



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

Information Supporting the Development of Numeric Nutrient Criteria

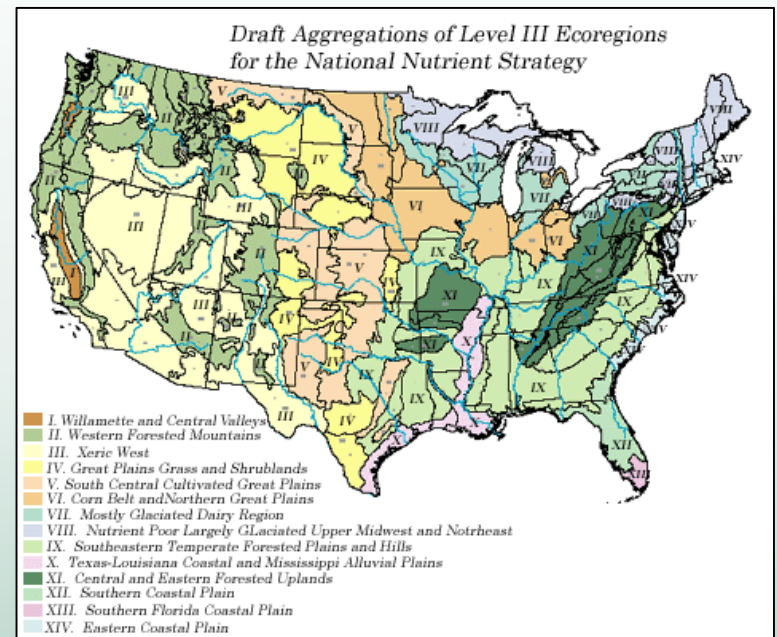
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Office of Water
U.S. Environmental Protection Agency

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




ELSEVIER

Contents lists available at [ScienceDirect](#)

Harmful Algae

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



Eutrophication and harmful algal blooms: A scientific consensus

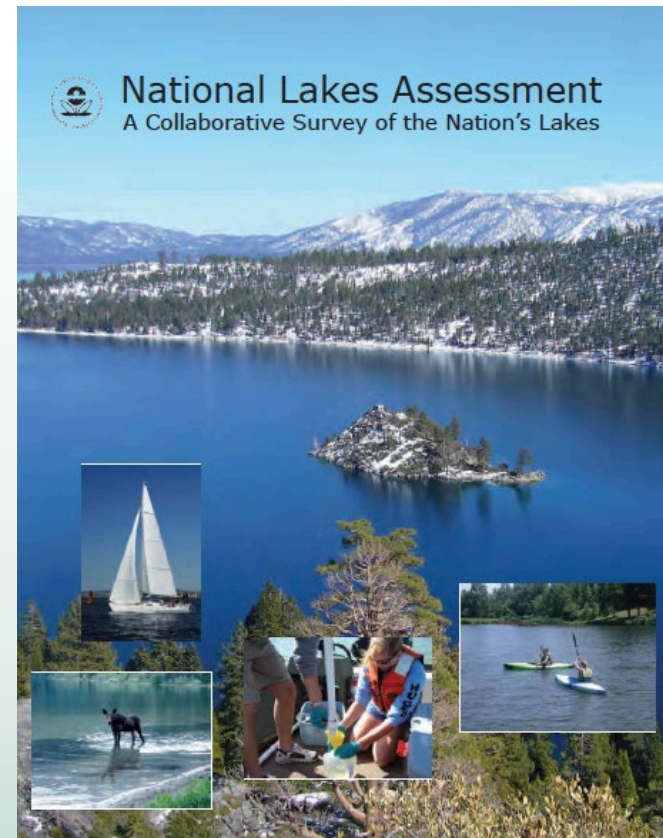
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Nationally Consistent Data for Lakes and Reservoirs are now Available

- 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.



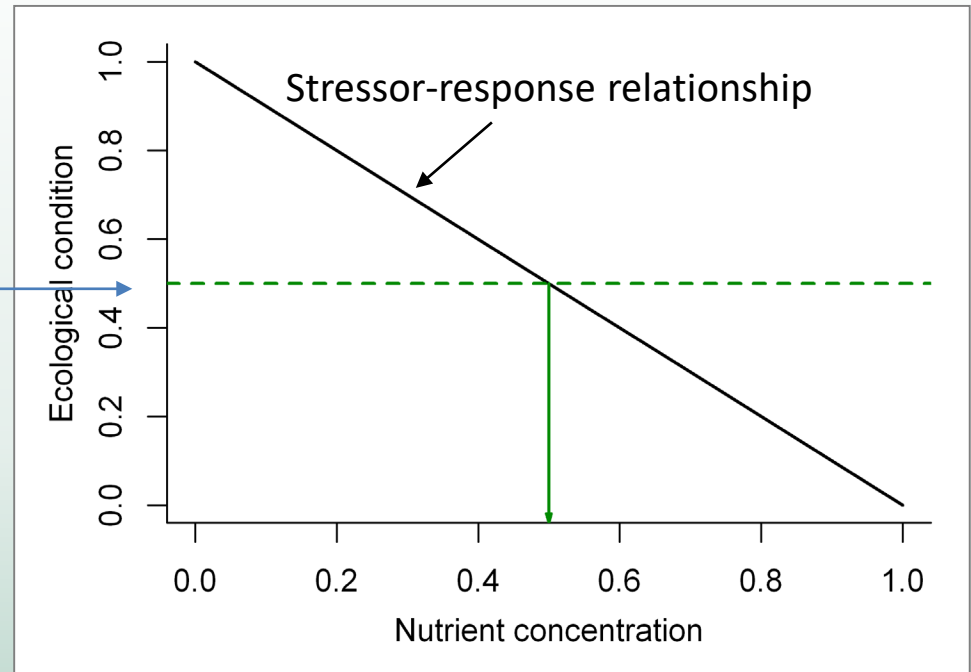
Benefits of Updated Recommended Criteria

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

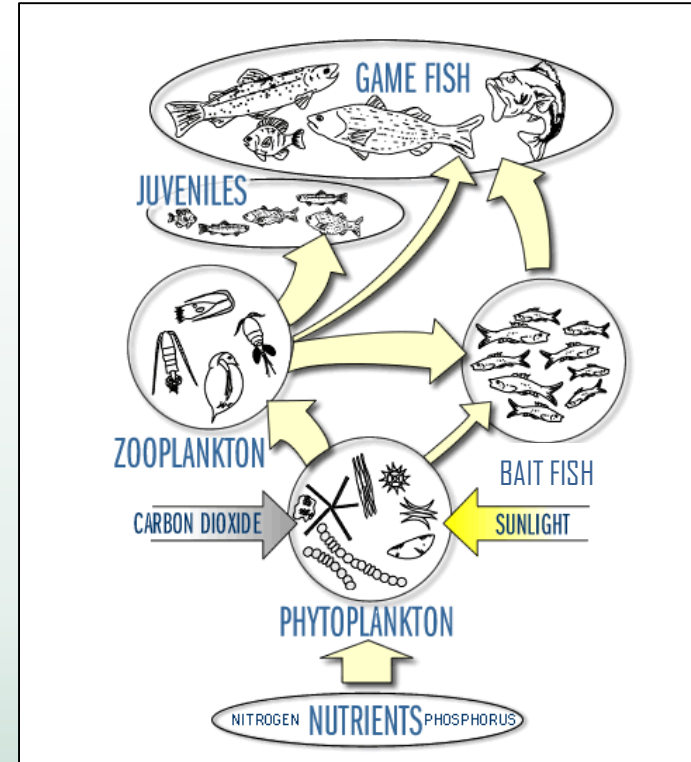
- Characteristics of useful assessment endpoints:
 - Responsive to nutrients
 - Quantitative
 - Linked directly to management goal
 - Data available
- Water quality management goals based on state designated uses:
 - “...restore and maintain the chemical, physical, and biological integrity...”
 - Three 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

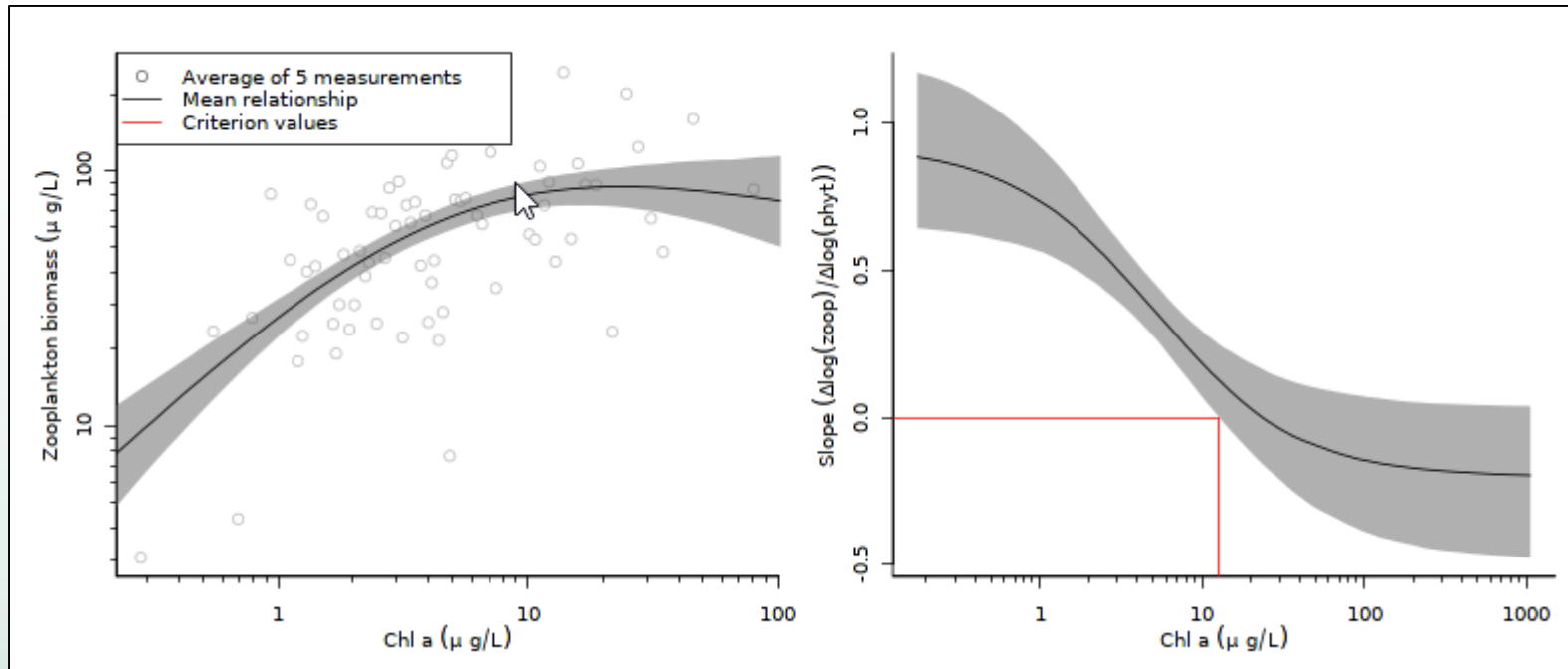
Aquatic Life Assessment Endpoint: Zooplankton

- 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

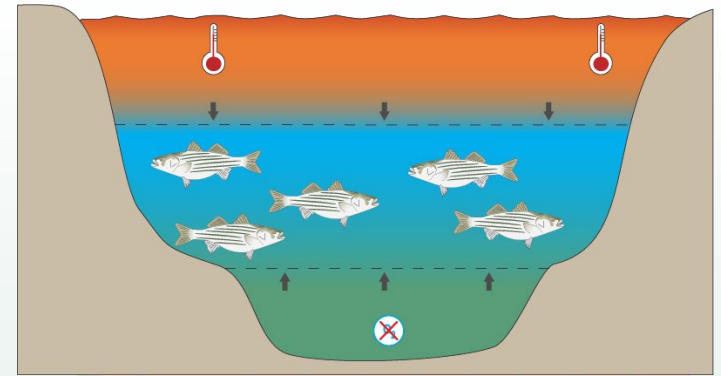


In lakes with high concentrations of phytoplankton and nutrients, transfer of energy from primary productivity to higher trophic levels is less efficient.

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

Aquatic Life Assessment Endpoint: Fish

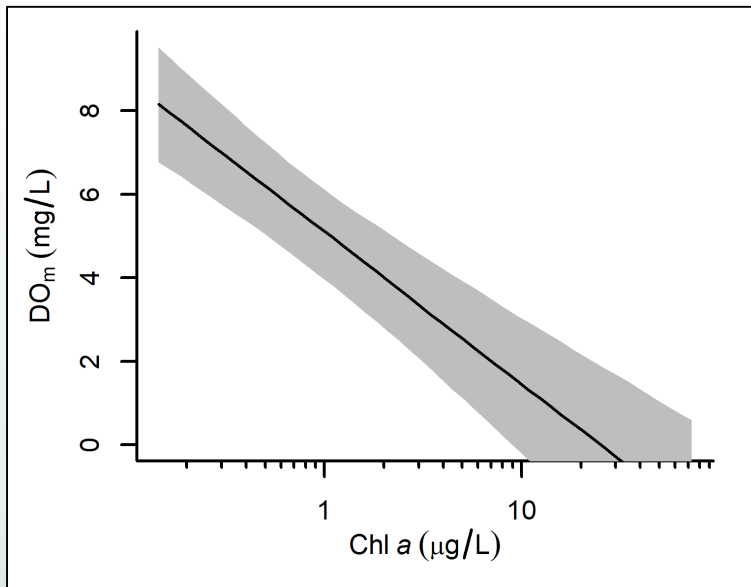
- Distribution of many fish species is limited by water temperature.
- In stratified lakes, depletion of oxygen in deep water below the thermocline can eliminate viable habitat for certain fish species.
- Endpoint: Sufficiently dissolved oxygen below thermocline to allow fish to persist through the summer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



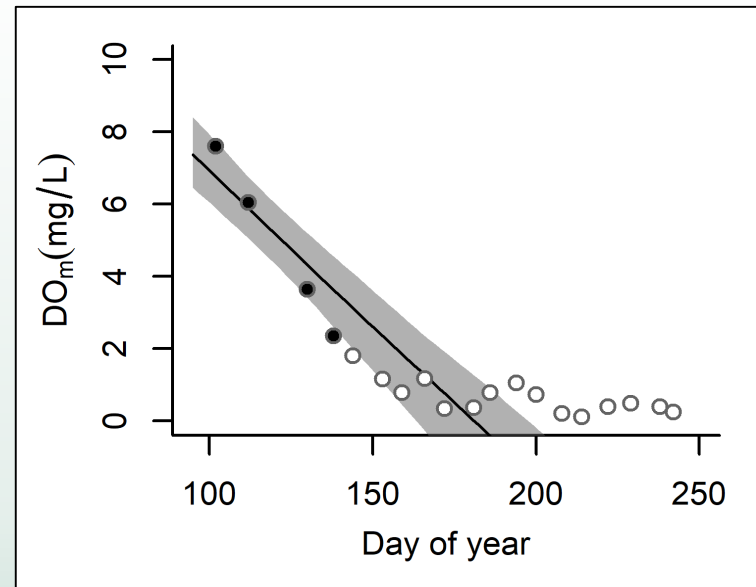
http://www.teachoceanscience.net/teaching_resources/education_modules/fish_and_physics/explore_trends/oxygen_and_water_temperature/

Chl *a* and Dissolved Oxygen

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



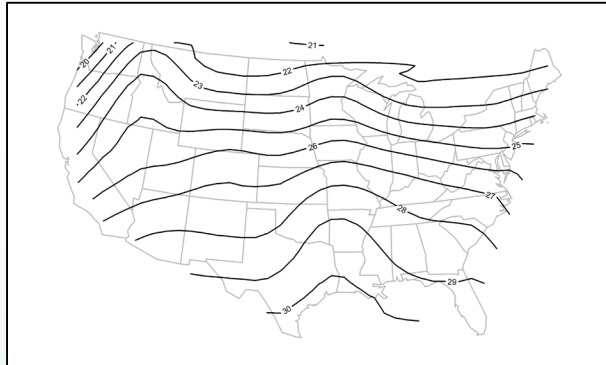
Number of days since stratification is also important.



Dissolved organic carbon and lake depth also influence DO_m .

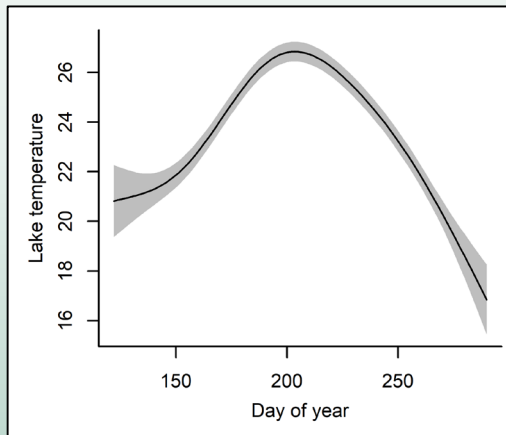
Lake Temperature Model

Location

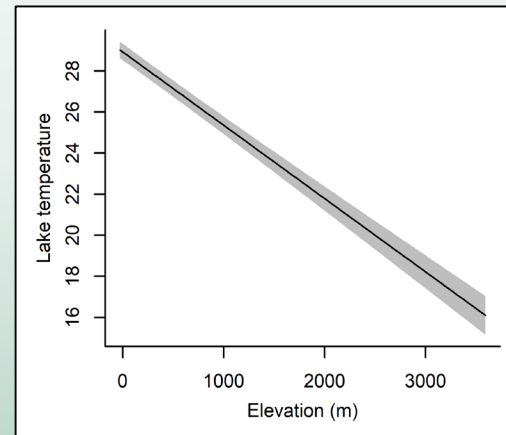


Lake surface temperature model varies with day of the year, elevation, and location.

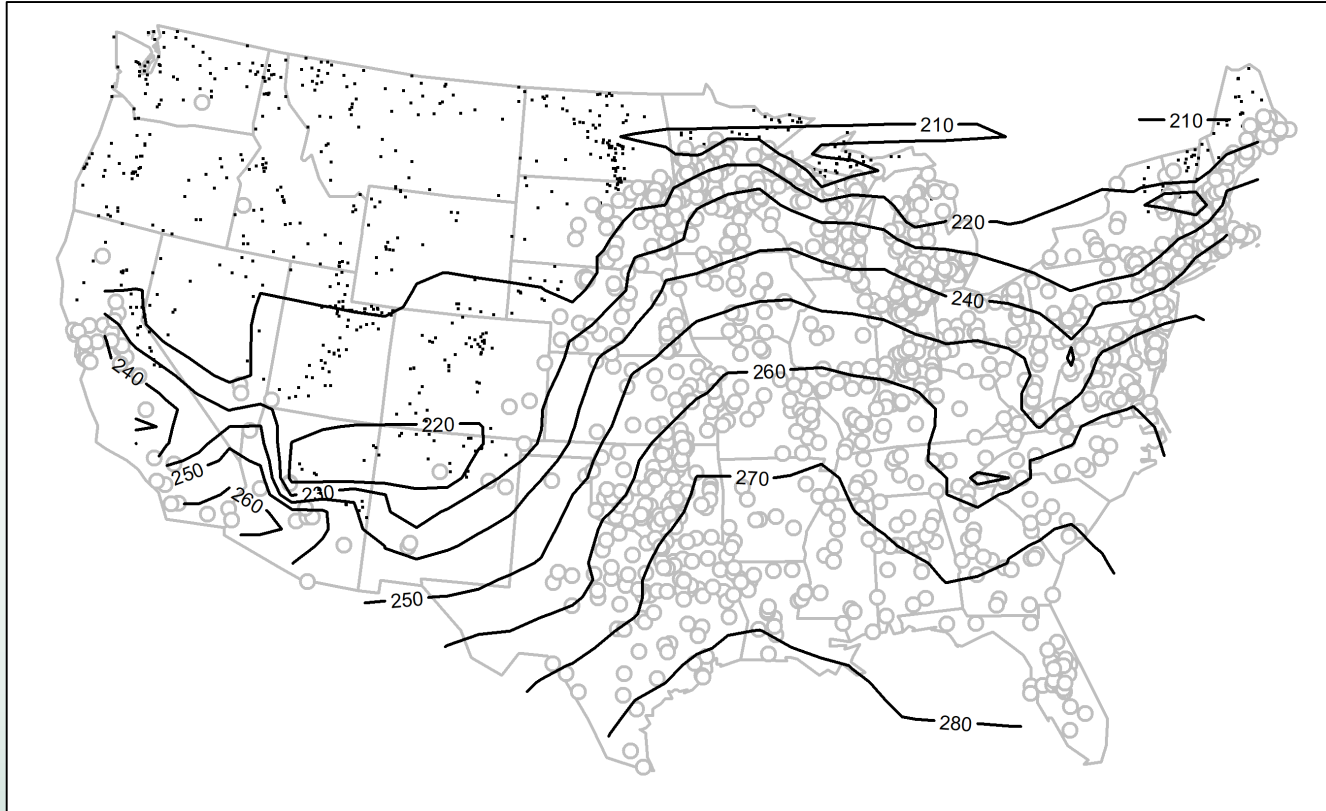
Day of the year



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.

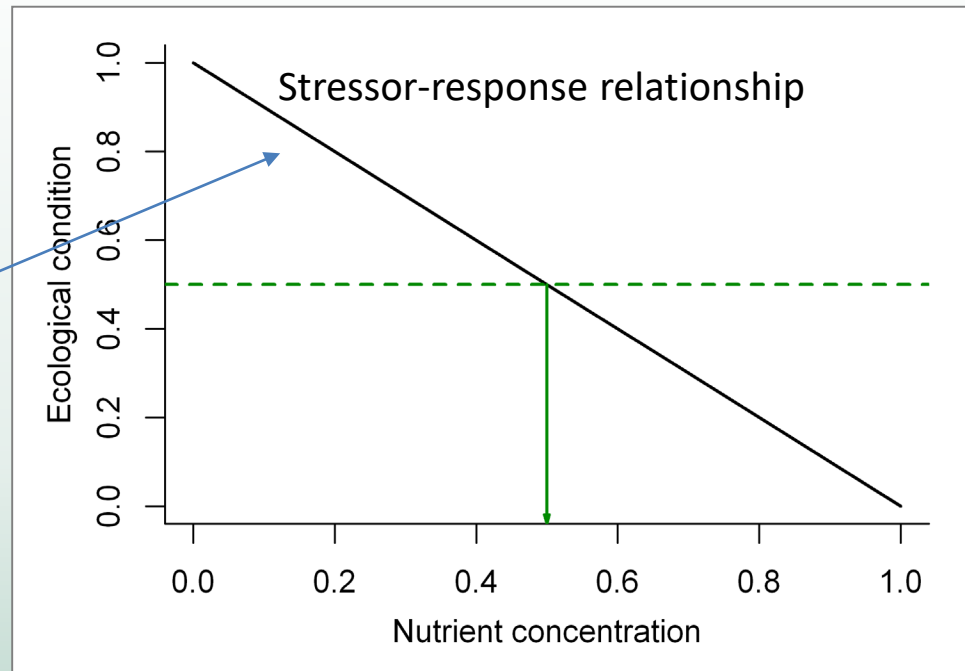
Assessment Endpoints: Summary

- 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?

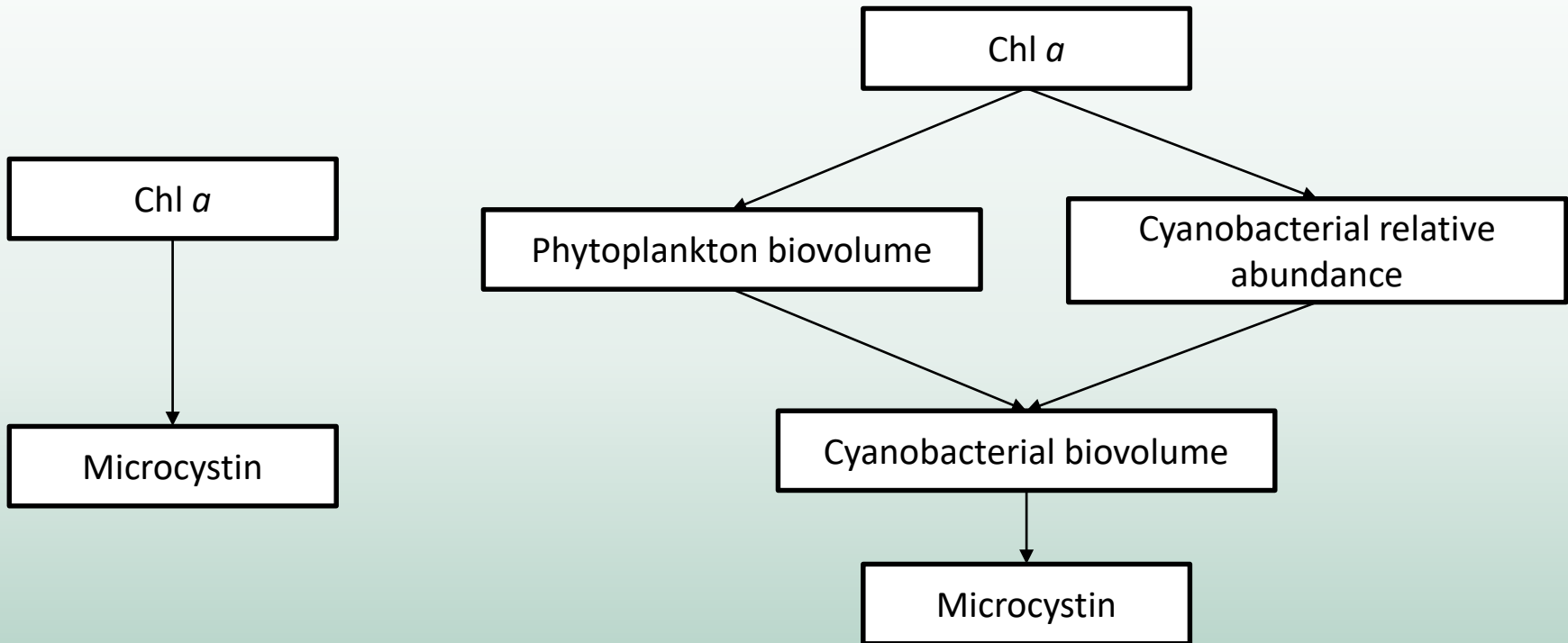


Approach

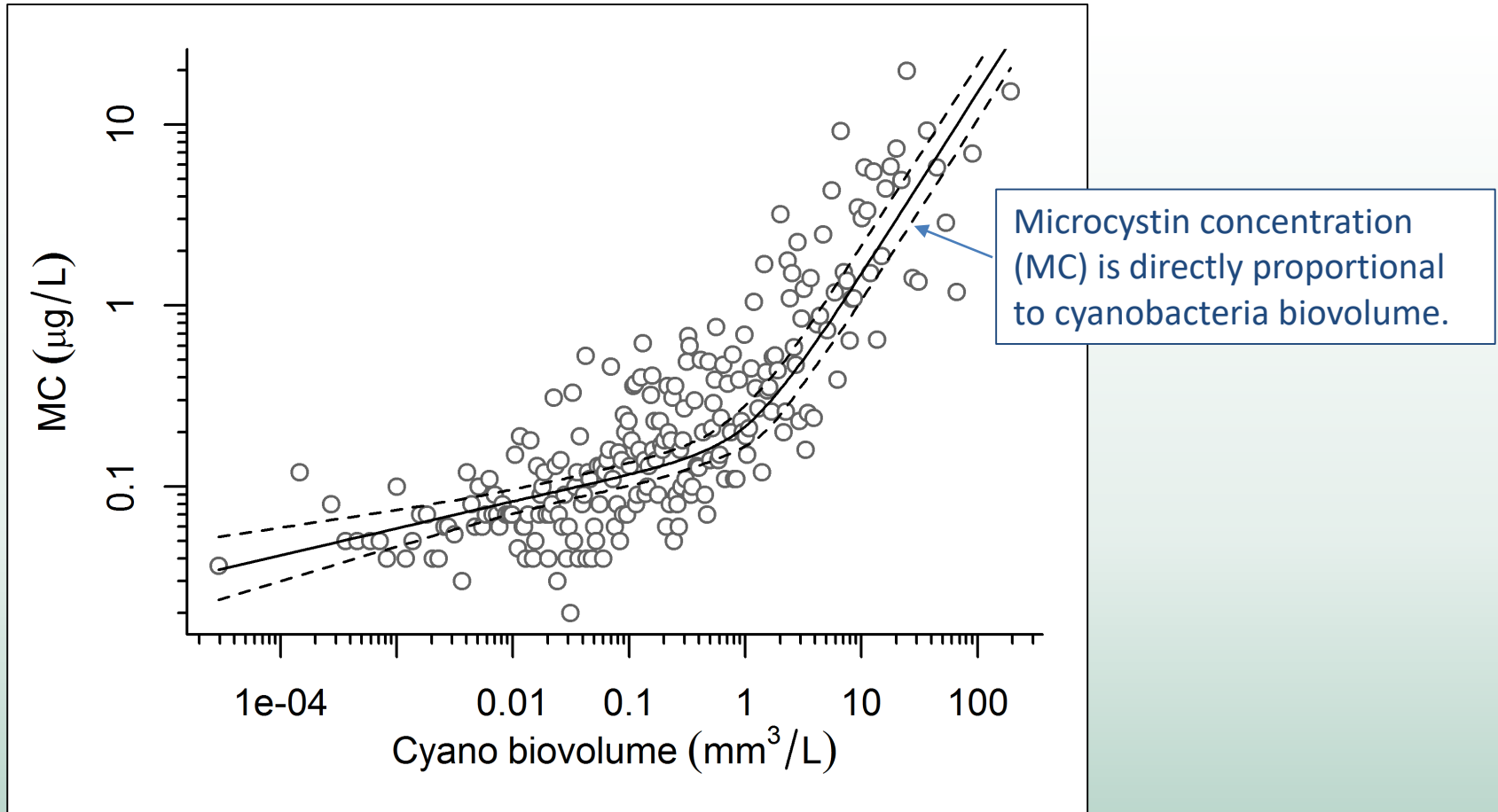
- Model known causal relationships.
 - Model proximal relationships when possible.
- Use functional forms that are consistent with underlying mechanisms.
- Model relationships among groups of measurements with Bayesian networks.

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



Phosphorus – Chlorophyll Models

Model equation:

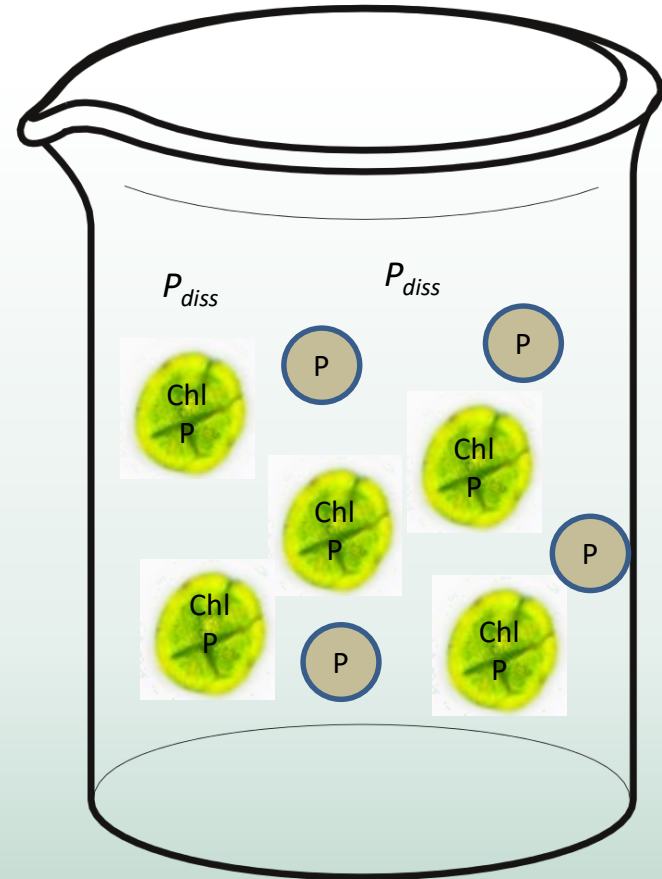
$$TP = d_1 Chl^k + d_2 Sed + P_{diss}$$

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

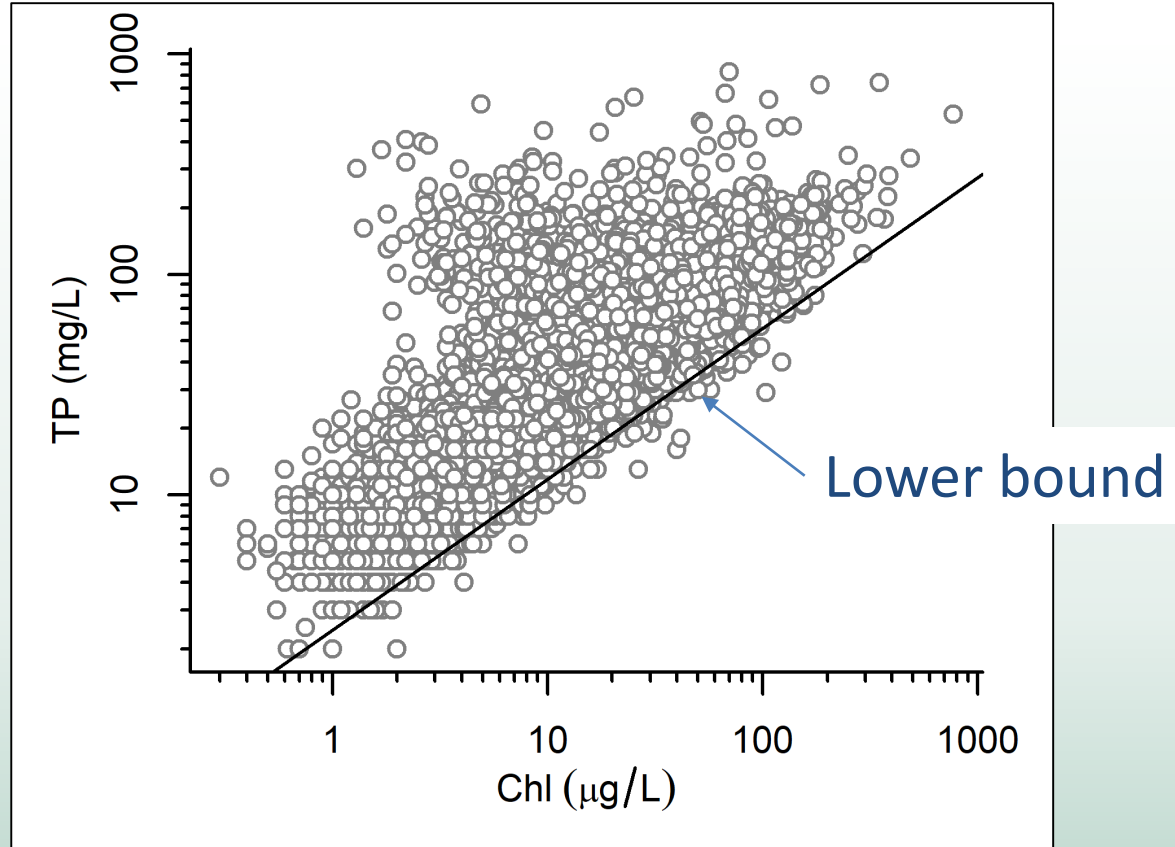
$$TP = d_1 Chl^k$$

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

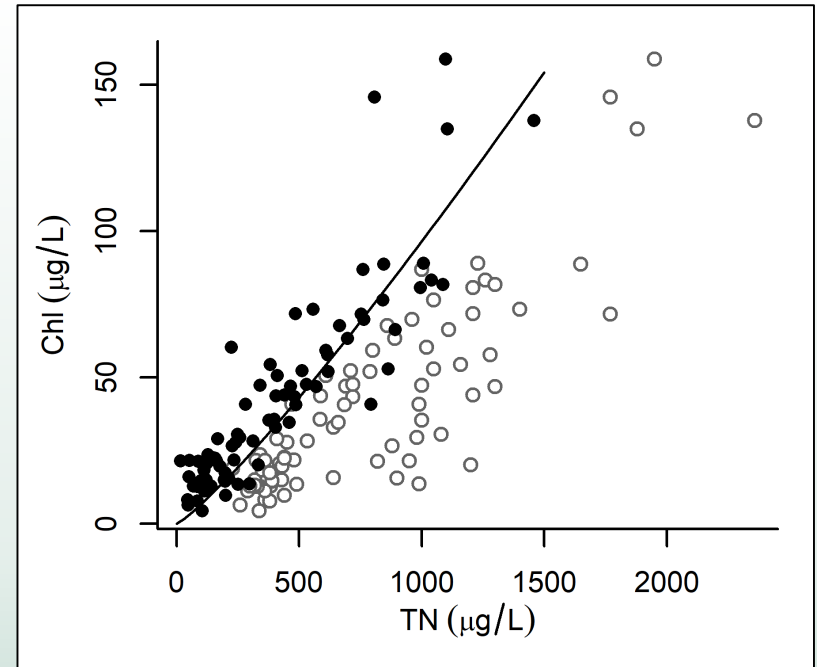
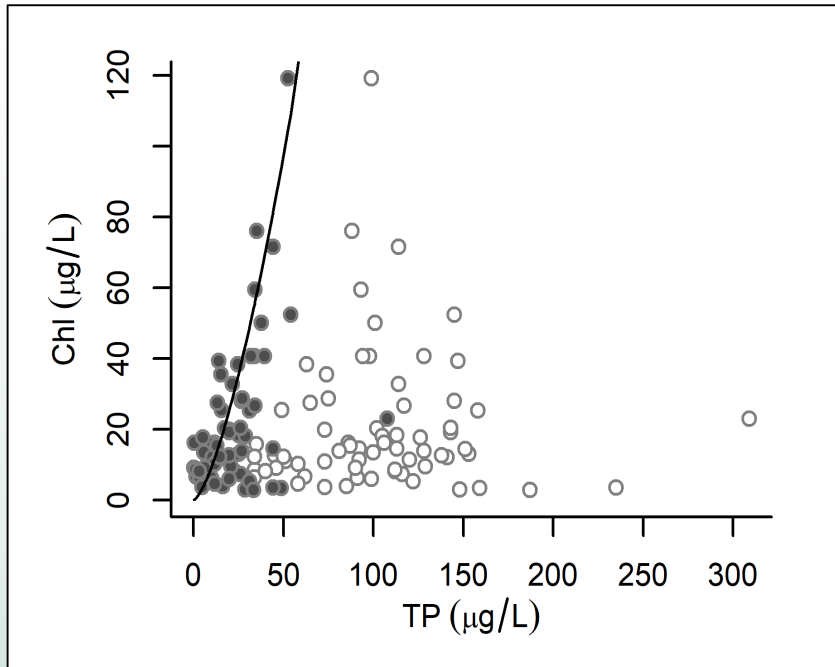
Lower bound between $\log(TP)$ and $\log(Chl)$ should be a straight line.



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.

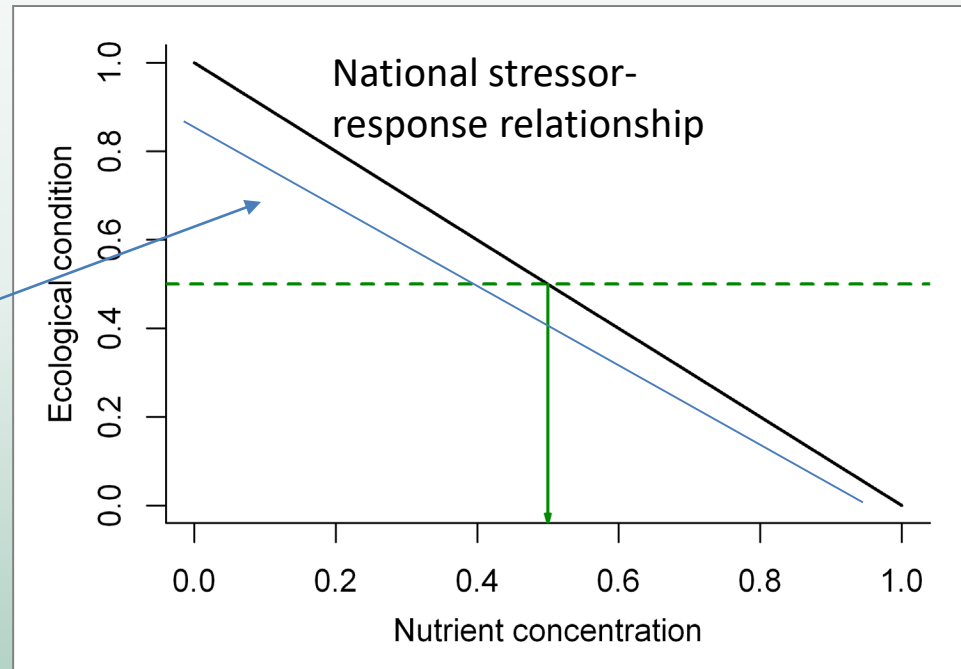
Stressor – Response: Summary

- 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 .

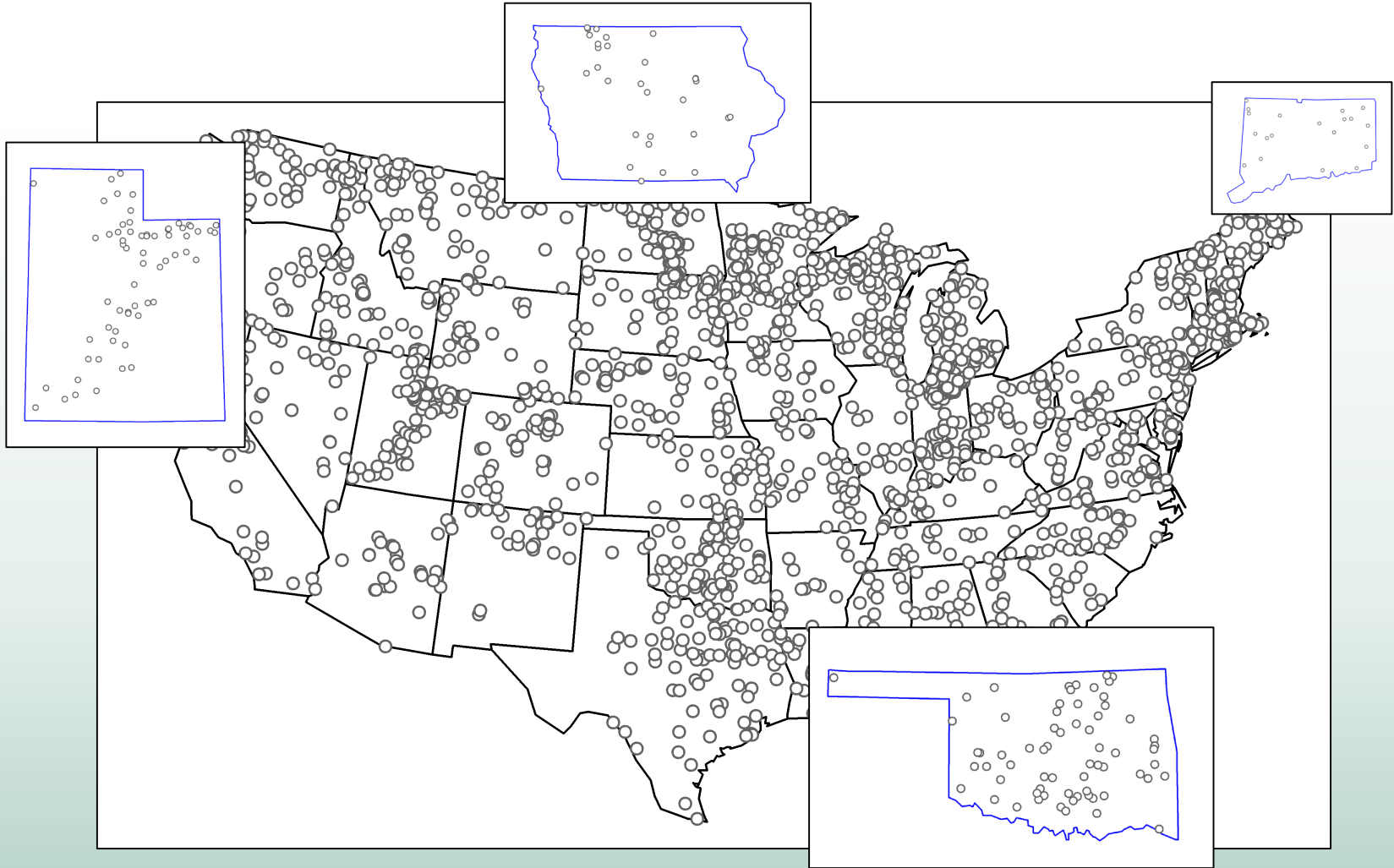
Tools that Combine State and National Data

- 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.

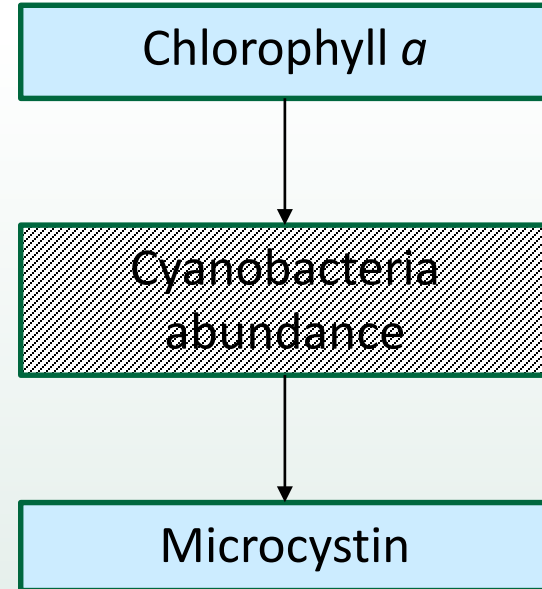


State – Specific Models

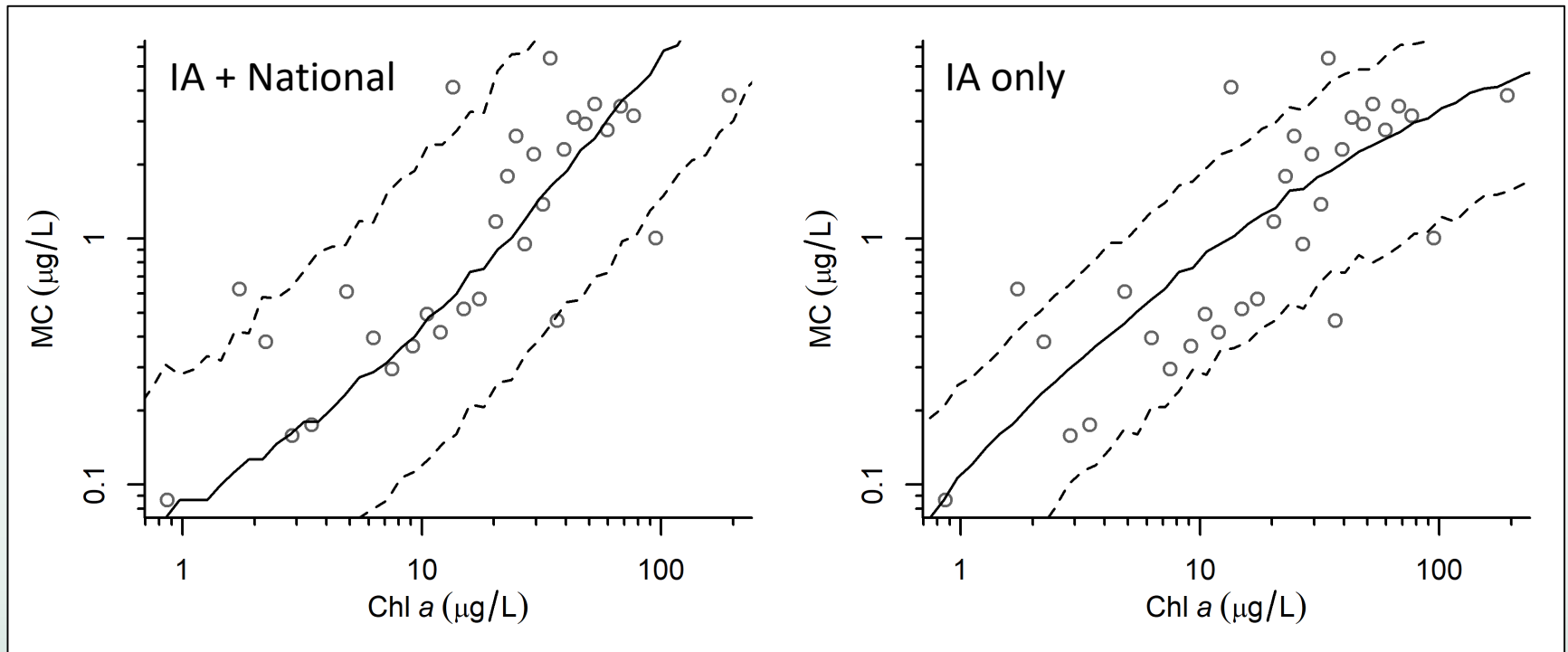


Example: Iowa Case Study

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



Iowa Case Study



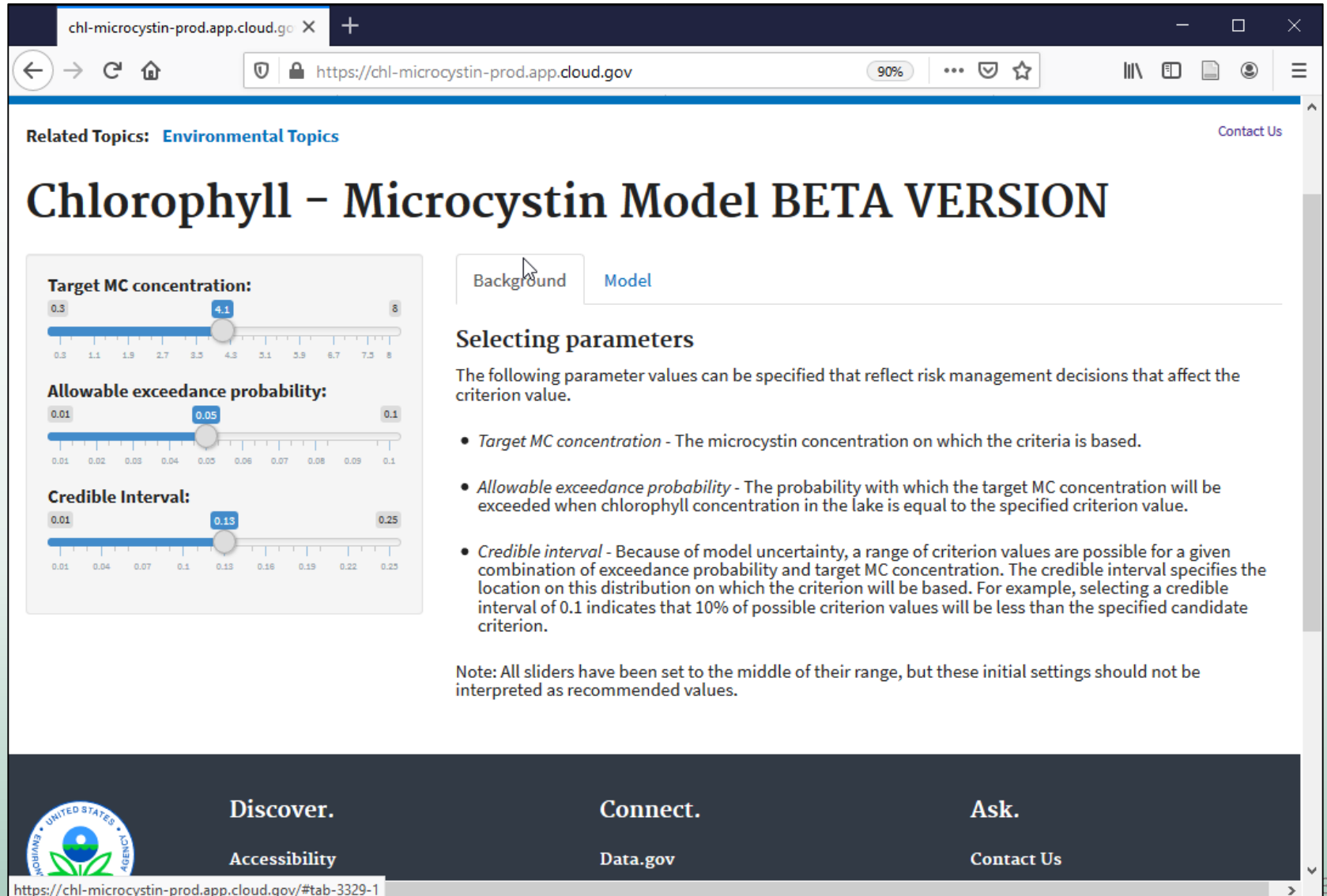
Combining IA data with national models yields a 13% improvement in model accuracy.

Criterion Graphical User Interfaces

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

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

Chlorophyll – Microcystin Model



chl-microcystin-prod.app.cloud.gov

https://chl-microcystin-prod.app.cloud.gov

Related Topics: [Environmental Topics](#) [Contact Us](#)

Chlorophyll – Microcystin Model BETA VERSION

Background **Model**

Selecting parameters

The following parameter values can be specified that reflect risk management decisions that affect the criterion value.

- *Target MC concentration* - The microcystin concentration on which the criteria is based.
- *Allowable exceedance probability* - The probability with which the target MC concentration will be exceeded when chlorophyll concentration in the lake is equal to the specified criterion value.
- *Credible interval* - Because of model uncertainty, a range of criterion values are possible for a given combination of exceedance probability and target MC concentration. The credible interval specifies the location on this distribution on which the criterion will be based. For example, selecting a credible interval of 0.1 indicates that 10% of possible criterion values will be less than the specified candidate criterion.

Note: All sliders have been set to the middle of their range, but these initial settings should not be interpreted as recommended values.

Target MC concentration: 0.3 4.1 8

Allowable exceedance probability: 0.01 0.05 0.1

Credible Interval: 0.01 0.15 0.25

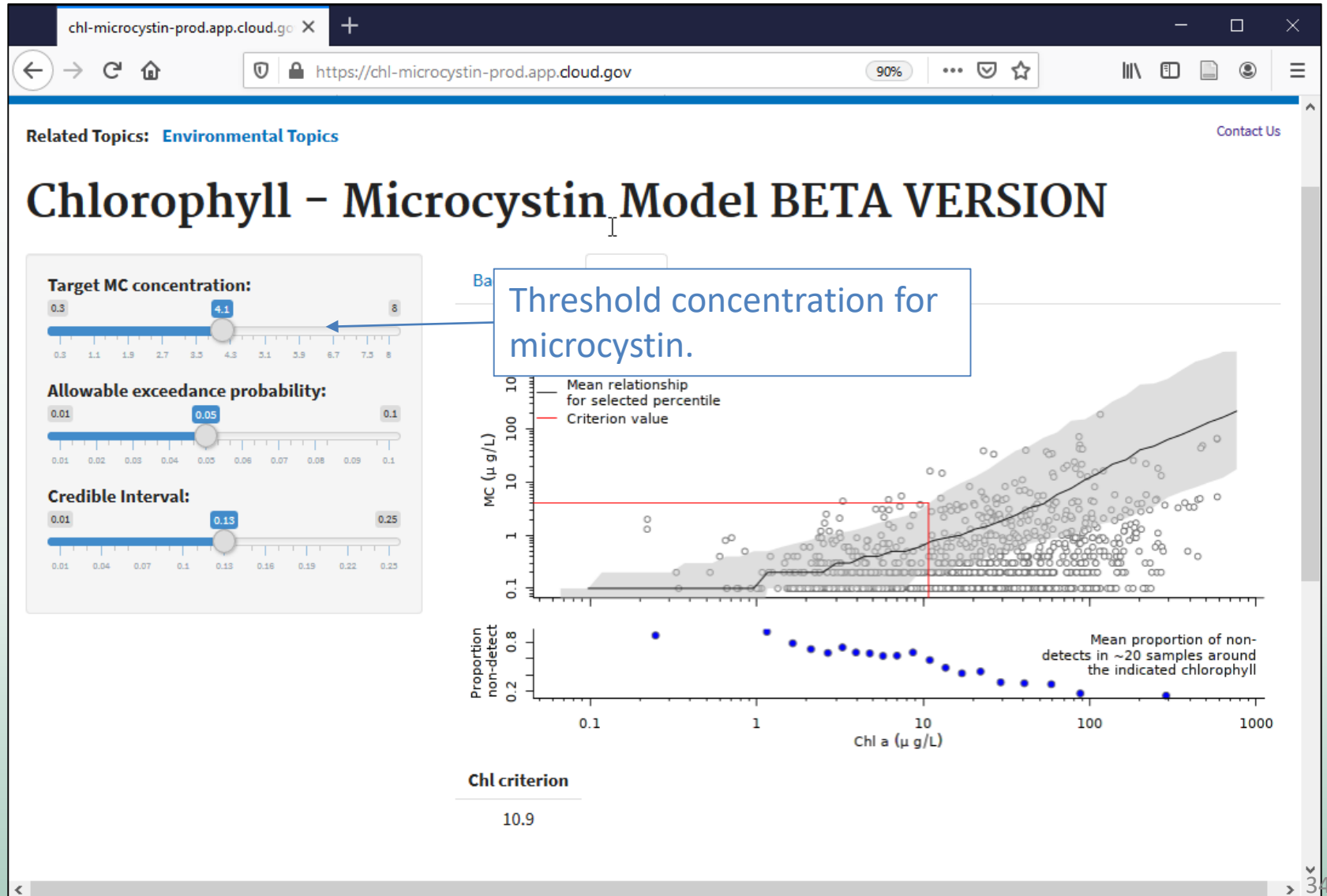
Discover. [Accessibility](#)

Connect. [Data.gov](#)

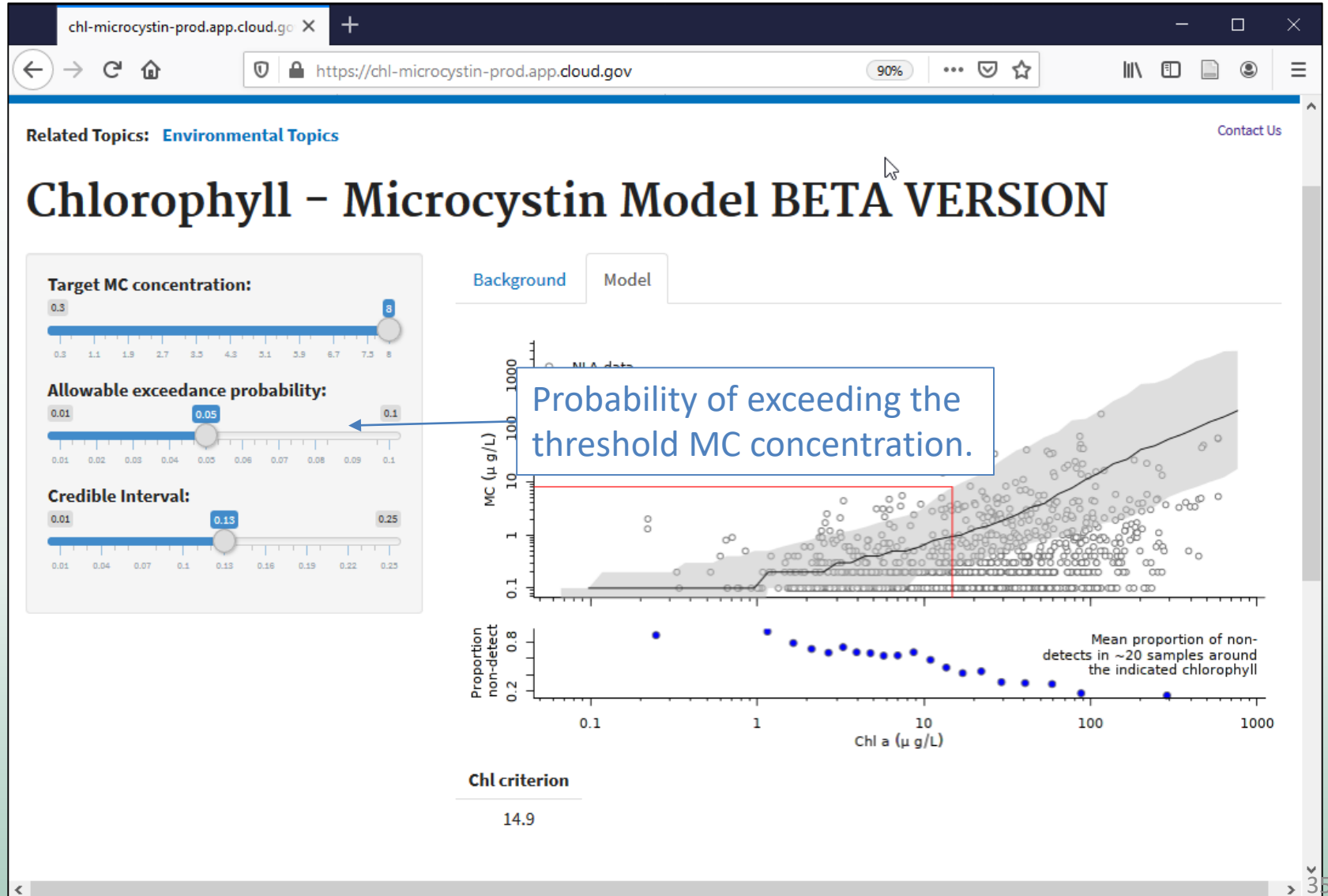
Ask. [Contact Us](#)

https://chl-microcystin-prod.app.cloud.gov/#tab-3329-1

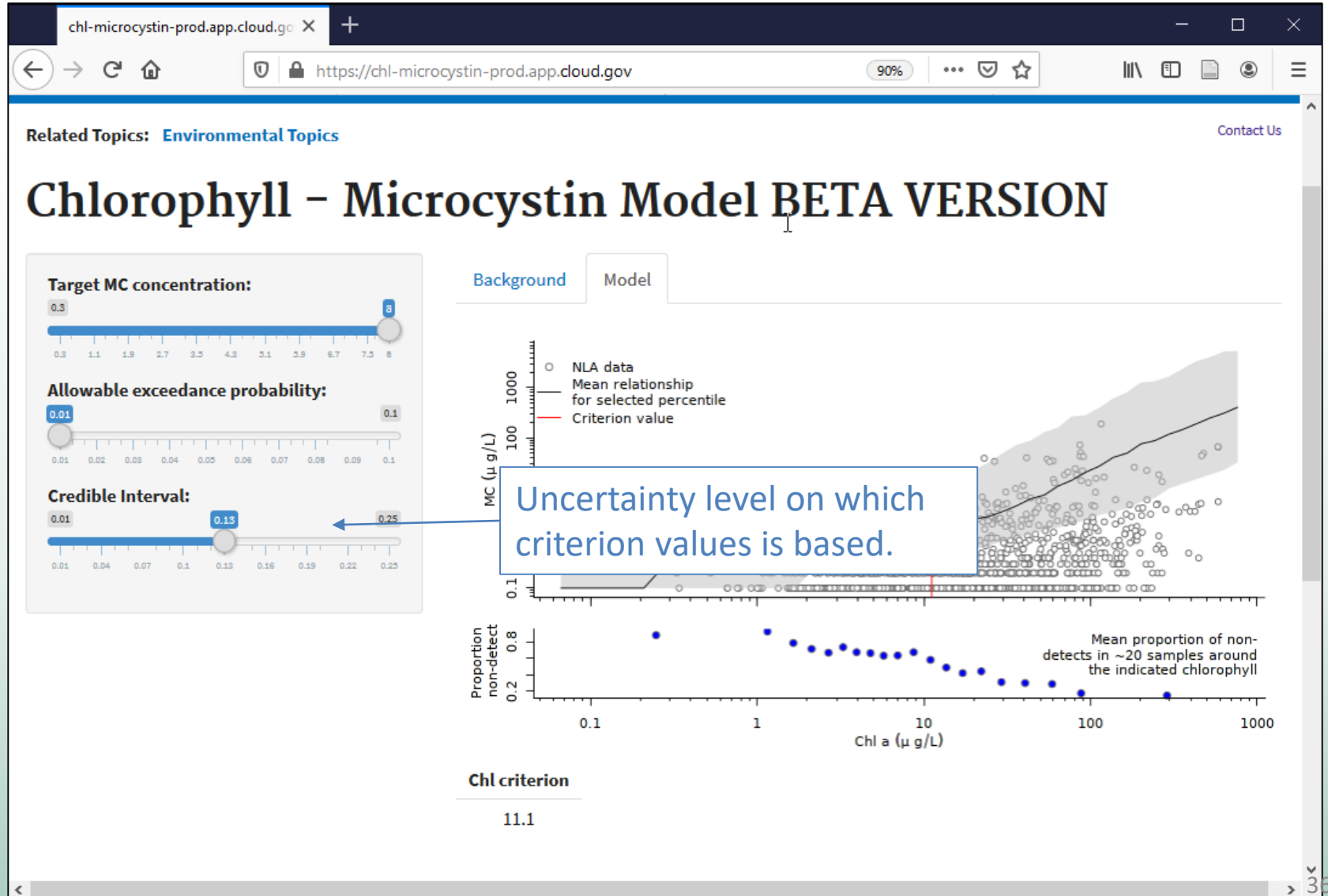
Chlorophyll – Microcystin Model



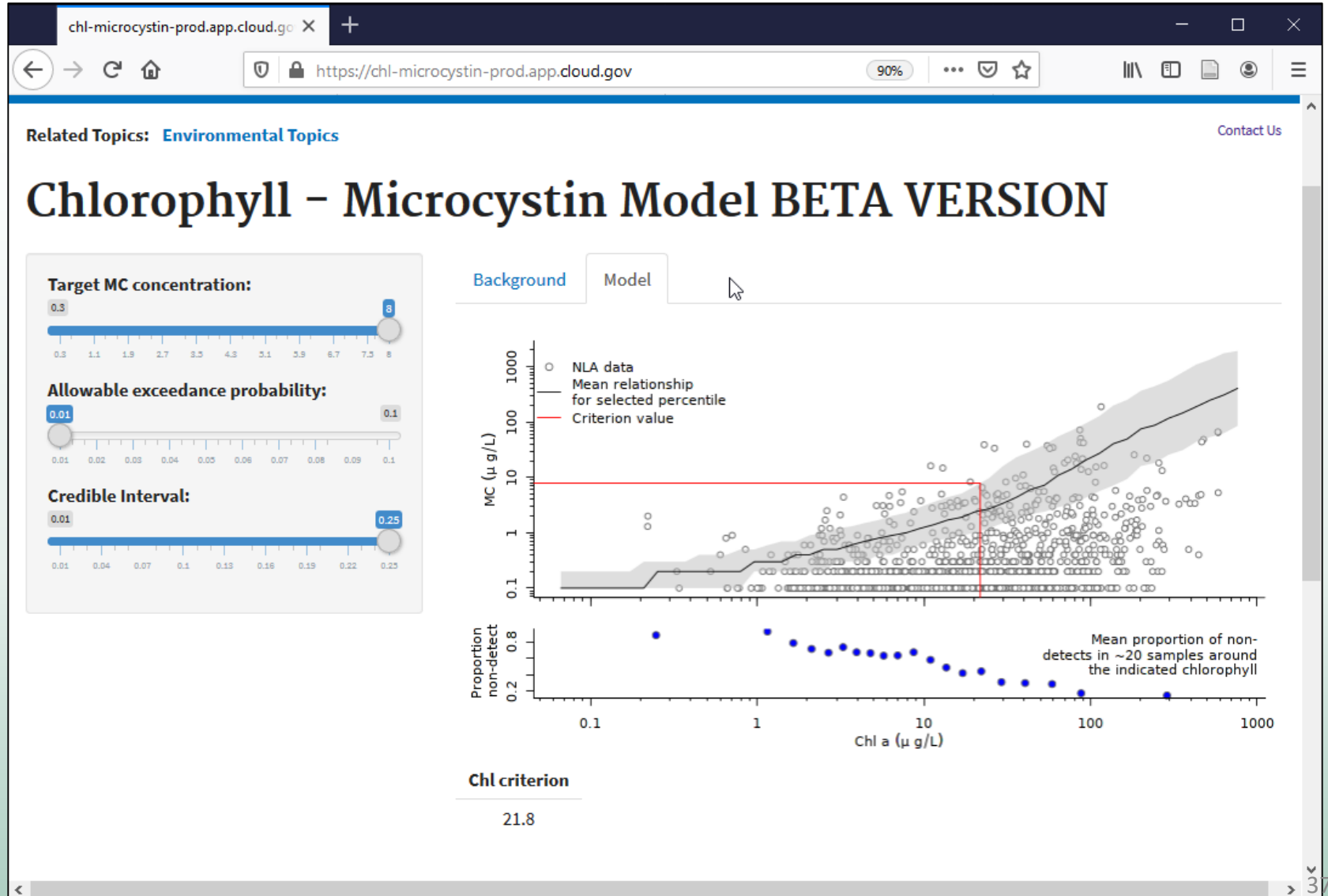
Chlorophyll – Microcystin Model



Chlorophyll – Microcystin Model



Chlorophyll – Microcystin Model

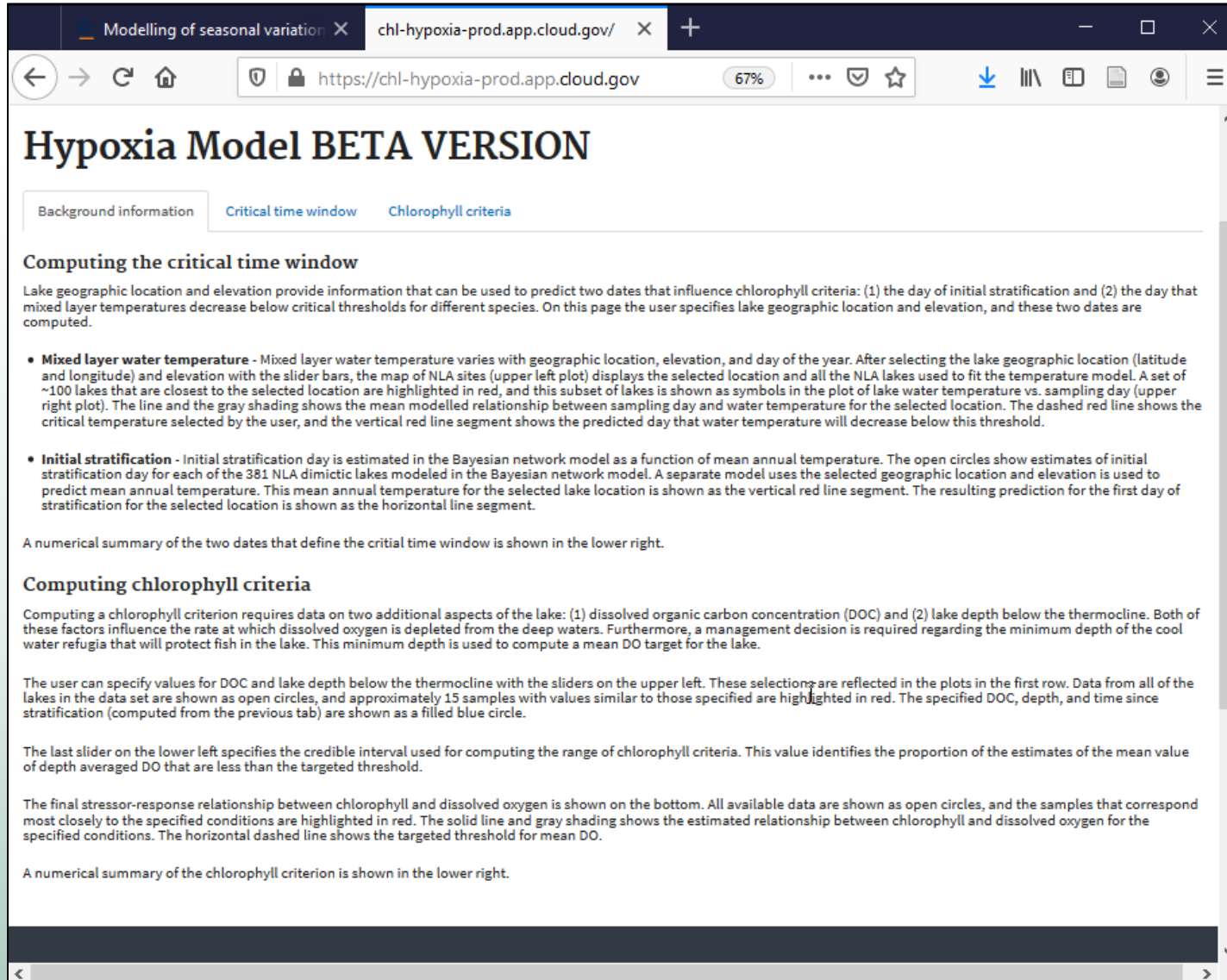


Criterion Graphical User Interfaces

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

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

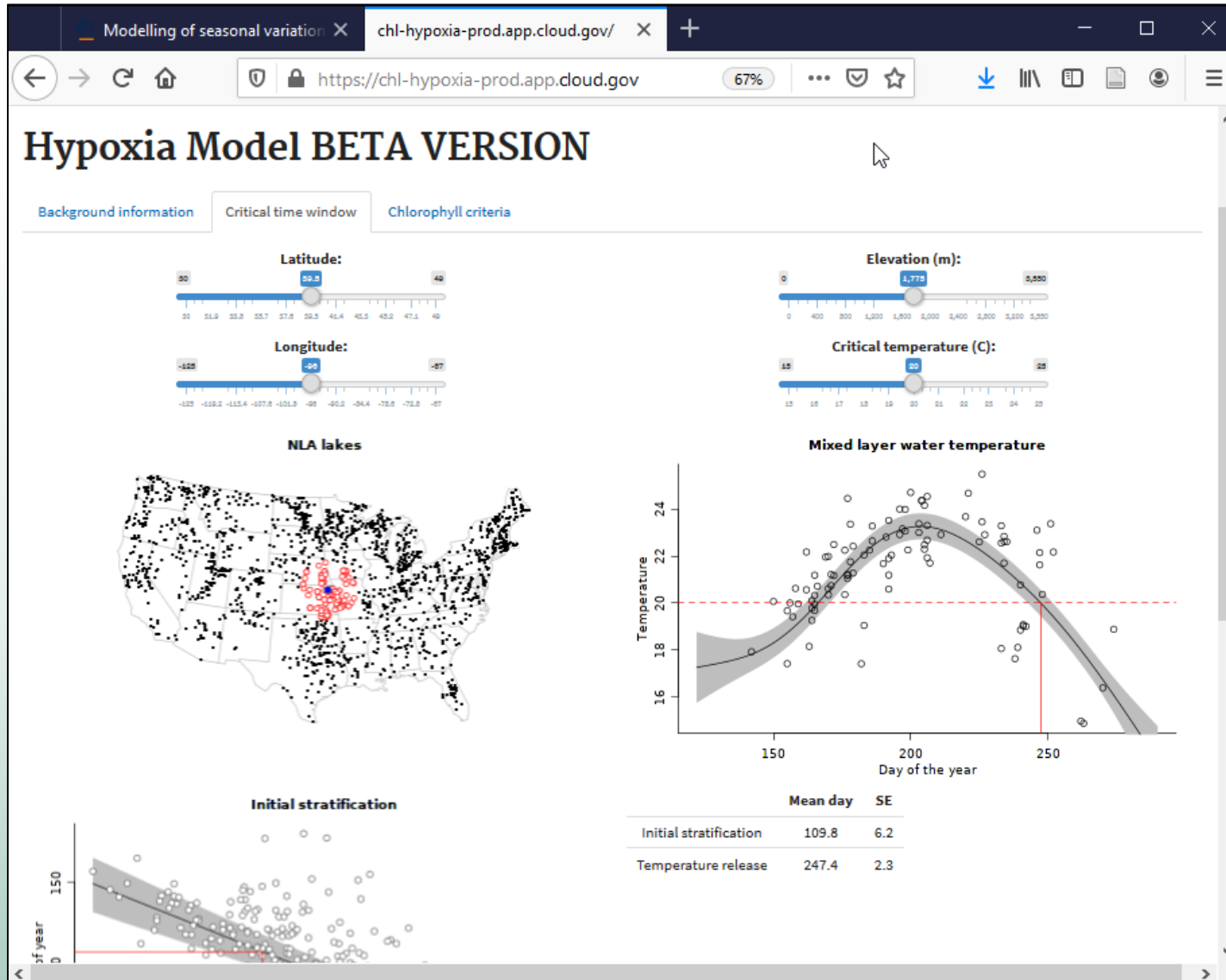
Chlorophyll – Hypoxia Model



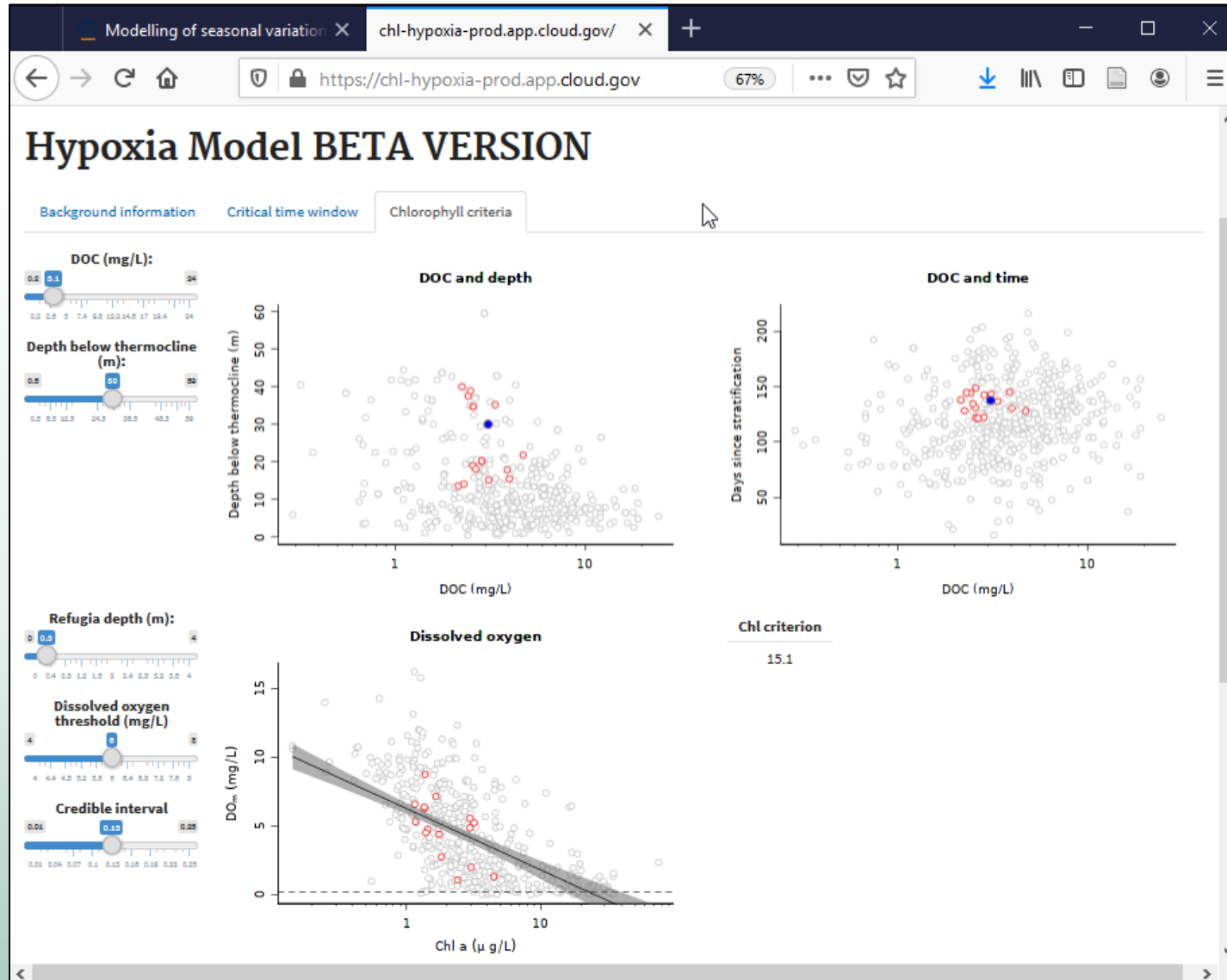
The screenshot shows a web browser window with the URL `https://chl-hypoxia-prod.app.cloud.gov`. The page title is "Hypoxia Model BETA VERSION". There are three tabs: "Modelling of seasonal variation", "chl-hypoxia-prod.app.cloud.gov", and a plus sign. The browser address bar shows the URL and a 67% zoom level. The page content includes:

- Navigation tabs: "Background information", "Critical time window" (selected), and "Chlorophyll criteria".
- Section: "Computing the critical time window"
 - Text: "Lake geographic location and elevation provide information that can be used to predict two dates that influence chlorophyll criteria: (1) the day of initial stratification and (2) the day that mixed layer temperatures decrease below critical thresholds for different species. On this page the user specifies lake geographic location and elevation, and these two dates are computed."
 - List-Group:
 - Mixed layer water temperature** - Mixed layer water temperature varies with geographic location, elevation, and day of the year. After selecting the lake geographic location (latitude and longitude) and elevation with the slider bars, the map of NLA sites (upper left plot) displays the selected location and all the NLA lakes used to fit the temperature model. A set of ~100 lakes that are closest to the selected location are highlighted in red, and this subset of lakes is shown as symbols in the plot of lake water temperature vs. sampling day (upper right plot). The line and the gray shading shows the mean modelled relationship between sampling day and water temperature for the selected location. The dashed red line shows the critical temperature selected by the user, and the vertical red line segment shows the predicted day that water temperature will decrease below this threshold.
 - Initial stratification** - Initial stratification day is estimated in the Bayesian network model as a function of mean annual temperature. The open circles show estimates of initial stratification day for each of the 381 NLA dimictic lakes modeled in the Bayesian network model. A separate model uses the selected geographic location and elevation is used to predict mean annual temperature. This mean annual temperature for the selected lake location is shown as the vertical red line segment. The resulting prediction for the first day of stratification for the selected location is shown as the horizontal line segment.
 - Text: "A numerical summary of the two dates that define the critical time window is shown in the lower right."
- Section: "Computing chlorophyll criteria"
 - Text: "Computing a chlorophyll criterion requires data on two additional aspects of the lake: (1) dissolved organic carbon concentration (DOC) and (2) lake depth below the thermocline. Both of these factors influence the rate at which dissolved oxygen is depleted from the deep waters. Furthermore, a management decision is required regarding the minimum depth of the cool water refugia that will protect fish in the lake. This minimum depth is used to compute a mean DO target for the lake."
 - Text: "The user can specify values for DOC and lake depth below the thermocline with the sliders on the upper left. These selections are reflected in the plots in the first row. Data from all of the lakes in the data set are shown as open circles, and approximately 15 samples with values similar to those specified are highlighted in red. The specified DOC, depth, and time since stratification (computed from the previous tab) are shown as a filled blue circle."
 - Text: "The last slider on the lower left specifies the credible interval used for computing the range of chlorophyll criteria. This value identifies the proportion of the estimates of the mean value of depth averaged DO that are less than the targeted threshold."
 - Text: "The final stressor-response relationship between chlorophyll and dissolved oxygen is shown on the bottom. All available data are shown as open circles, and the samples that correspond most closely to the specified conditions are highlighted in red. The solid line and gray shading shows the estimated relationship between chlorophyll and dissolved oxygen for the specified conditions. The horizontal dashed line shows the targeted threshold for mean DO."
 - Text: "A numerical summary of the chlorophyll criterion is shown in the lower right."

Chlorophyll – Hypoxia Model



Chlorophyll – Hypoxia Model



Criterion Graphical User Interfaces

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 - <https://chl-zooplankton-prod.app.cloud.gov/>
- TP-TN-Chl model:
 - <https://tp-tn-chl-prod.app.cloud.gov/>

Chlorophyll – Zooplankton Model

chl-zooplankton-prod.app.cloud.gov

https://chl-zooplankton-prod.app.cloud.gov 80%

EPA United States Environmental Protection Agency

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Chlorophyll criteria based on zooplankton BETA VERSION

Slope threshold:

0 0.04 0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40

Select depth class:

< 3.2 m

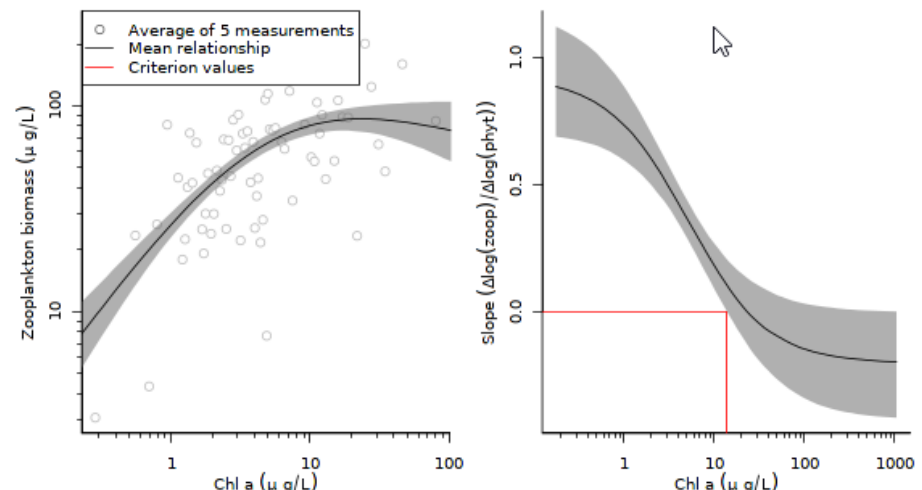
3.2 - 7.2 m

> 7.2 m

Credible interval:

0.01 0.15 0.25

0.01 0.04 0.07 0.1 0.15 0.18 0.19 0.22 0.25



Chl criterion

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Criterion Graphical User Interfaces

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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/>

Total Phosphorus – Total Nitrogen – Chlorophyll Model

tp-tn-chl-prod.app.cloud.gov/ x +

https://tp-tn-chl-prod.app.cloud.gov 80%

Related Topics: [Environmental Topics](#) [Contact Us](#)

Nutrient – Chlorophyll Models BETA VERSION

Background **Phosphorus** Nitrogen Candidate criteria

Selecting parameters

Factors that affect the relationships between total phosphorus (TP) and chlorophyll *a* (Chl *a*) and between total nitrogen (TN) and Chl *a* can be specified with sliders shown on the left.

- **Lake depth** - Lake depth influences the average amount of inorganic observed in a lake, where inorganic sediment concentrations in shallower tends to be greater than in deep lakes. Observations with lake depth near the selected lake depth are shown in green in the plotted TP data.
- **Dissolved organic carbon (DOC)** - DOC is an indicator of the amount allochthonous organic material in the lake. For the TN-Chl *a* model, DOC provide a means of estimating the dissolved organic nitrogen contribution to TN. Observations with DOC near the selected DOC concentration are shown in green in the plotted TN data.
- **Level III Ecoregion** - Ecoregions were defined by Omernik (2014) to identify regions of the United States in which ecosystems were thought to be similar. For these models, ecoregions provide a useful way to characterize differences in the amount of phosphorus (P) that is bound to inorganic sediment and differences in the relationship between dissolved organic carbon (DOC) and dissolved organic nitrogen. Observations collected in the selected ecoregion are shown in blue in the plotted data.

The last two sliders allow the user to specify the targeted Chl *a* concentration and the credible interval associated with the resulting model predictions of TP and TN.


Lake depth
0.5 35 70
0.5 7.5 14.5 21.5 28.5 35.5 42.5 49.5 56.5 63.5 70

DOC (mg/L)
0.5 10.2 20
0.5 2.5 4.5 6.5 8.5 10.5 12.5 14.5 16.5 18.5 20

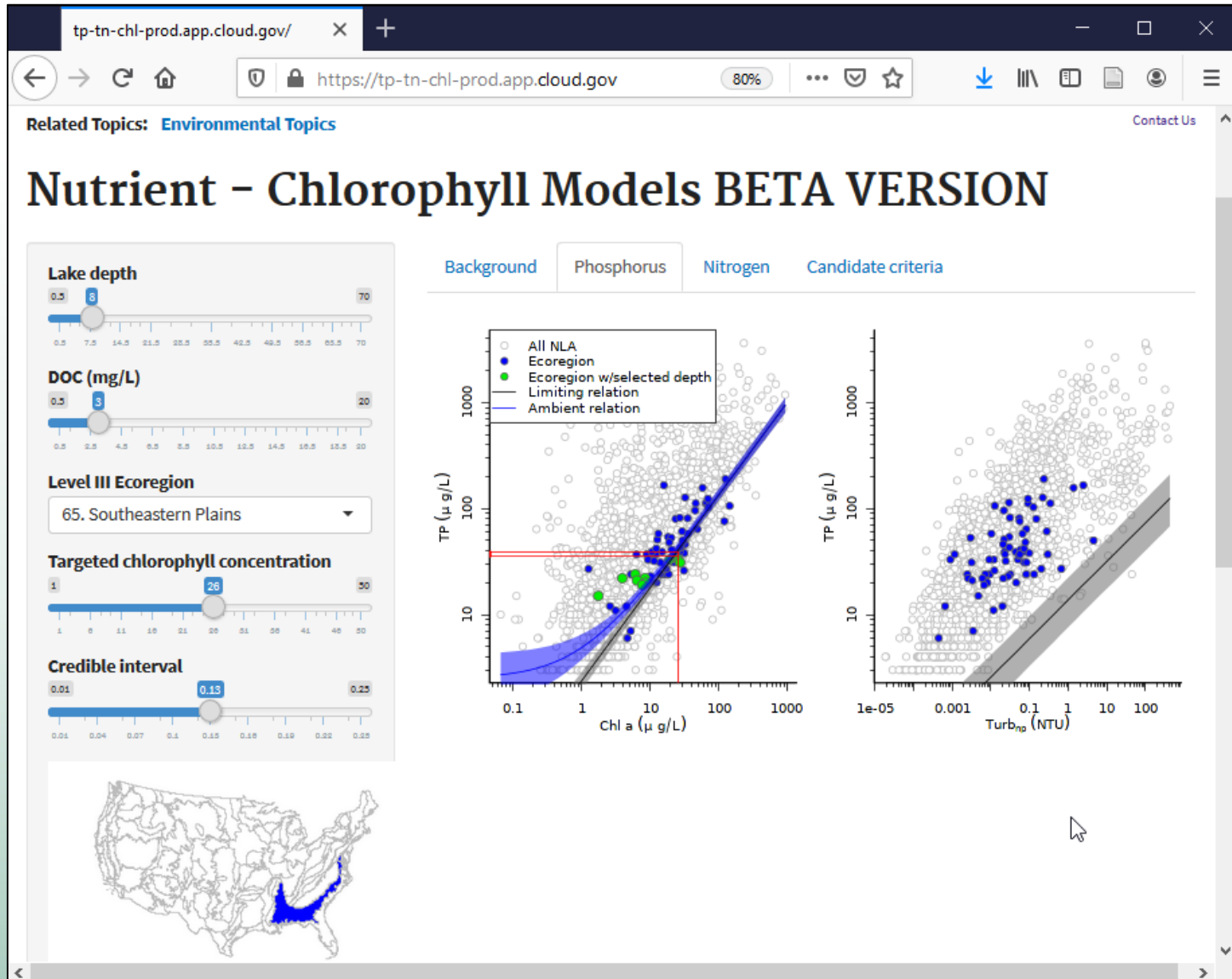
Level III Ecoregion
1. Coast Range

Targeted chlorophyll concentration
1 26 50
1 5 10 15 20 25 30 35 40 45 50

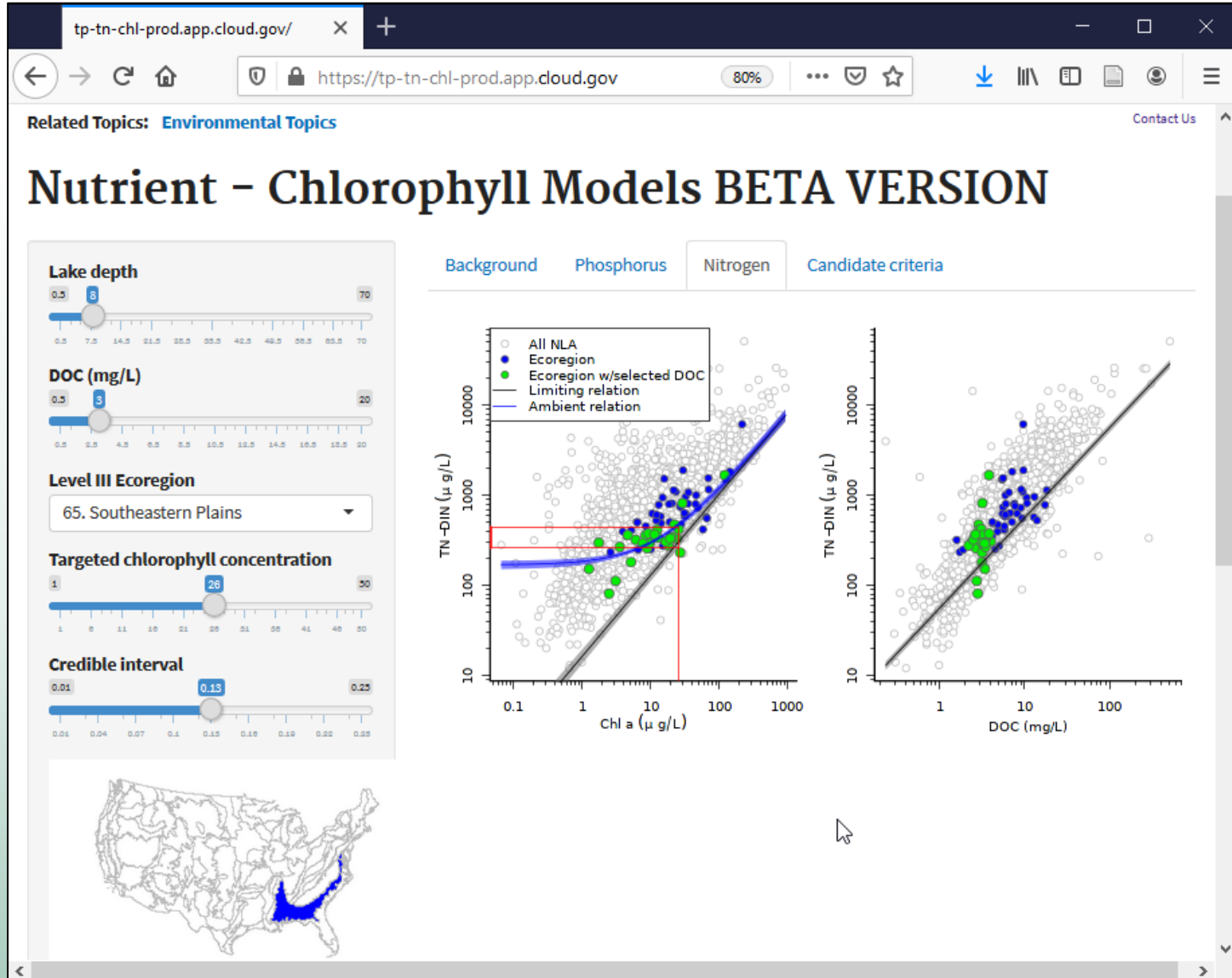
Credible interval
0.01 0.13 0.25
0.01 0.04 0.07 0.1 0.13 0.16 0.19 0.22 0.25



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](https://www.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>