A flow evaluation tool for Colorado using ELOHA

Thomas Wilding

Colorado State University

John Sanderson

The Nature Conservancy

N. LeRoy Poff *C.S.U.*

Brian Bledsoe *C.S.U.*

Nicole Rowan

CDM Consultants, Denver

Goals

- *Question:* what biotic response can be expected for a given change in flow?
- Turnaround time: yesterday!
- Apply at state or watershed scale.

ELOHA Framework

SCIENTIFIC PROCESS

Step 1. Hydrologic Foundation
– natural regime of floods, baseflows and droughts.

Step 2. Stream Classification
– distinguish groups of streams that are alike.

Step 3. Flow Alteration
– quantify change in peaks and lows.

Step 4. Flow-Ecology Relationships
– how do populations respond to flow change?

SOCIAL PROCESS

Societal values determine:

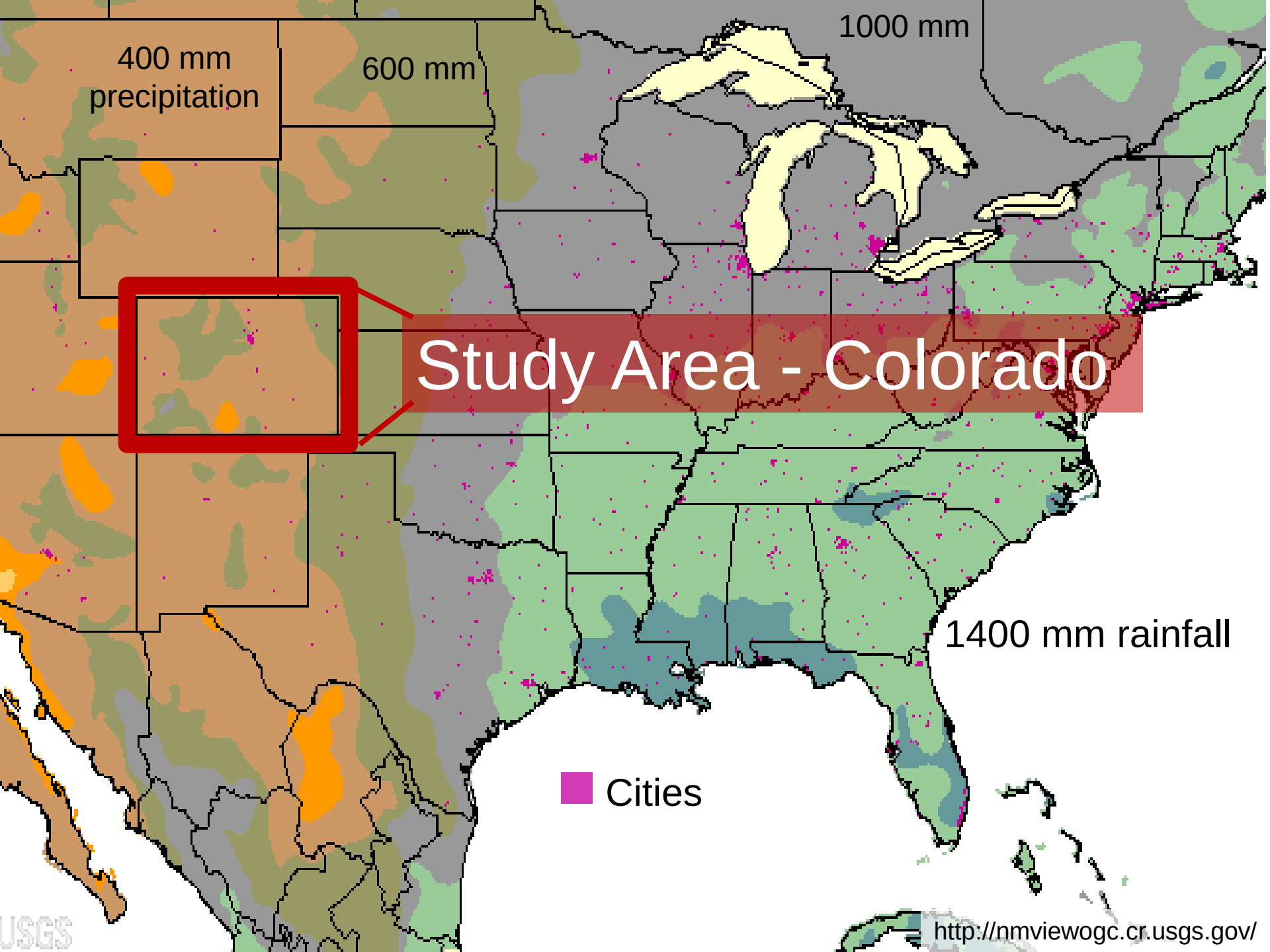
- Acceptable conditions
- Flow standards
- Implementation

Adaptive Adjustments

Monitoring and refinement

Summary

- Quantile regression used to derive flow-ecology response curves for combinations of biota, flow and stream type.
- Existing methods included if appropriate (e.g. low flow for trout).
- Predictions a good match with observed impacts in Roaring Fork River.
- Provides useful information to guide flow management for the *majority* of CO. rivers.


400 mm
precipitation
600 mm
1000 mm
Study Area - Colorado
1400 mm rainfall
Cities
http://nmviewogc.cr.usgs.gov/

High Water Use

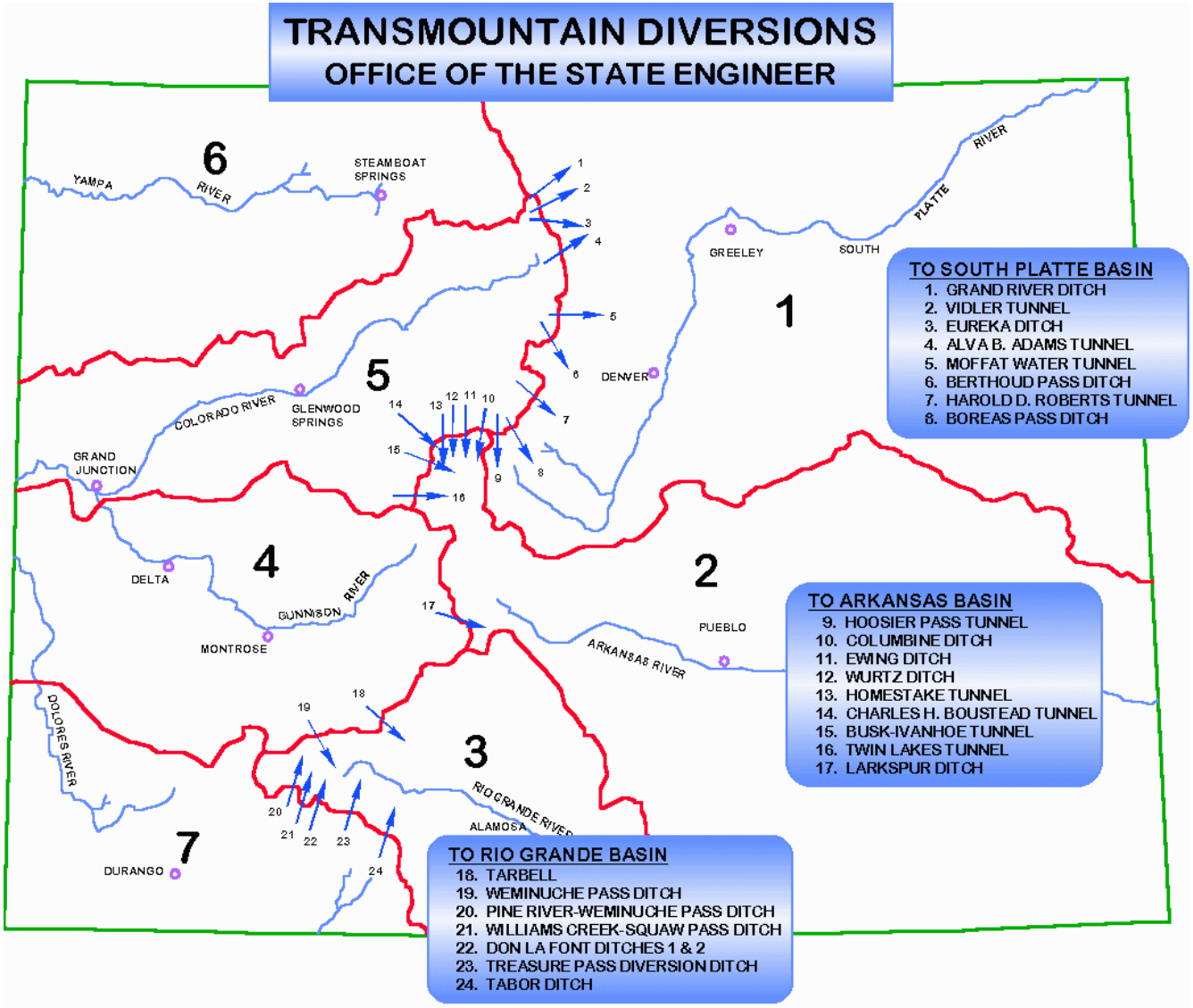
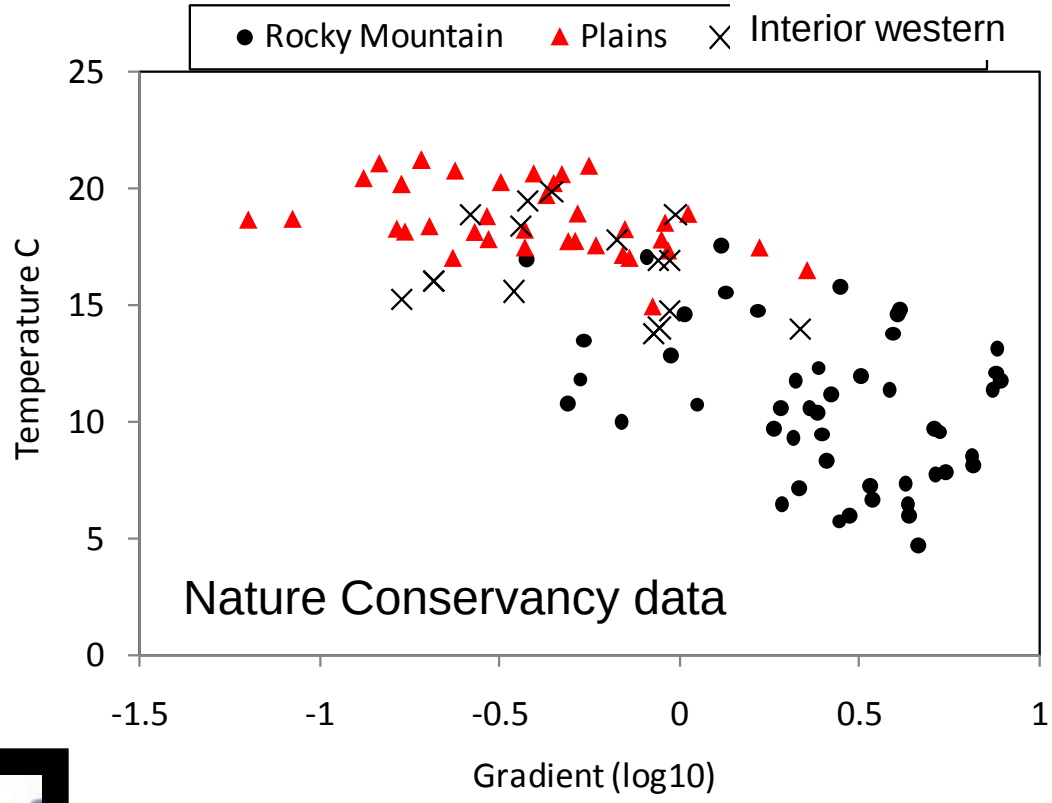
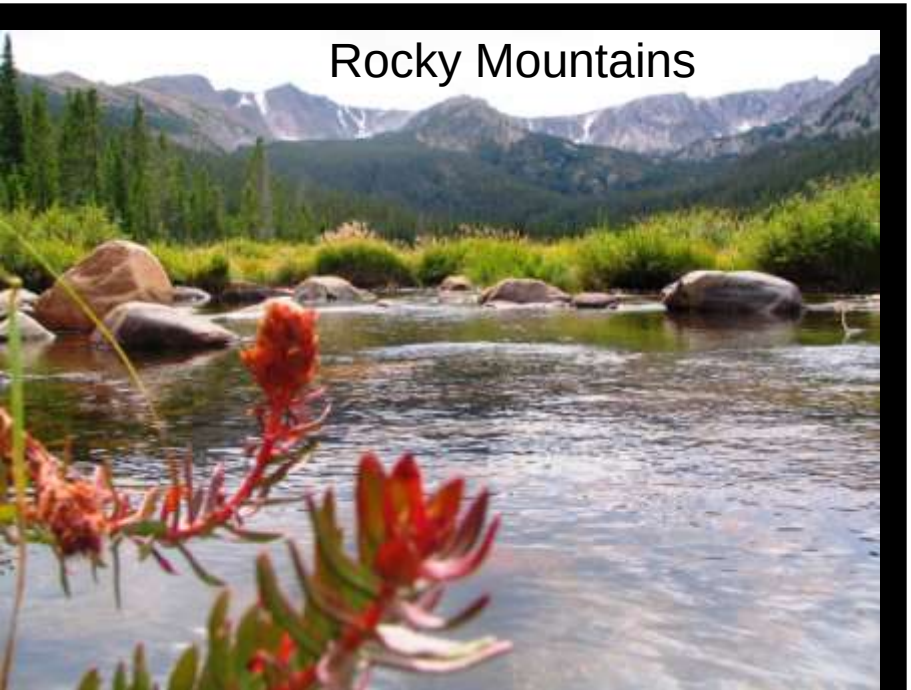


Figure 1.2





Great Plains

Data Sources

	Interior Western	Rocky Mountains	Great Plains	Total
Fish	**19**	**18**	**15**	50
Riparian vegetation	**20**	1	**8**	28
Invertebrates	9	**9**		18
Vertebrates (birds, beaver)	4			4
Terr. Invertebrates	2		1	3
Algae	2			2
Total	56	25	24	105
Other				44

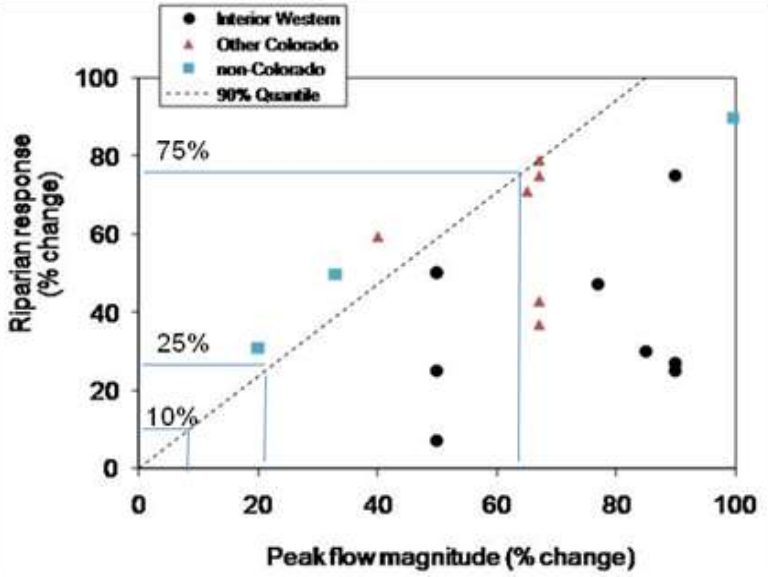
Number of studies available (by biotic group and stream type).

Flow metrics

- Annual peak flow and low flow.
- Represented as actual flow or dimensionless flow (e.g. peak flow / MAF).
- % change from natural flow often useful.

Data Analysis - Quantile regression

- Minimizes absolute deviations (cf. squared deviations) from a linear model (transformation still required).
- Quantile rank score test.
- Assume that bounds represent sites where flow metric a primary constraint.

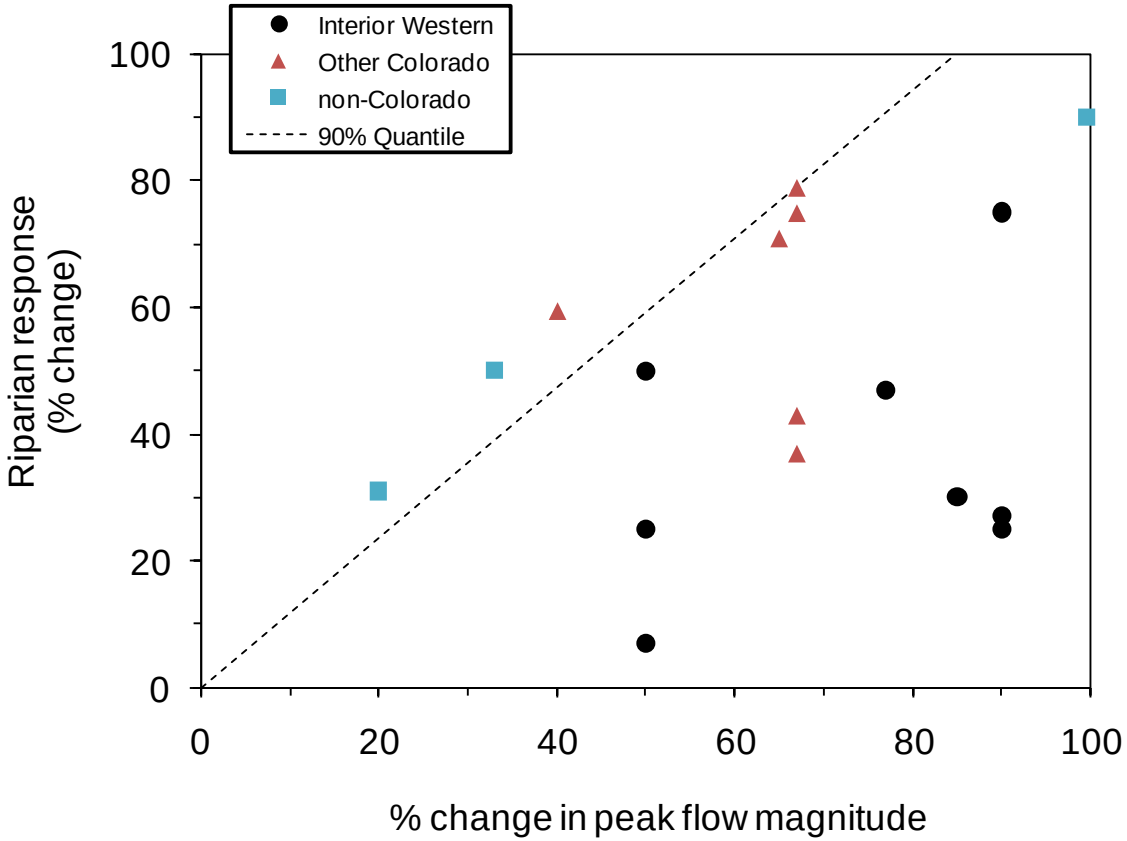


Cade, B. S., and B. R. Noon. 2003. A gentle introduction to quantile regression for ecologists. Frontiers in Ecology and the Environment 1(8):412-420.

Results

- Produced 11 methods covering:
  - peak and base flows.
  - three stream types.
  - Riparian veg., invertebrates, trout & warmwater fish (recreational paddling).
- Method selection:
  - Sufficient research to establish a response.
  - Produce a response to flow (flow sensitive biota).

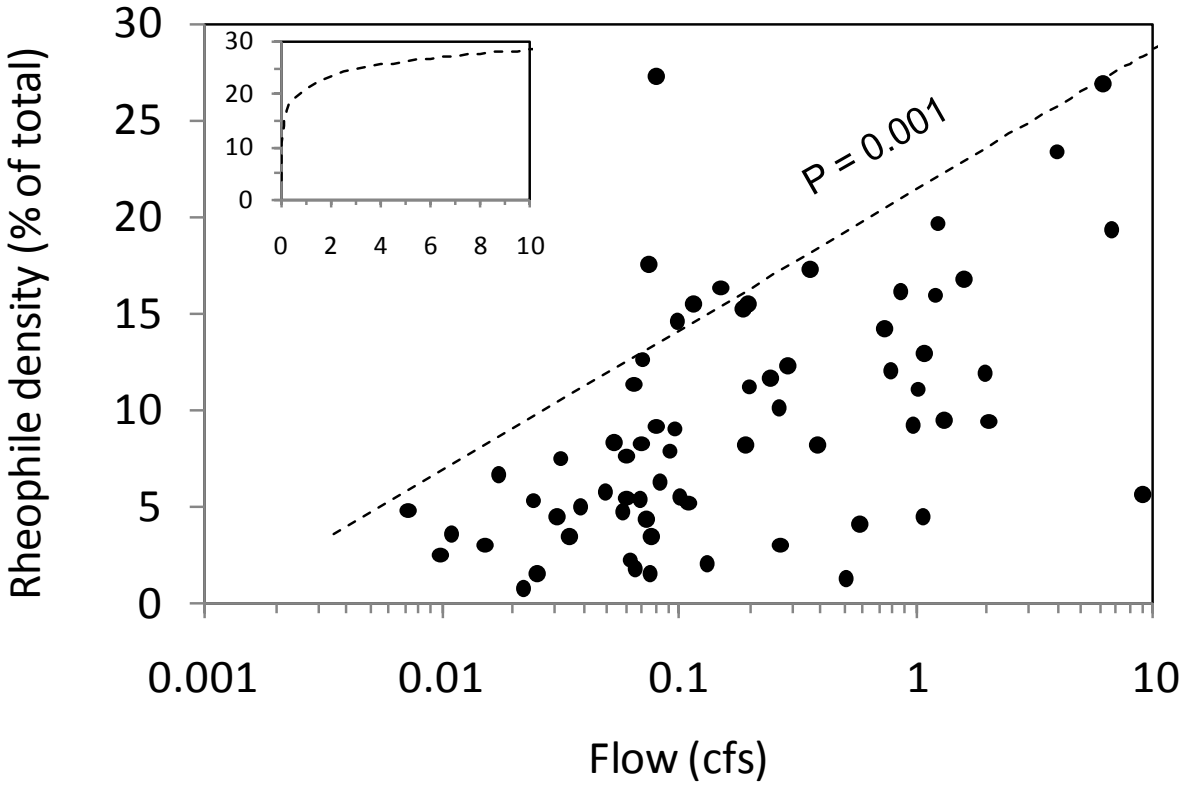
Riparian vegetation needs floods



Various data sources

Invertebrates depend on flowing water

– this plot describes *how much* more baseflow

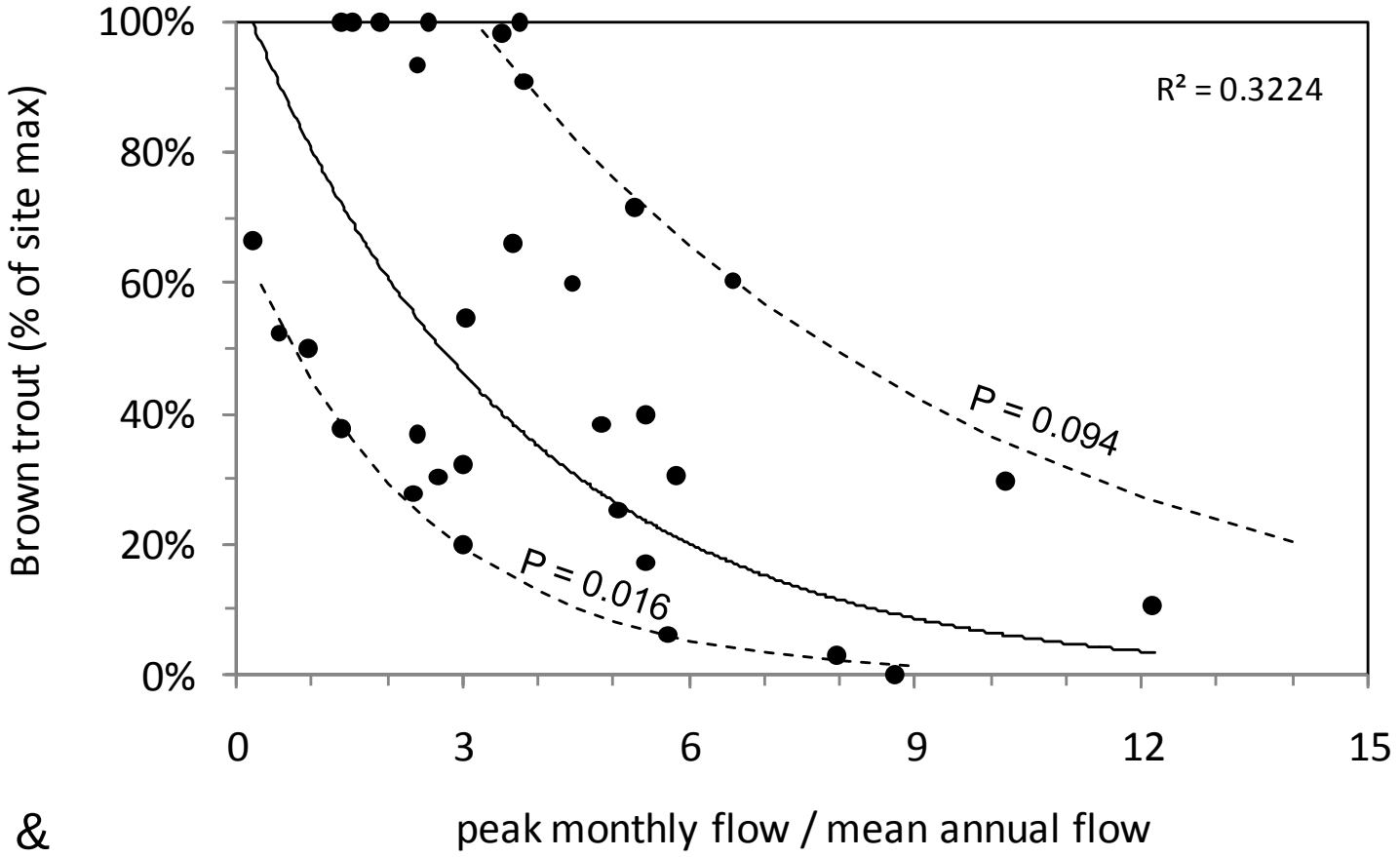


Data from McCarthy (2008)


Photo: Stephen Moore, Landcare Research

Trout recruitment & floods

– this plot describes *decline* for Rocky Mountain streams



Data from Nehring & Anderson (1986)

Trout prefer larger baseflows

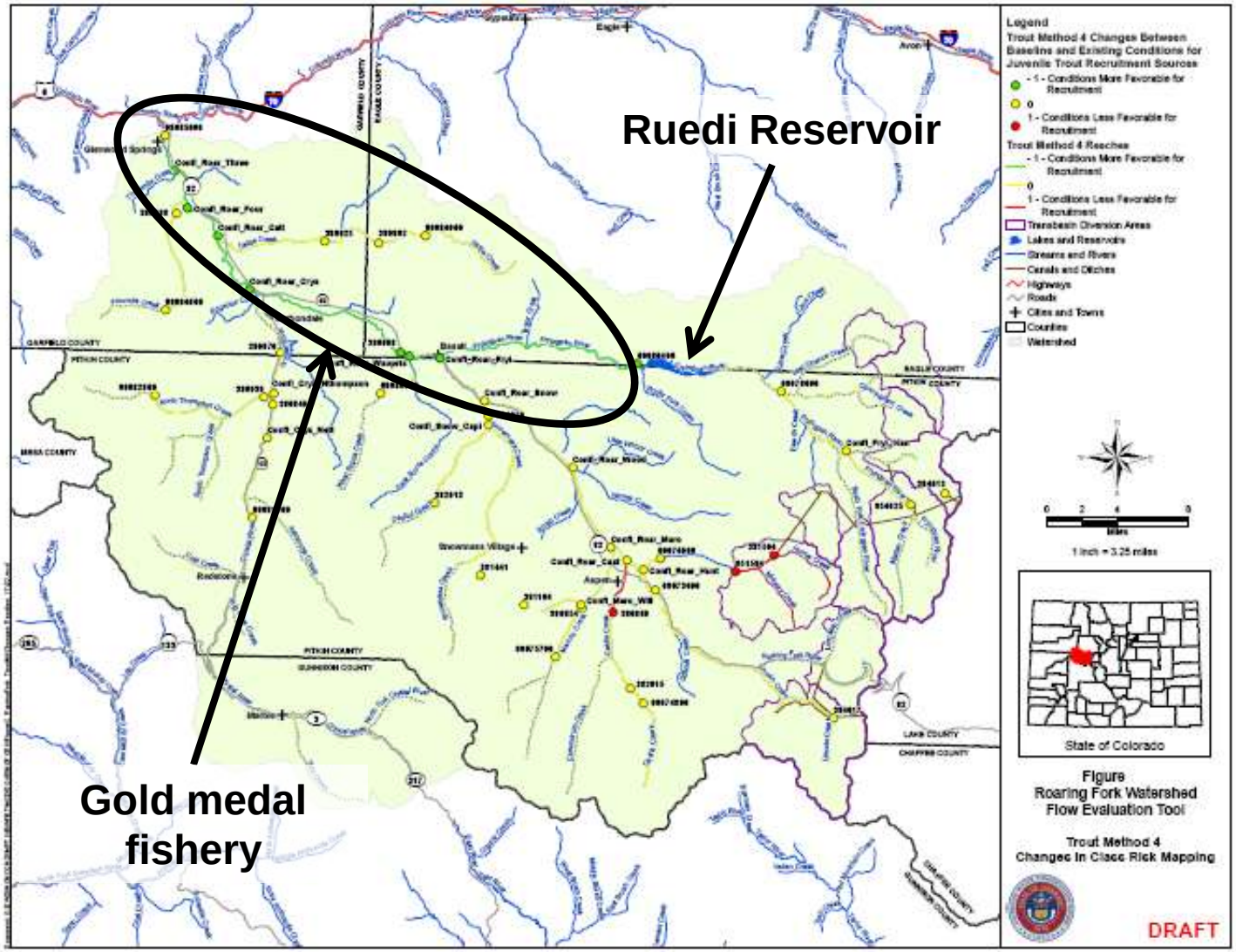
– this table for Rocky Mountain streams is from Binns & Eiserman (1979)

Rating	Summer low flow (% of nat. mean annual flow)	Description
0 (worst)	<10%	Inadequate to support trout.
1	10-15%	Potential for trout support is sporadic.
2	16-25%	May severely limit trout stock every few years.
3	26-55%	Low flow may occasionally limit trout numbers.
4 (best)	>55%	Low flow may very seldom limit trout.

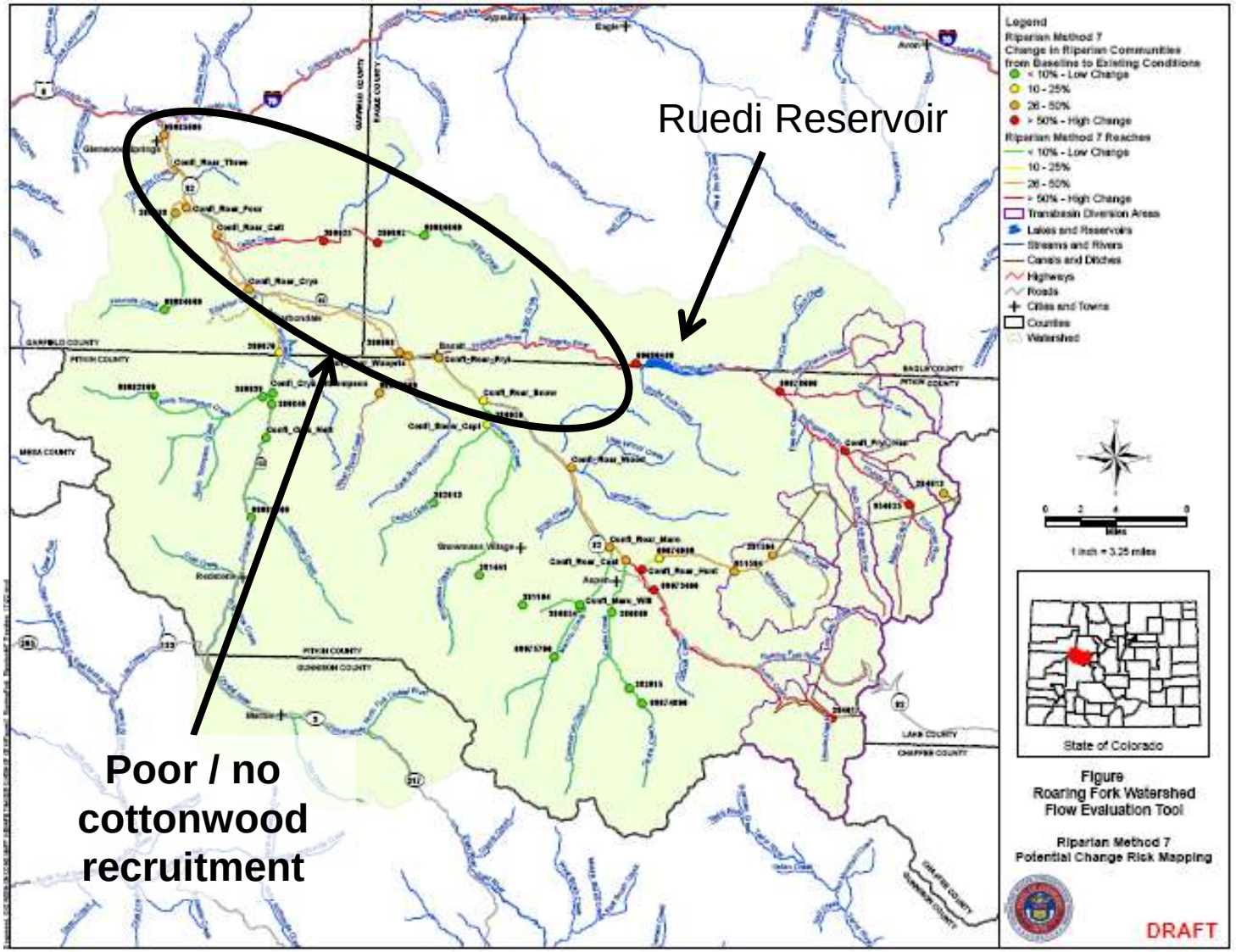
Application Pilot Study

- Roaring Fork River
  - Colorado River tributary (Aspen-Glenwood Springs)
  - Stream type is mostly Rocky Mountain (some Interior Western fishes at low elevtn.)

Trout recruitment & peak flow change



Riparian vegetation & peak flow change



Discussion

- Weaknesses
  - can only apply where hydrology understood.
  - reflects published research to date, not all ecosystem responses.
  - Potential for false predictions omnipresent.
- Strengths
  - Large scale is sometimes more appropriate (e.g. peak flow response).
  - Some information for a large area, covering a wide range of issues.

Acknowledgements

- Sponsor – Colorado Water Conservation Board
- Major data sources:
  - Binns & Eiserman, (mountain trout)
  - Nehring & Anderson (mountain trout)
  - Anderson & Stewart (western warmwater fishes)
  - McCarthy (mountain invertebrates)
  - Vinson (western invertebrates)
  - Tennant (plains fishes)
  - Rood (recreational paddling)