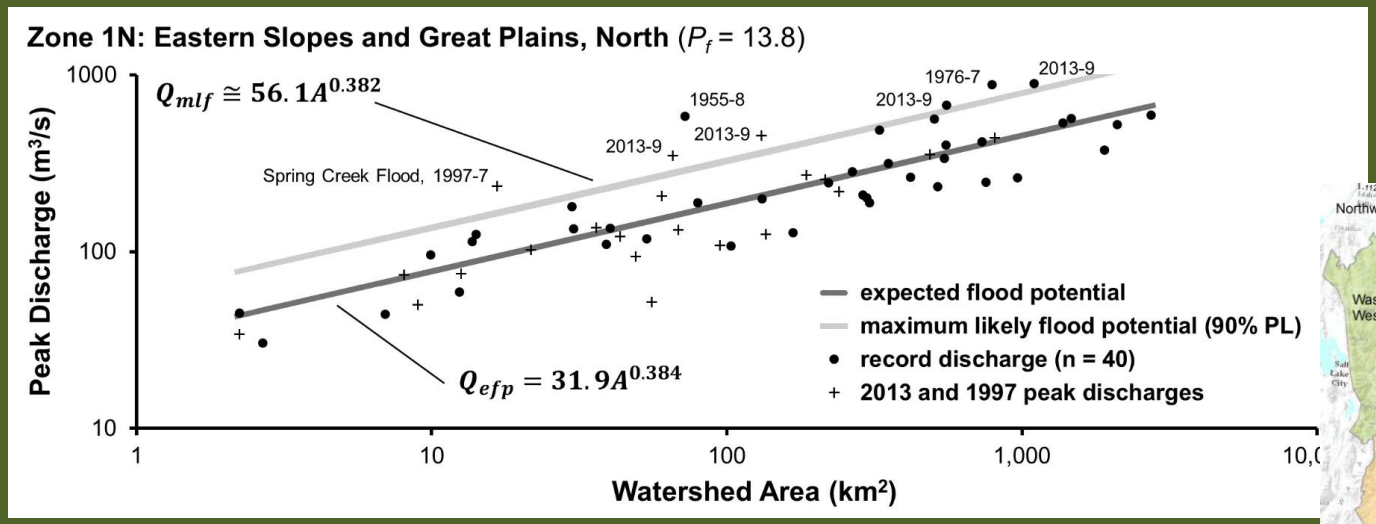


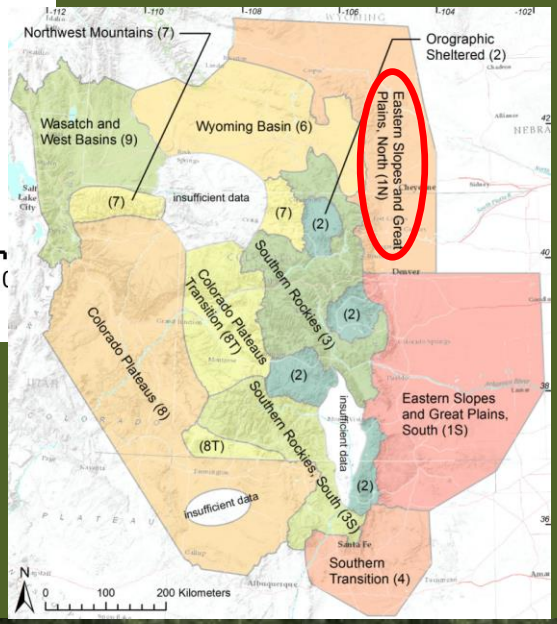




2013 Colorado Front Range Flood

- “Plus” symbols are indirect discharge measurements
- Extreme in St. Vrain and Little Thompson watersheds
- Expected magnitudes in other areas

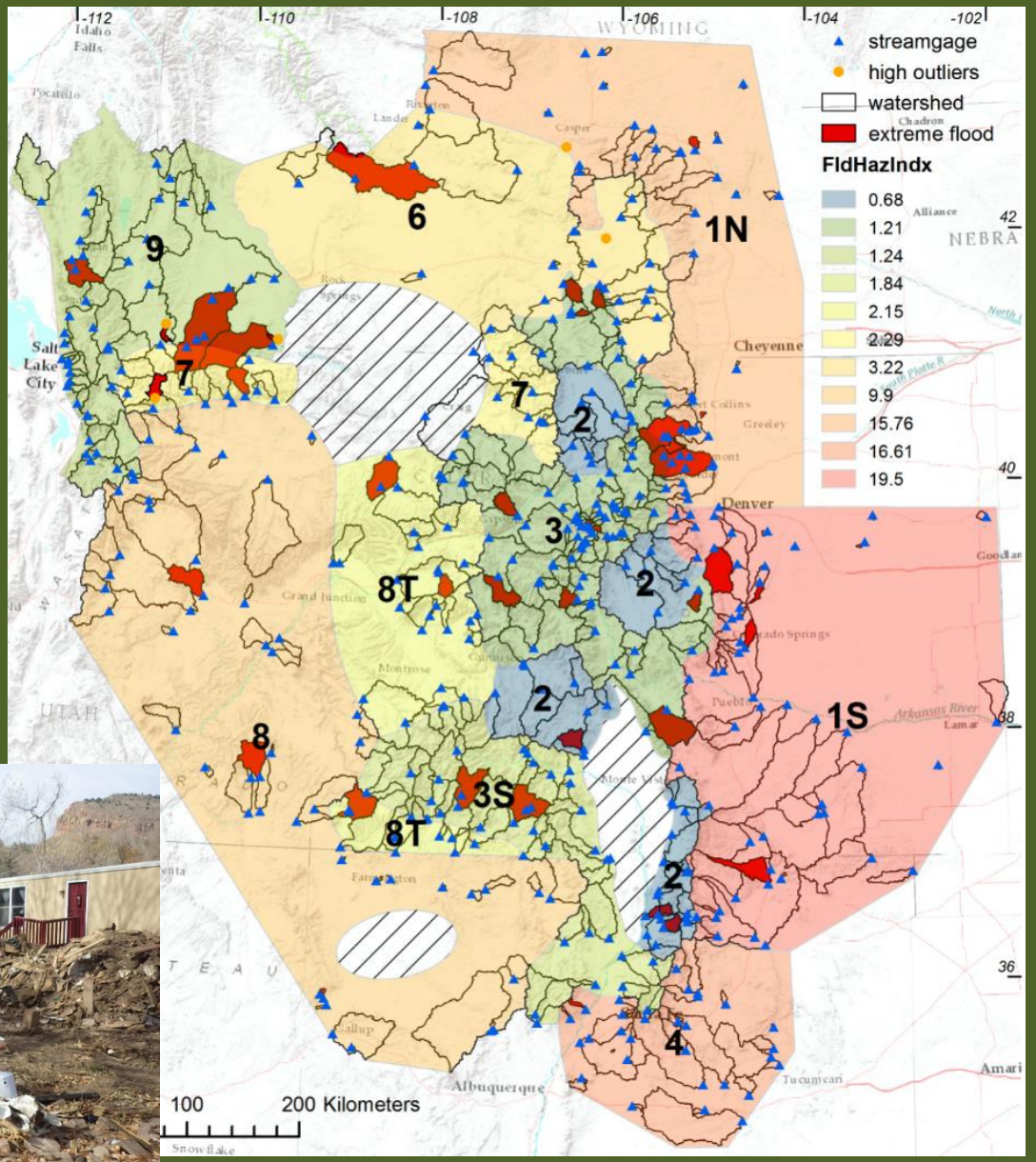




Extreme Floods

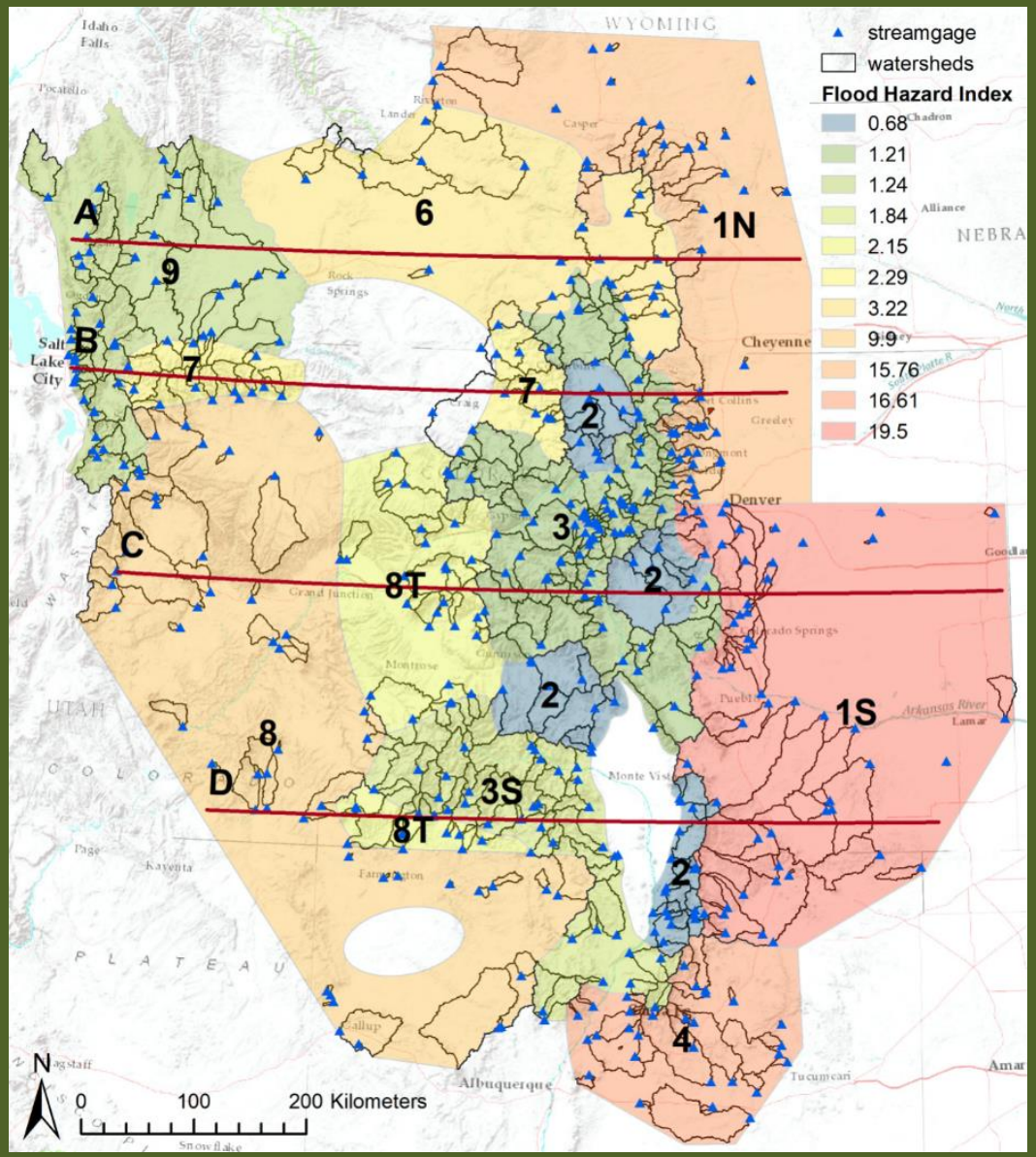
- Watersheds that have experienced extreme floods

Lyons, Colorado

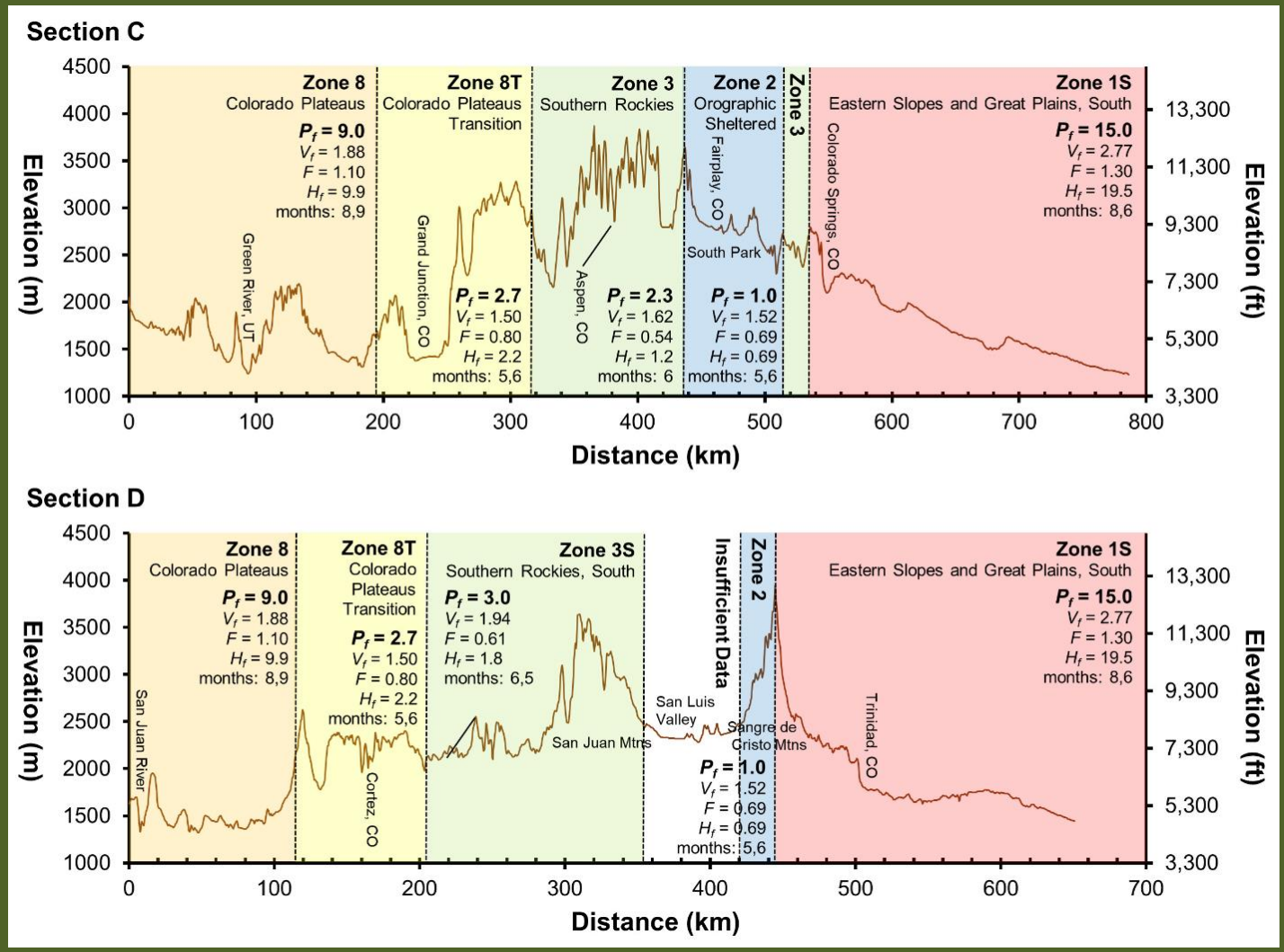


Region Cross Sections

- Warmer colors: greater flood potential
- Cooler colors: lesser flood potential

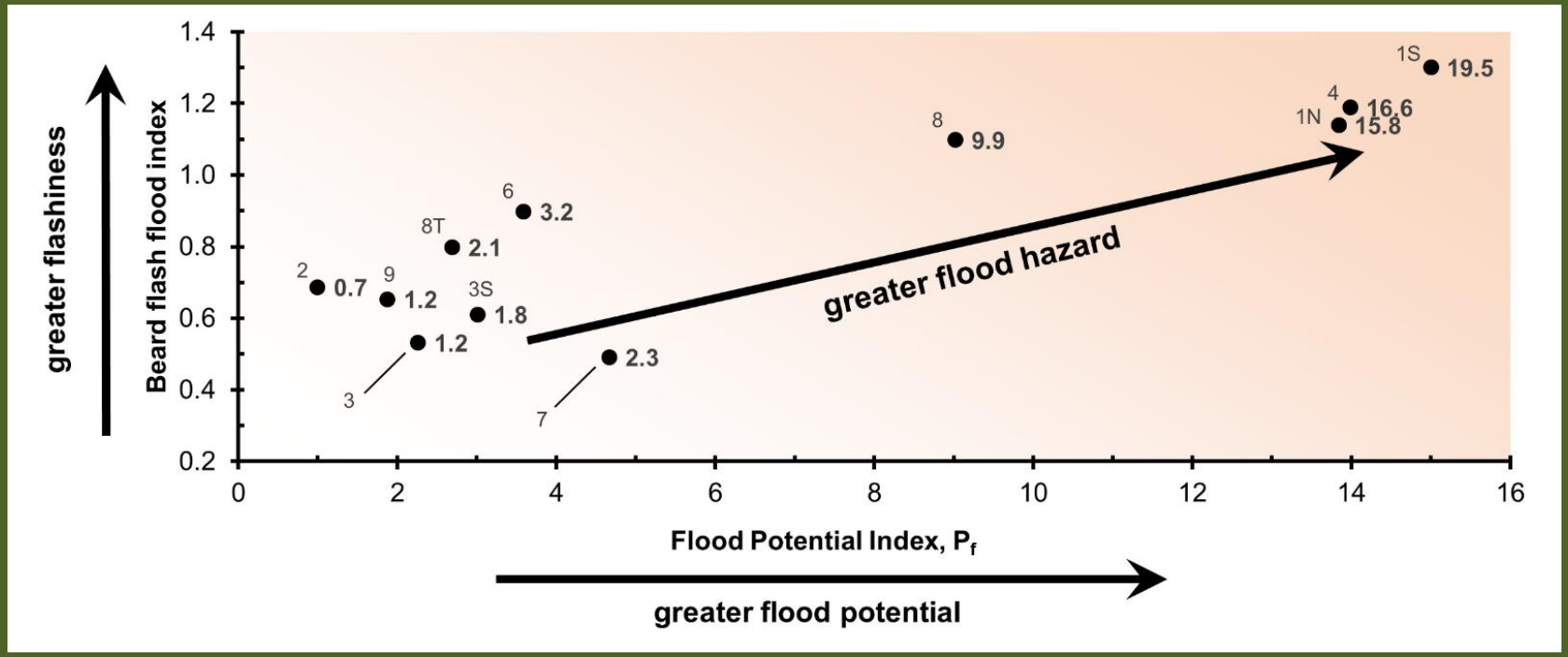


Region Cross Sections C & D



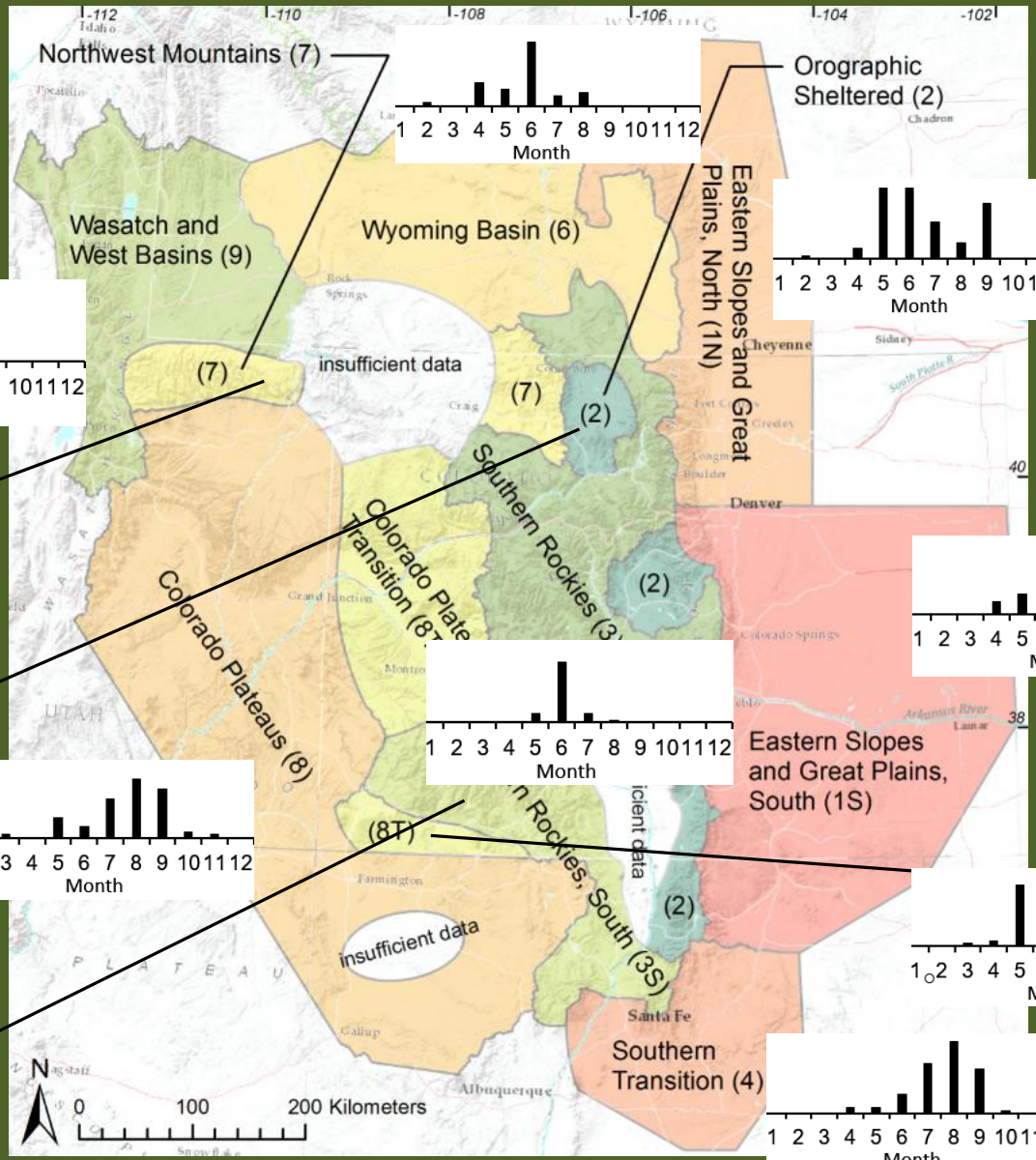
Flood Hazard

- Flood hazard index (H_f): bold values



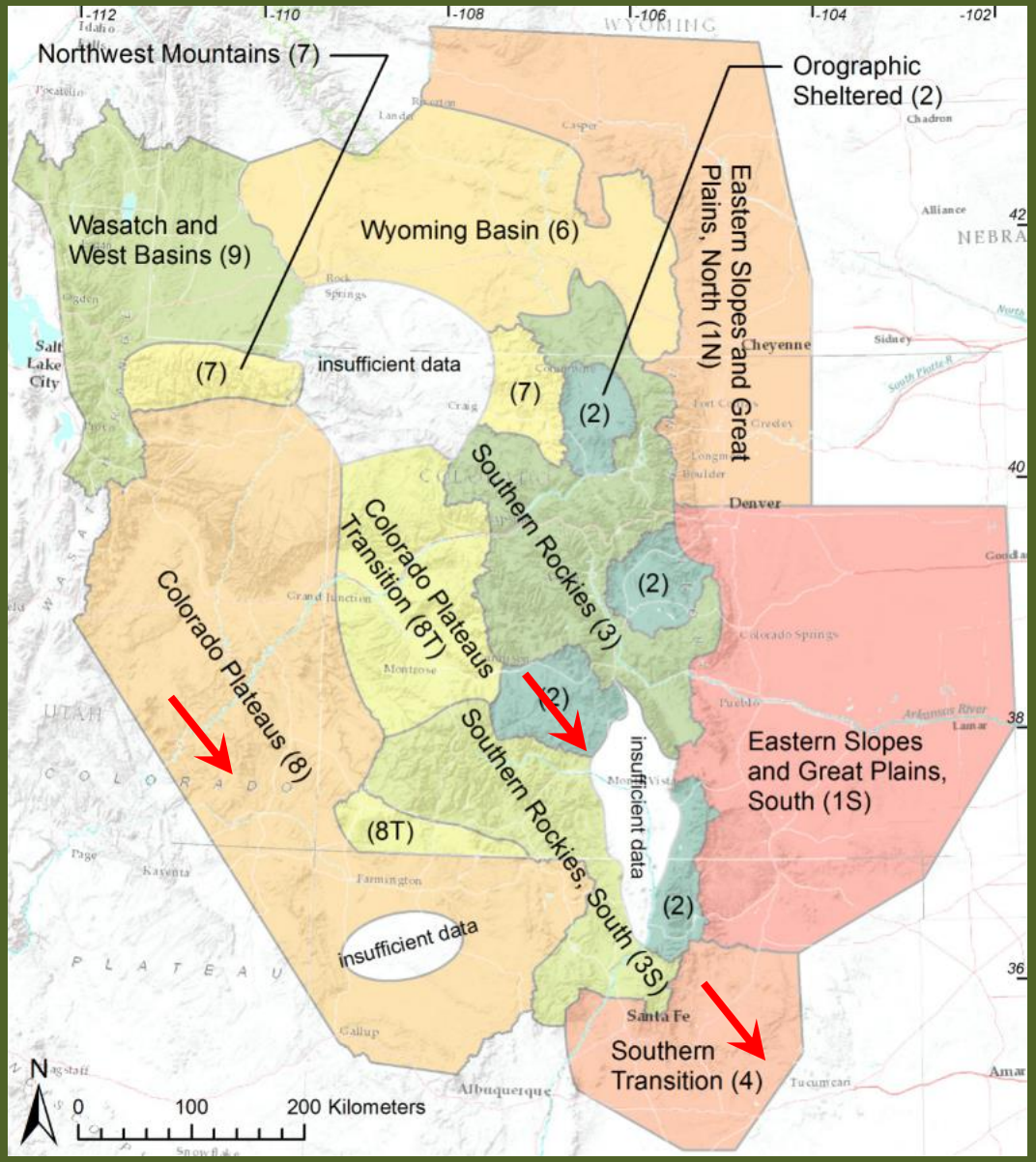
Timing of Large Floods

- Largest 5% floods



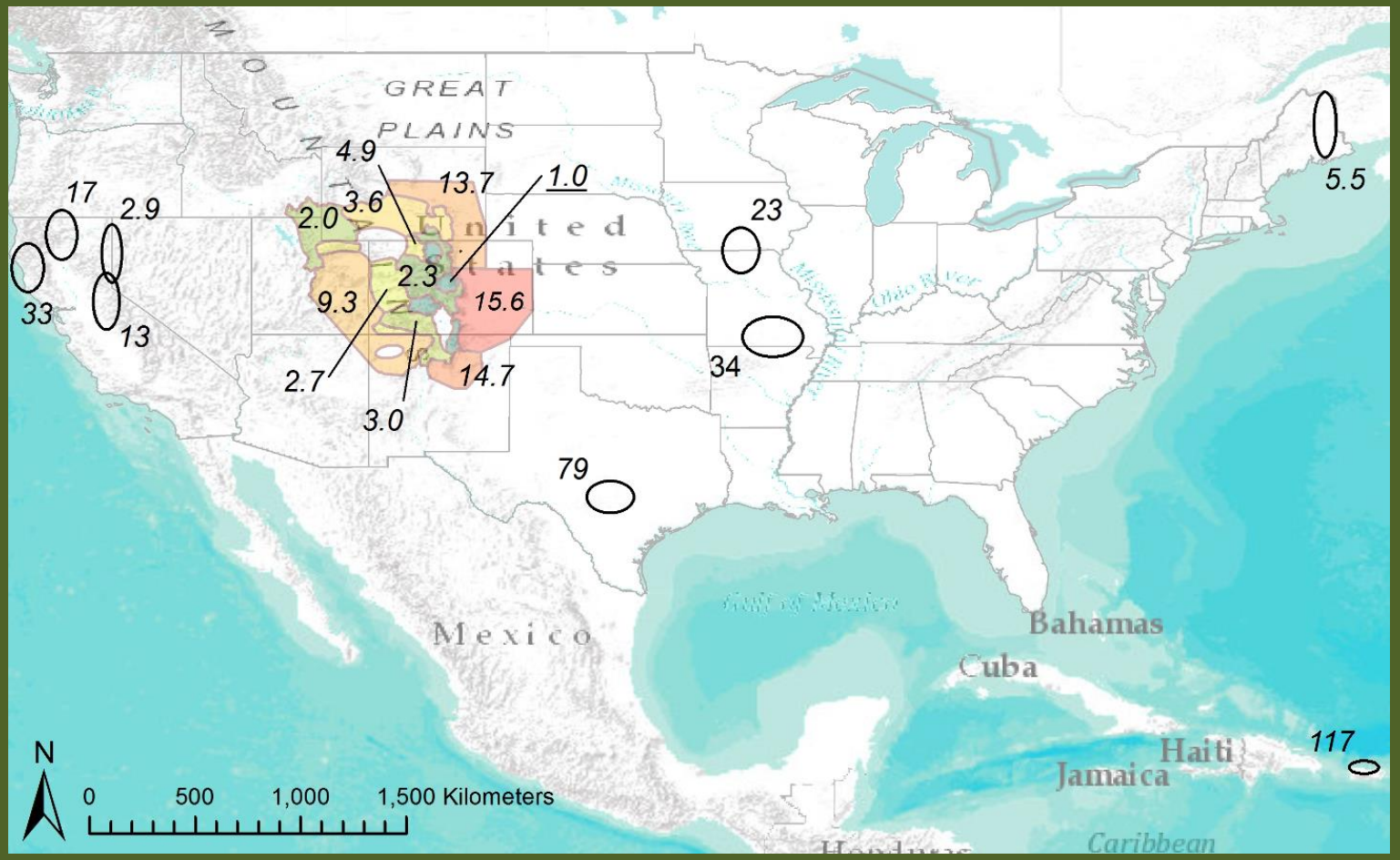
Significant Trends in Large Floods

- Zones 4, 8: adjusted for streamgage data frequency variability
- Zone 2: unadjusted, may be due to decreased streamgaging

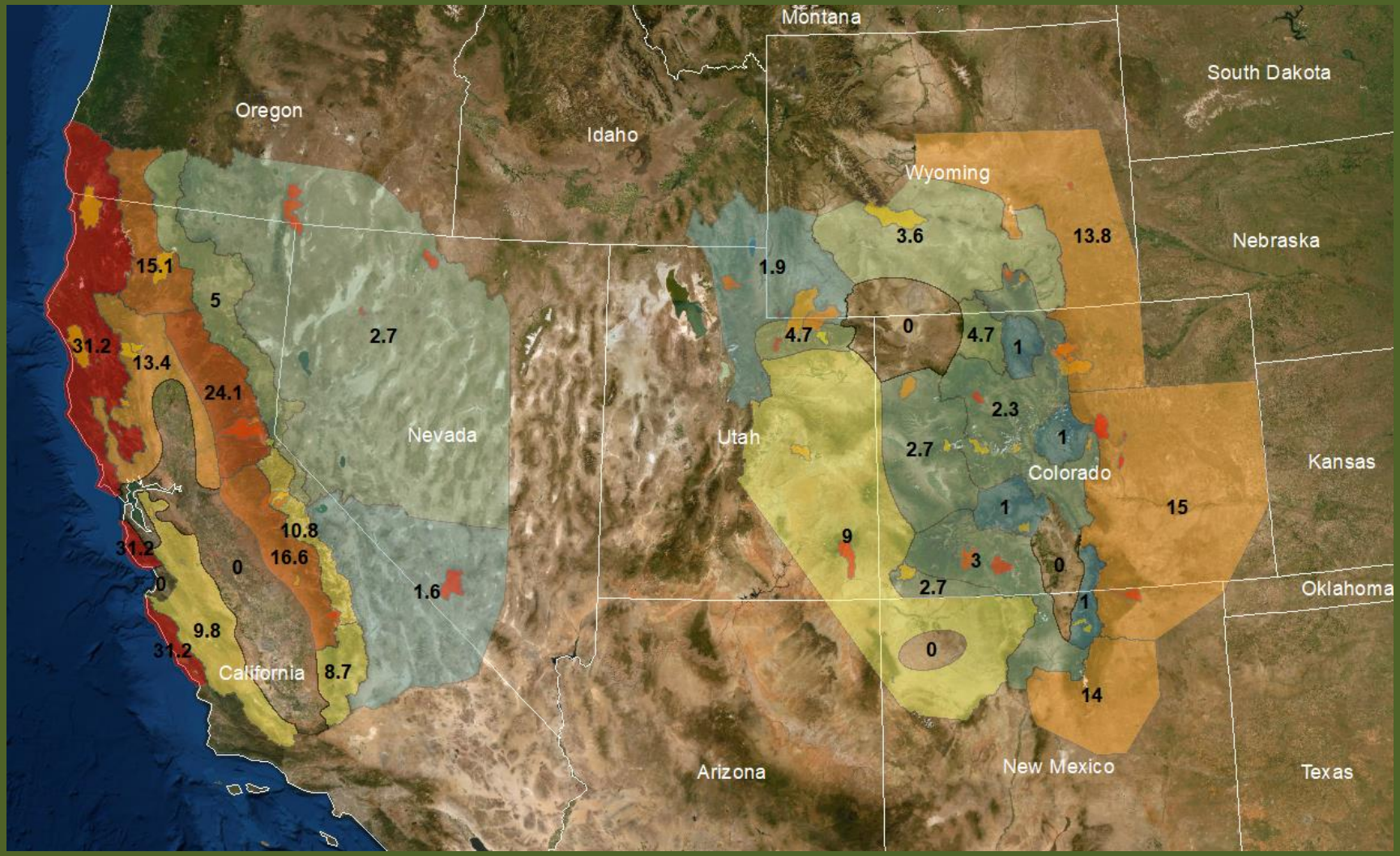


Continental-Scale Application

- Flood potential index (P_f) values



Continental-Scale Application (P_f values)



Questions Method Can Help Answer

- Magnitude of floods that can be expected at a given ungaged location?
- How reasonable are predictions from USGS regional regression equations or rainfall-runoff analyses?

Glen Haven, Colorado

Questions Method Can Help Answer

- Is a streamgage flood frequency analysis providing reasonable results?
- Or are the results potentially biased due to the presence or absence of a large flood in the gage record?

Jamestown, Colorado

Questions Method Can Help Answer

- What zones are prone to larger or smaller magnitude floods?
- Relevant for understanding:
  - Erosion hazards of stream corridors
  - Flood impacts from wildfires
  - Inherent risk of stream restoration in different areas
  - Variability in probable maximum precipitation

Glen Haven, Colorado

Questions Method Can Help Answer

- Is a specific flood extreme in magnitude?

Big Thompson River, Colorado
9/2013

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Questions?

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