Linking Nutrient Data from Reference Streams to Regional Dose-response Studies

or

Comparing Reference Stream Nutrient Concentrations to Harm-to-Beneficial-Use Concentrations Derived from Regional Nutrient Dose-response Studies: Implications for Setting Nutrient Criteria

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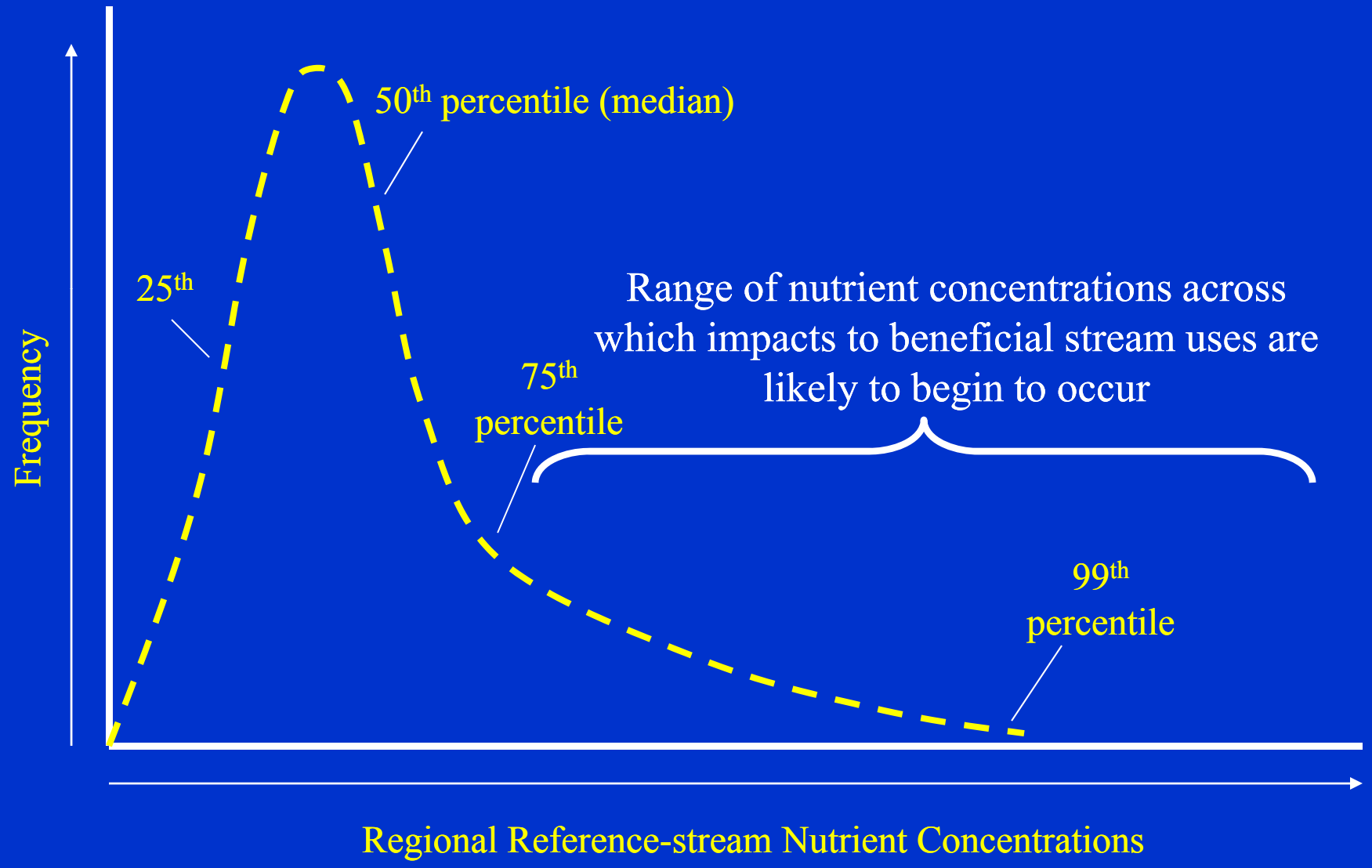
Presentation Overview

- Conceptual framework
- Why is this useful?
- Dose-response studies used and reference-data sources
  - Harm-to-beneficial use
- Regionalization
- Data handling
- Results: linkage between reference data and dose-response studies
- Precautionary considerations when using dose-response studies
- Conclusions, implications for nutrient criteria

Conceptual Framework



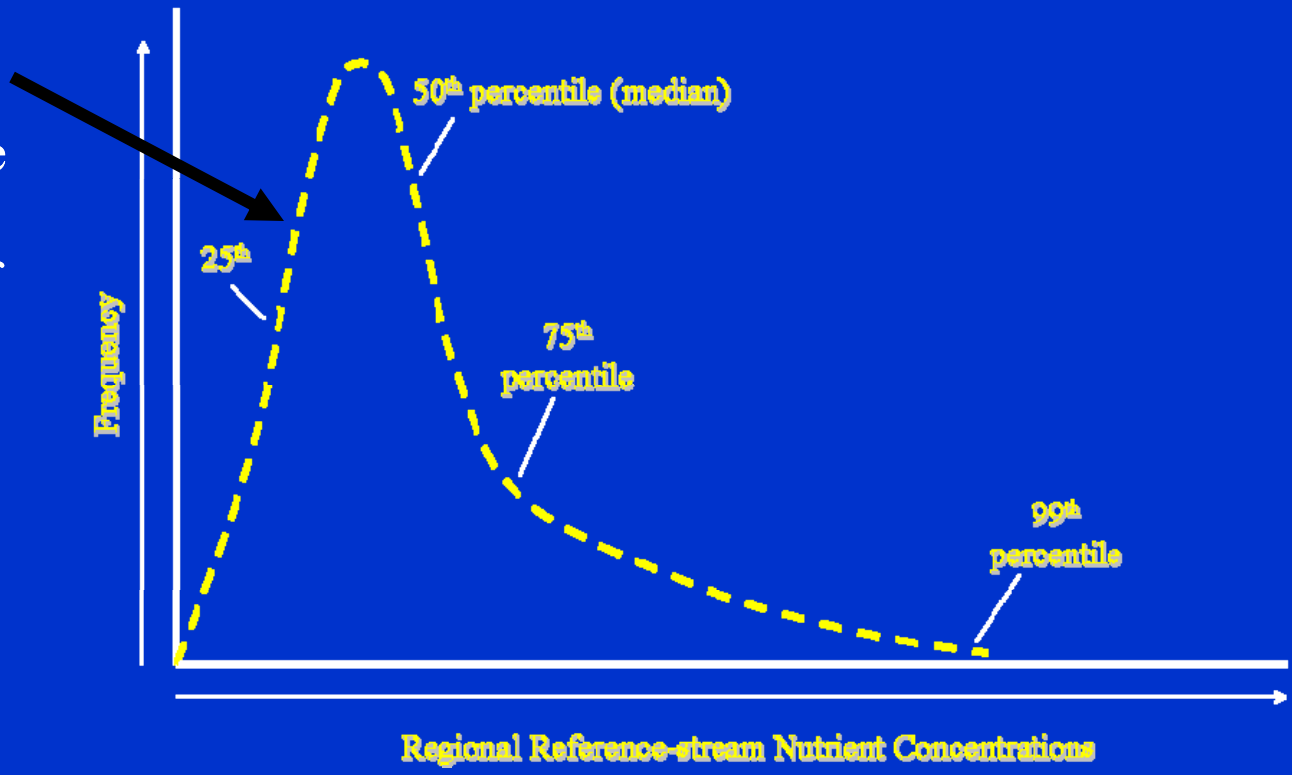
Why is making the comparison useful?

- Nutrient dose-response studies can provide scientific basis for criteria, however:
  - Often have low statistical certainty ($r^2 \sim 0.3$-0.4)
  - Specific to the individual stream studied
  - Limited number of studies in a region
  - Approximations of stream conditions (artificial stream studies)
  - Observational (correlation but not necessarily causation)

Why is making the comparison useful?

- Reference stream data represent conditions in the absence of major human impact, but don't tell us about harm-to-use *per se*
- Comparing reference data and results from dose-response studies provides a means to have greater confidence in both

For example:
Don't expect a harm-to-use nutrient concentration to fall at the 30th percentile of reference



Studies Used

- Six regionally applicable nutrient dose-response studies available
  - Welch *et al.* (1989) *soluble reactive phosphorus*
  - Watson *et al.* (1990) *soluble reactive phosphorus*
  - Sosiak (2002) *total phosphorus*
  - Bowman (2007) *total phosphorus*
  - Suplee *et al.* (2008) *total nitrogen*
  - Mebane (2010; 1st draft) *total phosphorus, total nitrogen*


Sosiak (2002)
Bowman *et al.*
(2007)
Welch *et al.*
(1989)
Suplee *et al.*
(2008)
Watson *et al.*
(1990)
Mebane
(2010)

Studies Used

- Harm to beneficial use
  - Nutrient concentrations resulting in benthic algal growth > 150 mg Chl*a*/m^2 (recreation and aesthetics use)
    - Welch *et al.* (1988)
    - Suplee *et al.* (2009)

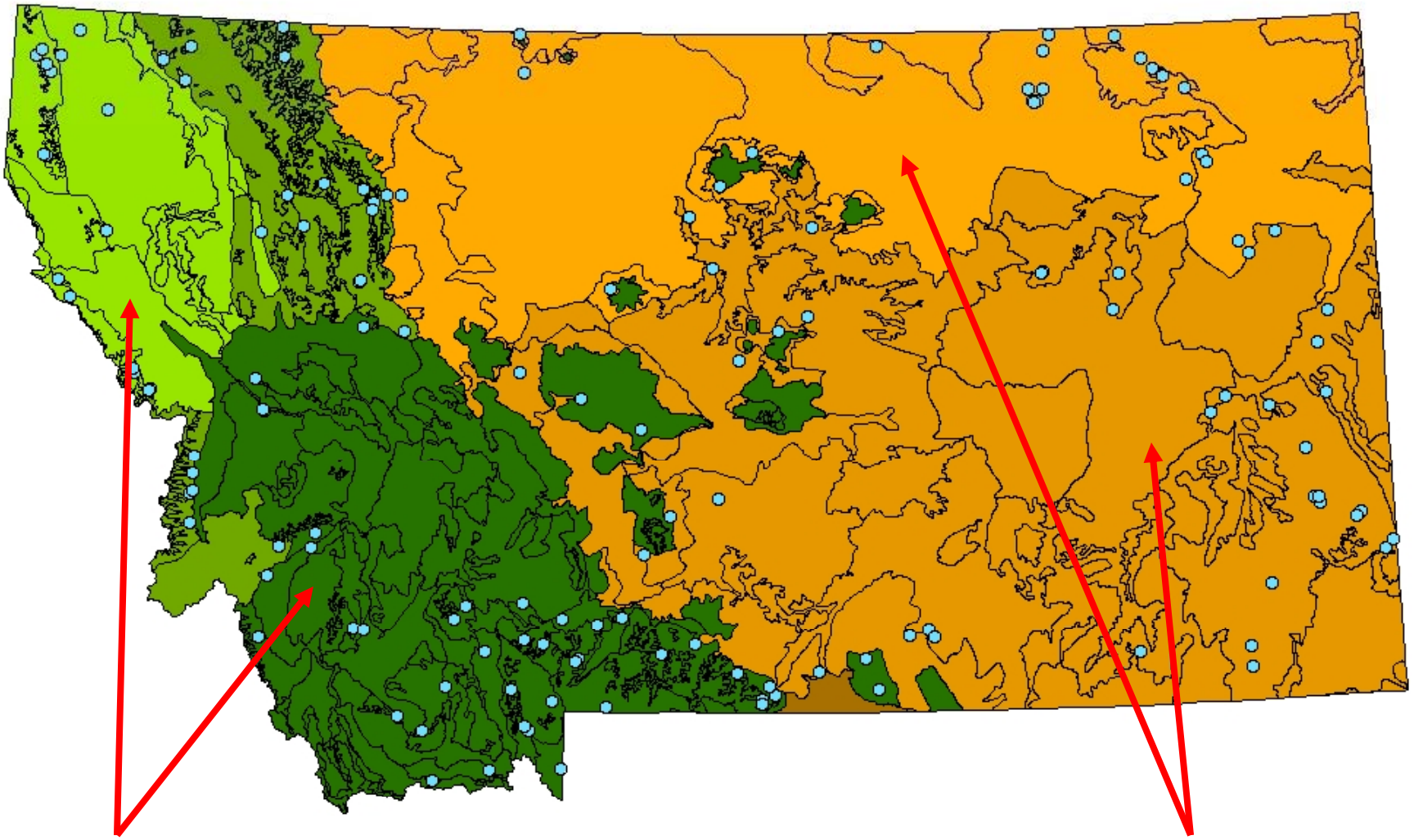
    } Rationale for 150 mg Chl*a*/m^2 presented in these articles

  - Nutrient concentrations resulting in exceedences of Montana dissolved oxygen standards (fish and aquatic life uses)

Reference-data Sources

- Stream reference sites (all in Montana)
  - Site accepted after a rigorous review of human impacts to site (GIS and site-collected data)
  - Nutrient concentrations and benthic algae growth NOT used as screening criteria (circular)
  - Aquatic life metrics (i.e., macroinvertebrate metrics) not used as screening criteria
  - Details in Suplee *et al.* (2005), *available at* http://www.deq.state.mt.us/wqinfo/Standards/PDF/Refsites_writeup_FINALPrintReady.pdf

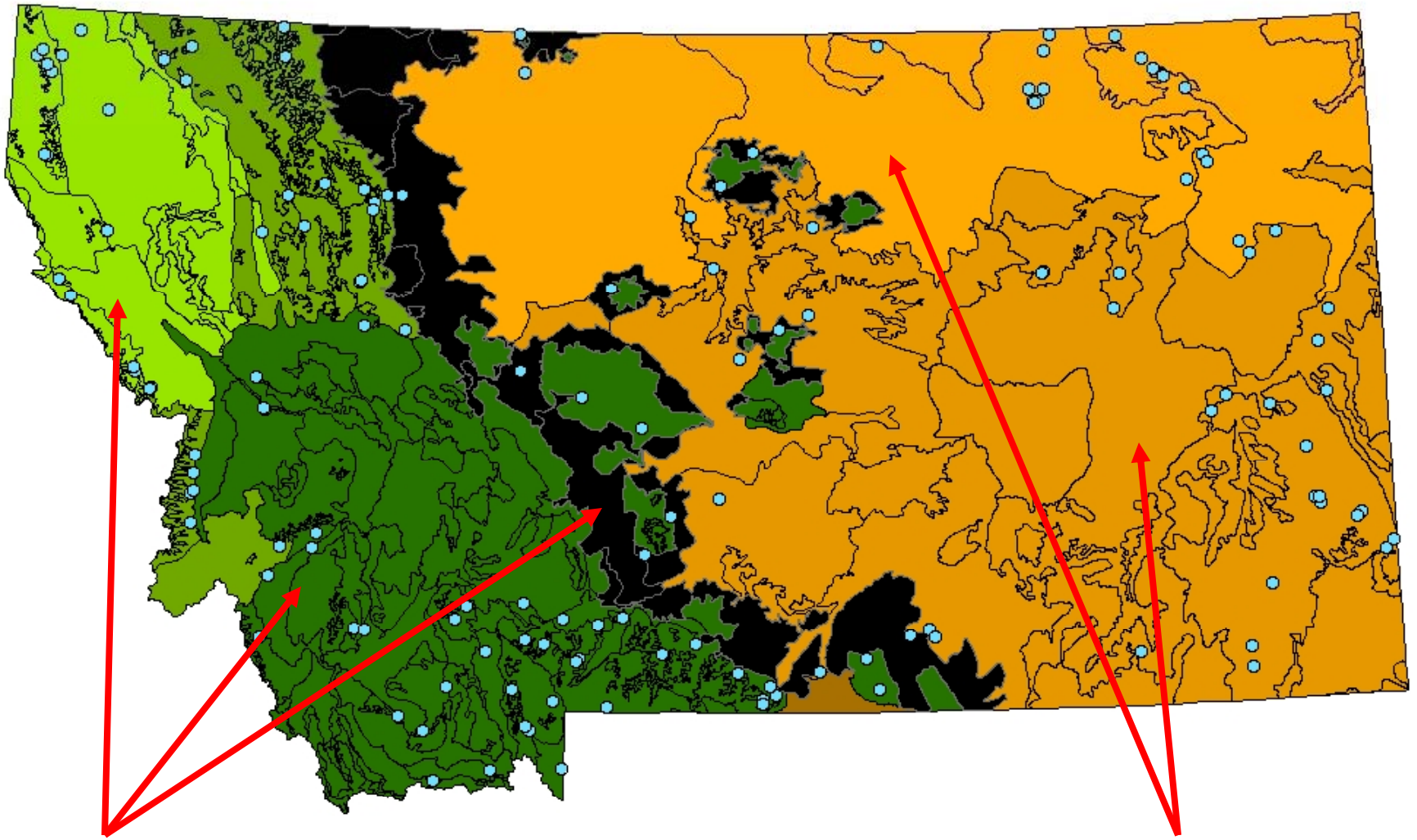
Blue dots: stream reference site locations
Level III ecoregions: colored areas



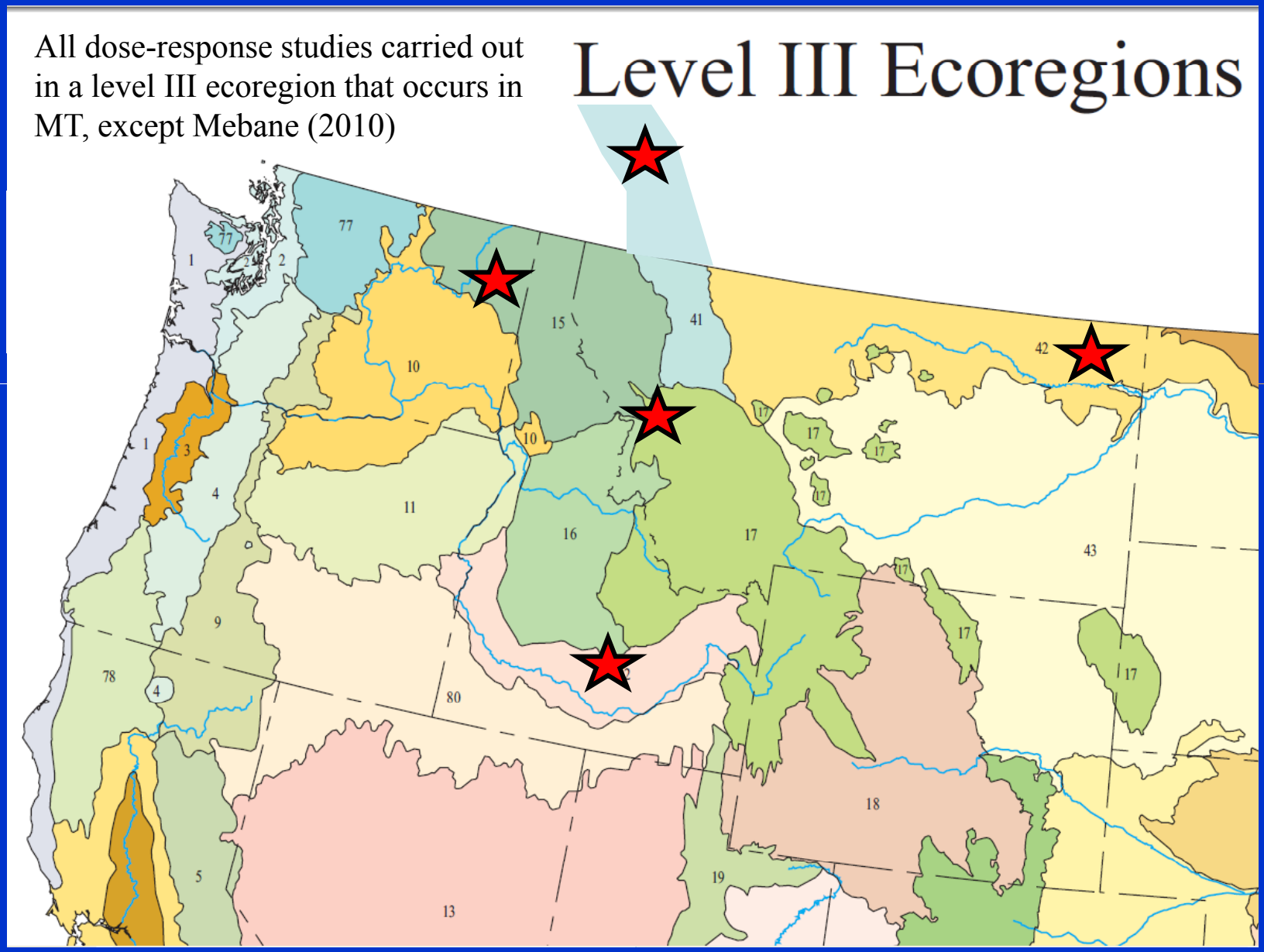
Mountainous ecoregions

Prairie ecoregions

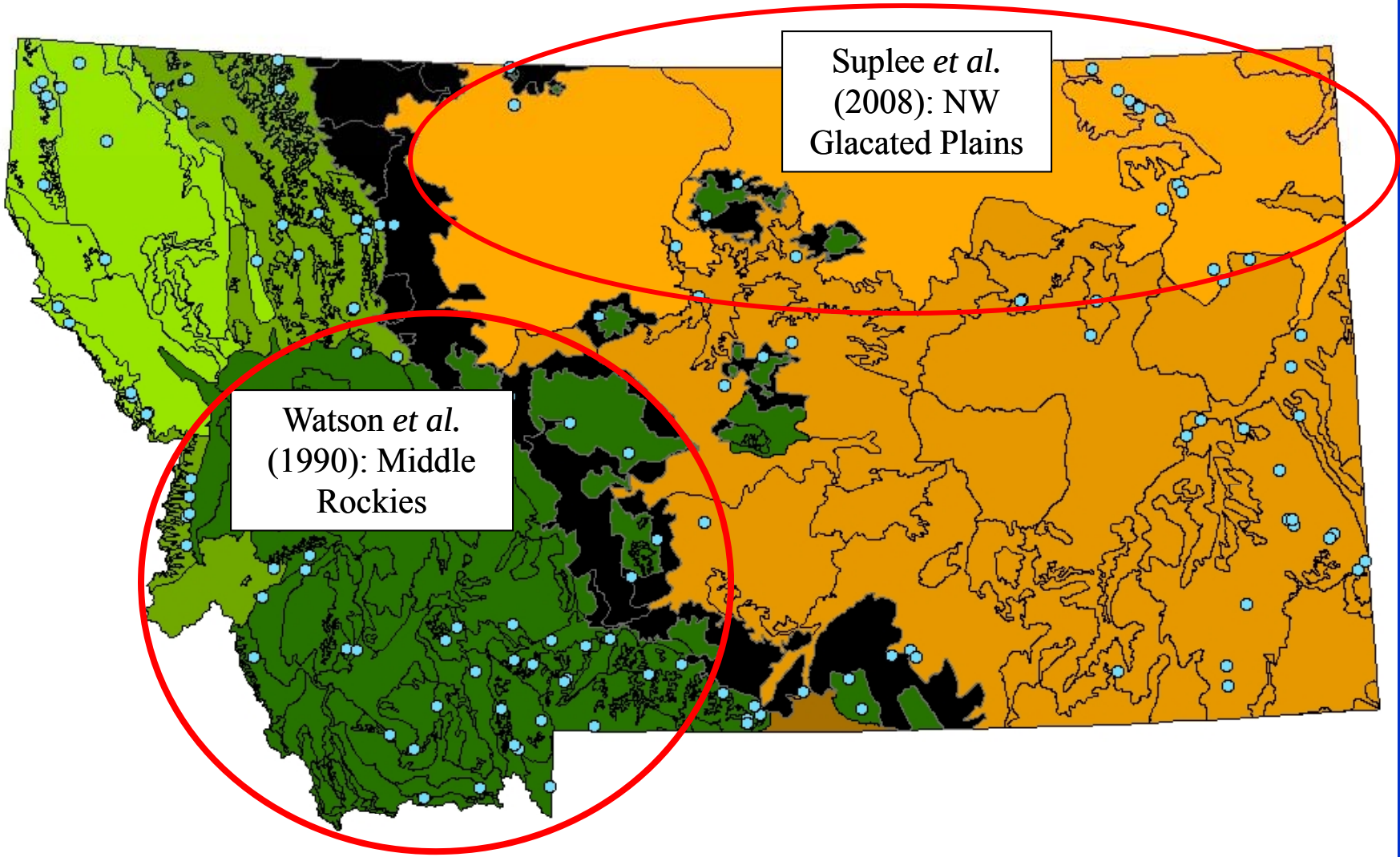
Black areas: level IV ecoregions whose streams are like those in mountainous (green) ecoregions



All dose-response studies carried out in a level III ecoregion that occurs in MT, except Mebane (2010)



Reference data to be compared to a dose-response study were drawn from the same region where the study took place



Reference-data Sources

- Only data collected during the "growing season" (late June through September 30th) were compared to the dose-response studies (which were also carried out in the summer)

Reference Data Handling

- Non-detects converted to values 50% of reported detection limit
- Duplicates samples (same site, day) averaged
- To assure each reference site contributed data equitably to an ecoregional dataset, an evenness index (Brillouin 1962) was applied until a J value of ≥ 0.9 was achieved
  - A subset of data from sites that over-contributed was randomly selected, and included with data from sites that contributed typical sample numbers
  - Carried out for each ecoregional zone
- The nutrient concentration from the dose-response study — at harm-to-use — was then matched to the same concentration in the reference distribution, and the corresponding percentile of the reference distribution recorded

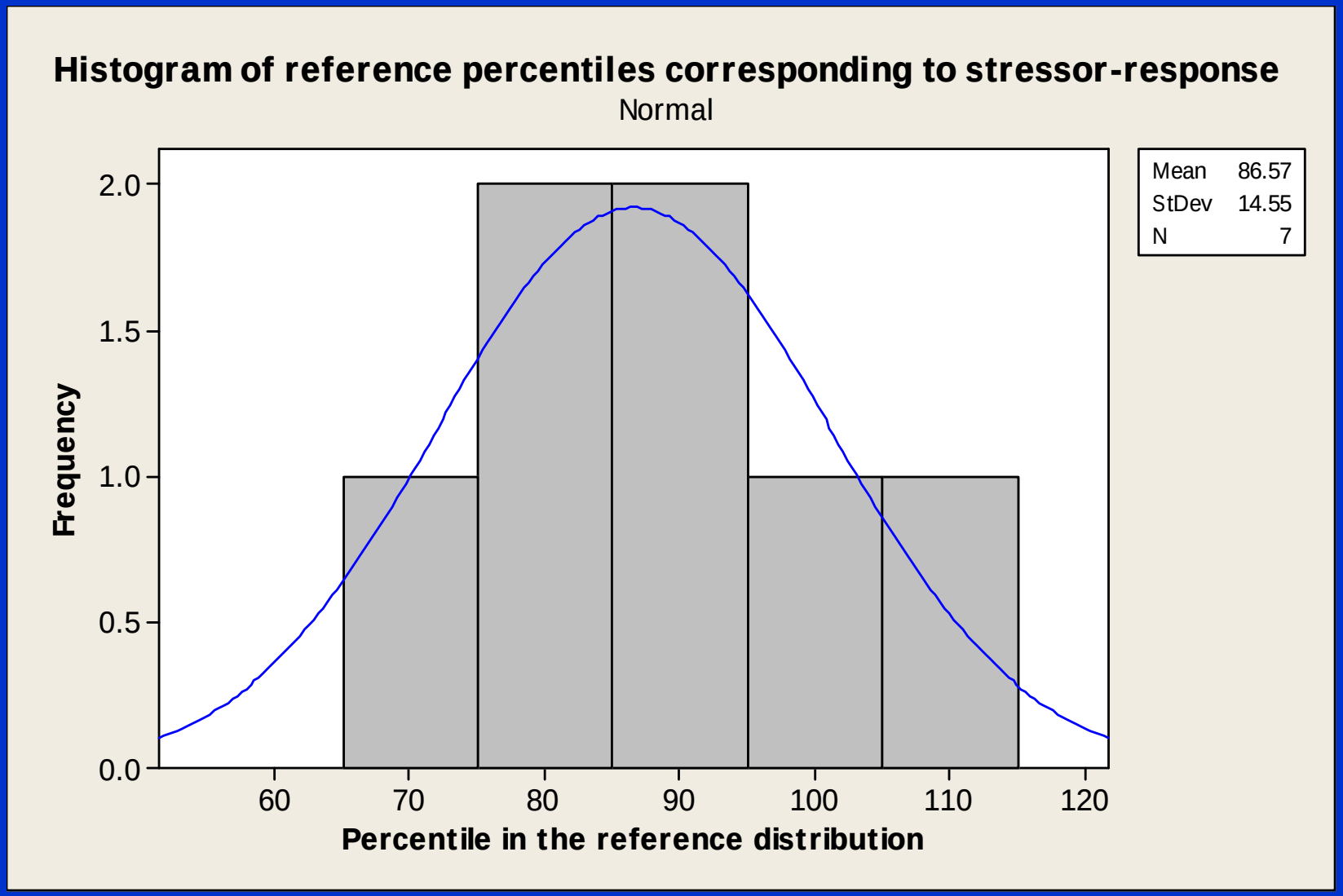
Results: Linkage between reference data and dose-response studies

All concentrations reported are 'as P' or 'as N'.

Dose-response Study	Most Senstive Beneficial Use Affected	Major Level III Ecoregion	Nutrient	Harm-to-use Conc. (mg/L)	No. Reference Datapoints	Percentile in Reference Distribution Corresponding to Dose-response study Concentration
Welch *et al.* (1989)	Recreation/aesthetics	Northern Rockies	SRP	0.01	54	**93rd**
Watson *et al.* (1990)	Recreation/aesthetics	Middle Rockies	SRP	0.011	106	**77th**
Sosiak (2002)	Recreation/aesthetics	Canadian Rockies	TP	0.018	28	**98th**
Bowman *et al.* (2007)*	Recreation/aesthetics	Canadian Rockies	TP	0.089	28	**107th**
Suplee *et al.* (2008)	Fish & aquatic life	Northwestern Glaciated Plains	TN	1.12	71	**65th**
Mebane (2010)	Recreation/aesthetics	Intermontane regions of Middle Rockies	TP	0.04	55	**76th**
Mebane (2010)	Recreation/aesthetics	Intermontane regions of Middle Rockies	TN	0.6	47	**90th**
					Mean:	**87**
					Median:	**90**

*Equation provided courtesy of the authors. Percentile beyond reference distribution interpolated.

Results: Linkage between reference data and dose-response studies



Precautionary Considerations when Using Dose-response Study Data

For comparison to reference data, dose-response studies that report soluble nutrients are only useful if the soluble concentration is a KNOWN dose to the stream (e.g., artificial stream study).

Highly Eutrophied Stream

Reference stream

These two streams' SRP concentrations may be similar, but reference stream's TP is much lower

Conclusions

- Harm-to-use nutrient concentrations from dose-response studies fell within the reference distribution as expected (upper percentiles and beyond)
- In aggregate, the studies' harm-to-use nutrient concentrations had a clear central tendency that corresponded to about the 90th percentile of the reference distributions
- USEPA recommends the 75th percentile of reference to develop nutrient criteria. Based on the present study, this one-size-fits all approach could result in overly restrictive criteria in some, but not all, cases

Implications for Nutrient Criteria

- In 2008 we recommended nutrient criteria based on the 90th of reference (by ecoregion), for all ecoregions. In retrospect, this led to criteria we now believe are too strict in some regions and too lax in others.

- Going forward:
  - Will develop criteria after giving consideration to (1) the specific ecoregion's dose-response study, (2) the *overall* pattern between dose-response and reference, and (3) other scientific literature applicable to the streams in question
  - **As a result, one ecoregion's criteria may correspond to the 70th of reference, while another ecoregion's may correspond to the 95th.**
  - Should result in more accurate nutrient criteria

Thank you!

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Eastern MT prairie-stream reference site