Draft Ambient Water Quality Criteria Recommendations for Lakes and Reservoirs of the Conterminous United States:

Information Supporting the Development of Numeric Nutrient Criteria

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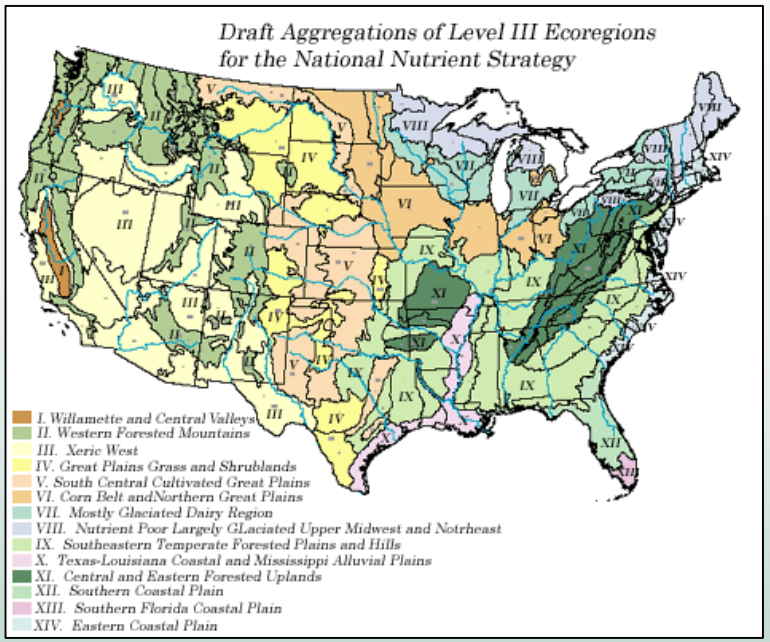
Office of Water
U.S. Environmental Protection Agency

Helpful Information to Start

- For webinar audio, adjust your computer volume using the speaker icon at the top of the Adobe screen or call 866-609-7191.
- Questions from participants will be answered at the end of the webinar. Submit questions in the “Q&A” pod.
- Please send comments on or before July 21st. To do so, visit Regulations.gov, Docket ID # EPA-HQ-OW-2019-0675.
- Today’s slides will be posted at: https://www.epa.gov/nutrient-policy-data/technical-support-numeric-nutrient-water-quality-criteria-development

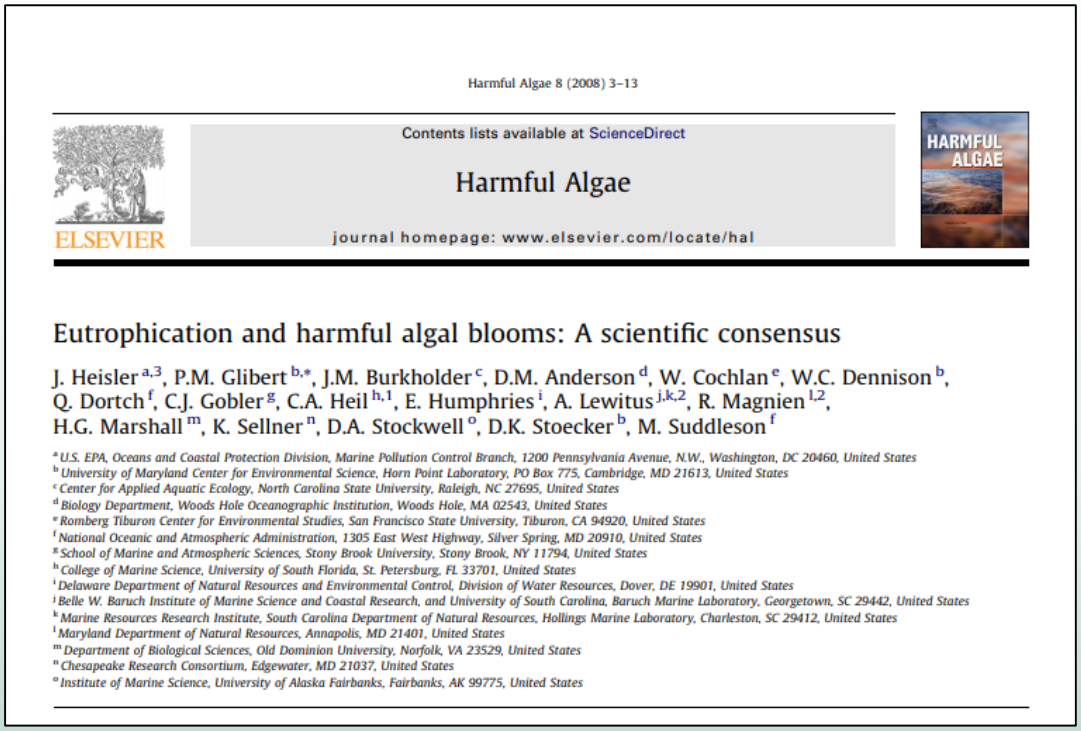
EPA's Existing Recommended Nutrient Criteria

- EPA published numeric nutrient criteria recommendations in 2000 – 2001 for lakes and reservoirs.
- U.S. classified into 14 nutrient ecoregions in which nutrient concentrations were expected to be similar.
- Criteria were derived using a reference distribution approach.
  - Numeric criterion values were the 25th percentile of all available total nitrogen (TN), total phosphorus (TP), chlorophyll *a* (chl *a*), and Secchi depth.
  - Data were sufficient to apply this approach in 12 of 14 ecoregions.
- Criticized for not linking directly to support of designated uses (aquatic life, recreation, and drinking water source).



Nutrients and Harmful Algal Blooms

- Latest science documents linkages between an increased frequency of harmful algal blooms and increased nutrient concentrations.



Harmful Algae 8 (2008) 3–13

Contents lists available at ScienceDirect

Harmful Algae

journal homepage: www.elsevier.com/locate/hal

Eutrophication and harmful algal blooms: A scientific consensus

J. Heisler [a,3], P.M. Glibert [b,*], J.M. Burkholder [c], D.M. Anderson [d], W. Cochlan [e], W.C. Dennison [b], Q. Dortch [f], C.J. Gobler [g], C.A. Heil [h,1], E. Humphries [i], A. Lewitus [j,k,2], R. Magnien [l,2], H.G. Marshall [m], K. Sellner [n], D.A. Stockwell [o], D.K. Stoecker [b], M. Suddleson [f]

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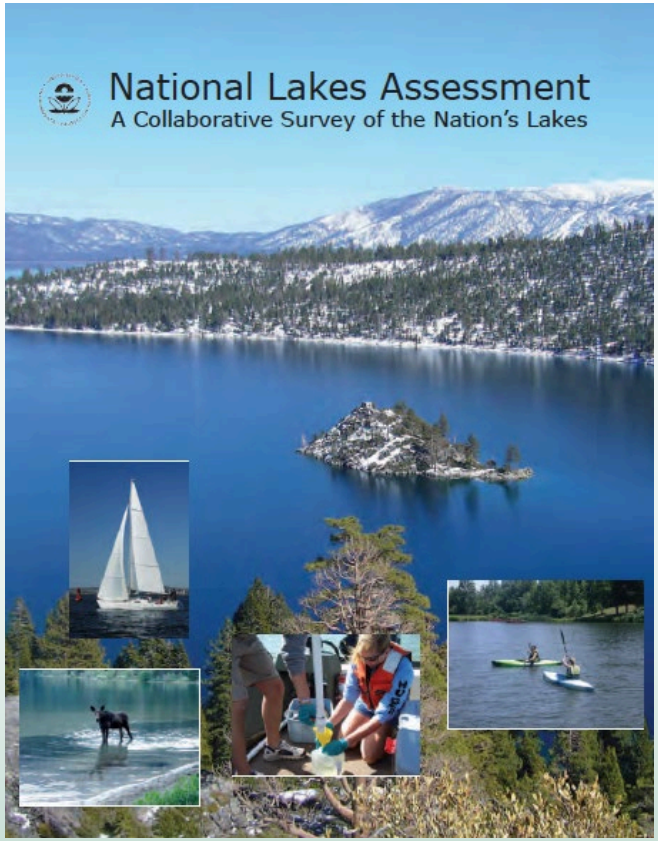
Nationally Consistent Data for Lakes and Reservoirs are now Available

- Lakes assessment data from the EPA's National Aquatic Resource Surveys.
  - Survey data from 2007 and 2012 included.
  - Extensive set of measurements collected at ~ 1800 randomly selected lakes.
  - Consistent protocols used to collect the same measurements from each of the lakes.
  - Data available for the stressors (TN and TP) and the responses (i.e., chl *a*, dissolved oxygen, microcystin, and zooplankton biomass) allow EPA to derive criteria specifically to prevent adverse effects.



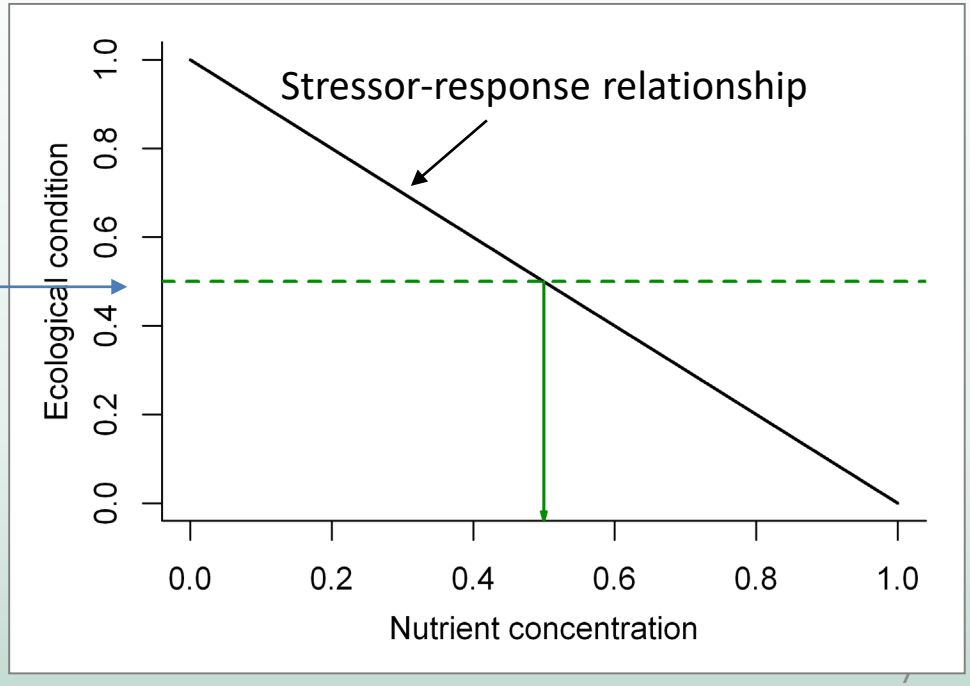
Benefits of Updated Recommended Criteria

1. Stressor-response relationships are used to link chl *a* concentration to attainment of each of three designated uses (aquatic life, recreation, and drinking water source).
2. When multiple use designations apply to a lake, states and tribes can calculate and compare candidate criteria for each applicable use to inform their risk management decisions (40 CFR 131.11(a)).
3. Criteria development tools are based on stressor-response models and can combine state and national data to derive state-specific values that reflect local conditions.
4. Tools provide flexibility for each state to incorporate their own risk management decisions in deriving final criteria.

Stressor – Response Analysis: Step 1

Define the endpoint and threshold.

How do we quantify "ecological condition" and set an appropriate threshold?



Defining Assessment Endpoints

- Characteristics of useful assessment endpoints:
  - Responsive to nutrients
  - Quantitative
  - Linked directly to management goal
  - Data available

- Water quality management goals based on state designated uses:
  - "…restore and maintain the chemical, physical, and biological integrity…"

  - Three designated uses that can be affected by nutrients
    - Aquatic life
    - Recreation
    - Drinking water source

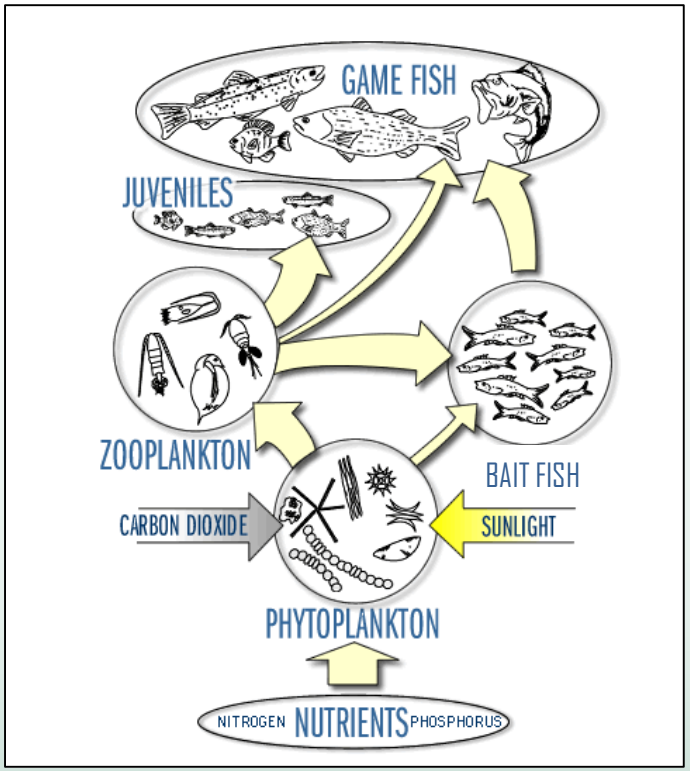
Defining Assessment Endpoints to Protect Aquatic Life

- Water quality management goal:
    - State designated use related to the protection and propagation of fish, shellfish and wildlife

- Selecting different endpoints ensures that aquatic life in different types of lakes is protected.
    - Zooplankton
    - Fish

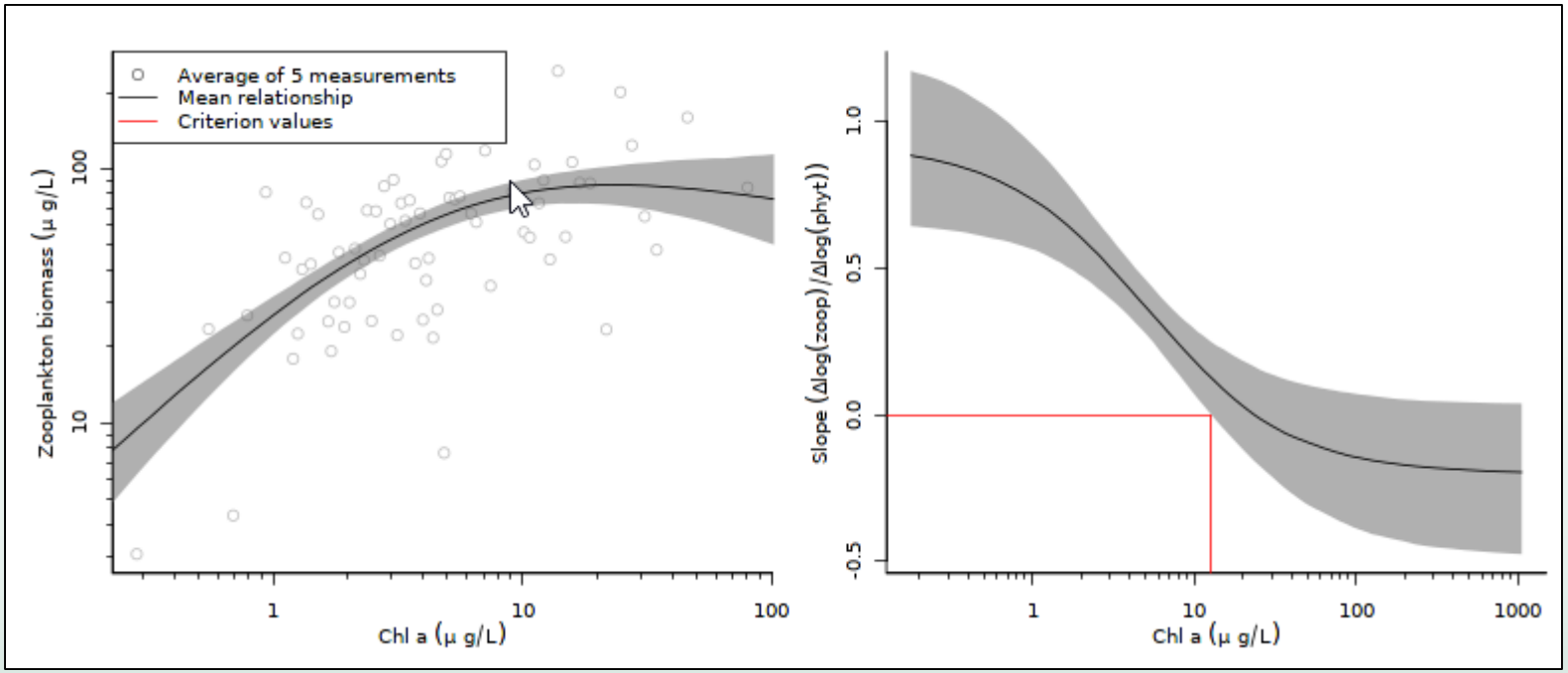
Aquatic Life Assessment Endpoint: Zooplankton

- Key link in lake food web
- Concurrent increases in phytoplankton and zooplankton biomass are indicative of an efficient transfer of resources up the food web.



http://www.waterontheweb.org/under/lakeecology/11_foodweb.html

Aquatic Life Assessment Endpoint: Zooplankton

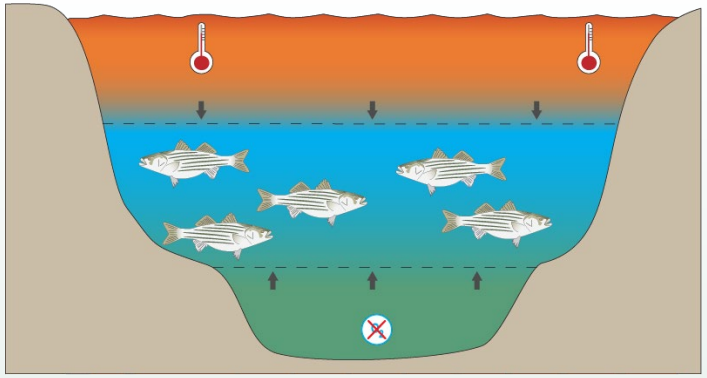


In lakes with high concentrations of phytoplankton and nutrients, transfer of energy from primary productivity to higher trophic levels is less efficient.

When chlorophyll *a* concentration increases, zooplankton biomass does not increase with phytoplankton.

Aquatic Life Assessment Endpoint: Fish

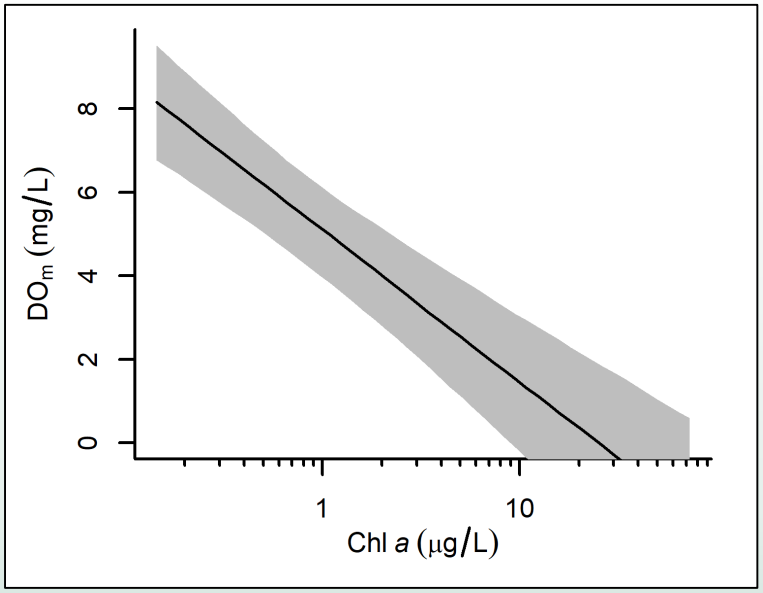
- Distribution of many fish species is limited by water temperature.
- In stratified lakes, depletion of oxygen in deep water below the thermocline can eliminate viable habitat for certain fish species.
- Endpoint: Sufficiently dissolved oxygen below thermocline to allow fish to persist through the summer (US EPA 1986).



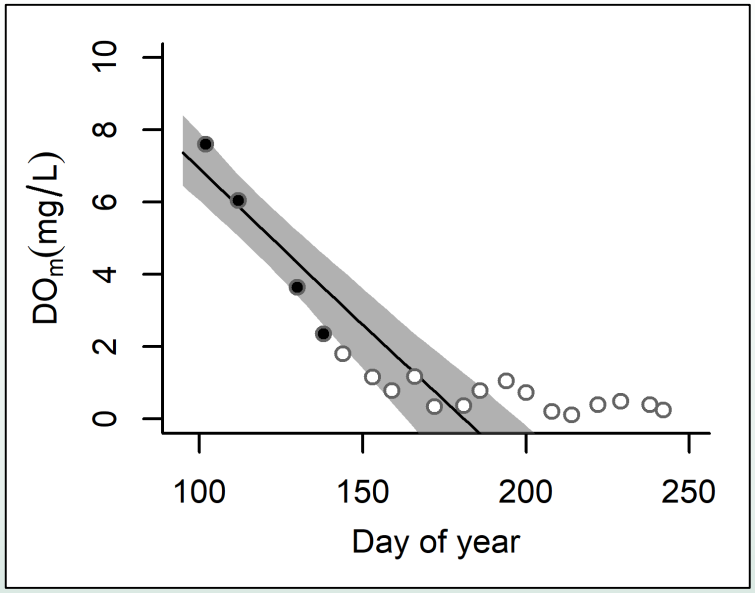
http://www.teachoceanscience.net/teaching_resources/education_modules/fish_and_physics/explore_trends/oxygen_and_water_temperature/

Chl *a* and Dissolved Oxygen

Depth-averaged dissolved oxygen (DO_m) decreases with increased Chl *a*.



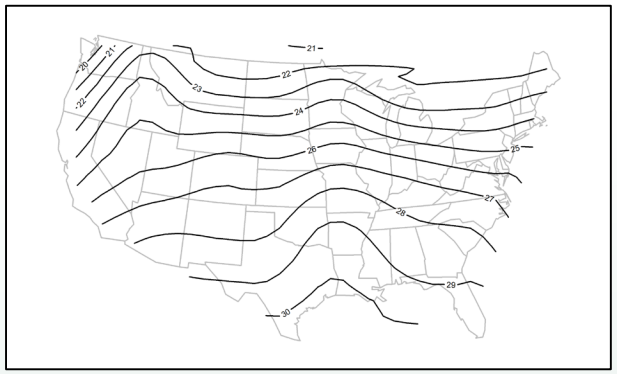
Number of days since stratification is also important.



Dissolved organic carbon and lake depth also influence DO_m.

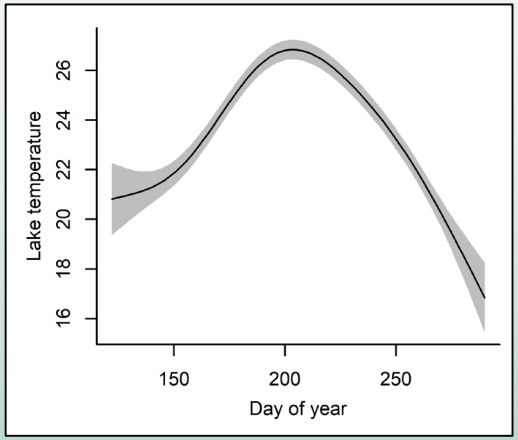
Lake Temperature Model

Location

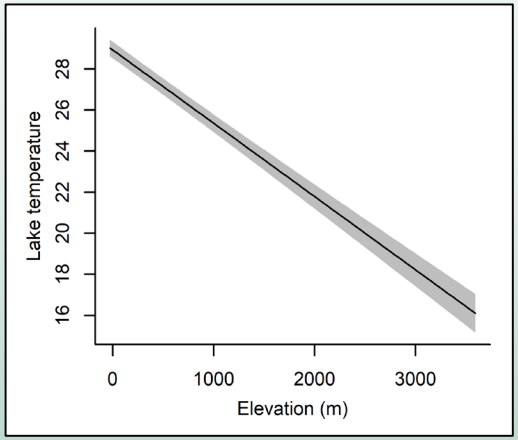


Lake surface temperature model varies with day of the year, elevation, and location.

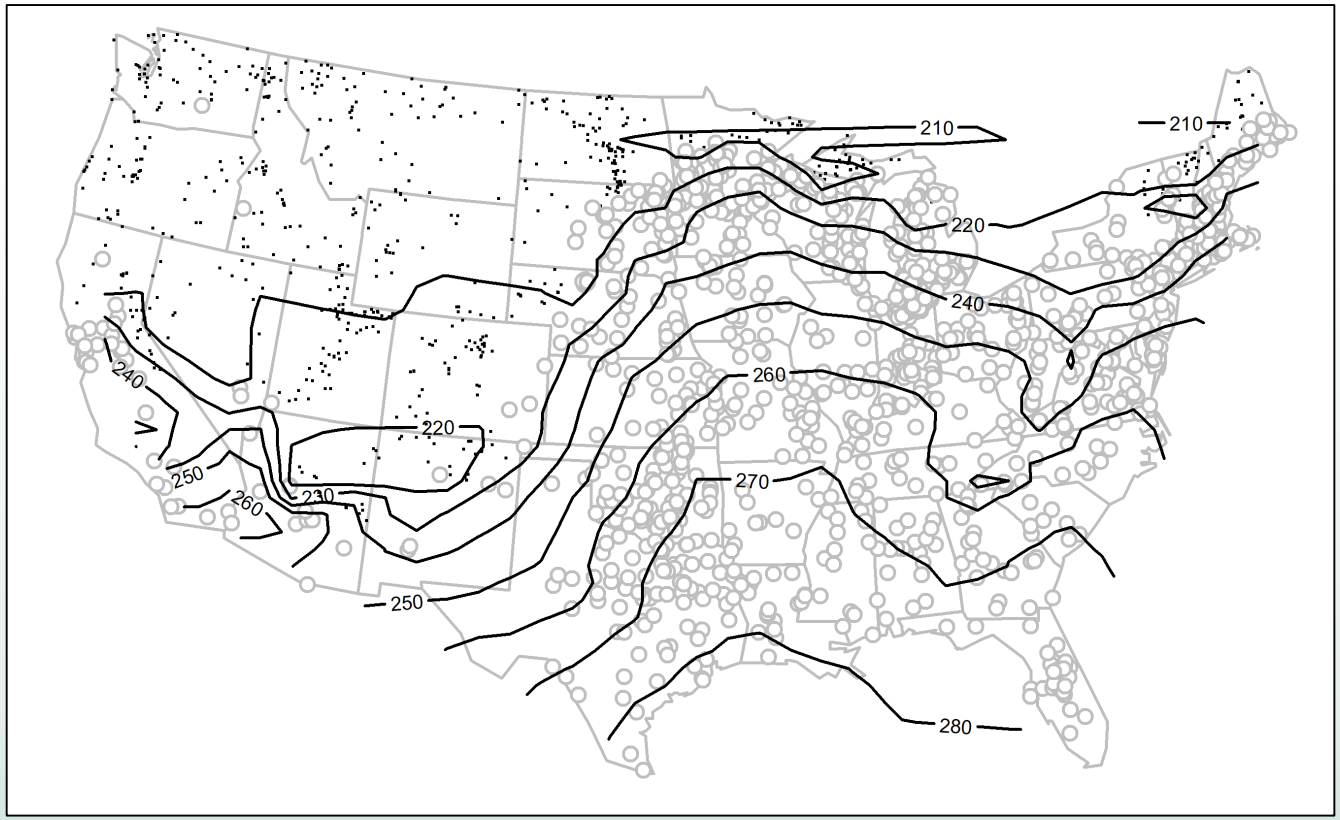
Day of the year



Elevation



Lake Surface Temperature



We can predict the average day of the year that surface lake decreases below different temperature limits (predictions for 24° shown).

Aquatic Life Assessment Endpoints: Summary

- Zooplankton endpoint can apply to all lakes.
- Fish/dissolved oxygen endpoint can apply to lakes that stratify seasonally and that harbor cool-water fish.

Defining Assessment Endpoints to Protect Drinking Water Sources

- Management goal:
    - State designated use related to protection of public water supplies

- Assessment endpoints: "…explicit expressions of the actual environmental value that is to be protected…"

- Endpoint ensures that drinking water source water are protected from microcystin, the most commonly occurring algal toxin. Focus on consumption by children.
    - US EPA Health Advisory

Defining Assessment Endpoints to Protect Recreational Waters

- Management goal:
    - State designated use related to allowing recreational activities in or on the water

- Assessment endpoints: "…explicit expressions of the actual environmental value that is to be protected…"

- Endpoint ensures that children swimming in recreational waters are protected from microcystin, the most commonly occurring algal toxin.
    - Criteria recommendation/swimming advisory values for microcystins.

Assessment Endpoints: Summary

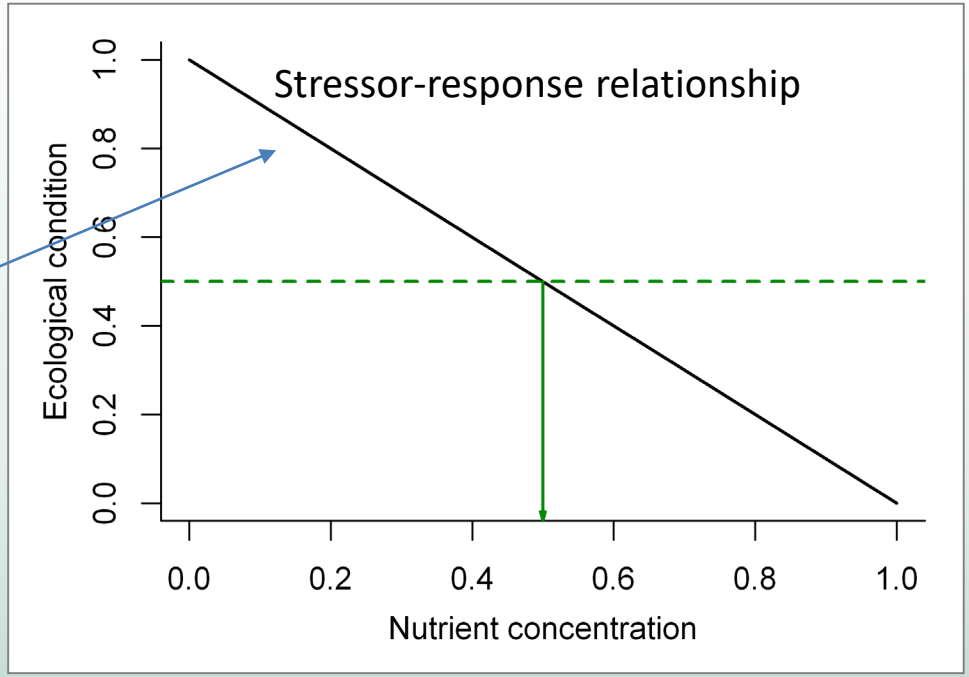
- Characteristics of useful assessment endpoints:
  - Responsive to nutrients
  - Quantitative
  - Linked directly to management goal
  - Data available

- National scale of 304(a) recommended criteria limited by data availability
  - Additional endpoints one might consider at local scales:
    - Fish abundance
    - Diatom composition
    - Water transparency

Stressor – Response Analysis: Step 2

Derive the stressor-response relationship.

How do we derive the position and shape of this line?



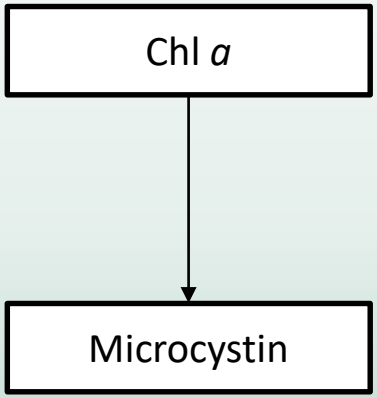
EPA United States Environmental Protection Agency

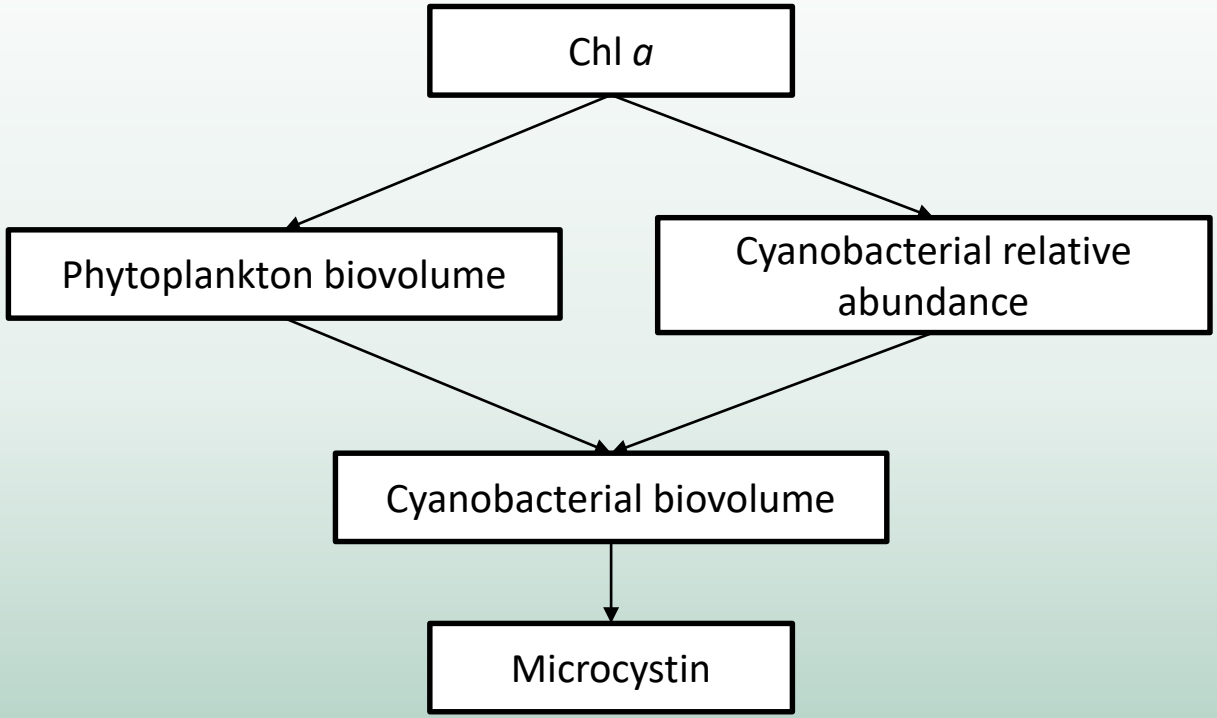
Approach

- Model known causal relationships.
  - Model proximal relationships when possible.
- Use functional forms that are consistent with underlying mechanisms.
- Model relationships among groups of measurements with Bayesian networks.

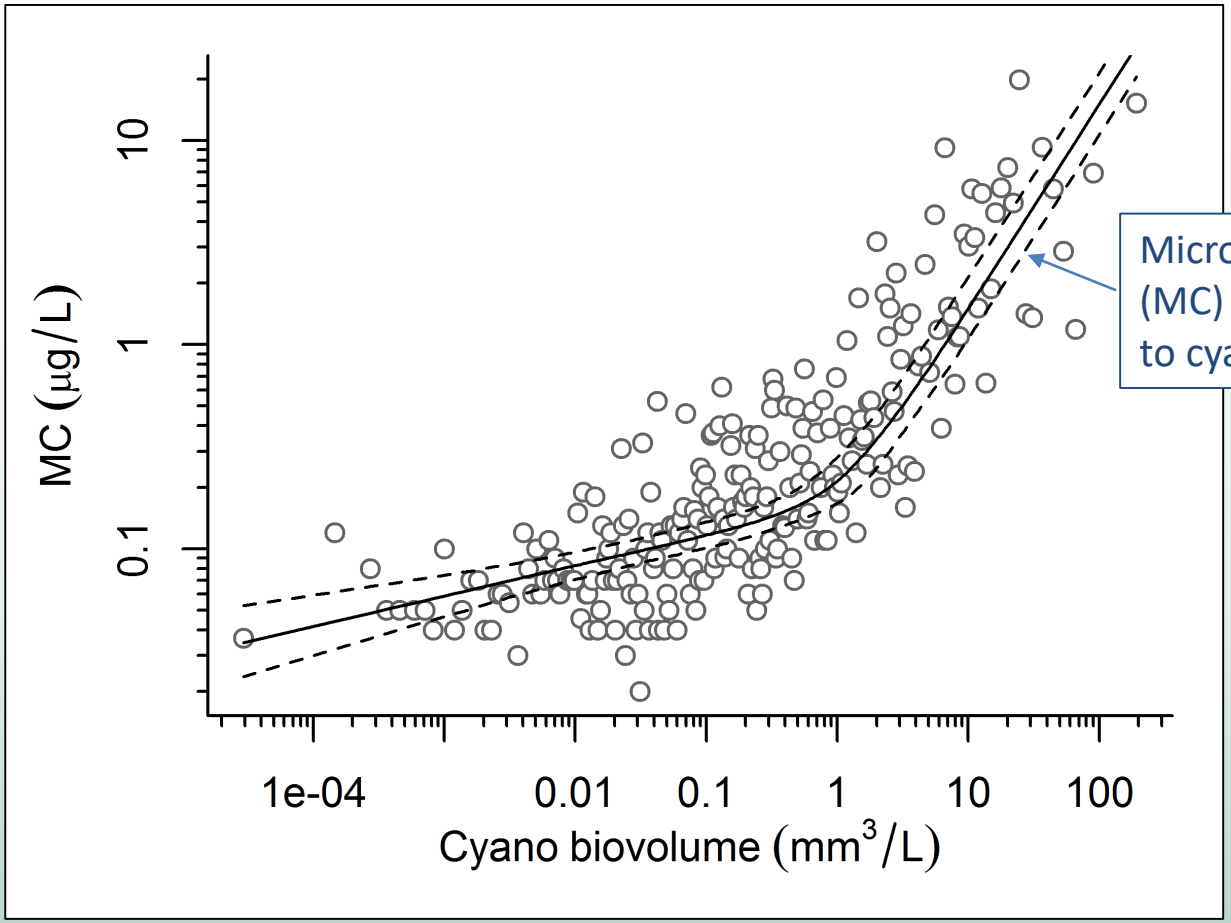
Stressor – Response Relationships

Modeling a network of relationships allows us to specify relationships between pairs of variables that better represent underlying mechanism.





Cyanobacterial Biovolume and Microcystin



Microcystin concentration (MC) is directly proportional to cyanobacteria biovolume.

Phosphorus – Chlorophyll Models

Model equation:

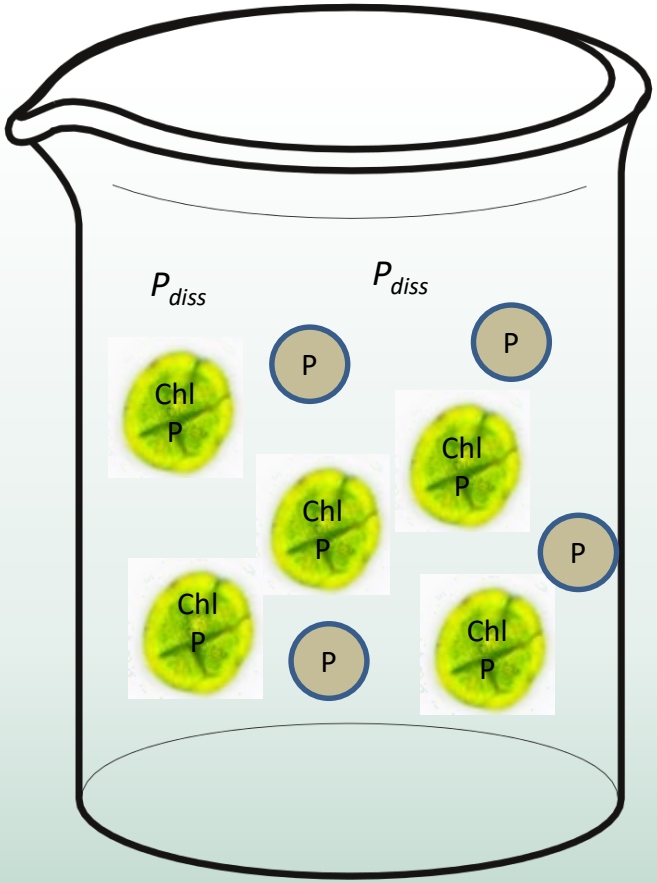
$$TP = d_1 Chl^k + d_2 Sed + P_{diss}$$

When sediment and P_{diss} concentrations are low, we can simplify to the following:

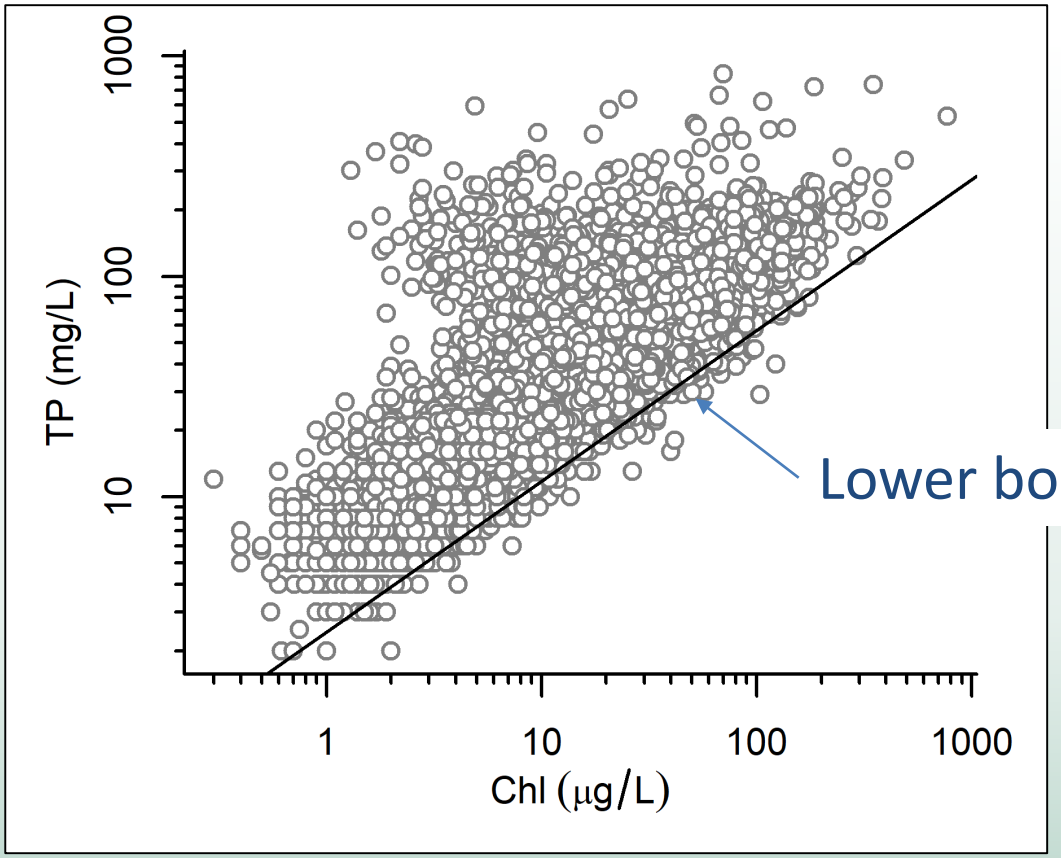
$$TP = d_1 Chl^k$$

$$\log(TP) = \log(d_1) + k\ log(Chl)$$

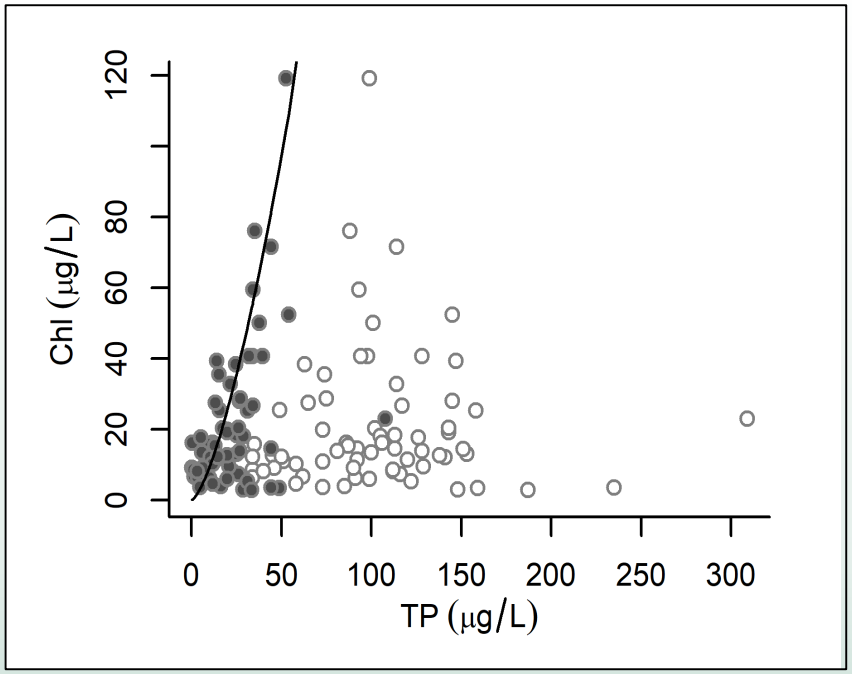
Lower bound between log(TP) and log(Chl) should be a straight line.

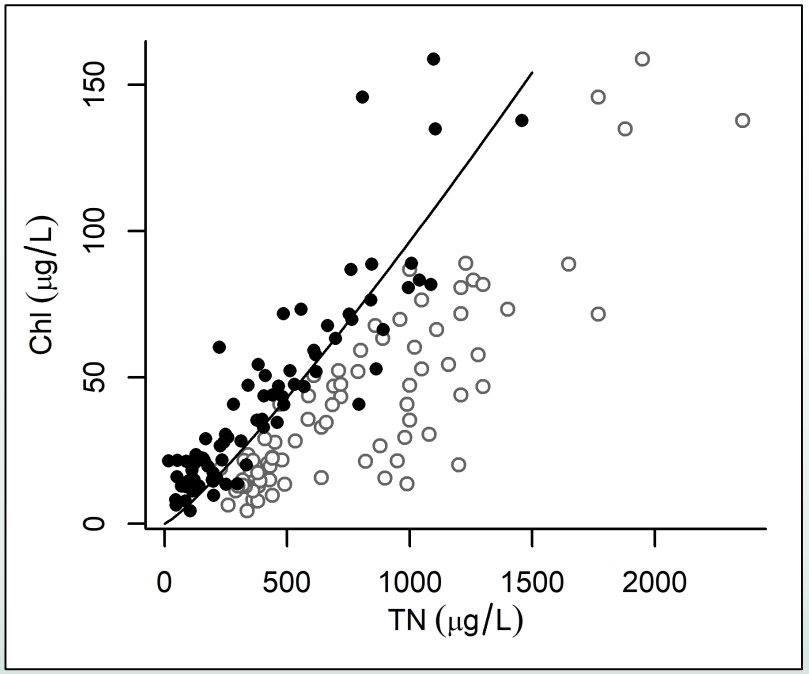


Data from MO Reservoirs



Relationships Between Total Phosphorus, Total Nitrogen, and Chl *a*





Raw measurements of TP and TN (open circles) are weakly associated with Chl. After controlling for the effects of phosphorus bound to sediment and dissolved organic nitrogen (filled circles), more precise relationships can be estimated.

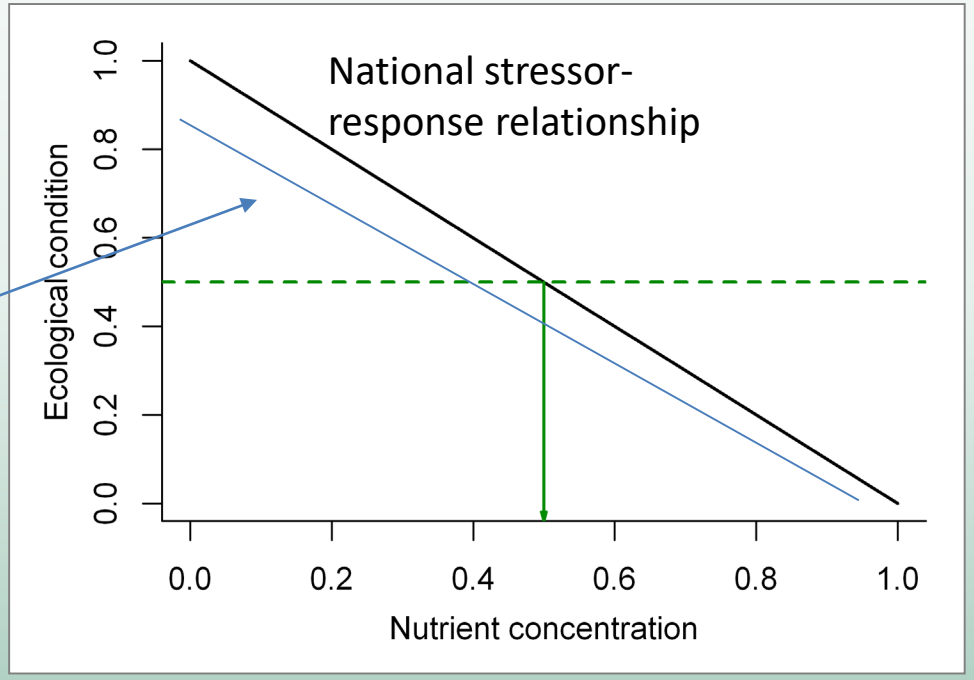
Stressor – Response: Summary

- Chl *a* criteria can be derived for three designated uses.
  - Drinking water and recreation: Chl *a* – microcystin model
  - Aquatic life:
    - Chl *a* – zooplankton model
    - Chl *a* – fish/hypoxia model
  - Final Chl *a* criteria would be based on the most sensitive use.
- TN and TP criteria can be derived from models linking nitrogen, phosphorus, and chl *a.*

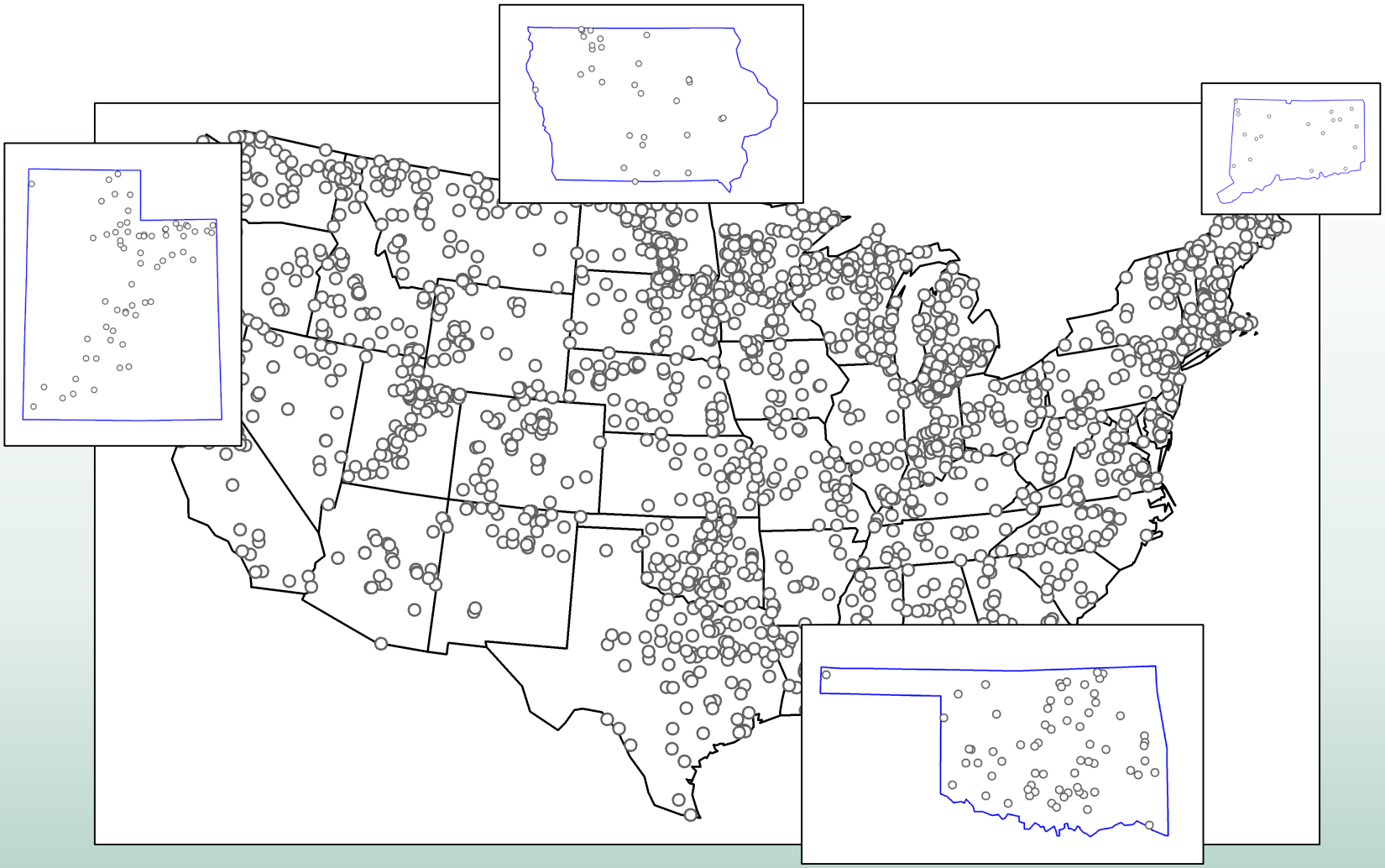
Tools that Combine State and National Data

- We have been working in partnership with states who volunteered to pilot test our tools for combining their state data with national models.
- Analysis results can be used to derive locally-applicable criteria.
- We will continue to work with states to combine state monitoring data with national models.

State data can reflect local conditions that can differ from national average.

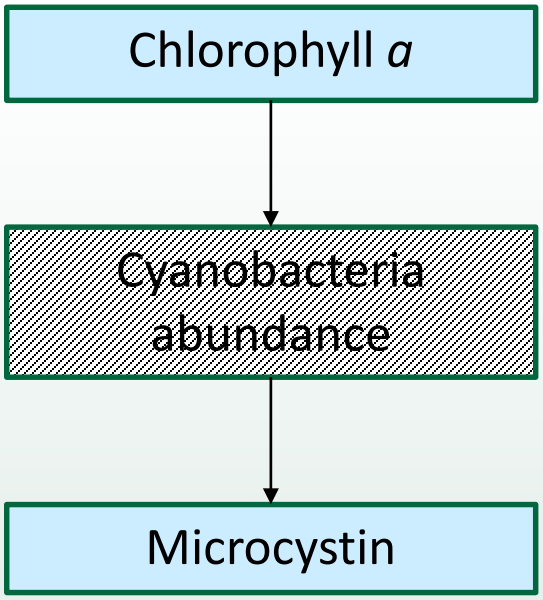


State – Specific Models

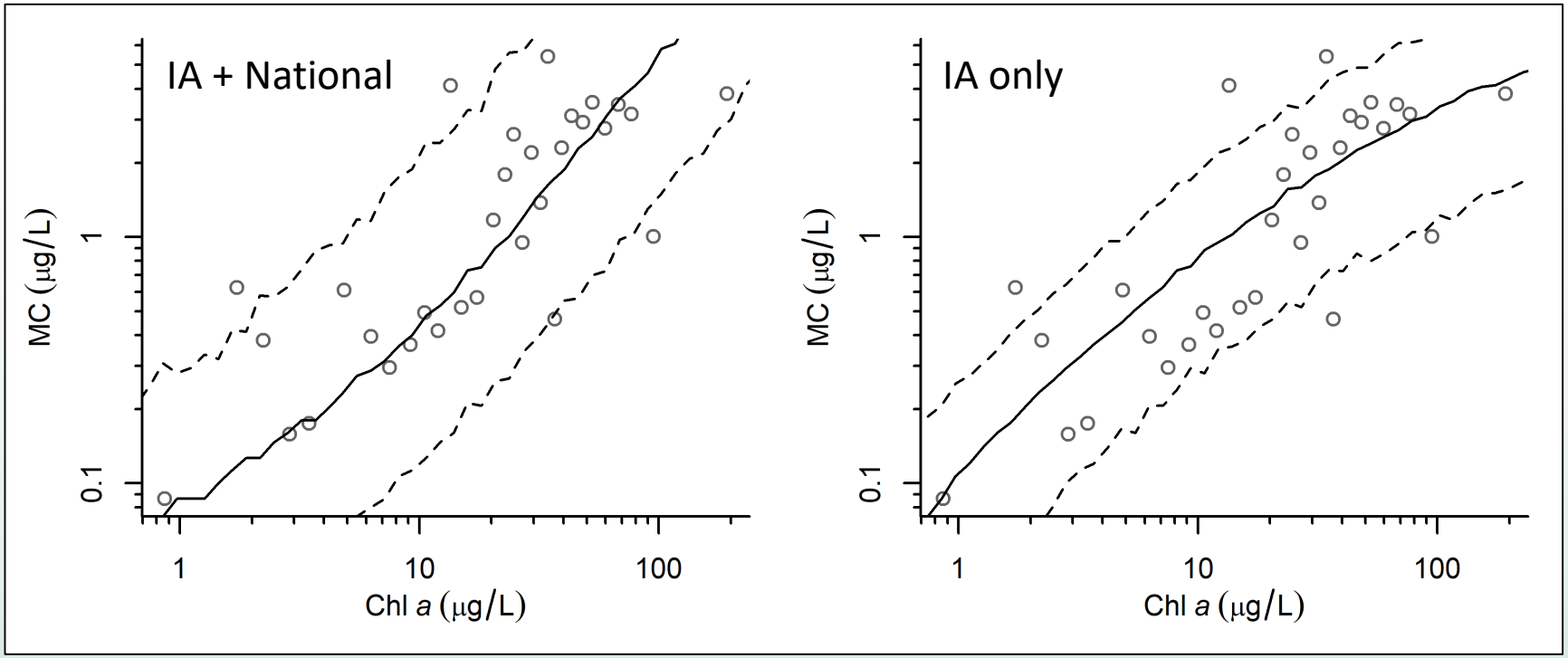


Example: Iowa Case Study

- Chl *a* and microcystin data were available in Iowa.
- National and Iowa data were used to develop a chl *a* - MC relationship.
- The national model sets a range for possible relationships in IA, and "fills in" for missing measurements.



Iowa Case Study



Combining IA data with national models yields a 13% improvement in model accuracy.

Criterion Graphical User Interfaces

Stressor-response models provided on-line as graphical tools.

- Microcystin model:
  - https://chl-microcystin-prod.app.cloud.gov/
- Hypoxia model:
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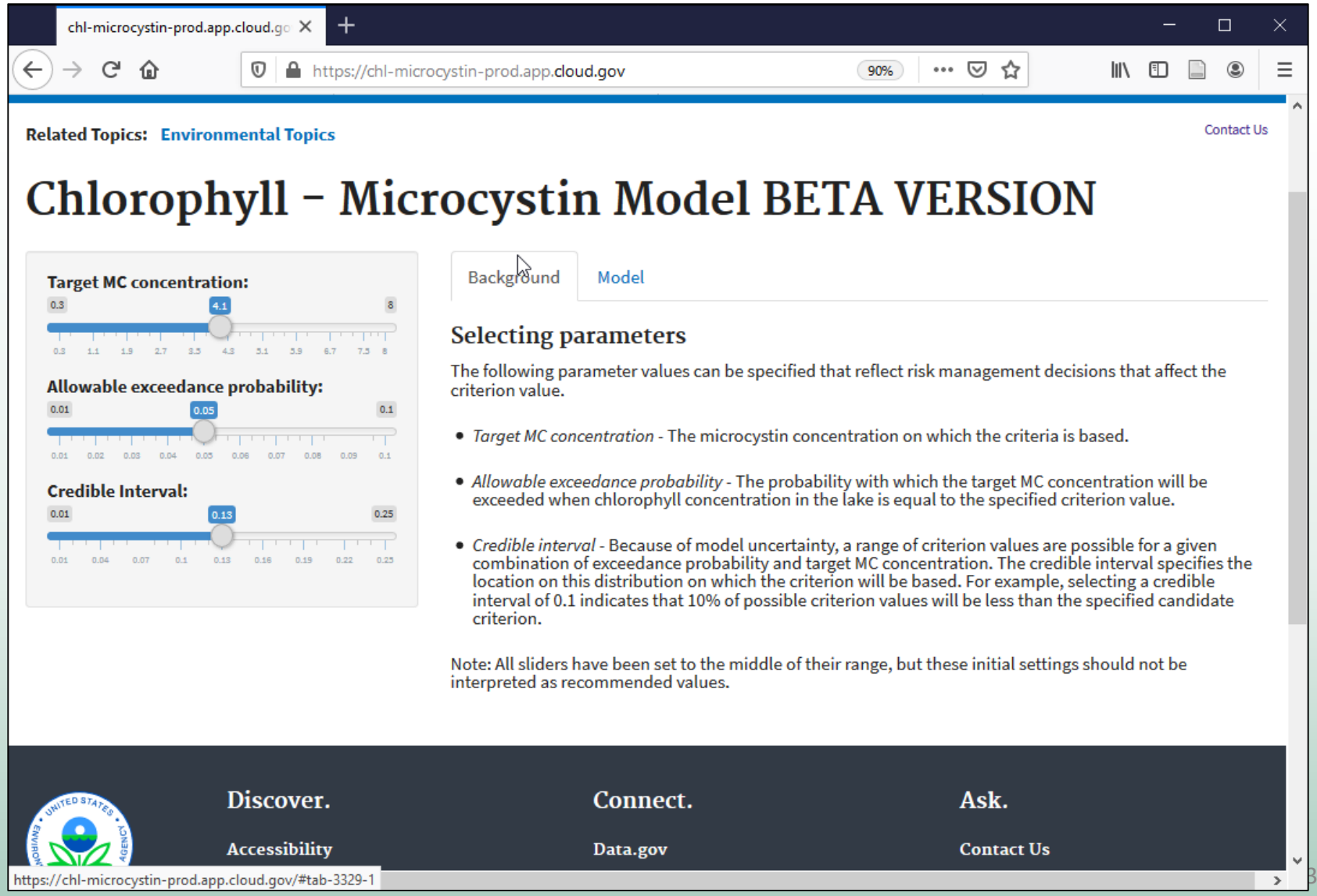
- Zooplankton model:
  - https://chl-zooplankton-prod.app.cloud.gov/
- TP-TN-Chl model:
  - https://tp-tn-chl-prod.app.cloud.gov/

Chlorophyll – Microcystin Model



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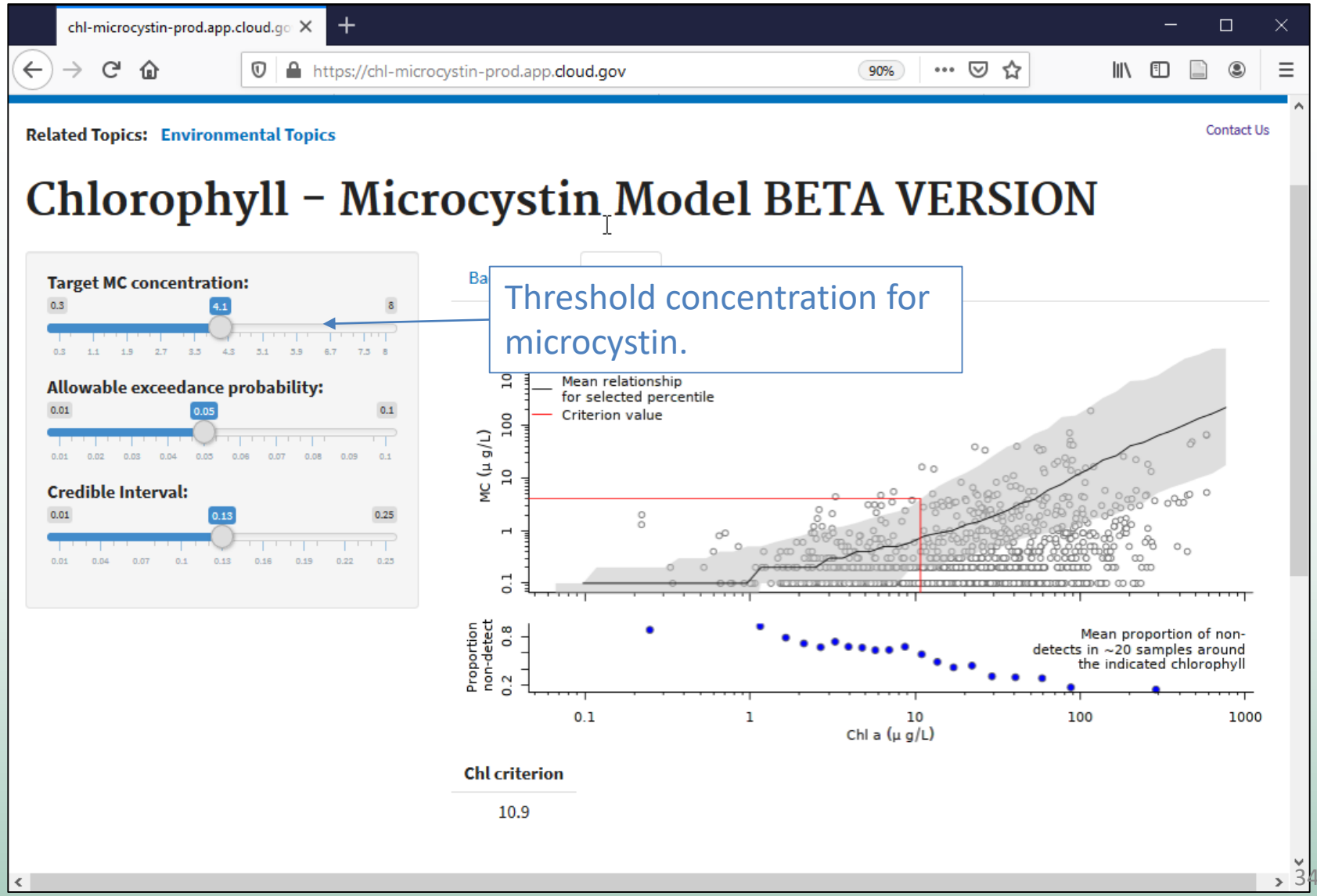

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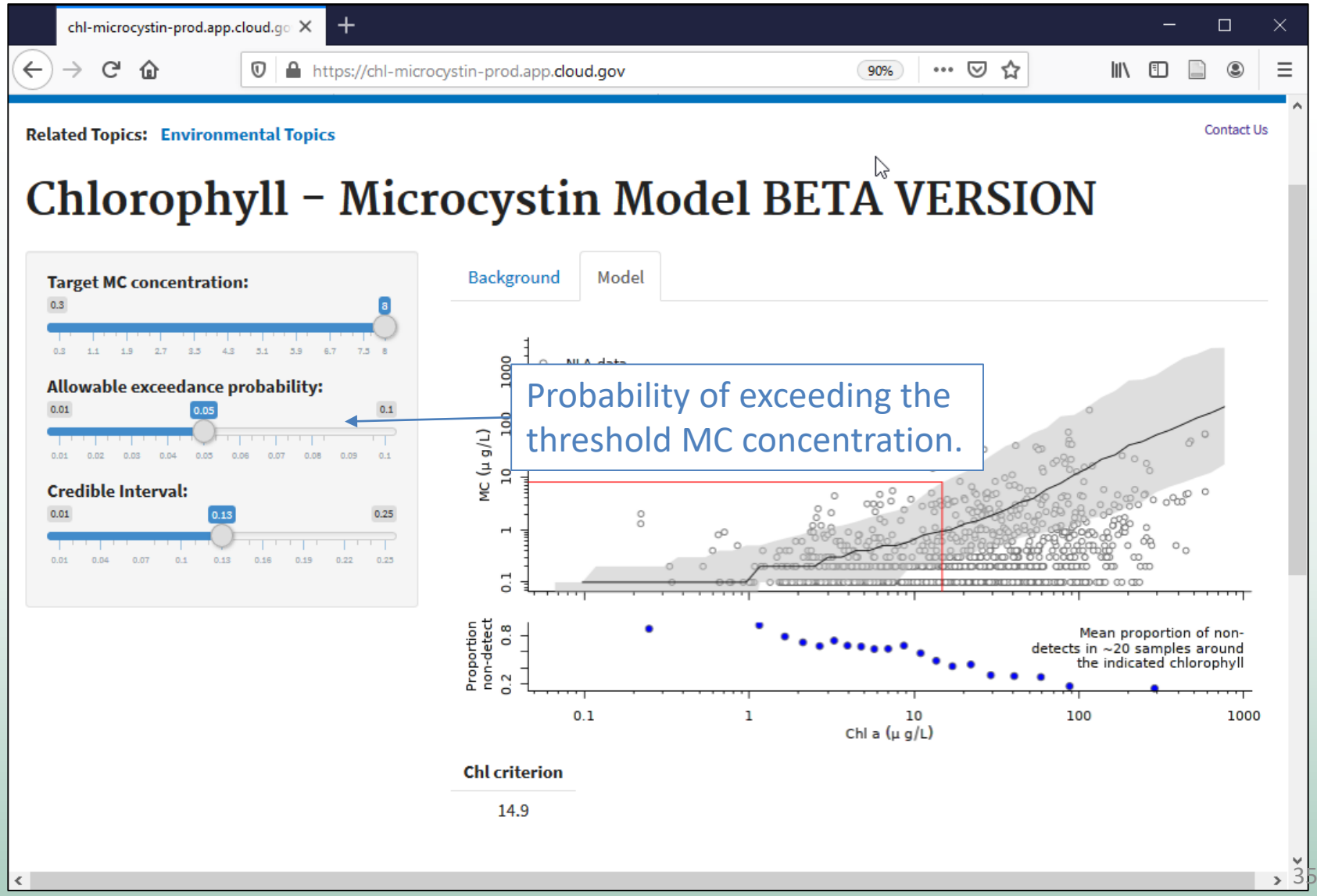

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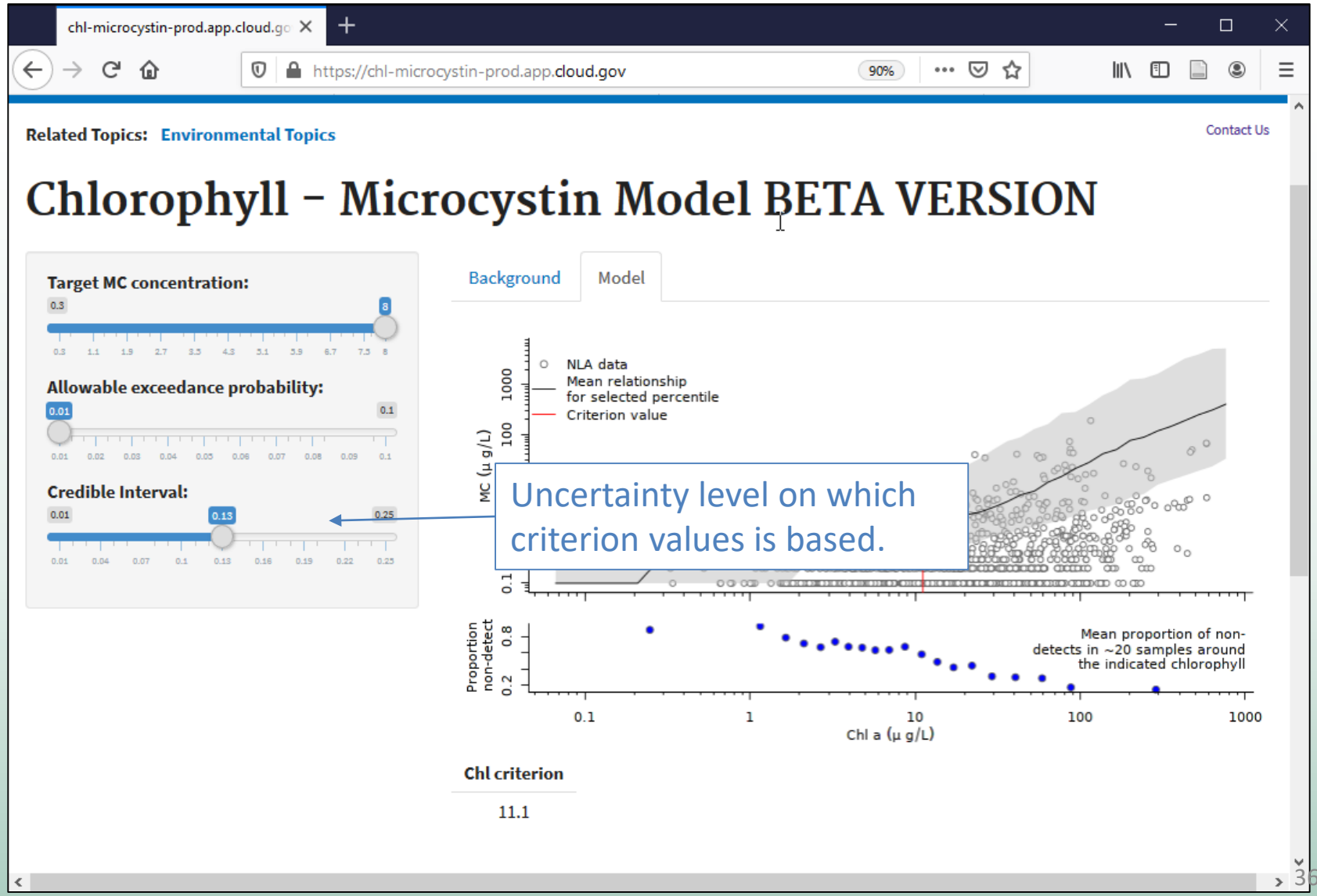

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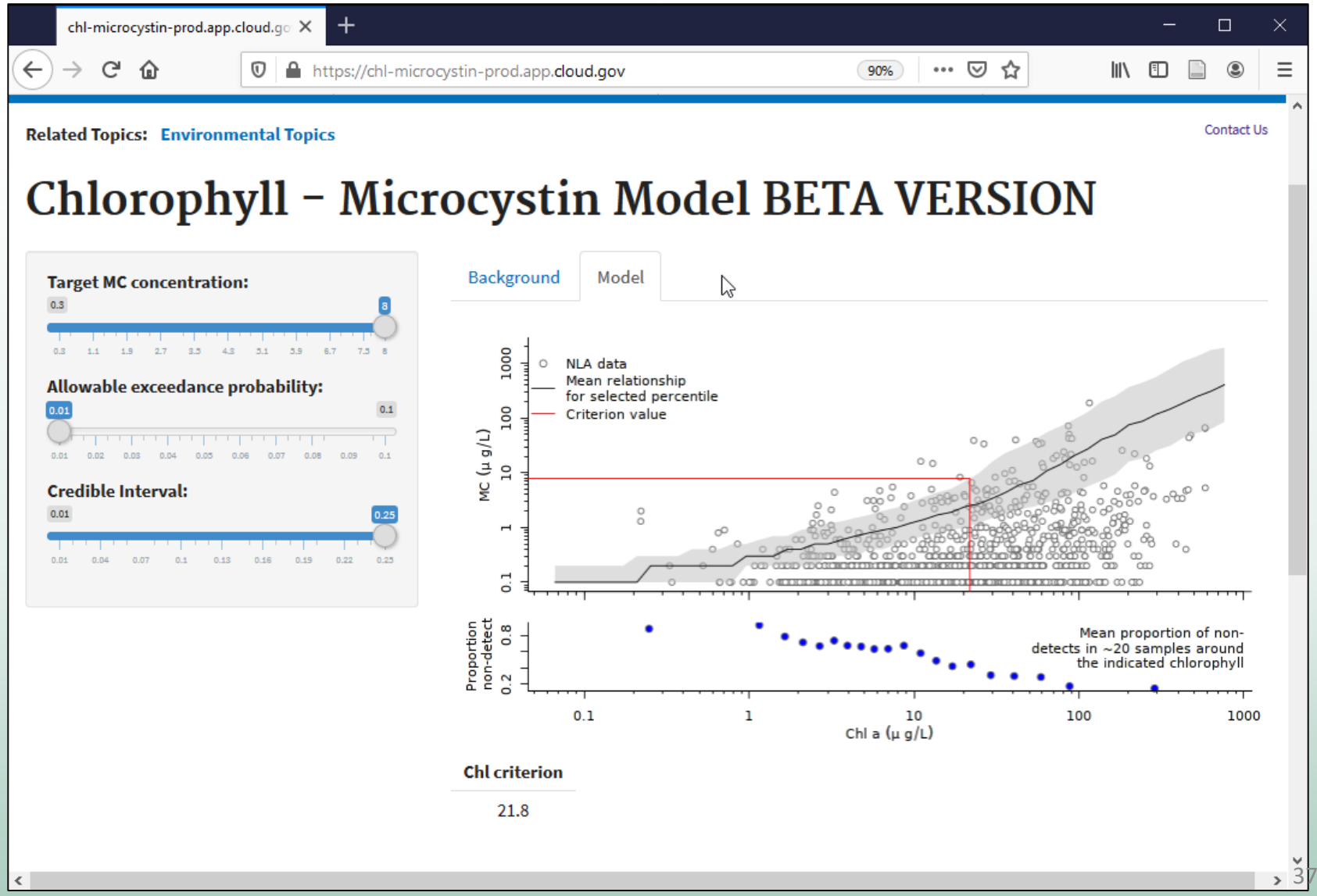

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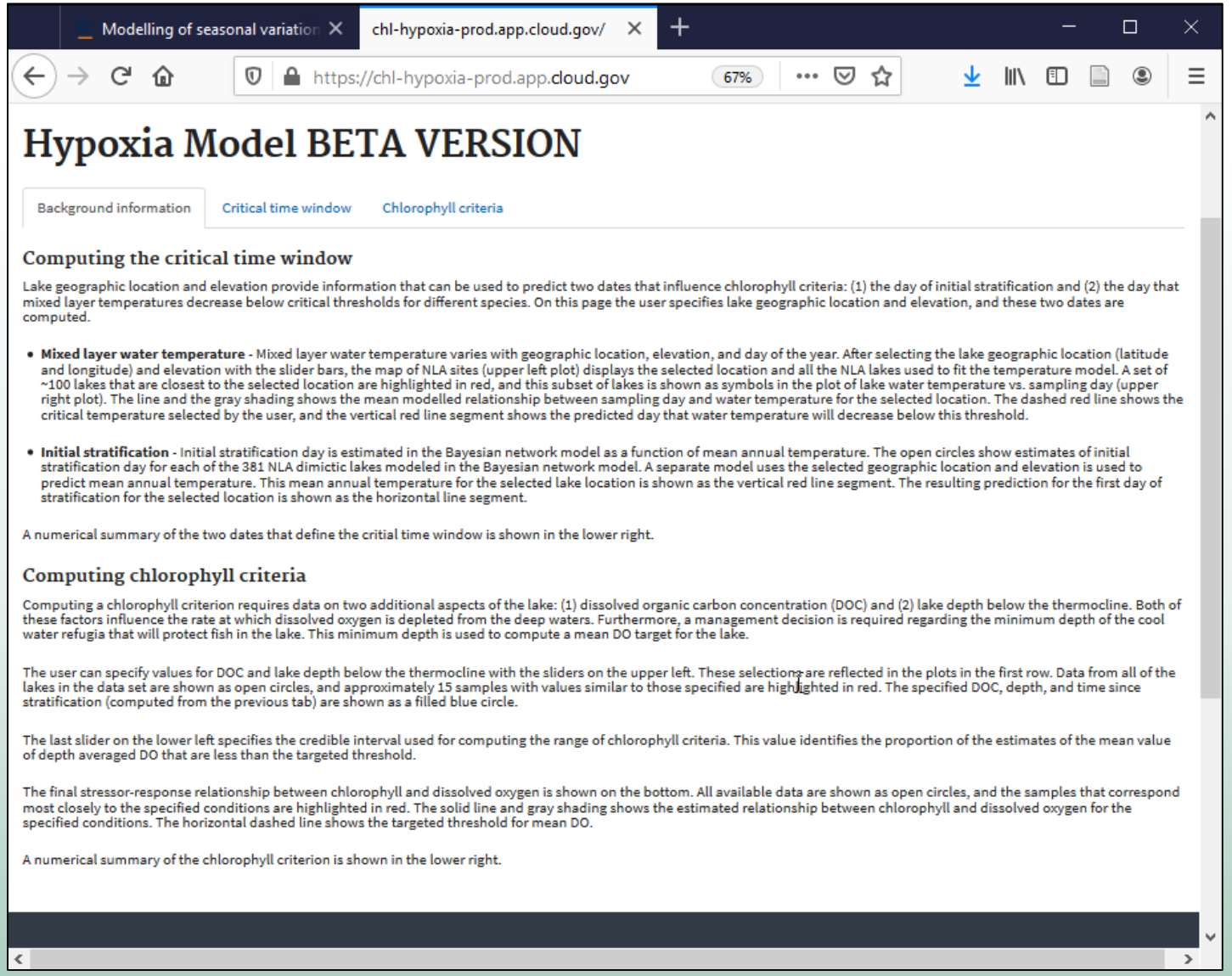
Chlorophyll – Hypoxia Model



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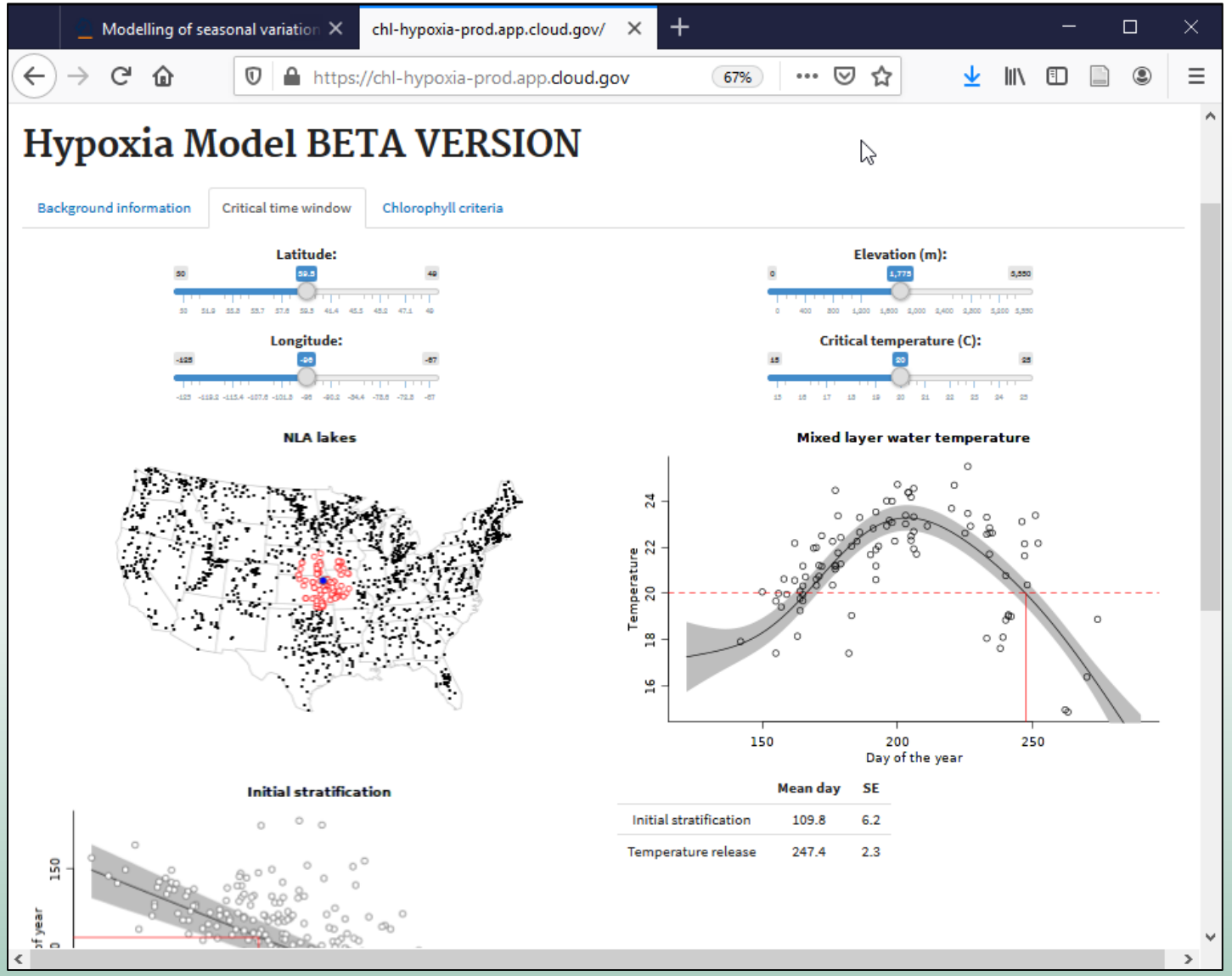

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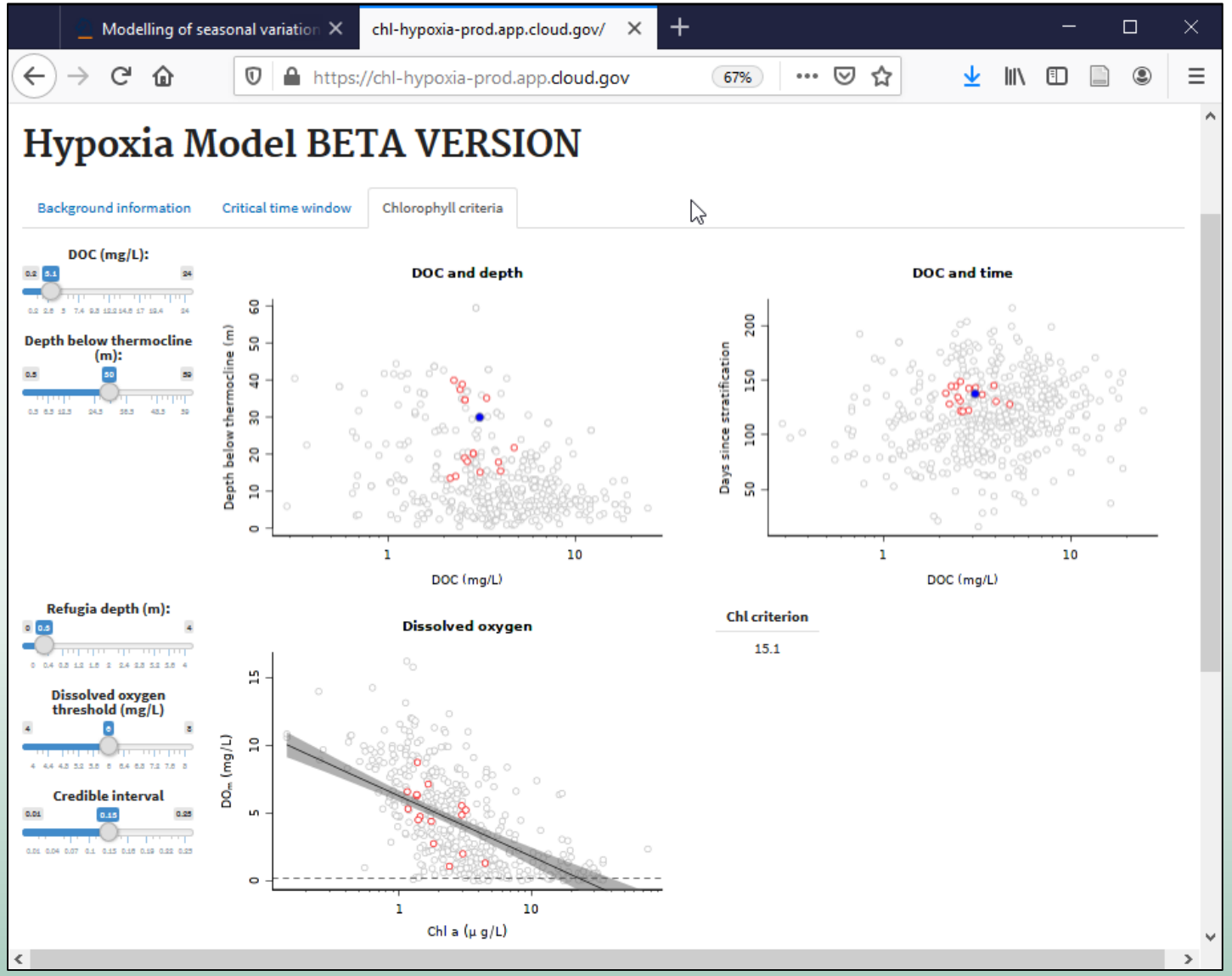

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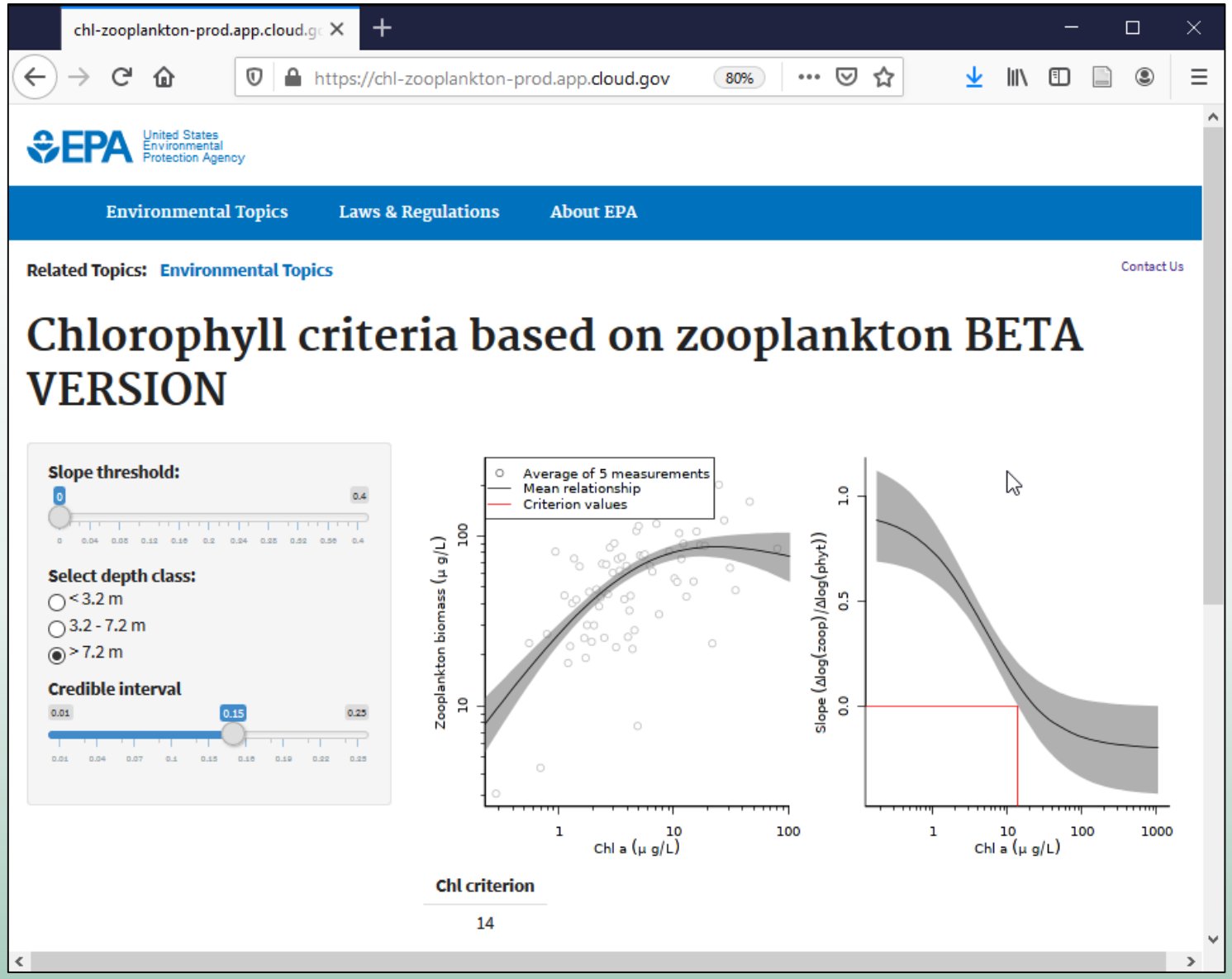

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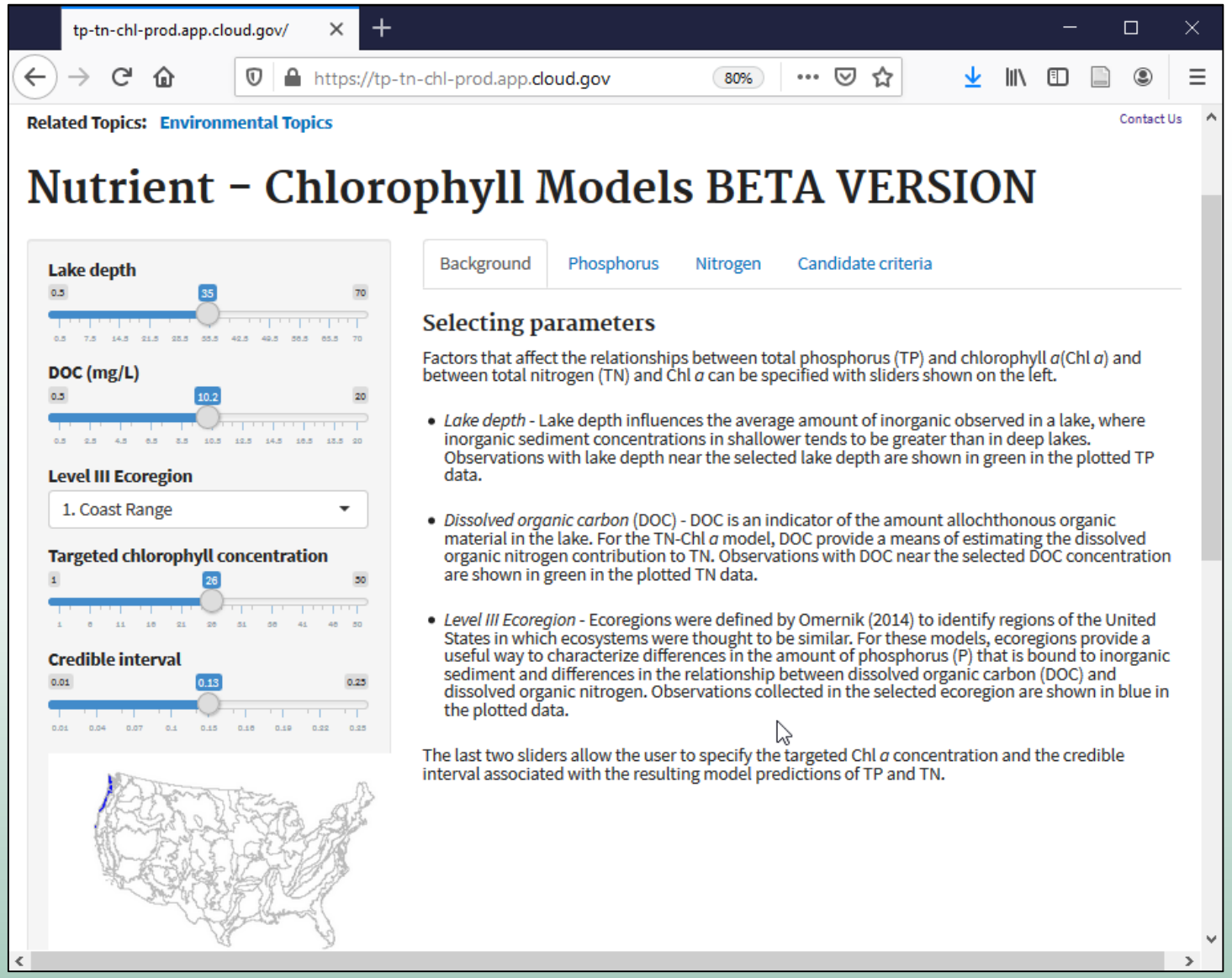
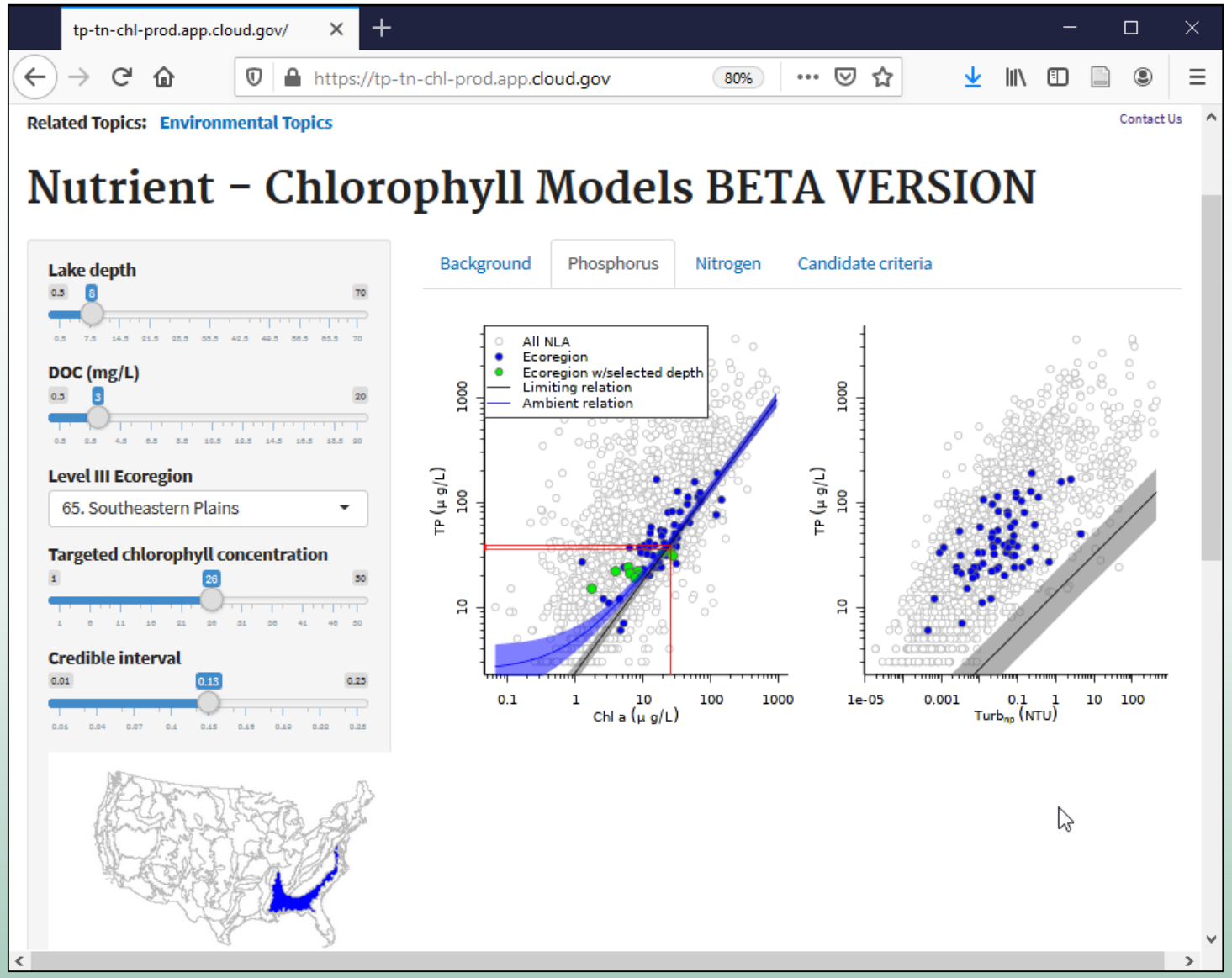
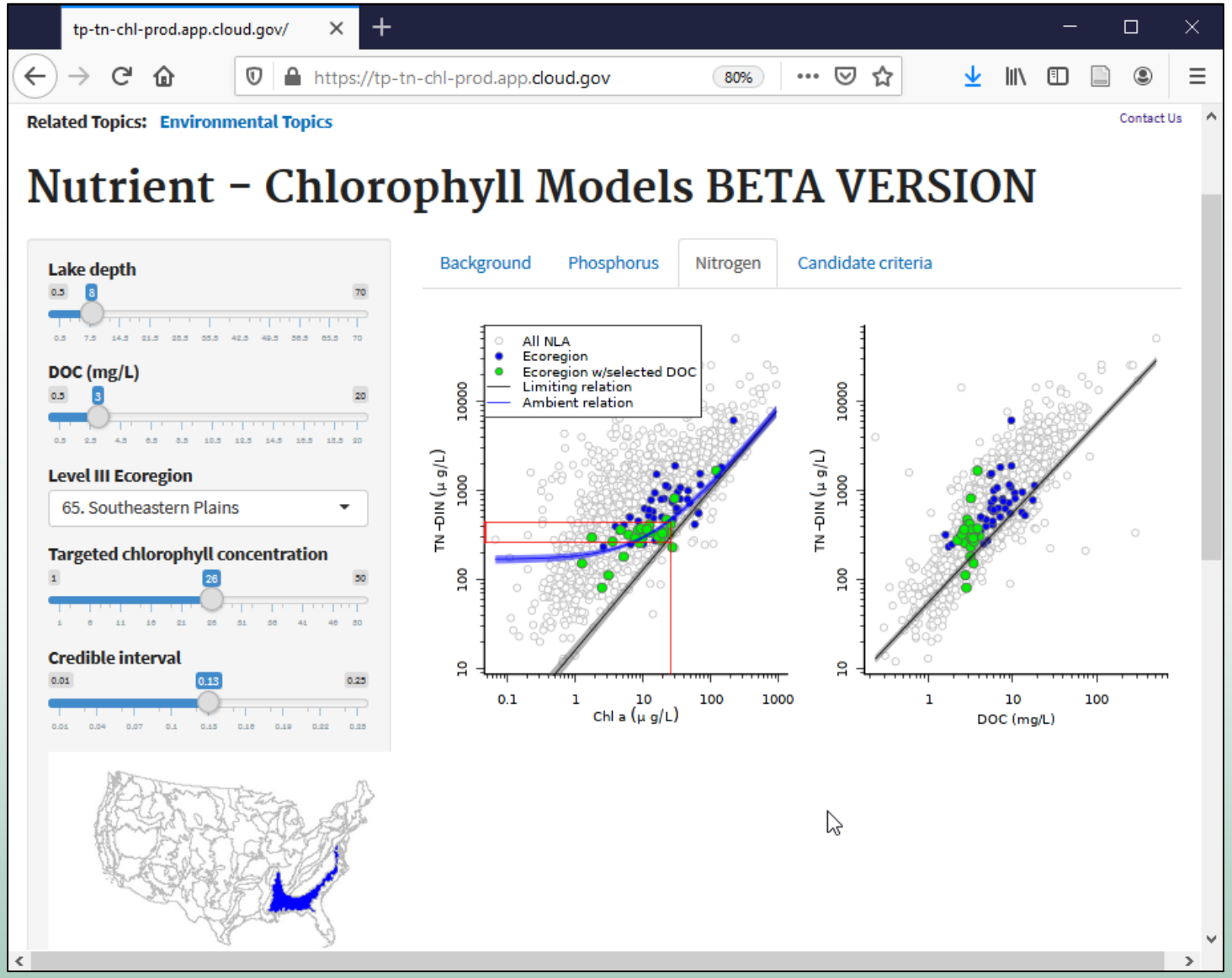
Total Phosphorus – Total Nitrogen – Chlorophyll Model



Total Phosphorus – Total Nitrogen – Chlorophyll Model



Total Phosphorus – Total Nitrogen – Chlorophyll Model



Next Steps

- May 22, 2020: Draft criteria published in Federal Register.
- July 21, 2020: End of comment period.
- Winter 2020 - 2021: Targeted release date for final criteria.

For more information, go to:
https://www.regulations.gov/docket?D=EPA-HQ-OW-2019-0675

Thank you!

- Please send comments on or before July 21st. To do so, visit Regulations.gov, Docket ID # EPA-HQ-OW-2019-0675.
- Today's slides will be posted at: https://www.epa.gov/nutrient-policy-data/technical-support-numeric-nutrient-water-quality-criteria-development