Biostimulatory thresholds to meet biointegrity goals

Presentation to Stakeholder Advisory Group

October 26

Goals for Stakeholder Advisory Group

- Present analyses to set biostimulatory thresholds
  - Modeling responses
  - Validating thresholds
  - Evaluating error rates
- Highlight key decision points about the basis of setting thresholds
  - Probability
  - Biointegrity (BI) goal
- Review options for evaluating multiple lines of evidence

Principles and assumptions

- A risk-based approach (not mechanistic) is appropriate for setting statewide thresholds
- We want numeric thresholds to reduce risk of failing to meet biointegrity goals, as measured with standard indices
  - Other biological endpoints may provide additional information about strengths and shortcomings of proposed thresholds
- Managing biostimulatory substances may not always be the sole cause of failing to meet biointegrity goals
  - Other stressors are often present

Approach

- Assemble statewide data set of biointegrity (BI) and biostimulatory data,
- Classify sites as meeting/not meeting BI goals
- Create logistic regression models to predict likelihood of meeting BI goal at increasing levels of biostimulatory stress
- Set biostimulatory thresholds where likelihood is sufficiently high (e.g., 90%)
- Validate biostimulatory thresholds with relative risk assessment
- Select lowest validated threshold for BI goal, biostimulatory factor
- Evaluate error rates (i.e., good BI) associated with failing single, multiple biostimulatory thresholds
- Supplement with additional analysis (e.g., species-level response, reference distributions)

We want default numbers to apply statewide

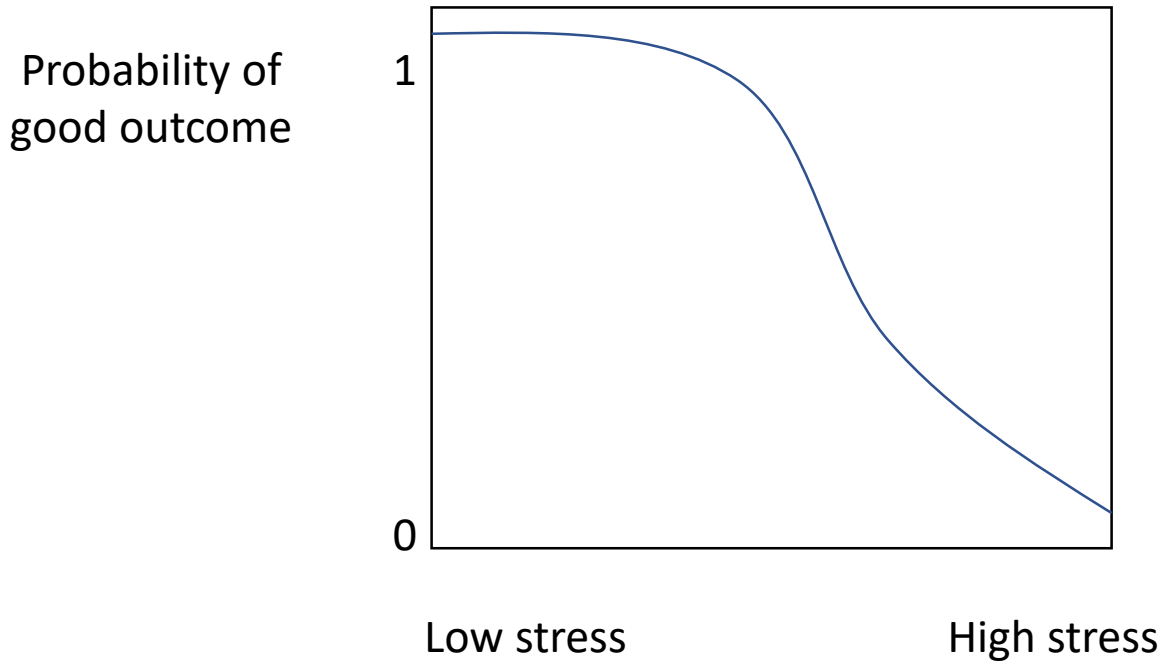
Shortcomings of this approach:

- Ignores complicating interactions among biostimulatory factors
  - E.g., moderate levels of N and P can create bigger problems than high levels of N alone.
- Ignores complicating influence of natural factors
  - Although indices are robust, responses in some stream types may be stronger than others
  - Shading, flow may moderate impacts of high nutrient concentrations

Where these concerns are important, a watershed approach may be better.

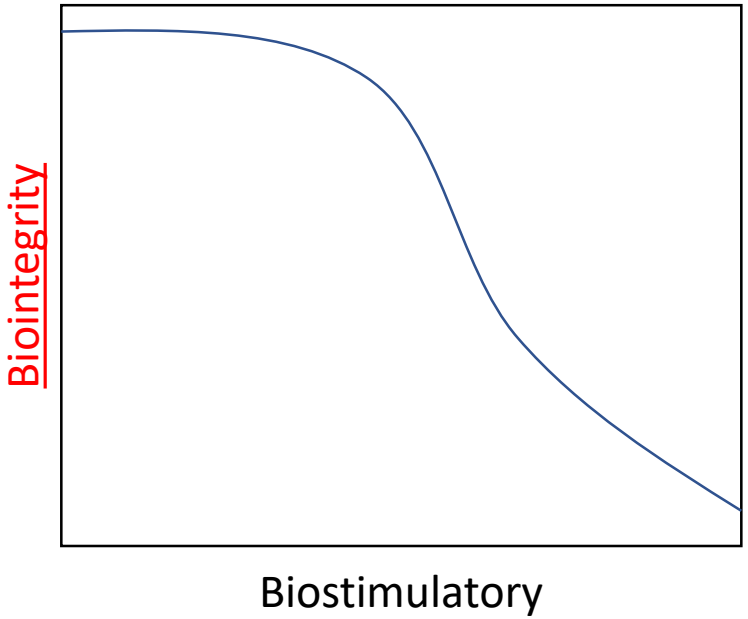
What does “logistic regression” mean?

- Risk-based, not causal or mechanistic
- Widely used to set environmental risk thresholds



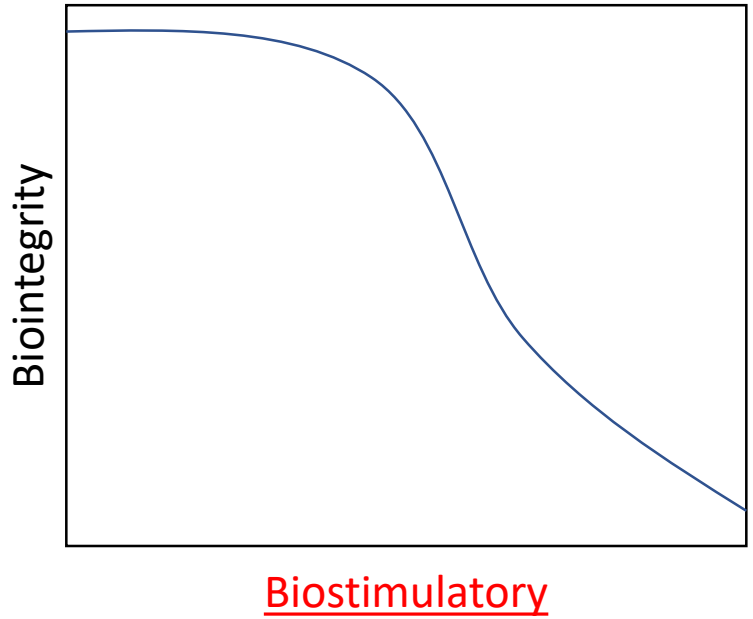
Biointegrity data

- CSCI
- ASCI
  - Diatom
  - Soft-bodied algae
  - Hybrid



- Biointegrity goals
  - 1st, 10th, and 30th percentiles of reference
    - WB staff indicates that these goals are likely to be the primary basis for biostimulatory thresholds
  - BCG3 and BCG4
    - Other bins were generally too scarce to model (especially for algae)
    - Evaluated to provide additional information supporting threshold-setting decisions

Biostimulatory data



Nutrients

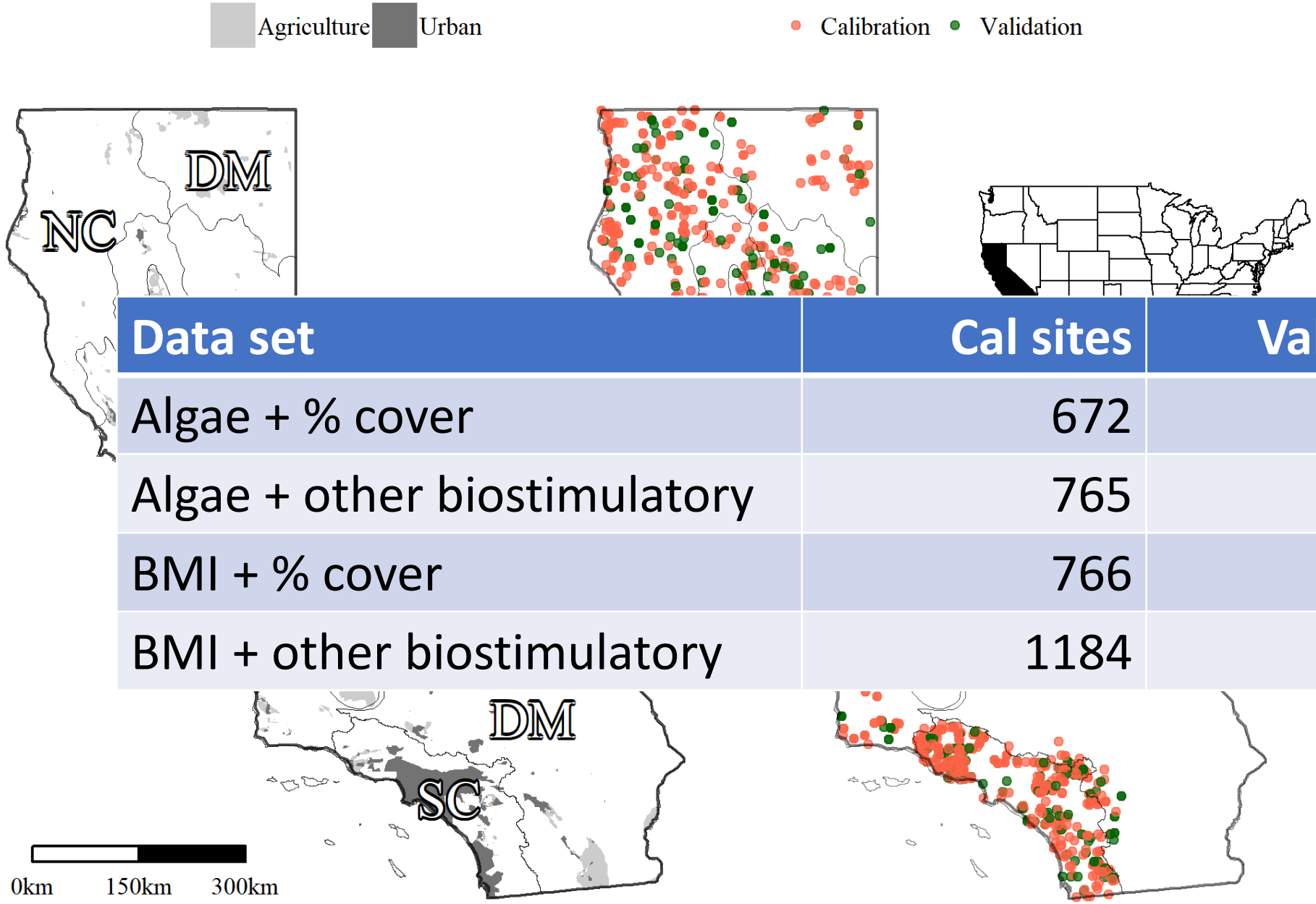
- Total N (mg/L)
- Total P (mg/L)

Organic matter

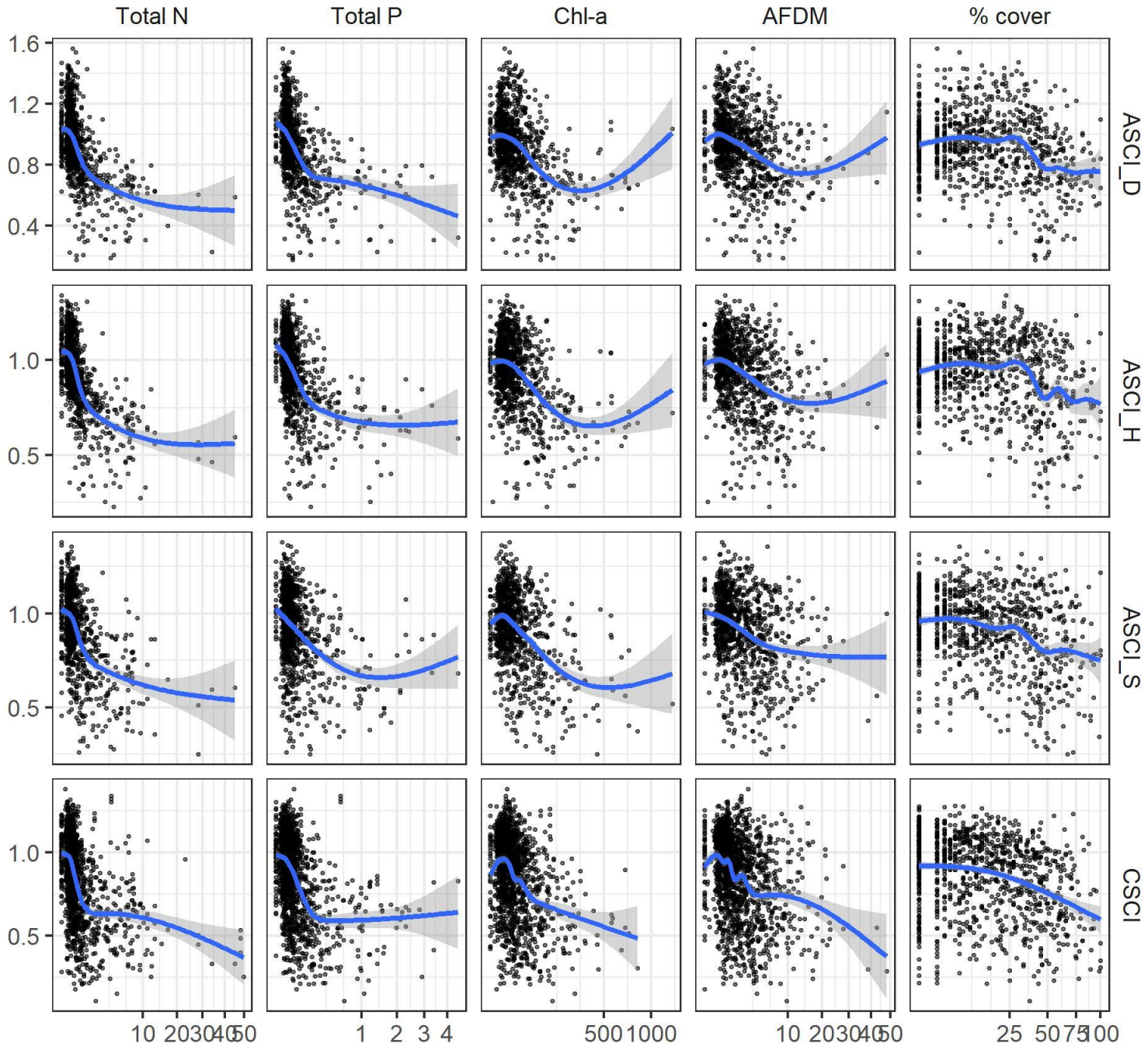
- Benthic chlorophyll-a (mg/m^2)
- Benthic AFDM (mg/cm^2) (multiply by 10 to convert to g/m^2)
- % macroalgae cover

(a) Land use and regions

(b) Data set



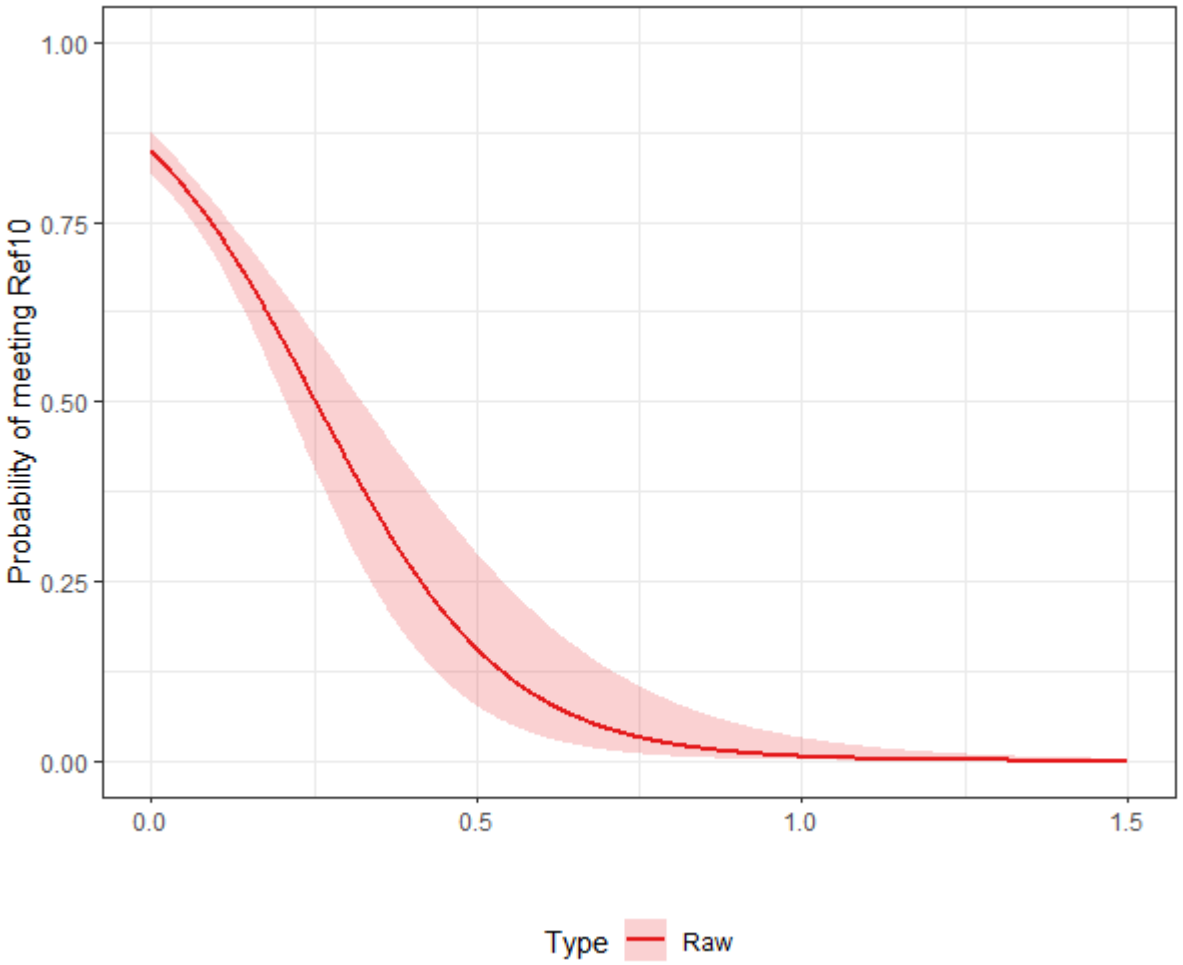
Data set	Cal sites	Val sites
Algae + % cover	672	218
Algae + other biostimulatory	765	248
BMI + % cover	766	250
BMI + other biostimulatory	1184	389



Relationships are noisy

Responses happen at low concentrations.

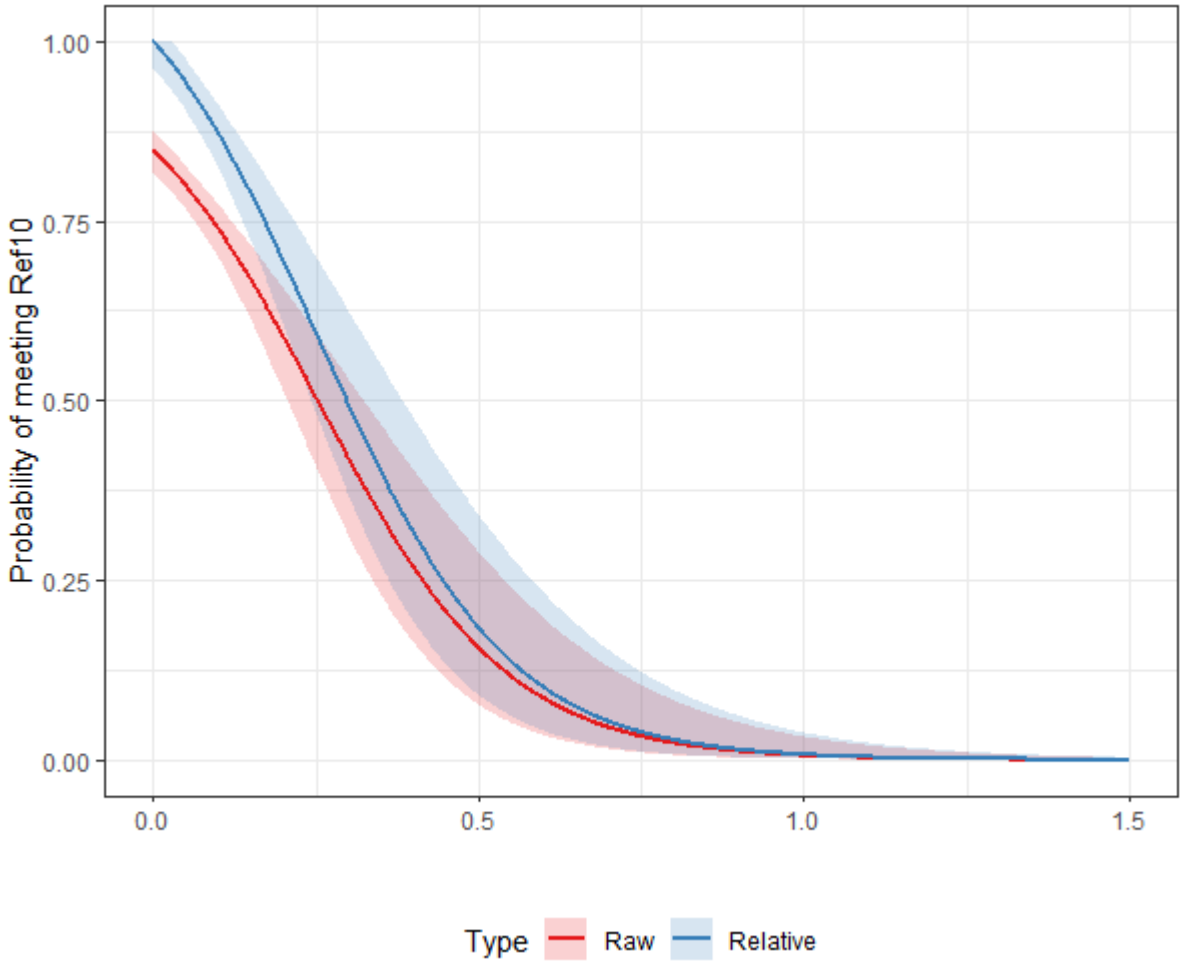
Apply models over a range of values



Biostimulatory factor	Max level evaluated*
Total N	3 mg/L
Total P	1.5 mg/L
Chlorophyll-a	300 mg/m^2
AFDM	75 mg/cm^2
% cover	100%

*Larger ranges have now been evaluated

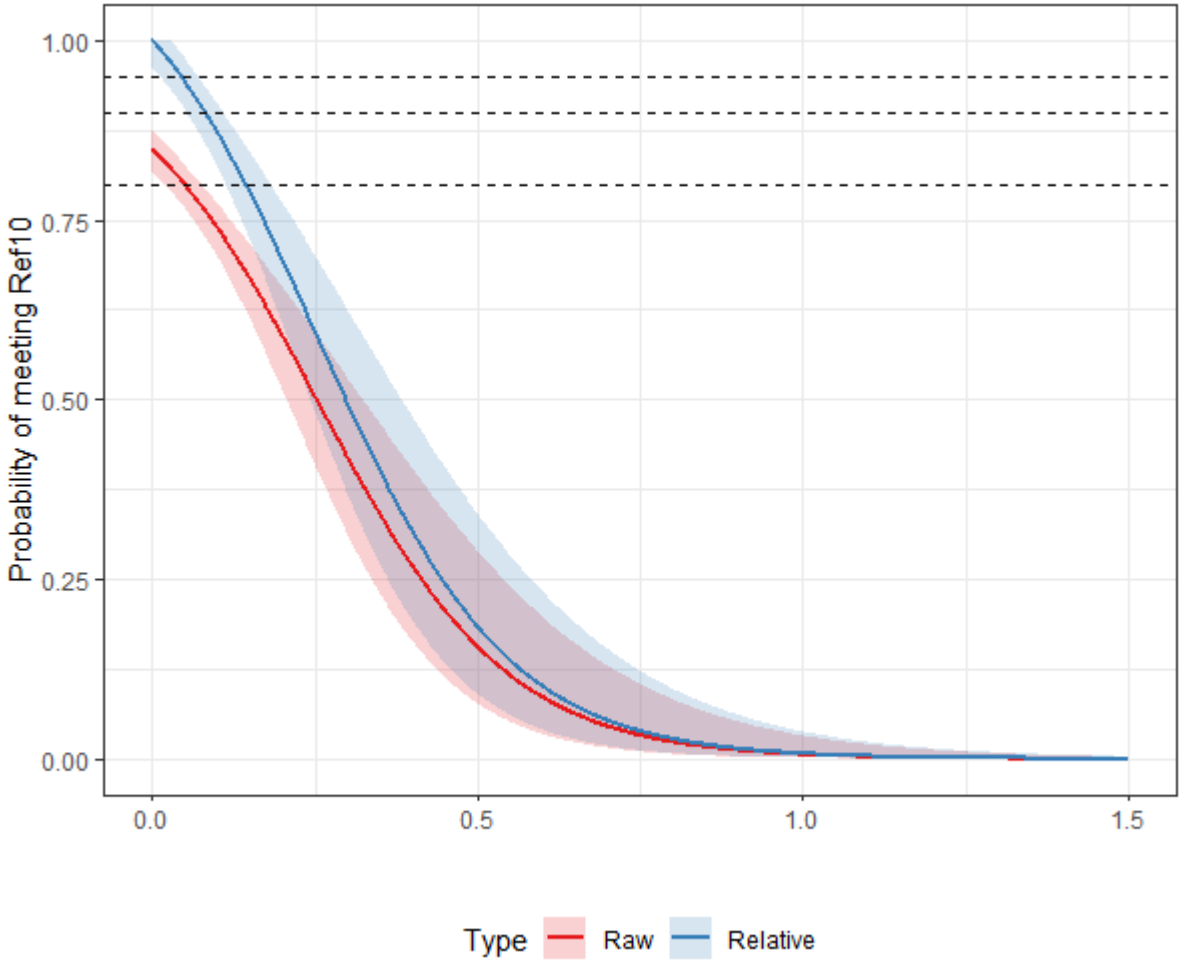
Relativize to account for background level of impacts



Result: Higher eut. thresholds.

“Likelihood” becomes “relative likelihood”

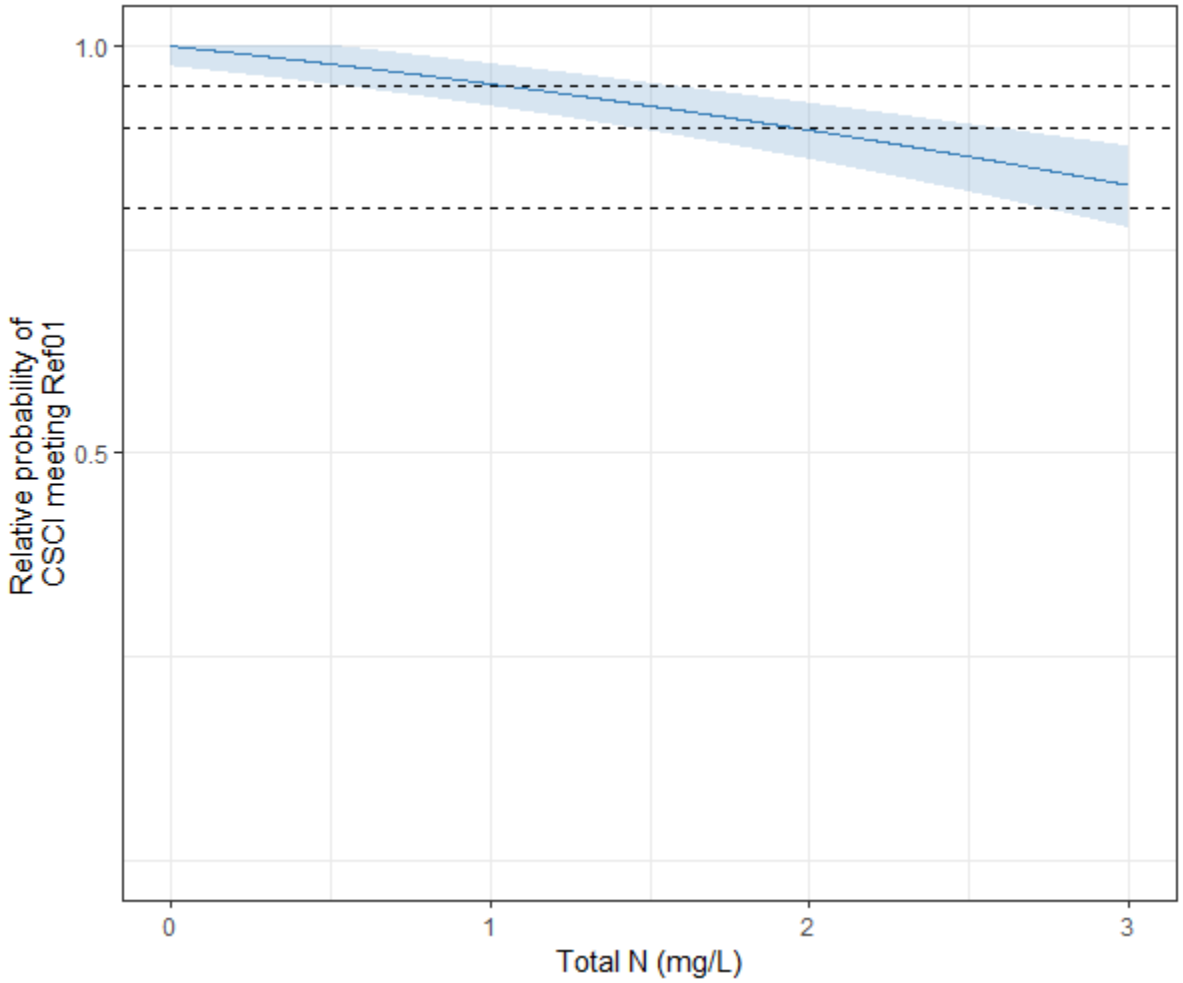
Set thresholds where likelihood is sufficiently high



"Sufficiently high" is both a technical and policy decision

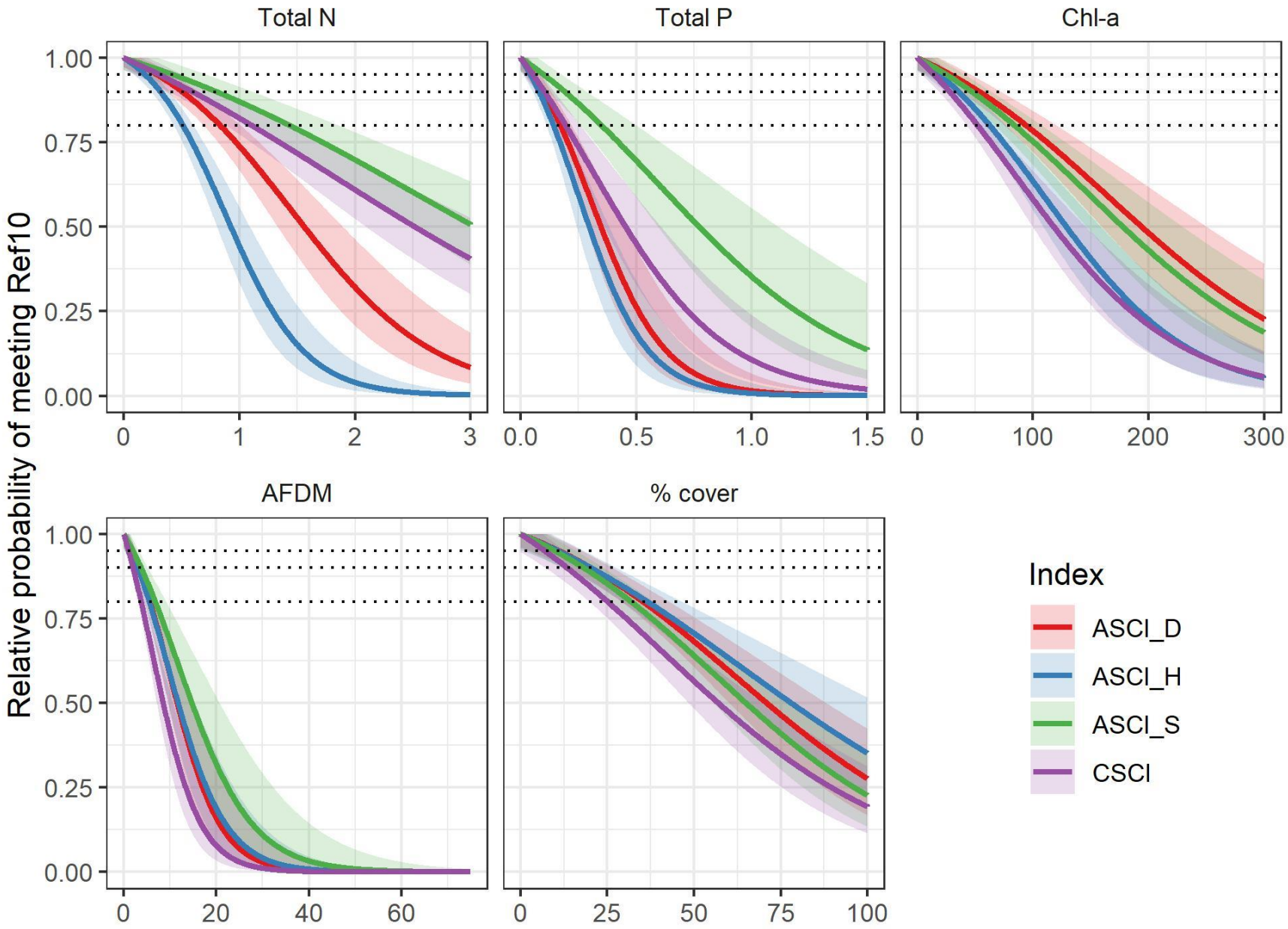
- Technical:
  - Does the threshold validate?
- Policy:
  - Risk tolerance?
  - Balance errors of overprotection vs. underprotection?

Set thresholds where likelihood is sufficiently high



Sometimes, no threshold found within evaluated range at evaluated probabilities.

“Even if stress is high, we are not sufficiently increasing the risk of failing to meet our [low] goal”



In general, ASCI-H and CSCI were more sensitive than ASCI-D, ASCI-S

Validation through relative risk assessment

Relative risk: If a site exceeds a biostimulatory threshold, does that increase the likelihood of failing to meet a biointegrity goal?

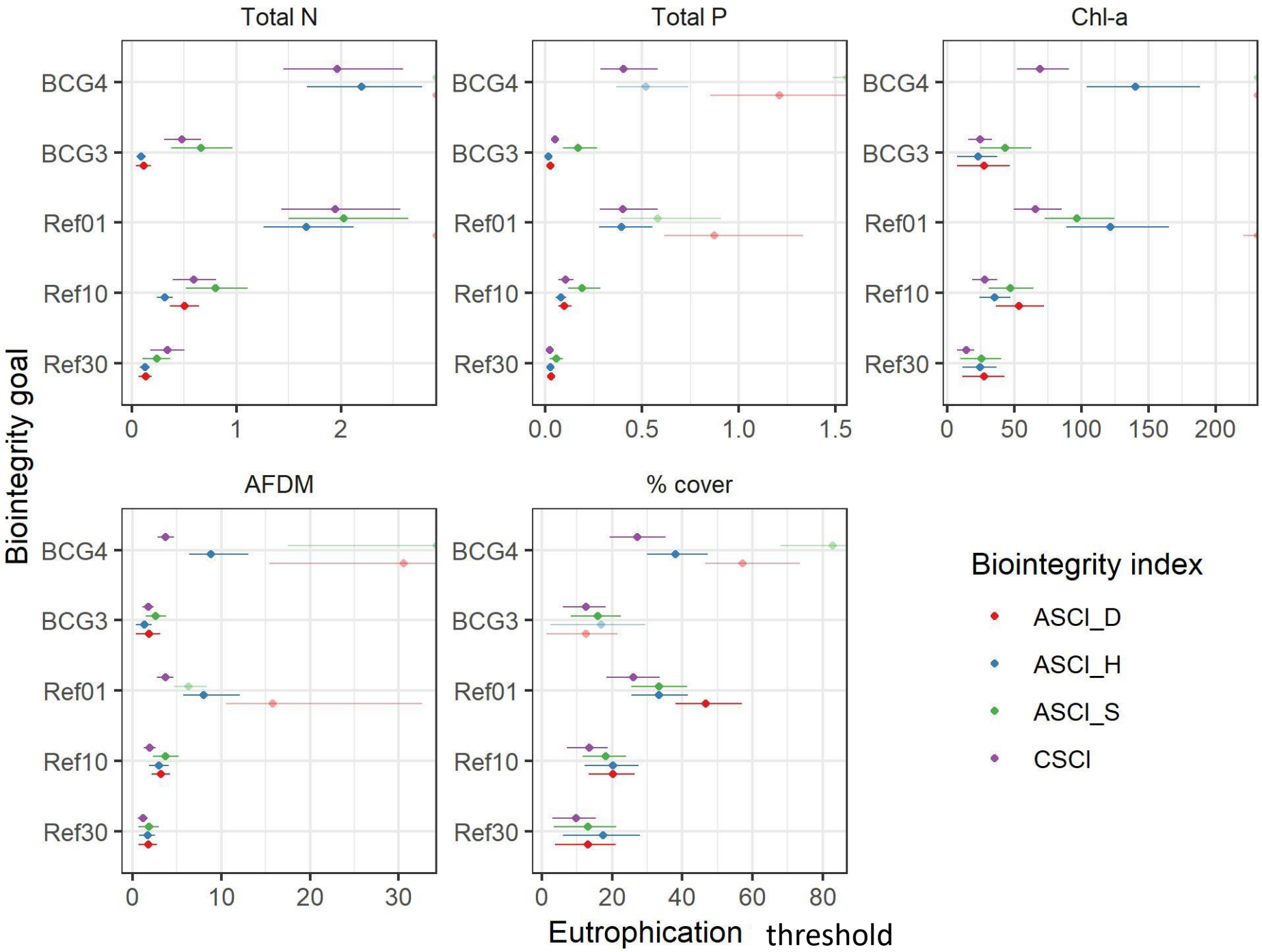
Calculated in both cal and val data sets:

$$\frac{\text{Frequency of BI failures where threshold is exceeded}}{\text{Frequency of BI failures where threshold is met}}$$

Validation: Both cal and val risk significantly greater than 1.

What probability reflects WB risk tolerance?

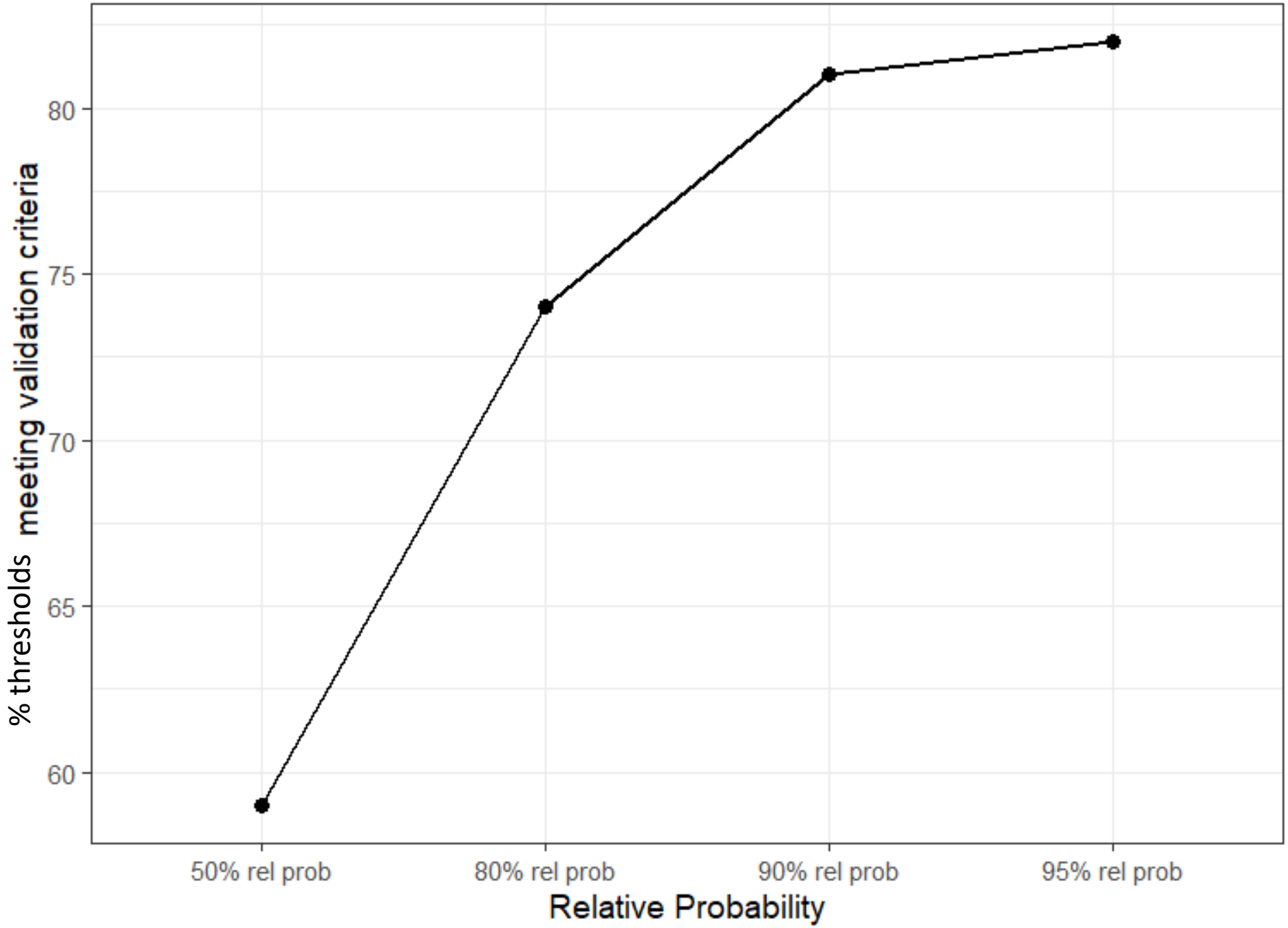
- We evaluated three options:
  - 80%
  - 90%
  - 95%
- Example statement: “If I keep total P below 0.08, I have a 90% chance of meeting my biointegrity goals.”
- Validation was best with 90% and 95%



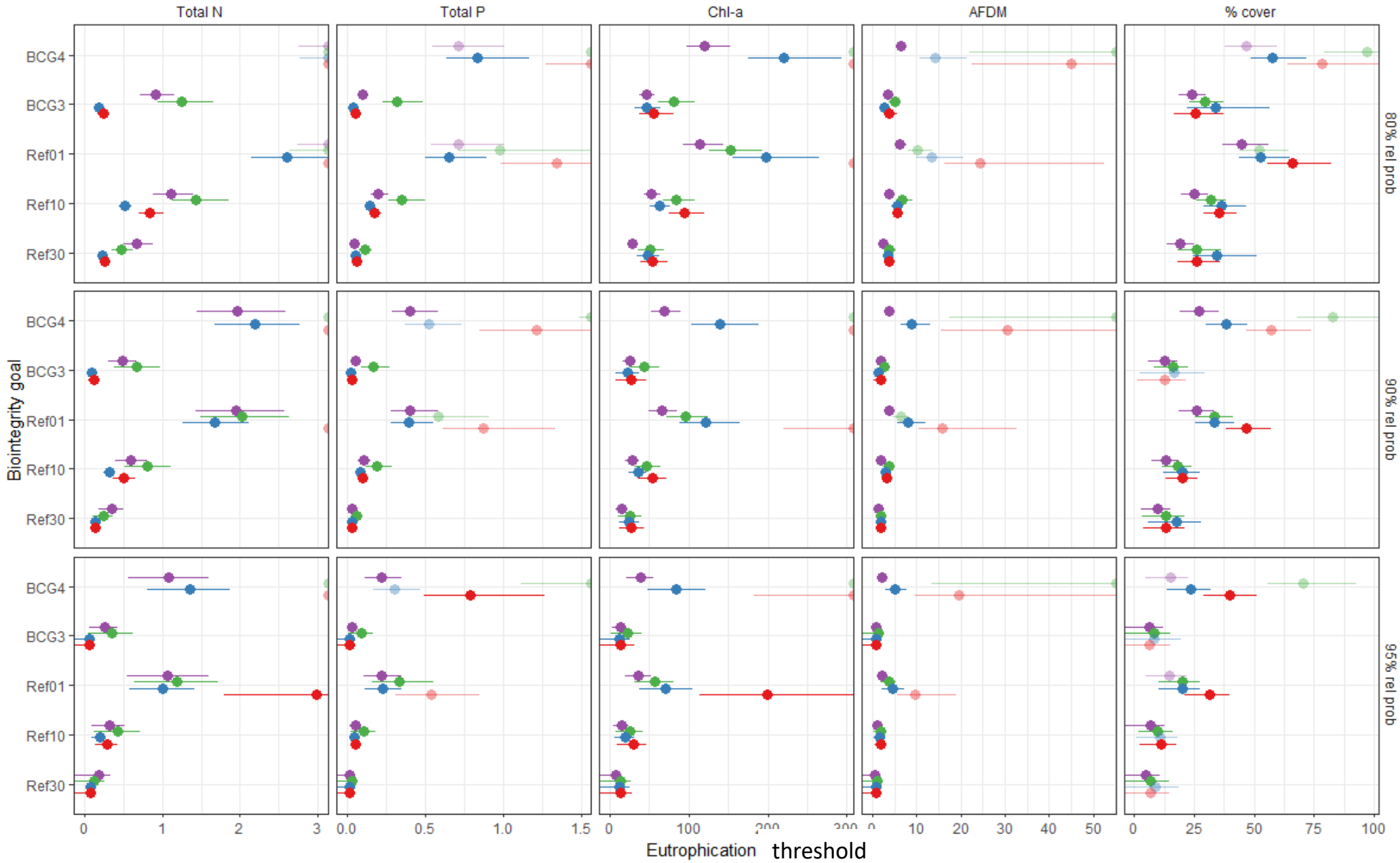
Thresholds to achieve a range of BI goals with 90% relative probability

Dark colors: Passed validation

Faint colors: Failed validation

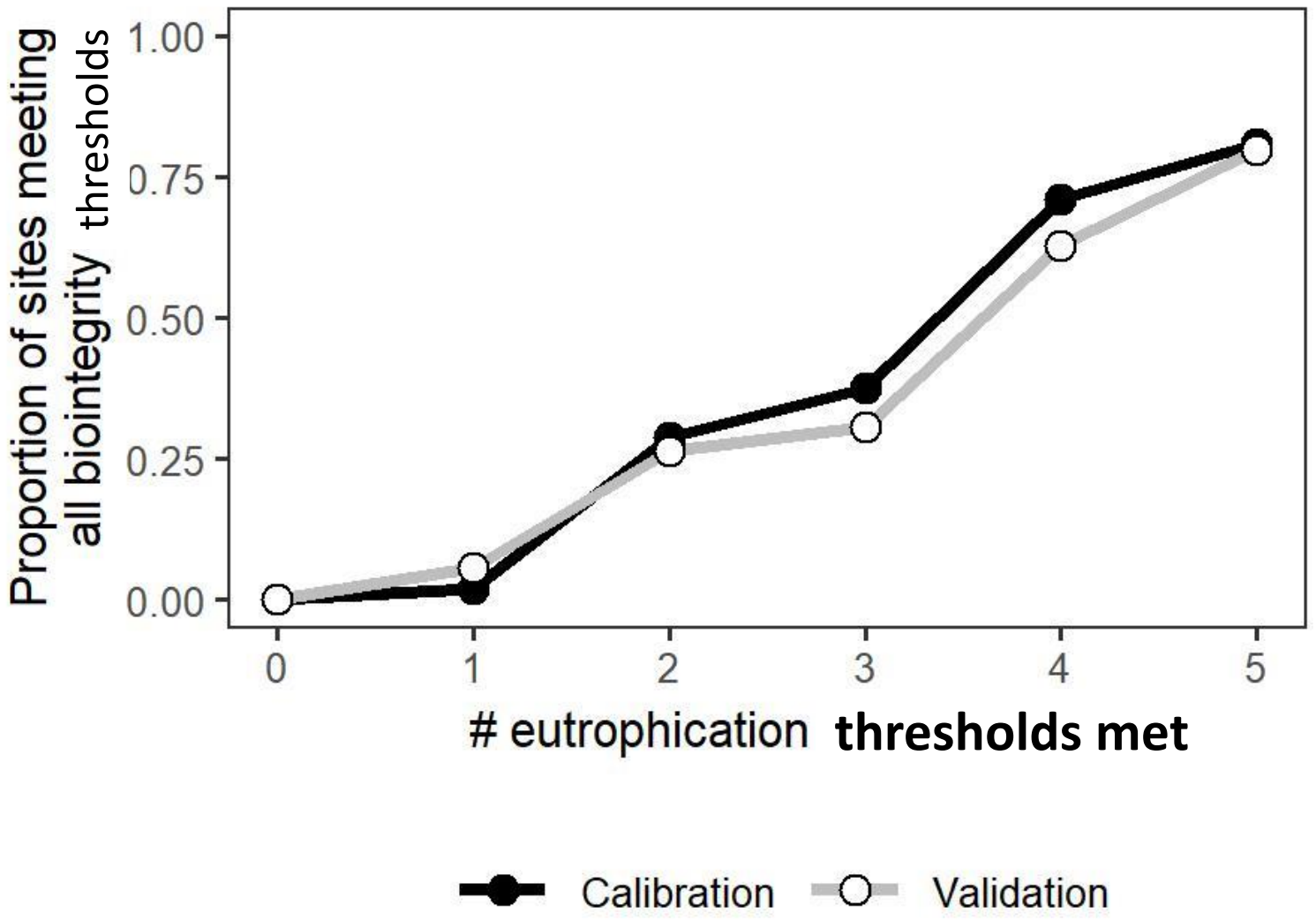


Higher probabilities resulted in more thresholds getting validated


Total N
Total P
Chl-a
AFDM
% cover
BCG4
BCG3
Ref01
Ref10
Ref30
80% rel prob
90% rel prob
95% rel prob
Biointegrity goal
0
1
2
3
0.0
0.5
1.0
1.5
0
100
200
0
10
20
30
40
50
0
25
50
75
100
Eutrophication threshold
Biointegrity index
ASCI_D
ASCI_H
ASCI_S
CSCI

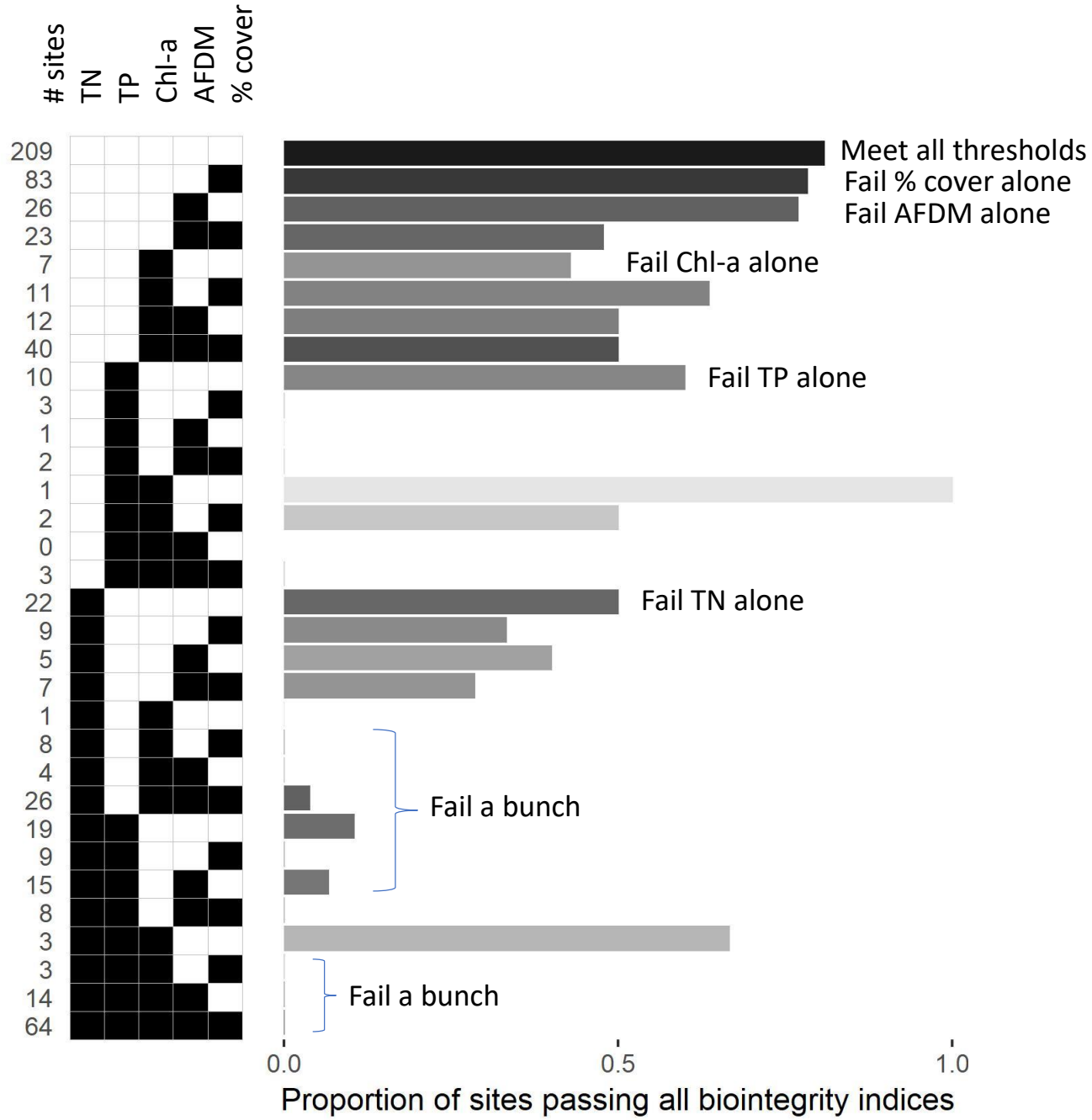
Summary of thresholds (Ref10, 90% prob)

Biostimulatory factor	Lowest validated threshold (index)	Highest validated threshold (index)	Relative Risk
Total N	0.32 (ASCI-H)	0.80 (ASCI-S)	11.3
Total P	0.08 (ASCI-H)	0.19 (ASCI-S)	5.6
Chl-a	28 (CSCI)	58 (ASCI-D)	2.4
AFDM	2.0 (CSCI)	3.7 (ASCI-S)	2.4
% cover	13 (CSCI)	21 (ASCI-D)	1.9



Failing single threshold: High (>50%) error rate!

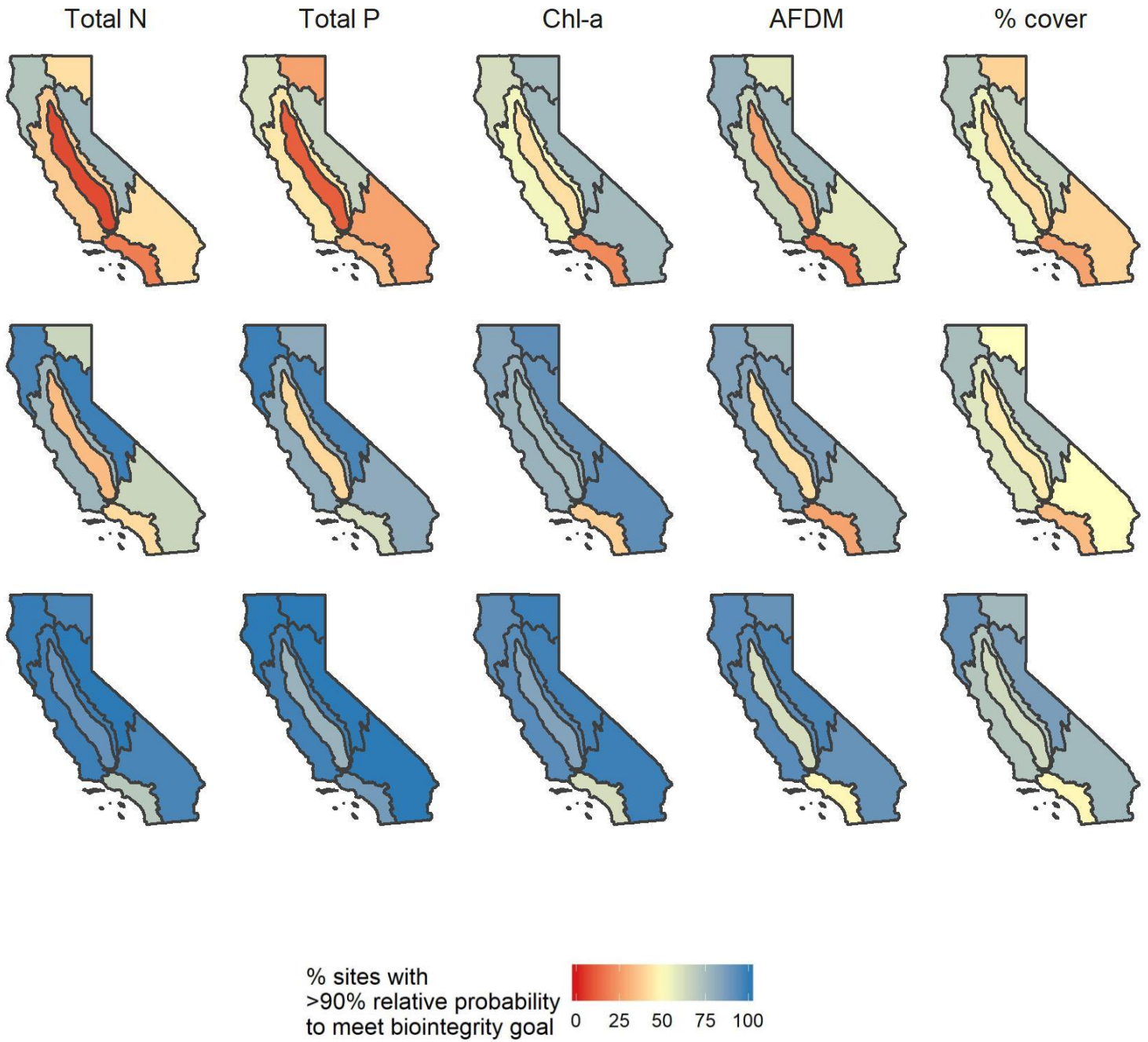
Much lower (30-37%) when multiple thresholds are exceeded.



Organic matter—especially % cover, AFDM—had the highest error rates.

Complex graph—review on your own!

Revisit analysis after options have been reviewed.



Most pervasive exceedance: % cover

Nutrient threshold exceedances are most extensive in Central Valley

OM exceedances are notably frequent in South Coast

WB staff are reviewing several options for evaluating multiple lines of evidence

- Independent applicability for some or all biostimulatory factors
- Different probabilities/BI goals for different factors
- Require exceedances for some or all biostimulatory factors to identify impairment, such as:
  - Any two factors
  - One nutrient and one organic matter
- Bioconfirmation
- Others?

We will re-evaluate error rates for preferred approaches

Key Findings: Nutrients and Organic Matter Indicators Linked to Aquatic Life (CSCI and ASCI)

- Strong evidence for risk-based biostimulatory thresholds
  - Fairly narrow range of responses at REF30 and REF10
  - Consistent endpoints (both bugs and algae)
    - CSCI, ASCI_H were most influential in determining lowest validated threshold
  - Nutrient thresholds tend to be more effective at protecting biointegrity than organic matter thresholds

- Use as single lines has high error rate
  - Evaluating multiple lines, bioconfirmation may help

Next steps

- Draft manuscript currently in review by advisory group
  - Feedback from advisory groups and decisions by WB staff will inform the next revision
  - Revised products will need additional review!
- WB staff will identify preferences for key decisions
  - Probability
  - BI goal
  - Options for multiple lines of evidence