NSTEPS New Mexico Lakes Analysis

Final Report

February 14, 2025

Prepared by Tetra Tech

Contents

Figures

Tables

INTRODUCTION

New Mexico has over 173 lakes and reservoirs, whose surface water quality is protected under the federal Clean Water Act and the state's water quality standards regulations. To protect water quality from nutrient pollution, the state utilizes a nutrient water quality standard that is expressed in narrative form with an explicit reference to nutrients and their effects (i.e., narrative nutrient criteria). New Mexico's narrative nutrient criteria state: "Plant nutrients from other than natural causes shall not be present in concentrations which will produce undesirable aquatic life or result in a dominance of nuisance species in surface waters of the state."

The New Mexico Environment Department (NMED) implements its nutrient water quality standard in biennial water quality assessments conducted using an assessment methodology that translates the narrative nutrient criteria into specific water quality parameters and quantitative thresholds. Periodically, NMED gathers new scientific information that could increase the accuracy of its assessments, reviewing the information for applicability to its assessment methodologies and as the basis for their potential revision. In light of U.S. EPA's recently published revised ambient water quality criteria recommendations for lakes and reservoirs (USEPA 2021), NMED is consulting with EPA on the role the criteria recommendations – expressed as nutrient stressor-response models – may have in supporting the state's potential revisions to its nutrient assessment methodology for lakes and reservoirs.

The objectives of this project were to:

1. Gather information from the state describing its lakes and reservoirs and their applicable water quality standards
2. Characterize EPA's 304(a) lake nutrient criteria models as a conceptual basis for translating New Mexico's narrative nutrient criteria into candidate numeric assessment thresholds in the state's assessment methodology for lakes and reservoirs
3. Demonstrate the national lake models' visualization tools (R-shiny apps), including a demonstration of the models that isolate the lakes in New Mexico that participated in the National Lakes Survey (NLA)
4. Characterize the state's relevant water quality data and discussing the factors that affect their incorporation into the national lake models
5. Determine which national lake models can be modified through the addition of New Mexico's water quality data

1.1 Background on National 304(a) Lake Criteria Models

U.S. EPA's Ambient Water Quality Criteria to Address Nutrient Pollution in Lakes and Reservoirs (USEPA 2021) outlines a recommended approach to derive chlorophyll, nitrogen, and phosphorus targets to protect aquatic life, recreation, and drinking water designated uses in lakes nationwide. The criteria development tools outlined in the report are based on stressor-response models developed using National Lakes Assessment (NLA) data. The purpose of the stressor-response models is to quantify the relationships between environmental stressors and ecosystem responses. For criteria setting purposes, the stressor-response models help the user to identify stressor targets associated with response levels that are protective of the designated use. The approach outlined in the report has flexibility for users to combine state and national data as well as incorporate risk management decisions.

1.2 New Mexico Standards and Assessment Context

New Mexico currently defines five aquatic life use classes (high quality coldwater, coldwater, coolwater, warmwater, and limited) and two recreational use classes (primary and secondary contact) for its lakes, which are used as endpoints to translate narrative nutrient criteria. Other designated uses in New Mexico include livestock watering, wildlife habitat, public water supply, irrigation, domestic water supply, and fish culture (NM Water Quality Control Commission 2022).

New Mexico's existing Consolidated Assessment and Listing Methodology (CALM) translates narrative nutrient criteria into numeric thresholds (NM Surface Water Quality Bureau 2021). The thresholds identified in the CALM are based on literature review (Nurnberg 1996, Dodds 2006) as well as analysis by Scott and Haggard (2011) who used changepoint and regression tree analysis to identify thresholds. Thresholds were identified for causal variables (TN and TP) and response variables (chlorophyll, % cyanobacteria, dissolved oxygen (DO), and pH) and were divided among three lake classes: cold, warm, and sinkhole (Table 1). The state is interested in updating these thresholds using data rather than literature values. New Mexico also recently updated their numeric criteria for microcystin and cyanotoxin, defining criteria as no more than three exceedances of 8 or 15 µg/L, respectively, in a 12-month period (NM Water Quality Control Commission 2022).

Table 1. Thresholds in New Mexico's current nutrient listing methodology for lakes and reservoirs. Reproduced from NM Surface Water Quality Bureau (2021).

	CAUSAL VARIABLES		**RESPONSE VARIABLES**			
Lake Group	**TP (mg/L)**	**TN (mg/L)**	**chl-a (µg/L)**	**% Cyano-bacteria[a]**	**DO[g] (mg/L)**	**pH[g]**
COLD	≤ 0.03 [b]	≤ 0.9[c]	≤ 7.5 [b]	≤ 38% [c]	*See NMAC for applicable DO and pH criterion*	
WARM	≤ 0.04[c]	≤ 1.4[c]	≤ 11[d]	≤ 38% [c]		
SINKHOLE	≤ 0.025 [e]	≤ 1.42 [e]	≤ 3.5[f]	-		

NOTES:

a. The cyanobacteria thresholds are expressed as a percentage of the total algae count.
b. Boundary between mesotrophic and eutrophic lakes (Nürnberg 1996).
c. Threshold values were derived from change point and regression tree analyses of water quality data from New Mexico (Scott and Haggard 2011).
d. Thresholds for Kansas Central Plains & SW Tablelands (Dodds 2006).
e. 75th percentile of NM sinkhole lake data.
f. Thresholds between oligotrophic and mesotrophic lakes (Nürnberg 1996).
g. DO and pH criteria are based on the designated aquatic life use(s) of the lake as assigned in 20.6.4.900(H) NMAC.

2 DATA

2.1 Phase 1

New Mexico Surface Water Quality Bureau provided several lake datasets, including water chemistry data, depth profile data, periphyton and phytoplankton data, lake metadata, and a crosswalk with water quality criteria (Table 2). Data processing and analyses using R (R Core Team 2023). Data from the various supplied datasets were compiled into a wide-formatted dataset, with unique rows for each unique site, date, and depth group observation. Additional site metadata including elevation, lake area, and HUC were gathered using latitude and longitude data along with geographic information system (GIS) and the United States Geological Survey (USGS) national hydrography dataset (NHD v2, USGS 2019). COMmon ID (COMID) were used to join available LakeCat (Hill et al 2018) data to the main dataset. Thermocline depths were estimated using the “rLakeAnalyzer” package (Winslow et al 2019). Random forest modeling to estimate DOC data was run using the “ranger” package (Wright and Ziegler 2017). National models were run using the “rstan” package (Stan Development Team 2023).

Variable names and units were harmonized to be consistent. Samples noted as "blank" or "duplicate" were removed. Non-detect samples were replaced with 1/2 the minimum detection limit. Samples measured within the top 1 meter were labeled surface samples. Data were screened for impossible values (e.g., negative concentrations) and visually checked for extreme values. No extreme values were observed. Twenty samples of negative turbidity values were removed. Skewed variables were natural log transformed before assessing extreme values. In skewed variables, zero values were replaced with ½ the minimum observed value to accommodate log transformation.

Table 2. Lake datasets provided by New Mexico Surface Water Quality Bureau for Phase 1.

Dataset	Variables	Date Range
Lake Chemistry data.xlsx	Chlorophyll, microcystin, N (ammonia, nitrate + nitrite, total Kjeldahl, total persulfate), P (total, orthophosphate), chloride, sulfate, total dissolved solids, total suspended solids	2011–2022
LakeDepthProfiles_NM.xlsx	DO, DO saturation, water temperature, pH, specific conductance, turbidity, salinity	2010–2022
Periphyton_Phytoplankton_Data_NM.xlsx	Counts of various phytoplankton taxa	2009–2022
Lake_Reservoir_MonitoringLocations.xlsx	Metadata linking monitoring locations, assessment units, geographic information, and water quality standards citation code	N/A
NM Lake Statistics.xlsx	Metadata describing lake morphometry (area, perimeter, sampled maximum depth) and watershed information	N/A

2.2 Phase 2

To enhance the comprehensiveness of the lake water quality dataset, additional data sources were integrated, including updated nutrient, chlorophyll, phytoplankton, and zooplankton data (Table 3). Newly available nutrient data were incorporated to ensure the most current information was represented, while chlorophyll data were updated by prioritizing the most recent and reliable sources. Phytoplankton data spanning multiple years were consolidated using common identifiers such as SiteID, date, lake information, class, and genus details. However, the 2007 and 2008 phytoplankton data with inconsistent spatial information were excluded to maintain dataset integrity. Standardization efforts included manually correcting phytoplankton classification, LakeID/SiteID, and LakeName fields through an external validation process. Zooplankton data were processed by aggregating counts by location and date, eliminating species-level subtotals to maintain a consistent structure. With these additions, lake and site metadata were systematically applied to any samples missing relevant information. To align with NMED's current assessment methods, analyses were conducted using data from June through September. All the new data was joined to the Phase 1 data to update the models.

Table 3. Lake datasets provided by New Mexico Surface Water Quality Bureau for Phase 2.

Dataset	Variables	Date Range
2024_Lake_Nutrient_data.xlsx	Nitrogen (ammonia as N), Nitrogen (Nitrite (NO2) + Nitrate (NO3) as N), Phosphorus as P, Total Kjeldahl nitrogen (Organic N & NH3)	2024
LAKE LENTIC1 DATA BY STUDY.xlsx	Chlorophyll-a	2001-2009
Kateri_Chloro_update.xlsx	Chlorophyll-a	2016-2024
2011_NMED_SWQB_phyto_2011 Results.xlsx	Phytoplankton	2011
2013-2017_NMED_SWQB_phyto.xlsx	Phytoplankton	2013-2017
20190109 NMED PHYTOS - OUTPUT_2018_data.xlsx	Phytoplankton	2018
20200123 NMED PHYTOS - OUTPUT_2019_data.xlsx	Phytoplankton	2019
20210223 NMED PHYTOS - OUTPUT_2020_data.xlsx	Phytoplankton	2020
20220101_NMED PHYTOS - OUTPUT_2021_data.xlsx	Phytoplankton	2021
20220606 NMED PHYTOS - OUTPUT_2022_data.xlsx	Phytoplankton	2022
20230103 NMED PHYTOS - OUTPUT_2022_data.xlsx	Phytoplankton	2022
20241127 NMED PHYTOS - OUTPUT_2024_data.xlsx	Phytoplankton	2024
20241028 NMED - ZOOPS - FINAL ONLY_BSA.xlsx	Zooplankton	2024

3 NATIONAL LAKE MODELS

Five stressor-response models were developed to identify chlorophyll targets (deepwater hypoxia, microcysin, and zooplankton) and nutrient targets (total nitrogen (TN) and total phosphorus (TP)). These Bayesian models use science-based understanding of the mechanisms at play within a lake ecosystem that can affect the processing of chlorophyll, nutrients, and DO by phytoplankton and zooplankton. The models are described in detail in USEPA (2021). The original models used 2007 and 2012 NLA data. The models were later updated to include 2017 NLA data (USEPA 2022).

Each national model includes a user-defined level of certainty. The credible interval serves as the level of certainty for the national models. A credible interval is the Bayesian equivalent of a confidence interval and specifies the level of confidence that the true result will fall within the defined intervals. An *X*% CI means there is an *X*% probability that the true relationship will fall within the defined interval around the line of best fit. A larger CI means the estimated criterion is more likely to be effective (protective).

For example, consider the microcystin-chlorophyll relationship in the national microcystin model. Figure 1 shows the microcystin threshold of 8 µg/L as a horizontal red line. The CI is denoted as a grey band surrounding the line of best fit (black line). The estimated chlorophyll criterion is shown as a vertical red line. The criterion line will be located at the intersection of the pre-defined threshold and the upper credible bound (left panel). Which certainty level to use is a risk-management decision that is dependent upon the specific goals of the agency.

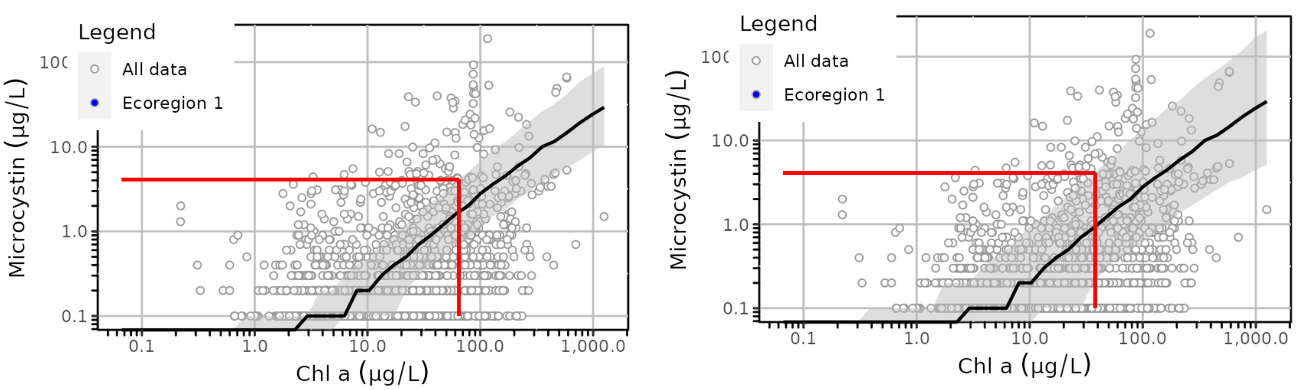

Figure 1. Example plot of microcystin vs chlorophyll. Certainty level shown as a grey band surrounding the line of best fit (black line). The left panel has a 50% certainty level, and the right panel has a 75% certainty level. The right panel has a wider certainty band, which equates to a more protective chlorophyll criteria (~64 vs ~38 µg/L, left vs right panel).

4 EVALUATION OF DATA AVAILABILITY FOR MODELING

For each national model, we explored the possibility of appending the input dataset to include additional state data. The goal is to increase the statistical power by increasing the sample size, while also increasing the proportion of the data that are state-specific. The data needs for each model are described in Table 4. The decision to run the published version of the model or add state data to the model inputs depended on state data availability, detailed in Table 5. Note that the sample size reflected in the table represents observations of the complete set of parameters matched in time and space, whereas the complete state dataset includes additional data not included in the “paired” data that are not reflected in the table. Many of the national models require additional input covariates such as dissolved organic carbon (DOC), turbidity, and lake depth. All models included NLA data from New Mexico (Table 5), even if additional state data were not added to the model. A detailed list of NLA data in New Mexico is provided in Appendix Table 13.

No state zooplankton data were available, so the national model was run as published for a range of conditions relevant for New Mexico. State data *were* available for the microcystin model, but microcystin data were limited to 12 samples, five of which were non-detects and all of which were < 8 µg/L. Rather than updating the national microcystin model with state data, the published version of the model was run for a range of conditions relevant for New Mexico. State data for the hypoxia, TN, and TP models were available, and the models were updated with state data. State data were overlaid on top of NLA data to visually compare data distributions. Any major differences between the datasets would warrant further investigation before rerunning the national models with appended state data. Distributions of New Mexico state data were similar to NLA data (Figure 2, Figure 3, Figure 4), and therefore the updated national models were run without further investigation.

Table 4. Summary of available state data for national model input.

Model	Input Data Needed	State Data Available	Decision
Zooplankton	Zooplankton biomass, chlorophyll, phytoplankton biomass	No	Run the published web version of the model
Microcystin	Cyanobacteria biovolume, phytoplankton biovolume, cyanobacteria proportion, chlorophyll, microcystin	Yes	Run the published web version of the model
Hypoxia	Dissolved oxygen (DO) and temperature profile, chlorophyll, DOC, maximum lake depth	Yes*	Rerun model with appended state data
TN	Chlorophyll, TN, DOC	Yes*	Rerun model with appended state data
TP	Chlorophyll, TP, lake maximum depth, turbidity	Yes	Rerun model with appended state data

* DOC data were limited and were imputed using a random forest model

Table 5. Sample sizes for national model applications.

Model	National Dataset (NLA)	New Mexico Samples in National Dataset (NLA)	New Mexico State Data Added to Model
Zooplankton	2,432	34	0
Microcystin	3,433	41	0
Hypoxia	776	12	12
TN	3,566	46	64
TP	3,434	46	75

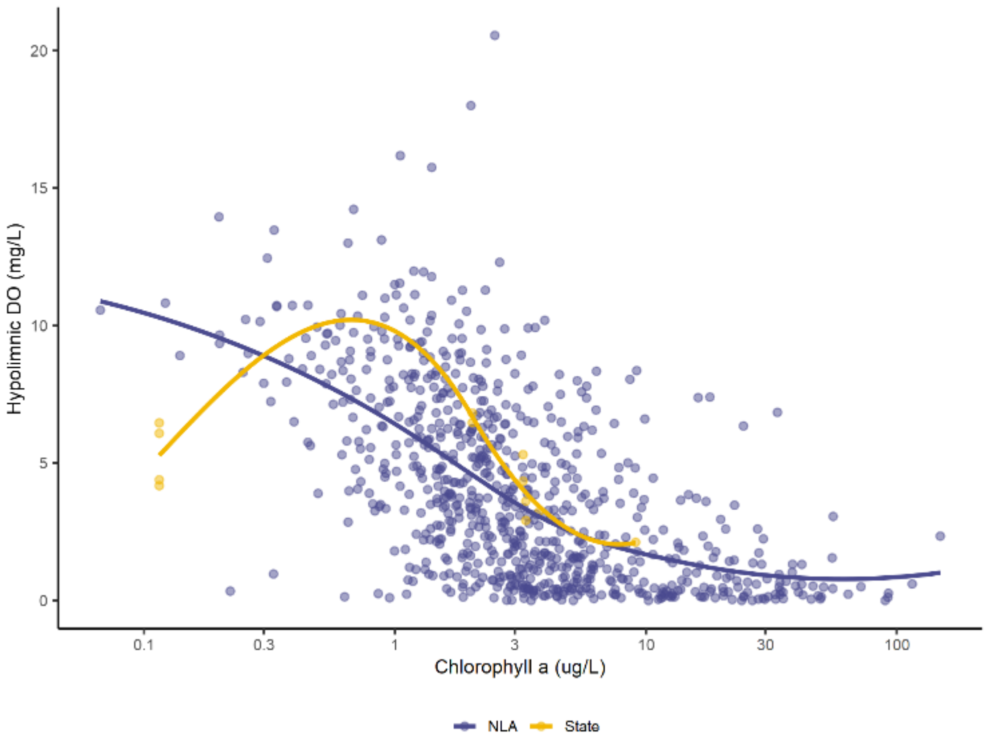

Figure 2. Comparison of New Mexico state data and NLA data for hypolimnetic DO and chlorophyll. Lines indicate an exploratory LOESS line.

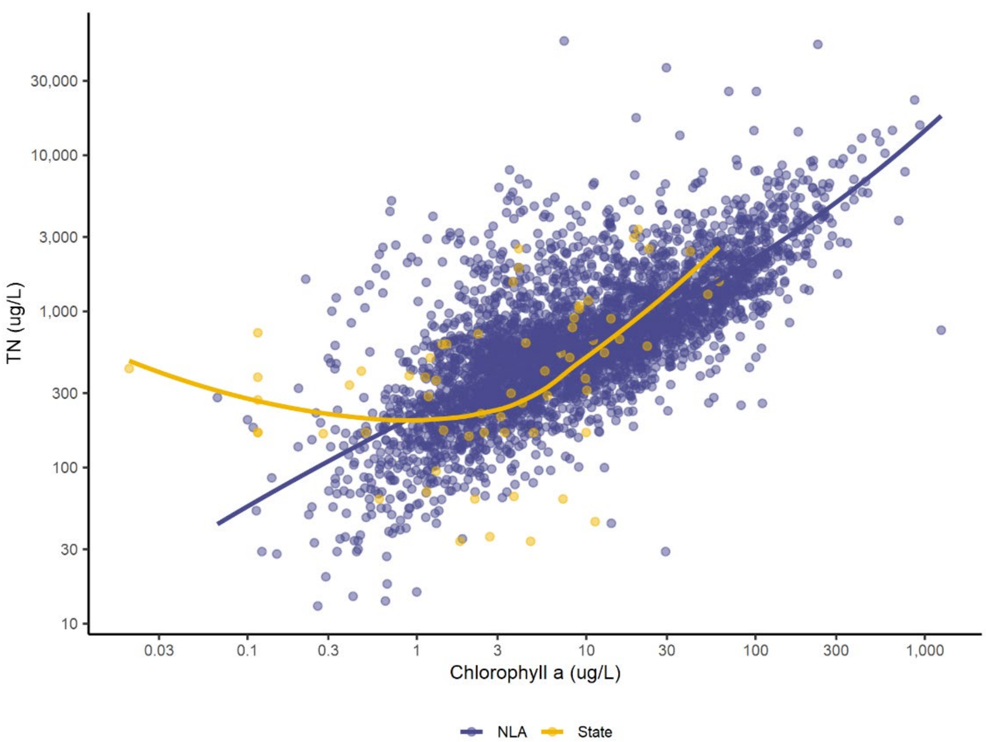

Figure 3. Comparison of New Mexico state data and NLA data for chlorophyll and TN. Lines indicate an exploratory LOESS line.

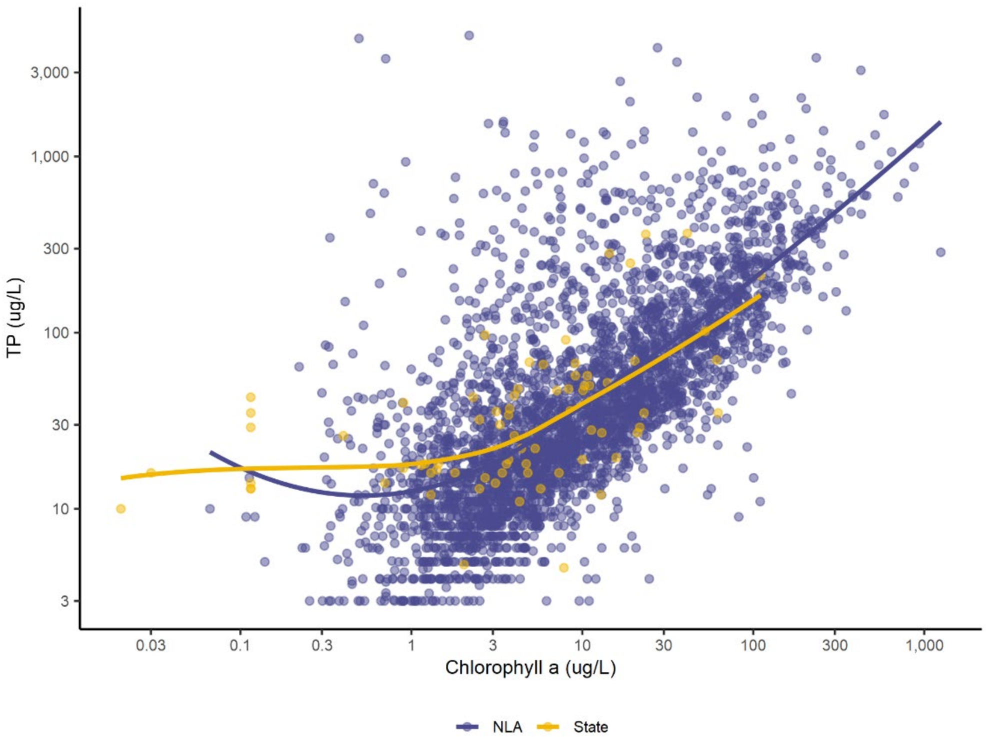

Figure 4. Comparison of New Mexico state data and NLA data for chlorophyll and TP. Lines indicate an exploratory LOESS line.

The hypoxia and TN models require DOC concentration as an input variable to represent allochthonous carbon and dissolved organic nitrogen (DON), respectively. DOC was more limited in the New Mexico state dataset than other input variables for these models, so imputing (i.e., estimating) DOC would enable a larger amount of input data to be included in the model update. When DOC data were not available for a given lake, DOC concentration was imputed using a random forest regression model. Random forest (Breiman 2001) is a machine learning technique that combines thousands of individual decision trees (classification and regression trees or CART (Breiman et.al. 1984) to develop a better performing model. Each “tree” in the “forest” is a bootstrapped version of the original dataset. Bootstrapping is a resampling technique that is used for modeling or to quantify uncertainty.

The random forest model was developed by EPA using log-transformed DOC data from NLA data collected across the conterminous United States. Landscape variables from the LakeCat dataset (Hill et al. 2018) were used as predictors. To develop a more parsimonious model with similar predictive power, the model was further refined to identify the nine most important predictors (in order of importance): 30-year precipitation normals, watershed slope, annual runoff, elevation, latitude, 30-year temperature maximum normals, soil compressive strength, percent woody wetland cover in the watershed, and maximum lake depth (Figure 5). DOC was not linearly related to each predictor variable but varied across the range of each predictor (Figure 6). The out-of-bag R^2 value (a conservative measure of model performance) was 0.71, meaning 71% of the observed variation in DOC concentrations was explained by the model.

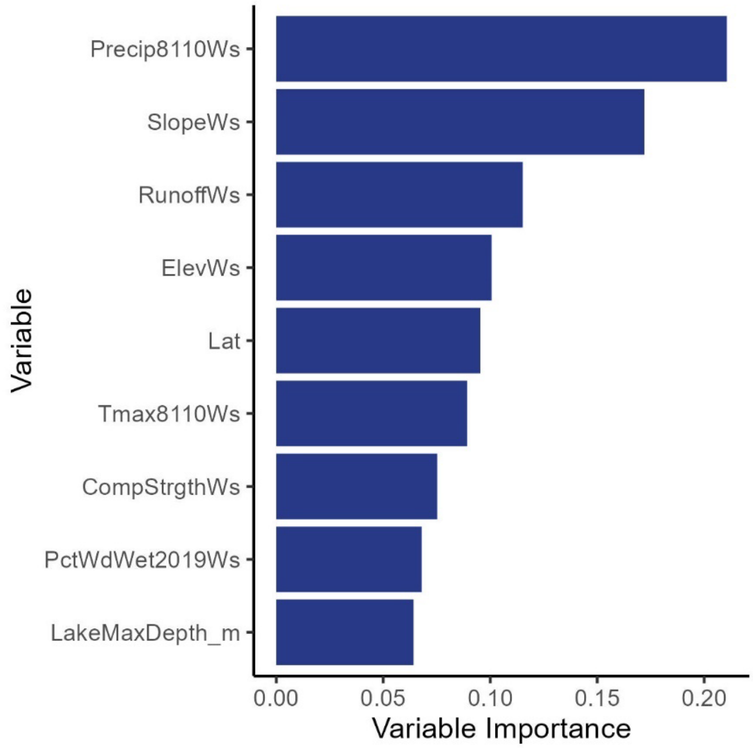

Figure 5. Variable importance rankings for the nine predictors in the DOC random forest model. Each value represents the relative importance of each variable in the model rather than an absolute value such as a coefficient in a linear regression.

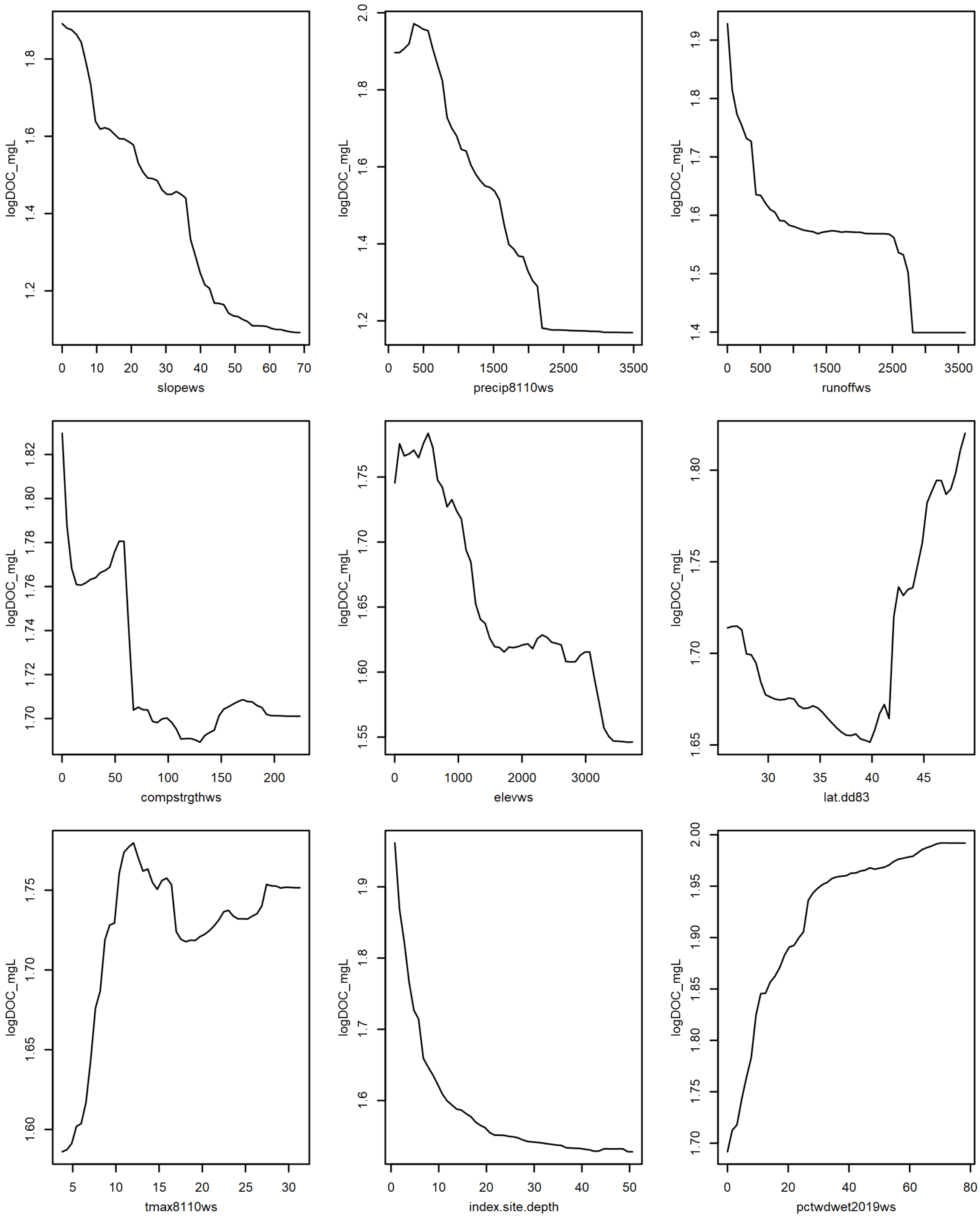

Figure 6. Partial dependence plots for the nine predictor variables in the DOC random forest model. Each plot shows the relationship between DOC and the predictor variable of interest, all other variables held equal.

5 EXPLORATION OF CYANOBACTERIA INDICATOR

The goal of analyzing cyanobacteria was to determine whether percent cyanobacteria should be included in the revised assessment methodology in the context of nutrient impairment, and if so whether chlorophyll, TN, and/or TP targets can be identified through the course of analysis. We explored both the relative proportion of cyanobacteria and total cyanobacteria cell count as potential endpoints. A logistic regression was used to analyze relative cyanobacteria proportion (because values were bounded by 0 and 1), and a linear regression was used to analyze total cyanobacteria cell count.

Proportion cyanobacteria was not statistically significantly related to chlorophyll, TN, or TP, and only 1-3% of the variability in proportion cyanobacteria was explained by these variables (Table 6, Figure 7, Figure 9, Figure 11). Cyanobacteria cell count was significantly correlated to chlorophyll concentration, though only 8% of the variability in cell count was explained, and it was uncommon to observe cell counts in excess of the World Health Organization recreational high guidance level 100,000 cells/mL (Table 6, Figure 8). Cyanobacteria cell count was not statistically significantly related to TN or TP, with 1-2% of variability explained (Table 6, Figure 10, Figure 12). Cyanobacteria indicators did not appear to be related to regional variability (see Figures 7-12) or time of year (not pictured).

Due to the lack of statistical relationship between cyanobacteria and nutrient indicators, as well as an overall low prevalence of cyanobacteria in lakes in New Mexico, we did not identify chlorophyll, TN, or TP targets associated with proportion cyanobacteria or cyanobacteria cell count.

Table 6. Statistical results for the logistic regression for proportion cyanobacteria and the linear regression for cyanobacteria cell count.

Endpoint	Stressor	R^2	p value
Proportion cyanobacteria	Chlorophyll	0.02	0.26
Proportion cyanobacteria	TN	0.01	0.59
Proportion cyanobacteria	TP	0.03	0.20
Cyanobacteria cell count	Chlorophyll	0.08	< 0.0001
Cyanobacteria cell count	TN	0.01	0.13
Cyanobacteria cell count	TP	0.02	0.53

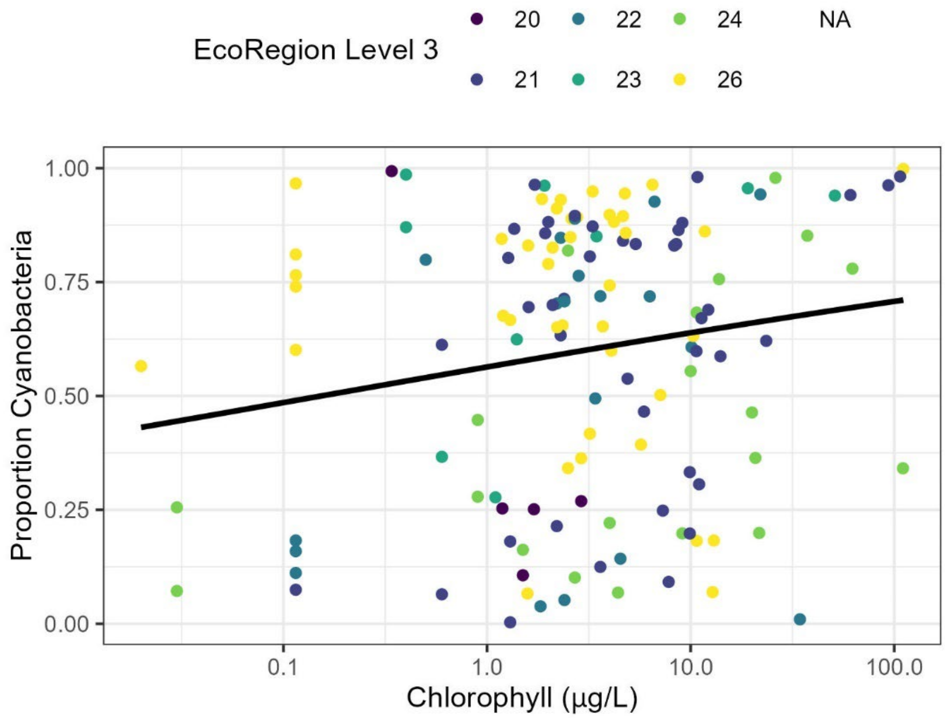

Figure 7. Relationship between proportion cyanobacteria and chlorophyll concentration. Black line represents a logistic regression.

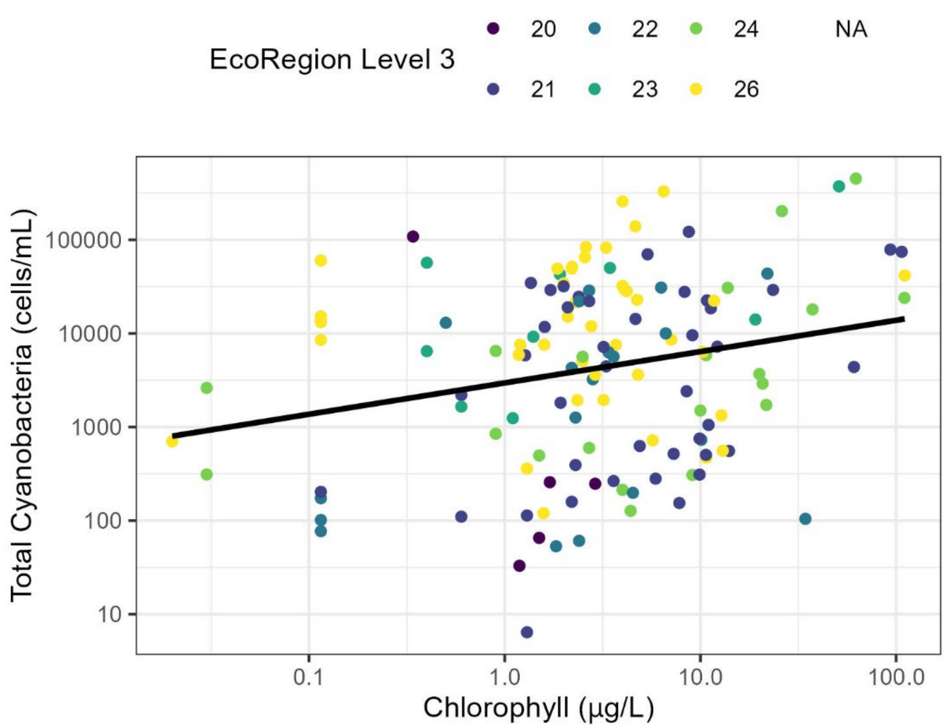

Figure 8. Relationship between cyanobacteria cell count and chlorophyll concentration. Black line represents a linear regression.

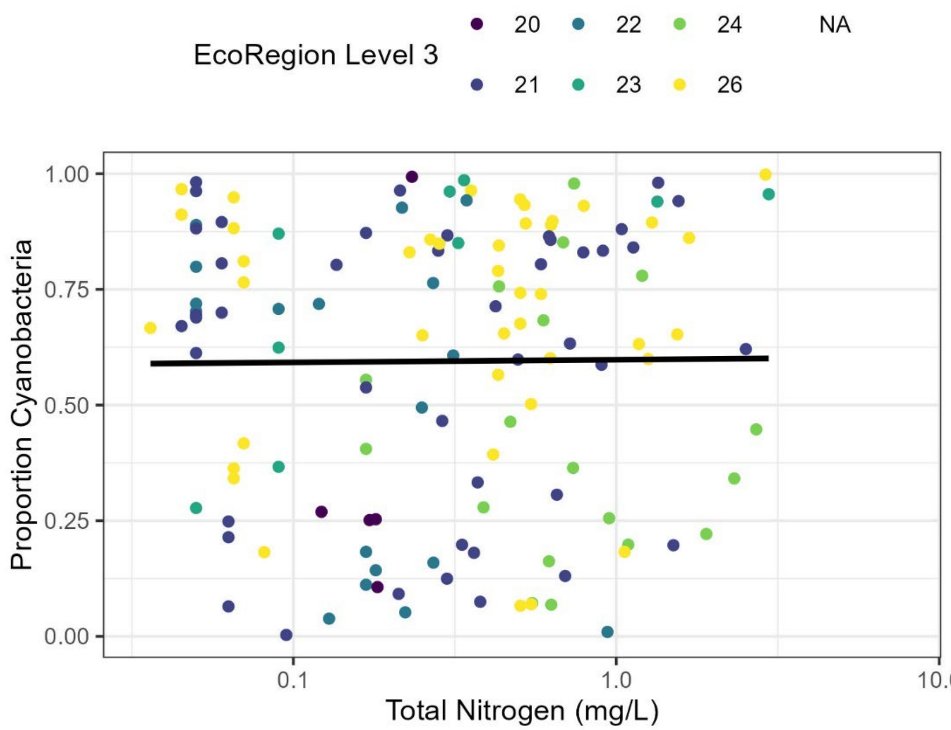

Figure 9. Relationship between proportion cyanobacteria and TN concentration. Black line represents a logistic regression.

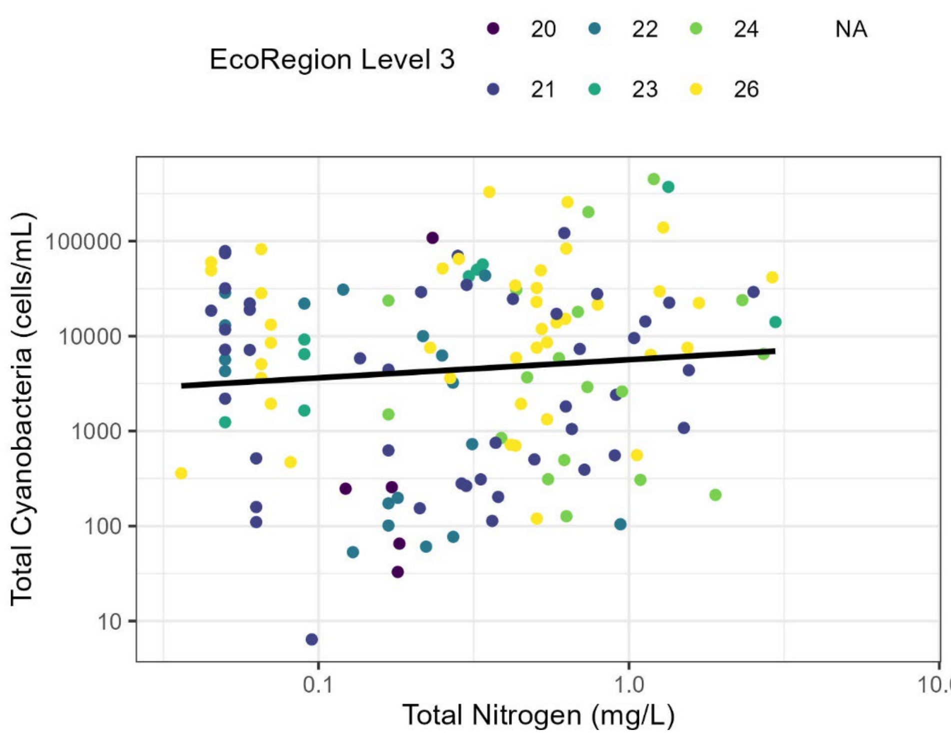

Figure 10. Relationship between cyanobacteria cell count and TN concentration. Black line represents a linear regression.

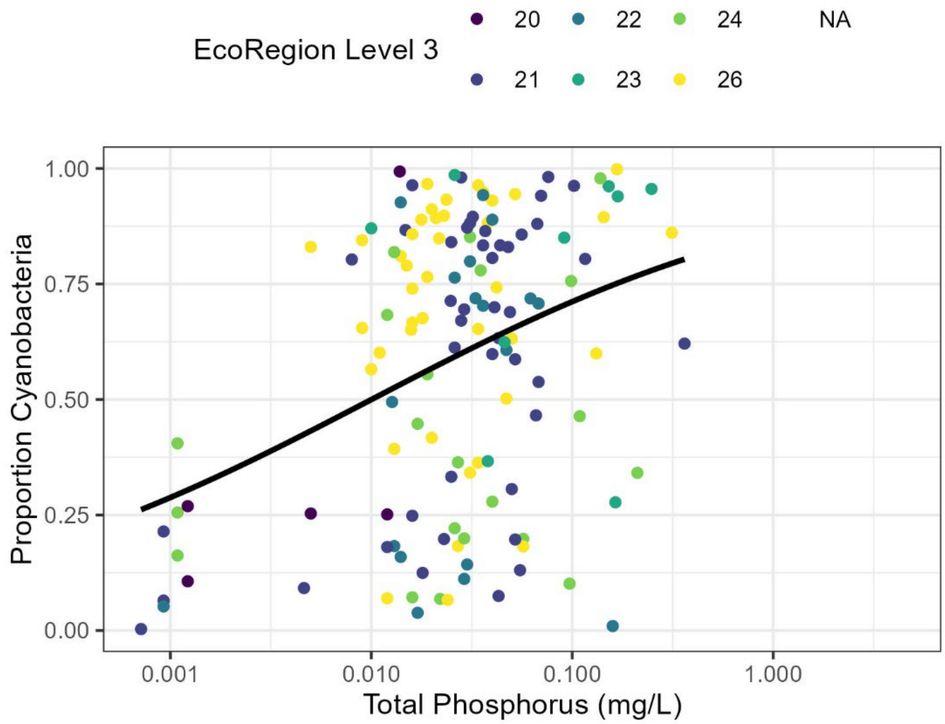

Figure 11. Relationship between proportion cyanobacteria and TP concentration. Black line represents a logistic regression.

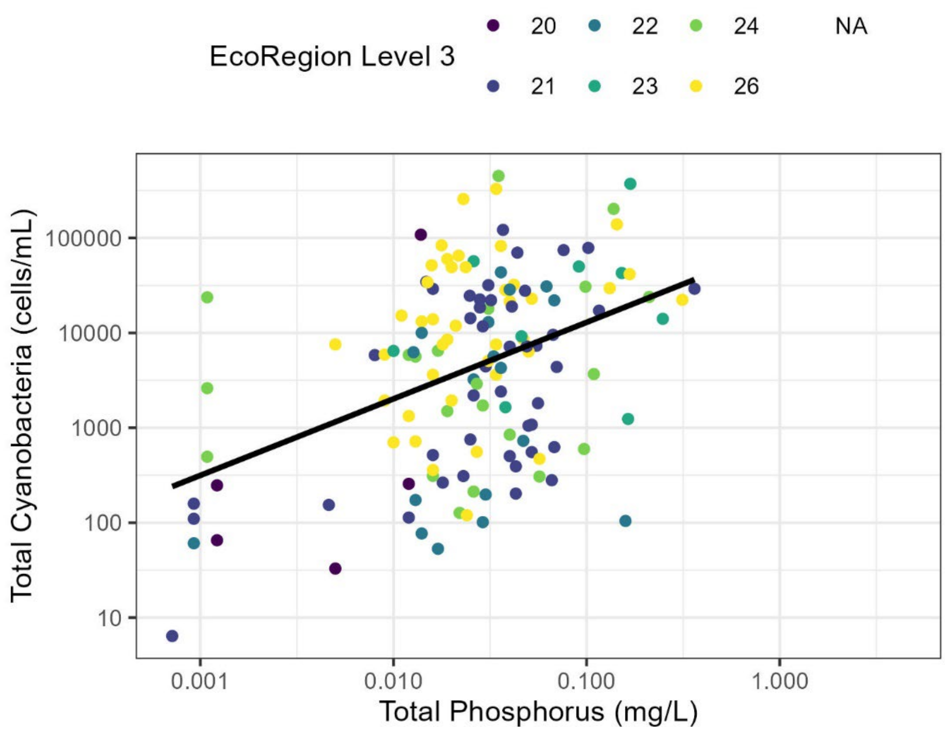

Figure 12. Relationship between cyanobacteria cell count and TP concentration. Black line represents a linear regression.

6 APPLICATION OF NATIONAL MODELS

6.1 Zooplankton vs. Chlorophyll

The national zooplankton model (USEPA 2021, 2022; https://nsteps.epa.gov/apps/chl-zooplankton/) analyzes the relationship between primary producers (chlorophyll) and primary consumers (zooplankton) in the water column in lakes (Figure 13). At low chlorophyll concentrations, it is expected that zooplankton biomass will increase as phytoplankton biomass increases. As chlorophyll concentrations increase, the connection between zooplankton and phytoplankton biomass becomes decoupled and the zooplankton response levels off (Figure 14, left panel). The user can select a slope threshold for this relationship that protects against that decoupling (Figure 14, right panel).

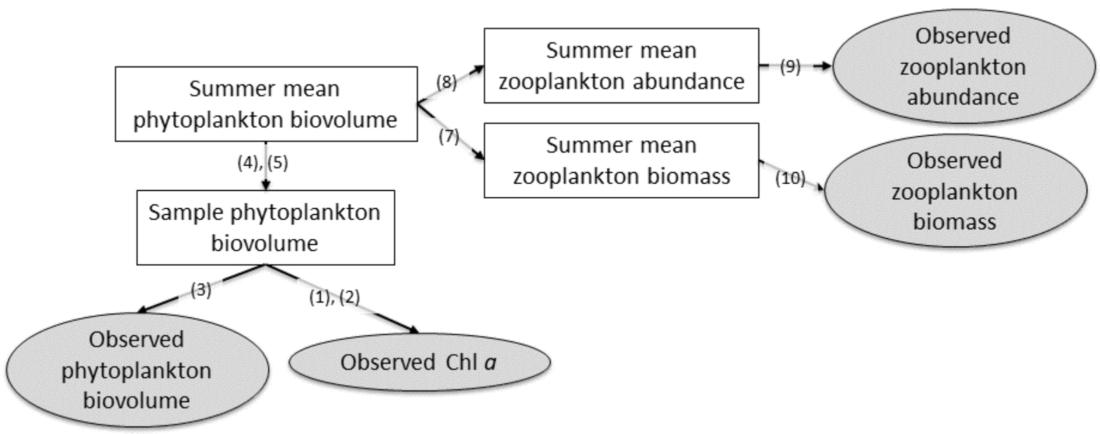

Figure 13. Conceptual diagram of the national zooplankton model (USEPA 2021).

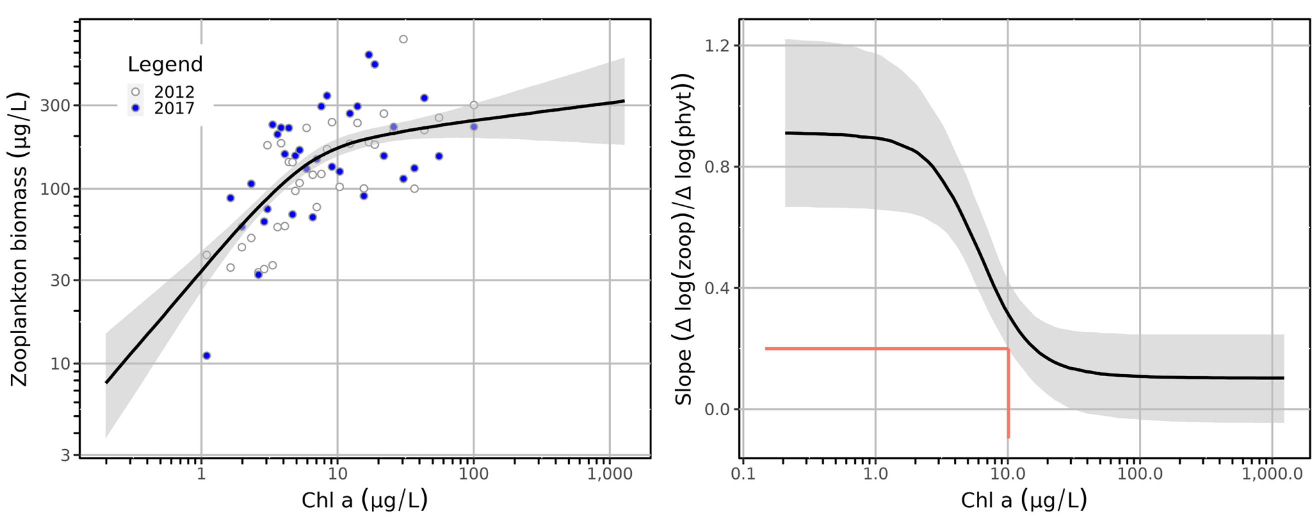

Figure 14. Modeled relationship between chlorophyll concentration and zooplankton biomass (left) and chlorophyll concentration and the slope of the chlorophyll-zooplankton relationship (right) in the zooplankton national model.

The slope threshold sets the target rate of change in zooplankton biomass relative to the rate of change in phytoplankton biomass, corresponding to protection of aquatic life use from a food web standpoint. Lakes with lower primary production have a more efficient trophic transfer from phytoplankton to zooplankton. Therefore, zooplankton biomass increases as chlorophyll increases. Conversely, lakes with higher primary production have a less efficient trophic transfer. In those lakes, zooplankton biomass is not as responsive to increases in chlorophyll. The proportional zooplankton increase at various slope thresholds is illustrated in Table 7, which shows that zooplankton biomass is more responsive to increases in phytoplankton at higher slope thresholds. For this analysis, lower slope thresholds were generally paired with higher certainty levels because the slope threshold was closer to the decoupling point (i.e., when the relationship between chlorophyll and zooplankton is weak).

Table 7. Example output from the zooplankton national model, illustrating the responsiveness of zooplankton biomass to increases in phytoplankton biomass.

Slope	Zooplankton proportional increase		
	Phytoplankton increase: x1.5	Phytoplankton increase: x2.0	Phytoplankton increase: x3.0
0.1	1.04	1.07	1.12
0.2	1.08	1.15	1.25
0.3	1.13	1.23	1.39

Zooplankton data were available for two lakes in New Mexico from a 2024 sampling effort: Heron Lake and Grindstone Canyon Reservoir. Paired zooplankton and chlorophyll data were available for three observations, and distributions were compared to NLA data collected in New Mexico (Figure 15). The NMED-collected data had higher zooplankton biomass per unit chlorophyll than NLA data, but this observation was made on a small sample size and zooplankton biomass values were in the same overall range as NLA data. Given the small sample size, these NMED data were not incorporated as an update to the national model but instead were used to interpret results from the published version of the model.

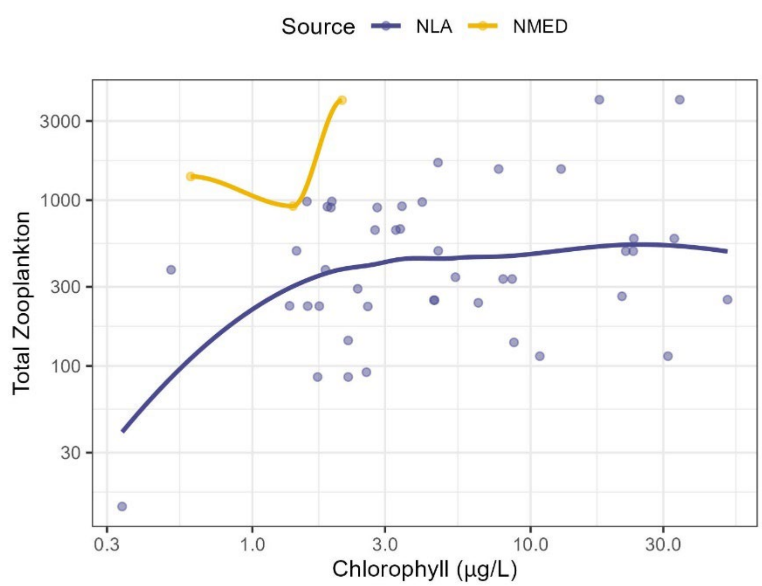

Figure 15. Comparison of NMED data and New Mexico NLA data for zooplankton and chlorophyll. Lines indicate an exploratory LOESS line.

The published national zooplankton model was run for conditions relevant to New Mexico. A range of slope thresholds (0.01 to 0.40) and certainty levels (0.75 to 0.99) were used in this analysis with latitude and longitude representing lakes in the three temperature classes for New Mexico (Figure 16). Note that higher certainty levels were applied to low slope thresholds, with the rationale that identifying a slope threshold close to the point at which the relationship levels off. **Chlorophyll targets across slope thresholds and certainty levels ranged from 3-26 µg/L in the temperature class ≤ 22.9°C, 2-17 µg/L in the temperature class between 22.9 and 24.9°C, and 3-15 µg/L in the temperature class between 24.9 and 27.9°C (**

Table 8**).** The coldest temperature class was the most common temperature class in New Mexico (Figure 16). Larger slope thresholds and higher certainty levels resulted in lower chlorophyll targets.

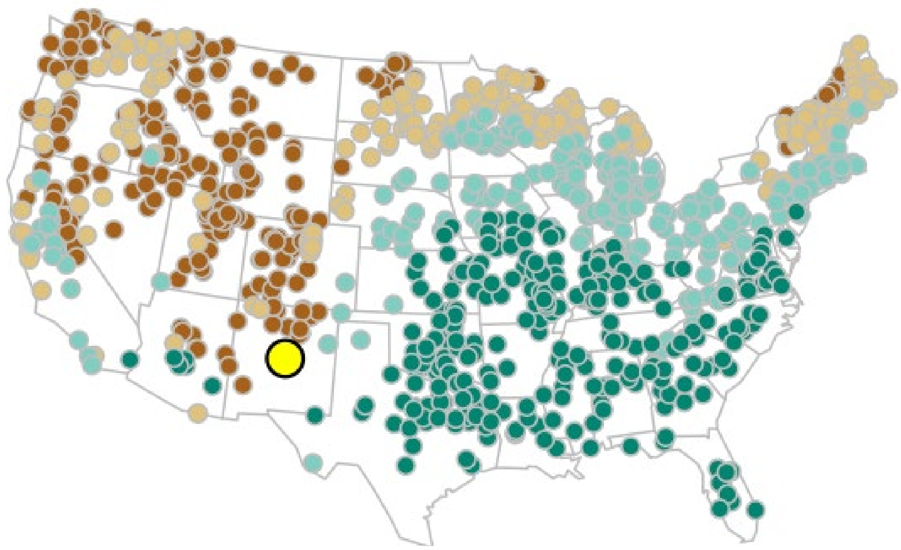

Figure 16. Temperature classes in the zooplankton national model. The four colors represent the four lake temperature classes based on maximum seasonal temperature (T ≤ 22.9°C, 22.9 < T ≤ 24.9°C, 24.9 < T ≤ 27.9°C, and > 27.9°C). The yellow represents the user-selected latitude and longitude setting selected in the online model application (https://nsteps.epa.gov/apps/chl-zooplankton/).

Table 8. Estimated chlorophyll targets from the zooplankton national model. Output in this table represents a range of slope thresholds and certainty levels, leading to a range of chlorophyll targets. NA values indicate a chlorophyll threshold below 1.

Slope threshold	Certainty level (%)	Chlorophyll target (µg/L) for each lake temperature class		
		T ≤ 22.9°C (brown)	T > 22.9°C & T ≤ 24.9°C (tan)	T > 24.9°C & T ≤ 27.9°C (teal)
0.4	99	3	NA	3
0.4	95	5	NA	5
0.4	90	5	NA	5
0.4	85	6	2	5
0.4	80	6	3	6
0.4	75	7	3	6
0.2	99	8	6	8
0.2	95	10	7	8
0.2	90	12	8	8
0.2	85	13	9	9
0.2	80	14	9	10
0.2	75	15	10	10
0.1	99	10	8	9
0.1	95	15	11	11
0.1	90	19	13	12
0.1	85	22	14	13
0.1	80	25	15	14
0.1	75	30	17	15
0.05	99	13	10	11
0.05	95	20	14	13
0.01	99	16	14	12
0.01	95	26	17	15

6.2 Microcystin vs. Chlorophyll

The national model for microcystin relates microcystin to chlorophyll through cyanobacterial biomass (Figure 17; USEPA 2021, 2022; https://nsteps.epa.gov/apps/chl-microcystin/). The model identifies a chlorophyll target for a given ecoregion and lake maximum depth when provided a target microcystin target, allowable exceedance probability, and certainty level.

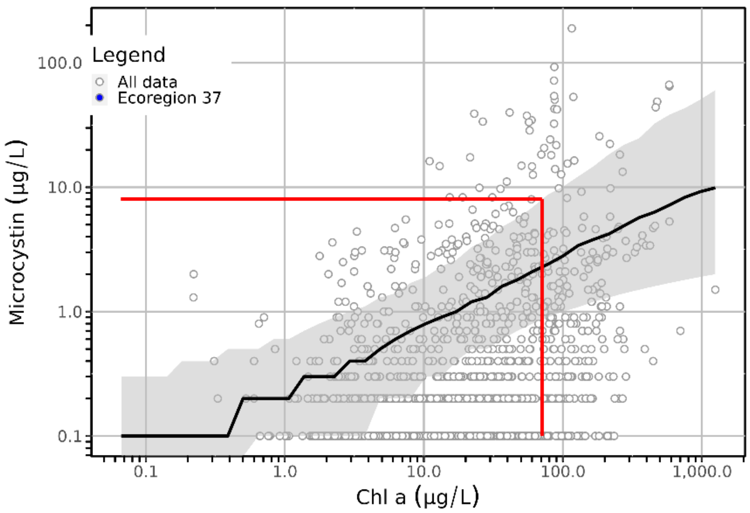

Figure 17. Modeled relationship between chlorophyll concentration and microcystin concentration in the microcystin national model. From USEPA (2021).

The microcystin target was selected as 8 µg/L according to New Mexico's water quality standard for primary contact recreation, which also specifies three exceedances over a 12-month period (NM Water Quality Control Commission 2022). This standard is similar to EPA's national recreational cyanotoxin criteria, which specify an 8 µg/L magnitude with three exceedances over a 100-day recreation season (USEPA 2019). The allowable exceedance choice for the national model represents the daily exceedance probability, which can be translated into a seasonal exceedance probability. Allowable exceedance probabilities of 0.01, 0.03, and 0.05 were chosen as examples, representing a probability of 1-5% the microcystin target would be exceeded on any given day. Certainty levels of 0.75 and 0.90 were chosen as examples to illustrate the sensitivity of the model.

Chlorophyll targets ranged from 15-143 µg/L (Table 9), suggesting that cyanotoxin issues likely will not arise in New Mexico lakes unless a lake becomes heavily eutrophic. The lowest targets were associated with low allowable exceedance probabilities (0.01) and high certainty levels (0.90). Targets varied by ecoregion and were lower in deeper lakes.

Table 9. Chlorophyll targets generated from the national microcystin model. Results are based on a microcystin target of 8 µg/L (NM Water Quality Control Commission 2022). Ecoregion 20 was run for the Navajo Reservoir only, which has a maximum depth of 120 m that exceeds the maximum input to the model of 50 m.

Ecoregion	Max Depth (m)	Allowable Exceedance Probability	Certainty Level (%)	Chlorophyll Target (µg/L)
Colorado Plateaus (20)	120 (50)	0.01	90	21
		0.03	90	30
		0.05	90	38
		0.01	75	38
		0.03	75	58
		0.05	75	72
Southern Rockies (21)	5	0.01	90	33
		0.03	90	44
		0.05	90	54
		0.01	75	53
		0.03	75	72
		0.05	75	85
	10-20	0.01	90	33
		0.03	90	47
		0.05	90	55
		0.01	75	52
		0.03	75	75
		0.05	75	89
Arizona/New Mexico Plateau (22)	5	0.01	90	33
		0.03	90	49
		0.05	90	62
		0.01	75	61
		0.03	75	88
		0.05	75	118
	10	0.01	90	31
		0.03	90	47
		0.05	90	64
		0.01	75	61
		0.03	75	92
		0.05	75	123

Ecoregion	Max Depth (m)	Allowable Exceedance Probability	Certainty Level (%)	Chlorophyll Target (µg/L)
Arizona/New Mexico Mountains (23)	5	0.01	90	29
		0.03	90	48
		0.05	90	64
		0.01	75	57
		0.03	75	96
		0.05	75	137
	10-20	0.01	90	29
		0.03	90	50
		0.05	90	68
		0.01	75	57
		0.03	75	102
		0.05	75	143
Chihuahuan Deserts (24)	5	0.01	90	16
		0.03	90	21
		0.05	90	27
		0.01	75	29
		0.03	75	41
		0.05	75	48
	10-20	0.01	90	15
		0.03	90	20
		0.05	90	25
		0.01	75	27
		0.03	75	41
		0.05	75	50
Southwestern Tablelands (26)	5	0.01	90	22
		0.03	90	36
		0.05	90	51
		0.01	75	37
		0.03	75	64
		0.05	75	92
	15	0.01	90	21
		0.03	90	37
		0.05	90	48
		0.01	75	38
		0.03	75	66
		0.05	75	91

6.3 Dissolved Oxygen vs. Chlorophyll

The national deep water hypoxia model (USEPA 2021, 2022; https://nsteps.epa.gov/apps/chl-hypoxia/) supposes that in seasonally stratified lakes, there may be a period during stratification when the epilimnion temperature is higher than the temperature optimum for fish species, and the cooler waters of the hypolimnion must have sufficient DO during this time to support fish species. The hypoxia model quantifies the decrease in DO during the stratified season and accounts for the impacts of eutrophication status, lake depth, and DOC concentration. The model assumes that hypolimnetic DO (DO_m) sampled on any given day (t_i) is a function of the time since the hypolimnion was isolated from the atmosphere (time since first day of stratification; t_0) and the volumetric oxygen demand of the water volume in the hypolimnion (VOD) (Figure 18). VOD is a function of the depth below the thermocline as well as the amount of carbon available to be respired (approximated from DOC and chlorophyll concentration). An example of the VOD vs chlorophyll relationship is shown in Figure 19.

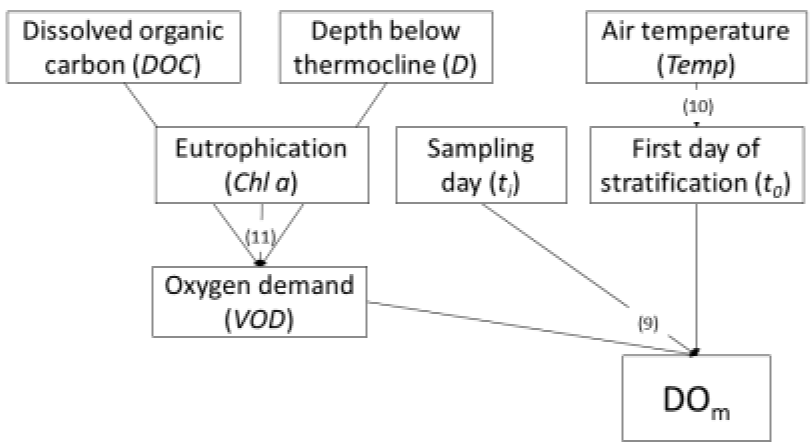

Figure 18. Conceptual diagram of the national DO model. Adapted from USEPA (2021).

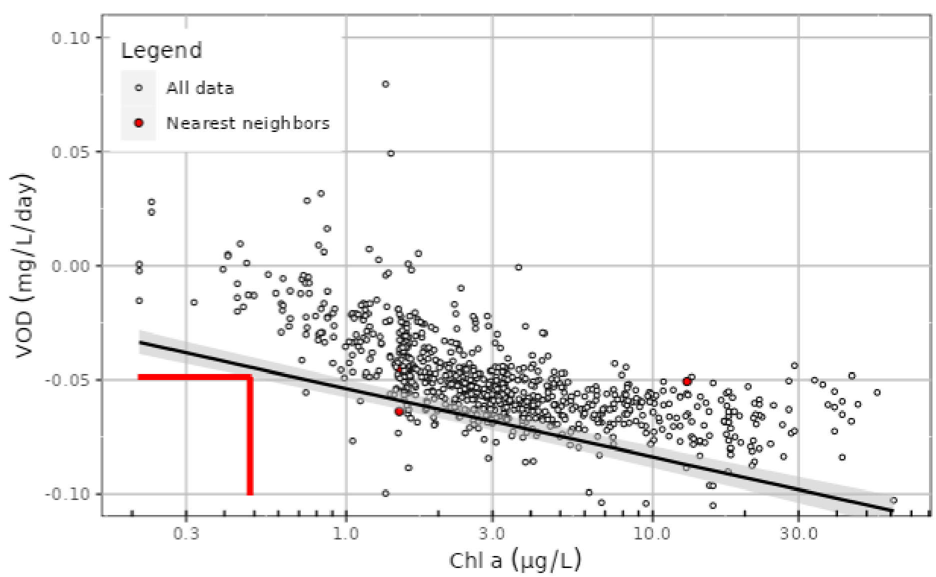

Figure 19. Example output of VOD vs chlorophyll from the national hypoxia model.

For the hypoxia model, lake-specific settings must be supplied to the model in two steps, first to determine the critical time window when temperature and DO must be maintained, and second to determine the chlorophyll target that would meet the maximum VOD that would support the DO target. To determine the critical time window, the user supplies the critical temperature (daily maximum value to support aquatic life uses), lake maximum depth, latitude, longitude, elevation, and area. Together, these inputs inform model predictions of the date of spring turnover and the date of temperature release (the day that epilimnion temperature decreases below the critical temperature and the fish species of interest can access DO in the surface water). To determine the chlorophyll target, the user supplies the DOC concentration, thermocline depth, refugia depth, DO threshold, and certainty level. Refugia depth is the minimum depth of cool water that provides sufficient habitat for certain fish. EPA (2021) references literature to support refugia depth as shallow as 0.3 m, whereas the state of Wisconsin uses 1 m as their refugia depth (Lyons et al 2018). The DO threshold represents the minimum DO concentration for the designated use, typically to support certain fish species.

DO profile data were available for lakes in New Mexico, so the national hypoxia model was rerun with appended state data. A summary of input conditions for the critical time window is presented in Table 10. These observations represent lakes that had complete metadata, profile data, and chlorophyll concentrations. The critical temperature and DO target were determined from New Mexico’s water quality standards. When not measured directly, DOC was estimated using a random forest model as described in Section 4. A refugia depth of 1.0 m was chosen, and a range of certainty levels (0.75-0.90) were supplied to test model sensitivity.

Table 10. Lakes in the New Mexico state dataset with profile data.

Lake	Ecoregion	Latitude	Longitude	Elevation (m)	Lake Area (km^2)	Lake Max Depth (m)	Critical Temp. (°C)
Hopewell Lake	21	36.70611	-106.234	2976	0.06	5	23
Abiquiu Reservoir	22	36.23742	-106.43	1908	13.2	38	25
El Vado Reservoir	21	36.59528	-106.733	2108	12.6	30	24
Heron Reservoir	21	36.68268	-106.706	2184	18.2	58	24
Cabresto Lake	21	36.74713	-105.498	2778	0.09	12.5	23
Conchas Reservoir	26	35.41422	-104.210	1282	13.8	27	32.2
Navajo Reservoir	20	36.82745	-107.602	1857	51.3	80	24

Model output indicated that in the geographic settings and water quality criteria relevant for New Mexico lakes, the critical temperature was not predicted to be exceeded. Thus, it was expected that in the lakes of interest, the target fish species would not experience the “thermal squeeze” that occurs when the epilimnion exceeds the critical temperature and DO at deeper depths is lower than the DO standard. It follows that the model output indicated that regardless of chlorophyll concentration, fish species in New Mexico lakes were anticipated to have sufficient temperature and DO conditions supportive of the range of aquatic life uses in the state. **Therefore, no chlorophyll targets were identified by the hypoxia model.**

6.4 Chlorophyll Targets Summary

A summary of chlorophyll and nutrient targets across the national models is provided in Table 12. Each model application resulted in a range of possible chlorophyll or nutrient targets due to the model sensitivity to covariates and/or management-relevant model settings (e.g., certainty level). These targets were evaluated by NMED and used as a reference for planned revisions to their assessment methodology.

NMED staff selected 10 µg/L as the chlorophyll target of interest, based largely on the zooplankton model with settings of a 0.2 slope threshold and 95% certainty level for the coldest lake group, which made up the majority of lakes in New Mexico. The zooplankton model was chosen over the microcystin or other models because it yielded more sensitive chlorophyll targets. Chlorophyll targets selected from similar levels of slope thresholds to protect against trophic decoupling, certainty levels, and lake temperature groupings were within 2-3 µg/L of 10 µg/L; these differences were evaluated by NMED and would not cause an appreciable discrepancy in the number of chlorophyll and nutrient exceedances statewide based on historical data.

Table 11. Summary of chlorophyll targets generated from cyanobacteria regressions and the national model applications in New Mexico lakes.

Model	Details	Temperature or Ecoregion Class	Target and Units	Concentration
Cyanobacteria Proportion	Logistic regression	Statewide	Chlorophyll (µg/L)	No target found (lack of statistical relationship)
Cyanobacteria Cell Count	Linear regression	Statewide	Chlorophyll (µg/L)	No target found (few high cyanobacteria observations)
Zooplankton	Slope threshold 0.01-0.4 Certainty Level 0.75-0.99	T ≤ 22.9°C	Chlorophyll (µg/L)	3-26
		T > 22.9°C & T ≤ 24.9°C		2-17
		T > 24.9°C & T ≤ 27.9°C		3-15
Microcystin	Range of depth in the ecoregion Allowable exceedance probability 0.01-0.05 Certainty level 0.75-0.90	Colorado Plateaus (20)	Chlorophyll (µg/L)	21-72
		Southern Rockies (21)		33-89
		Arizona/New Mexico Plateau (22)		31-123
		Arizona/New Mexico Mountains (23)		29-143
		Chihuahuan Deserts (24)		15-50
		Southwestern Tablelands (26)		21-92
Dissolved Oxygen	Refugia depth 1.0 Certainty level 0.75-0.90 Critical temp. 23-32.2°C		Chlorophyll (µg/L)	No target found (critical temperature not exceeded)

6.6 Nutrients vs. Chlorophyll

The national chlorophyll-nutrient models (USEPA 2021, 2022; https://nsteps.epa.gov/apps/tp-tn-chl/) relate chlorophyll and TN or TP concentrations, enabling the generation of a TN or TP target when a chlorophyll target of interest is supplied. The TN portion of the model supposes that TN is made up of phytoplankton-bound N, DON, and dissolved inorganic N (DIN). The model relates these constituents on an ecoregion-specific basis through TN, chlorophyll, and DOC as a proxy for DON, resulting in a TN target given a chlorophyll target and DOC concentration. The TP portion of the model supposes that TP is made up of phytoplankton-bound P, particulate P, and dissolved P. The model relates these constituents on an ecoregion-specific basis through TP, chlorophyll, and lake depth, resulting in a TP target given a chlorophyll target and depth.

The theoretical backing for these models identifies a "limiting relationship" (black line in Figure 20), representing the stressor-response relationship if all TN or TP was bound in phytoplankton biomass. Most lakes fall above this line (blue line in Figure 20), meaning there is some amount of TN or TP bound in other pools. Identifying an appropriate nutrient target (red line in Figure 20) involves cross-referencing the nutrient concentration that takes into account the non-phytoplankton pools. Note that the y axis for the TN model is TN - DIN, with the rationale that controlling phytoplankton biomass by limiting TN would require a reduction in bioavailable N (i.e., DIN) to minimal levels.

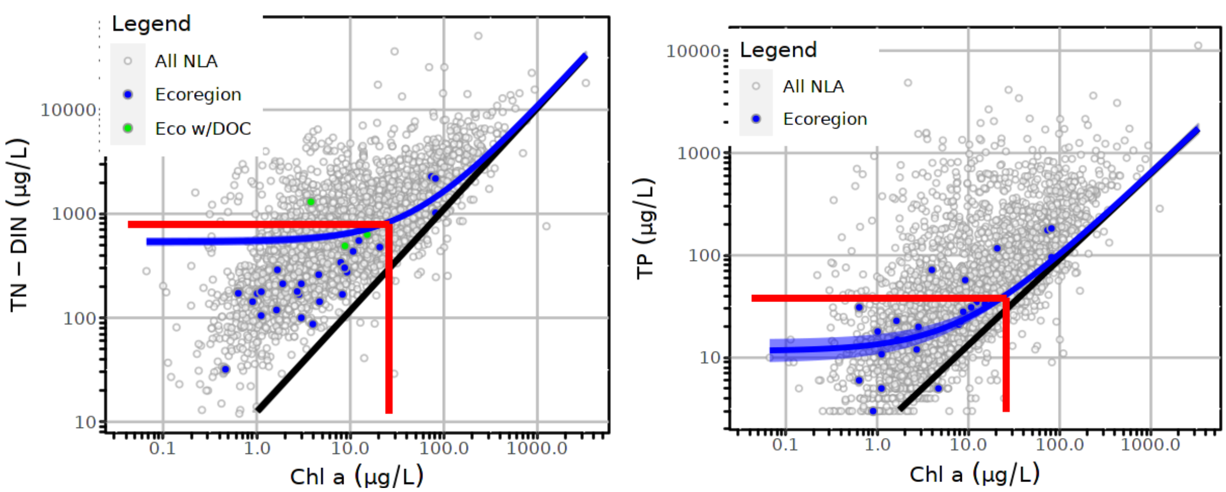

Figure 20. Example output from the national nutrient models.

The national TN and TP models were run with appended state data. Lake-specific inputs included lake maximum depth (TP model), DOC concentration (TN model), and ecoregion. When not measured directly, DOC was estimated using a random forest model as described in Section 4. To test model sensitivity, the model was also run with DOC concentrations ± 2 mg/L from the estimated concentration for each lake. **A chlorophyll target of 10 µg/L and a certainty level of 0.90 were supplied as model inputs**.

TN targets ranged from 192-690 µg/L when the estimated DOC concentrations were used as model input (Figure 21). These targets were lower than New Mexico's current TN targets (Table 1). When DOC concentrations varied ±2 mg/L from the estimated concentrations, the range of TN targets extended to 115-835 µg/L. When compared across DOC concentrations (estimated DOC ± 2 mg/L), TN targets differed by 76-144 µg/L within each lake, and lakes with higher overall TN targets had a wider range. Within each ecoregion, TN targets were tightly associated with DOC concentration, with higher DOC concentrations associated with higher TN targets (Figure 22). TN targets were highest in ecoregions 23, 24, and 26. Cold- and coolwater uses were generally associated with lower TN targets than warmwater uses (Figure 24).

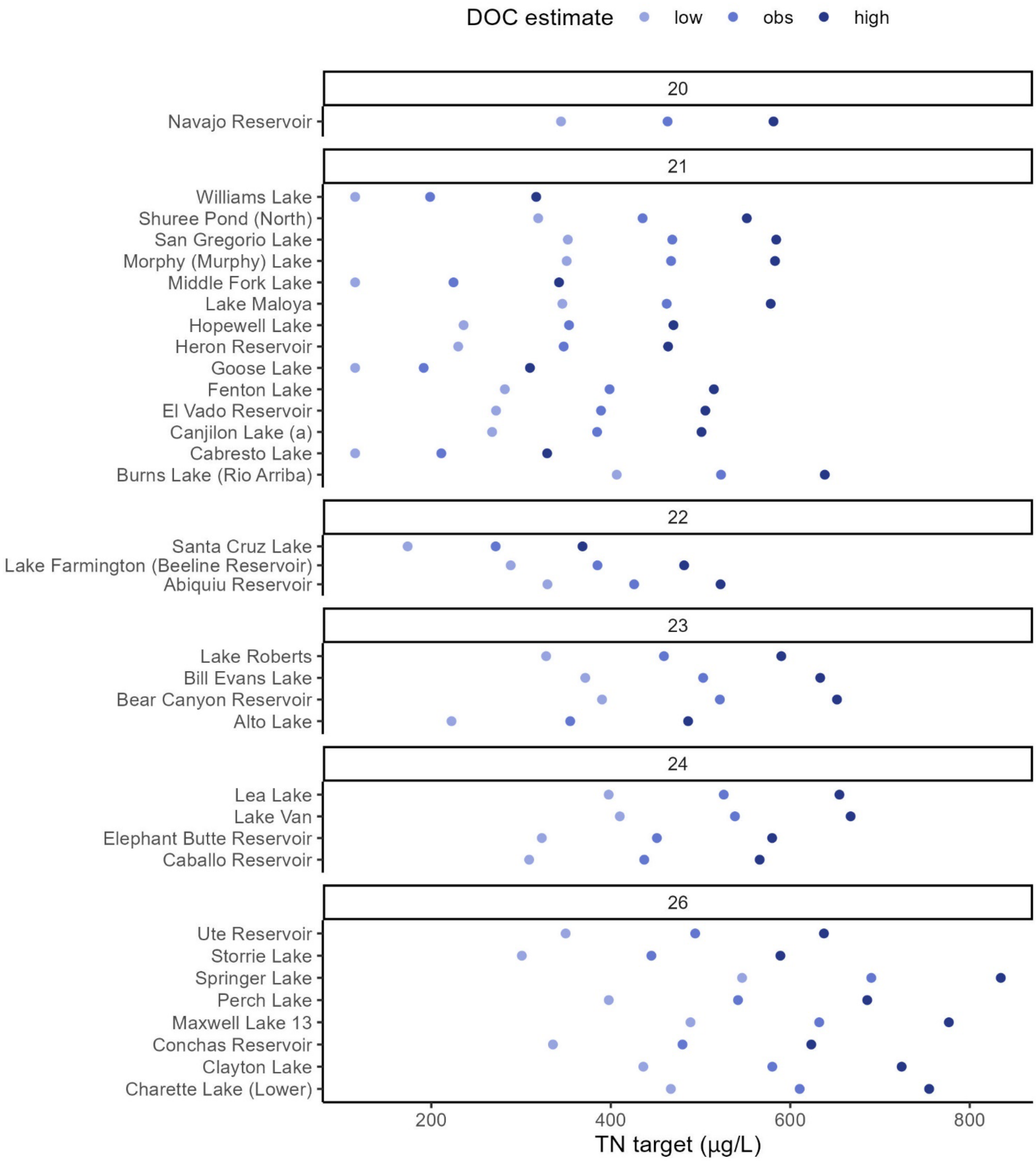

Figure 21. TN targets for each lake from the national nutrient model. Three sets of TN targets are provided for each lake, representing the estimated DOC concentration ("obs") ± 2 mg/L ("low" and "high"). Lower DOC concentrations were associated with lower TN targets, and higher DOC concentrations were associated with higher TN targets.

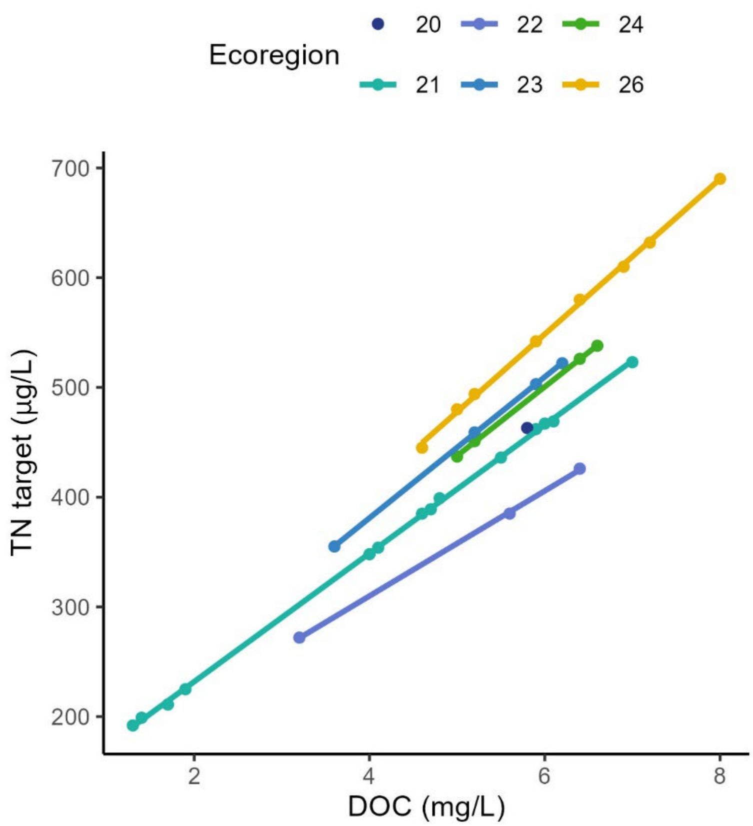

Figure 22. The relationship between TN target and DOC concentration for each ecoregion in New Mexico.

TP targets ranged from 18-41 µg/L (Figure 23). These targets were within range or below New Mexico's current TP targets (Table 1). TP targets were highest in ecoregion 23, but TP targets did not generally differ by temperature aquatic life use (Figure 25). Individual TN and TP targets for each lake are described in Appendix Table 14.

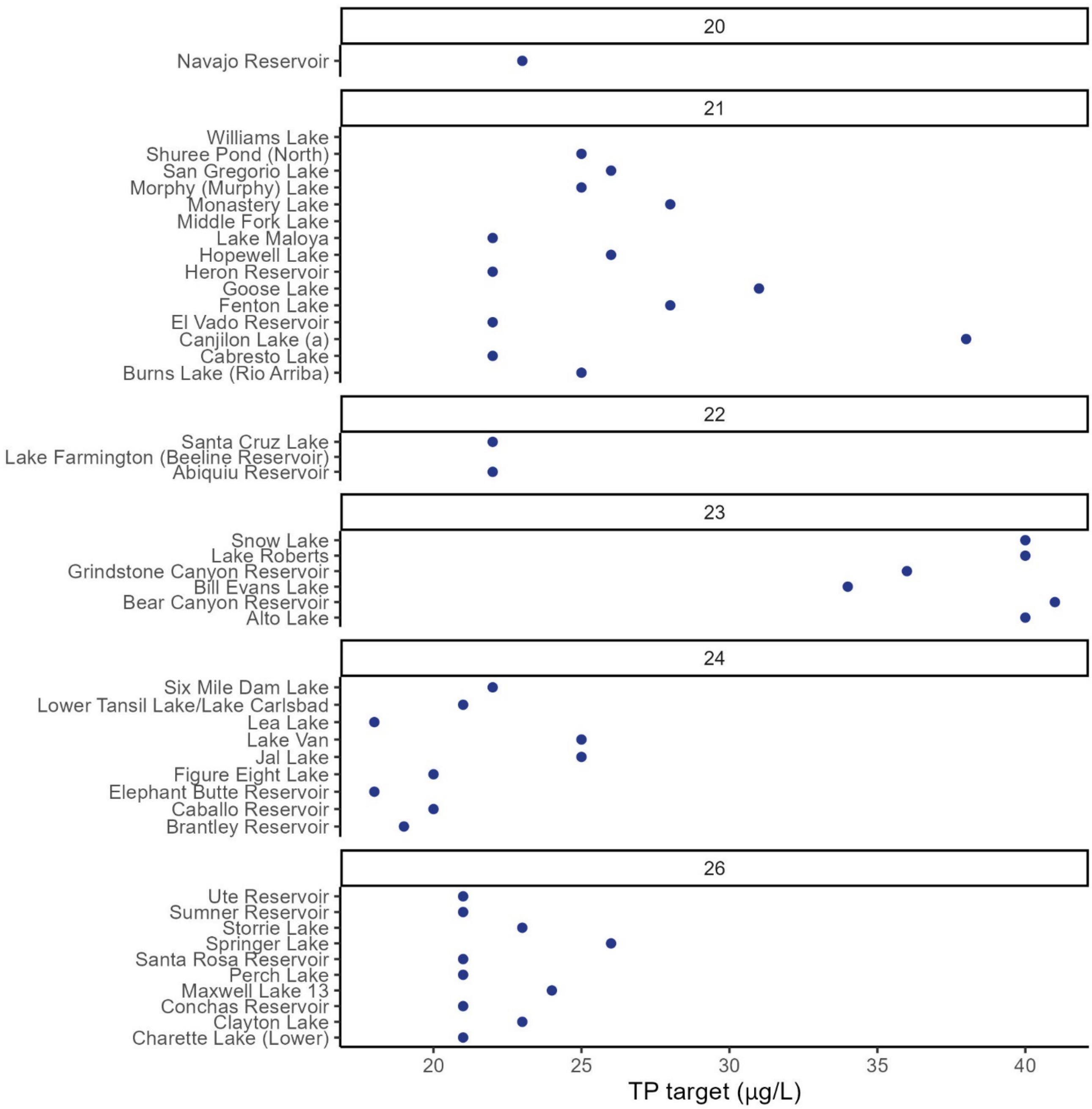

Figure 23. TP targets for each lake from the national nutrient model.

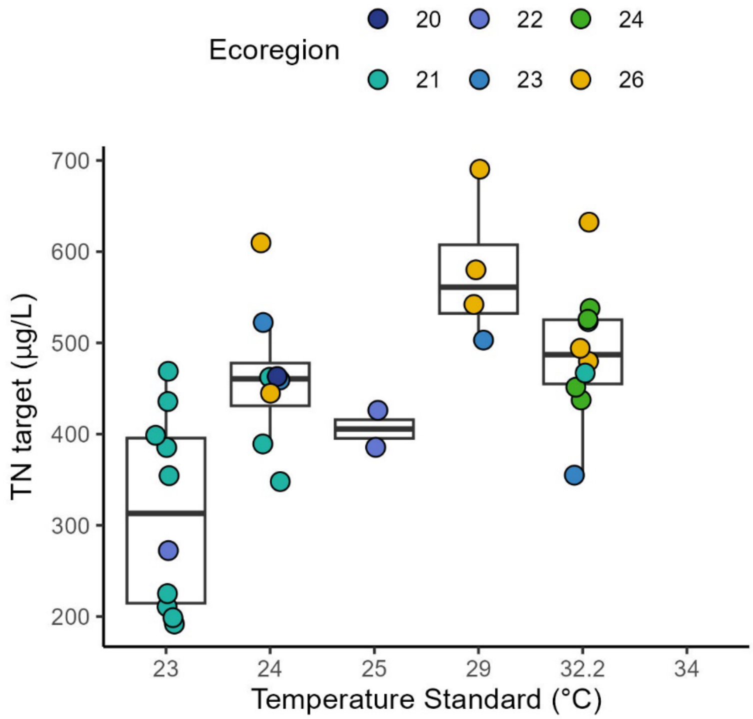

Figure 24. TN targets from the national nutrient model, summarized by ecoregion and temperature criteria.

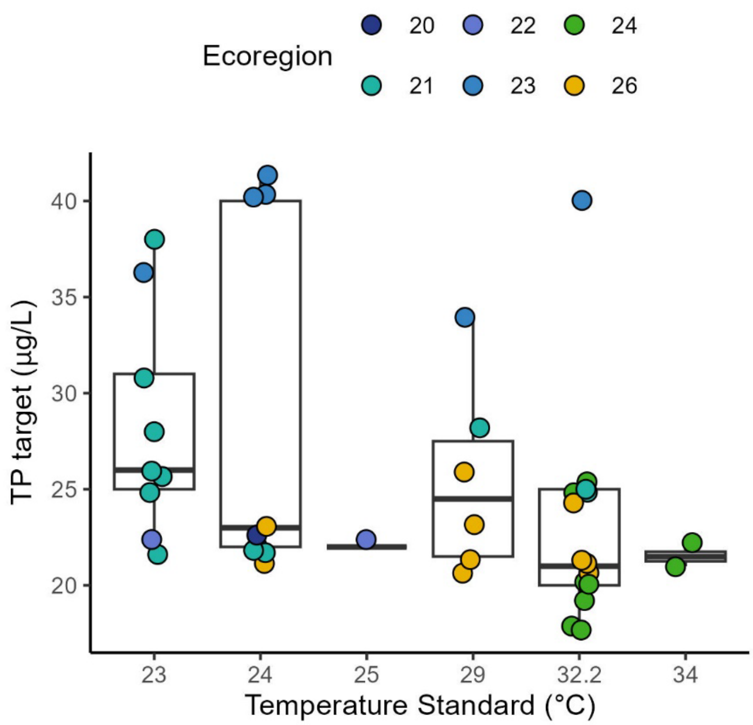

Figure 25. TP targets from the national nutrient model, summarized by ecoregion and temperature criteria.

6.7 TN and TP Targets

When translated from a chlorophyll target of 10 µg/L, the corresponding TN and TP targets are presented in Table 12 and Appendix Table 14. NMED may use these ranges to interpret nutrient targets for assessment purposes, which could be applied statewide, divided by ecoregion, or applied on a site-specific basis.

EPA's revised ambient water quality criteria recommendations for lakes and reservoirs were published in 2021 (USEPA 2021). At this time, we are not aware of any state or tribe that have fully implemented the national models in their published guidance or regulations, but several states are currently in the process of applying the models for use in developing numeric nutrient criteria development, translating narrative nutrient criteria, and/or updating lake assessment procedures.

Table 12. Summary of nutrient targets generated from cyanobacteria regressions and the national model application in New Mexico lakes.

Model	Details	Temperature or Ecoregion Class	Target and Units	Concentration
Cyanobacteria Proportion	Logistic regression	Statewide	TN (µg/L)	No target found (lack of statistical relationship)
Cyanobacteria Cell Count	Linear regression	Statewide	TN (µg/L)	No target found (lack of statistical relationship)
TN	Chlorophyll target 10 µg/L Certainty level 0.90 DOC ± 2 mg/L from estimated concentration	Colorado Plateaus (20)	TN (µg/L)	463
		Southern Rockies (21)		192-523
		Arizona/New Mexico Plateau (22)		272-426
		Arizona/New Mexico Mountains (23)		355-522
		Chihuahuan Deserts (24)		437-538
		Southwestern Tablelands (26)		445-690
Cyanobacteria Proportion	Logistic regression	Statewide	TP (µg/L)	No target found (lack of statistical relationship)
Cyanobacteria Cell Count	Linear regression	Statewide	TP (µg/L)	No target found (few high cyanobacteria observations)
TP	Chlorophyll target 10 µg/L Certainty level 0.90 Observed max. depth for each lake	Colorado Plateaus (20)	TP (µg/L)	23
		Southern Rockies (21)		22-38
		Arizona/New Mexico Plateau (22)		22
		Arizona/New Mexico Mountains (23)		34-41
		Chihuahuan Deserts (24)		18-25
		Southwestern Tablelands (26)		21-26

7 REFERENCES

Breiman L. 2001. Random Forests. Machine Learning 45(1), 5-32.

Breiman L, Friedman JH, Olshen RA, Stone CJ. 1984. Classification and Regression Trees. Wadsworth.

Dodds WK, Carney E, and Angelo RT. 2006. Determining ecoregional reference conditions for nutrients, Secchi depth and chlorophyll *a* in Kansas lakes and reservoirs. Lake and Reservoir Management 22(2):151-159.

Hill RA, Weber MH, Debbout R, Leibowitz SG, and Olsen AR. 2018. The Lake-Catchment (LakeCat) Dataset: characterizing landscape features for lake basins within the conterminous USA. Freshwater Science 37: 208–221.

Lyons J, Parks TP, Minahan KL, Ruesch AS. 2018. Evaluation of oxythermal metrics and benchmarks for the protection of cisco (*Coregonus artedi*) habitat quality and quantity in Wisconsin lakes. Canadian Journal of Fisheries and Aquatic Sciences 75(4): 600-608.

NM Surface Water Quality Bureau. 2021. Comprehensive Assessment and Listing Methodology (CALM): Procedures for Assessing Water Quality Standards Attainment for the State of New Mexico CWA §303(d) /§305(b) Integrated Report.

NM Water Quality Control Commission. 2022. Water Quality Standards for Interstate and Intrastate Surface Waters. 20.6.4.1

Nürnberg GK. 1996. Trophic state of clear and colored, soft and hardwater lakes with special consideration of nutrients, anoxia, phytoplankton and fish. Lake and Reservoir Management 12(4): 432-447.

R Core Team. 2023. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Scott JT and Haggard BE. 2011. Analytical support for identifying water quality thresholds in New Mexico surface waters. University of Arkansas. Available at: [Analytical Support for Identifying Water Quality Thresholds in New Mexico Surface Waters - FINAL REPORT (nm.gov)]

Stan Development Team. 2023. RStan: the R interface to Stan. R package version 2.26.13. https://mc-stan.org/.

[USEPA] United States Environmental Protection Agency. 2019. Recommended Human Health Recreational Ambient Water Quality Criteria or Swimming Advisories for Microcystins and Cylindrospermopsin. EPA 822-R-19-001.

[USEPA] United States Environmental Protection Agency. 2021. Ambient water quality criteria to address nutrient pollution in lakes and reservoirs. Office of Science and Technology: EPA-822-R-21-005.

[USEPA] United States Environmental Protection Agency. 2022. Description of updates made to lake criterion models.

[USGS] United States Geological Survey. 2019. National Hydrography Dataset (ver. USGS National Hydrography Dataset Best Resolution for Hydrologic Unit 4 – 2001). Accessed at https://www.usgs.gov/core-science-systems/ngp/national-hydrography/access-national-hydrography-products.

Winslow L, Read J, Woolway R, Brentrup J, Leach T, Zwart J, Albers S, and Collinge D. 2019. rLakeAnalyzer: Lake Physics Tools_. R package version 1.11.4.1. https://CRAN.R-project.org/package=rLakeAnalyzer.

Wright M and Ziegler A. 2017. ranger: A Fast Implementation of Random Forests for High Dimensional Data in C++ and R. Journal of Statistical Software, 77(1), 1-17. doi:10.18637/jss.v077.i01.

8 APPENDIX

Table 13. NLA lakes in New Mexico used in the development of the national models. An "x" indicates data from the lake were included in the input data for a particular model.

NLA Lake ID	Year	Latitude	Longitude	Ecoregion	Zooplankton Model	Microcystin Model	Hypoxia Model	Nutrient Models
NLA_NM-10001	2007	33.00711	-107.275	24				x
NLA_NM-10002	2007	35.66654	-106.301	21				x
NLA_NM-10003	2007	36.67344	-106.691	21			x	x
NLA_NM-10003	2017	36.69162	-106.698	21	x	x	x	x
NLA_NM-10005	2007	35.6908	-105.876	21			x	x
NLA_NM-10006	2007	36.56242	-104.594	26				x
NLA_NM-10009	2007	35.97547	-105.917	22			x	x
NLA_NM-10009	2012	35.97547	-105.917	22	x	x	x	x
NLA_NM-10009	2017	35.97467	-105.917	22	x	x	x	x
NLA_NM-10011	2007	35.75948	-105.142	26				x
NLA_NM-10011	2012	35.75948	-105.142	26	x	x		x
NLA_NM-10011	2017	35.7589	-105.145	26	x	x		x
NLA_NM-10015	2007	36.47751	-104.898	26				x
NLA_NM-10017	2007	36.6038	-104.64	26				x
NLA_NM-10019	2007	35.55993	-105.161	22				x
NLA_NM-10020	2007	36.0399	-106.849	21				x
NLA_NM-10020	2017	36.03989	-106.849	21	x	x		x
NLA_NM-10021	2007	36.82323	-107.464	21			x	x
NLA_NM-10022	2007	33.15857	-107.221	24				x
NLA_NM-10023	2007	35.50355	-104.225	26				x
NLA_NM-10024	2007	36.57446	-104.663	26				x
NLA_NM-10024	2017	36.5808	-104.654	26	x	x		x
NLA_NM-10027	2007	36.42565	-103.605	26				x
NLA_NM-10039	2012	36.89508	-105.136	21	x	x	x	x
NLA_NM-10051	2012	35.35147	-103.515	26	x	x		x
NLA_NM-10054	2012	36.83189	-104.227	21	x	x		x
NLA_NM-10055	2012	36.88343	-105.248	21		x		
NLA_NM-10056	2012	36.8016	-108.102	22	x	x	x	x

NLA Lake ID	Year	Latitude	Longitude	Ecoregion	Zooplankton Model	Microcystin Model	Hypoxia Model	Nutrient Models
NLA_NM-10060	2012	35.98186	-108.93	23	x	x	x	x
NLA_NM-10060	2017	35.98083	-108.932	23	x	x	x	x
NLA_NM-10072	2012	36.71359	-108.156	22		x		x
NLA_NM-10074	2012	36.17769	-104.818	26		x		x
NLA_NM-10074	2017	36.17599	-104.816	26		x		x
NLA_NM-10082	2012	35.66385	-105.235	26	x			x
NLA_NM-10082	2017	35.66711	-105.242	26	x	x		x
NLA_NM-10083	2012	36.59544	-105.417	21		x		x
NLA_NM-10083	2017	36.59538	-105.417	21		x		x
NLA_NM-10084	2012	36.87228	-106.928	21	x	x		x
NLA_NM-10094	2017	36.68847	-107.685	20	x	x		x
NLA_NM-10095	2017	36.77464	-105.194	21	x	x	x	x
NLA_NM-10110	2017	35.948	-105.22	26	x	x		x
NLA_NM-10113	2017	33.03037	-108.16	23	x	x		x

Table 14. Summary of TN and TP targets from the national nutrient models across lakes in New Mexico. NA indicates that a particular nutrient was not measured in a given lake, and thus no model output was generated.

Lake ID	Lake Name	Temp. Criteria (°C)	Ecoregion	Certainty Level	Chl Target (µg/L)	DOC (mg/L)	TP Target (µg/L)	TN Target (µg/L)
NM-2114_00	Abiquiu Reservoir	25	22	0.9	10	6.4	22	426
NM-2209.B_30	Alto Lake	32.2	23	0.9	10	3.6	40	355
NM-2504_30	Bear Canyon Reservoir	24	23	0.9	10	6.2	41	522
NM-2502.B_00	Bill Evans Lake	29	23	0.9	10	5.9	34	503
NM-2205_00	Brantley Reservoir	32.2	24	0.9	10	NA	19	NA
NM-9000.B_025	Burns Lake (Rio Arriba)	32.2	21	0.9	10	7	25	523
NM-2102.B_00	Caballo Reservoir	32.2	24	0.9	10	5	20	437
NM-2120.B_20	Cabresto Lake	23	21	0.9	10	1.7	22	211
NM-2116.B_10	Canjilon Lake (a)	23	21	0.9	10	4.6	38	385
NM-2305.5_10	Charette Lake (Lower)	24	26	0.9	10	6.9	21	610
NM-9000.B_030	Clayton Lake	29	26	0.9	10	6.4	23	580
NM-2304_00	Conchas Reservoir	32.2	26	0.9	10	5	21	480
NM-2117_00	El Vado Reservoir	24	21	0.9	10	4.7	22	389
NM-2104_00	Elephant Butte Reservoir	32.2	24	0.9	10	5.2	18	451
NM-2106.B_00	Fenton Lake	23	21	0.9	10	4.8	28	399
NM-9000.B_044	Figure Eight Lake	32.2	24	0.9	10	NA	20	NA
NM-2120.B_12	Goose Lake	23	21	0.9	10	1.3	31	192
NM-2209.B_20	Grindstone Canyon Reservoir	23	23	0.9	10	NA	36	NA
NM-2117_10	Heron Reservoir	24	21	0.9	10	4	22	348
NM-2112.B_00	Hopewell Lake	23	21	0.9	10	4.1	26	354
NM-2201_01	Jal Lake	32.2	24	0.9	10	NA	25	NA
NM-9000.B_006	Lake Farmington (Beeline Reservoir)	25	22	0.9	10	5.6	NA	385
NM-2305.B_20	Lake Maloya	24	21	0.9	10	5.9	22	462
NM-2504_20	Lake Roberts	24	23	0.9	10	5.2	40	459
NM-9000.B_071	Lake Van	32.2	24	0.9	10	6.6	25	538
NM-9000.B_001	Lea Lake	32.2	24	0.9	10	6.4	18	526
NM-2203.B_00	Lower Tansil Lake/Lake Carlsbad	34	24	0.9	10	NA	21	NA
NM-9000.B_081	Maxwell Lake 13	32.2	26	0.9	10	7.2	24	632

Lake ID	Lake Name	Temp. Criteria (°C)	Ecoregion	Certainty Level	Chl Target (µg/L)	DOC (mg/L)	TP Target (µg/L)	TN Target (µg/L)
NM-2120.B_55	Middle Fork Lake	23	21	0.9	10	1.9	NA	225
NM-2214.B_40	Monastery Lake	29	21	0.9	10	NA	28	NA
NM-2305.3.B_30	Morphy (Murphy) Lake	32.2	21	0.9	10	6	25	467
NM-2406_00	Navajo Reservoir	24	20	0.9	10	5.8	23	463
NM-2211.B_40	Perch Lake	29	26	0.9	10	5.9	21	542
NM-2106.B_10	San Gregorio Lake	23	21	0.9	10	6.1	26	469
NM-2118.B_00	Santa Cruz Lake	23	22	0.9	10	3.2	22	272
NM-2211.B_00	Santa Rosa Reservoir	29	26	0.9	10	NA	21	NA
NM-2306.B_30	Shuree Pond (North)	23	21	0.9	10	5.5	25	436
NM-2202.B_20	Six Mile Dam Lake	34	24	0.9	10	NA	22	NA
NM-2504_40	Snow Lake	24	23	0.9	10	NA	40	NA
NM-2305.1.B_10	Springer Lake	29	26	0.9	10	8	26	690
NM-2211.5_00	Storrie Lake	24	26	0.9	10	4.6	23	445
NM-2210_00	Sumner Reservoir	32.2	26	0.9	10	NA	21	NA
NM-2302_00	Ute Reservoir	32.2	26	0.9	10	5.2	21	494
NM-2120.B_75	Williams Lake	23	21	0.9	10	1.4	NA	199